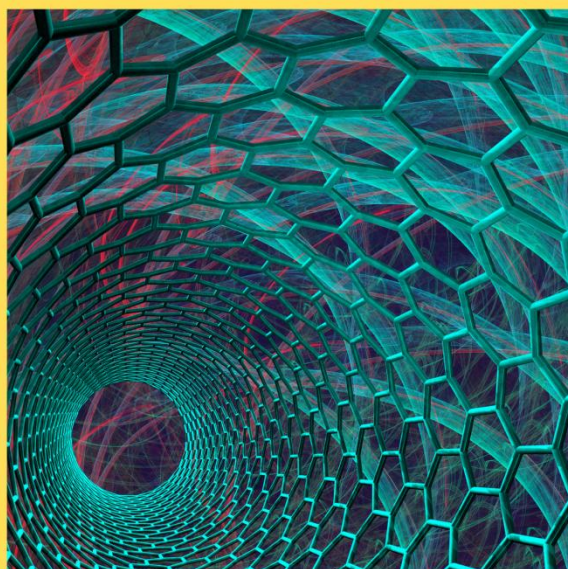


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Current Research of Nanotechnology in Science and Engineering Volume I



Editor:

Dr. Bassa Satyannarayana



First Edition: 2022

**CURRENT RESEARCH OF NANOTECHNOLOGY IN
SCIENCE AND ENGINEERING**

Volume I

It's a Present & Future Technology

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PREFACE

Nanotechnology is one of the most promising technologies of the twenty-first century. Nanotechnology is described as the design, development, and implementation of materials and technologies on the nanoscale with the smallest functional components (1 to 100 nm). Nanotechnology covers a wide range of issues, from standard device physics and chemistry extensions to entirely new techniques based on molecular self-assembly, from developing new Nano size materials to investigating whether we can directly alter matter at the atomic scale level.

Nanotechnology can be used in a variety of fields, including medical, agriculture, and environmental protection. Many diseases for which there are presently no treatments may be treated in the future as a result of nanotechnology. The use of nanotechnology in medical therapy needs a careful examination of its risks and potential side effects. Even scientists who oppose the use of nanotechnology agree that advancement in the field should continue since it offers enormous benefits, but more testing is needed to ensure its safety in people. Nano medicine may play a key role in the treatment of human and plant disorders, as well as the enhancement of normal human and plant physiology and systems, in the future.

Nanoscience and nanotechnology are the study and application of extremely small objects, with applications in chemistry, biology, physics, materials science, and engineering, among other fields. Nanotechnology is being used in a range of energy-related applications, including increasing the efficiency and cost-effectiveness of solar panels, producing new types of batteries, boosting fuel production efficiency through better catalysis, and building better lighting systems. Nano science and nanotechnology applications in engineering connect academic research in Nano science and nanotechnology to industry and everyday life. As a result, a diverse range of nanomaterials, nano devices, and nano systems have been developed and deployed for human benefit in a number of technical applications.

Nanoscience and Nanotechnology in Engineering is based on the authors' numerous lectures and courses given all over the world. Nanotechnology has also helped to design more efficient and long-lasting materials, such as self-cleaning and self-repairing concrete and windows. Coatings based on nanotechnology can help with fire protection, corrosion resistance, insulation, and a range of other applications. All scientists, academicians, researchers, and students working in the fields of chemistry, biology, physics, materials science, and engineering, among other fields, will find this book quite valuable.

This book with valuable book chapters from eminent scientists, academicians, and researchers will surely be a part of utmost information for the coming new research taken by the researchers in the field of chemistry, biology, physics, materials science, and engineering, among other subjects.

ABOUT THE BOOK

As scientists endeavour to comprehend the mechanisms of natural and biomolecular computing, Nano scale science and computing is becoming a key research subject. The architecture and design of molecular self-assembly, nanostructures, and molecular devices, as well as understanding and harnessing the computational processes of biomolecules in nature, are all topics in this discipline.

This book provides a unique and authoritative view of contemporary Nano scale science, engineering, and computing research. The book is appropriate for academic and industrial scientists and engineers working in Nano scale science, particularly those interested in molecular level computing.

Nano science and nanotechnology are the study and application of extremely small objects, and they can be applied in chemistry, biology, physics, materials science, and engineering, among other subjects. Nanotechnology is being employed in a variety of energy-related applications, including improving the efficiency and cost-effectiveness of solar panels, developing new types of batteries, improving the efficiency of fuel production through better catalysis, and developing better lighting systems. Engineering's application of Nano science and nanotechnology connects academic research in Nano science and nanotechnology to industry and everyday life. As a result, a wide range of nanomaterial's, Nano devices, and Nano systems for a variety of technical applications have been produced and deployed for human benefit. Nano science and Nanotechnology in Engineering is based on the many lectures and courses presented around the world by its authors. Nanotechnology has also aided in the development of more efficient and long-lasting materials, such as self-cleaning and self-repairing concrete and windows. Nanotechnology-based coatings assist in increasing fire resistance, corrosion resistance, insulation, and a variety of other uses. This book is very useful to all scientists, academicians, researchers and students in the field of chemistry, biology, physics, materials science, and engineering, among other subjects.

This book with valuable book chapters from eminent scientists, academicians, and researchers will surely be a part of utmost information for the coming new research taken by the researchers in the field of chemistry, biology, physics, materials science, and engineering, among other subjects.

Dr. Bassa Satyannarayana
Editor

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Chapter

1

**TECHNIQUES USED IN WATER SOFTENING AND
PURIFICATION**

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ABSTRACT

The availability of secure and affordable water to meet human needs is a significant challenge for the 21st century. The world's water supply is struggling to keep up with rapidly rising demand that is exacerbated by growth of population, global environment change, and deterioration of state of the water. It is impossible to overstate the importance of technological innovation in enabling water management that is integrated. In present scenario nanotechnology play an important role in improving the quality of water and treatment of wastewater. Present chapter explain waste water, water borne disease, toxic elements and purification of waste/toxic water through conventional method and with the help of Nanomaterials.

KEYWORDS: Waste water, ion-exchange method, Lime-soda process, Zeolite, Nano adsorption, Nano-catalyst.

INTRODUCTION

Human civilization's most valuable resource is water. However, we are still unable to provide fresh water to meet the needs of global demands, and this problem may increase over the time. Water is required by all living organisms, including plants and animals. Without water life does not exist on the earth. The entire organisms contain 65-75% of water in their body, which remove in the form of excreta. About 97% of water present in the ocean, which is unfit for drinking because lots of salt dissolve in ocean water causes dehydration. Remaining 3%, 2% of water present in the form of ice-caps and glacier and only 1% of water is fresh water¹, present in lakes, river, underground water, streams etc. but due to global warming and human activities water quality get reduce which is unfit for drinking purposes. According to the WHO (world health organization) impure or contaminated water responsible for about 6% of the worldwide disease². For the purification of waste water conventional methods such as lime-soda, ion-exchange, Zeolite process and reverse osmosis have been used. In recent past year nanomaterials have had an unparalleled impact on the water and wastewater treatment process. Because of their unique qualities such as high surface area and high adsorption capacity, nanomaterials hold enormous promise as the best possible solution to remediate organic and inorganic pollutants.

CHARACTERISTIC OF GOOD WATER

- a) It is transparent, odorless and colorless liquid.
- b) It is free from biological and bacteriological contamination.

- c) It is free from toxic and chemicals.
- d) It is free from essential nutrients like nitrogen, phosphorus etc. which causes Eutrophication.

MAJOR FACTS CAUSES DETERIORATION OF WATER

- a) Eutrophication
- b) Pesticides contamination
- c) Domestic sewage and ground water contamination
- d) Insufficient or incomplete treatment of domestic waste and industrial waste.

WATER BORNE DISEASE

It is caused by contamination of water by bacteria, virus, protozoa etc. The different water borne diseases are as follows;

- a) **Cholera:** it is highly contagious disease caused by bacteria vibrio cholerae. The typical symptoms are diarrhea, vomiting, dehydration, kidney failure etc.
- b) **Typhoid:** it is water borne disease caused by bacteria salmonella typhie. The major symptoms are weakness, constipation, diarrhea, vomiting etc.
- c) **Amoebiasis:** it is also water borne disease caused by protozoa's Entamoeba histolytica. The disease is characterized by liquid stool with mucus and blood.
- d) **Fluorosis:** if fluoride content is higher than 1.5 ppm causes Fluorosis. The major symptoms are deterioration of teeth and deformation of bone.

PREVENTION OF PURE DRINKING WATER

- a) Water must be boiled before drinking.
- b) Maintain personal hygiene
- c) Hygienic kitchen appliances

MEASUREMENT OF WATER QUALITY

DISSOLVE OXYGEN (DO)

Oxygen present in dissolve or diffuse form in water is known as dissolve oxygen. It is supplied by the diffusion of atmospheric oxygen into the water or by the photosynthesis of aquatic plants. Dissolve oxygen is very useful for all the aquatic plants and animals. It is measure in terms of mg/l.

FACTOR AFFECTING DISSOLVES OXYGEN LEVEL

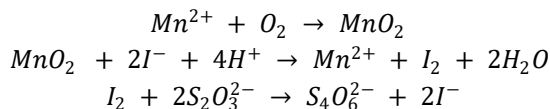
- a) Eutrophication
- b) Oxygen level also affected by amount of photosynthesis and degree of water wave action.
- c) Temperature and pressure are also affects the oxygen level in water. At high temperature and low pressure diffusion of oxygen decreases whereas at low temperature and high pressure diffusion of oxygen in water increases.

METHOD OF MEASUREMENT OF DO

Winkler method³

In this method, dissolve oxygen present in sample is combined with metal ion Mn^{2+} to form metal oxide precipitate. The oxidation of Mn^{2+} into MnO_2 is known as oxygen fixation. When MnO_2 form, iodide ions are added and MnO_2 react with iodide ion to form iodine. The liberated iodine or quantity of iodine is

titrated against sodium thiosulphate. The quantity of MnO_2 form is directly proportional to the amount of dissolve oxygen present in water. The reactions involve in this method are as follows;

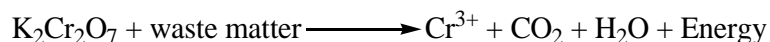


BIOLOGICAL OXYGEN DEMAND (BOD)

It is define as amount of dissolve oxygen required by aerobic bacteria or microorganism to decompose the organic waste present in the waste water. In BOD, amount of waste present in water is exactly proportionate to the amount of oxygen utilized. In fresh water BOD is 2mg/l whereas in impure water BOD is 10mg/l. The BOD measurement takes 3 days at 27°C and 5 days at 20°C.

CHEMICAL OXYGEN DEMAND (COD)

It is defined as oxygen required decomposing the entire organic and inorganic compound present in waste water. COD measurement takes few minute as compare to BOD. Like BOD, COD is also utilized oxygen from potassium dichromate to oxidized organic and inorganic matter present in water.



The amount of potassium dichromate consumed is proportionately proportional to the amount of waste present in water.

Table 1: Water quality parameter (Indian Standard)⁴

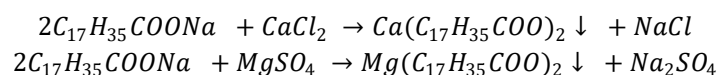
| S. No | Parameter | Maximum permissible limit | Health effect |
|-------|----------------------|---------------------------|--|
| 1 | Fluoride | 1.5 mg/l | Dental Fluorosis, deformation of skeleton |
| 2 | Aluminium | 0.2 mg/l | Alzheimer's disease |
| 3 | Copper | 1.5 mg/l | Liver damage, slow plant growth |
| 4 | pH | 6.5-8.5 | Bitter taste, mucosal membrane effect, aquatic like affected |
| 5 | Hardness | 600 mg/l | Causes hardness of water, skin irritation |
| 6 | Total dissolve solid | 2000 mg/l | Gastro-intestinal irritation, corrosion, |
| 7 | Nitrate | 100 mg/l | Blue baby disease |
| 8 | Mercury | 0.001 mg/l | Minamata disease |
| 9 | Arsenic | 0.05 mg/l | Carcinogenic, CNS affected |
| 10 | Chloride | 1000 mg/l | Taste affected, corrosive |
| 11 | Alkalinity | 600 mg/l | Boiled rice become yellow |
| 12 | Iron | 1.0 mg/l | Bitter taste causes turbidity |
| 13 | Calcium | 200 mg/l | Causes hardness of water, scale formation |
| 14 | Cadmium | 0.003 mg/l | Itai-Itai disease |
| 15 | Lead | 0.01 mg/l | Anaemia, damaged kidney, neurological impairment |

HARDNESS OF WATER

Due to presence of Ca & Mg salts like bicarbonates, carbonate, sulphates, chlorides in water, water does not produce lather with soap, known as hardness of water. It is due to presence of Ca & Mg salts like bicarbonates, carbonate, sulphates, chlorides etc.

FORMATION OF HARD WATER

Hard water is formed due to presence of minerals like Ca and Mg. they are not removed or separated by sedimentation or filtration. When hard water contains Ca and Mg impurity reacts with soap (sodium salt of stearic acid or pametic acid) to form curdy precipitate.

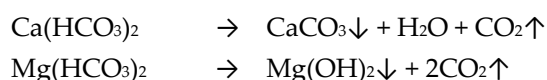


In above reaction, precipitate of calcium stearate or magnesium stearate are formed which are insoluble and separate out without producing lather.

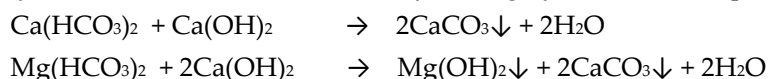
TYPES OF HARDNESS

TEMPORARY HARDNESS

Ca and Mg bicarbonate are responsible for temporary hardness. This type of hardness can be removed simply by boiling of water. Due to boiling bicarbonate is converted into carbonate (insoluble precipitate)



Temporary hardness can also be removed by adding hydrated lime to precipitate insoluble carbonate.



PERMANENT HARDNESS

It is caused by the presence of soluble salt of Ca and Mg other than bicarbonate such as chloride and sulphate. These impurities cannot be removed by boiling of water or hydrated lime. It can be removed by techniques like Lime-soda process, Zeolite, Ion-exchange resin, reverse osmosis etc.

DEGREE OF HARDNESS

The unit in which hardness is usually expressed, known as degree of hardness. Calcium carbonate ($CaCO_3$) equivalent is used to express Degree of hardness because $CaCO_3$ have molecular weight 100 and it is easily precipitate. Degree of hardness may be expressed as follows-

$$\text{Equivalent of } CaCO_3 = \frac{[\text{strengt h of substance producing hardness } (\frac{mg}{lit})] \times 100}{[\text{chemical equivalent of hardness producing substance}] \times 2}$$

UNIT OF HARDNESS

- i) **Parts per million (ppm):** It is define as the number of equivalent part calcium carbonate present per million (10^6) part of water by weight.

- ii) **Milligram per litre (mg/lit):** It is defined as the number of milligram of calcium carbonate present in one litre of water.
- iii) **Degree Clarke (°Cl):** It is define as the number of equivalent part of calcium carbonate present per 70,000 part of water.
- iv) **Degree French (°Fr):** It is define as the number of equivalent part of calcium carbonate present per 10⁵ part of water.

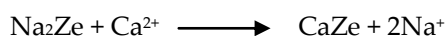
Correlation between ppm, mg/lit, °Cl and °Fr:

$$[1\text{ppm} = 1\text{mg/lit} = 0.07\text{ }^\circ\text{Cl} = 0.1\text{ }^\circ\text{Fr}]$$

GENERAL METHOD FOR WATER SOFTENING

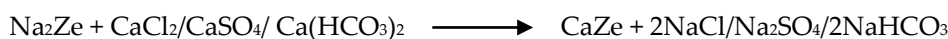
ZEOLITE PROCESS

Zeolite is a three-dimensional hydrated sodium aluminium silicate. Zeolite represented as $\text{Na}_2\text{OAl}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$ ($x = 2-10$ & $y = 2-6$). Zeolite are capable to exchange sodium ion with hardness producing ions like Ca^{2+} or Mg^{2+} . Zeolite process is also known as permutit method. Due to complex chemical formula of Zeolite, it can be written simply as Na_2Ze . The two Na^+ ions are replaced by one Ca^{2+} or Mg^{2+} ions.



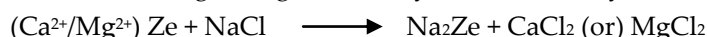
PROCESS

The apparatus used in Zeolite process, is made of metallic cylindrical which contain several layers (beds) in which Zeolite salt is kept. When hard water is pass through it, hardness producing ions exchange from the layers. Zeolite bed/layers exhausted after some time, means all Na^+ ions are exchange by Ca^{2+} or Mg^{2+} .



REGENERATION

The exhausted Zeolite again regenerated by treatment of layers with brine solution or 10% NaCl solution.



After treatment with brine solution, exhausted Zeolite layer is washed with cold water, by which CaCl_2 & MgCl_2 salt can be removed

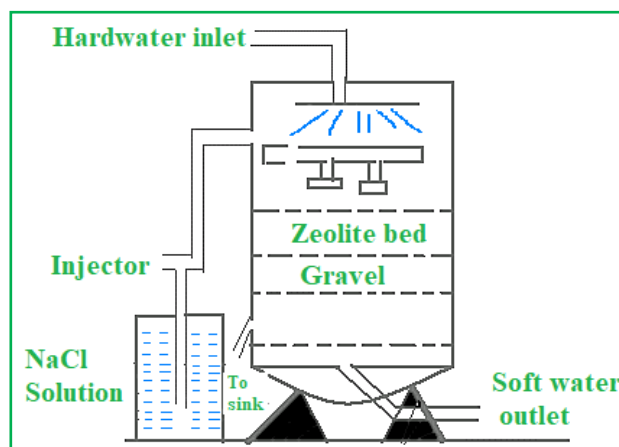
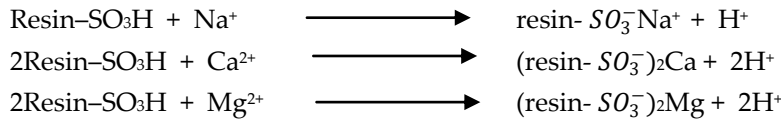


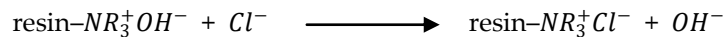
Fig 1: Regeneration of Zeolite

ION-EXCHANGE RESIN

From ion-exchange process both the cations and anions are completely removed by passing impure water into two different columns. First column contain sulphuric acid resin with acidic group $-\text{SO}_3\text{H}$. This column is known as cation exchange resin because it exchange only cations like Ca^{2+} , Mg^{2+} , Na^+ etc.



Whereas, second column contain resin with basic group like $-\text{NR}_3^+\text{OH}^-$. It is known as anion exchange resin because it exchanges anions like Cl^- , SO_4^{2-} etc.



The removal of H^+ ions from the first column and OH^- ions from the second column react to form water.

REGENERATION

When both the column are exhausted, then first and second column are treated with dilute sulphuric acid or HCl (generate H^+ ions) and aqueous NaOH (generate OH^- ions) respectively. So, they have to be regenerated.

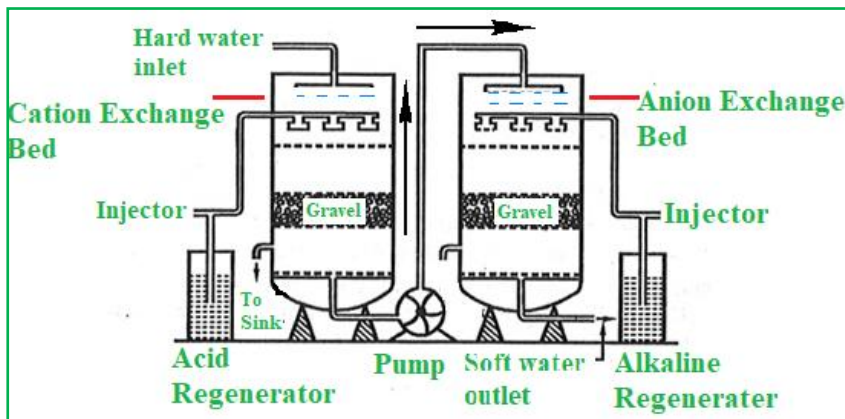
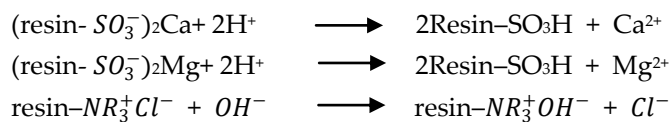


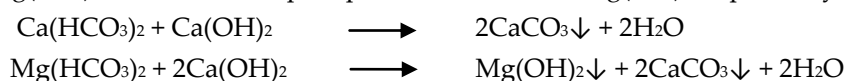
Fig 2: Regeneration process

LIME-SODA PROCESS

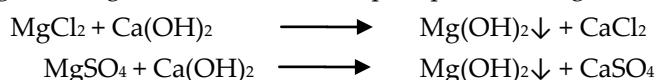
In lime-soda process, hydrated lime and soda ash are used to remove hardness producing ions.

HYDRATED LIME

By the treatment with hydrated lime temporary hardness can be removed. When $\text{Ca}(\text{OH})_2$ react with $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{CO}_3)_2$ form insoluble precipitate of CaCO_3 and $\text{Mg}(\text{OH})_2$ respectively.



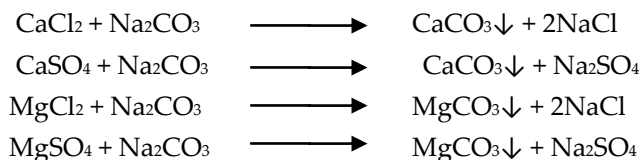
Hydrated lime is also used to remove permanent hardness (magnesium salt impurities only) from water. It reacts with MgSO_4 & MgCl_2 to form insoluble precipitate of magnesium hydroxide.



In above reaction calcium based impurities like CaCl_2 & CaSO_4 also form, which are soluble in water. Therefore calcium based impurities (CaCl_2 & CaSO_4) are not removed by lime treatment.

SODA ASH

Sodium carbonate (Na_2CO_3) is used to eliminate permanent hardness of water which caused by MgSO_4 & MgCl_2 or CaCl_2 & CaSO_4 .



The lime-soda required for the softening of hard water can be calculated by following formula-

$$\text{Lime requirement} = \frac{74}{100} [\text{temporary hardness of Ca} + 2 \times \text{temporary hardness of Mg} + \text{permanent hardness of Mg in terms of CaCO}_3 \text{ equivalents}]$$

$$\text{Soda requirement} = \frac{106}{100} [\text{permanent hardness of CaCl}_2 + \text{CaSO}_4 + \text{MgCl}_2 + \text{MgSO}_4 \text{ In terms of CaCO}_3 \text{ equivalents}]$$

REVERSE OSMOSIS

If we apply pressure higher to osmotic pressure on the solution portion then solvent (pure water) will flow reverse, higher concentration solution to low concentration solution, the process is known as reverse osmosis.

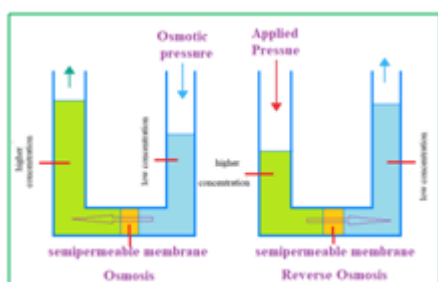


Fig 3: Reverse Osmosis

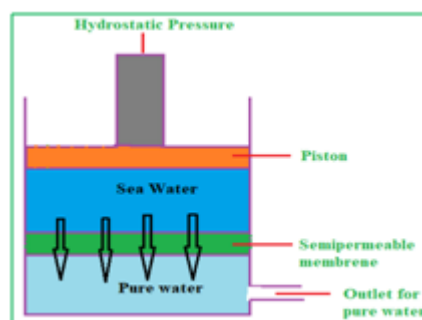


Fig 4: Purification of sea water

The reverse osmosis process can also be used in the purification of sea water, for this purpose salty water (sea water) is passed through a semi-permeable membrane under high pressure where sea water percolate the minute pores of the semi-permeable membrane and after this process water is purified.

ADVANTAGES

- 1) Reverse osmosis system have low maintenance requirement.
- 2) It also removes colloidal silica.
- 3) RO system required less energy as compare to other technology.
- 4) The reverse osmosis is used for converting sea water into drinking water.

NANOTECHNOLOGY IN WATER PURIFICATION

Materials having size in the range of 1-100 nm is known as nanomaterials. Nanomaterials are effectively used in purification of water because they possess a very large surface to volume ratio, spatial confinement, aspect ratio, short intraparticle diffusion distance and reduce imperfection. Advantages of Nanomaterials over other materials are as follows;

Effectiveness: Because of the high specialty of nanotechnology, new filters/devices are going to be formed for specific applications from Nanomaterials. Impurities that were antecedently difficult to remove; now they can be removed more successfully.

Simple method: Nanotechnology has the potential to drastically minimize the steps involved, resources, and energy required for purification of water.

Cost effectiveness: Incorporating or switching to nanotechnology-based water treatments will necessitate a large initial expenditure. On the other hand, once implemented, these advances have the potential to significantly reduce long-term water treatment costs.

Water treatment through Nanomaterials is described as follows;

NANO-ADSORPTION

Due to smaller pore size and large surface area nano-materials are used in purification of water. Heavy metals are trapped/adsorb on the surface of nanomaterial. The Nanomaterials such as carbon, carbon nanotubes, zinc oxide, magnesium oxide, titanium oxide and ferric oxides are frequently used to eliminate or remove heavy metal from impure water⁵. Carbon based nanomaterials are used in the purification of water contaminated by organic matter and heavy toxic metals.

NANO-PHOTO CATALYSTS

"Photo catalysis" is combination of two Greek words, "Photo" refers to light, and "catalysis" refers to any material that affects the rate of a chemical reaction without actually being a part of it. Photo catalytic oxidation is a high-tech oxidation method for removing pollutants and microbiological pathogens. It's a good way to improve the biodegradability of hazardous and non-biodegradable pollutants. Nano catalyst formed from metal oxides used in different oxidation reactions. They exhibited high catalytic reactivity towards toxic pollutants and change toxic pollutants into less polluted or environment friendly products⁶. According to literature, photo degradation of pollutant through modified form of titanium oxide give good results⁷.

REFERENCES

- [1] Adeleye, A. S., Conway, J. R., Garner, K., Huang, Y., Su, Y., Keller, A. A. (2016). Engineered Nanomaterials for Water Treatment and Remediation: Costs, Benefits, and Applicability. *Chemical Engineering Journal*, 286, 640–662. <https://doi.org/10.1016/j.cej.2015.10.105>.
- [2] Diarrhoeal disease <https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease> (accessed 2021-11-21).
- [3] Kenna, T. C. (2006). Determination of dissolved oxygen by winkler titration, 10.
- [4] IS 10500 (2012): Drinking Water. 16.
- [5] Anjum, M., Miandad, R., Waqas, M., Gehany, F., Barakat, M. A. (2019). Remediation of Wastewater Using Various Nano-Materials. *Arabian Journal of Chemistry*, 12 (8), 4897–4919. <https://doi.org/10.1016/j.arabjc.2016.10.004>.
- [6] Soppe, A. I. A., Heijman, S. G. J., Gensburger, I., Shantz, A., van Halem, D., Kroesbergen, J., Wubbels, G. H., Smeets, P. W. M. H. (2014). Critical Parameters in the Production of Ceramic Pot Filters for Household Water Treatment in Developing Countries. *Journal of Water and Health*, 13 (2), 587–599. <https://doi.org/10.2166/wh.2014.090>.
- [7] Yaqoob, A. A., Parveen, T., Umar, K., Mohamad Ibrahim, M. N. (2020). Role of Nanomaterials in the Treatment of Wastewater: A Review. *Water*, 12 (2), 495. <https://doi.org/10.3390/w12020495>.

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ABSTRACT

Nanotechnology is the study of particles with sizes ranging from 1 to 100 nanometers in one dimension. Particles reduced to the nanometer length scale have a higher surface area to volume size ratio and exhibit unusual properties, allowing them to be used in engineering, biomedical, agricultural, and allied fields. Physical, chemical, and biological methods of synthesis can be used to create nanomaterials from the bottom-up or top-down.

KEYWORDS: Nanotechnology, nanomaterials, Nano biotechnology, nanotech applications

INTRODUCTION

A nanometer is one-billionth of a meter (10^{-9} m or 10^{-7} cm), one hundred thousand times smaller than the diameter of a human hair, a thousand times smaller than the diameter of a red blood cell, or around half the size of the diameter of DNA (Scott and Chan, 2002). Nanotechnology is described as atomic, molecular, or macromolecular research and development with a length scale of one to one hundred nanometers in at least one dimension. On an atomic scale, structures, technologies, and systems with novel qualities and functionalities are created and used due to their small size and ability to reign or manipulate matter (Lengke *et al.*, 2007). Nanotechnology is an interdisciplinary study that combines scientific branches from biology, chemistry, physics, and engineering to open new possibilities of application (Kulzer and Orrit, 2004). The underlying principle of nanotechnology is that when a material's size is decreased to the nanoscale scale, its properties change substantially (Raliya and Tarafdar, 2012). In the long run, nanotechnology will most likely be studied in the context of nanotechnology, biotechnology, information technology, and cognitive technology convergence, integration, and synergy. Convergence entails the creation of new goods with improved capabilities, such as bottom-up assembly of small components and biological, computational, and cognitive capacities. The already-progressing combination of nanotechnology and biotechnology will result in the creation of innovative nanoscale materials. In the coming decades, the confluence of nanotechnology and biotechnology with information technology and cognitive science is predicted to develop significantly. Increased knowledge of biological systems will aid in the development of effective and adaptable biomimetic tools, systems, and architecture. These nanomaterials have innovative electrical, catalytic, magnetic, mechanical, thermal, or imaging characteristics due to their unique qualities (Boisselier and Astruc, 2009).

Nanomaterials are created in two ways: "bottom-up" processes (such as self-assembly) build nanoscale materials from atoms and molecules, and "top-down" procedures (such as milling) create nanoscale

materials from macro-scale counterparts. When compared to their macro-scale equivalents, nanoscale materials usually exhibit different or enhanced features (Petit *et al.*, 1993). "Intentionally generated nanomaterials," or simply "nanoparticles," will be the name given to such constructed or manufactured nanomaterials. Nanomaterials that are formed accidentally, such as diesel exhaust particles or other friction or airborne combustion byproducts, are not included in the concept of nanotechnology, nor are nanosized materials that occur naturally in the environment, such as viruses or volcanic ash (Roco, 2003). Information derived from inadvertently manufactured or naturally occurring nanosized materials (such as ultrafine particle matter) may aid in the comprehension of purposely produced nonmaterial.

CORE AND HISTORY OF NANOTECHNOLOGY

The first use of the beliefs found in 'nanotechnology' (but pre-dating the use of that name) was in "There's Plenty of Room at the Bottom", a talk given by physicist Richard Feynman at an American Physical Society meeting at California Institute of Technology on December 29, 1959. Feynman described a process for developing the ability to manipulate individual atoms and molecules, in which one set of precise tools is used to build and operate another proportionally smaller set, and so on down to the required scale. Scaling concerns would occur as a result of the changing magnitude of numerous physical phenomena, he noted: gravity would become less important, surface tension and van der Waal attraction would become increasingly essential, and so on. This basic concept seems reasonable, and exponential assembly adds parallelism to make a useful number of end products. Professor Norio Taniguchi of Tokyo University of Science defined "nanotechnology" as follows in a 1974 paper: Nanotechnology is primarily concerned with the separation, consolidation, and deformation of materials by a single atom or molecule. In the 1980s the basic idea of this definition was found out in much more depth by Dr. K. Eric Drexler, who promoted the technological significance of nanoscale phenomena and devices through speeches and the books *Engines of Creation: The coming era of Nanotechnology* (1986) and *Nanosystems: Molecular Machinery, Manufacturing, and Computation*, and so the term acquired its current sense. An engine of Creation is considered the first book on the topic of nanotechnology (Drexler, 1992).

EVOLUTION OF NANOTECHNOLOGY

The progressive increase of complexity in nanotechnology leads to progression and application in a wide range of fields, which can be explained by different generations in which a significant change in situation was observed or expected. Table 1 can help to simplify it.

Table 1: Successive development of complexity in nanotechnology

| Generation | Period | Theme | Foremost infuse area of applications in which advancement happens |
|------------|------------|------------------------|---|
| First | Up to 2001 | Passive nanotechnology | Top down approach, nano-structured metal, polymer, ceramics, catalyst, MEMS |
| Second | 2001-2005 | Active nanotechnology | Bottom up approach, adaptive nanostructure, solar cell, transistors, sensor, diagnostic assay, NEMS |
| Third | 2005-2010 | Nanosystem technology | Biomemetic nanostructure, novel therapeutics, targeted drug delivery, nanochips, agriculture |
| Fourth | 2010-2015 | Molecular nanosystem | Atomic manipulations and design nanoscale architecture |

MATERIALS PERSPECTIVE

As the size of the system shrinks, some physical phenomena become more prominent. These include statistical and quantum mechanical effects, such as the "quantum size effect," in which the electronic properties of solids are altered when particle size is reduced dramatically. Going from macro to micro dimensions does not influence this effect. When the nanoscale size range is reached, often at distances of 100 nanometers or less, in the so-called quantum realm, quantum effects become dominating. When contrasted to macroscopic systems, a multitude of physical (mechanical, electrical, optical, etc.) features alter. An increase in the surface area to volume ratio, for example, can change the mechanical, thermal, and catalytic properties of materials. Nanoionics refers to diffusion and reactions at the nanoscale, as well as nanostructures, materials, and nanodevices with rapid ion transport. Nanomechanics research is interested in the mechanical properties of nanosystems. Nanomaterials' catalytic activity creates possible dangers when they interact with biomaterials. Materials reduced to the nanoscale can show different properties compared to what they exhibit on a macro scale, enabling unique applications (Ahmad *et al.*, 2003). For instance, opaque substances become transparent (copper); stable materials turn combustible (aluminium); insoluble materials become soluble (gold). A material such as gold, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscale. Much of the fascination with nanotechnology stems from these quantum and surface phenomena that matter exhibits at the nanoscale.

MOLECULAR PERSPECTIVE

Modern synthetic chemistry has advanced to the point where tiny molecules may be prepared for nearly any structure. Today, these processes are utilized to make a wide range of valuable compounds, including medicines and commercial polymers. This ability increases the possibility of taking this level of control to the next level, i.e., finding ways to assemble single molecules into supramolecular assemblies made up of numerous molecules grouped in a well-defined pattern. Through a bottom-up approach, these systems leverage molecular self-assembly and or Supramolecular chemistry ideas to spontaneously arrange themselves into some useful configuration. The concept of molecular recognition is particularly important: non-covalent intermolecular forces can be used to design molecules so that a specific configuration or arrangement is favoured (Schmid, 2004). The Watson-Crick base pairing rules, as well as the specificity of an enzyme targeting a single substrate or the precise folding of a protein, are all direct results of this. As a result, two or more components can be built to be complementary and mutually appealing, resulting in a more complicated and useful system. The majority of useful structures necessitate sophisticated and thermodynamically improbable atom configurations. In biology, however, there are numerous examples of self-assembly based on molecular recognition, including Watson-Crick base pairing and enzyme-substrate interactions. The question for nanotechnology is whether these principles can be employed to create new structures in addition to those found in nature. Other difficulties arise when nanostructures are used in biological systems. Nanostructures can be so minute that they are cleared by the body too quickly to be useful for detection or imaging. Larger nanoparticles could build up in key organs, posing a toxicity risk. Scientists will have to take these considerations into account as they try to develop nanodevices that the body will tolerate.

TYPE OF NANOMATERIALS

CARBON-BASED NANOMATERIALS

These nanomaterials are largely made of carbon and typically have the shape of hollow spheres, ellipsoids, or tubes. Fullerenes are spherical and ellipsoidal carbon nanoparticles, while nanotubes are cylindrical carbon nanomaterials. These particles have a wide range of possible applications, including

better films and coatings, stronger and lighter materials, and electronic applications (Oberdorster *et al.*, 2006).

MATERIAL-BASED NANOMATERIALS

Quantum dots, nanogold, nanosilver, and metal oxides such as titanium dioxide, zinc oxide, magnesium oxide, iron oxide, and others are among these nanomaterials. A quantum dot is a tightly packed semiconductor crystal made up of hundreds or thousands of atoms and measuring a few nanometers to a few hundred nanometers in size. The optical characteristics of quantum dots alter as their size changes (Dreizin, 2009).

DENDRIMERS

These nanomaterials are made up of nanosized polymers that are made up of branching units. A dendrimer's surface has multiple chain ends that can be customized to conduct certain chemical tasks. This characteristic could be useful in catalysis as well. Furthermore, because three-dimensional dendrimers include internal spaces into which other molecules can be inserted, they may be beneficial for drug administration (Astruc *et al.*, 2010).

NANOCOMPOSITES

Nanoparticles can be combined with other nanoparticles or with larger, bulk-type materials. Nanoparticles, such as nanosized clays, are already being used to improve mechanical, thermal, barrier, and flame-retardant qualities in goods ranging from auto parts to packaging materials (Ajayan *et al.*, 2003).

NANOBIOTECHNOLOGY

A prospective method for increasing agriculture food grain production and, as a result, value-added products by strengthening the utilization of nanoscale characteristics. Nanobiotechnology brings up new avenues for research and applications in areas such as nutraceuticals and pharmaceuticals. It develops technology for higher-resolution materials and systems for biomolecule purification (Gazit, 2007).

MOLECULAR NANOTECHNOLOGY

Molecular nanotechnology, also known as molecular manufacturing, is defined as constructed nanosystems (nanoscale machines) that operate at the molecular level. Molecular nanotechnology is most closely related to the molecular assembler, a machine capable of producing a desired structure or device atom by atom utilizing mechanosynthesis principles. Manufacturing in the context of productive nanosystems is distinct from and distinct from the usual methods used to generate nanomaterials such as carbon nanotubes and nanoparticles (Lapshin, 2011).

NANOTECHNOLOGY APPLIANCES IN ALLIED SCIENCE AND ENGINEERING SECTOR

AGRICULTURE

Agriculture is the lifeblood of most developing countries, with over 60% of the people depending on it for survival (Brock *et al.*, 2011). Nanotechnology can improve our understanding of the biology of different crops, potentially increasing yields or nutritional benefits, as well as establishing improved systems for monitoring environmental conditions and administering nutrients or pesticides as needed. It may also provide access to higher-value crops or environmental rehabilitation. As a new enabling technology, nanotechnology has the potential to change agriculture and food systems. Agricultural and food system

security, disease treatment delivery methods, new instruments for molecular and cellular biology, new materials for pathogen detection, and environmental protection are some of the major ties between nanotechnology and agriculture and food system science and engineering (Welch and Graham, 1999).

Nanotechnology works on the same scale as a virus or disease-infecting particle and hence can identify and eradicate diseases at an early stage. Nanotechnology presents the promise of "Smart" therapeutic delivery systems that can be turned on long before macro symptoms manifest. A smart therapy delivery system, for example, could be a small device implanted in an animal that collects saliva samples regularly. Long before a fever develops, the integrated sensing, monitoring, and regulating system can detect sickness, alert the farmer, and activate bioactive systems including medications, insecticides, nutrition, Probiotics, nutraceuticals, and implantable cell bioreactors.

NANOFERTILIZER

Fertilizers serve a critical role in agriculture production, accounting for 35 to 40% of total productivity. Nano fertilizers may be the best option for improving nutrient use efficiency and overcoming the persistent problem of Eutrophication. Nano fertilizer has been attempted to synthesis to regulate the delivery of nutrients based on the needs of the crops, and it has also been stated that nano fertilizer is more efficient than conventional fertilizer (Liu *et al.*, 2006).

NANOFOOD

The application of nanotechnology techniques or equipment during the growth, manufacture, processing, or packaging of food is defined as nanofood. It does not include food that has been atomically changed or food created by nanomachines. Although there are ambitious plans to use nanomachines to create molecular meals, this is unachievable soon. Nanotechnologists, on the other hand, are more enthusiastic about the ability to alter the current food processing system and secure the safety of food items, thereby fostering a healthy food culture. They also want to increase the nutritional quality of food by using specific chemicals and altering how the body digests and absorbs food. Although some of these aims are still a long way off, nanotechnology is already being used in the food packaging business.

FOOD AND BIOPROCESS ENGINEERING

Nanotechnology can help to solve some engineering and scientific difficulties in the food and bioprocess industries, such as producing high-quality, safe food efficiently and sustainably. Bacteria detection and food quality monitoring utilizing biosensors; intelligent, active, and smart food packaging systems; and nano-encapsulation of bioactive food ingredients are just a few of the new nanotechnology used in the food sector. Food manufacturing, processing, safety, and packaging can all benefit from nanotechnology. Antimicrobial agents might be placed directly on the surface of the coated film using a nanocomposite coating method, which could improve food packaging. As needed for different goods, nanocomposites could increase or decrease the gas permeability of various fillers. They can also increase mechanical and heat resistance, as well as reduce oxygen transport. Nanotechnology is being used to identify chemical and biological contaminants in foods, according to research.

MEDICINE

Nanomaterials' unique features have been used in biological and medical research for a variety of applications (for example, contrast agents for cell imaging and therapeutics for treating cancer). This hybrid field is described by terms like biomedical nanotechnology, nanobiotechnology, and nanomedicine. Interfacing nanomaterials with biological molecules or structures can provide the

functionality to them. Nanomaterials are the same size as most biological molecules and structures. As a result, nanomaterials can be used in biomedical research and applications both *in vivo* and *in vitro*. Thus, the integrality of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles. Nanotechnology-on-a-chip is one more dimension of lab-on-a-chip technology. Magnetic nanoparticles bound to a suitable antibody, are used to label specific molecules, structures, or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for the detection of genetic sequences in a sample. Multicolour optical coding for biological assays has been achieved by embedding different-sized quantum dots into polymeric microbeads. Nanopore technology for the analysis of nucleic acids converts strings of nucleotides directly into electronic signatures (Langer and Tirrell, 2004).

DISEASE DETECTION AND DIAGNOSIS

Nanomaterials generated by chemical and biological processes are used in a variety of extremely promising fields of nanoscience. The use of bio-labelled nanoparticles to diagnose and cure cancer is perhaps the most well-known. This is a burgeoning field of study, with some early successes that appear to be promising. However, additional research is needed before nanoparticles are widely employed by doctors to treat cancer. The early detection of cancer is a crucial step in improving cancer treatment. Currently, cancer detection and diagnosis are based on changes in cells and tissues discovered through physical touch or imaging skills. Rather, scientists want to be able to detect the earliest molecular alterations, far before a physical checkup or imaging technologies can help (Ferrari, 2005). Scientists must be able to detect molecular changes even when they occur in only a small fraction of cells to diagnose cancer at its earliest stages. This necessitates the use of exceedingly sensitive tools. Nanostructures' ability to access and inspect single cells suggests that they may be able to meet this need. Many nanotechnology techniques will allow clinicians to conduct tests without physically modifying the cells or tissue obtained from patients. This is critical since the samples used by clinicians to screen for cancer are frequently in short supply. It is also significant since it can catch and preserve active cells. Scientists want to conduct experiments without changing cells so that they can be reused if more tests are required. Nanotechnologies that will aid in cancer treatment are now in various phases of development. Quantum dots, nanopores, and other devices for detection and diagnostics, according to experts, could be accessible for clinical usage in 5 to 15 years. In a similar period, therapeutic drugs are projected to be ready. In around 15 or 20 years, devices that combine detection and therapy could be employed in clinical settings.

DRUG DELIVERY

Nanotechnology has exploded in the medical field, with nanoparticles being used to deliver medications to specific cells. By depositing the active medication solely in the morbid region and at no greater dose than required, overall drug consumption and adverse effects can be greatly reduced. Costs and human suffering are reduced as a result of this extremely selective strategy. Dendrimers and nanoporous materials are good examples. Another example is drug encapsulation using block co-polymers that form micelles. They could hold small drug molecules transporting them to the desired location. Another vision is based on small electromechanical systems; NEMS are being investigated for the active release of drugs. Cancer treatment with iron nanoparticles or gold shells is one example of a potentially crucial use. A targeted or tailored therapy minimizes drug consumption and treatment costs, resulting in a social benefit through lowering public health system costs. The majority of mammalian cells have a diameter of 10,000 to 20,000 nanometers. This suggests that nanoscale devices (less than 100 nanometers) can interact with DNA and proteins inside cells and organelles. Nanotechnology-based tools may be able to identify

disease in a very small number of cells or tissue (Sahoo and Labhasetwar, 2003). They may be able to enter and monitor cells within a living organism as well. Nanotechnology is also enabling new possibilities in implanted delivery devices, which are frequently referred to as injectable medications due to their first-order kinetics (the blood concentration goes up rapidly, but drops exponentially over time). This quick rise may produce toxicity issues, and treatment efficacy may decrease as the drug concentration falls below the desired range.

CHEMISTRY, ENVIRONMENT, AND ENERGY

Nanotechnology is already used in chemical catalysis and filtration processes, to name two examples. Novel materials with specialized characteristics and chemical properties result from the synthesis, such as nanoparticles with a distinct chemical environment (ligand) or optical qualities. Chemistry is, in this sense, fundamental nanoscience. Chemistry will give unique "nanomaterials" in the short term, and superior processes such as "self-assembly" will enable energy and time-saving tactics in the long run. Because of its ability to synthesize specific molecules, nanotechnology can be used to explain all chemical production (Mauter and Elimelech, 2008). Thus, chemistry forms a base for nanotechnology providing tailor-made molecules, polymers, etcetera, as well as clusters and nanoparticles. As a result, chemistry serves as a foundation for nanotechnology, allowing for the creation of custom molecules, polymers, clusters, and nanoparticles.

FILTRATION

Photochemistry is projected to have a big impact on waste-water treatment, air purification, and energy storage. Filtration procedures that are both mechanical and chemical can be applied. The use of membranes with appropriate entire sizes and the pressing of the liquid through the membrane is one class of filtering procedures. Nanoporous membranes, which may be made up of nanotubes, are suited for mechanical filtering with extremely small pores (nanofiltration). Nanofiltration is mostly used to remove ions from fluids or to separate them. Ultra filtration, which works on a bigger scale, is a membrane filtering technology. The membrane filtering process is known as ultra-filtration on a wider scale, and it works between 10 and 100 nm. Medical applications, like renal dialysis, are a major field of application for ultra-filtration. Using magnetic separation techniques, magnetic nanoparticles provide an effective and dependable way for removing heavy metal pollutants from wastewater. When compared to typical precipitation and filtering procedures, using nanoscale particles boosts the effectiveness of pollutants absorption while also being relatively inexpensive. Some nanotechnology-based water treatment products are currently on the market, with more on the way. In a recent study, low-cost nanostructured separation membranes technologies were demonstrated to be successful in producing drinkable water (Thembela and Mbhuti, 2007).

CATALYST

Better insulation systems, the use of more efficient lighting or combustion systems, and the use of lighter and stronger materials in the transportation sector can all help to reduce energy usage. Currently, light bulbs convert just around 5% of the electrical energy they consume into light. Nanotechnological techniques such as light-emitting diodes (LEDs) and quantum caged atoms (QCAs) could significantly reduce lighting energy usage. Solar cells with layers of multiple different semiconductors stacked together to absorb light at different energies are increasing the efficiency of energy production, although they still only manage to use 40% of the Sun's energy.

ENERGY

Nanoparticles, in particular, benefit from their exceptionally high surface-to-volume ratio. Nanoparticles have a wide range of applications in catalysis, from fuel cells to catalytic converters to photo catalytic devices. Catalysis is very significant in the chemical industry. Because of their large surface area, platinum nanoparticles are now being considered for use in the next generation of automotive catalytic converters. This could reduce the amount of platinum required. However, tests have shown that if methane is mixed with ambient air, it will spontaneously explode, raising some worries. Their full use for catalytic applications may be determined by ongoing research at the Centre National de la Recherche Scientifique (CNRS) in France. Nanofiltration may become a popular application, but future studies must take care to rule out any potential harm. The efficiency of commercially available solar cells is significantly lower (15 to 20 percent). By utilizing nanostructures with a continuum of band gaps, nanotechnology could assist boost the efficiency of light conversion. At the moment, the internal combustion engine has an efficiency of around 30-40%. Nanotechnology has the potential to increase combustion by inventing particular catalysts with a large surface area. Scientists at the University of Toronto created a spray-on nanoparticle solution in 2005 that, when applied to a surface, quickly converts it into a solar collector (TERI Report, 2009).

INDUSTRIES AND ENGINEERING

TEXTILES

Engineered nanofibers already make garments water- and stain-resistant and wrinkle-free. Textiles treated with nanotechnology can be washed less frequently and at lower temperatures. Nanotechnology was used to integrate microscopic carbon particles membrane and provide the wearer with full-surface protection from electrostatic charges.

COSMETICS

Sunscreens are one of the areas where they can be used. The standard chemical UV protection method has poor long-term durability. A sunscreen based on mineral nanoparticles, such as titanium dioxide, has several benefits. Titanium oxide nanoparticles provide equal UV protection properties to the bulk material, but when particle size is reduced, the cosmetically unattractive whitening disappears. Finally, "Molecular Manufacturing" may one day enable the production of food and other necessities from component atoms and molecules. Some research organizations are already investigating this, albeit from a top-down perspective, utilizing cells rather than molecules. Although the practical use of such technology is distant in the future, it is believed that it will allow for the development of a more efficient and sustainable production process in which fewer raw materials are spent and a higher quality product is obtained (Raj *et al.*, 2012).

OPTICS

Due to their vast bandwidth and capacity, optical or optoelectronic devices are gradually replacing traditional analog electrical devices in modern communication technology. Photonic crystals and quantum dots are two promising examples. Photonic crystals are materials that have a periodic fluctuation in their refractive index and a lattice constant that is half the wavelength of the light they utilize. They provide a chosen band gap for the propagation of a specific wavelength, similar to a semiconductor, but light or photons rather than electrons. Quantum dots are nanoscale objects that can be used to make lasers, among other things. The advantage of a quantum dot laser over a regular semiconductor laser is that the wavelength emitted is proportional to the diameter of the dot. Quantum

dot lasers are less expensive and produce higher-quality beams than traditional laser diodes. Carbon nanotubes could be used to create screens with minimal energy usage (CNT). Carbon nanotubes are electrically conductive, and because of their small diameter (a few nanometers), they can be employed as field emitters with extraordinarily high efficiency in field emission displays (FED). The principle of operation resembles that of the cathode ray tube, but on a much smaller length scales (Capitanio *et al.*, 2005).

COMPUTERS

It is a device that performs data operations directly using quantum-mechanical phenomena like superposition and entanglement. Quantum computers differ from typical transistor-based computers. Quantum computation is based on the idea that quantum qualities can be used to represent data and execute operations on it. The quantum Turing machine, often known as the universal quantum computer, is a theoretical model. Even though quantum computing is still in its early stages, experiments have been conducted in which quantum computational processes were performed on a relatively tiny number of quantum bits. Much national government and military funding agencies continue to promote quantum computing research to create quantum computers for both civilian and national security reasons, such as cryptanalysis. If large-scale quantum computers can be created, they will be able to tackle certain problems significantly quicker than traditional computers (Drexler, 1992).

FUTURE TRANSPORTATION APPLICATION

The nano-engineering of steel, concrete, asphalt, and other cementation materials, as well as their recycled forms, holds significant potential for enhancing the performance, resiliency, and longevity of roadway and transportation infrastructure components while lowering their costs. New systems may include unique characteristics, such as the ability to create or transport energy, into classic infrastructure materials. Nanoscale sensors and gadgets may provide cost-effective continuous structural monitoring of bridges, tunnels, trains, parking structures, and pavements throughout time. Nanoscale sensors and devices may also serve to support an improved transportation infrastructure by communicating with vehicle-based systems to assist drivers in maintaining lane position, avoiding crashes, adjusting travel routes to avoid congestion, and other similar tasks (Chuah *et al.*, 2014; Firoozi *et al.*, 2014; Wong, 2014; Yusoff *et al.*, 2014; Agzenai *et al.*, 2015; De Nicola *et al.*, 2015; Firoozi *et al.*, 2015; Golestani *et al.*, 2015; Singh and Sangita, 2015; Sobolev, 2015).

Nanotechnology is being used in research to stimulate nerve cell proliferation, such as in damaged spinal cord or brain cells. A nanostructured gel fills the gap between existing cells and supports the growth of new cells in one approach. The visual nerves of hamsters have been studied in the past. The use of Nanofibres to restore injured spinal nerves in mice is another way being investigated (Ehrhardt and Frommer, 2012; Jain, 2012; Nunes *et al.*, 2012; Ahmadi and Ahmadi, 2013; Parpura and Verkhatsky, 2013; Zhan *et al.*, 2013; Qazi *et al.*, 2015).

FUTURE CHALLENGE AND POSSIBILITY OF NANOTECHNOLOGY

The acceptance of new types of technology by society is one of the most difficult difficulties in the field of nanotechnology. To ensure long-term investments and commercial acceptability of emerging advanced technologies, such as nanotechnology, scientists and engineers in this field will need to collaborate with other citizens. The industry has decreased its spending on research and development in recent years. This is becoming a significant impediment to the commercialization of nanotechnology. While government investments in research and technology have not declined in dollar terms, they are not increasing at fast

enough paces to support American nanotechnology competitiveness. This is a severe issue that is already affecting the crucial and necessary early phases of research and technology in this industry.

Integration of nanotechnology into cutting-edge products will be one of the most important future themes in nanotechnology research. To do so, it will become increasingly vital for teams of scientists and engineers from industry, academia, and government to handle the complex difficulties that nanotechnology raises. Some important directions in the area of chemically or colloidally prepared nanostructures include the development of useful nanoparticles from non-toxic materials, the development of new fabrication strategies that allow for the manufacturing of ultra-pure nanoparticles, the development of scale-up technologies that allow for the inexpensive production of nanoparticles on a large scale, and finally the continued exploration of new technological horizons.

REFERENCES

- [1] Agzenai Y, Pozuelo J, Sanz J, Perez I, Baselga J. (2015). Advanced Self-Healing Asphalt Composites in the Pavement Performance Field: Mechanisms at the Nano Level and New Repairing Methodologies. *Recent patents on nanotechnology*, 9(1): 43-50, 2015.
- [2] Ahmad A, Senapati S, Khan MI, Kumar R, Ramani R, Srinivas V, Sastry M (2003). Intracellular synthesis of gold nanoparticles by a novel alkalotolerant actinomycete, *Rhodococcus* species. *Nanotechnology* 14:824-828.
- [3] Ahmadi M, Ahmadi L. (2013). European Patent Law Framework regarding Nanotechnology Applications in Stem Cells. *Nanotech. L. & Bus.*, 10: 65-72.
- [4] Ajayan PM, Schadler LS, Braun PV (2003). *Nanocomposite science and technology*. Wiley.
- [5] Astruc D, Boisselier E, Ornelas C (2010). Dendrimers designed for functions: from physical, photophysical, and Supramolecular properties to applications in sensing, catalysis, molecular electronics, and nanomedicine. *Chem. Rev.* 110:1857-1959.
- [6] Boisselier E, Astruc D (2009). Gold nanoparticles in nanomedicine: preparation, imaging, diagnostics, therapies and toxicity. *Chem. Society Rev.* 38:1759-1782.
- [7] Brock DA, Douglas TE, Queller DC, Strassmann JE (2011). Primitive agriculture in a social amoeba. *Nature* 469:393-396.
- [8] Capitano M, Cicchi R, Pavone FS (2005). Position control and optical manipulation for nanotechnology applications. *The European Physical J. B -Condensed Matter and Complex Systems* 46:1-8.
- [9] Chuah S, Pan Z, Sanjayan JG, Wang CM, Duan WH. (2014). Nano reinforced cement and concrete composites and new perspective from graphene oxide. *Construction and Building Materials*, 73: 113-124, 2014.
- [10] De Nicola F, Castrucci P, Scarselli M, Nanni F, Cacciotti I, De Crescenzi M. (2015). Superhydrophobic multi-walled carbon nanotube coatings for stainless steel. *Nanotechnology*, 26(14): 145-152.
- [11] Dreizin EL (2009). Metal-based reactive nanomaterials. *Prog. Energy Combust. Sci.* 35:141-167.
- [12] Drexler KE (1992) *Nanosystems*. New York: Wiley-Interscience. Ferrari M (2005). Cancer Nanotechnology: Opportunities and Challenges. *Nat. Rev. Cancer* 5:161-171.
- [13] Ehrhardt DW, Frommer WB (2012). New technologies for 21st century plant science. *The Plant Cell*, 24(2): 374-394.
- [14] Firoozi AA, Taha M.R, Firoozi AA, Khan TA. (2015). Effect of ultrasonic treatment on clay microfabric evaluation by atomic force microscopy. *Measurement*, 66: 244-252.

- [15] Firoozi AA, Taha MR, Firoozi AA, Khan TA. (2014). Assessment of Nano-Zeolite on Soil Properties. Australian Journal of Basic and Applied Sciences. 292-295.
- [16] Gazit E (2007). Plenty of room for biology at the bottom: An introduction to bionanotechnology. Imperial College Press.
- [17] Golestani B, Nam B.H, Nejad F.M, Fallah S. (2015). Nanoclay application to asphalt concrete: Characterization of polymer and linear nanocomposite-modified asphalt binder and mixture. Construction and Building Materials, 91: 32-38.
- [18] Jain KK (2012). Nanoneurology The handbook of Nanomedicine, Springer, 343-367.
- [19] Khan TA, Taha MR, Firoozi AA, Firoozi AA (2015). October. Strength tests of enzyme-treated illite and black soil mixtures. In Proceedings of the Institution of Civil Engineers-Engineering Sustainability, 169(5): 214-222. Thomas Telford Ltd.
- [20] Kulzer F, Orrit M (2004). Single-molecule optics. Annu. Rev. Phys. Chem. 55:585-611.
- [21] Langer R, Tirrell DA (2004). Designing materials for biology and medicine. Nature 428:487-492.
- [22] Lapshin RV (2011). Feature-oriented scanning probe microscopy. In: Nalwa H. S. (PDF). Encyclopedia of Nanoscience and Nanotechnology. ACS pp. 105-115.
- [23] Lengke FM, Fleet EM, Southam G (2007). Biosynthesis of silver nanoparticles by filamentous cyanobacteria from a silver (I) nitrate complex. Langmuir 23:2694-2699.
- [24] Liu X, Feng Z, Zhang S, Zhang J, Xiao Q, Wang Y (2006). Preparation and testing of cementing nano-subnano composites of slow-or controlled release of fertilizers. Scientia Agricultura Sinica 39:1598-1604.
- [25] Mauter MS, Elimelech M (2008). Environmental applications of carbon-based nanomaterials. Environ. Sci. Technol. 42:5843-5859.
- [26] Nunes A, Al-Jamal KT, Kostarelos K. (2012). Therapeutics, imaging and toxicity of nanomaterials in the central nervous system. Journal of Controlled Release, 161(2): 290-306.
- [27] Oberdorster E, Zhu S, Blickley TM, Green PM, Haasch ML (2006). Ecotoxicology of carbon-based engineered nanoparticles: Effects of fullerene (C₆₀) on aquatic organisms. Carbon 44:1112-1120.
- [28] Parpura V, Verkhratsky A. (2013). Astroglial pathology: Could nanotechnology restore aberrant calcium signalling and pathological astroglial remodeling, Biochimica ET Biophysica Acta (BBA)-Molecular Cell Research, 18(7): 1625-1631.
- [29] Petit C, Lixon P, Pileni MP (1993). *In situ* syntheses of silver nanocluster in AOT reverse micelles. J. Phys. Chem. 97:12974-12983.
- [30] Qazi TH, Mooney DJ, Pumberger M, Geißler S, Duda GN (2015). Biomaterials based strategies for skeletal muscle tissue engineering: Existing technologies and future trends. Biomaterials, 53, 502-521.
- [31] Raj S, Jose S, Sumod US, Sabitha M (2012). Nanotechnology in cosmetics: Opportunities and challenges. J. Pharm. Bioallied. Sci. 4:186-193.
- [32] Raliya R, Tarafdar JC (2012). Novel Approach for Silver Nanoparticle Synthesis Using *Aspergillus terreus* CZR-1: Mechanism Perspective. J. Bionanosci. 6:12-16.
- [33] Roco MC (2003). Broader societal issues of nanotechnology. J. Nanopart. Res. 5:181-189.
- [34] Sahoo SK, Labhasetwar V (2003). Nanotech Approaches to Drug Delivery and Imaging. Drug Discov. Today 8:1112-1120.
- [35] Schmid G (2004). Nanoparticles from Theory to Applications. Wiley-VCH, Weinheim.
- [36] Scott N, Chan H (2002). Nanoscale science and engineering for agriculture and food system report. National Planning Workshop, Washington DC.
- [37] Singh A, Sangita AS (2015). Overview of Nanotechnology in Road Engineering. Journal of Nano-and Electronic Physics, 7(2): 2014-2022.

- [38] Sobolev K. (2015). Nanotechnology and Nano engineering of Construction Materials Nanotechnology in Construction, Springer, 3-13.
- [39] Subramanian KS, Tarafdar JC (2011). Prospects of nanotechnology in Indian farming. *Indian J. Agric. Sci.* 81:887-893.
- [40] TERI Report (2009). Nanotechnology development in India-a status report. TERI, India.
- [41] Thembela H, Mbhuti H (2007). Nanotechnology and the challenge of clean water. *Nat. Nanotechnol.* 2:663-664.
- [42] Welch RM, Graham RD (1999). A New Paradigm for World Agriculture: Meeting Human Needs, Productive, Sustainable, and Nutritious. *Field Crops Res.* 60:1-10.
- [43] Wong S. (2014). An Overview of Nanotechnology in Building Materials. *Canadian Young Scientist Journal*, 14(2): 18-21.
- [44] Yusoff NIM, Breem AAS, Alattug HN, Hamim A, Ahmad J. (2014). The effects of moisture susceptibility and ageing conditions on nano-silica/polymer-modified asphalt mixtures. *Construction and Building Materials*, 72: 139-147.
- [45] Zhan X, Gao M, Jiang Y, Zhang W, Wong WM, Yuan Q, Zhang W. (2013). Nanofiber scaffolds facilitate functional regeneration of peripheral nerve injury. *Nanomedicine: Nanotechnology, Biology and Medicine*, 9(3): 305-315.

ABSTRACT

Technology is actually a set of technological methodologies for creating, altering, utilizing and knowing about instruments, scientific machines, specified strategies, frameworks and procedures for getting sorted out them to deal with a problem, working on a prior solution for a problem, accomplishing an objective or perform a particular action. Green Nanotechnology, which is additionally known as Clean Technology, implies applying nanotechnology to upgrade the ecological supportability of cycles delivering adverse consequences. It incorporates making green nano-items and utilizing nano-items to support sustainability. The Green Nanotechnology under the broad umbrella of Green Chemistry and Nanotechnology gives a new hope for future generation as it is environment friendly, energy efficient, reduces wastes, lessens greenhouse gases emissions, cost effective, socially acceptable and sustainable. This technology has definitely revolutionized the fields of agriculture, cosmetics, textiles and clothing, food processing, medicine and health.

KEYWORDS: Green Technology, Nanotechnology, Sustainability, Clean tech, Green Future.

INTRODUCTION

In fact, the twenty first century is the century of the Environment. Government and residents cannot leave the present social difficulties like contamination of natural resources, waning natural environmental assets and changing environment as unsettled. We need to monitor our natural assets for future generations. The possibilities for progress have never been more prominent. In this way, inventive approaches, researches, education and innovative developments can assume focal part in building a green future, local area by local area.

The term Technology alludes to the utilization of information for experiential objectives. The logical information dealing with the creation, application and utilization of specialized technical means to improve the way of life of individuals by providing comfortability is known as innovation. Innovative technology has impacted the general public and its environmental factors in various ways that has assisted with growing further developed economies worldwide.

Nanotechnology is an inventive science that incorporates the plan, portrayal, creation and utilization of designs, gadgets and frameworks by controlling shape and size at the nanometer scale, which covers the size range from 1 nanometer to 100 nanometer (nm), where 1 nanometer is 1 billionth of a meter. It is prevalently the tiny size and a huge surface-to-volume proportion of nanoparticles (NPs) those records for great contrasts in their physical and chemical properties.

Clean Technology or Cleantech, is a cycle, product or administration that lessens negative natural effects through critical energy productivity improvements, the feasible utilization of natural assets or ecological insurance exercises. Clean Technology incorporates reusing sustainable power, information technology, green transportation, electric engines, Green Chemistry, grey water and that's just the beginning.

Green Nanotechnology has two objectives: creating nanomaterials and items without damaging the climate or human wellbeing, and delivering nano-items that give solutions for present environmental issues. It utilizes existing principles of Green Chemistry and green designing to make nanomaterials and nano-items without utilizing harmful toxic products but by using less energy and eco-friendly inexhaustible sources at every possible opportunity. Any unwanted by-products generated by various technological procedures give rise to different types of pollution leading to depletion of our precious natural resources and deterioration of the Earth's environment. Therefore, it is high time to rethink and implement new technologies in order to improve present conventional technologies. The present chapter deals with the application and advancement of Green Nanotechnology in various fields such as agriculture, cosmetics, clothing and textiles, food processing, medicines and health, the opportunities and the future challenges related to sustainability.

APPLICATIONS OF GREEN NANOTECHNOLOGY

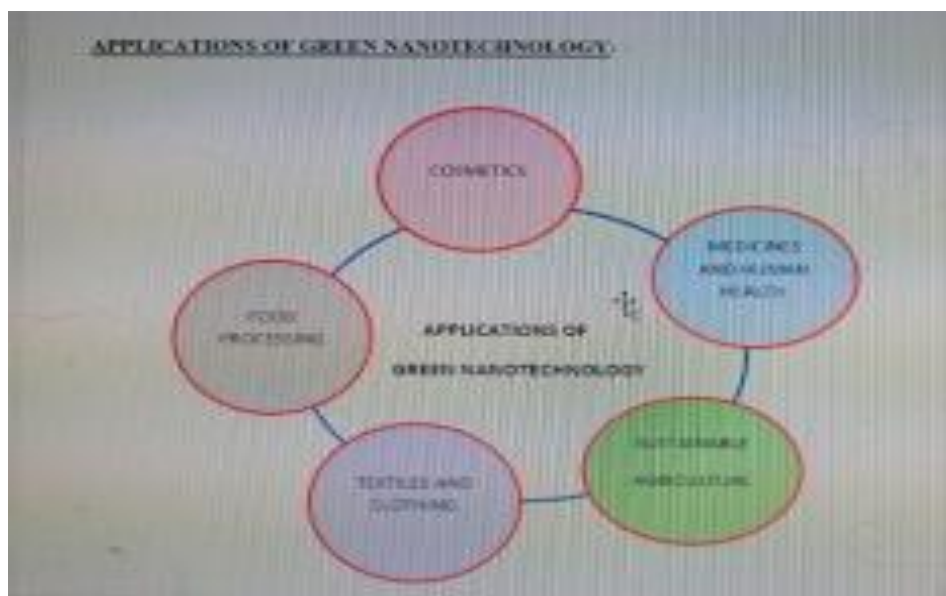


Fig 1: Applications of Green Nanotechnology
AGRICULTURE

Nature is an extraordinary instructor and nanotechnology applications in farming can be effective by assuming if regular natural cycles are invigorated in more prominent logical refinement or verbalization for fruitful execution. Endeavours to apply nanotechnology in agriculture started with the developing acknowledgment that customary cultivating advances would neither have the option to expand usefulness any further nor re-establish biological systems harmed by existing technologies back to their pristine state.

At the Nano scale, matter shows exceptional properties that are not shown by the mass materials. For instance, surface area, cation exchange capacity, ion adsorption, complexation and some more properties of the soil would multiply in the event when they are brought to Nano scale. In contrast to the particles of macro size, nanoparticles may have high extent of molecules present on the surface. This would lead to

fluctuate the valuable properties of nanomaterials in order to utilize these in agriculture. In this world mainstream of people are underneath destitution level which are being scatted in the rustic region where agricultural development isn't extremely powerful. Farming is in every case generally significant and stable area since it delivers and gives unrefined substances to food and feed businesses. In present day agriculture, sustainable production and proficiency are inconceivable without the utilization of agrochemicals like pesticides, manures, and so forth. In any case, each agrochemical has a few potential issues remembering pollution of water or deposits for food items that danger the person and natural wellbeing. Consequently, the exact administration, precise management and control of inputs could permit to diminish these threats. The advancement of the high-tech innovative agriculture framework with utilization of designed smart Nano tools could be phenomenal technique and excellent strategy to make an insurgency in farming practices to lessen and/or remove the negative impact of current agriculture practices on the environment just as to improve both the quality and amount of agricultural field yields.

Present day agriculture is an intensive chemical concentrated interaction beginning from fertilizers, pesticides to food preservation. Current nanotechnology instruments whenever utilized reasonably in future, can offer sustainable improvement along with the ideal, accurate, precise and more successful utilization of synthetic chemicals.

COSMETICS

It has been determined from various overviews that practically every one of the significant cosmetic makers uses nanotechnology in their different items.

NANO-VARIEGATION IN BEAUTY CARE PRODUCTS/ COSMETICS

- **Mineral-based cosmetic constituents with nano-sized aspects**

A few cosmetic products like sunscreens, utilize mineral-based materials and their presentation relies upon their molecule size.

- **Nano capsules**

Profoundly Nano capsules are sub microscopic particles that are made of a polymeric capsule surrounding an aqueous or oily core. It has been accounted for that the utilization of Nano capsules diminishes the penetration of UV- radiation.

- **Nano crystals**

These are clusters containing a few hundred to a huge number of particles (size somewhere in the range of 10 and 400 nm) that consolidate into a "bunch". They show physical and chemical properties somewhere close to that of mass solids and molecules. They permit protected and effective entry through skin.

- **Nano silver and Nano gold**

Cosmetic producers are tackling the improved antibacterial properties of nano-silver in a range of uses. A few manufacturers are as of now creating under- arm deodorants with claims that the silver in the product will give as long as 24-hour antibacterial protection. Nano-sized gold is professed to be exceptionally viable in cleaning and disinfecting the bacteria/microbes in the mouth and has additionally been added to toothpaste.

TEXTILES AND CLOTHING

Expanding public interest for strong, durable and attractive clothes made in a sustainable way has set out a freedom for nanomaterials to be incorporated into textile substrate. Nanomaterials can incite stain repellence, wrinkle freeness, static disposal and electrical conductivity to strands without undermining their comfort and flexibility.

The properties and execution of textile fibres are very important for texture assembling of clothes and use. While it is notable that textiles made of cotton fibres give beneficial properties like high absorbency and delicate quality for wear and comfort however extended utility of cotton fabrics in specific traditional and particularly non-old style applications is restricted to some degree because of comparatively low strength of fibre, not exactly acceptable sturdiness and easy creasing. On the other hand, textiles made with synthetic strands are mostly strong, wrinkle free, dirt resistant and antimicrobial. However, they surely do not have the comfort properties of cotton strands. Nanotechnology incites temptation to foster fibres with the benefits of both cotton and synthetic strands.

FOOD PROCESSING

In practical food sources where, bioactive component regularly gets degraded and ultimately prompted inactivation due to the antagonistic climate, Nano encapsulation of these bioactive components expands the time span of usability of food items by dialing back the degradation processes or forestalls debasement until the item is conveyed at the target site.

Microbial tainting has been prompting pathogenic contaminations and helpless sustenance related with food varieties. Novel nano-antimicrobials have shown promising consequences for protecting food deterioration. Nano-based "brilliant" and "dynamic" food packaging give various benefits over usual ordinary packaging strategies from furnishing better packaging material with better mechanical strength, hindrance properties, antimicrobial films to nano-detecting for microbe identification and making buyers aware of the safety status of food. The innovative technology of Nano encapsulation in food protection additionally force a few adverse consequences related with it.

The eatable nano-coatings on different food materials could give an obstruction to dampness and gas exchange, convey colours, flavours, enzymes, antioxidants and anti-browning agents and could likewise expand the time span of usability of fabricated food sources, even after the packaging is opened. The term nano-embodiment depicts the utilization of encapsulation on the nanometer scale with films, layers, covers or basically micro dispersion. The assurance of the protection of bioactive components or nutrients - vitamins, antioxidants, proteins and carbohydrates might be accomplished utilizing this technique. Nanotechnology determined food packaging materials are the biggest class of current nanotechnology applications for the food processing sector which incorporate consolidating nanomaterials to improve packaging properties (flexibility, gas obstruction properties, temperature/dampness stability) and fusing nanoparticles with antimicrobial or oxygen scavenging properties. 'Technologically Intelligent' food packaging with nano-sensors can screen and report the state of the food items. Nanostructures in the food sector may not make an immediate impact on human wellbeing. But these may cause a few unavoidable aftereffects. Nano scale eatable coatings have arisen as an appealing choice to preserve food quality, extend storage life span and forestall microbial decay, permitting direct exposure of humans to nanomaterials. Nanoparticles or other nanomaterials can enter the human body by inward breath, ingestion or by dermal infiltration. The toxic effects of nanoparticles rely not just upon their properties and path of entry in the body, concentration and span of exposure to nanoparticles, yet additionally on individual susceptibility and condition of organisms.

MEDICINES AND HEALTH

The turn of events and advancement in the area of nanotechnology and its applications to the field of medical prescriptions and pharmaceuticals has acquired upheaval the 20th century. Indeed, even today numerous sicknesses or infections like diabetes, malignant growth, Parkinson's disease, Alzheimer's disease, cardiovascular ailments and various sclerosis as well as different kinds of genuine provocative or communicable infections establish countless serious and complex ailments which are representing a significant issue for the humankind worldwide. Materials drawing closer Nano scale aspects show surprising properties with various special and hitherto unexploited applications.

Green nanotechnology joins the principles of green science and green designing to manufacture harmless and eco-accommodating Nano clusters to battle the issues influencing the human health or environment. Therefore, combination of green nanotechnology with drug delivery area has really initiated another domain of "green Nano medicine". The prospering interest for green nanotechnology-driven drug delivery frameworks has prompted the improvement of various kinds of medication conveyance gadgets such as inorganic (metallic) nanoparticles, quantum dots, organic polymeric nanoparticles, mesoporous silica nanoparticles, dendrimers, nanostructured lipid transporters, solid lipid nanoparticles and so forth. Metallic nanoparticles (NPs) are generally taken advantage of in the field of biomedical science and designing attributable for their different potential benefits, for example, the huge surface area that permits the foreign molecules (medication, tests, or protein) to tie, ingest, or entangle inside the outer layer of the particles. Metallic NPs like Gold (Au), Silver (Ag), Platinum (Pt), Palladium (Pd), Copper (Cu), Selenium (Se), Iron (Fe) and their oxides have drawn huge consideration as potential medication conveyance frameworks inferable from their arising applications in the field of clinical diagnostics and treatment.

Quantum Dots (QDs) have shown to be a key device in the area of biological imaging, detecting, and discovery which further urged researchers to foster substances for translational restorative medicinal and clinical examination. Due to having great biocompatibility and fantastic optical properties in quantum dots an expansive scope of QDs, for example, carbon dots (C-QDs), silicon QDs (Si-QDs), graphene QDs (G-QDs), nitrogen-doped QDs (N-QDs), Ag₂Se, Ag₂S, ZnS etc. have been developed. Various medications have been successfully fused inside QDs to convey them at the particular target site.

However, the synthesis of QDs by conventional techniques requires the utilization of heavy metal precursor and organic solvents that represent a potential threat to the environment. Hence, the best way to make the procedures "greener" is to adjust harmless engineered approaches that incorporate the utilization of non-toxic, environment amicable and inexhaustible natural substances as detecting solvents like oleic acid, castor oil and olive oil.

Using nano medication early detection and prevention, speedy more sensitive and more adaptable biochemical tests, improved diagnosis, legitimate treatment, follow-up of illnesses and repair of harmed tissue is possible. The mediation of gold particles with little fragments of DNA, can be utilized for identification of genetic sequence in a sample.

CONCLUSION

In this way **Green Nanotechnology** –

1. Needs less energy utilization during the nano fabricating/ manufacturing.
2. Is replacing the existing materials with the non- toxic, eco-friendly and harmless materials.
3. has the ability to recycle/ reuse the materials after application.
4. Provides solutions for the present environmental problems.

Albeit Green Nanotechnology presents many benefits over conventional strategies, there is still a lot of discussion about the worries brought about by nanotechnology. Since the nanoparticles are little to the point of being ingested into skin as well as breathed in, so it becomes obligatory to have extra explorative research rotating around the effect of nanotechnology on organisms be vigorously contemplated.

However, present sustainability issues have prompted investigations of basic, ecologically safe blend course. Among different natural biological entities, green approach to synthesize nanoparticles has arisen as promising substitute to overcome the restrictions of traditional synthesis approaches.

In this manner Green Nanotechnology under the wide umbrella of Green Chemistry and Nanotechnology gives another expectation for future generations as it is ecological cordial, environment friendly, energy proficient, diminishes squanders, reduces ozone harming substances outflows, socially acceptable and sustainable.

REFERENCES

- [1] Abbas S. S., Haneef M., Lohani M., Tabassum H., Khan A. F. (2016). Nanomaterials used as a plant's growth enhancer: an update. *Int. J. Pharm. Sci. Rev. Res.* 5 17–23.
- [2] Baruah S., Dutta J. (2009) Nanotechnology applications in pollution sensing and degradation in agriculture: a review. *Environ Chem Lett* 7(3):191–204
- [3] Das S.K., Das A.R., Guha A.K. (2009). Gold nanoparticles: microbial synthesis and application in water hygiene management. *Langmuir* 25, 8192–8199.
- [4] Som C., Wick P., Krug H., Nowack B. (2011). Environmental and health effects of nanomaterials in nanotextiles and façade coatings. *Environ. Int.*, 37, 1131–1142.
- [5] Besley J.C., Kramer V.L., Priest S.H. (2008). Expert opinion on nanotechnology: Risks, benefits, and regulation. *J. Nanopart. Res.*, 10, 549–558.
- [6] Khan A.K., Rashid R., Murtaza G., Zahra A. (2014). Gold Nanoparticles: Synthesis and Applications in Drug Delivery. *Trop. J. Pharm. Res.*, 13, 1169–1177.
- [7] Albrecht M.A., Evans C.W., Raston C.L. (2006) Green chemistry and the health implications of nanoparticles. *Green Chem* 8(5):417–432.
- [8] Sozer N. and Kokin J. L. (2008). Nanotechnology and its applications in the food sector. *Trends Biotechnol.* 27: 82–89.

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ABSTRACT

Although the discovery of many medical technologies and advancements in treating cancer and other diseases, still cancer cases are increasing unceasingly, and leading to the deaths of millions across the globe. There is a need to focus more on specific drug target development, for effective treatment. Nanotechnology has the potential to change the perceptions and outlooks of cancer treatment and it emerged as a new multi-disciplinary branch to address global issues. Doctors have started using nanotechnology for treating cancer for more than a decade, nanotechnology derived drugs (known as Nanomedicine) have shown effectiveness in treating cancer in a safer and precise manner, by delivering the specially designed nanoparticles with medicines to the tumor site, this has been stopped the drugs from damaging the healthy tissues around the tumor, and minimized the side effects. In this book chapter, our main focus is to illustrate the medical applications and progress of nanotechnology in treating cancer and other diseases.

KEYWORDS: Nanomedicine, Cancer treatment, medical applications

INTRODUCTION

NANOTECHNOLOGY AND NANOMEDICINE

Renewed Physicist Richard Feynman in 1959 for the first time projected and shared his thoughts and ideas on nanotechnology and nanoscience in a talk entitled "There's a huge opportunity for studying nanotechnology at Californian institute during American Physical Society meeting. For the first time-Professor Norio Taniguchi, coined the term Nanotechnology and its discovery leads to the development of a Scanning tunnelling microscope, with that we could differentiate the individual atoms that are where the nontechnology has begun. In simplest words, we can define technology at the nanoscale level.

Nanotechnology is an attractive word for the scientific community, they were fascinated with the field of nanoscience, as a broad term, scientists from biology, physics, chemistry and engineering started exploring more for the application of practical potential. The word itself is defining the meaning of nanotechnology, the technology which operates at the nanoscale level, which has applications in the reality, by using single atoms and molecules to produce functional structures (Kaehler, 1994).nanotechnology utilizes chemical, biological, physical and engineering sciences for the creation and formation of structures whose size is relatively very small and the length varies from nanometers to microns. In biology and medicine terms, nanotechnology can be defined as the technology which covers

the devices, systems and materials whose function and structure are related to small in size and length from nanometers to microns (10^{-9} m- 10^{-6} m) (Whitesides, 2003).

NANOTECHNOLOGY IN DEVELOPING POTENT CANCER DRUGS

At present mainly cancer treatment strategies include, either mainly chemotherapy follows, radiation and in most severe cases surgery and latest immunotherapy, among all these, four methods are expensive and cause damage to normal tissues and are not sure for complete eradication of cancer. But technology with nanoscale particles research (nanomedicine) offered many ways to treat cancer with direct chemotherapies or selectively chosen therapies for neoplasm's and cancer cells, helps in surgical removal of tumors and provided hope for the treatment efficacy towards better cancer treatment strategies like radiation-based and other treatment modalities, with all these added advantages of nanotechnology, which enhanced the better treatment strategies and decreased risk level of patients and prolonged the survival rate of cancer patients (Duan *et al.*, 2016; He *et al.*, 2016; Alshehri *et al.*, 2021). Investigate advances of nanotechnology happening cancer therapy reached beyond the drug delivery techniques into the creation for innovative therapeutically benefit methods through the applicable usage of those developed and advanced nanotechnology techniques such as nanoparticles. These nanoparticles are relatively small when compared with cells, but big enough to capture many small molecule compounds, which can be several types.

Nanoparticles can act as fully functional when together with ligands, including peptides, proteins, DNA or RNA strands, antibodies, aptamers and other small molecules. Either shows a direct impact on the therapeutical level in vitro or in vivo. With these advantages, nanotechnology enabled the paths for combinational drug deliveries, multi-modality treatments and combinational diagnostics and therapeutic strategies known as the agnostic method. The advancement of technology for developing innovative nanoparticle packages and active pharmaceutical ingredients enabled a wide exploration of the range of active ingredients. These innovative strategies comprise designing nanoparticles as antigen-presenting cells (artificial epitopes) and in vivo immune stimulant factors for exploiting sustained anti-tumor activity.

CONCEPT OF CANCER NANOMEDICINE

As per the statistical analysis from ICMR (Indian Council of Medical Research) and WHO (World Health organization), Cancer is the second-largest reported disease in India & the globe after heart disease even after the COVID-19 pandemic, the victims of cancer affected people were 2.25 million, and the chances of getting cancer before the age of 60-70 years is estimated as 9.81% in men and 9.42% in women. Critically only 12-14% of patients receive treatment in the early stages of cancer & many of the other patients have cancers that could have been prevented, screened for, or treated earlier (Acharya *et al.*, 2009). At present most cancer treatment includes surgery to remove the tumors, chemotherapy, radiation therapy & immunotherapies, although the latter is expensive & not yet widely available worldwide. Nevertheless, the best thing is that one-third of common cancers are preventable if they are diagnosed early. potential applications of nanoparticles were known for their healing application for cancer treatment, due to their enhancement of the rate and route of drug delivery system, reduce toxicity of drug, and provide and help drugs for flushing out from body, since the Doxil® discovery of first nanomedicine and other Nanomedicine's discovery have been approved by FDA due to their efficiency over other available drugs. Their mechanism includes effectiveness towards tumor microenvironment (TME), but still further requires further validation studies for further investigations (Ahmad *et al.*, 2021).

Fast development and usage of nanotechnology towards the development of nanomedicine products helped in providing proper therapeutic approaches against cancer (Wicki *et al.*, 2015). With the help of nanomedicine, now clinicians and researchers got an opportunity to achieve stringent targeting methods and multifunctional strategies for cancer treatment. Nanomedicine products had shown an impact on pharmacokinetic and pharmacodynamic profiles compared to traditional treatment strategies and optimised the efficacy of anti-cancer compounds, and several of the developed nanomedicine products which are currently in clinical and pre-clinical trials for their final approvals, and few got approved for emergency usage. Several first-generation nanomedicine products (table-1) have been approved and entered the market, they improved the therapeutic efficacy by drug tolerability enhancing (Shi *et al.*, 2011). Van der Meel *et al.* (2019) proposed four strategic directions for improved nanomedicine usage. (a) patient grouping based has become one of the common methods for drug development, instead, it should focus on dividing patients according to their need for cancer nanomedicine, so that they can easily be suitable for clinical trials (b) should replace conventional cancer drug prescription with investments in flexible prodrug and specific-site targeting drug (nanocarrier). (c) Combinational therapies will show good progress in clinical cancer care. (d) Immunotherapy with nanomedicine can modify myeloid and lymphoid cells behaviour, aids in developing anti-cancer immunity and advanced immunotherapy efficacy. Rather than alone, combination with nanomedicine, these four potential strategies will fasten and foster the enhancing successful cancer nanomedicine therapies.

LATEST STUDIES

We will discuss the proper utilization and few reported latest studies on nanomedicine in particular case studies in cancer patients. A recent review by (Mignani *et al.*, 2021), summarized that dendrimers have developed as efficient, original, hyper branched, assembled polymeric nanoparticles synthesised based on synthetic monomers, and they were considered as best-in-class agents' when either used as nanocarrier of drugs or as drugs by themselves for enhancing and modifying the profiles of pharmacokinetics and pharma dynamics of the drugs. In another study by (Sims *et al.*, 2017), overviewed many kinds of nanomaterials that were utilised or anticipated for the use of wide and extensive range of biomedical usages, including therapeutic delivery systems, diagnostics assays, and tissue engineering. Doxil and Abraxane are the two successfully developed nanoparticles using cancer Nanomedicines for drug delivery. Doxil is derived from doxorubicin (a liposomal formulation) and Abraxane is a derivative of paclitaxel (albumin-bound nanoparticle) (Gradishar, 2006; Yingchoncharoen *et al.*, 2016).

APPLICATIONS OF NANOTECHNOLOGY IN DEVELOPING DRUGS AND VACCINES FOR OTHER DISEASES (INCLUDING COVID-19)

Cancer patients and cardiac patients were suspected to expose to other diseases, as they were immuno compromised ones. Due to pandemics and other reasons, it would be problematic for that cancer patients or immunosuppressed persons to stay healthy and safe from pneumonia and from other lung-viral infections, which made them susceptible to covid-19. Virus-related ailments have contributed to an increase of 19% in the death rate in such immuno suppressed patients including those with cardiac and cancer (Wu and McGoogan, 2020). With the advances of nanotechnology, the nanoparticle-mediated delivery system can easily deliver antigens and adjuvant in a mono particulate carrier (Kang *et al.*, 2018; Shin *et al.*, 2020). Nanoparticles can help in the formulation of vaccine components which encapsulated to attach as antigen-presenting cells. These formulations will reduce the adverse effects and enhance the vaccine candidate's efficacy. mRNA-1273 is one of the well-known recently developed SAR-Cov2 nanotechnology-based vaccine candidates by Mordena company (Chauhan *et al.*, 2020), NVX-Cov2373,

full recombinant Severe acute respiratory syndrome coronavirus-2 (SARS-CoV2) glycoprotein derived nanoparticle vaccine by Novavax company, adjuvanted with support of MATRIX-M® (Weiss *et al.*, 2020)

CONCLUDING REMARKS & FUTURE PERSPECTIVE

Conventional therapies are confined to surgery for removing tumors, radiation techniques, chemotherapy methods for treatment and expensive immunotherapy with several disadvantages and side effects. Latest cancer treatments focused mainly on precise drug delivery to reach the cancer tissues to minimize the adverse effects on healthy tissues surrounded by cancer cells. Nanomedicine has the potential to bring changes in cancer treatment methods for proper diagnosis and improved treatment and translate cancer research into progressing nano-based cancer therapies and diagnostics to the clinicians, for precise treatment methods. Nanoparticle mediated drug delivery and other combinational oncology are rapidly progressing, with several major lines of area emerged as developing nanoparticle packages, API (active pharmaceutical ingredients) for facilitating a broader range of active ingredients, established delivery systems for immunogenic cargos and surface coatings for adjuvant for nanoparticle-mediated therapy, combinational and single therapies, includes radiotherapy and chemotherapy. Further encouragement to develop assays and kits for nano-based tests for early detection of cancer will be helpful to hasten the clinicians, patients and researchers to enable them to use these developed assays as conveniently for preventive measures.

REFERENCES

- [1] Acharya, S., Dilnawaz, F., & Sahoo, S. K. (2009). Targeted epidermal growth factor receptor nanoparticle bioconjugates for breast cancer therapy. *Biomaterials*, 30(29). <https://doi.org/10.1016/j.biomaterials.2009.07.008>
- [2] Ahmad, S., Idris, R. A. M., Wan Hanaffi, W. N., Perumal, K., Boer, J. C., Plebanski, M., Jaafar, J., Lim, J. K., & Mohamud, R. (2021). Cancer Nanomedicine and Immune System—Interactions and Challenges. *Frontiers in Nanotechnology*, 3. <https://doi.org/10.3389/fnano.2021.681305>
- [3] Alshehri, S., Imam, S. S., Rizwanullah, M., Akhter, S., Mahdi, W., Kazi, M., & Ahmad, J. (2021). Progress of cancer nanotechnology as diagnostics, therapeutics, and theranostics nanomedicine: Preclinical promise and translational challenges. In *Pharmaceutics* (Vol. 13, Issue 1). <https://doi.org/10.3390/pharmaceutics13010024>
- [4] Chauhan, G., Madou, M. J., Kalra, S., Chopra, V., Ghosh, D., & Martinez-Chapa, S. O. (2020). Nanotechnology for COVID-19: Therapeutics and Vaccine Research. In *ACS Nano* (Vol. 14, Issue 7). <https://doi.org/10.1021/acsnano.0c04006>
- [5] Duan, X., Chan, C., Guo, N., Han, W., Weichselbaum, R. R., & Lin, W. (2016). Photodynamic Therapy Mediated by Nontoxic Core-Shell Nanoparticles Synergizes with Immune Checkpoint Blockade To Elicit Antitumor Immunity and Antimetastatic Effect on Breast Cancer. *Journal of the American Chemical Society*, 138(51). <https://doi.org/10.1021/jacs.6b09538>
- [6] Gradishar, W. J. (2006). Albumin-bound paclitaxel: A next-generation taxane. *Expert Opinion on Pharmacotherapy*, 7(8). <https://doi.org/10.1517/14656566.7.8.1041>
- [7] He, C., Duan, X., Guo, N., Chan, C., Poon, C., Weichselbaum, R. R., & Lin, W. (2016). Core-shell nanoscale coordination polymers combine chemotherapy and photodynamic therapy to potentiate checkpoint blockade cancer immunotherapy. *Nature Communications*, 7. <https://doi.org/10.1038/ncomms12499>

- [8] Kaehler, T. (1994). Nanotechnology: Basic Concepts and Definitions. *Clinical Chemistry*, 40(9). <https://doi.org/10.1093/clinchem/40.9.1797>
- [9] Kang, S. H., Hong, S. J., Lee, Y. K., & Cho, S. (2018). Oral vaccine delivery for intestinal immunity- biological basis, barriers, delivery system, and M cell targeting. In *Polymers* (Vol. 10, Issue 9). <https://doi.org/10.3390/polym10090948>
- [10] Mignani, S., Shi, X., Guidolin, K., Zheng, G., Karpus, A., & Majoral, J. P. (2021). Clinical diagonal translation of nanoparticles: Case studies in dendrimer nanomedicine. In *Journal of Controlled Release* (Vol. 337). <https://doi.org/10.1016/j.jconrel.2021.07.036>
- [11] Shi, J., Xiao, Z., Kamaly, N., & Farokhzad, O. C. (2011). Self-assembled targeted nanoparticles: Evolution of technologies and bench to bedside translation. In *Accounts of Chemical Research* (Vol. 44, Issue 10). <https://doi.org/10.1021/ar200054n>
- [12] Shin, M. D., Shukla, S., Chung, Y. H., Beiss, V., Chan, S. K., Ortega-Rivera, O. A., Wirth, D. M., Chen, A., Sack, M., Pokorski, J. K., & Steinmetz, N. F. (2020). COVID-19 vaccine development and a potential nanomaterial path forward. In *Nature Nanotechnology* (Vol. 15, Issue 8). <https://doi.org/10.1038/s41565-020-0737-y>
- [13] Sims, C. M., Hanna, S. K., Heller, D. A., Horoszko, C. P., Johnson, M. E., Montoro Bustos, A. R., Reipa, V., Riley, K. R., & Nelson, B. C. (2017). Redox-active nanomaterials for nanomedicine applications. In *Nanoscale* (Vol. 9, Issue 40). <https://doi.org/10.1039/c7nr05429g>
- [14] van der Meel, R., Sulheim, E., Shi, Y., Kiessling, F., Mulder, W. J. M., & Lammers, T. (2019). Smart cancer nanomedicine. *Nature Nanotechnology*, 14(11). <https://doi.org/10.1038/s41565-019-0567-y>
- [15] Weiss, C., Carriere, M., Fusco, L., Fusco, L., Capua, I., Regla-Nava, J. A., Pasquali, M., Pasquali, M., Pasquali, M., Scott, J. A., Vitale, F., Vitale, F., Unal, M. A., Mattevi, C., Bedognetti, D., Merkoçi, A., Merkoçi, A., Tasciotti, E., Tasciotti, E., ... Delogu, L. G. (2020). Toward Nanotechnology-Enabled Approaches against the COVID-19 Pandemic. In *ACS Nano* (Vol. 14, Issue 6). <https://doi.org/10.1021/acsnano.0c03697>
- [16] Whitesides, G. M. (2003). The “right” size in nanobiotechnology. In *Nature Biotechnology* (Vol. 21, Issue 10). <https://doi.org/10.1038/nbt872>
- [17] Wicki, A., Witzigmann, D., Balasubramanian, V., & Huwyler, J. (2015). Nanomedicine in cancer therapy: Challenges, opportunities, and clinical applications. In *Journal of Controlled Release* (Vol. 200). <https://doi.org/10.1016/j.jconrel.2014.12.030>
- [18] Wu, Z., & McGoogan, J. M. (2020). Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China. *JAMA*, 323(13). <https://doi.org/10.1001/jama.2020.2648>
- [19] Yingchoncharoen, P., Kalinowski, D. S., & Richardson, D. R. (2016). Lipid-based drug delivery systems in cancer therapy: What is available and what is yet to come. *Pharmacological Reviews*, 68(3). <https://doi.org/10.1124/pr.115.012070>
- [20] Batist, G., Barton, J., Chaikin, P., Swenson, C., and Welles, L. (2005). Myocet (Liposome-encapsulated Doxorubicin Citrate): a New Approach in Breast Cancer Therapy. *Expert Opin. Pharmacother.* 3 (12), 1739–1751. doi:10.1517/14656566.3.12.1739
- [21] Barenholz, Y. (2012). Doxil - the First FDA-Approved Nano-Drug: Lessons Learned. *J. Control. Release* 160 (2), 117–134. doi:10.1016/j.jconrel.2012.03.020
- [22] Tejada-Berges, T., Granai, C., Gordinier, M., and Gajewski, W. (2014). Caelyx/Doxil for the Treatment of Metastatic Ovarian and Breast Cancer. *Expert Rev. Anticancer Ther.* 2 (2), 143–150. doi:10.1586/14737140.2.2.143

- [23] Pillai, G., and Ceballos-Coronel, M. L. (2013). Science and Technology of the Emerging Nanomedicines in Cancer Therapy: A Primer for Physicians and Pharmacists. *SAGE Open Med.* 1, 205031211351375. doi:10.1177/2050312113513759
- [24] Pillai, G. (2014). Nanomedicines for Cancer Therapy: An Update of FDA Approved and Those under Various Stages of Development. *SOJ Pharmacy & Pharmaceutical Sciences.* doi:10.15226/2374-6866/1/2/00109
- [25] Hartmann, M., Mayer-Nicolai, C., and Pfaff, O. (2013). Approval Probabilities and Regulatory Review Patterns for Anticancer Drugs in the European Union. *Crit. Rev. Oncol. Hematol.* 87 (2), 112–121. doi:10.1016/j.critrevonc.2013.01.004
- [26] Havel, H., Finch, G., Strode, P., Wolfgang, M., Zale, S., Bobe, I., et al. (2016). Nanomedicines: From Bench to Bedside and beyond. *Aaps J.* 18 (6), 1373–1378. doi:10.1208/s12248-016-9961-7
- [27] Krauss, A. C., Gao, X., Li, L., Manning, M. L., Patel, P., Fu, W., et al. (2019). FDA Approval Summary: (Daunorubicin and Cytarabine) Liposome for Injection for the Treatment of Adults with High-Risk Acute Myeloid Leukemia. *Clin. Cancer Res.* 25 (9), 2685–2690. doi:10.1158/1078-0432.ccr-18-2990
- [28] Patra, J. K., Das, G., Fraceto, L. F., Campos, E. V. R., Rodriguez-Torres, M. d. P., Acosta-Torres, L. S., et al. (2018). Nano Based Drug Delivery Systems: Recent Developments and Future Prospects. *J. Nanobiotechnol.* 16 (1), 71. doi:10.1186/s12951-018-0392-8
- [29] Massadeh, S., and Al Aamery, M. (2016). Nano-materials for Gene Therapy: An Efficient Way in Overcoming Challenges of Gene Delivery. *J. Biosens. Bioelectron.* 07 (01). doi:10.4172/2155-6210.1000195
- [30] Gradishar, W. J., Tjulandin, S., Davidson, N., Shaw, H., Desai, N., Bhar, P., et al. (2005). Phase III Trial of Nanoparticle Albumin-Bound Paclitaxel Compared with Polyethylated Castor Oil-Based Paclitaxel in Women with Breast Cancer. *Jco* 23 (31), 7794–7803. doi:10.1200/jco.2005.04.937
- [31] Fu, Q., Sun, J., Zhang, W., Sui, X., Yan, Z., and He, Z. (2009). Nanoparticle Albumin - Bound (NAB) Technology Is a Promising Method for Anti-cancer Drug Delivery. *Pra* 4 (3), 262–272. doi:10.2174/157489209789206869
- [32] Ventola, C. L. (2017). Progress in Nanomedicine: Approved and Investigational Nanodrugs. *P & T* 42 (12), 742–755.
- [33] Brandenburg, G., Poppenborg, S., Radcke, C., Wittmann, J., Krähmer, R., Pasut, G., et al. (2020). “Challenges in the Analytical Characterization of PEGylated Asparaginase,” in *Polymer-Protein Conjugates: From Pegylation and Beyonds*. Editors G. Pasut, and S. Zalipsky, 205–231. doi:10.1016/b978-0-444-64081-9.00010-3
- [34] Maeda, H. (2017). Polymer Therapeutics and the EPR Effect. *J. Drug Target.* 25 (9-10), 781–785. doi:10.1080/1061186x.2017.1365878
- [35] Guo, X., Wang, L., Wei, X., and Zhou, S. (2016). Polymer-based Drug Delivery Systems for Cancer Treatment. *J. Polym. Sci. Part. A: Polym. Chem.* 54 (22), 3525–3550. doi:10.1002/pola.28252
- [36] Sartor, O. (2003). Eligard: Leuprolide Acetate in a Novel Sustained-Release Delivery System. *Urology* 61 (2), 25–31. Doi: 10.1016/s0090-4295(02)02396-8.

Chapter

5

GRAPHENE IMPORTANCE IN NANOSCIENCE AND SYNTHESIS OF GRAPHENE OXIDE IN MODIFIED HUMMERS METHOD AND PHOTOCATALYTIC DEGRADATION OF METHYLENE BLUE UNDER VISIBLE LIGHT IRRADIATION

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ABSTRACT

Graphene is a very enormous and utmost material for composite with metals, non-metals and semiconductors in recent years, due to its has an eccentric atom-thick with two-dimensional (2D) structure, outstanding physical properties like high conductivity and charge mobility, huge specific surface area, exceptional mechanical, thermal and electrical properties. Thus, it has been regarded as a foremost component for functional materials, peculiarly for developing a variety of catalysts and it has been considered widely as an elevated precursor and a starting material for the synthesis of this processable material. This work describes the synthesis of Graphene oxide (GO) by Modified Hummer's method and characterization of GO by UV-visible diffuse reflectance spectroscopy (UV-DRS), Ultra violet visible spectroscopy (UV-Vis), X-ray diffraction (XRD), Energy dispersive spectroscopy (EDX) analysis and Field emission scanning electron microscopy (FESEM). The results obtained from sophisticated spectroscopic techniques for mentioned above are also explained in detailed and evaluation of catalytic application to habitant restorative, such as water exoneration of degradation of methylene blue under visible light irradiation.

KEYWORDS: Graphene, Graphene Oxide, Hummer's method, Methylene blue, Photo catalytic degradation

INTRODUCTION

Nanoscience is a collaborative field, as it combines the knowledge from different disciplines: physics, chemistry, and biology. Nanoscience is the art and science of exploit matter at the atomic or molecular scale and holds the promise of providing remarkable refinement in technologies for preserve the environment. The nanoparticles and nano sized materials have gained eminence in technological expansion due to their tuneable physicochemical characteristics such as wettability, melting point, catalytic activity, electrical, thermal conductivity, light absorption and scattering resulting in enhanced accomplishment over their bulk counterparts. The technology has magnificent prospects for enslavement across the medical, biotechnology, telecommunications, engineering, pharmaceutical, manufacturing, and information technology markets. Nanometer (nm) is an International System of unit that represents 10^{-9} meter in length. In principle, nanomaterials are narrated as materials with length of 1–1000 nm in at least one dimension; however, they are commonly elucidated to be of diameter in the range of 1 to 100 nm.

GRAPHENE

Graphene oxide (GO) represents an materialize field of versatile science that duration a variety of disciplines such as chemistry, physics, device fabrication, materials science and nanotechnology [1-3] The current graphene boom started in 2004 when Geim, Novoselov et al. published the deposition and characterization of single sheets of graphite on solid supports. Their unconventional experiments on graphene were honoured with the Nobel Prize in Physics in 2010 [4-7]. Exceptional electronic, mechanical and optical properties were discovered in quick succession as a significance of the experience gained from other carbon allotropism [8-9]. In particular, the electrical, the high charge carrier mobilities and thermal conductivity, combined with transparency and mechanical strength make graphene highly charismatic for future high-tech applications [30].

The current status of graphene oxide with respect to prototype applications has been wide-ranging reviewed.[10] Many graphene-based devices exceed reference systems, for example in high-frequency transistors, foldable and resilient electronic or photo detectors,[11] capacitors,[12] transparent electrodes,[13] sensors,[14] H₂ generation,[15] pollution management,[16] energy applications,[17] and composite materials for biomedical applications [30].

Graphene is a two-dimensional (2D) carbon allotrope which can be viewed as both a solid and a macromolecule with molecular weights of more than $10^6 - 10^7 \text{ gmol}^{-1}$. In natural graphite, the graphene layers stick cooperatively through hugely conspicuous π - π stacking interactions [30]. This noncovalent interlayer imperative contributes significantly to the high thermodynamic firmness of graphite. As a ramification, the wet chemistry of graphene is always bothered with conquer these synergy action. For example, an earmark exfoliation of graphite or the stabilization of solvent-dispersed graphene sheets always competes with conglomeration. It should be pointed out that a solid sample of graphene can only be stabilized on a support, such as a surface. A non-supported graphene powder can't be expected to exist since at least a partial restacking to graphite will take place! Another prospect of stabilizing individualized graphene is to "masking tape" the surface through chemical functionalization [18, 30] In inclusion; graphene is contemplate as the parent of all graphitic forms including fullerene (0D), carbon nanotubes (1D), and graphite (3D) as shown in Fig. 1. [31].

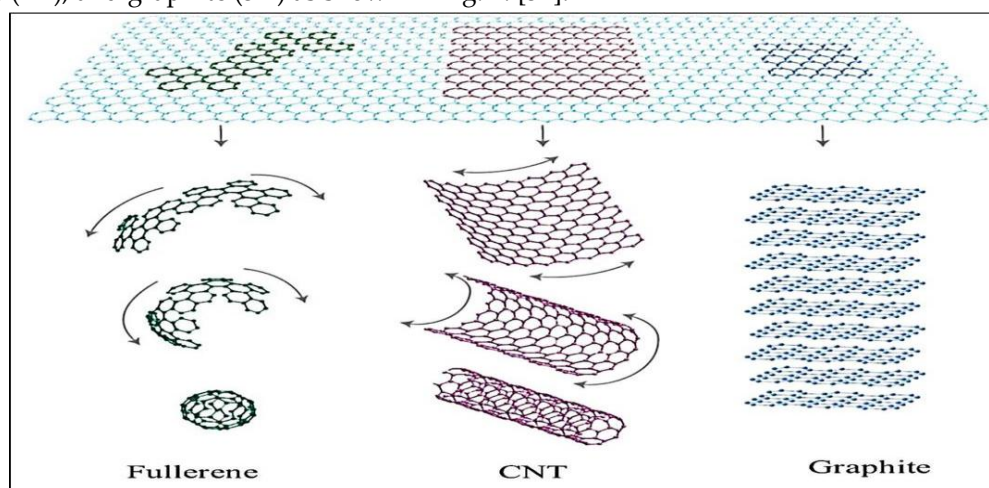


Fig. 1: A sheet of graphene rolled and stack together to form different allotropes of carbon [31].

PROPERTIES OF GRAPHENE

ELECTRONIC PROPERTIES: The electronic resources of graphene have received the bulk attentiveness. Sling graphene shows tremendously elevated low-temperature, charge carrier mobility with a value impending $200\,000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ [19], making it a marvelous conductor of electricity. This magnificent

conductivity is due to the astonishing property of graphene that its charge carriers act like mass less reliance particles or Dirac fermions, and electrons can travel distances in the order of micrometers without scattering under terrain conditions [21]. This idiosyncratic behaviour has led to supplemental phenomena in graphene. UV-DRS spectra divulge the graphene oxide has a zero-band gap 2D semiconductor due to it is like as a semi-metal, graphene exhibits a strong ambipolar electric field effect and the concentration of charge carriers can be as high as 10^{13} cm^{-1} , with room temperature mobilities of up to $15000 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$ having been measured [22]. Moreover, a peculiar half-integer Quantum Hall Effect (QHE) in graphene has been commemorating at room temperature [23, 29].

THERMAL PROPERTIES: The thermal conductivity of sling single-layer graphene at room temperature has been calculated in the range $(4.84 + 0.44) \times 10^3$ to $(5.30 + 0.48) \times 10^3 \text{ W m}^{-1} \text{ K}^{-1}$ [24]. The worthier thermal conduction property of graphene is favourable for making graphene as an outstanding material for thermal management [29]. The thermal conductivity of large-area, monolayer graphene grown by chemical vapour deposition (CVD) on an Au-coated SiN_x porous membrane can reach about $2500 \text{ W m}^{-1} \text{ K}^{-1}$ at 350 K [25,29].

MECHANICAL PROPERTIES: According to Changgu Lee, graphene is the brawny material ever tested, with a Tensile strength of 130.01 GPa and a Young's Modulus (defines stiffness) of 1 TPa [22]. Apart from this, graphene is incredible light weighing about only 0.766 mg/m^2 . [23, 31].

OPTICAL PROPERTIES: Graphene exhibit a hugely misty atomic monolayer in a vacuum, as it has a capability to absorb roughly 2.30 % of the white light. Adding another layer of graphene increases the amount of white light absorbed by approximately the same value (2.30 %) [24]. Once optical intensity reaches a certain threshold impregnate absorption takes place. Due to graphene's properties of wavelength-insensitive ultrafast macerate absorption, full band mode secure has been achieved [33].

THINNESS AND LIGHTNESS: Since graphene has only one carbon atom thick layer is found to be very light material. It has calculated $\sim 2,630 \text{ m}^2 \text{ g}^{-1}$ theoretical specific surface area and evidently, it could embed a football field with a sheet of graphene weighing less than a gram [34].

IMPERMEABILITY: The graphene nanosheets of closely linked carbon atoms can work like exceptional-fine atomic nets conclude other materials from getting through. Therefore, graphene is useful for trapping and detecting gasses and might also have auspicious applications holding gasses (such as hydrogen) that leak remarkably easily from standard containers [36].

The aforementioned unique structure and properties of graphene have recommended the significant potential of graphene in electronics, optoelectronics, electrochemical and biomedical applications [37-38]. Although, pure graphene nanosheets are slight to practical applications in spite of their exceptional properties [39]. For example, pure graphene has weak absorption for light, and thus pure graphene nanosheets are not suitable for collecting solar light efficiently. Therefore the challenges of practical applications of graphene induce a controlled functionality to pure graphene sheets. Instead of the pure graphene, functionalized graphene or graphene nanocomposites are attracting increasing interest for real applications [40-41]. The recent point on graphene as a general platform for nanocomposites has inspired numerous potential applications in energy and environmental facet by introducing controlled functional materials to graphene [42-43].

Graphite is one of the extended-known forms of pure carbon and familiar from everyday life. In ideal graphite these planes are hoard in an ABAB manner. Macroscopic single crystals of graphite do not occur in nature. It is fabricate from hexagonal planes of carbon atoms. So called Kish graphite which is frequently referred to as a single crystal-consists of numerous tiny crystallites (up to $100 \times 100 \mu\text{m}^2$) which are align randomly. Highly aligned pyrolytic graphite (HAPG) is feigned grown graphite with a close to perfect alignment perpendicular to the carbon planes. Along the in-plane directions, nevertheless, the

crystallites are again tiny and randomly aligned. Graphite can be of natural inception or synthetically generated [44]. The 3D stacking of the idiomatic sp^2 layers can further lead to a hexagonal (AB) or rhombohedra (ABC) stacking or the structure can be turbostratic with no regularities within the layer sequence [45]. Samples of natural graphite incorporate assorted portions of these structures, which influence the reactivity [44]. The ideal structure of graphite is shown in Fig.1. But flakes of natural graphite usually bear macroscopic cracks and holes that can materially affect the chemical reactivity.

Table 1: The summary on possession of graphene compared to other carbon families[46]

| Carbon allotropes | Graphite | Diamond | Fullerene (C ₆₀) | Carbon nanotubes | Graphene |
|---|-------------------------------|-----------------------------|------------------------------|--------------------------------|-----------------------------------|
| Hybridized form | sp^2 | sp^3 | Mainly sp^2 | Mainly sp^2 | sp^2 |
| Crystal structure | Cubic | Tabular | Truncated Icosahedron | Cylindrical | Honeycomb |
| Dimension | Three | Three | Zero | One | Two |
| Experimental specific surface area ($m^2 g^{-1}$) | ~10-20 | 20-160 | 80-90 | ~1300 | ~1500 |
| Density ($g cm^{-3}$) | 3.09-2.23 | 3.5-3.53 | 1.72 | >1 | >1 |
| Optical properties | Uniaxial | Isotropic | Non-linear optical response | Structure dependent properties | 97.7% of optical transmittance |
| Thermal conductivity ($W m^{-1} K^{-1}$) | 1500-2000 | 900-2320 | 0.4 | 3500 | 4840-5300 |
| Hardness | High | Ultrahigh | High | High | Highest (single layer) |
| Tenacity Flexible | non-elastic | - | Elastic | Flexible elastic | Flexible elastic |
| Electronic properties | Electrical conductor | Insulator, semiconductor or | Insulator | Metallic and semiconducting | Semimetal, zero-gap semiconductor |
| Electrical conductivity ($S cm^{-1}$) | Anisotropic $2-3 \times 10^4$ | - | 10^{-10} | Structure-dependent | 2000 |

GRAPHENE-BASED NANOCOMPOSITES

The composites of two or more materials with different properties have produced an end material with unique and enhanced properties. The nanocomposite materials based on nanoscale size effectively used to functionalize materials for various technological applications. The nanocomposites have combined properties of the component materials and their synergy effect observes by enhances the solubility,

dispersion stability, strength and lessening weight than the parent materials. In recent years, nanocomposites have emerged as a crucial issue in the field of nanotechnology due to their eccentric physicochemical properties and significant potential applications in the areas of electronics, photonics, catalysis, biotechnology, and environmental applications [47–49].

It has been known that, prior to the discovery of graphene, carbon nanotubes (CNTs) and polymer matrix are enthusiastic for the fabrication of numerous composites due to their magnificent electrical conductivity, high mechanical strength and large surface area [50]. Although, the broke solubility, difficult manipulation and high production cost of these composite matrixes fetter their potential applications. In contrast, graphene can easily modify to form a stable aqueous dispersion and be produced in a large-scale with low cost via the chemical conversion from graphite [51]. Moreover, graphene due to its better mechanical, electrical and electrochemical properties makes preferable for making nanocomposites materials [33]. Hence, to enhance the graphene applicability and intriguing property, by developing composites or functionalized with small molecules, nanoscale, and polymers.

In general, graphene nanocomposites based on the nature of the other materials could be classified into three, i.e. graphene-polymer, graphene-inorganic NPs and graphene-biomolecule nanocomposites. By integrating the functionality of molecules, inorganic NPs and polymers with graphene, graphene nanocomposites could create enhanced multifunctionality, which is not present in the pure state of graphene or the complement materials.

GRAPHENE-INORGANIC NANOCOMPOSITES:

Inorganic nanoparticles such as metal, metal oxide or semiconductor are another most widely used functionalization for graphene nanocomposites. Depending on the intrinsic characteristics of the materials, inorganic NPs provide different functionalities, which cannot be found in pristine graphene. Graphene-inorganic nanocomposites can have unique optical and electronic properties which combine the advantages of graphene and the inorganic NPs and promote the potential of graphene in many electronic and optoelectronic applications [52]. Semiconductor NPs, such as bismuth molybdate ($\text{Bi}_x\text{Mo}_y\text{O}_z$), zinc oxide (ZnO) and cadmium sulfide (CdS), have excellent optical properties and can improve the low-absorption value of pristine graphene. For example, Chang et al. reported ZnO Nanowires/nanorods because of their UV-active and wide-band gap could enhance the UV responses of graphene when they form graphene–ZnO [53]. Similarly, Bera et al. [54] reported CdS quantum dots-graphene nanocomposite for improved photo catalysis. Zhang et al [46]. Were investigated an enhanced photo catalytic and photoelectrical performances of titanium dioxide (TiO_2) NPs by forming nanocomposites with graphene. Hareesh et al. have reported gold (Au NPs) decorated graphene nanocomposites for surface-enhanced Raman scattering (SERS) and reduction of 4-nitrophenol to 4-aminophenol [47]. Magnetite (Fe_3O_4) NPs–graphene nanocomposites demonstrates an effective improvement of electromagnetic shielding efficiency and adsorption of organic and inorganic water pollutants [48-49]. Among various graphene oxide-based photo catalysts, bismuth molybdate (Bi_2MoO_6) is stable, innocuous and with a smaller band gap (2.5-2.8eV), has been contemplate as a promising candidate in organic dye degradation and water splitting [51-53]. In particular, mesoporous Bi_2MoO_6 , due to its large surface-to-volume ratio and comfortable porous structure, exhibits exceptional optical absorption ability and surface catalytic activity [54-57].

EXPERIMENTAL

MATERIALS

Nitric acid [HNO_3 78%], Ammonium molybdate [$(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \cdot 4\text{H}_2\text{O}$] and Ammonium hydroxide [NH_4OH], Ferric chloride [$\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$], Ferrous sulphate [$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$] Graphite Flakes (Sigma Aldrich), Sodium nitrate [NaNO_2], Potassium permanganate [KNO_3], Hydrogen peroxide 30% [H_2O_2], Sulphuric acid 98% [H_2SO_4], Hydrochloric acid 35% [HCl], Ortho phosphoric acid [H_3PO_4], Bismuth Nitrate [$\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$], and Methylene blue [$\text{C}_{16}\text{H}_{18}\text{ClN}_3\text{S}$]. All chemicals received from Merck India except Graphite flake received from Sigma Aldrich USA and used without further purifier.

SYNTHESIS OF GRAPHENE OXIDE BY MODIFIED HUMMER'S METHOD

Graphite flakes (2 g) and NaNO_2 (2 g) were mixed in 80 mL of H_2SO_4 (98%) and 10 ml of H_3PO_4 in a 1000 ml round bottom flask kept under at ice bath ($0-5^\circ\text{C}$) with continuous stirring. The mixture was stirred for 4 hrs at $0-5^\circ\text{C}$ temperature and potassium permanganate (12 g) was added to the suspension tremendously slowly. The rate of addition was meticulous controlled to keep the reaction temperature lower than 15°C . The mixture is diluted with very slow addition of 200 ml double distilled water, the ice bath was then removed and kept under stirring for 2 hrs at room temperature. The above mixture is kept in a reflux system at 90°C for 1h. After 1h, change the temperature to 30°C which gives brown colored solution. Again after 10 min, change it to 25°C , and maintain the temperature for 2 hrs. The solution is finally treated with 41 ml H_2O_2 by which color changes to bright yellow, 200-230 ml of water is taken in two separate beakers and equal amount of solution prepared is added and stirred for 1 hr. It is then kept without stirring for 2-4 hrs, where the particles settles at the bottom and remaining water is poured to filter. The resulting mixture is washed repeatedly by centrifugation with 5% HCl and then with distilled water assorted times until it forms gel like substance (pH- neutral). After centrifugation the gel like substance is vacuum dried [58].

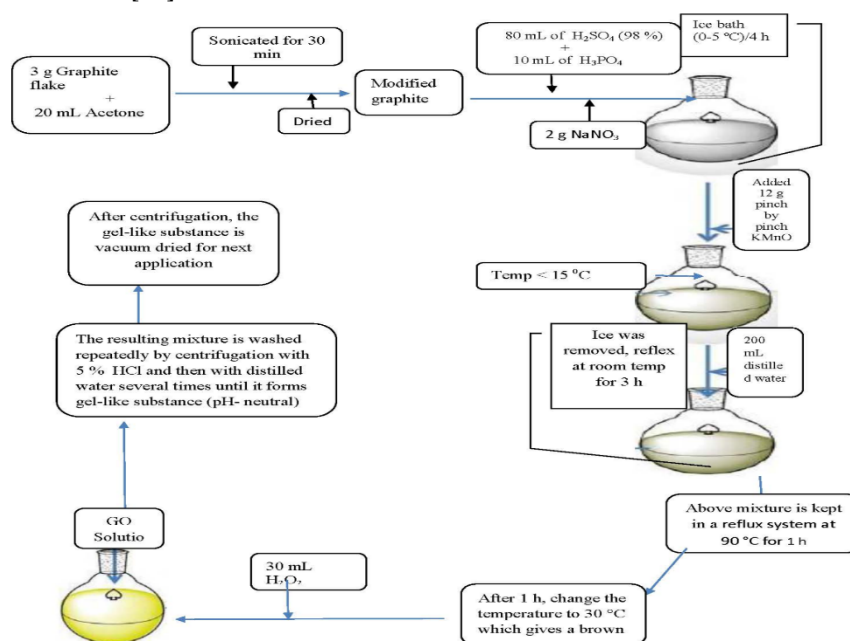


Fig. 2: The schematic synthesis diagram of graphene oxide by Hummers method

PHOTOCATALYTIC TEST

Organic pollutant such as methylene blue was chosen for photo catalytically activities evaluate of the as synthesized GO powder and Graphite flake (Sigma Aldrich USA). A 400 W HgX lamp was used as the

light source to provide the simulated solar light. The experiments performed at an ambient temperature. The photo catalysts (GO or Graphite flake) 0.05 g were added into 50 mL of organic pollutant 5 ppm solution, and suspension was magnetically stirred for 30 min in the dark to reach an adsorption-desorption equilibrium with the photo catalysts. At a every 30 min time intervals, a 3 mL solution collected and then analyzed on UV-Vis spectrophotometer during the photo degradation process and same experiment perform as blank (without GO or Graphite flake). The concentration of methylene blue was determined by monitoring the variations in the main absorption centered at 664nm.

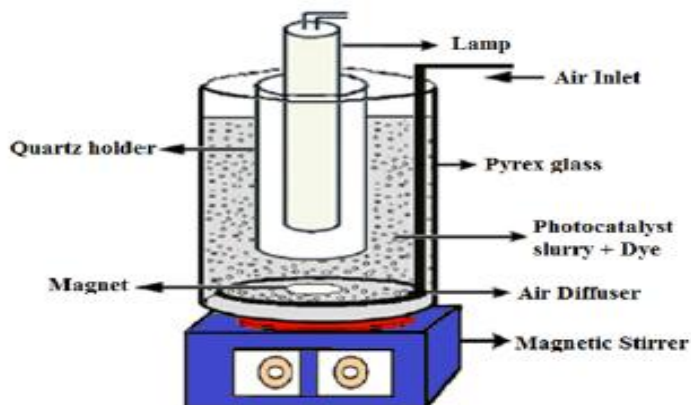


Fig. 3: Schematic diagram of the photocatalytic reactor system

CHARACTERIZATION

The size and morphology of the product were obtained with a Scanning electron microscope (FESEM-CARL Zeiss Germany, Model Ultra 55 FESEM, Gemini column, 1nm Resolution, detector is INLENSE), Energy dispersive spectroscopy (Oxford company, model 20 nm X Ma) UV-Vis & UV-Vis diffuse reflectance spectra of the sample were obtained in the range 300 – 800 nm using a UV-vis spectrophotometer (UV2550, Shimadzu, Japan) barium sulphate (BaSO_4) was used as a reflectance standard. The crystalline structure of the Graphene Oxide (GO) was investigated by powder X-ray diffraction (XRD, PanAlytical, X-Pert pro, and Netherland) radiation.

RESULTS AND DISCUSSION

Figure 4. shows the UV-Visible spectra of Graphene Oxide (GO), the broad shoulder peak at 291nm is $n - \pi^*$ transition due to C-O bonding and the peak at 215nm is $\pi - \pi^*$ transition due to C=C bonding is an aromatic ring, whereas the absorption over 291 nm is expected to be basis by the conjugated fused ring plane; this indicates a $sp^2 - \pi$ conjugated lattice.

The XRD pattern acquire for as correlate Graphene oxide (GO) nanoparticles by Hummer's method is shown in Figure 6.6b. The diffraction peak of pure graphite is found around $2\theta = 26^\circ$, corresponding to the highly organized layer structure with an interlayer distance of 0.34 nm along the (002) aligned is shown as illustration in Figure 6a. The XRD pattern for synthesized GO by Modified Hummer's method is shown in Figure 6.6b. It shows the diffraction peak at $2\theta = 10^\circ$, which is mainly due to the oxidation of graphite. The disappearance of the peak at 26° and appearance of the peak at 10° , shows that the product is absolutely oxidized after the chemical oxidation and exfoliation, indicating an increase in d-spacing from 0.34 nm to 0.82 nm.

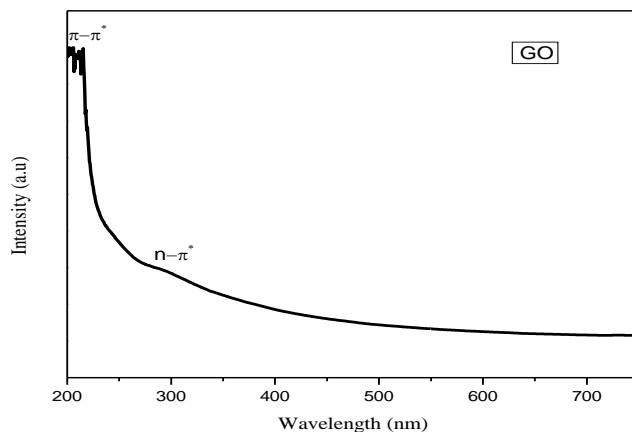


Fig. 4: UV-Visible spectra of Graphene Oxide

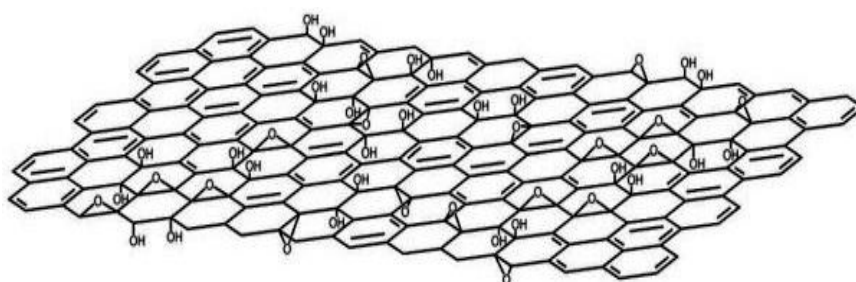


Fig. 5: Possible structure of Graphene Oxide

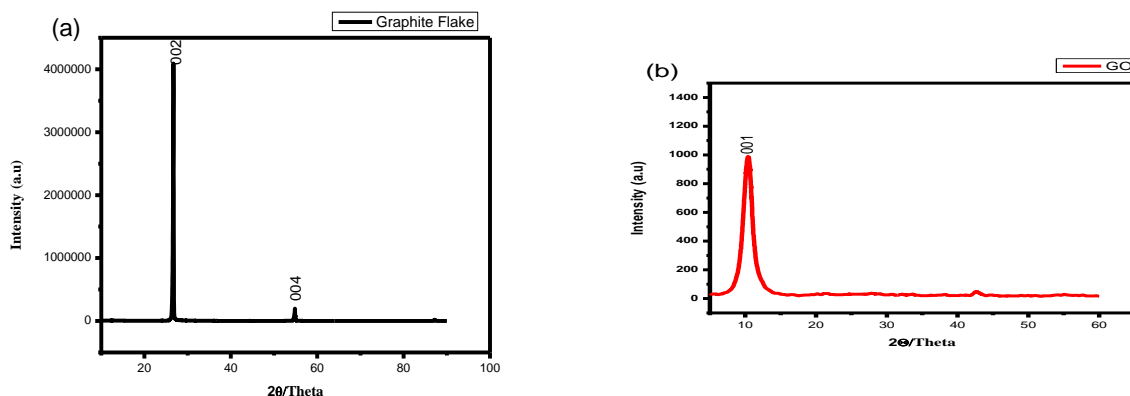


Fig. 6: XRD pattern of (a) Graphite flake, (b) Graphene Oxide

It shows single flakes of Graphene Oxide (GO) may be observed. Graphene Oxide flakes have proportionately substantial surface and well defined and connected three-dimensional Graphene Oxide sheets, forming a porous network that similitude a loose sponge like structure with 49.38 nm range in size. Fig.8.shows the EDX spectra of Graphene Oxide, which divulge to sterility of C, H, O elemental analysis and some defiled of the elemental with K, S due KMnO_4 and H_2SO_4 are predecessor for the oxidation of Graphene Oxide (GO)

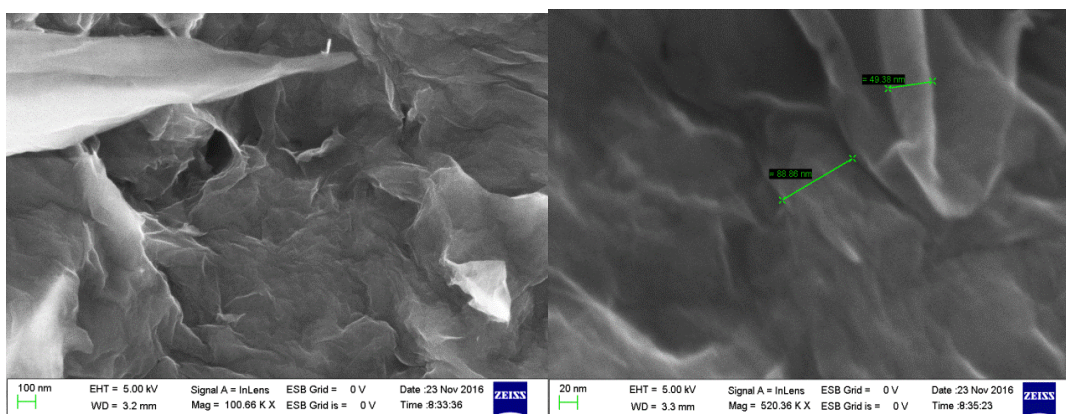


Fig. 7: Shows the FESEM images of Graphene Oxide

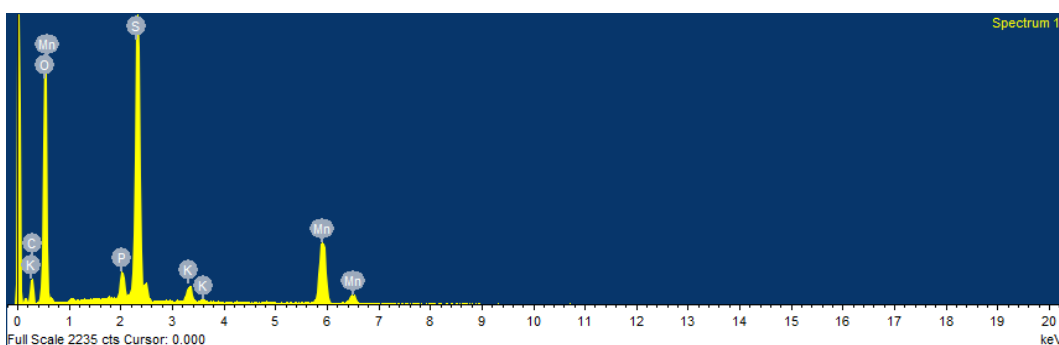


Fig. 8: EDX spectra of Graphene Oxide

Figure.9 Shows Ultra Violet Diffuse-Reflectance Spectroscopy (UV-DRS) is an essential method for charactering the optical state, electronic state and calculates the band gap of semiconductor materials. The DRS spectra of as synthesized of Graphene Oxide (GO) and the band gap calculated and the band gap is zero, due to its revealed Graphene Oxide (GO) as a non-semiconductor, it's like metal so Graphene Oxide (GO) as a semi metal.

$$\text{Band gap energy } (E_g) = h \cdot c / \lambda \text{ ----- (1)}$$

Where λ , E_g , h , c , is band gap energy, plank constant, speed of light, cut of wavelength respectively.

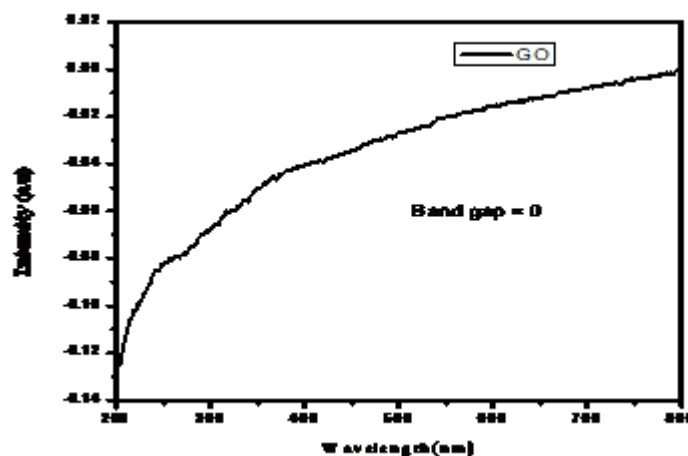


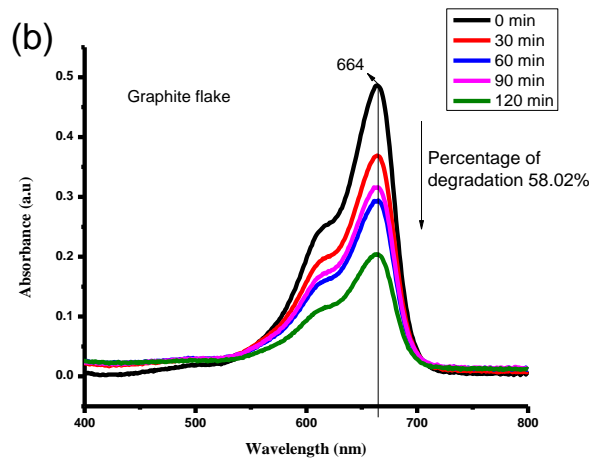
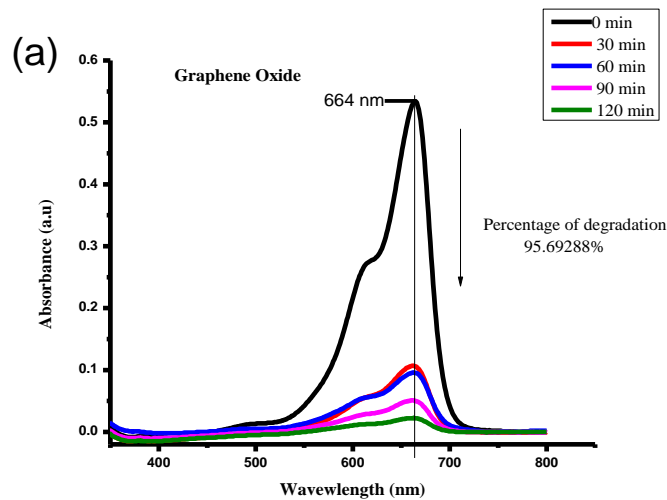
Fig. 9: UV-DRS spectrum of Graphene Oxide

PHOTOCATALYTIC EFFECT

Normally, photo catalytic degradation of dyes by a photo catalyst is captiously rely upon on particle size, translucent, band gap energy, morphology, charge recombination and efficient charge separation. Graphene Oxide (GO) as a good efficiency for charge separation. Figure 10. Shows the photo catalytic activity under visible light irradiation over degradation of Methylene blue was select as indicative facsimile containment. The initiation of adsorption – desorption equipoise was attain under continued stirring 30 min before the degradation reaction was accomplish, estimate degradation under visible light irradiation measured to UV- Visible spectrometer to the cut off filter 664nm. Figure 10a shows the degradation of MB with Graphene oxide (GO) and Figure 10b shows the drawn the graph between % of degradation and time with increase time degradation also increased, the increases of dye degradation below 30 minutes is rapidly after 30 minutes the degradation of dye also slow due to Graphene Oxide (GO) has large surface area so the degradation of starting 30 minutes is rapidly. So the effect of dye degradation not only depend on photo light (visible or ultra violet) also depend on surface area also due to this reason Graphene Oxide best material for composite to semiconductors and metals. Figure 10c shows the 7.6 % degradation of MB in absence of catalyst within 120 min. Figure 10d shows a plot between time vs. % of degradation of MB under GO, GF and in absence of catalyst. Among them Graphene oxide (GO) responds more toward the degradation of MB under visible light irradiation.

$$\% \text{ of degradation} = (A_0 - A_t) / A_0 * 100 \quad \text{Eq ----- (2)}$$

Where A_0 and A_t are respectively initial absorbance.



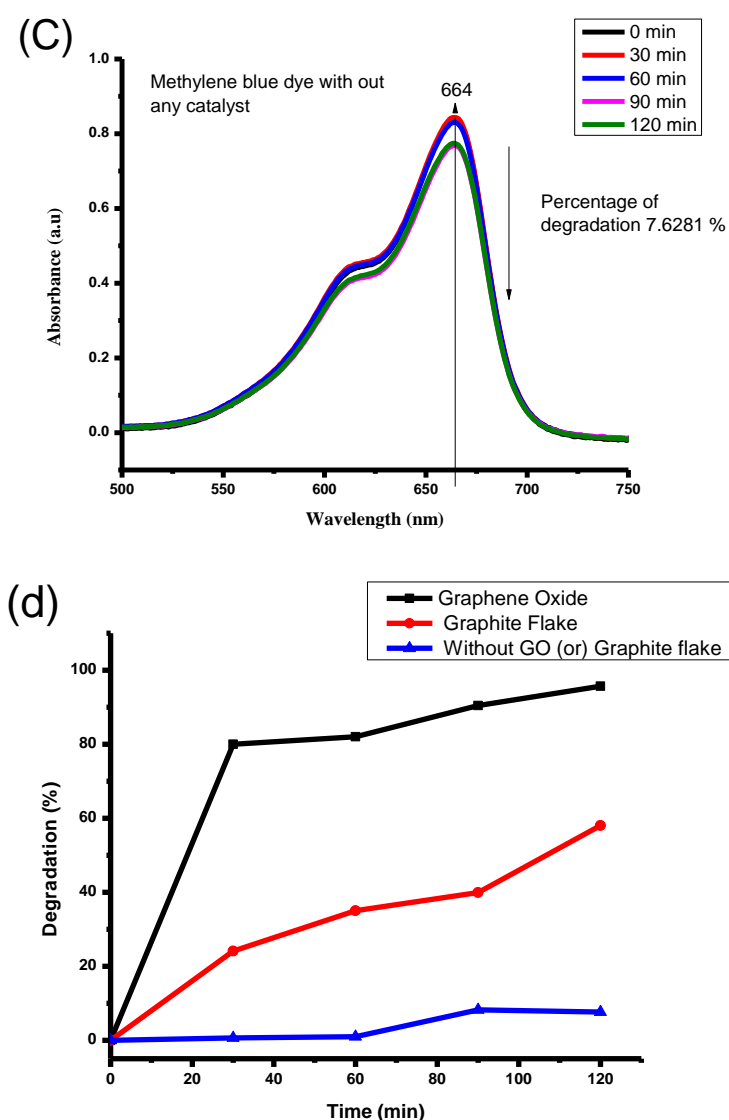


Fig. 10: (a) Degradation of methylene blue under visible light irradiation (b) % of dye degradation as a function of time 't' (c) % of MB dye degradation without catalyst and (d) % of MB dye degradation

CONCLUSION

The synthesis of Graphene Oxide (GO) prepared by modified hummer's method and confirmed by XRD for the graphite flake disappearance of the peak at 26° and appearance of the peak at 10° , shows that the product is completely oxidized after the chemical oxidation to formation of Graphene Oxide (GO) and presence of C-O ($n-\pi$ transition), C=C ($\pi-\pi$ transition) bonds analysis by UV-Visible spectroscopy and FE-SEM image revealed sponge porous with huge surface area and photo catalytic activity revealed the degradation of methylene blue dye with Graphene Oxide as a catalyst i.e. catalytic activity depend on the surface area and photo light.

REFERENCES

- [1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Bubonos, V. Grigorieva, A.A. Firsov (2004), Electric Field Effect in Atomically Thin carbon film, J. Science 306 (2), 666-669.

- [2] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, M. I. Katsnelson, I. V. Grigorieva, S. V. Dubonos, A. A. Firsov (2005), recent advances in graphene-based nanomaterials]. *Nature*. 438 (2), 197-206.
- [3] K. S. Novoselov, D. Jiang, F. Schedin, T. J. Booth, V. V. Khotkevich, S.V. Morozov, A. K. Geim. (2005), An overview of the graphene nanostructures and nanocomposites *Proc. Natl. Acad. Sci. The USA*. 102 (1), 10451- 10462.
- [4] M. I. Katsnelson, K. S. Novoselov, A. K. Geim (2006), Chiral Tunneling And The Klein Paradox In Graphene, *Nat. Phys.* 34(2), 620-628.
- [5] K. S. Novoselov, E. McCann, S. V. Morozov, V. I. Fal'ko, M. I. Katsnelson, U. Zeitler, D. Jiang, F. Schedin, A. K. Geim (2006), The low energy electronic band structure of graphene. *Nat. Phys.*, 10(2), 177-186.
- [6] A. K. Geim (2011), Chemistry with Graphene and Graphene Oxide, *Angew. Chem.* 123 (50), 6966-7100
- [7] K. S. Novoselov (2011), Graphene: materials in the Flatland *Angew. Chem*, 123(2), 7123-7133.
- [8] A. H. C. Neto, N. M. R. Peres, K. S. Novoselov, A. K. Geim (2009), Graphene *Rev. Mod. Phys.*, 81(2), 101-114.
- [9] C. N. Lau, W. Bao, J. Velasco (2012) Electronic properties of grapheme: a perspective from scanning tunnelling microscopy, *Mater. Today*. 15(2), 238-246.
- [10] M. J. Allen, V. C. Tung, R. B. Kaner (2010), Honeycomb carbon: A review of grapheme, *Chem. Rev.*, 110 (2), 132-143.
- [11] H. Chen, X. Guo (2013), A new parameter based on grapheme oxide, *Small*, 9(2), 1144-1152.
- [12] Y. Huang, J. Liang, Y. Chen (2012), an Overview of the Applications of Graphene-Based Materials in Supercapacitors, *Small*, 8 (9), 1805-1812.
- [13] D. Chen, H. Feng, J. Li (2012) Graphene oxide preparation and functionalization, *Chem. Rev.* 112(10), 6023-6034.
- [14] G. Xie, K. Zhang, B. Guo, Q. Liu, L. Fang, J. R. Gong (2013), Graphene-based materials for hydrogen generation from light-driven water splitting, *Adv. Mater.* 25(15), 3820-3828.
- [15] K. L. G. Zhao, X. Wang (2012), A brief review of graphene-based material synthesis and its application in environmental pollution, *Chin. Sci. Bull.* 2012, 57 (21), 1223-1234.
- [16] B. Luo, S. Liu, L. Zhi (2012), Chemical Approaches toward Graphene-Based Nanomaterials *Small*. 8 (12), 630-640.
- [17] C. Chung, Y. K. Kim, D. Shin, S. R. Ryoo, B. H. Hong, D. H. Min (2013), Biomedical application of grapheme and grapheme oxide, *Acc. Chem. Res.*, 46(13), 2211-2223.
- [18] J. I. Paredes, S. Villar-Rodil, A. Martinez-Alonso, J. M. D. Tascn (2008), Thermal reduction of grapheme oxide, *Langmuir*. 24(12), 10560-10571.
- [19] K. I. Bolotin, K. J. Sikes, Z. Jiang, M. Klima, G. Fudenberg, J. Hone, P. Kim, and H. L. Stormer (2008), Ultra high electron mobility in suspended grapheme, *Solid State Commun.*, 146, 351–355.
- [20] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva and A. A. Firsov (2004) electric field effect in automatically thin carbon film, *Science.*, 306 (10), 666-669.
- [21] Y. Zhu, S. Murali, W. Cai, X. Li, J. W. Suk, J. R. Potts, and R. S. Ruoff (2010), Synthesis, properties and application of grapheme oxide, *Adv. Mater.* 22 (8), 3906–3924.
- [22] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva , A. A. Firsov (2004), Biosensors based on nanomaterials, *Science*, 306(7), 666–669.

- [23] K. S. Novoselov, Z. Jiang, Y. Zhang, S. V. Morozov, H. L. Stormer, U. Zeitler, J. C. Maan, G. S. Boebinger, P. Kim, A. K. Geim, *Science*. 2007, 315, 1379.
- [24] J. H. Seol, I. Jo, A. L. Moore, L. Lindsay, Z. H. Aitken, M. T. Pettes, X. Li, Z. Yao, R. Huang, D. Broido, N. Mingo, R. S. Ruoff, and L. Shi (2010), Room temperature and quantum effect grapheme, *Science*, 328 (8), 213–216.
- [25] W. Cai, A. L. Moore, Y. Zhu, X. Li, S. Chen, L. Shi and. S. Ruoff (2010), thermal properties of bended grapheme nanoribbins, *Nano Lett.*, 10(9), 1645–1651.
- [26] Lee, Changgu (2008), Measurement of elastic properties and intrinsic strength of momolayer graphene *Science*, 321(5), 385– 388.
- [27] X. Qi, K.Y. Pu, H. Li, X. Zhou, S. Wu, Q.L. Fan, B. Liu, F. Boey, W. Huang (2010), Single layer Graphene oxide: a noval substrate for dip pin nanolithography, *Angew. Chem. Int. Ed Engl.*, 49(3), 9426–9429.
- [28] Nair, R. R. Blake, P. Grigorenko, A. N.; Novoselov, K. S. Booth, T. J. Stauber, T. Peres, N. M. R. Geim, A. K (2008), Fine structure constant defines visual transparency of grapheme, *Science*, 320 (8), 1308–1308.
- [29] Feng-Qiang Xiong, Xuming Wei, Xiaojia Zheng, Dong Zhong, Wen-Hua Zhang, and Can Li. J. (2014), Fabrication of multilayered TiO₂ nanotubes arrays, *Mater. Chem. A*, 2(3), 4510-4513.
- [30] S. Eliger (2014), Chemistry with grapheme and grapheme oxide, *Angew. Chem. Int. Ed.* 53 (10), 7720-7738.
- [31] Y. Xie, C. He, L. Liu, L. Mao, K. Wang, Q. Huang, M. Liu, Q. Wan, F. Deng, H. Huang, X. Zhang, Y. Wei, (2015), Fabrication of silica nanoparticles based polymer nanocomposite, *RSC Adv*, 5(3), 82503–82512.
- [32] Mattei, Tobias A. MD; Rehman, Azeem A. B.S. (2014), Graphene has potential to reshape of neurosurgery, *Neurosurgery*, 74(6), 499-516.
- [33] Santosh K. Tiwari, V. Kumar, A. Huczko, R. Oraon, A. De, G.C. Nayak, (2016) Magical allotropes of carbon: prospects and application,. *Materials Sciences*, 41 (4), 257-317.
- [34] B Paulchamy, G Arthi, and BD Lignesh (2015), A stepwise approach to synthesis of grapheme oxide, *J Nanomed Nanotechnol*, 6(1), 12-18
- [35] V. Berry, *Carbon N. Y.* (2013), Impermeability of graphene oxide and its application, *Material science*, 62 (2), 1–10.
- [36] Y. Wang, H. Chang, H. Wu, H. Liu (2013), Bioinspired prospects of graphene oxide, *J. Mater. Chem. B Mater. Biol. Med*, 1 (5), 3521- 3534.
- [37] X. Shi, H. Chang, S. Chen, C. Lai, A. Khademhosseini, H. Wu, (2011), two dimensional graphene Derivatives, *Adv. Funct. Mater*, 22 (6), 751–759.
- [38] H. Chang, H. Wu, (2013), Graphene Based Nanocomposites, *Energy Environ. Sci*, 6 (3), 3483.
- [39] C. Xu, B. Xu, Y. Gu, Z. Xiong, J. Sun, X.S. Zhao (2013), Graphene based electrode for electrochemical storage, *Energy Environ. Sci.* 6 (5), 1388-1392.
- [40] G. Eda, M. Chhowalla (2009), Graphene based composites thin films for electronics, *Nano Lett*, 9 (2), 814–818.
- [41] K.C. Kemp, H. Seema, M. Saleh, N.H. Le, K. Mahesh, V. Chandra, K.S. Kim (2013), Environmental application of graphene, *Nanoscale*, 5(2), 3149–3171.
- [42] Q. Xiang, J. Yu, M. Jaroniec (2012), Graphene based semiconductor for photocatalysis, *Chem. Soc. Rev*, 41(4), 782–796.
- [43] C. Zhang, N. Mahmood, H. Yin, Y. Hou (2014), *Handbook of Carbon Nano Materials*, 51–82.

- [44] N. V. Kozhemyakina, S. Eigler, R. E. Dinnebier, A. Inayat, W. Schwieger, A. Hirsch (2013), Fullerenes Nanotubes Carbon Nanostruct., 21(6), 804-807.
- [45] H. Lipson, A. R. Stokes (1942), A new structure of carbon, Nature, 149(10), 328-333.
- [46] Z.S. Wu, G. Zhou, L.-C. Yin, W. Ren, F. Li, H.-M. Cheng, Graphene metal oxide nanocomposite electrode materials, Nano Energy. 2012, 1(2), 107-131.
- [47] D.R. Paul, L.M. Robeson (2008), Polymer nanotechnology: Nanocomposites, Polymer, 49 (3), 3187-3204.
- [48] J. Molina (2016), Graphene based fabrics and their application, RSC Adv, 6 (3), 68261-68291.
- [49] C. Sanchez, B. Julián, P. Belleville, M. Popall (2005), Application of hybrid organic and inorganic nanocomposites, J. Mater. Chem, 15 (3), 3559-3567.
- [50] Y. Xie, C. He, L. Liu, L. Mao, K. Wang, Q. Huang, M. Liu, Q. Wan, F. Deng, H. Huang, X. Zhang, Y. Wei (2015), recent progress and development of polymeric nanocomposites, RSC Adv. 5 (5), 82503-82512.
- [51] M. Miculescu, V.K. Thakur, F. Miculescu, S.I. Voicu (2016), graphene based Polymer nanocomposite membrane, Adv. Technol. 27 (3), 844-859.
- [52] C.Y. Mingchao Wang, L. Ma (2012), the effects of vacancy defects on the fracture, Computational Materials Science 54 (5), 236-239.
- [53] B. J. Jin, Z. B. Jiao and Y. P. Bi (2015), controllable electrostatic self-assembly of graphene J. Mater. Chem. A, 3 (2), 19702-19709.
- [54] Y. Ma, Y. L. Jia, Z. B. Jiao, M. Yang, Y. X. Qi and Y. P. Bi (2015), enhanced photochemical performance of porous grapheme, Chem. Commun., 51 (3), 6655- 6663.
- [55] X. X. Yao, W. W. Wang, W. Chen and X. H. Liu (2016), nanomaterials for the removal of heavy metals, Nanoscience, 5(3), 211-218.
- [56] Z. Dai, F. Qin, H. P. Zhao, F. Tian, Y. L. Liu and R. Chen (2015), morphological evolution and visible light induced degradation, Nanoscale, 7 (2), 11991- 11998
- [57] Y. Hao, Xi. Dong, Xi. Wang, S. Zhai, H. Ma, and Xi. Zhang (2016), efficient photocatalytic dyedegradation with graphene nanosheet, J. Mater. Chem. A, 4(2), 8298-8309
- [58] Paulchamy et al (2015), synthesis, technology and application of carbon nanomaterials, J Nanomed Nanotechnol 2015, 6 (1), 1-10

COMSOL MULTIPHYSICS MODELING OF DIELECTRIC
MODULATED IMPACT IONIZATION FIELD EFFECT
TRANSISTOR BIOSENSORS FOR RESPIRATORY DISEASES

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ABSTRACT

In chemo-sensors, studying and estimating the covid-SARs issues using bio sensor with biomarker based analysis in a non-invasive manner is research trend. Decrement of oxygen vacancies and potential barrier lowering, depletion layer variations beneath the gate due to applied gate voltages, and deformation effects of gate surface due to varied load leads to a path to estimate performance characteristics of the sensor device. In the present work a bio sensor is designed using semiconductor metal oxide gate field effect transistor (MOSFET). Based on the semiconductor device physics, device modelling studies, the adverse effects caused by adding dopant are estimated. Metal oxide (MOX) sensor surface of the gate is coated with bio molecules of nano particles (NP) as sensing layer at the nano level gives best gas sensing nature. Exhale breathes analysis which is in huge demand in the field of medical health technology. The semiconductor device modelling is performed to study the loading and mechanical bending effects of the device. Effects of surface loads on the MOSFET gate produces deformation of gate and variation of device performance reaction towards sensitivity is estimated by using COMSOL Multiphysics 5.5.

KEYWORDS: Chemo sensors, MOSFET modelling, solid state device physics, bio-species, impact ionization effect.

INTRODUCTION

Covid-SARs related studies with bio marker analysis in non-invasive manner are great demand. The biosensor is the most promising and maintains as the best alternative device to CMOS-based sensors due to its high sensitivity, predominance on the effect due to dielectric-modulation, and functioning at even very small channel lengths. Studying the mechanical optical, electrical, microbial characteristics of the sensor using device simulations and device physics leads to the development of best biosensors. In chemo-sensors humidity causes adverse effects in the mechanical and electrical properties of the composite at the nano level. This main problem can be reduced slightly or nullified due to the thermal processes such as sinter and annealing. Previous studies researchers followed many device modelling tools to design bio sensors few are Synopsis TCAD, VISUALTCAD. W.Guan ^[1] previously indicated that extended gate metal oxide

semiconductor field effect transistor sensors might be used to determine uric acid in blood and urine. N. Kannan et.al [2] developed conventional I-MOS and compared the performance with respect to DIMOS device. G.Wenga [2] designed the CMOS compatible label free biosensor with a top-gate polysilicon nano wire field effect transistor. In this current work to mitigate the adverse effects of sub threshold swings, and impact ionization effects on the conventional Planar bulk MOSFETs, a separate structure with reduced gate lengths, high K-dielectric materials can be replaced. A nano gap is created in the Dielectric modulated Impact ionisation transistor (DMII) biosensor, which uses a mix of gold and chromium materials as gate materials [8]. Immersed bio molecules/ species added as load on the surface of the gate of DMII MOSFET. From the findings, semiconductor device sensor performance is estimated by using COMSOL 5.5 Multiphysics. Effects of dielectric material and doping concentration variations on the surface studies are observed for the dielectric modulated impact ionization (DM II) MOS sensor. The dielectric-modulated FET (DMII-FET) based biosensors are highly sensitive to both dielectric modulations and change in biomolecule charges, with both the effects altering the device characteristics in reverse directions are resulting in lower sensitivity [3].

EXPERIMENTATION

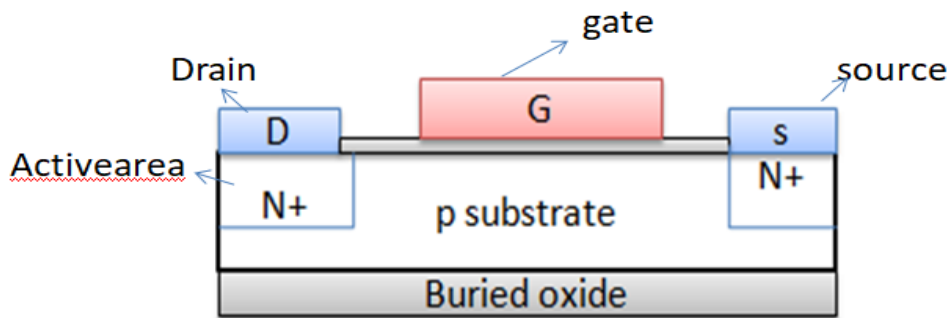


Fig. 1. Conventional p-channel –MOSFET

A conventional Impact Ionized (II MOS) device is a gated p-i-n diode, with the V_g controlling the channel inversion charges and causing the drain-source voltage to appear throughout the intrinsic area beyond the gate region [11-12]. The electrical field in the intrinsic area generates impact ionisation, which causes the impact ionised transistor to flip on abruptly when a critical value is achieved [5, 10].

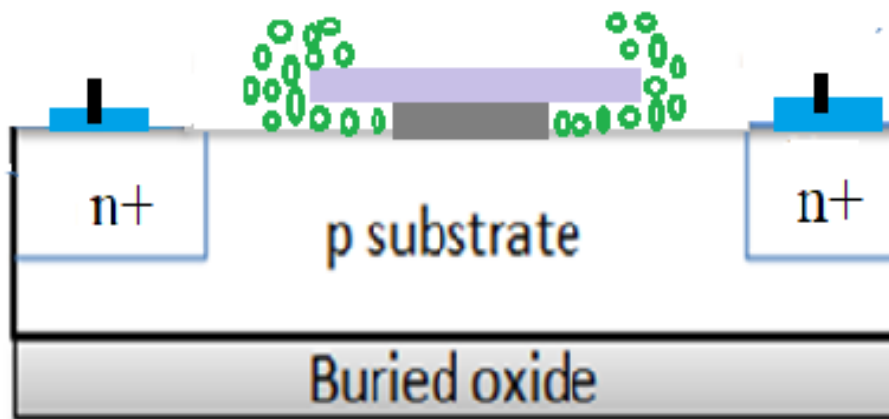


Fig. 2: (a) Design of DMII p-channel –MOSFET Bio sensor

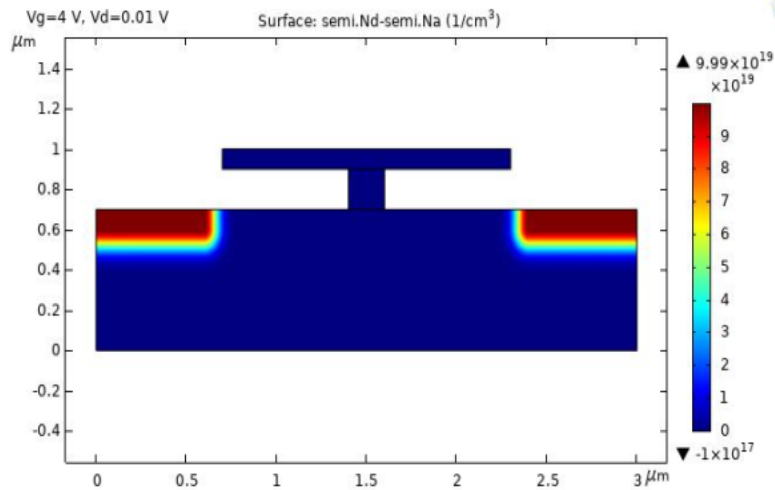


Fig. 2: (b) COMSOL Simulated p-channels –MOSFET

PHYSICAL DEVICE STRUCTURE OF DMII MOSFET BIO SENSOR

Figures 2(a) and 2(b) illustrate the architectures of conventional p-channel –MOS [11-13] and COMSOL simulated DMII MOSFET structures, respectively, with gate voltage (V_g) of 4V and drain voltage (V_d) of 0.01V. The acceptor and donor doping profiles in the source and drain areas are modelled as a Gaussian distributions, with acceptor doping (N_A) of 1×10^{17} atoms/cm³ and donor doping (N_D) of 1×10^{20} cm³.

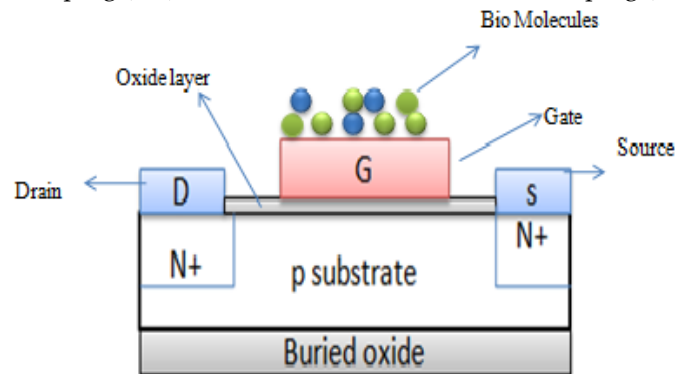


Fig.3: DMII MOSFET as Bio sensor with bio species as loading elements

The physical dimensions and few parameters fixed to perform the device simulation are: film thickness silicon substrate (T_{Si}) is 100nm, gate oxide thickness (T_{ox}) is 5 nm, buried oxide thickness (T_{boxide}) of 300nm, silicon film doping quantity of 2×10^{15} cm⁻³, channel length (L) is maintained at 200nm, and a nanogap thickness (T_{GAP}) is 15 nm, chromium (Cr) work function of 4.5eV and the chromium gate length (L_{Cr}) of 25 nm, work function of gold (Au) is 5.1eV and gold gate length (L_G) of 125 nm is Constructed. For the conventional I-MOS, the gate length (L_G) of 125 nm and work function of the gate (Φ_M) of 4.6eV is maintained. The length of the intrinsic area (L_{Int}) outside of gate region is 75 nm for both devices. The nano gap in the gate construction has been proven [9]. After etching the edges of the chromium gate structure to create the nano gap, dielectric constant (K) of air is 1 that fills the nano gap [4]. Immobilization of biomolecules ($K > 1$) improves bio sensing in a Dielectric-Modulated Impact-Ionization (DMII MOSFET) transistor. When the effective dielectric constant rises, the gate capacitance rises and, as a result, the threshold voltage falls. Thus, the detection of a sub-threshold voltage change in (V_{TH}) results in the loading impact of bio molecules on the gate element's surface. [9]- [5]

MODELLING

The modelling of the DMII MOSFET biosensor is meant to study the device's sensitivity to detect the immobilisation influence of the bio molecules' nano gap. Because bio molecules have a different dielectric constant than air/free space, the immobilisation incident is imitated in the simulation by modifying the dielectric constant of the nano gap. A value of $K = 2$ and 12 are used to indicate a category of bio molecules with the low and a high dielectric constants. To model the impact ionization Selberherr's Model with Band-to-Band tunnelling effects are considered. In the COMSOL Multiphysics stationary and semiconductor physics is taken in to consideration with relative permittivity of 11.7 approximately (12), carrier lifetime is $10\mu\text{s}$ and energy band gap of 1.12eV . Taking the thin insulator gate with analytical doping model, and trap assisted recombination effect, Shockley-Read Hall modelling is preferred. Doping concentrations for source and drain are given with aurora mobility models of uniform doping, and electron affinity is of 4.05V is taken in to consideration. Input gate voltages are given in the range of 0V - 5V with free triangular shaped meshing at the edges given to simulate the nodal analysis.

RESULTS AND DISCUSSION

Because of the vertical nano gap below the gate, dielectric modulation, and the presence of bio species, FET-based biosensors can detect the presence of charge-free bio molecules [3-5,7-8].

According to the findings, the DMII MOSFET's sensitivity for bio molecule detection is strongly dependent on the nano gap length, with a significant loss in sensitivity for short impact ionisation channel lengths. Previous studies have found a sub-threshold slope of $2\text{-}10\text{ mV/dec}$ [8-9,13].

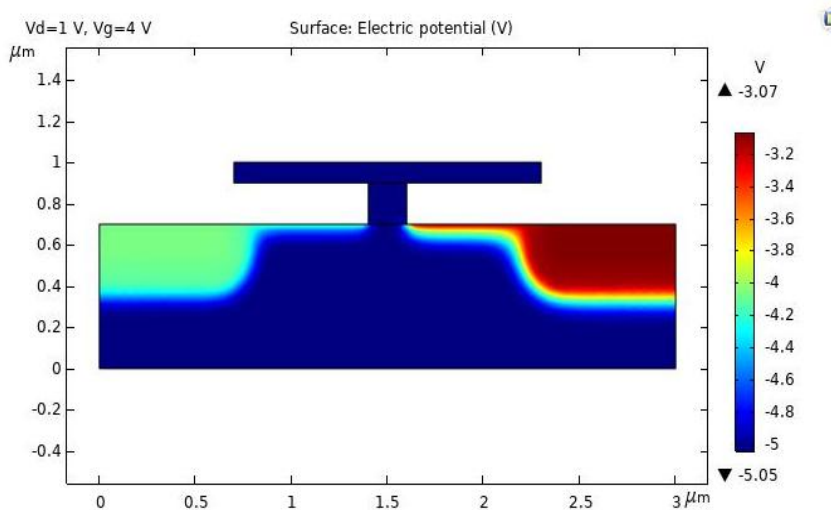


Fig. 4: COMSOL Simulated p-channel –MOSFET

According to the COMSOL Multiphysics simulations, the DMII MOSFET generates very sensitive bio-sensing nature with prospective uses in the biomedical area for detecting diverse bio-molecules/ species instead of standard poly silicon.

The DMII MOS biosensor's I_D vs. V_G properties, as the simulated device is a p-Channel MOSFET with A negative sweep is applied to the gate with $V_S = 5\text{V}$ and $V_D = 0\text{V}$. The DMII MOS operates at 1.06V in the absence of bio molecular immobilisation ($K=1$), whereas the standard I-MOS runs at 1.36V . The greater dielectric thickness in the nanogap area of DMII MOS (with $K = 1$) accounts for the higher turn on voltage of the DMII MOS compared to the traditional MOS.

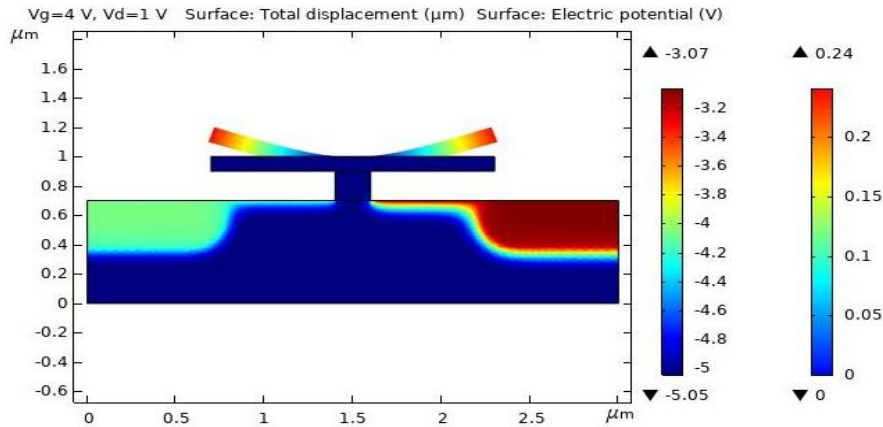


Fig. 5: COMSOL Simulated p-channel MOSFET with Bio molecules as load

As a result, the gate control of the channel is reduced and the turn on voltage is enhanced. The inclusion of high dielectric constant bio molecules ($K = 12$) lowers the V_T of DMII MOS to 2.29V (an 86 percent V_T shift), resulting in a very sensitive biosensor even at shorter channel lengths.

Another measure to consider for device sensitivity is the On-state current I_{ON} , which rises 14-15 times when bio molecules are present vs an empty nano gap. Examining the transverse electric field profile along the channel of the DMII MOS, as shown in Fig. 4, may help to explain the significant shift in V_T generated by nano gap vaccination. The DMII MOS is activated by impact ionisation caused by a strong horizontal electric field in the intrinsic region^[10]. The empty nano gap generates a low inversion in the channel area underneath the nano gap, allowing VSD to emerge across a greater length of the silicon film. As a result, impact ionisation takes place at a much higher gate voltage.

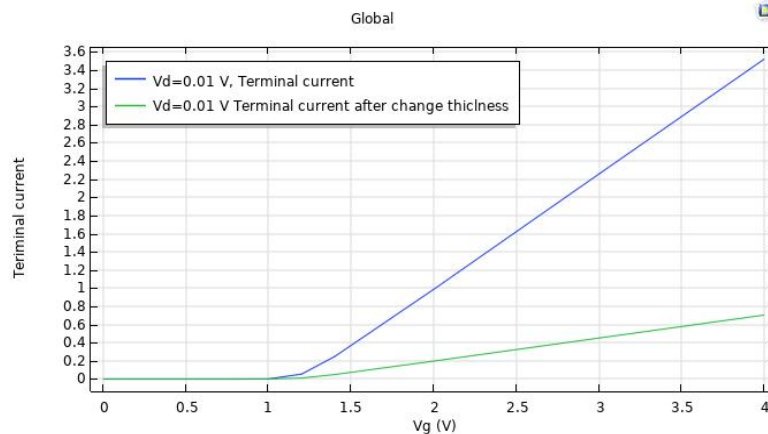


Fig. 6: COMSOL Simulated p-channel -DMII-MOSFET with reduced (V_{Th})

CONCLUSION

Enough inversion happens in the channel area underneath the nano gaps as a result of bio molecular vaccination and subsequent dielectric-modulation of the nanogap. As a result, VSD can now be seen over a shorter length of silicon film. This will cause the DMII MOS's electric field profile to resemble that of a conventional MOS, resulting in a decrease in $V_{(Th)}$, as illustrated in figure.6. The effects of surface loads on the MOSFET gate produces deformation of gate and variation of device performance reaction towards sensitivity is estimated through the loading and mechanical bending effects of the device.

REFERENCES

- [1] W. Guan., X. Duan, and M. A. Reed. (2014). "Highly specific and sensitive nonenzymatic determination of uric acid in serum and urine by extended gate field effect transistor sensors", *Biosensors and Bioelectronics*, Vol.51, pp.225–231.
- [2] G. Wenga., E. Jacques., A-C. Salaun, R. Rogel., L. Pichon., and F. Geneste. (2013). "Step-gate polysilicon nanowires field effect transistor compatible with CMOS technology for label-free DNA biosensor", *Biosensors and Bioelectronics*, Vol.40, pp.141-146.
- [3] C.H. Kim., C. Jung., K.B. Lee., H.G. Park., and Y.K. Choi. (2011). "Label-free DNA detection with a nanogapembedded complementary metal oxide semiconductor", *Nanotechnology*, vol. 22, no. 13, p. 135502.
- [4] J. M. Choi., J.W. Han., S.J. Choi., and Y.K. Choi. (2010). "Analytical modelling of a nanogap-embedded FET for application as a biosensor." *IEEE Trans. on Electron Devices*, vol. 57, no. 12, pp. 3477-3484.
- [5] B. Gu., T.J. Park., J.H. Ahn., X.J. Huang., S.Y. Lee., and Y.K. Choi. (2009). "Nanogap Field-Effect Transistor Biosensors for Electrical Detection of Avian Influenza." *Small*, vol. 5, no. 21, pp. 2407-2412.
- [6] C. Onal., R.Woo. H.-Y. S. Koh., P. B. Griffin., and J. D. Plummer. (2009). "A novel depletion-IMOS (DIMOS) device with improved reliability and reduced operating voltage," *IEEE Electron Device Lett.*, vol. 30, no. 1, pp. 64–67.
- [7] C.H. Kim., C. Jung., H.G. Park., and Y.K. Choi. (2008). "Novel dielectric modulated field-effect transistor for label-free DNA detection." *Biochip Journal*, vol. 2, no. 2, pp. 127-134.
- [8] H. Im., X.J. Huang., B. Gu., and Y.K. Choi. (2007). "A dielectric-modulated field effect transistor for bio sensing." *Nature Nanotechnology*, vol. 2, no. 7, pp. 430-434.
- [9] F. Mayer., C. Le Royer., G. Le Carval., C. Tabone., L. Clavelier., and S. Deleonibus. (2006). "Co-integration of 2 mV/decsubthreshold slope impact ionization MOS (I-MOS) with CMOS." *Proceedings of the 36th European Solid-State Device Research Conference, ESSDERC 2006*, pp. 303-306.
- [10] F. Mayer., C. Le Royer., G. Le Carval., L. Clavelier., and S. Deleonibus. (2006). "Static and dynamic TCAD analysis of IMOS performance: From the single device to the circuit." *IEEE Trans. on Electron Devices*, vol. 53, no. 8, pp. 1852-1857.
- [11] Mohammad Hayath Rajvee, S.V. Jagadeesh Chandra, P. Rajesh Kumar, CH.V.V. Ramana, Kalahasthi Neelama, R. S. Dubey, (2021) "Synthesis and Analysis of Zirconium Titanate Thin Films by using Sol-Gel Method", *Biointerface Research in Applied Chemistry* Vol. 11, pp. 12761 – 12768.
- [12] W. Y. Choi., J. Y. Song., J. D. Lee., Y. J. Park., and B.-G. Park. (2005). "100-nm n-/p-channel I-MOS using a novel self-aligned structure," *IEEE Electron Device Lett.*, vol. 26, no. 4, pp. 261–263.
- [13] K. Gopalakrishnan., P.B. Griffin., and J.D. Plummer. (2005). "Impact ionization MOS (I-MOS)-Part I: device and circuit simulations," *IEEE Trans. Electron Devices* , vol. 52, no. 1, pp. 69-76.
- [14] K. Gopalakrishnan., R. Woo., C. Jungemann., P.B. Griffin., and J.D. Plummer. (2005). "Impact ionization MOS (I-MOS)-Part II: experimental results," *IEEE Trans. Electron Devices*, vol. 52, no. 1, pp. 77-84.
- [15] D. Sarkar, N. Singh and K. Banerjee, "A Novel Enhanced Electric-Field Impact-Ionization MOS Transistor", *IEEE Electron Device Lett.*, Vol.31, No.11 pp.1175-1177, 20

ABSTRACT

Nanotechnology deals with manipulating materials at nano scale (10^{-9} m). Nanotechnology came into existence in the year 1959 and gained the popularity in 1980s. Nanotechnology has opened new areas of application in medicine, food and dietary industry, water treatment, basic sciences like chemistry and botany, environment, genetics, civil engineering, education, defence, rural and agricultural science, architecture bioengineering, etc. Nanotechnology enjoys the central position amongst the latest technological advancement. The number of publications on different applications of nanotechnology is increasing day by day. For example increasing fertilizer efficiency, soil quality, nano-biosensors, nano-electronics, nano-weapons of mass destruction, nano-architecture. This review article gives broad outline of present and prospective applications of the nanotechnology with respect to basic science (molecular chemistry, atomic physics, genetics, microbiology, botany, education, environmental science, defence etc.), information sciences (molecular coding, molecular modelling, simulation) and engineering sciences (mechanical, chemical, electrical, biomedical, civil, architecture, biotechnology). This article will give and insight into the varied applications of nanotechnology and will open new frontiers for the liking to subject.

KEYWORDS: Nanotechnology, Basic Sciences, Engineering Technology, Biotechnology

INTRODUCTION

The literal meaning of the word nano in Latin is ‘Dwarf’. The term nanotechnology was first conceptualized by Noble Laureate Richard P. Fennan, a physicist from South California way back in 1952. Eric Drexler popularized the term ‘nanotechnology’. Nanotechnology deals with the study of the particles which are of the scale of billionth part of a meter. Since the invent of nanotechnology, it has found wide applications in various areas like nanoscale material, molecular and cellular biology, biotechnology, nanomachines, controlled delivery system, pollution detection. This review is about the development of nanotechnologies related to different walks of life. First, a brief discussion is made about the applications of nanotechnology in basic science and engineering. Then a detailed study of the Applications of nanotechnology to the particular area is presented. The literature review has shown a few application of nanotechnology to medicine⁽¹⁻⁶⁾, food industry and dietary science⁽⁷⁻⁹⁾, water treatment⁽¹⁰⁻¹¹⁾, chemistry⁽¹²⁻¹⁴⁾, environment⁽¹⁵⁻¹⁶⁾, biotechnology⁽¹⁷⁻¹⁹⁾, civil engineering⁽²⁰⁻²⁵⁾, education⁽²⁶⁻²⁸⁾, defence⁽²⁹⁾, rural and agricultural science⁽³⁰⁻³⁴⁾, architecture⁽³⁵⁻³⁶⁾, bioengineering⁽³⁷⁻³⁹⁾, electronics and telecommunication⁽⁴⁰⁻⁴¹⁾.



Fig. 1: various applications of nanotechnology in science and technology

APPLICATION IN MEDICINE

Cancer treatment ⁽¹⁾: In their review, authors have discussed several recent techniques on the progress of effective and specific cellular/molecular techniques related to the diagnosis and treatment of gastrointestinal cancer. The review discussed the mechanism of Janus nanoparticle at first place followed by presentation of recent discovery and challenges in the field of cancer treatment. The authors conclude that Janus nanoparticles open the probability of improved methods of earlier diagnosis of cancer. Added to this nanoparticle characteristics allow for the specific treatment of neoplasm's and cancer cells, thus lowering the potential side effects.

Orthopaedics ⁽²⁾: This article proposes the nanotechnological applications of orthopaedics as in drug delivery. It includes nanotherapeutics for the treatment of arthritis and bone cancer. Nanotechnologies are widely used in orthopaedics and suppose to play a valuable role in forthcoming developments. The work recognizes the carbon nanotubes of nanofibers as coating for implant and joint replacement. Nanoparticles can become free through depletion of embedded materials by oxidation combined with hydrolysis that accelerate exposure and may lead to toxicity as well.

Erectile dysfunction ⁽³⁾: The authors and co-worker provide the scientific evidence for the nanotechnology based delivery method for treatment of erectile dysfunction(ED). They studied four method of ED treatment in form of topical drug, injectable gels, hydro gels and encapsulation of drugs. They conclude that the study provided the evidence for role of nanotechnology for ED therapies and these therapies might be advantageous over the existing one for treating male ED.

Combating MDR bacteria ⁽⁴⁾: In their review, researchers discussed and summarized the recent advances of probable nanomaterials to elude the Multi Drug Resistance (MDR) bacteria, such as *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Mycobacterium tuberculosis*, methicillin-resistant *Staphylococcus aureus*, vancomycin resistant enterococci, *Klebsiella pneumonia* and others. They also summarized the combined strategies like radiation and nanoparticle drug effectiveness against MDR bacteria. The authors conclude that nanoparticle demonstrated activity against MDR and showed potential for synergistic combination of radiation with nanoparticles.

Breast cancer therapy ⁽⁵⁾: The workers reviewed nanotechnology related tools for drug delivery and existing scheme for addressing the chronological bio-barriers. The article refers to the conventional method like hormone therapy, immunotherapy, systemic chemotherapy, side effect. They discussed the application of nanoparticles in anti-cancer therapy, obstacle of anti-cancer therapy. They conclude that there are number of nanoparticles which differ pertaining to several properties like size, charge, profile, surface, therapeutic effect and drug payload. The authors felt need to identify physio-chemical properties which would lead to injectable nanovectors to overcome barriers in nanotherapy.

Nervous system therapy⁽⁶⁾: In this article, authors discussed the role of nanotechnology in neurology with respect to neuro diagnosis, nanowires for brain activity monitoring, neuro protection, advancement in nervous system drug delivery system, nanofibers brain inserts, nano scaffold for neural tissue repair, and nanoparticles as an assistance to neurosurgery. Authors draw the conclusion that nanotechnology will improve the drug delivery for CNS disorder.

APPLICATION IN FOOD INDUSTRY AND DIETARY SCIENCE

Food industry ⁽⁷⁾: Researches reviewed the application as well as usefulness of nanotechnology with realms of food industry. These include nanosensors, bioactive nanoencapsulation, packages, and edible thin film. The conclusion from the review is that nanotechnology increases the security and quality of food with considerable reduction in time for pathogen detection. The micro fluid and inorganic nanoparticle lead to manufacturing of efficient sensor for pathogen and pesticide detection. Functionalised food with nanoparticles enhances food quality and safety. Authors raised concern over toxicity, accumulation and biotransformation of nanomaterials in plants.

Dietary science ⁽⁸⁾: In their work, authors felt the need for research in the field of absorption and excretion of nanoparticles. They found out interim and long-term effects of nanoparticles. Their work discusses the nutrient delivery, microstructure of food, toxicity, nanopathology and targeted nutrient delivery system. In their conclusion they found out the probable zones of application of nanotechnology for improving bioavailability of nutritional factors: (a) improvement and modification of composition of food (b) new development in targeted drug delivery system (c) biomarker identification and characterization (d) biomolecules site identification.

Food science ⁽⁹⁾: Author and Co-worker reviewed potential applications of nanoparticles in the food industry so as to deliver consumers food that is innocuous and free from contaminants. This also ensure the consumer food acceptability with enhanced functional properties. Aspects of nanotechnology application concerning increased food nutrition and organoleptic characteristics of foods have also been addressed concisely in conjunction fewer understandings on issues like safety and regulations concerns on nanoprocessed food products. They found promising results in food preservation via nanomaterial as they prove to be useful to protect the food from odours, off-flavours, gases, lipids and moisture. Nanomaterials offer exceptional delivery systems to transport bioactive combinations to the targeted tissues. They advise obligatory testing of nano-foods before their release to the market place.

WATER TREATMENT

Water purification⁽¹⁰⁾: Writer of this article reported nanosorbents as separation media in water purification in order to various aspects of nanoparticles such as zero valent Iron as nanosorbents, carbon nanotubes nanoceramics as nanofilters and removal of nanoparticles after water treatment are discussed. They conclude that processes such as RO, NF are becoming the standard membrane water purification techniques as these are flexible, modular, measurable and comparatively easier with regard to operation and maintenance. Authors raise concern over the fate and toxicity of the nanomaterials as double edged sword.

Water security ⁽¹¹⁾: A new perspective regarding the water treatment is reported by researchers wherein new approaches and opportunities for nanotechnological applications to increase the efficiency as well as affordability of water treatment procedures are discussed. Barriers related to potential development and implementation barriers and need to overcome them are discussed.

APPLICATIONS IN CHEMISTRY

Photo catalysis for water purification⁽¹²⁾: An interesting study by authors with respect to photocatalysis is reported where various nanomaterials such as carbon, ceramic, metal, polymer and semiconductor are discussed as photo catalyst keeping in mind the various aspect of nanomaterials such as size, morphology, physical and chemical properties. Materials like carbon nanotubes (CNT), SWCNTs i.e. single-walled carbon nanotubes and MWCNTs viz. multi-walled carbon nanotubes, C-60 fullerenes are reported as photo catalysts. Application of photo catalysts for water splitting, hydrogen production and the factors affecting the efficiency of the photo catalyst were discussed. Conclusion was drawn that different factors affecting the catalytic activity are electron hole pair separation as well as recombination rate. Other factors include temperature, catalytic structure, pH and intensity of incident light. Ultimately they concluded that photo catalytic technique is emerging as efficient and green technique with regard to energy sector and in pollution.

Computational chemistry for carbon nanotubes and fullerenes ⁽¹³⁾: Computational approach was applied to carbon nanotubes and fullerenes by researchers and covered computational techniques for nanoscale simulation for instance classical molecular dynamics, general tight-binding molecular dynamics, ab initio simulation methods, quantum conductance in nanoscale systems as applied to carbon and boron nitride nanotubes. Other areas related discussed are molecular electronics, nanotube-based sensors and actuators endofullerenes as qubits for solid-state quantum computer design. The authors drew conclusion that certain areas such as nano manipulation and atomic and molecular level entity controls with ability of self-assembly can lead to larger functional materials structure.

Carbon nanotubes production and application⁽¹⁴⁾: Authors in their work, reported structure of the carbon nanotubes emphasizing the structures of SWCNT and MWCNT and their synthetic method viz. electric arc discharge, chemical vapour deposition method and laser ablation. The applications of CNTs like drug and gene delivery, cancer cell identification, artificial implants, tissue engineering, biomedical application, are dealt with in detail. They conclude that because of their appealing chemical and physical features, nanomaterials explain possibility and promise in regenerative medicine. Carbon nanotubes (purified/modified) have the potential to be used in a wide range of medical applications. Furthermore, the foreign material encapsulation in carbon nanotubes can open up the possibility of biomedical uses.

PROSPECTS IN ENVIRONMENTAL SCIENCE

Nanotechnology in prevention of pollution ⁽¹⁵⁾: Researchers in this article give insight by asserting nanotechnology's role in pollution prevention. Nanoparticles have the ability to absorb a significant amount of pollutants due the large surface area and high superficial energy hence they have vast application in preventing air pollution, water pollution, cleaning of oil spill with environmentally friendly materials, textile products and antimicrobial coating, and green manufacturing. In the realm of environmental technology, nanotechnology, also known as nanoparticles, will have a favourable impact on those who are involved. The main issue with this technology is that it lacks the ability to deliver information.

Nanotechnology as in global warming ⁽¹⁶⁾: Nanotechnology and its products (or nanomaterials) are mostly used in renewable energy applications (e.g., solar and hydrogen fuel cells), which produce practically zero emissions. One strategy to slow down and ultimately stop global warming will be to increase the use and efficacy of renewable energy whereas consecutively reducing the consumption of current fuels. The production of nanomaterials and devices, on the other hand, may have a negative impact on global warming. Furthermore, the economics of using nanotechnologies to address global warming must be continuously monitored, necessitating a thorough cost-benefit study. Without a doubt, strong

commitments to cut greenhouse gas emissions by large corporations and governments are also critical for our future.

APPLICATIONS IN BIOTECHNOLOGY

mRNA vaccines for COVID-19⁽¹⁷⁾: The unique Nano carrier (LNPs) i.e. lipid nanoparticles is behind the extraordinary success of two mRNA centred vaccines, which achieved 95% effectiveness in phase III clinical trials. LNPs differ from bi-layered liposomes with respect to enhanced cargo stability, possess hard shape, and aid in improved cellular penetration. This emergency use authorization (EUA) represents a watershed moment for nanotechnology, demonstrating its enormous potential for vaccine delivery and pandemic preparedness. The relevance of the nanoscale delivery systems to preserve contents from degradation, enable targeted bio distribution, and cellular delivery are highlighted by these nanocarrier-based vaccinations.

Modelling and verification for DNA nanotechnology ⁽¹⁸⁾: The workers modeled a DNA walker that navigates a series of junctions on its own, and established design principles that improve the likelihood of correct computational output. They devised a revolutionary continuous-time Markov chain parameter synthesis method that guarantees a predetermined level of performance for the synthesized models. DNA origami is a popular way to make nanoscale shapes out of DNA. From the scratch, model can create a new discrete stochastic assembly model of DNA origami. The folding mechanism of a novel polymorphic DNA origami tile, regulating the eventual shape, can be shown using the model, which qualitatively reproduces experimentally observed behaviour.

Bio applications of DNA-nanotechnology on the solid-liquid interface ⁽¹⁹⁾: The evolution of DNA nanotechnology is briefly discussed in this review. The significance of structural DNA-nanotechnology in modifying the features of flat interfaces along with changes of nanoparticle boundaries is highlighted, and their successful bio-applications are thoroughly reviewed. Furthermore, improvements in DNA-nano devices at interfaces for enhanced in-vitro and in-vivo bio-sensing are discussed. DNA nanotechnology is being proposed as a strategy for engineering cell membranes in order to disclose protein levels and cell function. Finally, the obstacles and prospects for this new field are discussed. To start, further kinetics research is needed so as to improve DNA nanostructure interfacial systems and broaden the range of bio applications. Second, especially in complex contexts like biological samples, the stability of DNA binding at interfaces is a key obstacle that must be dealt with. Third, for all types of interfacial dynamic DNA machines, reversibility is a must. Because of the diverse possibilities related to interfaces and the fast expanding DNA-nanotechnology toolbox, authors are hopeful that bio applications that use DNA nanotechnology for the solid-liquid interface in addition to understanding of reaction kinetics will grow in the future.

ROLE OF NANOSCIENCE IN CIVIL ENGINEERING

Glass technology ⁽²⁰⁾: Researchers discuss important features of these linkages, starting at the nanoscale, with the goal of emphasizing their role in both existing and future glass research and engineering. They propose that many of glass's valuable properties are due to the nanoscale, although they don't notice it at first. Researchers discussed various aspects of glass technology like chemical bonding, localized electronic state, photosensitivity, polychromaticism, photochromism, and photo nucleation, glass transition, phase separation, nucleation and crystal growth, glass ceramic processing, polymorphism. They also shed light on recent advances in glass technology like bio-glass, chemically tempered glass. As demonstrated by the material reviewed, authors conclude that the knowledge of glass science and

engineering has played a vital role in the research, production, and use of glass during the existing and previous centuries.

The main objective of the study done by A. R. Abdine ⁽²¹⁾ was to understand how different varieties of glass used in the building cover can help minimise energy use in office structures. To test its efficiency, the chosen type was coupled with various windows to wall ratios (WWRs) and alignments. A simulation tool viz. Design Builder 3.1 was used for this, and afterwards comparison was performed so as to examine the performance of various types of glass along with different orientations having glass widths. The findings suggest that when using glass which has been treated with nanotechnology (Low-E) with Solar Heat Gain Coefficient (SHGC) = 0.23, Light Transmission (LT) = 0.42, and U Value (UV) = 1.55 lowers energy intake by more than 20% as compared to normal 6mm glass.

Nanotechnology in civil engineering: The study done by authors ⁽²²⁾ examined the use of equipment to reach nanoscale material characteristics. It has been discovered that a better knowledge and engineering of complex structures formed of steel, cement or composite materials at the nanoscale would undoubtedly result in a modern construction materials that are stronger, more durable, and have other features. The study dealt with nanocement, nanocomposite, metal and mineral nanomaterials, and nanocoatings for concrete, nanosteel, bacterial capacity, nanoglass, and nano particle for fire protection, clay/polymer nanocomposite with respect to environment, cost and methods. The authors concluded that nanotechnology is a fast growing field of research in which novel properties of nanoscale materials can be used for the benefit of construction infrastructure, and to bring down the cost of construction infrastructure in the future.

Another study ⁽²³⁾ attempted to establish and investigate nanomaterials and their applications in different sectors of the real estate industry. Nanomaterial technologies are helpful for building infrastructure and effectively safeguarding the environmental sustainability. The area of study was concrete, asphalt concrete, asphalt concrete timber, brick mortar, steel, glass, and paint. Nanotechnology can aid with facades, skeletons, interior design, building systems and other things. Nanotechnology has enabled the manufacturing and accessibility of building material that are multi-functional with high efficacy and supplementary value, while also enhancing the quality, design, and longevity of building materials and ensuring energy efficiency.

An expansive overview of the nanotechnology's applicability in civil engineering was reported by the authors ⁽²⁴⁾. The authors explored the area of steel, concrete, pavement and water treatment. The conclusions are drawn from the information presented in the paper:

- Nanomaterials appear to play an essential role in civil engineering, which could lead to advancements in solving general engineering challenges.
- Various developments could potentially improve the time and life-cycle cost of civil engineering projects.
- Nanotechnology is area of research where nanoscale produced novel materials can be used for the betterment of civil engineering and development of novel construction materials.

Nanotechnology in built environment ⁽²⁵⁾: The article reports that India is one of the top five countries existing in the world for technical publications in nanoscience and technology. This study investigates advanced nanomaterials with their impact on the building sector and the built environment in India and worldwide. The article is about the use of nanomaterials and development of global and India technology with comparative study of the applicability for hotel and office rooms. Authors draw conclusion that Silica fume (70% particle having size diameters within the 100nm range) are not marketed as nanomaterials by the manufacturers for concrete as mentioned in Indian codes such as IS: 456-2000 and IS: 1026-2019. But it is in use since 30 years and is widely available in most major global concrete supplier

products. As a result, marketing and selling nano-products is still a struggle. Currently, India lacks a regulation structure for nanotechnology. The epidemic has provided India with an opportunity to join the microelectronics and nanotechnology bandwagon, helping to make 'Make in India' a success.

NANOTECHNOLOGY AND EDUCATION

Nano education⁽²⁶⁾: In this study the current state of advances and developments in nanotechnology and Nano education is covered concisely with regard to applications. With a few simple examples, instructional strategies for nanotechnology are also offered. The article addresses general framework of nanotechnology, current status of nanoeducation, nanoeducation curriculums, and teaching strategies of nanoeducation. The authors conclude nanotechnology teaching should be included in all undergraduate engineering programs. In order to educate students in nanotechnology, government, industry, and academic bodies should work together to create partnership.

Nanotechnology in undergraduate engineering curriculum⁽²⁷⁾: The goal of the study is to provide students having a wide understanding of basic sciences like atomic physics, molecular chemistry, microbiology, genetics, etc., engineering sciences which include mechanical, electrical, chemical, biochemical, computer, and so on, and information sciences including molecular coding, data analysis, imaging and visualization, bio-computation, molecular modelling and simulation of complex structures etc. as well as their application to nanotechnology. A framework for integrating nanotechnology teaching into traditional undergraduate engineering curriculum is provided. Teaching strategies for nanotechnology are also discussed. The authors suggest that nanotechnology teaching should be included in all undergraduate engineering programs. In order to educate students in nanotechnology, government, industry, and academic bodies should work together to create partnership.

Chemical nanotechnology as basic course in interdisciplinary sciences⁽²⁸⁾: A genuine commitment was made by the authors to identify and combat the various misconceptions about nanotechnology. In addition, a real attempt was made to encourage students, as informed citizens, to think about the social, political, economic, environmental, and ethical issues that come with a nanotechnology as a powerful tool. The authors observed that curriculum was quite well, and verbal advertising could result in sustained student interest. The half-semester format did not limit coverage of the topics, but a full-semester would relax the pace of the course. Full semester version of the course should include more advanced laboratory exercises, additional molecular modelling assignments, student project presentations, and a field trip to a modern research facility like scanning probe and electron microscopy.

NANOTECHNOLOGY IN DEFENCE

Role of nanotechnology in defence⁽²⁹⁾: Nanotechnology (NT) is becoming a global 'industrial force.' With its numerous applications and intrinsic capacity to manufacture new materials such as noncorroding and flexible iron, it has the potential to lower costs. According to the NanoBusiness Alliance trade group, NT was used in \$13 billion worth of products in 2004, accounting for less than 0.1 percent of global output. However, by 2014, it is estimated that this number will have risen to about \$3 trillion, in other words 15% of production output. NT provides critical defence applications such as sensor development, troop protection kits, and improvements to C4ISR which stand for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance systems, among others. Investing in the design and development of more powerful yet lightweight batteries, smart fabrics, reinforced armor, small surveillance devices, and enhancing the performance of UAVs/UCAVs, could be a good example. In this field, India should avoid focusing on overly ambitious military goals and instead begin with technologically achievable work. Defence scientists and engineers in India must collaborate with their

civilian counterparts. There's also a need to involve the military in the research, development, and planning process from the start. Finally, the military utility of NT must be considered in conjunction with a few additional technologies such as information technology and biotechnology.

APPLICATION IN RURAL AND AGRICULTURE SCIENCE

Nanotechnology as new frontier in agriculture⁽³⁰⁾: This article provides an overview of nanotechnology's existing and future applications in agriculture and food. It explains the application of nanotechnology with respect to nanoscale carriers, nanopesticides, nanoherbicides, smart dust (smart mini Lab.), disinfectants, crop improvement, nanolamination and food packaging. Nanotechnology offers tremendous potential in the agriculture sector to facilitate and build the next stage of precision farming practices. It will improve agricultural potential, allowing farmers to collect bigger harvests in a more environmentally friendly manner, especially in difficult conditions. But, at the same time, public acceptance of this unique technology must be considered. It is also vital to develop a future nanotechnology workforce that is well-trained. In order to understand the mechanism toxicity due to nanomaterials and subsequent effects on the natural environment, further research is needed. If we can overcome these obstacles, emerging countries can look forward to a bright and prosperous future.

Nanotechnology in animal health and productional improvement⁽³¹⁾: The article deals with use of nanomaterials as metallic nanoparticles, quantum dots, magnetic nanoparticles, liposomes, carbon nanotubes, fullerenes, and dendrimers for disease diagnosis, drug delivery, animal nutrition, animal breeding and reproduction, and value enhancement of animal products. It also refers to use of nanoparticles in the food industry, hygiene improvement, increase product shelf life, and avoid food-borne illnesses and chemical contamination. The authors summarize that nanomaterials provide a slew of benefits, including cost savings, reduced consumer risk, and a speedier approach, all of which will help enhance the clinical side of veterinary medicine in the future. Nanotechnology is being used in the food sector to increase the shelf life, safety, and quality control of foods. Despite all of the advantages and potential that nanotechnology provides, it is still in its early phases of development and is not widely used. There are also few concerns regarding nanoparticles' effect on human health and the environment.

Rural application potentials of nanotechnology⁽³²⁾: This review study compiled a list of some of the most encouraging and substantial nanotechnology applications in agriculture, human health, energy, environment, clean water, food, and other consumer goods. The article emphasizes the role of nanotechnology in agriculture, nanomaterials for soil fertility, smart pesticide, nanosensors, animal health and fisheries, nanotechnology for food production and processing, nutrient delivery, food safety and food packaging water treatment, energy and environment, and safety and regulation of nanomaterials. The assessment concluded with a discussion of the possible hazards of nanomaterials, as well as the technical and financial hurdles of incorporating nanotechnology into rural community development.

Nanotechnology as an instrument in animal products processing and marketing⁽³³⁾: This study covered a vast area of applications of nanotechnology for animal products, including nanomeat, nanomilk, nanoeggs, and nanomeat packaging. The packaging material makes it simple to transport animal products that retain their natural qualities and freshness. Nanotechnology allows for the manufacturing of a varied range of livestock-based foods in a relatively short amount of time. The productivity can also be boosted directly through genomic changes or disease prevention.

Nanotechnology applications on fluid flow in agriculture and water recourses⁽³⁴⁾: Unique difficulties can be tackled more creatively and with more success while working on nanoscale. Nano-clays and zeolites to improve soil quality and fertility, seed germination with nano-polymer coatings, precision farming, nano-

biosensors and a satellite monitoring system, Nanoherbicides to combat weed management, nano-fertilizers to increase nutrient productivity and efficiency, reduce soil toxicity, and minimise contamination issues. Nanotechnology has a lot of potential for sustainable agriculture, especially in developing nations.

APPLICATION IN ARCHITECTURE

Role of nanotechnology in architecture and built Environment ⁽³⁵⁾: Authors in this article have tried to correlate the two facets i.e. science and technology under the nanotechnology so as to design practical and innovative material and devices using nanomaterials. Interesting ideas like the metamorphic capsule, air quality, the floating conference center, and multi-storey apartment building with the application of innovative nanomaterials are discussed. Authors are confident that the finding of the article will prove beneficial in the field of architecture and building materials thus serving the cause of sustainability and material use.

Role of nanotechnology in human comfort in interior environment⁽³⁶⁾: Investigators here have dealt with nanomaterials which are helpful in keeping the interiors of the home clean and hygienic e.g. self-cleaning (or lotus effect), self-cleaning (or photo catalysis), easy to clean approach, air purification, anti-fogging, thermal insulation, vacuum insulation panels, thermal insulation through aero gel, temperature regulation by phase change materials (i.e. PCM), solar protection, UV protection, anti-graffiti and fire proofing, Authors summaries their finding that the nanoarchitecture is an area which is developing rapidly and the scope of nanoarchitectural materials will bring comfort to the interior space.

APPLICATIONS IN BIOENGINEERING

Bone tissue engineering ⁽³⁷⁾: This study examines recent advances in bone tissue engineering, with a particular focus on the encouraging role of nanotechnology, as well as future research directions. New breakthroughs in promoting bioactivity by modifying the nanoscale interior surfaces of scaffolds are investigated, followed by an assessment of ways for employing scaffolds as a mean for local drug delivery to stimulate bone regeneration or integration and seeding cells into the scaffold. Critical issues are presented in order to direct future research into developing materials and medicines that will bring cutting-edge technology to the masses. The adaptable scaffolds integrates with bone tissue while being actively resorbed or rebuilt in an anticipated manner, with controlled osteogenic activity, utilising the biological doctrines of bone repair that have evolved over millions of years. These abilities will lead to faster bone growth, shorter healing times, and quicker return to function.

Single cell detection ⁽³⁸⁾: The progress of nanotechnologies relevant to single cell detection is discussed in this paper. First, a short overview of current nanotechnology is given. Second, description of an overview of the major concerns in cell biology that single-cell detection could help answer. Finally, single-cell detection nanotechnology is discussed and grouped into four categories: nanomaterials as labels, nanomanipulation, nanodevices, and nano Secondary Ion Mass Spectrometry (or nanoSIMS). Finally, the prospects for single-cell detection and analysis are addressed, as well as future trends. Researchers have produced a range of nanolabels, including QDs, Au/Ag nanoparticles, and nanoeggs, to improve image resolution when traditional imaging methods are coupled with nanolabels. These nanolabels have also been employed as nanosensors to monitor physiological factors such as PH, ion concentration, temperature, and so on. Single-cell data has a lot of promise for therapeutic applications that require quick, en masse single-cell identification.

Tissue regeneration ⁽³⁹⁾: The promises of nanomaterials for neural, bone, cartilage, bladder tissue engineering and vascular applications are discussed in this review paper. Furthermore, the likely risk and

toxicity of nanomaterials with respect to synthesis and use in relation to human health is identified as an important future area of research. Although there are many obstacles ahead, synthesized nanomaterials can match the features of the natural ECM and hence have a lot of potential in tissue engineering. The molecular mechanisms mediating in-vivo interactions among nanomaterials and cells will considerably improve the field's progress in the future.

NANOTECHNOLOGY IN ELECTRONICS AND TELECOMMUNICATION

Role of nanotechnology in electronic ⁽⁴⁰⁾: This article is the review of the stances adopted by different institutions in relation to that topic from 2000 to 2016. There are two primary positions that had been identified. One places an emphasis on nanotechnologies' technical advantages in resolving important development issues themes. The alternative viewpoint, which we refer to as contextual, examines nanotechnologies inside the nanoelectronic framework in social, economic, and political factors. A wide range of micro materials and nanomaterials with distinct mechanical, electrical, and photonic properties have been reported and utilized as functional elements in device applications. Self-assembly of silica microspheres, for example, produced a photonic crystal with a full three-dimensional band gap. Nanoelectronic circuits, solar cells, and nanosensors for the detection of biological and chemical species, self-assembly, contact printing, and dielectrophoresis had all been built with semiconductor nanowires. In the field of electronics, a new field is evolving that will be a huge leap forward in computer and electronics technology. Quantum computing and quantum technology are the fields concerned. Science and technology have always had an impact on society, but there is no way of knowing what novel scientific discoveries will be discovered next or how technology will be used e.g. Nokia Morph, contact Lens, electronic paper.

Nanotechnology in communication engineering ⁽⁴¹⁾: Nanotechnology could give excellent solutions for power efficient computation, sensing, human machine interface and memory enlargement in telecommunication engineering. In communication systems nanotechnology provides the opportunity to make computer processors and sensors that are more energy efficient, less expensive, far smaller, faster than current modules. This paper presents a quick overview of numerous difficulties linked to nanotechnology in communication systems, as well as a basic notion of the potential application of various nanotechnology breakthroughs in communication systems and future possibilities. This article provides a review of the use of nanotechnology in more advanced and extensively used telecom engineering techniques and intended to be utilized in a more intellectual in the near term where the notion of nanotechnology was presented as one of the techniques used for the development of many areas of telecommunications engineering. Molecular communication is the combination of biology and nanotechnology to interface with biological systems, as well as computer science for the integration into larger-scale systems for information and communication processing. Nano networking is a revolutionary concept that will enhance the capabilities of Nano machines by linking them in a single Nano core network that can connect to the internet, providing a new way of future Nano networking by improving the concept and deployment of the internet of things.

CONCLUSION

Nanotechnology has proved to be a modern tool for the development of the basic science and technology. The review done has shown the vast and varied application of nanotechnology to the various sectors of life. Nanotechnology has been proved to effective in medicine as in cancer treatment, orthopaedics, gene therapy, nervous system therapy. Nanotechnology is solving the problems pertaining to the food production, dietary science, food for drug delivery system, and nanofoods. Electronics, automotive,

packaging, construction, health care, energy, and defence are just a few of the industries where nanomaterials have shown potential. Nanoparticles are expected to be less expensive than many other nanomaterials, and they have a high strength-to-weight ratio, among other benefits. Nanostructured ceramic coatings for machine parts are far more durable than traditional coatings. Nanotechnology-enabled lubricants and motor oils also reduce wear and tear, allowing moving parts to last longer. Catalysis with nanoparticles is becoming more popular as a way to speed up chemical reactions. This results in lowering the catalytic materials amount required to achieve the synthesis, saving money and lowering pollution for example petroleum refinery and automotive catalytic converters.

In the field of built environment nanotechnology has become a boon with applications like environmental sensors, air purifiers and filters, degreasers and stain removers, antibacterial cleansers, specialty paints and sealing solutions, e.g. self-cleaning home paints all made with nano-engineered materials. In the personal care sector nanomaterials such as titanium dioxide and zinc oxide are providing the sun protection. Nanotechnology can solve the drinking water problem of the world through quick, low-cost detection of the pollutants and their subsequent treatment. To summarise, nanotechnology has become the wonder science with potential application in every field of life. The concerns associated with the use and mitigation of the nanomaterials are to be dealt with proper regulation and disposal mechanism.

REFERENCES

- [1] Vyas, D., Castro, P., Saadeh, Y., & Vyas, A. (2014). The role of nanotechnology in gastrointestinal cancer. *Journal of biomedical nanotechnology*, 10(11), 3204-3218.
- [2] Tasker, L. H., Sparey-Taylor, G. J., & Nokes, L. D. M. (2007). Applications of nanotechnology in orthopedics. *Clinical Orthopedics and Related Research (1976-2007)*, 456, 243-249.
- [3] Asrar, K., Okolnikova, G. E., Hesam, A. A. R., & Svintsov, A. P. (2021). On the role of nanotechnology in the construction industry and energy efficiency of buildings. *International research journal (5-1 (107))*, 125-131.
- [4] Singh, R., Smitha, M. S., & Singh, S. P. (2014). The role of nanotechnology in combating multi-drug resistant bacteria. *Journal of nanoscience and nanotechnology*, 14(7), 4745-4756.
- [5] Tanaka, T., Decuzzi, P., Cristofanilli, M., Sakamoto, J. H., Tasciotti, E., Robertson, F. M., & Ferrari, M. (2009). Nanotechnology for breast cancer therapy. *Biomedical microdevices*, 11(1), 49-63.
- [6] Jain, K. K. (2006). Role of nanotechnology in developing new therapies for diseases of the nervous system.
- [7] Duran, N., & Marcato, P. D. (2013). Nanobiotechnology perspectives. Role of nanotechnology in the food industry: a review. *International Journal of Food Science & Technology*, 48(6), 1127-1134.
- [8] Sharif, M. K., Butt, M. S., & Sharif, H. R. (2017). Role of nanotechnology in enhancing bioavailability and delivery of dietary factors. In *Nutrient delivery* (pp. 587-618). Academic Press.
- [9] Singh, T., Shukla, S., Kumar, P., Wahla, V., Bajpai, V. K., & Rather, I. A. (2017). Application of nanotechnology in food science: perception and overview. *Frontiers in microbiology*, 8, 1501.
- [10] Sayan, B., Indranil, S., Aniruddha, M., Dhruvajyoti, C., Uday, C. G., & Debashis, C. (2013). Role of nanotechnology in water treatment and purification: potential applications and implications. *Int J Chem Sci Technol*, 3(3), 59.
- [11] Alvarez, P. J., Chan, C. K., Elimelech, M., Halas, N. J., & Villagrán, D. (2018). Emerging opportunities for nanotechnology to enhance water security. *Nature nanotechnology*, 13(8), 634-641.
- [12] Tahir, M. B., Sohaib, M., Sagir, M., & Rafique, M. (2020). Role of Nanotechnology in Photocatalysis. *Reference Module in Materials Science and Materials Engineering*.

- [13] Srivastava, D., Menon, M., & Cho, K. (2001). Computational nanotechnology with carbon nanotubes and fullerenes. *Computing in Science & Engineering*, 3(4), 42-55.
- [14] Eatemadi, A., Daraee, H., Karimkhanloo, H., Kouhi, M., Zarghami, N., Akbarzadeh, A., & Joo, S. W. (2014). Carbon nanotubes: properties, synthesis, purification, and medical applications. *Nanoscale research letters*, 9(1), 1-13.
- [15] Khursheed, Z., & Parihar, R. S. Role of nanotechnology in pollution prevention.
- [16] Khan, W. S., Ceylan, M., Asmatulu, R., & Asmatulu, R. (2012, September). Effects of nanotechnology on global warming. In *ASEE Midwest section conference*, Rollo, MO (Vol. 19, p. 21).
- [17] Zeng, L., Xiao, L., Zhang, J., & Fu, H. (2020). The role of nanotechnology in subgrade and pavement engineering: a review. *Journal of Nanoscience and Nanotechnology*, 20(8), 4607-4618.
- [18] Dannenberg, F. G. W. (2016). *Modelling and verification for DNA nanotechnology* (Doctoral dissertation, University of Oxford).
- [19] Wang, W., Yu, S., Huang, S., Bi, S., Han, H., Zhang, J. R., & Zhu, J. J. (2019). Bioapplications of DNA nanotechnology at the solid-liquid interface. *Chemical Society Reviews*, 48(18), 4892-4920.
- [20] Mauro, J. C., Ellison, A. J., & Pye, L. D. (2013). Glass: the nanotechnology connection. *International Journal of Applied Glass Science*, 4(2), 64-75.
- [21] Abdin, A. R., El Bakery, A. R., & Mohamed, M. A. (2018). The role of nanotechnology in improving the efficiency of energy use with a special reference to glass treated with nanotechnology in office buildings. *Ain Shams Engineering Journal*, 9(4), 2671-2682.
- [22] Firoozi, A. A., Taha, M. R., & Firoozi, A. A. (2014). Nanotechnology in civil engineering. *EJGE*, 19, 4673-4682.
- [23] Asrar, K., Okolnikova, G. E., Hesam, A. A. R., & Svintsov, A. P. (2021). On the role of nanotechnology in the construction industry and energy efficiency of buildings. *International research journal*, (5-1 (107)), 125-131.
- [24] Nabizadeh Rafsanjani, H., & Kadivar, M. (2011). Application of nanotechnology in civil engineering. In *Advanced Materials Research* (Vol. 261, pp. 520-523). Trans Tech Publications Ltd.
- [25] Ghosal, M., & Chakraborty, A. (2021, August). The Growing Use of Nanotechnology in the Built Environment: A Review. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1170, No. 1, p. 012007). IOP Publishing.
- [26] Ozel, S., & Ozel, Y. (2008, July). Nanotechnology in education: nanoeducation. In *WSEAS International Conference. Proceedings. Mathematics and Computers in Science and Engineering* (No. 5). WSEAS.
- [27] Uddin, M., & Chowdhury, A. R. (2001, August). Integration of nanotechnology into the undergraduate engineering curriculum. In *International Conference on Engineering Education* (Vol. 8, pp. 6-9).
- [28] Porter Jr, L. A. (2007). Chemical nanotechnology: A liberal arts approach to a basic course in emerging interdisciplinary science and technology. *Journal of chemical education*, 84(2), 259.
- [29] Lele, A. (2009). Role of Nanotechnology in defence. *Strategic Analysis*, 33(2), 229-241.
- [30] Ali, M. A., Rehman, I., Iqbal, A., Din, S., Rao, A. Q., Latif, A., & Husnain, T. (2014). Nanotechnology, a new frontier in Agriculture. *Adv life sci*, 1(3), 129-138.
- [31] Muktar, Y., Bikila, T., & Keffale, M. (2015). Application of nanotechnology for animal health and production improvement: a review. *World Appl Sci J*, 33(10), 1588-1596.
- [32] Mondal, S. (2020). Potential of Nanotechnology for Rural Applications. *Arabian Journal for Science and Engineering*, 45(7), 5011-5042.

- [33] Verma, A. K., Singh, V. P., & Vikas, P. (2012). Application of nanotechnology as a tool in animal products processing and marketing: an overview. *American Journal of Food Technology*, 7(8), 445-451.
- [34] Hamad, H. T., Al-Sharify, Z. T., Al-Najjar, S. Z., & Gadooa, Z. A. (2020, June). A review on nanotechnology and its applications on Fluid Flow in agriculture and water resources. In *IOP Conference Series: Materials Science and Engineering* (Vol. 870, No. 1, p. 012038). IOP Publishing.
- [35] Niroumand, H., Zain, M. F. M., & Jamil, M. (2013). The role of nanotechnology in architecture and built environment. *Procedia-Social and Behavioral Sciences*, 89, 10-15.
- [36] El-Alfy, K. S., Azzam, H. M., Elwazeer, M. A., & Elbeialy, M. M. (2021). The Role of Nanotechnology to Realize Human Comfort in Interior Spaces. (Dept. A). *MEJ.Mansoura Engineering Journal*, 37(3), 31-50.
- [37] Saiz, E., Zimmermann, E. A., Lee, J. S., Wegst, U. G., & Tomsia, A. P. (2013). Perspectives on the role of nanotechnology in bone tissue engineering. *Dental Materials*, 29(1), 103-115.
- [38] Wang, C., Zhang, Y., Xia, M., Zhu, X., Qi, S., Shen, H., & Tang, L. (2014). The role of nanotechnology in single-cell detection: a review. *Journal of biomedical nanotechnology*, 10(10), 2598-2619.
- [39] Zhang, L., & Webster, T. J. (2009). Nanotechnology and nanomaterials: promises for improved tissue regeneration. *Nano today*, 4(1), 66-80.
- [40] Kandil, M. "The role of nanotechnology in electronic properties of materials." *ENRRA*, Cairo (2016).
- [41] Elmustafa, S. A. A., & Sohal, H. S. (2017). Nanotechnology in communication engineering: issues, applications, and future possibilities. *World Scientific News*, (66), 134-148.

ABSTRACT

Synthesis of new dithiocarbamates namely AMPDTC prepared from 2-amino-6-methyl pyridine and Carbon disulphide. 2-amino-6-methyl pyridine is one of the important compounds of unique series of amino pyridine. The main interest is to prepare the new dithiocarbamate metals [AMPDTC] complexes with Mn and Fe metals. Elemental analysis, IR, ¹HNMR spectra, X-ray powder diffraction, and TGA-DTA studies were used to synthesise and characterise dithiocarbamate. The ligands behave as isobidentate ones, according to infrared and ¹HNMR data. The electronic spectra show that charge transfer transitions are mostly centred on the ligand. Interesting fragmentation patterns have been reported in thermal studies, and kinetic parameters such as order of thermal radiations (n) and activation energy E have also been evaluated.

KEYWORDS: Dithiocarbamates, Metal complexes, Biological activity

INTRODUCTION

The formation of complexes with metal ions is where dithiocarbamate ligands come into their own. This is because there is a single pair of electron donating characters present. They also form stable chelates with metals^{1, 2} that have five or six members. Dithiocarbamates have numerous applications in many fields, including pharmacy, medicine, and agriculture, photography, and polymer technology, in addition to their ability to form complexes with metal ions. These are biologically applicable as antiviral, antibacterial, and anticancer activities. Literature survey revealed that many number of dithiocarbamates have been synthesized from Primary and secondary amines. The proposal work based on the synthesis of new dithiocarbamates namely AMPDTC prepared from 2-amino-6-methyl pyridine and Carbon disulphide. 2-amino-6-methyl pyridine is one of the important compounds of unique series of amino pyridine. The main interest is to prepare the new dithiocarbamate metals [AMPDTC] complexes with Mn and Fe metals. The antibacterial activity of the synthesised dithiocarbamate ligand and its metal complexes was further extended by the Paper disc method against microorganisms such as E.Coli, Bacillus substilis, and Klebsiella.

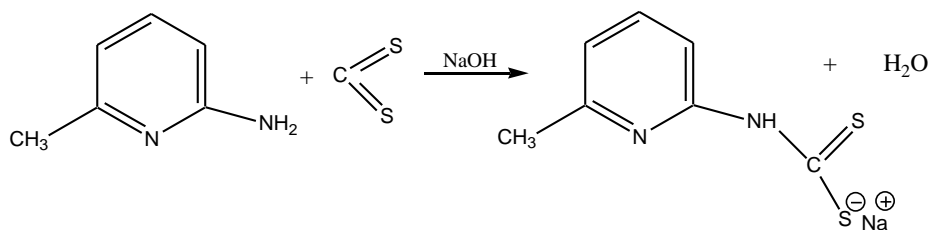
MATERIALS AND METHODS

In the current study, analytical reagent grade chemicals were used. Organic compounds are 2-Amino-6-methyl Pyridine (HiMedia), Carbon disulphide (Qualigens) and Methanol (AR-Loba). Inorganic compounds are Manganese Chloride (SD Fine), Ferric chloride (Sigma Aldrich), Sodium acetate trihydrate (AR-Merck) and Sodium Hydroxide (SD Fine).

PREPARATION OF LIGAND

The cold methanolic solution of 2-Amino-6-methyl pyridine (0.51gm in 10 cm³) is transfer into the clean casserole; add 5ml of 5N NaOH solution. To this mixture gradually add Carbon disulphide (8ml) drop wise over a period of 30 minutes with constant stirring, oily precipitate separates out. The white precipitate formed was allowed to stand for 5 hours in the water bath for crystallization. The product was filtered on a Buchner funnel through suction, washed with Methanol and sucked dry. The resulting product was recrystallized from ether and vacuum-dried over a calcium chloride dessicator. The yield is 80%, and the melting point is 195 - 197^o C.

The new dithiocarbamate is,



Scheme 1: preparation of dithiocarbamate

PREPARATION OF MANGANESE (II) AND IRON (III) METAL COMPLEXES

Metal complexes have been derved by adding an appropriate amount of dithiocarbamate ligand in 50% Methanol to a metal salt solution of Mn and Fe metal ions in the presence of sodium acetate and refluxing the mixture for four hours on a water bath. This reaction mixture was poured over a large amount of cold water. With a high yield, a coloured precipitate of metal complex was obtained. These products were washed several times with hot water and cold methanol to remove unreacted metal salts and ligands, and then dried in a vacuum dessicator. High purity samples were obtained directly. TLC was also used to check the purity.

An elemental analyzer was used to perform elemental analyses on both the ligands and complexes. After digesting the complexes with conc. HNO₃, the metal contents were determined using atomic absorption spectroscopy. Conductivity measurements were performed at 300 + 0.1^oK using a Beclanan Re-18A type conductivity bridge on freshly prepared 10 M solutions in DMF. The Guoy method was used to measure magnetic susceptibility at room temperature.

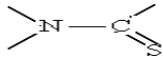
The infrared spectra were obtained using KBr pellets in the range and a Perkin-Elmer IR 598 Spectrometer (4000-200cm⁻¹). At room temperature, 1H NMR spectra were recorded on an av-300 MHz NMR spectrometer in DMSO-d₆ solvent. The TG and DTA curves were recorded simultaneously for powdered samples on an IUGAKU 8150 thermo analyser at a heating rate of 10^oK min⁻¹ and a chart speed of 2.5 min⁻¹ as the reference material. The powder diffraction patterns were obtained using an X-ray powder diffraction model on a Lynx-Eye Detector, Make: Burker Axs, Model: D8 Advance.

RESULTS AND DISCUSSION

CHARACTERIZATION OF THE LIGAND

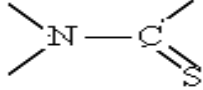
Elemental analysis revealed that the proportion composition of carbon, hydrogen, nitrogen and sulphur had been in appropriate settlement with theoretically computed values.

IR spectrum of the compound clearly revealed that the formation of dithiocarbamate has taken place and

the peak at 1500-1450 cm⁻¹ shows the existence of Thioureide band  in the compound. The peak at 1459 cm⁻¹ assignable to ν (N-CSS) stretching frequency. This band defines a carbon, nitrogen bond order between a single bond (ν =1250-1350 cm⁻¹) and a double bond (ν =1640-1690 cm⁻¹). The presence

of a band in that region indicates that electrons in the dithiocarbamate moiety are strongly delocalized. The above dithiocarbamate peaks are in good agreement with the reported literature for the Thioureide band. The peak at 1616 cm^{-1} is observed which is characteristic of ($>\text{C}=\text{N}$) of the pyridine ring. Analytical data and spectral data of Sodium 2-amino-6-methyl pyridine dithiocarbamate is given in the Table-1

Table 1: Analytical and Spectral data of AMPDTC

| | | |
|--|--|----------------|
| Molecular Formulae | $\text{C}_7\text{H}_7\text{N}_2\text{S}_2\text{Na}$ | |
| Colour | Colour less | |
| Melting Point | 195-197°C | |
| Elementary Analysis | Found (%) | Calculated (%) |
| Carbon | 40.05 | 40.76 |
| Hydrogen | 3.00 | 3.42 |
| Nitrogen | 13.00 | 13.58 |
| Sulphur | 31.30 | 31.90 |
| Yield | 80 % | |
| I.R Absorption Bands | | |
|  | 1460 cm^{-1} , 770 cm^{-1} , 1130 cm^{-1} | |

INFRARED SPECTRAL STUDIES

A plot of IR spectra shows the recurrence or wave number of episode radiation on the X-hub and its conveyance on the Y-hub. The wave number unit is often utilized, since it is straightforwardly relative to the energy of vibration and as such current IR instruments are direct in cm^{-1} scale. It was seen that the IR spectra of all the Manganese (II), and Iron (III) particle buildings gave an extensive number of pinnacles, each comparing to a specific vibrational progress.

Table. 1 portrays the investigation of IR range of the ligand and metal buildings of Mn and Fe. The ordinary IR range is displayed in Fig 1, 2 and 3.

FT-IR. INVESTIGATION OF THE LIGAND

The ordinary I.R spectra of AMPDTC ligand is introduced in the Fig 9.1. As concern the 2-Amino-6-methyl pyridine dithiocarbamate moiety, two fundamental districts of the IR are of primary interest. In The first place, the ($1420\text{-}1490\text{ cm}^{-1}$) district, which is fundamentally, related with ν (N-CSS) extending vibrations. Second, the 769 cm^{-1} area, which is related with ν (C-S) extending vibrations, the powerless band is in the 1130 cm^{-1} district and is related with the ν (C=S) extending vibrations.

The trademark band at 1473 cm^{-1} , is assignable to ν (N-CSS); this band characterizes a carbon Nitrogen bond request between a solitary bond ($\nu =1250\text{-}1350\text{ cm}^{-1}$) and a twofold bond ($\nu =1600\text{-}1700\text{ cm}^{-1}$), The presence of a band in that area shows that, of the three potential reverberation structures announced by Chatt *et al.*, portrayed by a solid delocalization of electrons in the dithiocarbamate moiety.

The band at $3200\text{-}3250\text{ cm}^{-1}$ related with the ν (N-H) extending vibrations and the band at $1550\text{-}1590\text{ cm}^{-1}$, is related with the ν (N=C) bond extending in the Pyridine ring.

The groups at 2910-2930 cm^{-1} and 1330-1380 cm^{-1} , are related with the ν (C-H) extending vibrations and δ (C-H) bowing vibrations of Methyl bunch which is connected to the Pyridine ring in sixth position.

FT-IR. CHARACTERIZATION OF MN (II) COMPLEX

The interpretation of FTIR spectra of dithiocarbamates complexes of Transition metals has been tremendous hobby each diagnostically to decide the mode of co-ordination and as a median of assessing the character of bonding in these complexes. The FTIR. spectrum of the [AMPDTC] ligand is compared with the Mn (II) complex. The typical FTIR spectra of [AMPDTC] Mn ligand are presented in the Fig 2.

A solid band displayed at 1460 cm^{-1} in the FTIR range of the ligand, which is allotted to the Thioureide bond is moved to 1575 cm^{-1} area. On Passage from the free dithiocarbamate ligand to their complicated, the ν (N-CSS) mode is moved to higher energies, showing an increment of Carbon-Nitrogen twofold bond character and thus a more prominent commitment of the construction. The Infrared dynamic ν (N-CSS) mode is touchy to both chain length and the steric effect of the substituents. As twofold person is more articulated in the complicated it tends to be inferred that the ligand is co-ordinated through S, S molecules.

To recognize the holding sort of the dithiocarbamate ligand in their buildings, the Bonati-Ugo strategy is, by a long shot, the most famous one. It comprises of following the 950-1060 cm^{-1} phantom district, where the ν (C-S) modes are thought to show up. Truth be told, the groups due to - CSS moieties are typically coupled to different vibrations and are exceptionally touchy to the climate around this gathering, however they are likewise valuable to recognize Mono dentate and Bidentate Co-appointment. The presence of just one band in the explored area, generally ascribed to ν (SCS) mode, it shows totally even holding of the dithiocarbamate ligand to metal in bidentate mode, where as a doublet is normal for the Mono dentate co-appointment.

Basing on the above idea the presence of single band at 980-1030 cm^{-1} district is accepted to ν (C-S) extending vibrational mode and it demonstrates the symmetric bidentate conduct of the ligand that implies the AMPDTC ligand is co-ordinated through both the sulfur molecules.

Alongside these groups new groups are framed which are not seen in the spectra of the ligand, the band at 450 cm^{-1} is allocated to the ν (Mn-S) metal ligand obligation of the complex. The presence of a wide band at 3442 cm^{-1} can be relegated to the ν (O-H) extending vibrations of co-ordinated water atoms present in the complicated and the band at 1575 cm^{-1} due to ν (C=N) of the pyridine ring doesn't show any significant change in the intricate, which demonstrates that the pyridine Nitrogen's isn't partaking in the perplexing arrangement. In the spectra of both ligand and perplexing, no huge change is noticed, for ν (N-H) extending mode, demonstrating non-association of amino nitrogen in Co-appointment. The two more vulnerable groups at 800-750 cm^{-1} and 750-720 cm^{-1} are allotted separately to - OH shaking and swaying vibrations of co-ordinated water in the complex.

FTIR ANALYSIS OF Fe (III) COMPLEX

The FTIR. spectrum of the [AMPDTC] ligand is compared with the Fe (III) complex. The typical FTIR spectra of [AMPDTC] Fe ligand is presented in the Fig 3.

A solid band displayed at 1473 cm^{-1} in the FTIR range of the ligand, which is allocated to the Thioureide bond, is moved to 1530 cm^{-1} area, this shift to higher wave number backings extensive twofold person of the (N-CSS) bond^{3, 4, 5}. As twofold person is more articulated^{3, 4} in the perplexing it very well may be presumed that the ligand is co-ordinated by means of S, S particles, and this is upheld by the standard structures given by Chatt et al. The presence of a solitary solid band at 950-1060 cm^{-1} locale is appointed

to ν (C-S) extending vibrational mode. The ν (C=S) groups at 1156 cm^{-1} and ν (C-S) groups at 769 cm^{-1} in the ligand shows negative and positive shift, separately in the spectra of the complex demonstrating the co-appointment of both S-S atom. This demonstrates the bidentate conduct of the AMPDTC ligand in the complex; any other way a doublet would be normal in the $950\text{-}1060\text{ cm}^{-1}$ locale as on account of Mono dentate co-appointment. Alongside these groups new groups are framed which are not seen in the spectra of the ligand, the band at 410 cm^{-1} is relegated to the ν (Fe-S) metal ligand obligation of the complex. The presence of a wide band at 3438 cm^{-1} can be allotted to the ν (O-H) extending vibrations of co-ordinated water particles present in the mind boggling and the band at $1550\text{-}1570\text{ cm}^{-1}$ due to ν (C=N) of the pyridine ring doesn't show significant change in the complicated which demonstrates that the pyridine Nitrogen isn't partaking in the intricate development. In the spectra of both ligand and intricate, no huge change is noticed, for ν (N-H) extending mode, demonstrates the non-inclusion of amino nitrogen in Co-appointment.

The band recorded for both the buildings and free dithiocarbamate forerunners in the $410\text{-}630\text{ cm}^{-1}$ territory can be attributed to the commitment of ν (C-S), ν (M-S) vibrational modes. The two more vulnerable groups at $800\text{-}750\text{ cm}^{-1}$ and $750\text{-}720\text{ cm}^{-1}$ are allocated separately to -OH shaking and swaying vibrations of co-ordinated water in the complex.

Table 2: The important IR Bands of the Ligand and Their Metal Complexes

| Compound | OH (water) | ν (C-N) (Thioureide bond) | ν (C-S) | ν (M-S) |
|--------------------------|------------|----------------------------------|-------------|-------------|
| AMPDTC | - | 1473 | 1130,789 | - |
| (AMPDTC) ₂ Mn | 3442 | 1575 | 975 | 420 |
| (AMPDTC) ₂ Fe | 3438 | 1530 | 990 | 412 |

COMPLEX STUDIES OF ¹H NUCLEAR MAGNETIC RESONANCE SPECTRA

In the present study, ¹H NMR spectra were recorded on an av-300 MHz NMR spectrometer in Apotex Pharma chem. India pvt. Limited Bangalore in DMSO-d₆ solvent at room temperature.

ANALYSIS OF AMPDTC AND ITS METAL COMPLEXES

Fig. 4, 5 & 6. Portray the prominent the significant synthetic shift upsides of the ligand and metal edifices, these qualities are summed up in Table.3.

Fig.4. gives the regular NMR range of the ligand AMPDTC. The methyl protons of the picoline of dithiocarbamate ligand were seen at $2.60\text{-}3.60\text{ ppm}$. The tops in the fragrant area were viewed as a bunch of multiplets in the reach $6.6\text{-}7.6\text{ ppm}$, 7, 8 and the sign because of proton connected to the Nitrogen, in Thioureide bond is showed up as a singlet at 7.4 ppm .

Fig.5. gives the ordinary NMR range of the [AMPDTC] Mn. In the complex [AMPDTC] Mn the sign because of proton attached to Nitrogen in Thioureide bond is moved from 7.34 to 7.85 ppm on account of the ligand. The down field shift of the complex may ascribed to an expansion of the Π - bond character and the delocalization of electron along the C-N bond contributed by the substituents and furthermore the bidentate idea of the dithiocarbamate ligand. On complexation, the electron thickness on -NH diminishes, the precessional recurrence of Nitrogen containing proton increments, thus the sign is moved to down field locales.

It was seen that the sweet-smelling ring protons of reach $6.74\text{-}7.45\text{ ppm}$ become expansive and less serious when contrasted with the relating dithiocarbamate ligand. This impact might be because of the

floating of ring electrons towards the metal particle.

The expansive sign at 9.8 ppm on account of Manganese (II) complex shows the complexation of water atom to metal particle.

Fig.6. gives the ordinary NMR range of the [AMPDTC] Fe .In the complex [AMPDTC] Fe the sign because of the nitrogen containing proton is moved from 7.34 to 7.81 ppm on account of the ligand. The down field shift of the complex may credited to an increment of the π -bond character or the delocalization of electron along the C-N bond contributed by the substituents and furthermore the bidentate idea of the dithiocarbamate ligand.

It was seen that the sweet-smelling ring protons of reach 6.6-7.6 ppm become expansive and less concentrated when contrasted with the relating dithiocarbamate ligand 2. This impact might be because of the floating of ring electrons towards the metal particle.

The expansive sign at 10.1 ppm on account of Iron (III) complex shows the complexation of water particle to metal particle.

Table 3: ¹HNMR Spectrum of the ligands and its metal complexes in DMSO-d₆ in ppm

| Compound | H-N-C (thioureide bond) | CH ₃ | OH | Ar-H |
|--------------------------|----------------------------|-----------------|------|----------|
| AMPDTC | 7.34 | 2.60 | – | 6.6-7.6 |
| (AMPDTC) ₂ Mn | 7.65 | 2.54 | 9.8 | 7.45-8.2 |
| (AMPDTC) ₂ Fe | 7.89 | 2.51 | 10.1 | 5.42-6.4 |

ESR STUDIES OF COORDINATION COMPLEXES

The ESR unearthly examinations are conveyed distinctly for Mn [AMPDTC] complex. As a result of the way that the Spin-Orbit coupling constants for the 4d and 5d gatherings are a lot bigger than for the 3d gathering, Spin-cross section unwinding times are generally exceptionally low. In this way it is frequently hard to notice a range by any means besides at extremely low temperatures.

The designs of complex in arrangement might be not quite the same as those present in the strong state. In arrangement the ESR range will be diverse because of the expansion in partition between Mn-Mn for tumbling movement of Iron species in the arrangement. The ESR spectra were acquired in answer for all Iron buildings in DMF medium at fluid nitrogen temperature.

The ESR spectra of the complex in polycrystalline state display just a single expansive sign, which is ascribed to dipolar widening and improved twist – grid unwinding. ESR spectra acquired for copper complex in DMF at fluid nitrogen temperature and agent ESR range of Mn (II) particle complex are introduced in Fig.7. In this low temperature range, four pinnacles of little force have been recognized which are considered to start from g^{\parallel} part.

The twist Hamiltonian, orbital decrease and holding boundaries of the complex were given in Table.4. The g^{\parallel} and g^{\perp} are figured from the range utilizing DPPH free revolutionary as g marker. Kivelson and Neiman have revealed that g^{\parallel} esteem is under 2.3 for covalent person and it is more noteworthy than 2.3 for ionic person of the metal-ligand bond in complex. Applying this model, the covalent bond character can be anticipated to exist between the metal and the ligand for complex.

The pattern $g^{\parallel} > g_{ave} > g^{\perp} > 2.0023$ noticed for the complex proposes that the unpaired electron is restricted in $dx^2 - y^2$ orbital of the Mn (II) complex. The most reduced g esteem (>2.04) likewise reliable with a $dx^2 - y^2$ ground state. It was seen that the G an incentive for the Cu-complex was under four and recommends that there are no collaborations between Mn-Mn focuses in DMF medium.

The ESR boundaries g_{\parallel} , g_{\perp} , A_{\parallel}^* and A_{\perp}^* of the intricate and the energies of d-d changes are utilized to assess the orbital decrease boundaries (K_{\parallel} , K_{\perp}), the holding boundaries (α^2), the dipolar cooperation (P) and the Fermi consistent association term (K). The noticed $K_{\parallel} < K_{\perp}$ demonstrates the presence of huge in plane π -holding. The α^2 values for the current chelate 0.4109 supporting the covalent idea of the complex. Giordano and Bereman recommended the distinguishing proof of holding bunches from the upsides of dipolar term P. The decrease of P esteems from the free particle esteem (0.036 cm^{-1}) may be credited to the solid covalent holding. The lower P and α^2 values for [AMPDTC] Mn complex propose the presence of solid in-plane π holding which in concurrence with higher ligand field. The states of ESR lines, ESR information along with the electronic ghostly information propose square planar calculation for copper complex.

Table 4: Spin Hamiltonian and orbital reduction parameters of Mn complex in DMF solution

| Parameters | Mn (AMPDTC) ₂ |
|-------------------|--------------------------|
| g_{\parallel} | 2.2373 |
| g_{\perp} | 2.1699 |
| g_{ave} | 2.2290 |
| G | 2.5369 |
| A_{\parallel}^* | 0.0113 |
| A_{\perp}^* | 0.0016 |
| A_{ave}^* | 0.0062 |
| d-d | 25600 |
| K_{\parallel} | 0.6241 |
| K_{\perp} | 0.8052 |
| P^* | 0.0301 |
| α^2 | 0.3990 |

THERMAL ANALYSIS OF [AMPDTC] MN AND [AMPDTC] FE COMPLEX

TG methods were utilized to follow the warm conduct of buildings. As per the outcomes got, the edifices are not unpredictable and their disintegration happens in various advances. The commonplace Thermo gram of [AMPDTC] Mn complex is displayed in the Fig.8. Thermogravimetric examinations on the buildings affirmed their proposed atomic formulae. The [AMPDTC] Mn complex is thermally steady up to 171°C. The thermo gram of the complicated shows a First phase of disintegration around 196.35°C to 257.26°C, which demonstrates the presence of cross section water and this deterioration compares to endothermic parchedness of the complex^{9,10} and gives anhydrous complex. The subsequent disintegration stage with two (or) three endothermic pinnacles is known as steady transitional conformed to 229.55°C and they under goes deterioration bringing about the deficiency of ligand moiety at 292.44°C and 497.56°C. Exothermic decay happens to give the comparing Manganese sulfide as the last deterioration item at a high temperature i.e. above 801.30°C. The decay conduct of the buildings is seen in nitrogen air.

All the exploratory mass misfortune and absolute mass misfortune rate esteems found were introduced in the Table.5.

TG methods were utilized to follow the warm conduct of buildings. As per the outcomes got, the edifices are not unpredictable and their disintegration happens in various advances. Thermogravimetric examinations on the buildings affirmed their proposed atomic formulae. The commonplace Thermo gram of [AMPDTC] Fe complex is displayed in the Fig.9. The [AMPDTC] Fe complex is thermally steady up to 179.78°C. The thermo gram of the complicated shows a First phase of disintegration around 102.45°C to 168.54°C, which demonstrates the presence of cross section water and this deterioration compares to endothermic parchedness of the complex and gives anhydrous complex. The subsequent decay stage with two (or) three endothermic pinnacles is known as steady middle of the road conformed to 249.73°C and then under goes disintegration bringing about the deficiency of ligand moiety at 362.44°C and 590.16°C. Exothermic deterioration happens to give the comparing Iron sulfide as the last disintegration item at a high temperature i.e. above 930°C. The deterioration conduct of the complex is seen in nitrogen air. All the trial mass misfortune and complete mass misfortune rate esteems found were introduced in the Table 5.

Table 5: Thermal analytical data of the Ligand and their metal complexes

| Complex- X=H ₂ O | Molecular weight in gms | Weight of the complex taken in mgs | Temperature Range during weight loss in °C | % of Fraction of weight | Probable assignment |
|--|-------------------------------|---|--|-------------------------------|---|
| [Mn.L ₂ .X ₂] L= C ₇ H ₇ N ₂ S ₂ | 438.938 | 8.1910 | 90-180 230-590 Above 590 | 5.1580 78.8033 9.5913 | Loss of 2H ₂ O molecule. Loss of two L molecules. Remaining residue Corresponds to MnO. |
| [Fe.L ₂ .X ₂] L=C ₇ H ₇ N ₂ S ₂ | 439.847 | 12.1630 | 70-210 430-590 Above 590 | 5.5135 84.2341 17.1439 | Loss of 2H ₂ O molecule. Loss of two L molecules. Remaining residue Corresponds to FeO. |

CONDUCTIVITY MEASUREMENTS OF METAL COMPLEXES

The molar electrical phenomenon of complexes in DMF (~2 x 10⁻³ M) determined at 27±2°C victimisation Systronic 303 direct reading physical phenomenon bridge. The dithiocarmate metal complexes of Mn (II) and Fe (III) area unit ready from the 2-Amino-6-methyl alkali and Carbon disulphide. It absolutely was discovered that these complexes area unit soluble in dimethyl formamide (DMF). Therefore, these metal chelates area unit dissolved in DMF to perform physical phenomenon measurements.

A best-known quantity of solid complicated is transferred into 25ml normal flask and dissolved in dimethyl formamide (DMF). The contents area unit created up to the mark with DMF. The complicated resolution is transferred into a clean and dry 100ml beaker and also the physical phenomenon values area unit measured. If the Molar electrical phenomenon price (k) is quite 10 Ohm⁻¹.cm⁻¹. mol⁻¹ the metal complexes area unit aforesaid to be electrolytic in nature. If the k price is a smaller amount 10 Ohm⁻¹.cm⁻¹. mol⁻¹ the metal complexes area unit aforesaid to be non-electrolytic in nature. The physical phenomenon measurements area unit used for the determination of electronic nature of the metal complexes.

The electrical phenomenon values of all the metal complexes are given in Table.6. The molar electrical phenomenon values for all the recently synthesized complexes are within the vary 2.53 – 2.99 $\text{Ohm}^{-1}.\text{cm}^{-1}.\text{mol}^{-1}$ that indicates the non-electrolytic nature.

Table 6: Conductance data for M [AMPDTC] complexes (with cell constant 1.00)

| Metal Complex | Conductance (Ohm's) | Specific conductance ($\text{Ohm}^{-1}.\text{cm}^{-1}$) | Molar conductance ($\text{Ohm}^{-1}.\text{cm}^{-1}.\text{mol}^{-1}$) |
|--------------------------|------------------------|---|--|
| [AMPDTC] ₂ Mn | 0.035X10 ⁻³ | 0.035X10 ⁻³ | 35 |
| [AMPDTC] ₂ Fe | 0.025X10 ⁻³ | 0.025X10 ⁻³ | 25 |

MAGNETIC SUSCEPTIBILITY MEASUREMENTS OF METAL COMPLEX

The magnetic moment values for all of the complexes are represented within side the Table.7. The magnetic moments of the present (AMPDTC)₂ Mn complex is 3.42 B.M. This shows the formation of low-spin complex, and digital spectral statistics endorse the rectangular planar geometry for the Manganese complex. The (AMPDTC)₂ Fe complex indicates magnetic moment 3.70 B.M. and this is much less than the spin-only value, displaying decreased paramagnetism, which endorses the formation of low-spin complex having octahedral geometry. The magnetic measurements found out that the complexes are displaying decreased paramagnetism suggesting that the ligand is robust and the complexes are low-spin, internal orbital complexes.

Table 7: Magnetic moments of Metal chelate complexes

| Metal Complex | Magnetic moment (B.M) |
|--------------------------|-----------------------|
| (AMPDTC) ₂ Mn | 3.42 |
| (AMPDTC) ₂ Fe | 3.70 |

POWDER X-RAY DIFFRACTION STUDIES OF AMPDTC-MN AND AMPDTC-FE COMPLEX

The diffractogram record (sixteen diffractions) displays Fig.10. among 2-80 (2θ) values. Where θ is Bragg angle. All the primary peaks are indicated and calculated values of Miller indices (h k l) together with d-spacing and 2θ are given inside the Table.8. All the Peaks had been listed and 2θ values as compared in graph. Comparison values reveals that there is ideal settlement among values of 2θ and d-values^{11, 12}, thirteen. The powder X-ray diffraction facts confirmed same features with very negative crystalline. The styles are qualitative and dispersive in depth for Mn complex. The XRD styles are used to give an explanation for qualitatively the diploma of crystallinity. The diffractogram record (thirteen diffractions) displays Fig.11. Between 2-80 (2θ) values. Where θ is Bragg angle. All the primary peaks are indicated and calculated values of Miller indices (h k l) together with d-spacing and 2θ are given inside the Table.9. All the Peaks had been listed and 2θ values as compared in graph. Comparison values reveals that there is ideal settlement among values of 2θ and d-values. The powder X-ray diffraction facts confirmed same features with very negative crystalline. The styles are qualitative and dispersive in depth for Fe complex. The XRD styles are used to give an explanation for qualitatively the diploma of crystallinity.

Table 8: X-ray Diffraction data of AMPDTC-Mn Complex

| S.No. | 2 θ expt | 2 θ calc | d expt | d calc | h k l |
|-------|-----------------|-----------------|---------|---------|---------|
| 1 | 11.64455 | 11.64454 | 7.59322 | 7.59345 | 2 1 1 |
| 2 | 13.88366 | 13.88366 | 6.37324 | 6.37332 | 4 1 1 |
| 3 | 17.64759 | 17.64760 | 5.02150 | 5.02154 | 5 2 1 |
| 4 | 19.07534 | 19.07534 | 4.64875 | 4.64878 | 5 4 2 |
| 5 | 20.04740 | 20.04736 | 4.42549 | 4.42549 | 6 4 2 |
| 6 | 22.64731 | 22.64728 | 3.92298 | 3.92299 | 8 7 1 |
| 7 | 24.63296 | 24.63294 | 3.61106 | 3.61108 | 8 6 1 |
| 8 | 26.72232 | 26.7223 | 3.33327 | 3.33331 | 9 8 3 |
| 9 | 28.71865 | 28.71864 | 3.10594 | 3.10728 | 10 7 2 |
| 10 | 30.13617 | 30.13622 | 2.96299 | 2.96301 | 10 9 1 |
| 11 | 31.16592 | 31.16594 | 2.86740 | 2.86743 | 11 9 0 |
| 12 | 38.90770 | 38.90774 | 2.31282 | 2.31284 | 12 6 1 |
| 13 | 39.95965 | 39.95962 | 2.25433 | 2.25435 | 12 8 3 |
| 14 | 41.62096 | 41.62086 | 2.16811 | 2.16812 | 14 9 2 |
| 15 | 45.87737 | 45.87724 | 1.97637 | 1.97636 | 14 11 2 |
| 16 | 47.83538 | 47.83530 | 1.89994 | 1.89995 | 16 10 1 |

Table 9: X-ray Diffraction data of AMPDTC-Fe Complex

| S.No. | 2 θ expt | 2 θ calc | d expt | d calc | h k l |
|-------|-----------------|-----------------|----------|----------|---------|
| 1 | 5.74963 | 5.749636 | 15.35833 | 15.35952 | 2 1 0 |
| 2 | 10.12735 | 10.12724 | 8.72712 | 8.727239 | 3 2 1 |
| 3 | 12.43091 | 12.43004 | 7.11460 | 7.115093 | 4 3 1 |
| 4 | 15.57899 | 15.57968 | 5.68330 | 5.68346 | 6 3 2 |
| 5 | 18.01738 | 18.01688 | 4.91927 | 4.91940 | 7 5 2 |
| 6 | 19.19132 | 19.19084 | 4.62092 | 4.62103 | 8 6 0 |
| 7 | 21.25106 | 21.24996 | 4.17747 | 4.17767 | 9 6 5 |
| 8 | 24.90087 | 24.90028 | 3.57281 | 3.57289 | 9 7 2 |
| 9 | 26.28889 | 26.28890 | 3.38723 | 3.38726 | 10 8 5 |
| 10 | 28.19587 | 28.19468 | 3.16233 | 3.16245 | 11 8 2 |
| 11 | 34.47616 | 34.47580 | 2.59929 | 2.59931 | 12 9 2 |
| 12 | 36.60534 | 36.60452 | 2.45283 | 2.45288 | 14 2 0 |
| 13 | 50.37448 | 50.37348 | 1.80996 | 1.81005 | 14 11 2 |

ANTIBACTERIAL ACTIVITY

METHOD EMPLOYED

To show the antibacterial interest of the ligand and steel complexes on micro organism paper disc diffusion process become hired.

Nutrient agar medium become hired for the testing. Peptone (5g) becomes dissolved in a liter of distilled water. Beef extract (5g) become delivered to the peptone answer and agar (15g) become combined. The contents had been combined very well and the pH becomes adjusted to 7.4-7.6. The answer becomes

sterilized with inside the autoclave for 10-15 mins at 15 lbs. in step with sq. inch pressure, to show the equal.

TESTING EQUIPMENT

Petri plates of equal size, warm air oven, Autoclave, sterilized pipettes and clear out paper. The giftresearch is atry anddiscover the antibacterial interest of ligand and their steel complexes14, 15 in opposition to Escherichia coli, Klebsiella and Bacillus subtilis with inside thevariety50-150 $\mu\text{m/ml}$.choosing serial paper disc diffusion method. The Antibacterial interestoutcomeshad been given with inside the Table 10. Theoutcomes of the organicinterest of the steel complexes indicated the subsequent facts. A comparative observe of the ligand and their complexes suggests that maximum of the steel chelates exhibited better antibacterial interest than that of the loose ligand. The growthwith inside the antibacterial interest of steel chelates becomedefined on the premise of overtones idea and chelation theory.

Table 10: Antibacterial activities of ligands and their transition metal complexes (Zone formation in mm)

| Compound | E.Coli | KLEBSIELLA | BACILLUS |
|--------------------------|--------|------------|----------|
| AMPDTC | 6 | 8 | 7 |
| (AMPDTC) ₂ Mn | 10 | 11 | 13 |
| (AMPDTC) ₂ Fe | 15 | 13 | 12 |

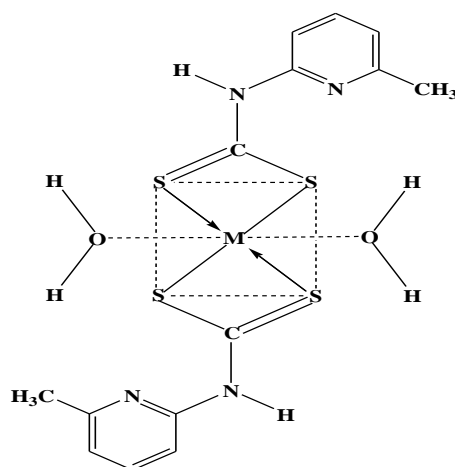


Fig. 1: Structure of metal complexes (AMPDTC)₂Mn & (AMPDTC)₂Fe

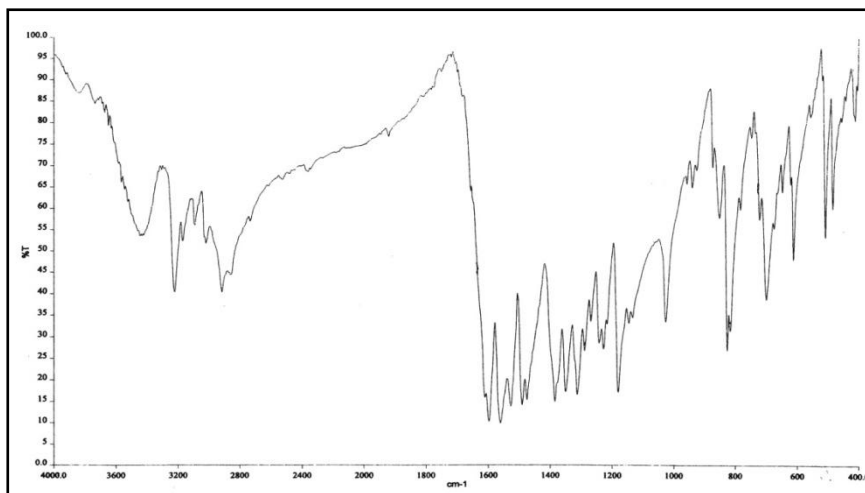


Fig. 2: IR SPECTRUM OF AMPDTC Ligand

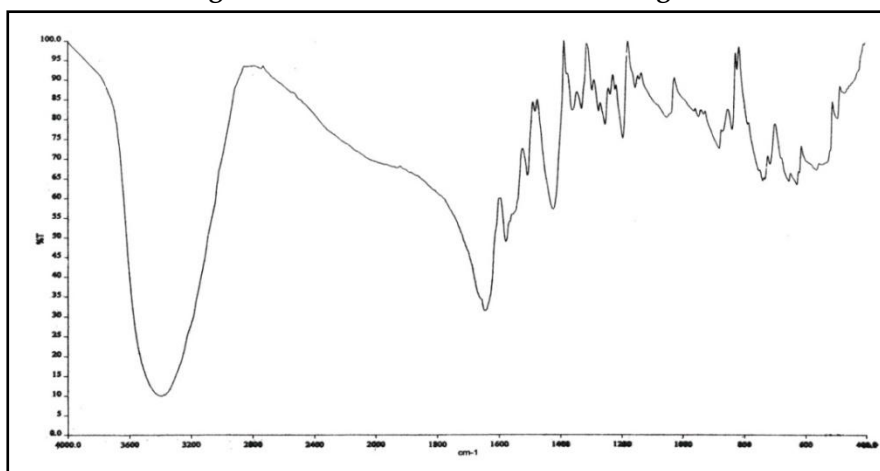


Fig. 3: FTIR SPECTRUM OF AMPDTC -Mn Complex

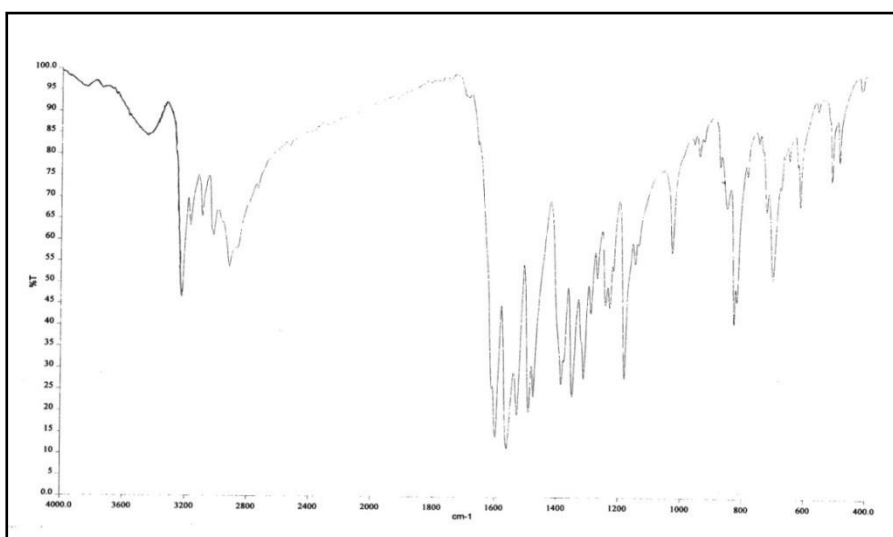


Fig. 4: FTIR SPECTRUM OF AMPDTC -Fe Complex

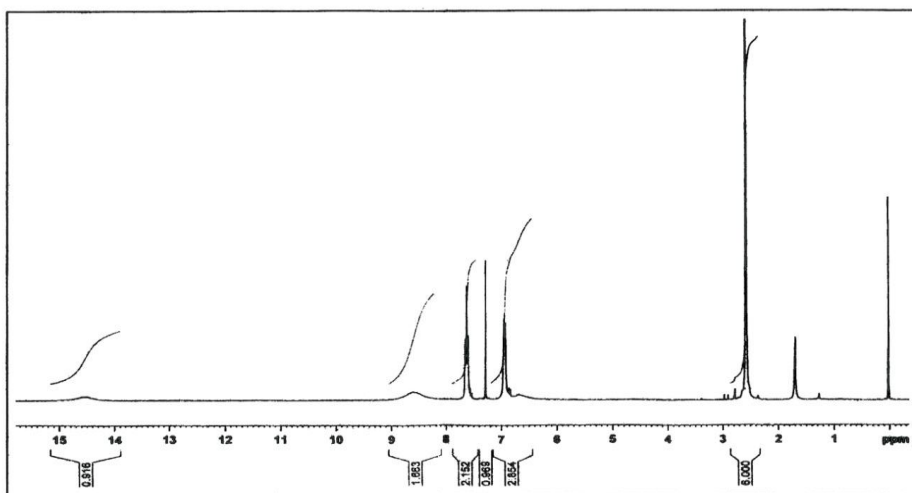


Fig. 5: NMR SPECTRUM OF AMPDTC Ligand

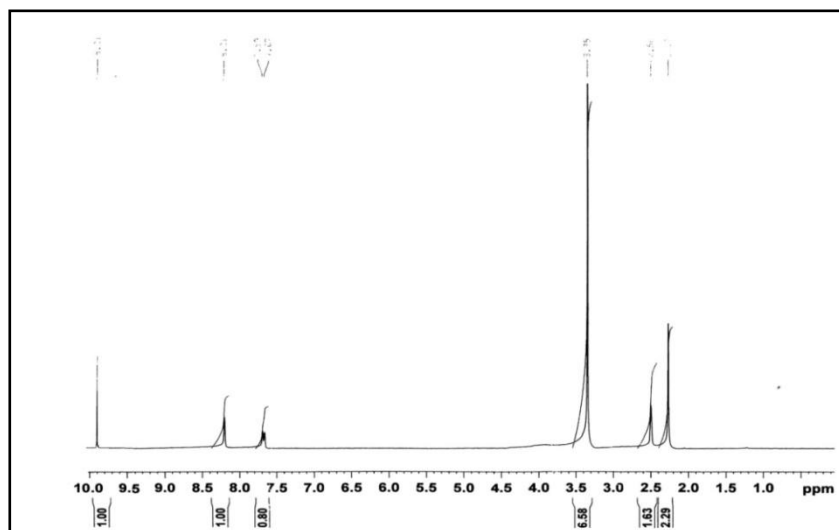


Fig. 6: NMR Spectrum of AMPDTC-Mn Complex

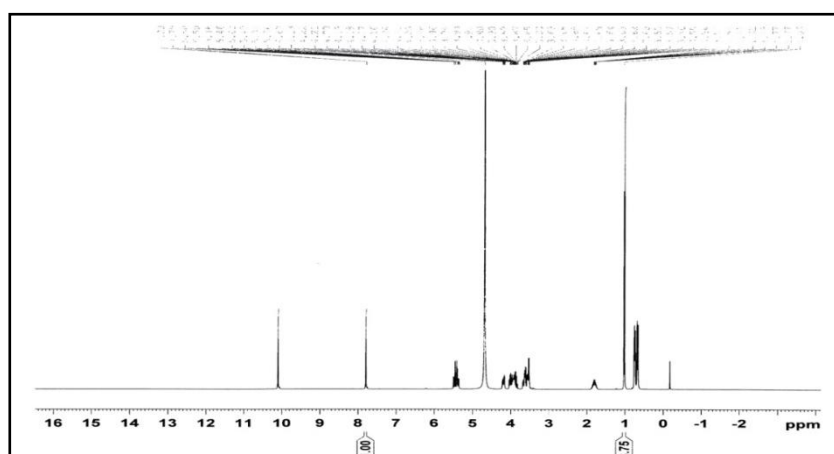


Fig. 7: NMR Spectrum of AMPDTC-Fe Complex

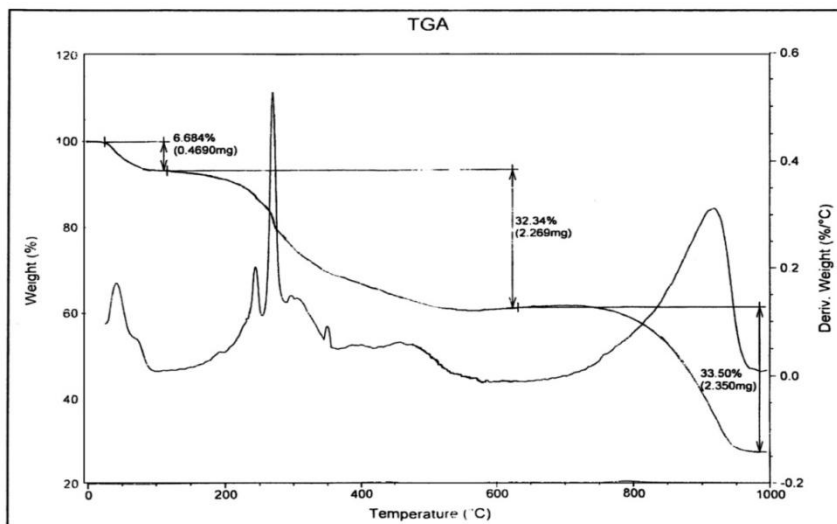


Fig. 8: TGA&DTA SPECTRUM OF AMPDTC-Mn Complex

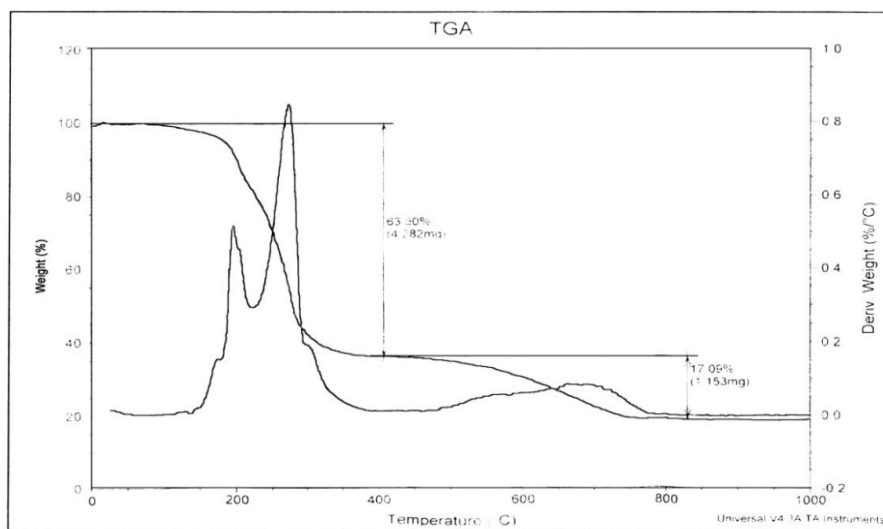


Fig. 9: TGA&DTA SPECTRUM OF AMPDTC-Fe Complex

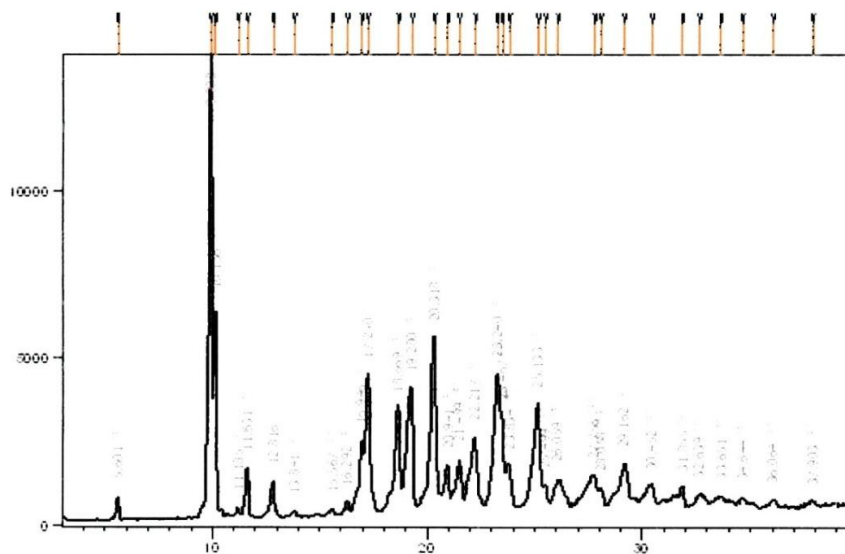


Fig. 10: PXRD SPECTRUM OF AMPDTC-Mn complex

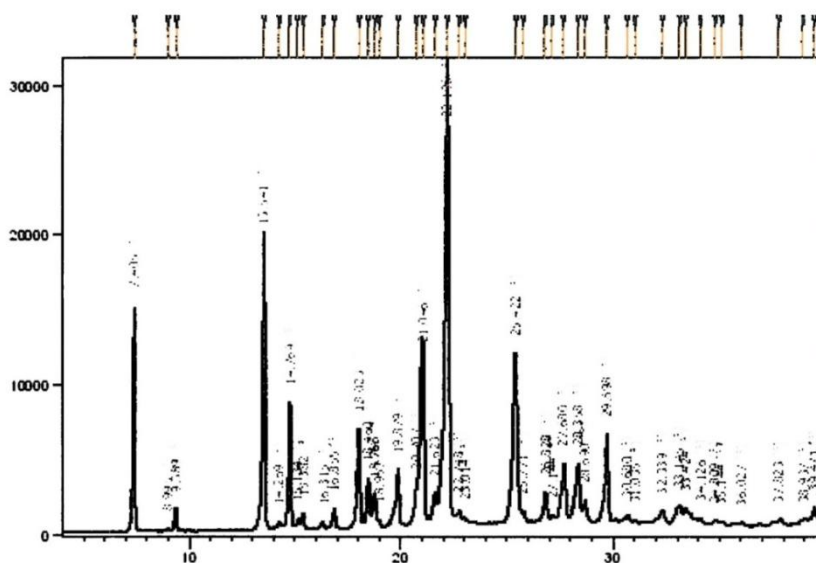


Fig. 11: PXRD SRECRUM OF AMPDTC-Fe complex

CONCLUSION

Finally basing at the above records it may be concluded that 2-amino 6-methyl pyridine dithiocarbamate ligand act as an excellent complexing agent in the direction of many transition steel ions. By the use of above spectral research it is miles concluded that they behave as bidentate throughout complexation. All the steel complexes deliver no fee and are thermally stable. As such no unmarried method is impartial of predicting very last systems of the complexes, the complete record to be had from all of the research is clubbed collectively and tentative systems of the complexes below research have been formulated as follows Table 9.

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REFERENCES

- [1] G. Hogarth. (2012). "Metal-dithiocarbamate complexes: chemistry and biological activity," *Mini-Reviews in Medicinal Chemistry*, vol. 12, no. 12, pp. 1202–1215.
- [2] L.A. Ramos and E.T.G. Cavalheiro. (2013). "Preparation, characterization and thermal decomposition of sodium and potassium salts of dithiocarbamate," *Brazilian Journal of Thermal Analysis*, vol. 2, no. 1, pp. 38–44.
- [3] M. Tarique and M. Aslam. (2009). "Physico-chemical study of complexes of some 3d-series transition metals with piperazine 1, 4-dicarbodithioate," *Oriental Journal of Chemistry*, vol. 25, pp. 207–210.
- [4] N. F. Kamaludin., N. Awang., I. Baba, A. Hamid., and C. K. Meng. (2013). "Synthesis, characterization and crystal structure of organotin(IV) N-butyl-N-phenyldithiocarbamate compounds and their cytotoxicity in human leukemia cell lines," *Pakistan Journal of Biological Sciences*, vol. 16, no. 1, pp. 12–21.

- [5] S. B. Kaila, M. R. Kumar, and A. Thakur. (2012). "Synthesis and physico-chemical investigations on some bis (Carbodi- thioato) Nitrosyl complexes of cobalt (I)," *IOSR Journal of Applied Chemistry*, vol. 1, no. 3, pp. 1–9.
- [6] M. Monim-ul-Mehboob, T. Ruffer, H. Langetal. (2018). "Synthesis, crystal structure and DFT calculations of a cyanido-bridged dinuclear zinc(II) complex of cis -1,2-diaminocyclohexane (Dach) containing a dinuclear cyanidozincate(II) anion, $[Zn_2(Dach)_4(CN)]_2[Zn_2(CN)_7]2CH_3OH$," *Journal of Molecular Structure*, vol. 1169, pp. 110–118.
- [7] M. Rajarajan. (2013). "Synthesis, characterization and biological evaluation of Hg(II), Cu(II), Ni(II), Co(II), and Zn(II) di-thiocarbamate complexes," *Novus International Journal of Chemistry*, vol. 2, no. 1, pp. 1–6.
- [8] A. F. A. Muthalib, I. Baba, Y. Farina, and M. W. Samsudin. (2011). "Synthesis and characterization of diphenyltin(IV) di- thiocarbamate compounds," *Malaysian Journal of Analytical Sciences*, vol. 15, no. 1, pp. 106–112.
- [9] B. A. Prakasam, M. Lahtinen, A. Peuronen et al. (2016). "Synthesis, NMR spectral and structural studies on mixed ligand complexes of Pd(II) dithiocarbamates: first structural report on palladium(II) dithiocarbamate with SCN–ligand," *Journal of Molecular Structure*, vol. 1108, pp. 195–202.
- [10] G. Gomathi, E. Sathiyaraj, S. Thirumaran, and S. Ciattini. (2016). "Effect of functionlization of N,N-dibenzyl dithiocarbamate: synthesis, spectral and structural studies on bis(N-benzyl-N-(4-methoxybenzyl)dithiocarbamate-S,S')zinc(II) and bis(N-benzyl-N-(4-cholrobenzyl)dithiocarbamate-S,S')cadmiu- m(II) and their use for the preparation of MS (M Zn, Cd)," *Journal of Sulfur Chemistry*, vol. 37, no. 1, pp. 23–36.
- [11] H. Nabipour. (2011). "Synthesis of a new dithiocarbamate cobalt complex and its nanoparticles with the study of their bi- ological properties," *International Journal of Nano Di- mension*, vol. 1, no. 3, pp. 225–232.
- [12] J. S. J. Hargreaves. (2016). "Some considerations related to the use of the scherrer equation in powder X-ray diffraction as applied to heterogeneous catalysts," *Catalysis, Structure and Re- activity*, vol. 2, no. 1–4, pp. 33–37.
- [13] R. Ghorbani-Vaghei., M. Amiri., and H. Veisi. (2012). "A new and facile protocol for the synthesis of dithiocarbamate-linked 3, 4-dihydro-2H-pyran using N-halo catalysts under mild conditions reaction," *Bulletin of the Korean Chemical Society*, vol. 33, no. 12, pp. 4047–4051.
- [14] S. Z. Khan, M. K. Amir, I. Ullah et al. (2016). "New heteroleptic palladium (II) dithiocarbamates: synthesis, characterization, packing and anticancer activity against five different cancer celllines," *Applied Organometallic Chemistry*, vol. 30, no. 6, pp. 392–398.
- [15] A. L. Niles, R. A. Moravec, and T. L. Riss. (2009). "In vitro viability and cytotoxicity testing and same-well multi-parametric combinations for high throughput screening," *Current Chemical Genomics*, vol. 3, pp. 33–41.

ABSTRACT

Nanotechnology (NT) has a remarkable perspective to modernize agriculture science and agricultural-based industries including farming, food and seed production, food borne pathogen detection, and fisheries/aquaculture. It has evolved as a tool utilizing nano-scaled nano-materials (NMs) or particles (NPs) for the improvement of biotechnology, genetics, disease diagnosis, and health improvement. Nanotechnology includes nano-materials, nano-sensors, nano-capsule, nano-vaccines (DNA/RNA), gene delivery, drug delivery, and nano-pharmaceuticals have the prospective in the agricultural field, which directly may lead to sustainability and availability of food resources. Nanotechnology emerges as a science in the year 1974. Present work reviewed and summarized the potential of nanotechnology and nanomaterial for their practices in the agricultural and food industry.

KEYWORDS: Nano-scale, Food, Agriculture, Nutrition

INTRODUCTION

Nanotechnology is an advanced field of science utilizing nanoscale particles to manipulate substances for the amelioration of fertilizers, pesticides, herbicides, and growth promoters and regulators. In 1974, Norio Taniguchi coined the term 'nano-technology' and defined as "nano-technology mainly consists of the processing of separation, consolidation, and deformation of materials by one atom or one molecule" [1]. Nano-technology is extensively emerging technology that influences several trait of the agriculture industry from crop growing to harvesting including produce processing, packing, to enhance adequate shelf-life, and nutrients bio-accessibility [2]. Nano-particles can function as 'magic bullets', encompassing active compounds like herbicides, chemicals, or genes, to discharge their slow and constant release and action at target specific plant or animal parts [3]. Nano-materials like silica, gold, silver, nano clays, and titanium dioxide were implying to enhance the productivity of crops via increased efficacy of agricultural input, thereby also ensuring the minimal usage of agri-inputs.

American Society for Testing and Materials (ASTM) under Astm E2456 - 06, (2012) standard defined Nano-materials (NMs) as natural or synthetic materials, usually 1 and 100 nm, nano-size particles having a high surface-area-to-volume (SA:V) ratio [4]. NMs have distinctive and nifty physical and chemical properties, which increase their worthy in several different fields, viz life science, computer electronics, and biochemical industrial [5].

In India, Nanoscience and Technology Mission (NSTM) begin in the year 2007 with an allocation of 100 crore rupees in five years plan in the Department of Science and Technology (DST). Department of Science and Technology (DST) is the nodal agency for implementing the "Nano Mission" and several other institutes in India are also actively involved in Nanotechnology science (Fig. 1). DST had also

launched a Nano Science and Technology programme called the Nano Science and Technology Initiative (NSTI) and the Nano Mission is the descendant of this programme. According to ASSOCHAM, India ranks 3rd in the field of nano-technology research and development, after China and USA.

In the last two decades, a noteworthy development and expansion was seen on nano-technology based activities with its numerous applications in the field of agronomy and husbandry [6–8]. Nanotechnology has the prospective to deliver effective benefits and remedies to multiple agriculture-related difficulties.

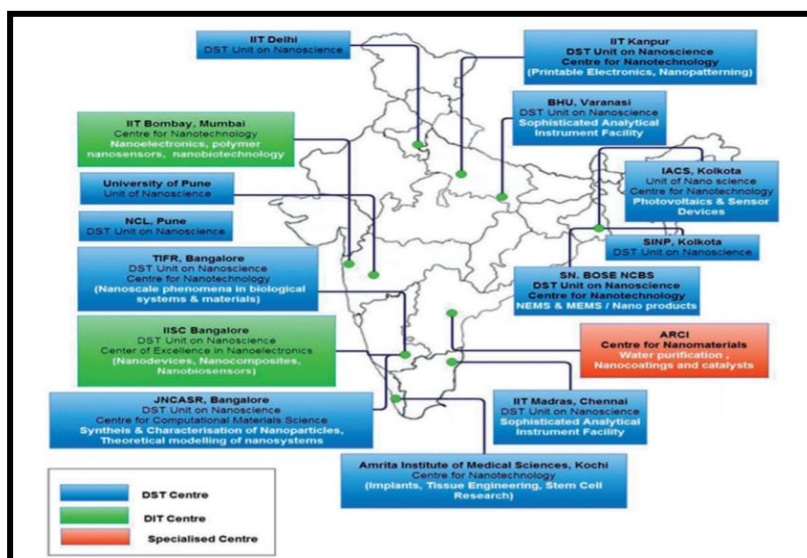


Fig. 1: Nanotechnology centers In India
(Source: DST; dst.gov.in/scientific-programme/ser.nsti.htm)

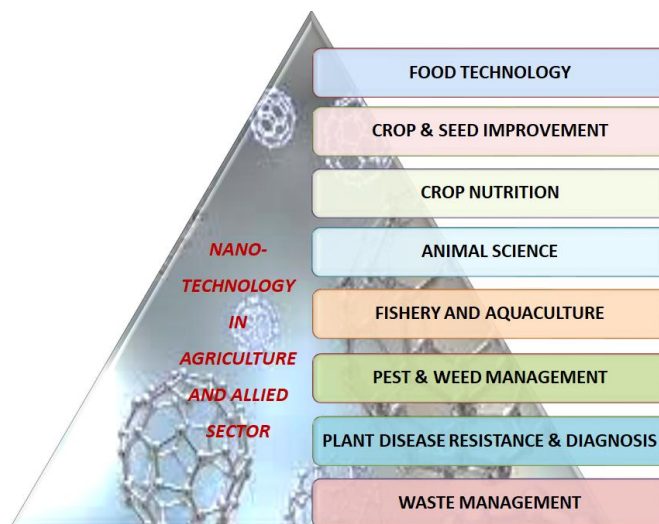


Fig. 2: Nanotechnology in various agriculture and allied sector

NANOTECHNOLOGY IN THE FOOD INDUSTRY

Several nanomaterials implemented in different fields of the food industry including food pathobiology, processing, formulation, packaging, uncovering and detecting food borne pathogens, and preservation to extend shelf-life of food and related foodstuffs. Thus, utilization of nanomaterial provides advantages in Food nanostructured for food processing to food canning and Nano-sensing of foodstuffs for good food quality and food security assessment [9]. Chitosan/ nano silica coatings [10, 11] are nano-edible coatings

used to increase the freshness and preservation of food items. Nano-based “smart” and “active” food packaging techniques like antimicrobial food packaging, nanocomposite and nano laminate (clay, silicate nano platelets, silica (SiO₂) nanoparticles, chitin or chitosan) for preservation and extending food shelf-life [2, 12, 13]. Nano-based packing for antimicrobial effects involves the improvement of mechanical and barrier properties along with traceability and bio sensing. Nano biosensors are used to detect certain chemicals, microbes, and toxins, thereby providing a real-time status about food [14]. Carbon-coated copper nanoparticles are developed and used as a moisture sensor [15]. Thus nanotechnology help in the improvement of organoleptic characteristics, increases bioavailability and absorption rate and add or increase taste and flavour to food. Bioavailability of micronutrients, (vitamin B12, vitamin A, folic acid and iron) in food items [16].

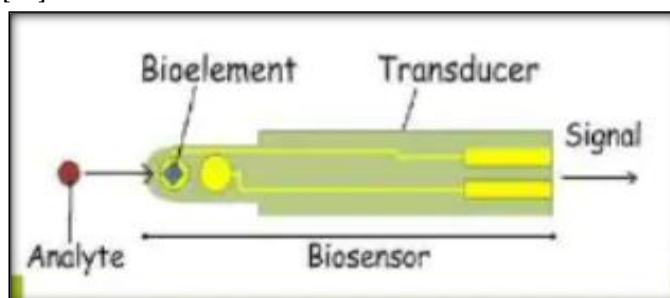


Fig. 3: Biosensor (Google open source)

NANOTECHNOLOGY IN AGRICULTURE, CROP, AND SEED IMPROVEMENT

Gene-based nano-transfer method is applied for agriculture and crop enhancement. Nano-pesticides (NPs) are effectively implies for plant/crop protection. The uses of nano-sensors and electronic based monitoring systems significantly helpful in precision farming. Nano-materials (NMs) are likewise suggested for increasing and stimulate stress tolerance in plant against environmental stressors and soil nutritional enhancement. Bio plastic or nano-material infused with plant beneficial microbes or spores such as plant growth promoting (PGP) microbiota, rhizobia, ectomycorrhizal fungi (AM), and *Trichoderma harzianum* are used to stimulate significant plant growth and nutrition and increase plant yield. Different nanoparticle-formulations based, comprising nano-emulsified based pesticides, herbicides, manures, and biosensors, have been extensively examined for plant protection, pest resistance, and soil enhancement. Nano-agrochemicals (Chitosan hydrogel, bifenthrin nanosphere, neonicotinoid, etc.) are utilized for agronomic and crop augmentations; application of nano-sensors/nano-biosensors in crop fortification from diseases; nanodevices for genetic manipulation [17].

Antimicrobial Nano Emulsions are used for decontamination of food equipment and food packaging. Bio-Indicators are employed to detect the bio-magnification due to pesticides and fertilizers. Anti-bacterial Silver Nano-Particles are used to enhancing the life span of agronomic produce.

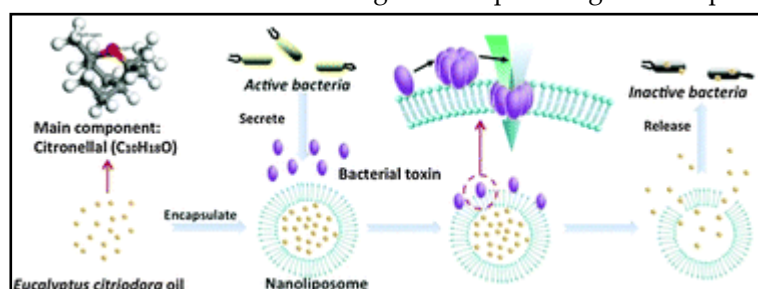


Fig. 4: Nanoliposomes containing antibiotic Eucalyptus citriodora shows antimicrobial activity (Lin *et al.*, 2014)

NANOTECHNOLOGY IN FISHERIES AND AQUACULTURE

Nanomaterials are applied to various aspects in aquacultural activities viz. pond sterilization, treatment of water, uncovering and monitoring of freshwater and marine diseases, effective transfer of hormones, nutrients, and drugs/vaccines to boost aquaculture production [18, 19]. According to the Russian Academy of Science, the growth of young carps and sturgeon can be increased to 30% when fed with iron nanoparticles. Similarly, Nano Check a 40 nm lanthanum-based compound helps in the absorption of phosphates from water and prevents algal growth. Several studies documented the use of titanium dioxide (TiO₂) based photocatalyst agents for the pathogens (microorganisms) inactivation [20, 21, 22]. Nano net are employed to reduction in mortality rate and ensure 100% survival rate of fishes. Additionally, they are also supportive to drop nitrite and nitrate levels in water and improve the water quality [23]. Nano-based photocatalytic adsorbents and hydrogel bio films are broadly used in water purification free fluoride, nitrate, and E. coli from the polluted water. Magnetic konjac glucomannan (KGM) aero gels are developed to decontaminate water from arsenite. The global use of graphene and graphene oxide (GO) as these nano-materials plays role in eliminating several categories of impurities from water [24, 25, 26].

Nanoparticles (like chitosan and poly-lactide-co-glycoside acid along with mild inflammatory inducers are used and applied for the fishes and shellfishes protection against bacterial and viral diseases. Recombinant DNA based development of chitosan nano-particles showed and used against white spot syndrome virus (WSSV) in shrimps defence. Recently, RNA interference (RNAi) nanomaterial was used for the down-regulation genes diagnosis and protection of *Penaeus vannamei* against white spot syndrome virus (WSSV) [27, 28].

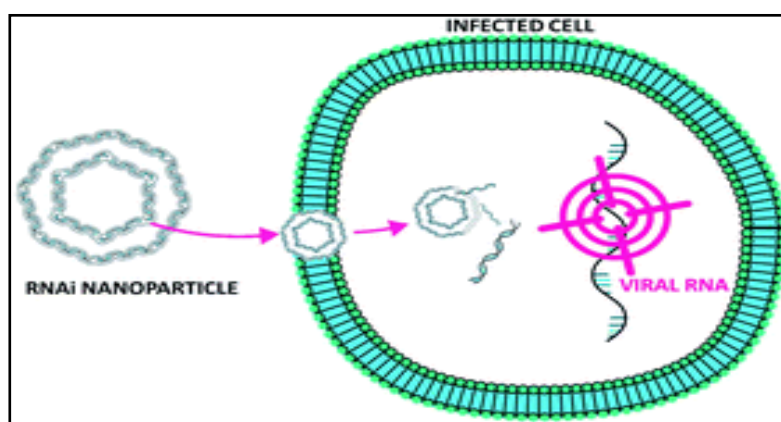


Fig. 5: RNA interference (RNAi) nanomaterials
(Source - Ufaz *et al.*, 2018 [28])

The addition of Nano-Selenium (Nano-Se) or selano methionine and Glutathione peroxidase (GSH-Px) supplemented dietary feed are also experimentally proven for fish (crucian carp) weight and growth status.

Nano-barcoding and tagging are developed as a monitoring system for coding details of aquatic products processing industry and export.

Nano micelles, liposomes, nano-emulsions complexes improve the utilization efficiency of nutrients in the fodder.

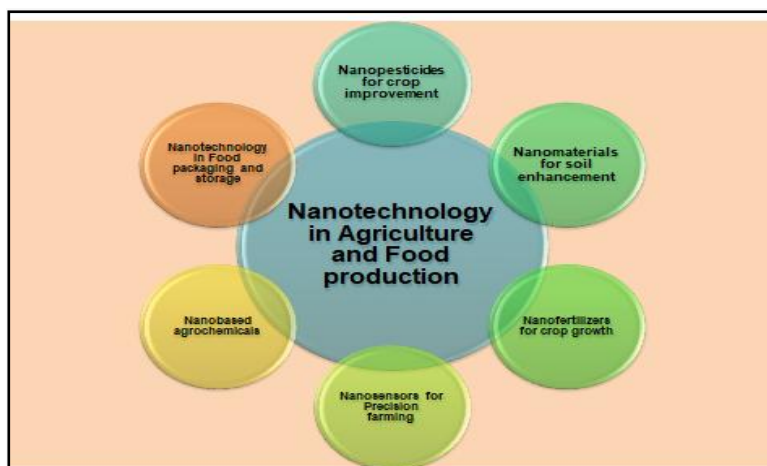


Fig. 6: Application of nanotechnology in different fields of agriculture

NANOPARTICLES AND THEIR ROLE

- **Carbon nanomaterial-** graphene, graphene oxide, carbon dots, and fullerenes are used for enhanced and enrichment of seed germination. Graphene nanotubes or nanomaterials (GNs) are characterized as single- or multi-walled nanotubes (SWNTs or MWNTSs). Recently quantum dots (QDs) or fluorescent labelled NPs are used for plant protein labelling [29, 30, 31]. Graphene is used in agriculture as a plant growth stimulator, can increase germination rates, and is a component of fertilizers [32, 33, 34]. Minimal graphene concentrations also enhanced the seed germination in tomato seeds [35].
- **Nanorods (NRs)** – Gold nanorods are used for the transportation of auxin based growth regulator (2, 4-D) employed to promote cell growth in tobacco (*Nicotiana tabacum*) plant tissue culture [36]. Similarly, gold nanorods were also helpful in physiological changes and phytotoxicity activities in plants [37].
- **Nanoencapsulation** - emerges as a protective method as it involves encapsulation of any drugs/substance within a homogeneous or heterogeneous capsule. This is useful for the precision and controlled distribution of any drug/substance for protecting against adverse and abrupt environmental changes [38, 39]. Encapsulation varies at two levels or types based on their size i.e. macro-encapsulation, and micro-encapsulation. Nan capsule (NCs) are organic, inorganic and biologically active components and with a size of <200 nm. Having a core filled with oil and surrounded by a shell. The cavity is either empty or filled with polar or non polar solvent.

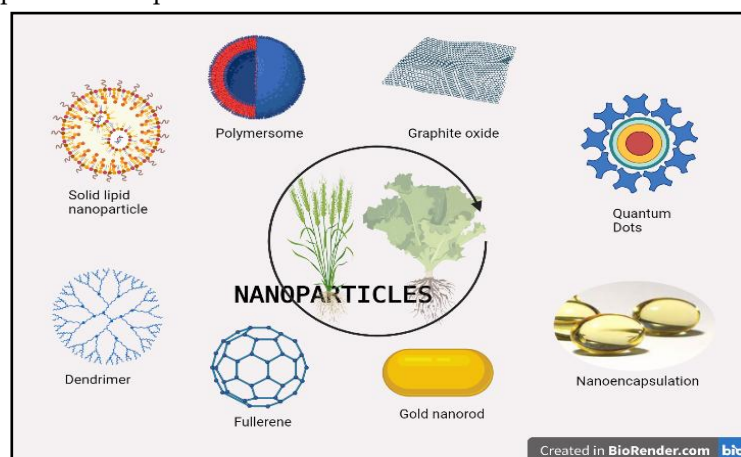


Fig. 7: Different Nanoparticles

CONCLUSION

Potential utilization of nanomaterials and nanoparticles is involved in several benefits to the agronomical development of society, farmers, leading to the sustainable development of agriculture. Few benefits are stated below:

- Improvement and enhancement of agriculture and crop production
- Improvement in foods packaging and shelf life longevity
- Improvement in the precision disease detection and drug delivery
- It helps risk-free nutritional additives to combat malnutrition.
- Green nano-based applications are helpful in water and soil purification both at the quality and quantity levels.

Regardless of the advantages of Nano based technology in various aspects of agronomy, there are always hidden obstacles related to the cost and commercialization, and concerns safety issues involving the public, environment, and health.

REFERENCES

- [1] Taniguchi N., Arakawa C., Kobayashi T. (1974). On the basic concept of nano-technology; Proceedings of the International Conference on Production Engineering; Tokyo, Japan. 26–29.
- [2] Duncan, T.V. (2011). Applications of nanotechnology in food packaging and food safety: barrier materials, antimicrobials and sensors. *Curr. Opin. Colloid Interface Sci.* 363, 1–24 <https://doi.org/10.1016/J.JCIS.2011.07.017>.
- [3] Perea-de-Lugue, A., Rubiales, D. (2009). Nanotechnology for Parasitic Plant Control. *Pest Management Science Journal.* 65(5):540-5. DOI: 10.1002/ps.1732.
- [4] Roduner, E. (2006). Size matters: why nanomaterials are different. *Chem. Soc. Rev.* 35, 583–592. doi: 10.1039/b502142c
- [5] Jeevanandam, J., Barhoum, A., Chan, Y. S., Dufresne, A., Danquah, M. K. (2018). Review on nanoparticles and nanostructured materials: history, sources, toxicity and regulations. *Beilstein J. Nanotechnol.* 9, 1050–1074. Doi: 10.3762/bjnano.9.98.
- [6] Lv, M., Liu, Y., Gang, J.H., Kou, X.H., Xin, Z.H., Yang, D.Y. (2018) Engineering nanomaterials-based biosensors for food safety detection. *Biosens. Bioelectron.* 106, 122–128.
- [7] Chen, Y.W., Lee, H.V., Juan, J.C., Phang, S.M. (2016) Production of new cellulose nanomaterial from red algae marine biomass *Gelidium elegans*. *Carbohydr. Polym.* 151, 1210–1219.
- [8] Prasad, R., Bhattacharyya, A., Nguyen, Q.D. (2017) Nanotechnology in sustainable agriculture: Recent developments, challenges, and perspectives. *Front. Microbiol.* 8, 1014, doi:10.3389/fmicb.2017.01014.
- [9] Ezhilarasi, P. N., Karthik, P., Chhanwal, N., and Anandharamakrishnan, C. (2013). Nanoencapsulation techniques for food bioactive components: a review. *Food Bioprocess Technol.* 6, 628–647. Doi: 10.1007/s11947-012-0944-0.
- [10] Shi, S., Wang, W., Liu, L., Wu, S., Wei, Y., and Li, W. (2013). Effect of chitosan/nano-silica coating on the physicochemical characteristics of longan fruit under ambient temperature. *J. Food Eng.* 118, 125–131. doi: 10.1016/j.jfoodeng.2013.03.029
- [11] Yu, Y., Zhang, S., Ren, Y., Li, H., Zhang, X., and Di, J. (2012). Jujube preservation using chitosan film with nano-silicon dioxide. *J. Food Eng.* 113, 408–414. Doi: 10.1016/j.jfoodeng.2012.06.021.

- [12] Singh, T., Shukla, S., Kumar, P., Wahla, V., & Bajpai, V. K. (2017). Application of Nanotechnology in Food Science: Perception and Overview. *Frontiers in microbiology*, 8, 1501. <https://doi.org/10.3389/fmicb.2017.01501>.
- [13] Othman, S. H. (2014). Bio-nanocomposite materials for food packaging applications: types of biopolymer and nano-sized filler. *Agric. Agric. Sci. Proc.* 2, 296–303. Doi: 10.1016/j.aaspro.2014.11.042.
- [14] Mustafa, F., Andreescu, S. (2018) Chemical and biological sensors for food-quality monitoring and smart packaging, *Foods*, 7(10) 168.
- [15] Athanassiou, E. K., Grass, R.N., Stark, W.J. (2006) Large-scale production of carbon-coated copper nanoparticles for sensor applications. *Nanotechnology*.28; 17(6):1668-73. Doi: 10.1088/0957-4484/17/6/022.
- [16] Arshad, R., Gulshad, L., Haq, I. U., Farooq, M. A., Al-Farga, A., Siddique, R., Manzoor, M. F., & Karrar, E. (2021). Nanotechnology: A novel tool to enhance the bioavailability of micronutrients. *Food science & nutrition*, 9(6), 3354–3361. <https://doi.org/10.1002/fsn3.2311>.
- [17] Sekhon, B.S. (2014) Nanotechnology in Agri-Food Production: An Overview. *Nanotechnology Science and Applications*, 7, 31-53. <https://doi.org/10.2147/NSA.S39406>.
- [18] Bhattacharyya A., Janardana Reddy S, Mahbub Hasan M, Adeyemi M, Regina Mary R, Naika HR (2015) Nanotechnology: a unique future technology in aquaculture for food security. *International Journal of Bioassay* 04: 4115– 4416.
- [19] Huang, S., Wang, L., Liu, L., Hou, Y., Li, L. (2015) Nanotechnology in agriculture, livestock, and aquaculture in China. A review. *Agronomy for Sustainable Development* 35: 369– 400.
- [20] Hu, C., Lan, Y., Qu, J., Hu, X., Wang, A. (2006) Ag/AgBr/TiO₂ visible light photocatalyst for destruction of azodyes and bacteria. *The Journal of Physical Chemistry B* 110: 4066– 4072.
- [21] Ouyang, K., Dai, K., Walker, S.L., Huang, Q., Yin, X., CAI, P. (2016). Efficient photocatalytic disinfection of *Escherichia coli* O157: H7 using C 70-TiO₂ hybrid under visible light irradiation. *Scientific reports* 6: 25702.
- [22] Park, J., Kettleson, E., An, W-J., Tang, Y,, Biswas, P, (2013) Inactivation of *E. coli* in water using photocatalytic, nanostructured films synthesized by aerosol routes. *Catalysts* 3: 247– 260.
- [23] Liu A, Cao Y, Dai M, Liao ZW (2008) Nanomaterial application in carp aquiculture experiment. *Fish Modernization* 2: 24– 27.
- [24] Motamedi, E., Talebi Atouei, M., Kassae, M.Z. (2014) Comparison of nitrate removal from water via graphene oxide coated Fe, Ni and Co nanoparticles. *Materials Research Bulletin* 54: 34– 40.
- [25] Kuang, L., Liu, Y., Fu, D., Zhao, Y. (2017) FeOOH-graphene oxide nanocomposites for fluoride removal from water: Acetate mediated nano FeOOH growth and adsorption mechanism. *Journal of Colloid and Interface Science* 490: 259– 269.
- [26] Liu L, Cui Z, Ma Q, Cui W, Zhang X (2016) One-step synthesis of magnetic iron–aluminum oxide/graphene oxide nanoparticles as a selective adsorbent for fluoride removal from aqueous solution. *RSC Advances* 6: 10783– 10791.
- [27] Zhu, F., Zhang, X. (2012). Protection of shrimp against white spot syndrome virus (WSSV) with β -1,3-D-glucan-encapsulated vp28-siRNA particles. *Mar Biotechnol (NY)*.14(1):63-68. Doi: 10.1007/s10126-011-9387-2.
- [28] Ufaz, S., Balter, A., Tzror, C., Einbender, S., Koshet, O., Shainsky-Roitman, J., Yaari, Z.A., & Schroeder, A. (2018). Anti-viral RNAi nanoparticles protect shrimp against white spot disease. *Mol. Syst. Des. Eng.*, 2018, 3, 38-48.

- [29] Pyrzynska, K. (2011). Carbon nanotubes as sorbents in the analysis of pesticides. *Chemosphere* 83, 1407–1413.
- [30] Chahine, N. O., Collette, N. M., Thomas, B. C., Genetos, D. C., and Loots, G. G. (2014). Nanocomposite scaffold for chondrocyte growth and cartilage tissue engineering: effects of carbon nanotube surface functionalization. *Tissue engineering Part A*. 20, 2305–2315. doi: 10.1089/ten.TEA.2013.0328.
- [31] Prasad, R., Bhattacharyya, A., Nguyen, Q.D. (2017). Nanotechnology in Sustainable Agriculture: Recent Developments, Challenges, and Perspectives. *Frontiers in Microbiology*20; 8:1014. Doi: 10.3389/fmicb.2017.01014.
- [32] Cheng, F., Liu, Y. F., Lu, G. Y., Zhang, X. K., Xie, L. L., Yuan, C. F., Xu, B. B. (2016). Graphene oxide modulates root growth of *Brassica napus* L. and regulates ABA and IAA concentration. *Journal of Plant Physiology*, 193, 57-63. <https://doi.org/10.1016/j.jplph.2016.02.011>
- [33] Shen, S., Liu, Y., Wang, F., Yao, G., Xie, L., Xu, B. (2019). Graphene Oxide Regulates Root Development and Influences IAA Concentration in Rice. *Journal of Plant Growth Regulation*, 38, 241-248. <https://doi.org/10.1007/s00344-018-9836-5>
- [34] Zaytseva, O., Neumann, G. (2016). Carbon nanomaterials: Production, impact on plant development, agricultural and environmental applications. *Chemical and Biological Technologies in Agriculture*, 3(1), 1–26. <https://doi.org/10.1186/s40538-016-0070-8>.
- [35] Zhang, M., Gao, B., Chen, J., Li, Y. (2015). Effects of graphene on seed germination and seedling growth. *Journal of Nanoparticle Research*, 8(8387), 1-14. <https://doi.org/10.1007/s11051-015-2885-9>.
- [36] Wan, Y., Li, J., Ren, H., Huang, J., and Yuan, H. (2014). Physiological investigation of gold nanorods toward watermelon. *Journal of Nanoscience and Nanotechnology*. 14, 6089–6094. Doi: 10.1166/jnn.2014.8853.
- [37] Nima, A. Z., Lahiani, M. H., Watanabe, F., Xu, Y., Khodakovskaya, M. V., Biris, A. S. (2014). Plasmonically active nanorods for delivery of bio-active agents and high-sensitivity SERS detection in planta. *RSC Advances*. 4, 64985–64993. Doi: 10.1039/C4RA10358K.
- [38] Ezhilarasi, P. N., Karthik, P., Chhanwal, N., Anandharamkrishnan, C. (2012). Nanoencapsulation techniques for food bioactive components: a Review. *Food Bioprocess Technol*. 6, 628–647. Doi: 10.1007/s11947-012-0944-0.
- [39] Ozdemir, M., Kemerli, T. (2016). Innovative applications of micro and nanoencapsulation in food packaging, in *Encapsulation and Controlled Release Technologies in Food Systems*, ed. J. M. Lakkis (Chichester: John Wiley & Sons, Ltd).
- [40] Adapted from “Figure 5 Different Nanoparticles”, by BioRender.com (2021). Retrieved from <https://app.biorender.com/biorender-templates>

ABSTRACT

Bio-synthesis of Nanoparticles through various plant materials is also known as green technology which comprises non-involvement of harmful chemicals. The current analysis reported that the *Achyranthes aspera* plant extract is used for the preparation of silver-nanoparticles (SNPs). These SNPs are embedded with chitosan (CS) bio-polymer, which is useful to protect the accumulation of nanoparticles. The membrane (SNP-CS) is characterized by FT-IR, EDS, FESEM, XRD and UV-Visible. The presence of SNPs was confirmed through the images of the Field Emission Scanning Electron Microscope (FESEM), the average particle size 20nm and their crystal structure also estimated by using XRD. The relative absorbance of formed SNPs is shown between 425nm to 435nm in UV-VIS Spectroscopy. This novel technique provides a selective methodology for the removal of inorganic ions and has been satisfactorily applied to its quantification in parenteral solutions. This chapter provides the information about the film which has been shown to be effective for the detection and the removal of inorganic pollutants such as fluorides, phosphates, nitrites, thiocyanates from natural wastes and wastewaters within the response time of 2-3 sec.

KEYWORDS: SNP-CS, Fluorides, Phosphates, Nitrites, Thiocyanate ions

INTRODUCTION

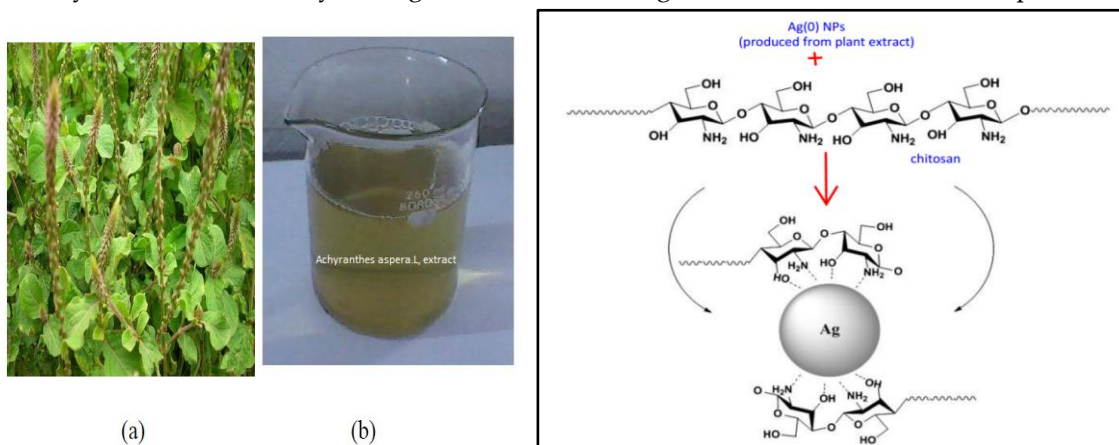
The water quality depends upon the analysis of their colour, odour and taste. The water-bodies like ponds, lakes and rivers are the most predominant source of people consuming drinking water. According to the enhancement of pollution in the environment due to the increasing population, the availability of surface water dwindles with time and most of it capitulates to severe pollution. The rapid industrialization and urbanization of the present human society which implies more contamination in water bodies and these contaminations including heavy metal ions, bacteria, organics, viruses and so on, such contamination is serious harmful to health of human-beings for example in Nalgonda District water contaminated with fluoride and nearly one lakh people-effect from fluorosis disease so that it is health effecting substance which is not a nutrient. The presence of fluoride concentration in ground water significantly varies from place to place, and it naturally occurs through rock and soil formation in the form of fluorspar, fluorapatite, amphiboles, geochemical deposit, natural water systems and earth crust. In addition to the fluoride can also be found in various industrial work, chiefly electroplating, glass, semiconductor, ceramic and fertilizer industries. In this area, fluoride impurity dissolved in water bodies due to anthropogenic activities like granite polishing, pharma-industrial effluents & other agricultural waste (pesticides).

Phosphorus is a nutrient required by all organisms for the basic processes of life, and also a natural element found in rocks soils and organic material. Phosphates are chemical compounds made from the elements phosphorous and oxygen. Phosphorus strongly adheres to soil cells and is used by plants, and its concentrations in pure water are usually very low. The low concentrations of phosphorous in water also known as phosphate which restricts the plant growth. The phosphate hugely dissolved in water through man-made causes like septic systems, laundries, industrial discharge fertilizer runoff and improperly treated waste water, moreover the increasing phosphates impact that the (Eutrophication) excess plant growth and decomposition. Suppose that large growth of algae (algal blooms) implies that they can severely reduce or eliminate oxygen in the water resulting to illness in fish and raising the death toll of fish. According to the EPA total phosphate should not exceed 0.05mg L⁻¹ in a stream where it enters to lake or reservoir. Similarly another pollutant Nitrite widely exists in ground and surface water systems as a consequence of agricultural activity, improper human and animal waste disposal. According to the Environmental protect agency (EPA) the Maximum Contaminant Level (MCL) for nitrite measured as nitrogen in drinking water is 1 milligram per litre (parts per mil-lion). Even trace amounts of nitrite ions are unsafe to human health, due to their potential toxicity.

SCN⁻ is another pollutant which is a metabolite of cyanide detoxification, a toxic substance with similar toxicity that has foremost attention of researchers in various fields such as medicine, food chemistry and ecology. Thiocyanate generally exists in industrial effluents, pesticides and organism metabolites. Low concentrated Thiocyanate present in human serum, saliva and urine, and its toxicity causes anorexia, fatigue and mental status changes including psychosis, seizures, weakness, tinnitus and hyper-reflexia. So that novel materials (with high sensitivity and efficiency) are essential for the removal of these pollutants in the water systems.

METHODS

Preparation of SNP-CS film: 2 g CS was dissolved in 200 ml 2% (V/V) acetic acid solution under magnetic stirring. When the solution became clear, silver nanoparticles, Chitosan solutions were mixed in 2:3 ratios. Finally, films were made by casting the solution on the glass slides, dried at room temperature.



**Fig. 1: (a) Leaves of Achyranthes aspera
(b) Photograph of aqueous extract of achyranthes aspera solution**

EFFECT OF REACTION DURATION

The formation of silver nanoparticles (SNPs) was evidenced with the change in colour of the solution from colourless to light yellowish colour. The formation of silver nanoparticles was monitored through

UV-VIS spectrophotometer at different time intervals. The spectrum obtained at 90 min shows the absorption maximum at 437nm. The intensity of the peak increases gradually with increase of time. The position of the peak is stable up to 24hrs. Now these nanoparticles can be embedded in chitosan to produce SNP-CS for further application.

RESULTS AND DISCUSSION

FTIR SPECTRA OF CHITOSAN AND ITS DERIVATIVE SNP-CS

Perkin Elmer version 10.03.06, Spectrophotometer is used to record FTIR spectra of SNP-CS film. The spectral band for chitosan appear at 3,526 cm⁻¹ (axial OH group), 2,364 cm⁻¹ (CN asymmetric band stretching), 3,337 cm⁻¹ (N-H stretching), 1,754 cm⁻¹ (amide linkage), 1,523 cm⁻¹ (NH angular deformation in CONH plane), 1,673 cm⁻¹ (CO band stretching), 1,320 cm⁻¹ (CN band stretching, axial deformation of amino group) and 1,140- 1,026 cm⁻¹ (ether linkage, C-O-C band stretching). In SNP-CS, (Figure) shows bands are shifted to higher frequencies i.e., 3353.51 cm⁻¹ (overlap of O- H and N- H stretching vibrations), 2922.34 cm⁻¹ (C- H stretching), 1744.89 cm⁻¹, 1728.74 cm⁻¹ (-NH₂ bending in amide linkage), 1569.07 cm⁻¹, 1411.41 cm⁻¹, 1070.14 cm⁻¹, 649.17 cm⁻¹ [C-C, C-O (esters and ethers) and C-O (polyols)] more pronounced shift in the FTIR spectrum could be observed in the complexes (Figure inside). The major differences are: the peak at 3,526 cm⁻¹ corresponding to the stretching vibration of amino group (-NH₂) and hydroxyl group (-OH), shifted to lower frequency (3339 cm⁻¹), and the peak of 3339 cm⁻¹ becomes wider, which indicates hydrogen bonding is enhanced and may be explained as that the additive effect of water absorbed on the surface of SNP and the -OH group of CS. This suggests that SNPs were capped by the polymer. The polar groups O- H of polysaccharide have the good aptitude of coordination reaction with metal ions (e.g., with silver ions). When O-H groups and Ag ions form coordination bonds, the interactions among the resultant silver particles and oxygen atoms of O-H groups become stronger with increasing amount of silver. This can lead to analogous changes both in the positions and in the strengths of FTIR spectra of CS.

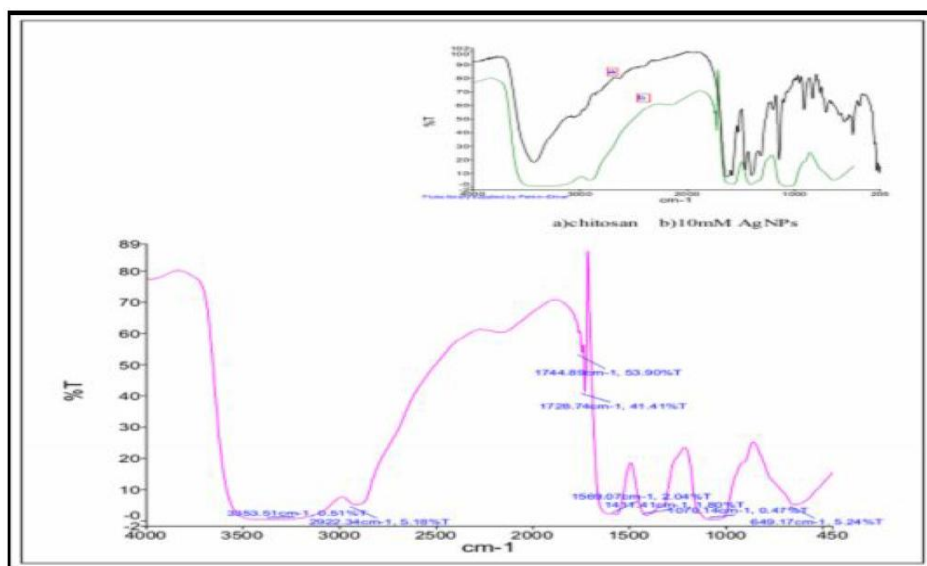


Fig. 2: FT-IR Spectra of SNP-CS membrane

XRD

X-ray diffractometer (PAN Analytical X' Pert, Almelo, The Netherlands) equipped with Ni filter and CuK α ($\lambda = 1.54056 \text{ \AA}$) radiation source is used to record XRD. The XRD pattern for SNPs synthesized

using natural plants extract is shown in the figure and the broad diffraction peaks around their bases indicating that the silver particles are in nanosized.

The mean particle diameter of SNPs was calculated from the XRD pattern according to the line width of the plane, refraction peak using the following Scherrer's equation: The equation uses the reference peak width at angle θ , where λ is the X-ray wavelength (1.5418 Å), β 1/2 is the width of the XRD peak at half height and K is a shape factor. The particle sizes of the samples in our study have been estimated by using the Scherrer's equation and were found to be ~17nm for the strongest peak.

$$D = K \lambda / \beta \cos \theta$$

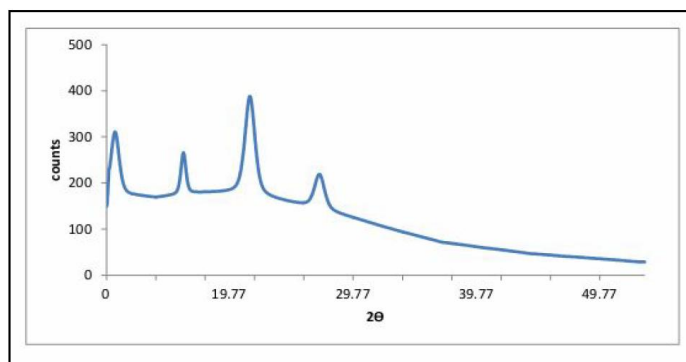


Fig. 3: XRD Spectra of SNP-CS membrane

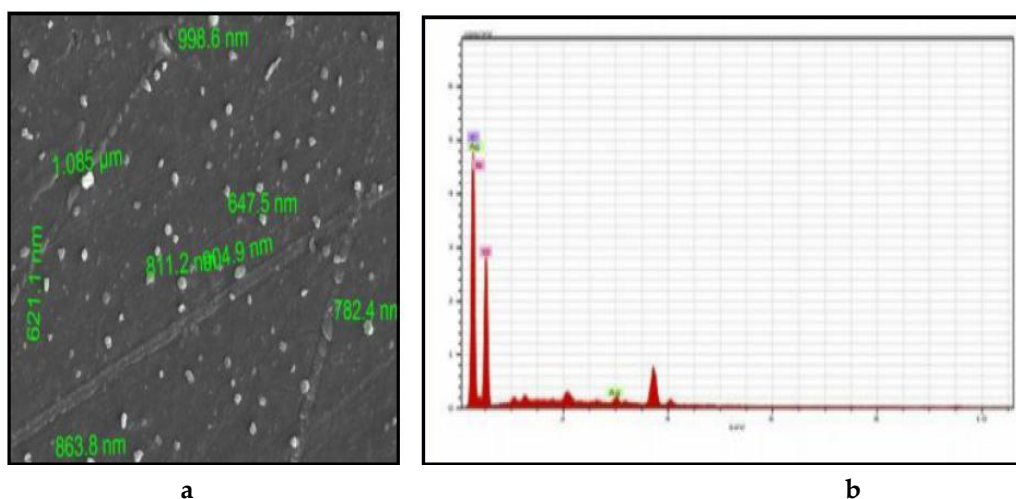
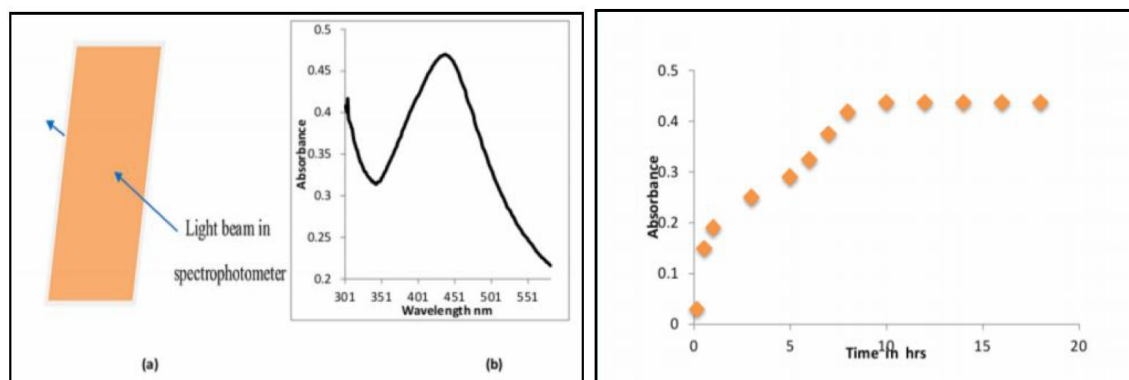


Fig. 4: (a) SEM image of the SNP-CS using *Achyranthes aspera* L, extracts
(b) EDS Spectra of SNPs.

UV-VIS SPECTROSCOPY

UV-visible spectroscopic data of each sample was analyzed by using UV-visible spectrophotometer (Jasco V-670) in the range 250-750 nm and the wavelength corresponding to maximum absorption (λ_{max}) was recorded which are identical to the characteristics UV-visible spectrum of metallic SNPs. Chitosan in 1% (v/v) acetic acid is used as blank. Due to the excitation of Surface Plasmon vibrations SNPs absorb radiation in the visible region of the EMS (380-450 nm), and this is responsible for the striking yellow-brown color of silver nanoparticles. SNPs stability was checked up to six months and it was found that stability is nearly constant even up to six months. Due to Vander Waals forces or Coulomb's forces of

attraction the individual particles have a tendency to form large sized agglomerates during the preparation of SNP suspension. Chitosan is used as a stabilizer in order to prevent the agglomeration of small particles which can form a protective layer on the particle's surface. A strong physical adsorption of the CS onto the surface of the SNPs is also an indication of better stabilization. The evolution of UV–VIS absorption spectrum of silver nanoparticles embedded in chitosan membrane was shown in Figure 5b. A Plasmon absorbance of the membrane was observed between 410–450 nm.



1
Fig. 5: (a) Schematic diagram of the SNP-CS thin film sensor; path of the light beam in the spectrometer is shown. (b) Surface Plasmon resonance (SPR) spectrum of the SNP-CS.

2
Fig. 5: (c) Changes in the SPR band of the AgNps at various time intervals using UV–vis spectrophotometer.

DISSOLUTION AND SWELLING TEST OF SNP-CS

The swelling studies of SNP-CS were carried out in distilled water at room temperature for a period of 24 hrs the percentage of swelling of these films was calculated by using the eq.

$$\text{Percentage of swelling} = \frac{W_s - W}{W} \times 100$$

Where, W_s is the weight of swollen SNP-CS film (g) and W is the weight of dry CS film. It was observed that SNP-CS film had 37.5% swelling when allowed to remain in distilled water for 24hrs at room temperature.

SENSING EXPERIMENTS

All experiments (except those related to the temperature dependence) were carried out at the ambient temperature of 25°C. The sensor film was immersed in ultra-pure water (Millipore Milli-Q, resistivity = 18 M Ω cm) then placed in a spectrometer; the SPR spectrum of the film was monitored at first time. The water was removed and replaced with the analytic solution. The SPR spectrum of the film was recorded. A fresh film was used for each new experiment. The reproducibility of the sensing process was examined by running repeated batches of selected experiments.

POLLUTANT (THIOCYANATE, FLUORIDE, PHOSPHATE, NITRITE) SENSING OF ECO SNP-CS FILM

To investigate the sensitivity effect of the SNP-CS toward pollutants, pollutants with the concentrations of 2 to 25 ppm was added to the SNP-CS. The sensing ability and selectivity of the prepared SNP-CS were

studied by using UV/VIS spectroscopy. On interaction of pollutants with SNP-CS, pollutants undergo diffusion into the polymer matrix during which the metal changes into metal salt. A clear blue shift of the peak is observed at higher concentrations of pollutant. This aspect can be exploited by including the peak shift, $\Delta A = [A_{\max}(0) - A_{\max}(t)]$ in the sensor response.

The absorbance spectra for a set of selected concentrations are shown in Figures. For each measurement, fresh film of SNP-CS is taken. The spectra show small but definite and reproducible decrease in intensity within a few minutes. In addition to the decrease in intensity, the peak undergoes a blue shift which becomes prominent at higher concentrations and the LSPR peak intensity at 437 nm decreases and another peak appears at decreased wavelength as the pollutant concentration is increased. Changes in absorbance at two different wavelengths as a function of pollutant concentration are provided in the figures. We have plotted absorbance ratio as a function of pollutant concentration, within the range of 2 to 25 ppm the absorbance ratio is almost linear which indicates that the SNP-CS is active for detection and removal of pollutant content in the solution.

CONCLUSION

The silver NPs dispersion in a chitosan bio polymer matrix played a more important role in colorimetric sensing applications. In this study we have shown the feasibility of forming silver nanoparticles from silver nitrate through green process using aqueous extract of *Achyranthes aspera* L. Based on the unique LSPR properties of metallic nanoparticles, Colorimetric assays have showed to be very useful due to their simplicity, high sensitivity, low detection limit, low cost, fast response time and great reproducibility. The present study reports the application of nanoparticles for the removal of nitrite ions using AgNPs-CS film with high selectivity and sensitivity over Mn^{+2} , Fe^{+3} , CO^{+2} , Ni^{+2} , Zn^{+2} , K^+ , Mg^{+2} , Ba^{+2} ions. Keeping these significance properties in mind, in the near future we can use this thin film as a filter to remove inorganic pollutants for the water purification at room temperature.

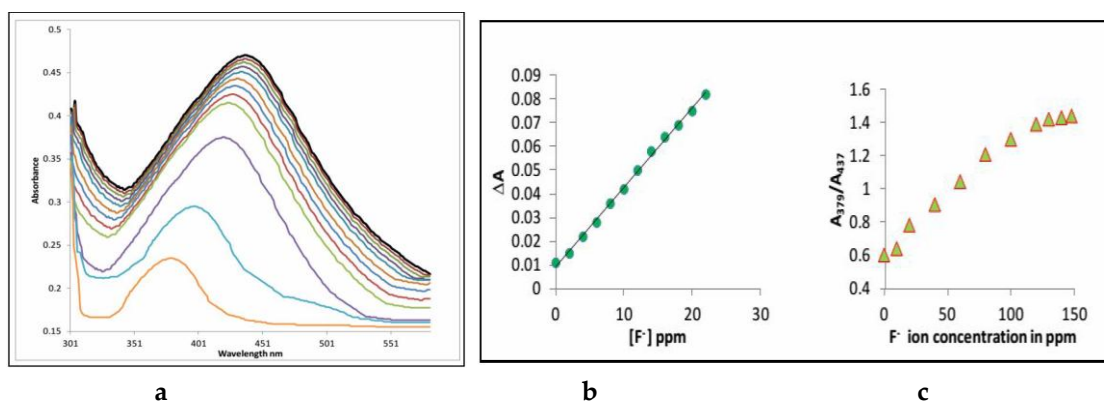


Fig. 6: a) UV-VIS absorption response of green SNP-CS film upon addition of different concentrations of F⁻ ions.

b) Plot of absorbance intensity at 379 nm versus F⁻ concentration

c) Ratio of absorbance peak (A₃₇₉/A₄₃₇) of SNP-CS exposed to increased F⁻ content.

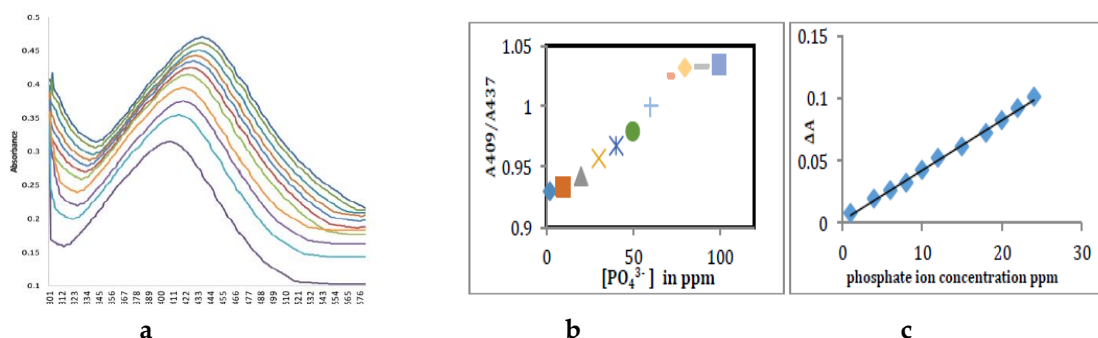


Fig. 7: a) UV-VIS absorption response of green SNP-CS film upon addition of different concentrations of PO_4^{3-} ions.

b) Plot of absorbance intensity at 409 nm versus PO_4^{3-} concentration
c) Ratio of absorbance peak (A_{409}/A_{437}) of SNP-CS exposed to increased PO_4^{3-} content.

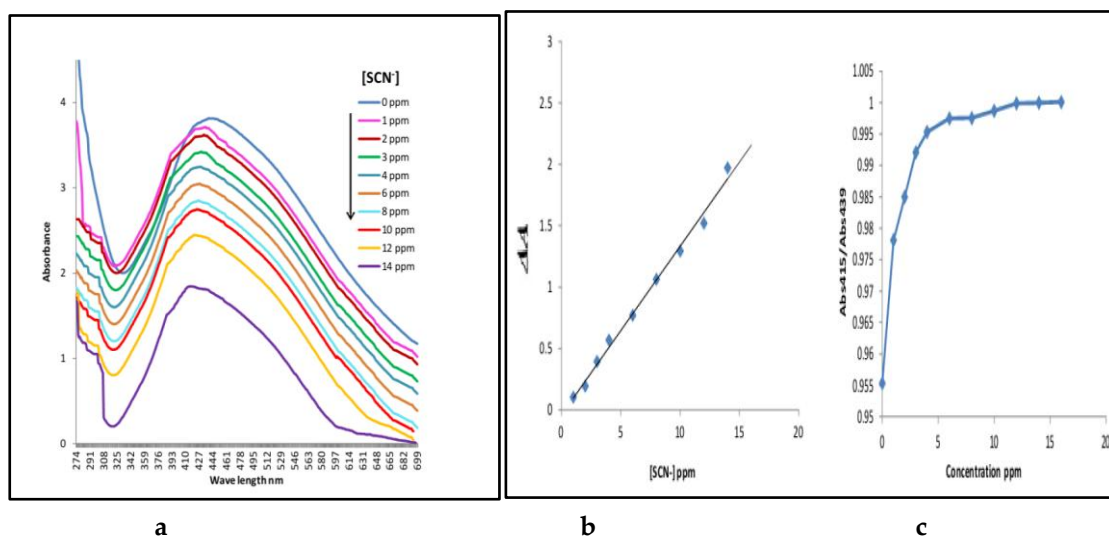


Fig. 8: a) UV-VIS absorption response of green SNP-CS film upon addition of different concentrations of SCN^- ions.

b) Plot of absorbance intensity at 415 nm versus SCN^- concentration
c) Ratio of absorbance peak (A_{415}/A_{439}) of SNP-CS exposed to increased SCN^- content.

REFERENCES

[1] DurgaPraveena, V., & Vijaya Kumar, K., (2016). Eco-Friendly Silver Nano Films for the Adsorption of Fluoride Ions Based on Light Scattering Phenomenon. *International Journal of ChemTech Research*, 9(4), 288-295.

[2] DurgaPraveena, V., Vijaya Kumar, K., & Venkataratnam, K., (2016). Phosphate Removal from Aqueous Solutions by a Nano-Structured Ag-Chitosan Film. *Journal of Nanoscience and Technology*, 2(3), 134-137.

[3] DurgaPraveena, V., & Vijaya Kumar, K., (2016). Eco-Friendly Silver Nano Films for the Adsorption of Nitrite Ions Based on Light Scattering Phenomenon. *International Journal of PharmTech Research*, 9(6), 241-249.

- [4] DurgaPraveena, V., & Vijaya Kumar, K., (2015). Green synthesis of Silver Nanoparticles from AchyranthesAspera Plant Extract in Chitosan Matrix and Evaluation of their Antimicrobial Activities. *International Journal of Innovative Science, Engineering & Technology*, 2(4), 741-752.
- [5] DurgaPraveena, V., & Vijaya Kumar, K., (2014). Physicochemical Studies on Nano Silver Particles Prepared By Green and Chemical Methods. *Advanced Materials Research*, (938), 242-250.
- [6] DurgaPraveena, V., & Vijaya Kumar, K., (2014). Green synthesis of Silver Nanoparticles from AchyranthesAspera Plant Extract in Chitosan Matrix and Evaluation of their Antimicrobial Activities. *Indian Journal of Advances in Chemical Science*, 2(3), 171-177.
- [7] DurgaPraveena, V., & Vijaya Kumar, K., (2013). Synthesis and Characterization of Chitosan based Silver Nano Composite System for Antibacterial Applications. *International Conference on Advanced Nanomaterials & Emerging Engineering Technologies* (ICANMEET-2013) organized by Sathyabama University, Chennai, India in association with DRDO, New Delhi, India, 24th -26th July, 2013.
- [8] Hazen Drive, (2009). Environmental services Concord New Hampshire 03301(603)271-3503.
- [9] WHO 1985a Guidelines for the study of dietary intake of chemical contaminants. Geneva, World Health Organization Offset Publication No. 87.
- [10] United States Environmental Protection Agency, National Primary Drinking Water Regulations: Contaminant Specific Fact Sheets, Inorganic Chemicals, Consumer Version. Washington, DC, 1995.
- [11] Toyoda, A., Taira, A., (2000). A new method for treating fluorine wastewater to reduce sludge and running costs. *IEEE Trans, Semiconductor Manufacture*, 13, 305-309.
- [12] WHO and UNICEF (2010) Progress on Sanitation and Drinking-Water., Geneva, Switzerland.
- [13] Zhu, CS., Bai, GL., Liu, XL., Li, Y., (2006). Screening high-fluoride and high-arsenic drinking waters and surveying endemic fluorosis and arsenic in Shaanxi province in western China. *Water Research*. 40, 3015-3022.
- [14] Bishnoi, M., Arora, S., (2007). Potable groundwater quality in some villages of Haryana, India: Focus on fluoride. *Journal of Environmental Biology*, 28, 291-294.
- [15] Shailaja, K., Johnson, MEC. (2007). Fluorides in groundwater and its impact on health. *Journal of Environ Biology*, 28, 331-332.
- [16] Tripathy, SS., Bersillon, JL., Gopal, K., (2006). Removal of fluoride from drinking water by adsorption onto alum impregnated activated alumina. *Sep Purif Technol*, 50, 310-317.
- [17] Auffan, M., Rose, J., Bottero, J.Y., (2009). Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective. *National Nanotechnology*, 4, 634 -641.
- [18] Pradeep, T., Anshup, (2009). Noble metal nanoparticles for water purification: A critical review. *Thin Solid Films*, 517, 6441-6478.
- [19] Zhang, L., Yi, M., (2009). Electrochemical nitrite biosensor based on the immobilization of haemoglobin on an electrode modified by multiwall carbon nanotubes and positively charged gold nanoparticle. *Bioprocess Biosyst. Eng.*, 32, 485 – 492.
- [20] The XRD patterns were indexed with reference to the crystal structures from the ASTM chart card No. 04-0783.
- [21] Uzum, C., Shahwan, T., Eroglu, AE. Hallam, KR., Scott, TB. (2009). Synthesis and characterization of kaolinite-supported zero-valent iron nanoparticles and their application for the removal of aqueous Cu²⁺ and Co²⁺ ions. *Appl Clay Sci.*, 43, 172-181.
- [22] Fakhri, A., Adami, S., (2013). Response Surface Methodology for Adsorption of Fluoride Ion Using Nanoparticle of Zero Valent Iron from Aqueous Solution. *J Chem Eng Process Technol.*, 4, 161-167.

- [23] Yuan, H., Ma, W., Chen, C., Zhao, J., Liu, J., Zhu, H., GAO, X., (2007). Shape and SPR evolution of thorny gold nanoparticles promoted by silver ions. *Chem. Mater.*, 9, 1592 – 1600.
- [24] Xiao, N., Yu, C., (2010). Rapid-response and highly sensitive non-crosslinking colorimetric nitrite sensor using 4-aminothiophenol modified gold nanorods. *Anal. Chem.*, 82, 3659 – 3663.
- [25] Daniel, W. L., Han, M. S., Lee, J. S., Marking, C. A., (2009). Colorimetric nitrite and nitrate detection with gold nanoparticle probes and kinetic end points. *J. Am. Chem. Soc.*, 131, 6362 – 6363.
- [26] Hausa, J., Van Diner. P.,(2002). A nanoscale optical biosensor: sensitivity and selectivity of an approach based on the localized surface plasmon resonance of triangular silver nanoparticles. *J. Am. Chem. Soc.*, 124, 10596–10604.
- [27] Dubs, ST., Pimpan, V., (2008). Green Synthesis of Silver nanoparticles for Ammonia Sensing. *TALANTA*, 76, 29-33.
- [28] Ramesh, G. V., Radhakrishnan, T.P., (2011). A Universal Sensor for Mercury (Hg, HgI, HgII) Based on Silver Nanoparticle-Embedded Polymer Thin Film. *ACS Appl. Mater. Interfaces*, 3, 988 – 994.
- [29] Pandey, S., Gopal, K., Karuna, G., Nanda, K., (2012). Green synthesis of biopolymer–silver nanoparticle nanocomposite: An optical sensor for ammonia detection. *International Journal of Biological Macromolecules*, 51, 583–589.

ABSTRACT

This chapter is aimed to explain the importance of nano fluids/nano lubricants in Mechanical Engineering through characterization of nano fluids like thermal conductivity, viscosity, flash point and fire point tests of CuO based engine oils. CuO based engine oils are synthesized nanoparticles using wet precipitation method and those nanoparticles are characterized using XRD and TEM analytical techniques. The prepared CuO nanoparticles are separated in three different mass concentrations i.e., 0.1wt%, 0.2wt% and 0.5wt% of CuO nanoparticles are mixed to commercially available engine oil for the experimental investigations. KD2 pro thermal property analyzer, Redwood Viscometer-I and Cleveland open cup apparatus are used to evaluate thermo physical properties like thermal conductivity, viscosity, flash and fire point of nanoparticle based engine oil.

KEYWORDS: Nano fluids, Nano lubricants, CuO nanoparticles, Engine oil, Automobile Engineering.

INTRODUCTION

Nano fluid is an engine lubricant produced by mixing, of CuO nanoparticles as additive into commercially available SAE 20W 40, 10W 30 and 15W 40 three different types of Engines oil's. Recent investigations into nanofluids show that they have improved thermo physical properties over the conventional fluids like water, ethylene glycol etc. In spite of best thermal design, materials, and the performance of any engine oil is restricted due to its inherited poor thermal conductivity. Solution to this problem can be sort out from the newly discovered nano materials based nanolubricant. It has been also observed that nanofluids have potential to improved thermo physical properties over the conventional fluids. [1-2]

BACKGROUND OF STUDY

The use of petroleum products in the transportation sector has been steadily increasing, which contribute in a larger extent to the rapid depletion of the natural resources. Even a 10% increase in the efficiency of engines by decreasing friction is considered to be a significant improvement. Lubrication is essential to reduce friction and wear in engine parts thus minimizing the associated dissipative energy loss. Thermal conductivity is the most important property of lubricating oil, which accounts for its heat transferring ability. Other important properties of lubricating oil include the flash point and the pour point, which are related to oil storage and handling. These properties of lubricant can be further improved by the use of various wear reducing agents. With the invention of nano structured materials in the recent years, this project concentrated to use nanoparticles as lubricant additives to improve their lubrication properties. [3-4]

Recent manufacture technology provides excessive opportunities to process different material at nanometer scales. Nano-structured or nanophase materials have made of nanometer-size substances engineered on the atomic or molecular scale to produce either new or greater physical properties not showed by conventional solids. All physical mechanisms have a critical length scale below which the physical properties of materials are changed. Therefore, solid particles smaller than 100 nm have properties different from those of conventional solids. Many kinds of liquids, such as water, ethylene glycol, and oil, have been used as host liquids in nanofluids. There are different types of nanoparticles used to disperse in fluids as given below.

- 1) Metallic nano particles.
- 2) Non-metallic nano particles.
- 3) Metallic and non-metallic oxides.
- 4) Carbon nano tubes.
- 5) Ceramics and composites.

Materials for base fluids and nano particles are varied. Stable and highly conductive nanofluids can be produced by one-step production and two-step production methods. These both methodologies for making nano particle suspensions suffer from agglomeration of nano particles, which is an important issue in all technology containing nano powders. Therefore, production and suspension of closely non-agglomerated or mono dispersed nano particles in liquids is the important to important enhancement in the thermal properties of nanofluids.

METHODS AND MATERIAL

In this preparation process 400ml of deionised water is taken in a 1000ml of the beaker to these 10grams of Copper chloride was added along with 20grams of sodium hydroxide pellets. The reaction mixture was heated along with magnetic stirring and the process is carried out for one hour at 90°C. The pH value 7 of the so formed copper oxide wet precipitate is neutralized by adding droplets of Hydrochloric acid. Washed the wet precipitate copper oxide with deionised water to remove the impurity ions present in the solution. Copper oxide nanofluids are obtained by dispersing the wet precipitate into the required amount of deionised water under ultrasonic vibration for about 4hours to have uniform dispersion of copper oxide nanoparticles. Copper oxide particles with fluid are washed with distilled water and acetone for 3 to 4 times and by using centrifugation method and the fine particles are collected. Obtained Wet copper oxide particles are kept in muffle furnace at 350°C for 3hours to remove impurity ions known as "Calcination". The obtained CuO particles removed from muffle furnace and make fine nanopowder by using ball milling method at for 3hours. The fine Copper oxide nanoparticles are in brownish-black in colour as shown in figure 1. As a result, the color of the solution changes from blue to black after the reaction, and then the mixture was cooled to room temperature the chemical reaction can be represented as

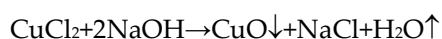


Fig. 1: Snapshots of Synthesis of CuO Nanoparticles

The synthesized CuO nanoparticles are mixed into three different types of engine oils with 0.1wt%, 0.2wt% and 0.5wt% concentrations by using probe sonication for 12hours as shown in figure 2.



Fig. 2: Weighing and Probe sonication of CuO-Engine oils.

RESULTS AND DISCUSSION

XRD (X-RAY DIFFRACTION)

The average particle size of the CuO nano particles is calculated by Debye scherrer formula and it is found that 25-30nm. Lattice parameters of unit cell of CuO are found to be $a = 4.446 \text{ \AA}$, $b = 3.628 \text{ \AA}$, $c = 5.228 \text{ \AA}$ reported in ICDD Card. The HKL values (111), (111), (202), (020), (202), (113), (310), (220) are in accordance with the literature values reported in JCPDS file.

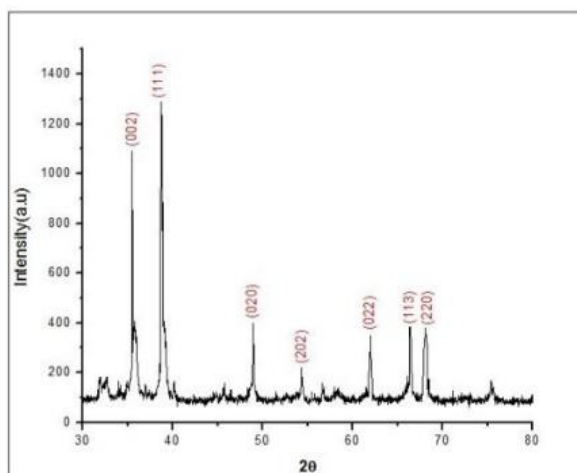


Fig. 3: XRD of CuO powder

TEM (TRANSMISSION ELECTRON MICROSCOPE)

The formation of CuO nanoparticles with accurate dimensions can be studied by using TEM. The image shows that the average size of CuO nanoparticles is found that $27 \pm 1.52 \text{ nm}$ as shown in figure 4.

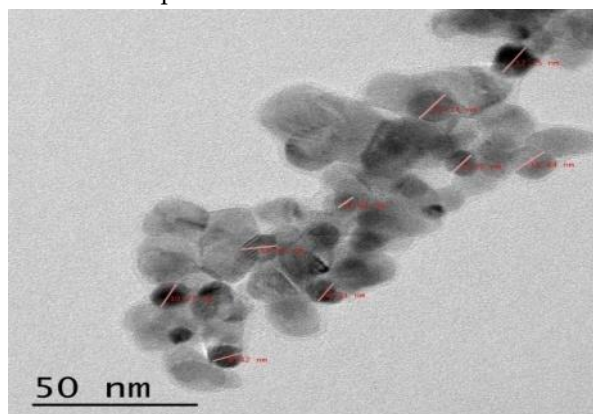


Fig. 4: TEM image of CuO powder

THERMAL CONDUCTIVITY

KD2 pro thermal property analyzer consists of a platinum wire as needle which is used a sensor needle to find the thermal conductivity of nanofluid at room temperature as shown in fig 5. The range of the sensor needle 0.2–2 W/mK with an accuracy of $\pm 5\%$ can be used for measuring thermal conductivity of fluids. Each measurement cycle consists of 90 seconds. During the first 30 seconds, the instrument will equilibrate which is then trailed by heating and cooling of sensor needle for 30 seconds each.



Fig. 5: KD2 pro thermal analyzer

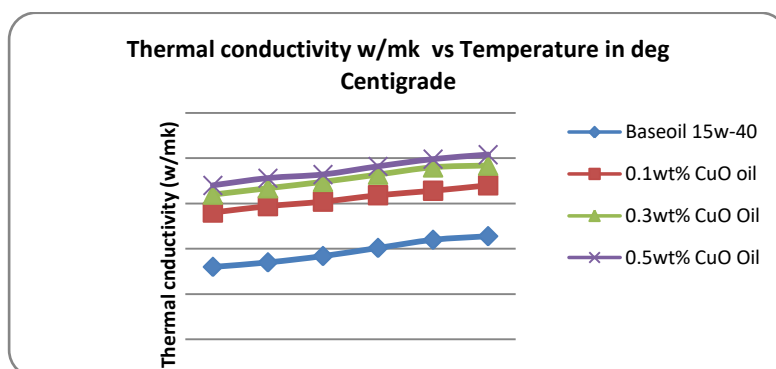


Fig. 6: Thermal conductivity vs. Temp. 15W-40/CuO NP's

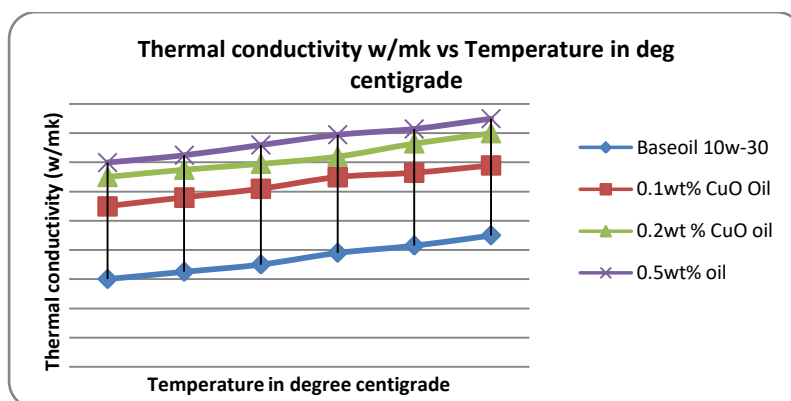


Fig. 7: Thermal conductivity vs. Temp. 10W-30/CuO NP's

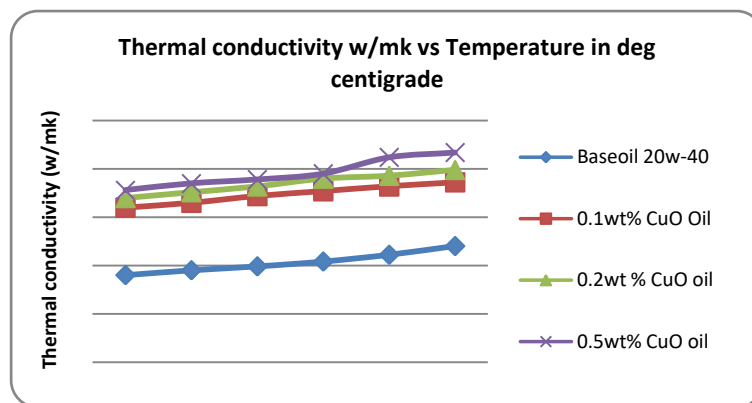


Fig. 8: Thermal conductivity vs. Temp. 20W-40/CuO NP's

VISCOSITY

For the measurement of viscosity of CuO nanoparticles in engine oil's Redwood viscometer is used and experimental procedure is followed by standard laboratory technique as shown in figure 9. The rate of oil resistance against flowing is called viscosity, which is one of the most important factors for selecting engine oil. Because of the importance of viscosity for a nanofluid, we have done experimentally for the finding of viscosity.



Fig. 9: Redwood viscometer-I

The below tables 1, 2 & 3 shows the obtained experimental values of kinematic viscosity at 40°C and 100°C of 20W 40, 10W 30 & 15W 40 engine oils with CuO mass concentrations.

Table 1: Viscosity of 20W 40 engine oil with CuONP's

| S.No. | Oil samples | Kinematic viscosity (cSt) 40°C | Kinematic viscosity (cSt) 100°C |
|-------|-------------------------|--------------------------------|---------------------------------|
| 1. | 20w 40 oil | 138.8 | 15.68 |
| 2. | 20w 40 oil + CuO 0.1wt% | 141 | 15.84 |
| 3. | 20w 40 oil + CuO 0.2wt% | 144.77 | 15.92 |
| 4. | 20w 40 oil + CuO 0.5wt% | 146 | 16.12 |

Table 2: Viscosity of 10W 30 Engine Oil with CuO NP's

| S.No. | Oil samples | Kinematic viscosity (cSt) 40°C | Kinematic viscosity (cSt) 100°C |
|-------|-------------------------|--------------------------------|---------------------------------|
| 1. | 10w 30 oil | 141.25 | 15.96 |
| 2. | 10w 30 oil + CuO 0.1wt% | 143.3 | 16.24 |
| 3. | 10w 30 oil + CuO 0.2wt% | 145 | 16.45 |
| 4. | 10w 30 oil + CuO 0.5wt% | 146.58 | 17 |

Table 3: Viscosity of 15W 40 Engine Oil with CuO NP's

| S.No. | Oil samples | Kinematic viscosity (cSt) 40°C | Kinematic viscosity (cSt) 100°C |
|-------|-------------------------|--------------------------------|---------------------------------|
| 1. | 15w-40 oil | 139 | 15.93 |
| 2. | 15w 40 oil + CuO 0.1wt% | 142.44 | 16.13 |
| 3. | 15w 40 oil + CuO 0.2wt% | 144.77 | 16.92 |
| 4. | 15w 40 oil + CuO 0.5wt% | 146.35 | 16.98 |

FLASH AND FIRE POINT

Flash and fire point measurement is experimentally done on Cleveland open cup apparatus. In this experiment, the sample is warmed up according to the methods. When the flash point is reached, there is a blue color flame produced at above the sample. The sample is heated continuously until permanent flame is detected which is known as Fire point. Temperature readings are to be noted for flash and fire points using high capacity thermometers.



Fig. 10: Cleveland open cup apparatus

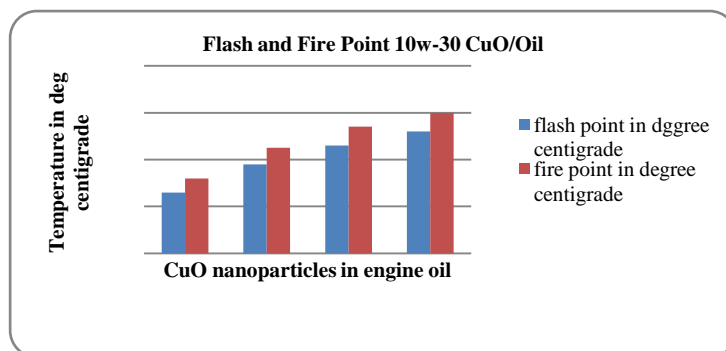


Fig. 11: Flash and Fire point of 15W 40 CuO/Oil

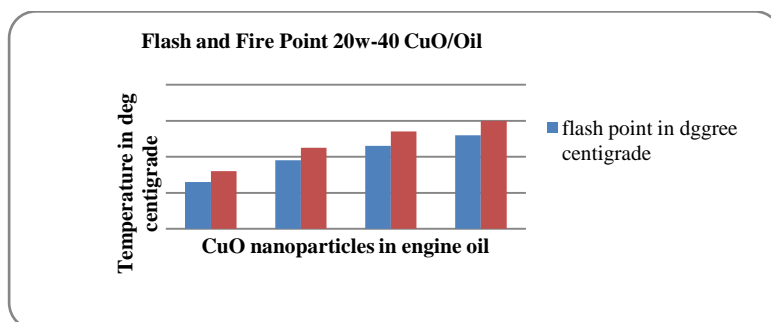


Fig. 12: Flash and Fire point of 15W 40 CuO/Oil

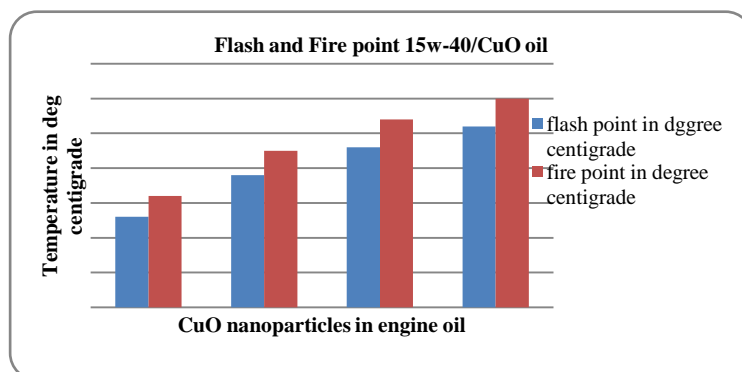


Fig. 13: Flash and Fire point of 15W 40 CuO/Oil

CONCLUSIONS

- Thermal conductivity of three different types of engine oils (base fluid) and engine oils with CuO nanoparticles increases almost linearly with temperature (30 to 45 °C).
- At different mass concentration of CuO nanoparticles, the improvement in thermal conductivity is gradually increasing with respect to temperature. This rise in the thermal conductivity is more at high temperature (30°C to 45 °C). Same is true for higher value of mass concentration of nanoparticles.
- But in the visual inspection it seems that at 0.5wt% CuO, it is difficult to mix with engine oil due to the formation of agglomeration. However, at 0.1wt% and 0.2wt% CuO nanoparticles with engine oil shows nearly 5.7% of improvement in thermal conductivity.
- The results show that viscosity increases with the nanoparticles concentration, while going from 0.1 to 0.5% mass concentration and due to increase in concentration of nanoparticle, particle to particle bonding increase which results in more rise in viscosity.

- On the basis of size effect, viscosity of engine oil with nanoparticles increases with the increases size of nanoparticles at constant temperature. The results show that all the three types of oils with CuO nanoparticles viscosity increases at constant temperature.
- Adding CuO nanoparticles to the base oil causes an increase in the flash and fire point of the base oil because CuO nanoparticles have high melting point.
- The rate of change in flash point of the CuO nanoparticles with engine oils at 0.1 wt. % concentration with respect to the base oil is nearly 7.5%, and the highest amount of increase is at 0.5 wt. % sample, which is nearly 13%.

REFERENCES

- [1] T.-H. Hong, H.-S. Yang, and C. J. Choi (2005). "Study of the Enhanced Thermal Conductivity of Fe Nanofluid." *Journal of Applied Physics* vol. 97: 064311.
- [2] Chopkar, M. P. K. Das, & I. Manna. (2006). "Synthesis and characterization of nanofluid for advanced heat transfer applications", *Scr. Mater*, vol. 55, pp. 549–552.
- [3] Hwang YJ, Ahn YC, Shin HS, Lee CG, Kim GT, Park HS, Lee JK. (2006). "Investigation on characteristics of thermal conductivity enhancement of nanofluids". *CurrAppl Phys* vol.6: pp.1068–1071
- [4] Sarit k. Das, Stephen U.S. Choi, Wenhua Yu & T. Pradeep. (2007). "Nanofluid science & technology", A John Wiley & Sons, Inc., Publication.

Chapter

12

ISOLATION, STRUCTURE ELUCIDATION AND NMR
STUDIES OF NOVEL TETRA OLIGOSACCHARIDE AND
THEIR DFT

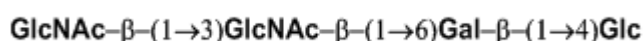
MUZEEB KHAN, ANIL MISHRA AND DESH DEEPAK*

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ABSTRACT

Milk is the all complete food for mammals and supplies all the energy and nutrients needed for the proper growth and development of the neonate before they are able to digest other types of food. Milk which contains the various mixtures of bioactive components such as high-quality proteins, lipids, carbohydrates, vitamins, minerals, enzymes, hormones, immune globulins and growth factors which influences the immune system of infants, providing protection, tolerance, facilitating development and an appropriate inflammatory response.

From milk of different origins, such as that of Humans, Donkeys, Cows, Buffalos, Sheeps, Goats, Yaks, a number of oligosaccharides have been isolated that have shown anti-tumour, anti-cancer, anti-complementary, anti-inflammatory, anticoagulant, antiviral, antibacterial properties. Keeping in mind the biological activity of Shyamadhenu milk and oligosaccharide present therein, it was collected in bulk and was processed by method of Kobata and Ginsburg for obtaining its oligosaccharides content. During the process the milk was deproteinated, filtered by microfilter and lyophilized followed by the gel filtration, HPLC, column chromatography and thin layer chromatography, which resulted into the isolation of a novel milk oligosaccharides namely Inose. The structure of isolated oligosaccharides was elucidated by chemical transformations, chemical degradation, NMR (^1H , ^{13}C and 2D COSY, TOCSY HSQC) and mass spectrometry.



KEYWORDS: Bovine milk, oligosaccharide, NMR Studies.

INTRODUCTION

Milk is a substance secreted by all mammals to provide nutrition and immunological protection to their newborns [1]. Its main components are carbohydrates, lipids, proteins, fats, immune globin, and lipids. Each component is present in a specific amount and has a specific function. One of the major components is sugar, which contains lactose and oligosaccharides. Oligosaccharides are bioactive macromolecules found in mammalian milk that are receiving a lot of commercial attention. These complex carbohydrates (oligosaccharides) are known to be responsible for the beneficial effects of breastfed newborns and perform a variety of bioactive functions, including Probiotics enrichment of a protective micro biota, limiting the virulence of several pathogens, and increasing postnatal neural development [2]. They also inhibit pathogenic microorganism adhesion to the intestinal and urinary tract by acting as receptor analogues to prevent gastric and urogenital infections. As a result, these oligosaccharides have anti-inflammatory, anti-tumor, anti-thrombotic, immunological stimulant, anti-

cancer, antiviral, antibacterial, and cardio protective properties [3, 4]. Furthermore, these oligosaccharides have been isolated from the milk of a variety of mammalian species, including buffalo, equine, caprine, elephant, donkey, rat, goat, camel, and human. Simple and complex oligosaccharides can be found in bovine milk. Recent study has found that bovine milk contains oligosaccharide analogues to human milk oligosaccharide (HMO), implying that they have a comparable protective and nutritive role in the immune systems of babies and humans [5]. The toxin's binding to the intestinal mucosa in these species' suckling young is inhibited by bovine milk oligosaccharide (BMO). There are several texts that demonstrate the significance and benefit of cow milk in human existence. Ayurveda recognises the curative value of cow milk, particularly that of the black cow. It is supposed to boost vitality and immunity, nourish bodily tissues, function as a natural aphrodisiac, rejuvenate and enhance intelligence, increase breast milk in nursing mothers, and help with bowel motility and bleeding disorders. According to the Rigveda, cow milk is Amrita, which protects humans from ailments, and its milk has therapeutic and preventative properties. Cow milk as a drink offers vitality or OJA in man, the inner strength to battle ailments, according to Charaksutrasthan. It is a full diet that provides the ability to think clearly and wisely. It brings us happiness and serenity. It protects the human body from vata, pitta, heart illness, and leucoderma, according to Indian ancient physician Dhanvantri. Several studies have shown that supplementing with bovine milk can help with diarrhoea in people with immune deficiency syndrome, NSAID-induced diarrhoea, and other conditions. In light of this, milk from Shyama Dhenu was collected in bulk and processed according to the Kobata and Ginsburg technique for the separation of new milk oligosaccharide [6]. Following the procedure, a novel milk oligosaccharide was isolated from cow's milk, and its structure was determined using chemical degradation, chemical transformation, and spectroscopic methods such as ¹H NMR, ¹³C NMR, and 2D NMR i.e. COSY TOCSY, HSQC methodology, and mass spectrometry.

MATERIAL AND METHOD

GENERAL PROCEDURE

An AA-5 series automated polarimeter in 1dm tube was used to detect optical rotations. On a Bruker AM 300 and 300 FT NMR spectrometer, ¹H and ¹³C NMR spectra of oligosaccharides were recorded in D₂O, and spectra of acetylated oligosaccharides were recorded in CDCl₃ at 25 °C. A MICROMASS QUATTRO II triple quadrupole mass spectrometer was used to record the ES-MS. The elemental analyzer CARLO-ELBA 1108 was used to record the C, H, and N analyses. TLC with 50 % aqueous H₂SO₄ reagent and Paper Chromatography with acetyl acetone and p-dimethyl amino benzaldehyde reagents were used to visualise the sugars. For TLC, silica gel G (SRL) and CC silica gel were used as absorbents (SRL, 60- 120 mesh). PC was carried out using Whatman No.1 filter paper with an ethyl acetate-pyridine (2:1) solvent solution saturated with H₂O. In gel permeation chromatography, Sephadex G-25 (PHARMACIA) was utilised. The substance was freeze dried using a CT 60e (HETO) lyophilizer and centrifuged using a cooling centrifuged Remi instruments C-23 JJRCI 763 centrifuge. A reverse phase HPLC system with a Perkin Elmer 250 solvent delivery system, 235 diode array detector, and G.P. 100 printer plotter was used to assess the homogeneity of the compounds. Aldrich Chemicals provided authentic samples of N-acetylglucosamine (GlcNAc), N-acetylgalactosamine (GalNAc), galactose (Gal), glucose (Glc), fucose (Fuc), and silicic acid.

ISOLATION OF SHYAMADHENU MILK OLIGOSACCHARIDE BY KOBATA AND GINSBURG METHOD

Isolation of Shyamadhenu (Black Cow) milk oligosaccharide by Kobata and Ginsberg method 12 litre Black cow milk was collected from a Shyamadhenu and then processed by method of Kobata and Ginsberg (20). Milk was collected and kept at -20°C for 12 hours before being centrifuged at 4°C for 15 minutes at 5000 rpm. Filtration via a glass wool column in the cold removed the solidified lipid layer. Ethanol was added to the clear filtrate to reach a final concentration of 70 percent, and the solution was kept at 0°C overnight. The lactose and protein-rich white precipitate was centrifuged and washed twice with 70 percent ethanol at 0°C . The supernatant and washings were mixed together, filtered through a microfilter, and lyophilized to provide a crude oligosaccharide combination (255 gm). The presence of N-acetyl sugars in the lyophilized sample was confirmed by the Morgan-Elson test (21) and the thiobarbituric acid assay. This lyophilized material (34 gm) was further purified by fractionating it by using Sephadex G-25 chromatography at a flow rate of 3 ml/m with glass triple distilled water as the eluant. The presence of neutral sugar was determined in each fraction using the phenol sulphuric acid reagent. The oligosaccharide combination was finally obtained at a weight of 28 gm.

ACETYLATED SHYAMADHENU MILK OLIGOSACCHARIDE MIXTURE

Dry oligosaccharides from pooled fractions (13 gm) were acetylated at 60°C for 24 hours using pyridine (13 ml) and acetic anhydride (13 ml). The reaction mixture was then evaporated under reduced pressure, and the viscous residue was collected in CHCl_3 and washed with 2 N HCl, ice cold 2N NaHCO_3 , and H_2O in that order. The acetylated mixture was obtained after drying the organic layer over anhydrous Na_2SO_4 , filtering, and drying to dryness (15.5g). Using CHCl_3 : MeOH as an eluent, non-polar acetyl derivatives of oligosaccharides were resolved satisfactorily on TLC. The spots were detected by spraying them with 50 percent H_2SO_4 and then heating them.

PURIFICATION OF ACETYLATED MILK OLIGOSACCHARIDE ON SILICA GEL COLUMN

Purification of acetylated derivatives into compounds was carried out using a silica gel column chromatography system with a silica ratio of 1:100 and varied proportions of hexane: The CHCl_3 , CHCl_3 , CHCl_3 :MeOH mixture was fractionated into twelve fractions: I(259mg), II(92mg), III(164mg), IV(2.05gm), V(1.95gm), VI(2.82gm), VII(120mg), VIII(286mg), IX(726mg), and X(187mg). These fractions have a combination of two to three chemicals in them. The isolation of one chromatographically pure chemical f resulted from repeated column chromatography of fraction V. (58 mg).

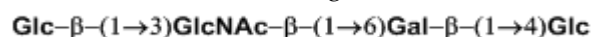
DEACETYLATION OF COMPOUND

In a stoppered hydrolysis flask, deacetylation of acetylated oligosaccharide f (58 mg) was carried out in 2ml acetone and 13ml NH_3 for 24 hours. After removing the ammonia under decreased pressure for 24 hours, an equal amount of CHCl_3 and water was added, and the chemical was recovered in the aqueous phase. The water layer was then freeze dried, yielding deacetylated oligosaccharide F (32 mg).

RESULTS AND DISCUSSION

The existence of normal and amino sugars in compound F, $\text{C}_{28}\text{H}_{48}\text{O}_{21}\text{N}_2$ was demonstrated by positive Phenol sulphuric acid test [7], Fiegl test [8], and Morgan-Elson test [9]. F at 300 MHz ^1H NMR spectra revealed four doublets for five protons in the anomeric proton region at 5.25(1H), 4.65(1H), 4.52(1H), and 4.45(1H), implying that compound F is a tetrasaccharide in its reducing form. The emergence of four signals for five anomeric carbons at 101.4(2C), 101.1(1C), 91.7(1C), and 89.2(1C) in the ^{13}C NMR spectra of

acetylated F further supported. These data led to the suggestion that it may be a tetrasaccharide in its reducing form. The four monosaccharide units present in compound Inose have been designated as S₁, S₂, S₃ and S₄ for convenience starting from the reducing end. Methylglycosidation of compound F by MeOH/H⁺ followed by its acid hydrolysis led to the isolation of α and β -methyl glucoside, GlcNAc and Gal which suggested the presence of glucose at the reducing end in the oligosaccharide. The reducing and free nature of glucose was further supported by the presence of two anomeric proton signals as doublets and their coupling constants, for α and β Glc at δ 5.25(1H)(J= 3.6Hz) and δ 4.65 (1H)(J= 8.1 Hz) respectively. The presence of lactosyl moiety at the reducing terminal was indicated by two anomeric proton doublets resonating at 4.45(1H) (J= 7.5Hz) and 4.65 (1H) (J= 8.1 Hz) for Gal and Glc residues, respectively, as well as the H-2 proton signals of -Glc as structural reported group for lactosyl moiety, appearing as a triplet at 3.28(J= 8.7Hz. Furthermore, the ¹H NMR revealed the existence of another anomeric proton as a doublet at 4.45(J=7.5Hz) and one singlet of three protons at 2.09 for the NHAc group, which was corroborated by the presence of just one GlcNHAc unit in compound F. The presence of another anomeric proton doublet at 4.52(1H) (J=7.5Hz) and one triplet at 3.20(1H) (J=8.7Hz) indicated that the fourth monosaccharide in F is the unsubstituted -Glc (S₄) molecule, which might be present at the non-reducing end of the tetrasaccharide. The absence of a downfield shifted H-4 proton resonance of -Gal (S₂), which appeared as a doublet at 3.92 (J=2.7Hz) instead of the downfield shifted chemical shift of this proton around 4.13-4.15 due to substitution in the 3-position by a -linked GlcNHAc, along with the up field shifted -GlcNHAc anomeric proton, confirmed that -Gal(S₂) is not substituted that This means that the -GlcNHAc in compound F is 1-6 connected to Gal, as evidenced by the 1H-1H connectivities in the acetylated molecule F's HOMOCOSY spectrum. Further, the existence of the GlcNHAc H-3 proton, which appears as a triplet in the downfield region at 4.05 (J=5.1 Hz), indicates that GlcNHAc (S₃) is replaced at the 3-position by a -Glc (S₄), which is the fourth monosaccharide present at the non-reducing end of the tetrasaccharide. COSY, TOCSY, and HSQC investigations of the acetylated compound F corroborated all of the 1H NMR assignments for structural reporter protons of monosaccharide units of compound F. The tetrasaccharide composition of compound F was further verified by the chemical shifts of the anomeric carbon of F in the ¹³C NMR spectra of acetylated compound F at 101.4 (2C, -GlcNHAc and -Glc), 101.1(1C, -Gal), 91.7(1C, -Glc), and 89.2(1C, -Glc), which correspond to the anomeric carbon values. The 1H and ¹³C cross peaks of -Glc (6.26 \times 89.2) and -Glc(5.67 \times 91.7) in the HSQC spectrum of acetylated compound F confirmed anomeric assignments in 1H and ¹³C NMR spectra of compound. It also has cross peaks for one -Gal, -Glc, and -GlcNAc moieties at 4.48 101.4 (2C), 4.48 101.1 (1C), and cross peaks for glycosidically linked carbons with three protons at 4.48 101.4 (2C) and 4.48 101.1 (1C), respectively. Three cross peaks for four glycosidically connected carbons were also found at 3.90 70.3, 3.79 73.3, 3.85 75.6, and 3.82 75.5. The chemical shift pattern of 1H, ¹³C, HOMOCOSY, TOCSY, and HSQC NMR tests indicated that molecule F was a tetrasaccharide with the following structure.

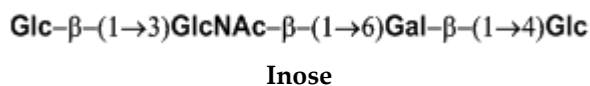


The tetrasaccharide nature of F was also confirmed by the FAB-MS spectrum analysis of acetylated compound F, which revealed the highest mass ion peaks at m/z 1276 [M+Na]⁺ as pseudomolecular ion peak, which was in agreement with the derived composition with the molecular ion expected at m/z 1253 for an acetylated tetrasaccharide with the molecular It also confirms the monosaccharide unit sequence in the tetrasaccharide F. The existence of a terminal hexosyl moiety in the tetrasaccharide was shown by the fragment ion at m/z 331, which was created by the cleavage of terminal non-reducing Glc (S₄) and the subsequent creation of fragment ion at m/z 922[S₁, S₂, S₃]. The existence of a fragment ion at m/z 922 indicated that the tetrasaccharide included a trisaccharide including c-Gal (S₂) - Glc (S₁) sugar. The existence of additional amino sugar in the tetrasaccharide is confirmed by the subsequent loss of an

NHCOCH₃ from fragment ion at m/z 922 [S1-S2-S3] leading to ion at m/z 864. The presence of the lactosyl moiety (S2-S1) is further confirmed by the presence of a mass ion fragment at m/z 619, which was produced by the fragmentation of a molecular ion at m/z 1253 at the N-acetyl glucosamine residue starting from the non-reducing terminal of the tetrasaccharide, as well as the formation of complementary fragment ions at m/z 634, which correspond (S3). This proved that the lactosyl moiety was connected to the disaccharide Glc-GlcNAc. The lactosyl disaccharide at m/z 619 fractured further to generate fragment ions at m/z 289(S2) and m/z 331(S1), confirming the presence of Glc at the tetrasaccharide's reducing terminus.

The FAB mass spectrum of compound F also contained other mass ion peaks at m/z 1192[1276-2CH₂=C=O], 1120[11922-CH₂=C=O,-OCH₃], 1031[1192-CH₃COOH, CH₃CO, NHCOCH₃], 1014[1031-OH], 970[1120-CH₃COO-CH₃COOH-OCH₃], 865[1014-2CH₃COO-OCH₃], 833[865-OCH₃], 747[865-2CH₃COO], 705[747-CH₂=C=O], 679[865-CH₃COO], 659[865-2CH₃COOH-CH₃CO], 637[679-CH₂=C=O], 577[619-CH₃COOH], 517[577-CH₃COOH], 475[517-CH₂=C=O], 426[517-CH₃COOH-OCH₃], 391[475-CH₂=C=O], 373[475-CH₃COOH-CH₂=C=O], 211[331-CH₃COOH], 229[331-CH₃COOH-CH₂=C=O], 169[229-CH₃COOH], 109[169-CH₃COOH]. This fragmentation also supported the formation of various fragment mass ion that served as anchoring units of the tetrasaccharide.

The structure of compound F was determined using physico-chemical methods and chemical transformations, and it is as follows:



CONCLUSION

In conclusion, Inose, a novel milk oligosaccharide, was isolated from Shyamadhenu milk and its structure was determined using ¹H, ¹³C, 2D NMR spectroscopy and mass spectrometry.

REFERENCES

- [1] Bodo C. Melnik, (2015). Milk-A Nutrient System of Mammalian Evolution Promoting mTORC1-Dependent Translation. *Int J Mol Sci.* 16(8) 17048–17087.
- [2] Danielle L Aldredge¹, Maria R Geronimo, Serenus Hua, Charles C Nwosu, Carlito B Lebrilla, Daniela Barile (2013) Annotation and structural elucidation of bovine milk oligosaccharides and determination of novel fucosylated structures. *Glycobiology*23 (6):664-76.
- [3] Ehresmann, D.W., Dieg, E. F., Hatch, M. T., (1979) Antiviral properties of algal polysaccharide and related compound. *Marine in Algae Pharmaceutical Science*, 58, 293-302.
- [4] Piere, J., (1982) *Journal of Immunology Research*, 17, 429-459.
- [5] Angela M. Zivkovic and Daniela Barile (2011) Oligosaccharides for improving Human Health. *American society for Nutrition. Adv. Nutr.* 2, 284-289.
- [6] Kobata, A. Ginsburg V. (1970) *J.Biol.Chem.*, 245, 1484.
- [7] Dubois M., K.A. Gilles, J.K. Hamilton, P.A Rebers and F., Smith (1956).Colorimetric method for determination of sugars and related substances.*Anal.Chem.* 28, 350.
- [8] Fiegl, F., (1975) spot test in organic analysis. Elsevier Publication, Amsterdam, 337.
- [9] Partridge, S.M. and Westall, R.G. (1948) Filter – paper partition chromatography of sugars (I). General description and application to the qualitative analysis of sugars in apple juice, egg white and fetal blood of sheep, *JBiochem.* 42, 238-250.

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ABSTRACT

Medicinal plant secondary metabolites and extracts are frequently utilised to treat a variety of chronic conditions. The presence of pharmacologically important secondary metabolites varies according to a range of aspects, including the ageing of medicinal plants, the time of harvest, and environmental factors. This issue can be resolved with standardised herbal extracts and purified metabolites. However, for the majority of herbal medications, formulation stability and active component absorption are limiting issues. The innovation of new pharmaceutical drug delivery systems is crucial for overcoming the challenges mentioned earlier. Also, treatment effectiveness is mainly dependent on selecting the suitable formulation. In recent years, phytotherapeutics have found a novel drug delivery system to increase patient compliance, therapeutic value, minimise toxicity, increase bioavailability, and avoid the need for frequent administration of a drug. This purpose can be accomplished by developing innovative drug administration vehicles for biologically or pharmacologically active herbal constituents. Scientific approaches to the design of drug delivery systems for herbal medicines have recently become the focus of pharmaceutical or herbal drug scientists. The development of herbal medicines as a novel formulation has been delayed for a long time due to a lack of scientific verification and operational complications such as selection of medicinal plants, extraction, isolation, and identification of individual drug components, as well as standardisation of both single ingredients and complex polyherbal formulations. Over other conventional herbal formulations, various nano-based herbal formulations are available, including liposomes, phytosomes, solid lipid nanoparticles, microemulsion and polymeric nanoparticles. Compared with traditional herbal formulations, nanotechnology-based herbal formulations offer many benefits, including enhanced solubility of phytocomponents, improved bioavailability, lesser toxicity, increased pharmacological activity, and enhanced macrophage distribution in tissue, constant drug distribution, and protection from physicochemical damage. This review will discuss in detail the importance of novel drug delivery technologies and their potential impact on herbal medications in the future.

KEYWORDS: Herbal drugs, NDDS, Phytoconstituent.

INTRODUCTION

In Worldwide, numerous human populations have been using medicinal herbs or medicinal beneficial plants as a reservoir of food and to cure infections prior to exploring allopathic therapies. Herbal medicines or medicinal plants serve an essential role in the treatment of a wide range of illnesses. Herbal medications are used by over 70% to 80% of the worldwide people as their first layer of protection against

different diseases. Furthermore, world health organizations promote the use of herbal medicines to treat a variety of ailments. It has an anticipated budget of three hundred million euro's in Europe and a consistent 10% increase in expenditure on botanical treatments in the United States alone (1). Herbal medicines have a number of advantages over other conventional formulations, including their minimal price, convenience of availability, and safety in terms of administration. A growing interest in creating novel drug delivery systems for natural or herbal medications has attracted the attentions of researchers in recent years. There are numerous advantages of the innovative medication delivery technology over conventional drug administration systems, including delivering a drug in a controlled manner by maintaining an optimal drug concentration and rate, dosage accuracy, increased efficacy and safety, target-specific drug delivery at the required dose, and minimal toxicities(2).The limitations of conventional drug delivery systems include medicines with a half-life that require subsequent administration to achieve the desired concentration, poor solubility, which leads to decreased bioavailability, stability, and toxicity issues. Thus, Drug delivery methods for herbal medicines that are nano-sized and innovative in design may have a future in improving the activity of plant medicines while also reducing difficulties associated with conventional drug delivery systems. In this review article, an effort is made to summarise recent breakthroughs in nanotechnology-based medication delivery systems as well as herbal medicines.

LIPOSOMES

Dr Alec D. Bangham, a British haematologist, was the first to characterise liposomes, which were discovered in 1961(3). Liposomes have been around since the 1970s, and they are used to deliver drugs to specific locations in the body. Biocompatible, biodegradable, and amphiphilicity are the most promising for drug delivery of herbal drugs. Drug delivery systems like liposomes may fulfil the need or requirement for novel drug delivery systems like nontoxic, biocompatible, biodegradable, increasing the efficacy of drugs, reducing the toxicity of drugs, and active targeting. Liposomal drug delivery systems are becoming increasingly important in treatment of cancer, where liposome-encapsulated chemotherapeutic drugs have demonstrated a significant increase the effect and decreased toxic effects when compared to the unencapsulated anticancer agent. Liposomal drug delivery systems are becoming increasingly important in cancer therapy (4). On a global scale, cancer has the highest death rate. The onset and progression of the disease may be influenced by oxidative stress and other environmental factors such as genetic mutations and epigenetic changes (5). Curcumin powder is made from the rhizome of the turmeric plant, which contains curcumin, a yellow-colored polyphenolic phytochemical. Turmeric is used to cure a wide range of illnesses, including malignancies of the lung, cervix, prostate, breast, bone, and liver. Turmeric is also used to treat a variety of other diseases. Poor water solubility, low bioavailability, quick metabolism, and systemic elimination have all contributed to curcumin's ineffectiveness in drug development (6).Curcumin liposomes are created by combining a cholesterol-based cationic lipid with curcumin. On this basis, curcumin liposomes were created in order to increase the stability, cellular absorption, and cytotoxicity of curcumin. Toxicities of curcumin encapsulated in liposomes were greater than those of free curcumin when tested on the HeLa, A549, HepG2, and 1301 cell lines. Researchers discovered that curcumin with ED50 values ranging from 2.5 to 10 µg was 2–8 times more hazardous than natural curcumin. It is possible that this is due to the fact that the synthetic cholesterol-based cationic lipid promotes curcumin uptake into the cells (7). In another study, curcumin nanoliposomes were prepared using salmon, soya, and rapeseed lecithin. Salmon lecithin contains a variety of fatty acids, particularly unsaturated fatty acids, which are known for their health benefits. When compared to rapeseed and soya lecithin, the bioavailability of nanoliposomes containing salmon

lecithin was enhanced by their greater solubility and entrapment efficiency. Curcumin nanoliposomes are more effective at inhibiting the MCF-7 cell line. Curcumin-nanoliposomes' inhibitory activity may be dose-dependent. Curcumin-nanoliposomes increase curcumin's bioavailability, which enhances its effect on cell proliferation (8). Quercetin is a flavonoid that occurs naturally and is present in a variety of foods medicinal plants, fruits, and dietary supplements. Recent flavonoid research has revealed quercetin's promising pharmacological effects, including antioxidant, cardiovascular, neurogenerative-aging, anti-inflammatory, and anticancer activity. Quercetin is a critical component in alternative or complementary medicine owing to its high therapeutic potential, ease of availability, and affordability. There are several fundamental disadvantages of employing quercetin in therapeutic applications, including its low bioavailability, inadequate solubility in water, short half-life, chemical instability, and low stability in aqueous solutions. A study in rats was conducted to determine the efficiency of quercetin liposomes in the treatment of streptozotocin-induced diabetic nephropathy. It is obvious from the results of the research that quercetin and pegylated quercetin liposomes dramatically alleviate diabetic nephropathy in rats that have been treated with these compounds. The group that received pegylated quercetin liposomes had higher quercetin concentrations in plasma than the group that did not get pegylated quercetin liposomes, however, the treatment did not successfully manage diabetic nephropathy symptoms. These formulations may be beneficial in lowering oxidative stress, inhibiting the production of advanced glycation end products (AGE), and delaying the advancement of diabetic nephropathy (9). The Eudragit coating on liposomes enhances the vesicles' physical stability by mimicking the gastrointestinal conditions. The *in-vitro* results are also consistent with those that demonstrate quercetin eudragit-coated liposomes reduce elevated reactive oxygen species levels and extend the effect of quercetin in cells for up to six hours. The formulation of quercetin eudragit-coated liposomes has the potential to regulate pro-inflammatory and pro-oxidant conditions that can result in DNA damage and cell modification (10). Another study used a thin-layer evaporation method to prepare liposomal quercetin. Liposomal quercetin is more effective as an antioxidant than free quercetin. The liposomal quercetin exhibits improved polar solubility and bioavailability, which alleviates the issues associated with quercetin application and promotes its use in the treatment of tumours. Liposomal quercetin inhibits human breast cancer (MCF-7 cells) more effectively *in-vitro*, resulting in a decrease in cell proliferation and an increase in antitoxic effect (11). Quercetin is a potentially beneficial plant metabolite for the treatment of liver injury. Nanopreparation of quercetin have been developed and found to be effective in protecting rats' livers from oxidative damage. The nanoliposomes were spherical in shape and contained quercetin in the lipid bilayer's centre. Nanoliposomal quercetin significantly outperformed pure quercetin in terms control of serum levels such as glutamic-pyruvic transaminase, glutamic-oxal acetic transaminase, and direct bilirubin. In histopathological studies, nanoliposomal quercetin effectively reduced hepatic injury and protected hepatocytes from damage (12). Catechins are naturally occurring polyphenolic phytochemicals that have the ability to protect cells and have a variety of beneficial pharmacological actions, including free radical scavenging, antiviral, anti-inflammatory, anticancer, and anti-aging properties. Green tea is naturally high in antioxidants, particularly epigallocatechin-3-gallate (EGCG), which has been shown to inhibit microglia-mediated inflammation and protect neurons. The primary disadvantage is that epigallocatechin-3-gallate is highly unstable and has low bioavailability in nature. Liposomes containing PS and EGCG are prepared, and the resulting liposomes are smaller, more stable, and have a better oral bioavailability. With vitamin E, EGCG is protected from the effects of oxygenation, which improves its capacity for absorption and encapsulation. As an inhibitor of the neuroinflammatory response, EGCG-loaded liposomes have been found to be crucial in the neuroinflammatory response. During neuroinflammatory responses, these effects have been

demonstrated in the prevention of cells from undergoing apoptosis (cell death). According to an *in-vivo* investigation, LPS administered to the unilateral midbrain substantia nigra region of rats resulted in the amelioration of the Parkinsonian syndrome in these animals. Post-treatment of EGCG-loaded liposomes inhibited the neuroinflammation mechanism, including TNF- secretion (14). Silymarin is a polyphenolic substance obtained from the seeds of the plant *silybum marianum*, which grows in the Mediterranean region. Among its many pharmacological qualities are its anti-inflammatory, cancer-fighting, and antiviral properties, and many others. However, silymarin is only seldom used to treat a range of liver illnesses, including as chronic liver disease, cirrhosis, and hepatocellular carcinoma, according to the National Institutes of Health. The key obstacle is silymarin having poor solubility in aqueous medium, lesser bioavailability and insufficient intestinal absorption. Silymarin buccal liposomal is prepared to address the bioavailability issue. In order to determine if liposomal dosage forms intended for buccal distribution achieve the appropriate bioavailability at a lower dose when treating children with liver disease. The experimental results clearly show that using stearyl amine as a positive charge inducer allows for 70% encapsulation and product stability at 4°C for three months. *In-vitro* permeation studies revealed that formulations containing lecithin, stearyl amine, cholesterol, and tween 20 in a 9:1:1:0.5 molar ratios had a higher permeation rate than silymarin alone (15). On the other hand, multidrug-resistant tumours have a substantial impact on the effectiveness of anticancer medicines. To enhance antitumor efficacy, encapsulated vincristine is prepared in folic acid-conjugated PEGylated liposomes. In both *In-vitro* and *In-vivo* studies, the folic acid linked PEGylated liposomes of vincristine were found to have the greatest cytotoxic potential. In accordance with the TUNEL assay, the folic acid conjugated PEGylated liposomes of vincristine are effective in inhibiting tumour growth and had a higher apoptotic index than the parent compound. (16).

PHYTOSOMES

Diverse medicinal plants have significant pharmacological effects that can be used to treat a variety of diseases. The primary disadvantage of using phytochemicals is their low bioavailability. Multiple carrier systems are available to improve the phytochemical bioavailability; among many one novel method is phytosomes. Plants that are medicinal in nature are referred to as "phyto," and cell structure is referred to as "some" (17). A potent drug delivery mechanism in polar conditions, phytosomes are an excellent choice for poorly soluble medicines; their ability to increase absorption and availability results in a minimum dose and sufficient to produce a better biological effect. Plant extracts can be combined with phosphatidylcholine in an aprotic solvent to form phytosomes, which contain phospholipids as well as phytochemicals that have therapeutic properties. Phytosomes are suitable for being administered orally, intravenously, or transdermally. Primary advantages of phytosomes include their high entrapment efficiency and the formation of a depot that releases the drug contents slowly over a period of time (18). The study was designed to compare the systemic availability of curcumin versus curcumin in a phosphatidylcholine-based formulation. Curcumin formulated with phosphatidylcholine (Meriva) is found to have a fivefold increase in plasma concentration following administration. Additionally, curcumin formulated with phosphatidylcholine demonstrated significantly greater absorption and accumulation of curcumin in the liver when compared to unformulated curcumin. In comparison to curcumin that has not been formulated with phosphatidylcholine, curcumin that has been formulated provides significantly higher systemic levels of the parent compound (19). In another study, it was found that curcumin phytosomes were capable of reducing glial activation in GFAP-IL-6 mice, which are employed as an animal model of chronic glial activation. The formulation was administered at three different doses (218, 438, and 874 ppm) for four weeks, and the results showed a significant reduction in

neuroinflammation as well as the number of activated microglia in the hippocampus and cerebellum in the rats. Microglia in the hippocampus and cerebellum of GFAP-IL6 mice were reduced by 26.2 and 48 percent, respectively, when phytosomal curcumin was administered at a dose of 874ppm, when compared to GFAP-IL6 mice fed normal food. Furthermore, the number of GFAP+ astrocytes in the hippocampus of GFAP-IL-6 mice was reduced considerably (20). Despite the fact that quercetin has numerous pharmacological advantages; it also has a number of disadvantages, including poor solubility and less oral absorption. In order to increase the oral absorption of quercetin by healthy human volunteers, phytosomes containing quercetin were developed. The administration of two doses with different forms of quercetin phytosomal formulation (250 and 500 mg) improved solubility without adverse effects, significant increases in oral absorption, AUC (18 fold larger than quercetin), and reaching the maximum concentration (20 fold greater than quercetin) in plasma when compared with quercetin (500 mg) alone (21). In another study, a silybin-phospholipid complex was prepared and investigated for its pharmacokinetics in rats. The silybin-phospholipid combination was much more soluble in water and n-Octanol. The silybin-phospholipid complex and the silybin-N-methylglucamine combination were administered orally to rats, and the mean plasma concentration-time curves for both conformed to the open single compartment model with first-order absorption. When compared to silybin-N-methylglucamine, the pharmacokinetic parameters T_{max}, C_{max}, and AUC of the silybin-phospholipid complex were dramatically improved. The oral bioavailability of the silybin phospholipid complex improved significantly. This may be due to the lipophilic property of the silybin-phospholipid complex (22). A new nanophytosome was prepared from epigallocatechin-3-gallate and egg phospholipid complex and evaluated for its anti-inflammatory potential in a rat model. Microscopy images obtained using scanning electron microscopy (SEM), and transmission electron microscopy (TEM) revealed that phytosomes were nanoscale in size, with an average particle size of 100-250 nm. Further, it was confirmed by Malvern Zetasizer data. The optimal addition rate, stirring temperature, and phospholipid concentration resulted in a greater influence on entrapment efficiency. Pure EGCG and its phytosomal preparation were found to have anti-inflammatory properties that significantly reduced carrageenan-induced rat paw oedema in a rat model (23).

SOLID LIPID NANOPARTICLES (SLNPS)

Solid lipid nanoparticles (SLNPs) are a widely used nanocarrier innovation for a variety of pharmaceuticals, including herbal remedies. The lipids in these nanoparticles, which range in size from 50 nm to 1000 nm, are stable at room temperature as well as in the body. Surfactants that are biocompatible are essential in the production of solid lipid nanoparticles. Physical stability, degradation resistance, controlled release, and ease of manufacture are some of the benefits of SLNPs over traditional drug delivery techniques. The manufacturing of SLNPs is both affordable and feasible on a huge scale. Unlike liposomes, storage and drug leakage issues are lower in solid lipid nanoparticles. Toxicity and acidity were significantly reduced in SLNPs produced with biodegradable polymeric components. Because most lipophilic chemicals may be easily incorporated into SLNPs, encapsulating cytotoxic substances in SLNPs may be the best alternative for oral delivery of the drugs (4, 24). Curcuminoids coated with solid lipid nanoparticles were created using the microemulsion process (SLNs). The amount of lipid and emulsifier has the most significant influence on mean particle size and drug incorporation efficacy. When compared to a free curcuminoid cream formulation, an effective formulation with an average particle size of 447 nm and 70 percent encapsulation sustained the release of the medication for twelve hours and remained stable for up to six months was found to be more effective. Curcuminoids' light and oxygen sensitivity were significantly reduced by integrating them into SLNs. SLNs are a

promising carrier system for molecules that are sensitive to light and oxygen. The results of an in-vivo investigation conducted on healthy volunteers revealed that after three weeks of therapy, a cream containing SLN curcuminoid dramatically decreased skin wrinkles while simultaneously improving skin moisture and viscoelasticity (25). The oral bioavailabilities of cancer drug are improved by SLNs. Another study discovered that surface-modified curcumin-loaded SLNs with N-carboxymethyl chitosan dramatically increased oral bioavailability by enhancing cellular absorption and lymphatic uptake, respectively (26). Resveratrol is a natural polyphenol rich in high antioxidant capacity and is found in many foods, fruits, and nuts. The main problem associated with resveratrol is its low oral bioavailability. As resveratrol-loaded stearic acid SLNs were stabilised with poloxamer 188, they demonstrated a remarkable 8-fold increase in the oral bioavailability of resveratrol when compared to the drug solution formulation (27). For effective drug release and tumour cell delivery, nanoparticles were developed a podophyllotoxin-loaded solid lipid nanoparticle by the solvent emulsification-evaporation method. When the SLNs were detected using transmission electron microscopy, the results revealed that they were homogeneous and spherical in shape. The size of SLNs was 50 nm, and drug release was time-dependent. Podophyllotoxin-SLNs show better anti-tumor potency against human embryonic kidney 293 cells (293T) and HeLa cells when compared with free podophyllotoxin. Podophyllotoxin-SLNs have been shown to effectively reduce cancer growth for a longer period of time as well as promote apoptotic and cellular uptake processes in tumour cells (28). A solid lipid nanoparticle of podophyllotoxin is synthesized by enfolding it in stearic acid using a modified microemulsion process to boost efficacy and lessen harmful effects. The mean diameter of the particles was 56.5±25.8 nm, and the entrapment effectiveness of podophyllotoxin in the nanoparticles was 85.6 percent. Stearic acid solid lipid nanoparticles look promising for epidermal delivery (29).

MICROEMULSIONS

Microemulsions have emerged as a significant part in the development of novel delivery strategies for hydrophobic pharmaceuticals. Schulman and colleagues were the first to propose the concept of microemulsions and to coin the term "microemulsion." A microemulsion is a liquid solution composed of water, oil, and an amphiphile that is optically isotropic and thermodynamically stable, according to Danielsson and Lindman's definition published in 1981 (31). Microemulsion droplets have a diameter ranging from 10 to 100 nanometers (nm). Microemulsions provide a number of advantages over other novel drug delivery systems, including enhanced drug solubility, better thermodynamic stability, a simpler fabrication procedure, optical clarity, and excellent kinetic stability. Microemulsions were identified to be nanostructured vehicles capable of delivering medications via oral, parenteral, and ocular, pulmonary and transdermal routes (32). Curcumin's solubility, stability, and oral absorption were all improved by the use of microemulsion techniques. The resulting optimised microemulsion formulation is stable for two months, enhances solubility, and exhibits considerable penetration. The improved formulation contains 3.3 g/100 g vitamin E, 53.8 g/100 g Tween 20, 6.6 g/100 g ethanol, and water (36.3 g/100 g), with curcumin solubility up to 14.57 mg/ml and 70% penetration over the artificial membrane (33). In another study, eucalyptol microemulsions were developed for the topical administration of curcumin. The fastest curcumin delivery flux was produced by optimised microemulsion containing 25% water, 25% eucalyptol, 37.5% ethanol, and 12.5% polysorbate 80. The eucalyptol microemulsion is well-suited for the administration of curcumin via the skin's surface (34). Another study designed a microemulsion of curcumin and myristic acid to inhibit *Staphylococcus epidermidis*. Acne vulgaris is caused by *Staphylococcus epidermidis*, gram-positive bacteria. The optimised formulated microemulsion contains 5% F127, 31.6% isopropanol, 15.9% myristic acid, and 47.5% water

was shown to have the highest curcumin accumulation in the skin. Curcumin-loaded myristic acid microemulsions exhibit superior inhibitory efficacy against *Staphylococcus epidermidis*, which may indicate a desired synergy between the two (35). Livergol is a herbal formulation with hepatoprotective activity. The efficiency of livergol is evaluated through an examination of its hepatoprotective properties in an animal model of bromobenzene-induced liver injury. One of the ingredients of Livergol is *Silybum marianum*, a liver-protective medicinal herb. Bromobenzene is a hepatotoxin that is used to induce oxidative stress and is followed by elevations in serum biomarkers. Controlled release, high diffusion and absorption rates, and improved oral bioavailability have all been used to establish the microemulsion formulation's hepatoprotective benefits against bromobenzene toxicity (36). A piperine microemulsion was developed and evaluated for its safety and efficacy in the treatment of Alzheimer's disease. Caproyl 90 (oil)/Tween 80/Cremophor RH 40 (surfactant) were selected microemulsion systems, as was Transcutol HP (co-surfactant). The results of a colchicine-induced brain toxicity study revealed that a microemulsion formulation (particle size 150 nm) increases piperine efficacy and improves its distribution to the brain, leading to an enhanced therapeutic outcome than free piperine. Surfactants included in the formulation could be the cause of the nephrotoxicity (37). Lycopene is a nutraceutical obtained from tomatoes that has a variety of pharmacological benefits, including antioxidant activity and neurological illnesses. The primary barriers to treating neurological illnesses are insufficient solubility, instability, and lower bioavailability. A lycopene-loaded microemulsion was prepared and evaluated for the efficiency of brain targeting. Lycopene and (R)-(+)-limonene as the oil phases, Tween 80, Transcutol HP, and water make up the optimised lycopene microemulsion formulation. According to the physicochemical properties, it was observed that the microemulsion had high lycopene incorporation content, small droplet sizes, a spherical ultrastructural morphology, and good *in-vitro* stability. *In-vivo* experiments also demonstrated that the formulation has higher bioavailability than the existing formulation. As an outcome, the microemulsion drug delivery system may be employed to boost the therapeutic efficacy of lycopene, particularly in neurological disorders, as well as a promising and adaptable nanocarrier for the oral delivery of a variety of other poorly water-soluble therapeutics. (38). Lycopene-olive oil microemulsions were prepared with various ratios of lecithin, 1-propanol, olive oil, and water in order to assess their ability to generate microemulsions. Optimum tomato pomace: microemulsion ratio was considered to be 1:5 W/W. The maximum efficiency achieved was 88%. The optimised proportions are lecithin: 1-propanol: water: olive oil (53.33:26.67:10:10 wt %). Olive oil and lycopene's health-promoting characteristics can be improved with microemulsion formulations because of their strong solubility in water and non-polar solvents (39).

POLYMERIC NANOPARTICLES

One of the most examined encapsulation strategies in modern medicine is polymer-based nanoparticles. Nanoparticles are colloidal systems made up of particles size from 10 to 1000 nm. Nanocapsules are referred to as such because the medicine is contained within a hollow encased by a polymer coating. The medication is uniformly distributed in nanospheres, a polymeric matrix (40). In the pharmaceutical industry, the primary focus is on developing a novel formulation that can deliver the medication in a regulated manner and release the medication only at a specified location. When compared with existing formulations, polymeric nanoparticles have many numbers of benefits compared to other traditional formulations, with greater solubility, increased bioavailability, reduced dose, better therapeutic effectiveness, improved stability, improved intracellular pharmaceutical administration, and improved absorption of herbal medicines. The objective of polymer-based curcumin nanoparticles preparation is to improve curcumin's anticancer therapeutic effectiveness and oral bioavailability. The emulsification-

diffusion-evaporation technique was used to make the curcumin-loaded with Eudragit E-100 nanoparticles with acceptable significant impact on the effectiveness and small particle sizes. Pharmacokinetic and toxicological tests show that, curcumin eudrajit nanoparticles were found to have a higher oral bioavailability than pure curcumin. According to *in-vivo* investigations, increased curcumin polymeric nanoparticles accumulation in tumour cells resulted in improved anticancer efficacy and survival time in mice (41). The emulsion diffusion-evaporation method is used to make curcumin nanoparticles. The curcumin-coated nanoparticles have a spherical structure shape and particle 264 nm sizewith entrapment 76.9%. Piperine is used to improve absorption. Curcumin nanoparticles increase oral bioavailability by nine times in rats (250 mg/kg) as compared to curcumin-piperine suspension (42). To improve encapsulation efficiency and drug release qualities, chitosan nanoparticles with quercetin have been designed with 200 nm size and 79.9% efficiency of encapsulation. A considerable reduction in the size of the tumour (metastatic adenocarcinoma of breast and adenocarcinoma cells) and the level of superoxide dismutase markedly increased in mice compared with the disease control group (43). The nanoprecipitation method is used to prepare silymarin-loaded Eudragit nanoparticles, resulting in 84.70 nm spherical-shaped nanoparticles with 100% drug release after twelve hours. A rat animal model is used to evaluate hepatoprotection, and carbon tetrachloride serves as a hepatotoxicant. Silymarin nanoparticles have shown no adverse effects at 50 mg/kg dose for body weight. In comparison to the advertised product, the silymarin nanoparticles treated group exhibits a considerable improvement in various biochemical indicators, which is further validated by histological investigation (44). In an *in-vitro* study, the combination of curcumin and camptothecin in chitosan-functionalized PLGA (poly lactic acid/poly glycolic acid) nanomaterials had a synergistic effect on colon-26 cells. PLGA nanoparticles were thought to be given a positive charge after being functionalized with chitosan, allowing them to better adhere to negatively charged cell surfaces and be taken up by the cells. Importantly, cationic camptothecin-loaded nanoparticles showed improved cell absorption than free camptothecin or camptothecin-loaded nanoparticles, which suggest enhanced cell surface contact. In terms of anticancer action, cationic camptothecin/curcumin 4:1 weight loaded nanoparticles outperformed the individual treatment groups, with the highest drop in anti-apoptotic Bcl-2 expression and activation of cell apoptosis (45). Hypericin nanoparticles photosensitizer naturally, synthesised from *hypericum perforatum*, were employed for the initial recognition of ovarian cancer using polymeric-loaded hypericin nanoparticles. Hypericin (Photosensitizer) are difficult to administer systemically due to their high lipophilicity or unsolvable nature in physiologically suitable solvent vehicle, which limits their diagnostic potential. To address these difficulties, biodegradable and biocompatible chemical polymers such as PLGA were used to create a dispersion of hypericin-containing polymeric nanoparticles. The produced hypericin nanoparticles were 200–300 nm in size and had up to 70% encapsulation effectiveness. In-vitro activity of polylactic acid nanoparticles was higher than that of polylactic-co-glycolic acid nanoparticles (46).

CONCLUSION

Herbal medicines contain phytoconstituents that can heal a variety of ailments. Significant advantages of using phytoconstituents are their low toxicity and lack of undesirable effects. Many people in developing countries still use herbal medicine as their first choice of treatment. Ayurveda, Siddha, Unani, and Homeopathy are Indian traditional medical systems that are still followed in different parts of the world. Inadequate solubility, reduction of bioavailability, lack of oral absorption, instability, and unexpected toxicity are only some of the difficulties that can't be handled by conventional herbal formulations. To overcome these obstacles and increase treatment efficacy, Novel drug delivery system technologies are being developed using diverse nanoformulation methodologies. The use of liposomes, phytosomes, solid

lipid nanoparticles, microemulsions, and polymeric nanoparticles in herbal formulations has enhanced the therapeutic effects of plant-derived chemicals. The primary goals of designing advance drug delivery systems are to enhance efficacy, patient comfort, and safety. This review emphasises the usefulness of diverse phytochemicals in medicine administration as well as their role in illness prevention.

REFERENCES

- [1] Chan, K., (2003). Some aspects of toxic contaminants in herbal medicines. *Chemosphere*, 52(9), 1361–1371.
- [2] Bandawane, A., Saudagar, R., (2019). A review on novel drug delivery system: a recent trend. *Journal of Drug Delivery and Therapeutics*, 9(3), 517-521.
- [3] Bangham A. D (1983). *Liposomes*. Marcel Dekker, New York, 1st Edition, 1-26.
- [4] Musthaba, S. M., Baboota, S., Ahmed, S., Ahuja, A., & Ali, J. (2009). Status of novel drug delivery technology for phytotherapeutics. *Expert opinion on drug delivery*, 6(6), 625–637.
- [5] Erez, A., Shchelochkov, O. A., Plon, S. E., Scaglia, F., & Lee, B. (2011). Insights into the pathogenesis and treatment of cancer from inborn errors of metabolism. *American journal of human genetics*, 88(4), 402–421.
- [6] Feng, T., Wei, Y., Lee, R. J., & Zhao, L. (2017). Liposomal curcumin and its application in cancer. *International journal of nanomedicine*, 12, 6027–6044.
- [7] Apiratikul, N., Penglong, T., Suksen, K., Svasti, S., Chairoungdua, A., & Yingyongnarongkula, B. (2013). *In vitro* delivery of curcumin with cholesterol-based cationic liposomes. *Bioorganicheskaiakhimii*, 39(4), 497–503.
- [8] Hasan, M., Belhaj, N., Benachour, H., Barberi-Heyob, M., Kahn, C. J., Jabbari, E., Linder, M., & Arab-Tehrany, E. (2014). Liposome encapsulation of curcumin: physico-chemical characterizations and effects on MCF7 cancer cell proliferation. *International journal of pharmaceutics*, 461(1-2), 519–528.
- [9] Tang, L., Li, K., Zhang, Y., Li, H., Li, A., Xu, Y., & Wei, B. (2020). Quercetin liposomes ameliorate streptozotocin-induced diabetic nephropathy in diabetic rats. *Scientific reports*, 10(1), 2440.
- [10] Caddeo, C., Gabriele, M., Fernández-Busquets, X., Valenti, D., Fadda, A. M., Pucci, L., & Manconi, M. (2019). Antioxidant activity of quercetin in Eudragit-coated liposomes for intestinal delivery. *International journal of pharmaceutics*, 565, 64–69.
- [11] Rezaei-Sadabady, R., Eidi, A., Zarghami, N., & Barzegar, A. (2016). Intracellular ROS protection efficiency and free radical-scavenging activity of quercetin and quercetin-encapsulated liposomes. *Artificial cells, nanomedicine, and biotechnology*, 44(1), 128–134.
- [12] Liu, X., Zhang, Y., Liu, L., Pan, Y., Hu, Y., Yang, P., & Liao, M. (2020). Protective and therapeutic effects of nanoliposomal quercetin on acute liver injury in rats. *BMC pharmacology & toxicology*, 21(1), 11.
- [13] Wani, M. C., Taylor, H. L., Wall, M. E., Coggon, P., & McPhail, A. T. (1971). Plant antitumor agents. VI. The isolation and structure of taxol, a novel antileukemic and antitumor agent from *Taxus brevifolia*. *Journal of the American Chemical Society*, 93(9), 2325–2327.
- [14] Cheng, C. Y., Barro, L., Tsai, S. T., Feng, T. W., Wu, X. Y., Chao, C. W., Yu, R. S., Chin, T. Y., & Hsieh, M. F. (2021). Epigallocatechin-3-Gallate-Loaded Liposomes Favor Anti-Inflammation of Microglia Cells and Promote Neuroprotection. *International journal of molecular sciences*, 22(6), 3037.
- [15] El-Samaligy, M. S., Afifi, N. N., & Mahmoud, E. A. (2006). Increasing bioavailability of silymarin using a buccal liposomal delivery system: preparation and experimental design investigation. *International journal of pharmaceutics*, 308(1-2), 140–148.

- [16] Lu, W., Wang, C., Feng, L., Yang, X., Wang, F. (2013). Folic acid-conjugated liposomal vincristine for multidrug resistant cancer therapy. *Asian Journal of Pharmaceutical Sciences*. 8(2), 118–127.
- [17] Nagar, G. (2019). Phytosomes: a novel drug delivery for herbal extracts. *International Journal of Pharmaceutical Sciences and Research*. 4(3), 949-959.
- [18] Jain, N., Gupta, B.P., Thakur, N. (2010). Phytosome: a novel drug delivery system for herbal medicine. *International Journal of Pharmaceutical Sciences and Research*. 2(4), 224–228.
- [19] Marczyklo, T. H., Verschoyle, R. D., Cooke, D. N., Morazzoni, P., Steward, W. P., & Gescher, A. J. (2007). Comparison of systemic availability of curcumin with that of curcumin formulated with phosphatidylcholine. *Cancer chemotherapy and pharmacology*, 60(2), 171–177.
- [20] Ullah, F., Liang, H., Niedermayer, G., Münch, G., & Gyengesi, E. (2020). Evaluation of Phytosomal Curcumin as an Anti-inflammatory Agent for Chronic Glial Activation in the GFAP-IL6 Mouse Model. *Frontiers in neuroscience*, 14, 170.
- [21] Riva, A., Ronchi, M., Petrangolini, G., Bosisio, S., & Allegrini, P. (2019). Improved Oral Absorption of Quercetin from Quercetin Phytosome®, a New Delivery System Based on Food Grade Lecithin. *European journal of drug metabolism and pharmacokinetics*, 44(2), 169–177.
- [22] Yanyu, X., Yunmei, S., Zhipeng, C., & Qineng, P. (2006). The preparation of silybin-phospholipid complex and the study on its pharmacokinetics in rats. *International journal of pharmaceutics*, 307(1), 77–82.
- [23] H Shariare, M., Afnan, K., Iqbal, F., an Altamimi, M., Ahamad, S. R., S Aldughaim, M., K Alanazi, F., & Kazi, M. (2020). Development and Optimization of Epigallocatechin-3-Gallate (EGCG) Nano Phytosome Using Design of Experiment (DoE) and Their *In Vivo* Anti-Inflammatory Studies. *Molecules (Basel, Switzerland)*, 25(22), 5453.
- [24] Khan, T., & Gaurav, P. (2018). PhytoNanotechnology: Enhancing Delivery of Plant Based Anti-Cancer Drugs. *Frontiers in pharmacology*, 8, 1002.
- [25] Tiyaboonchai, W., Tungpradit, W., & Plianbangchang, P. (2007). Formulation and characterization of curcuminoids loaded solid lipid nanoparticles. *International Journal of Pharmaceutics*, 337(1-2), 299-306.
- [26] Baek, J. S., & Cho, C. W. (2017). Surface modification of solid lipid nanoparticles for oral delivery of curcumin: Improvement of bioavailability through enhanced cellular uptake, and lymphatic uptake. *European journal of pharmaceutics and biopharmaceutics*. 117, 132–140.
- [27] Pandita, D., Kumar, S., Poonia, N., & Lather, V. (2014). Solid lipid nanoparticles enhance oral bioavailability of resveratrol, a natural polyphenol. *Food Research International*, 62, 1165-1174.
- [28] Zhu, R. R., Qin, L. L., Wang, M., Wu, S. M., Wang, S. L., Zhang, R., Liu, Z. X., Sun, X. Y., & Yao, S. D. (2009). Preparation, characterization, and anti-tumor property of podophyllotoxin-loaded solid lipid nanoparticles. *Nanotechnology*, 20(5), 055702.
- [29] Xie, F. M., Zeng, K., Li, G. F., Lin, Z. F., & Sun, L. D. (2005). Preparation of stearic acid solid lipid nanoparticles containing podophyllotoxin. *Di Yi Jun Yi Da Xue Xue Bao*, 25(1), 99–101.
- [30] Cilurzo, F., Cristiano, M. C., Di Marzio, L., Cosco, D., Carafa, M., Ventura, C. A., Fresta, M., & Paolino, D. (2015). Influence of the Supramolecular Micro-Assembly of Multiple Emulsions on their Biopharmaceutical Features and *In vivo* Therapeutic Response. *Current drug targets*, 16(14), 1612–1622.
- [31] Varadharajan, R., & Leermakers, F. (2020). The physics of microemulsions extracted from modeling balanced tensionless surfactant-loaded liquid-liquid interfaces. *The Journal of chemical physics*, 152(9), 094902.

- [32] Kumar, G. A., Averineni, R. K., Deshpande, P. B., Shavi, G., Reddy, M. S., & Nayanabhirama, U. (2010). Novel drug delivery systems: A microemulsion based approach. *Pharma times*, 42(4), 69-73.
- [33] Bergonzi, M. C., Hamdouch, R., Mazzacuva, F., Isacchi, B., & Bilia, A. R. (2014). Optimization, characterization and in vitro evaluation of curcumin microemulsions. *LWT-Food Science and Technology*, 59(1), 148-155.
- [34] Liu, C. H., & Chang, F. Y. (2011). Development and characterization of eucalyptol microemulsions for topic delivery of curcumin. *Chemical and Pharmaceutical Bulletin*, 59(2), 172-178.
- [35] Liu, C. H., & Huang, H. Y. (2012). Antimicrobial activity of curcumin-loaded myristic acid microemulsions against *Staphylococcus epidermis*. *Chemical and Pharmaceutical Bulletin*, 60(9), 1118-1124.
- [36] Kalantari, A., Salimi, A., Kalantari, H., Ebrahimi Broojeni, J., Rashidi, I., Raesi Vanani, A., & Bácskay, I. (2019). The hepatoprotective effect of livergol microemulsion preparation (nanoparticle) against bromobenzene induced toxicity in mice. *Toxicology reports*, 6, 444-448.
- [37] Etman, S. M., Elnaggar, Y., Abdelmonsif, D. A., & Abdallah, O. Y. (2018). Oral Brain-Targeted Microemulsion for Enhanced Piperine Delivery in Alzheimer's disease Therapy: In Vitro Appraisal, In Vivo Activity, and Nanotoxicity. *AAPS PharmSciTech*, 19(8), 3698-3711.
- [38] Guo, Y., Mao, X., Zhang, J., Sun, P., Wang, H., Zhang, Y., Ma, Y., Xu, S., Lv, R., & Liu, X. (2019). Oral delivery of lycopene-loaded microemulsion for brain-targeting: preparation, characterization, pharmacokinetic evaluation and tissue distribution. *Drug delivery*, 26(1), 1191-1205.
- [39] Amiri-Rigi, A., & Abbasi, S. (2019). Extraction of lycopene using a lecithin-based olive oil microemulsion. *Food chemistry*, 272, 568-573.
- [40] Ipar, V. S., Dsouza, A., & Devarajan, P. V. (2019). Enhancing Curcumin Oral Bioavailability Through Nanoformulations. *European journal of drug metabolism and pharmacokinetics*, 44(4), 459-480.
- [41] Chaurasia, S., Chaubey, P., Patel, R. R., Kumar, N., & Mishra, B. (2016). Curcumin-polymeric nanoparticles against colon-26 tumor-bearing mice: cytotoxicity, pharmacokinetic and anticancer efficacy studies. *Drug development and industrial pharmacy*, 42(5), 694-700.
- [42] Shaikh, J., Ankola, D. D., Beniwal, V., Singh, D., & Kumar, M. N. (2009). Nanoparticle encapsulation improves oral bioavailability of curcumin by at least 9-fold when compared to curcumin administered with piperine as absorption enhancer. *European journal of pharmaceutical sciences*. 37(3-4), 223-230.
- [43] Baksi, R., Singh, D. P., Borse, S. P., Rana, R., Sharma, V., & Nivsarkar, M. (2018). *In vitro* and *in vivo* anticancer efficacy potential of Quercetin loaded polymeric nanoparticles. *Biomedicine & Pharmacotherapy*, 106, 1513-1526.
- [44] El-Nahas, A. E., Allam, A. N., Abdelmonsif, D. A., & El-Kamel, A. H. (2017). Silymarin-loaded eudragit nanoparticles: formulation, characterization, and hepatoprotective and toxicity evaluation. *AAPS PharmSciTech*, 18(8), 3076-3086.
- [45] Xiao, B., Si, X., Han, M. K., Viennois, E., Zhang, M., & Merlin, D. (2015). Co-delivery of camptothecin and curcumin by cationic polymeric nanoparticles for synergistic colon cancer combination chemotherapy. *Journal of Materials Chemistry B*, 3(39), 7724-7733.
- [46] Zeisser-Labouèbe, M., Lange, N., Gurny, R., & Delie, F. (2006). Hypericin-loaded nanoparticles for the photodynamic treatment of ovarian cancer. *International journal of pharmaceuticals*, 326(1-2), 174-181.

ABSTRACT

Alzheimer's disease is the most common type of dementia. It's a progressive disease that begins with modest memory loss and advances to the inability to talk and respond to the environment. Alzheimer's disease affects older adults, but it is rare. Around 50 million individuals worldwide have dementia, with 60-70 percent having Alzheimer's. Every five years beyond age 65, the disease's prevalence doubles. By 2060, this population is expected to quadruple to 14 million. The condition usually manifests after age 60, and the risk increases with age. Symptoms include forgetting previous events or discussions. Alzheimer's disease causes significant memory loss and loss of daily function. Medications may temporarily alleviate or delay symptoms. These medicines can help patients with Alzheimer's disease function better and keep some independence. Various programmes and services exist to assist Alzheimer's patients and their caretakers. Alzheimer's disease has no cure or alteration in the brain. Dehydration, starvation, or infection can cause death in advanced stages of the condition.

KEYWORDS: Alzheimer's disease, Plaques, Tangles, Brain, Medications, Healthy lifestyle.

INTRODUCTION

Alzheimer's disease is a degenerative brain illness that impairs memory, thinking, and basic task performance [1-4]. The majority of late-onset patients are in their mid-60s. Alzheimer's disease with early start is unusual and usually occurs between 30 and 60. Among the elderly, Alzheimer's disease [5] is the most frequent [6]. Dr. Alois Alzheimer named Alzheimer's disease. A woman who died of a rare mental ailment in 1906 had alterations in her brain tissue. Her symptoms were forgetfulness, stuttering, and unpredictable behaviour. Her brain had several aberrant aggregates (now known as amyloid plaques) and twisted fibre bundles (now called neurofibrillary, or tau, tangles).

They are still considered to be among the most visible signs of Alzheimer's disease. The brain's connections between nerve cells (neurons) also break down. Neurons connect the brain to muscles and organs throughout the body. Other complex brain alterations may cause Alzheimer's disease. The hippocampus, the part of the brain responsible for memory formation, appears to be the site of this damage. Additional parts of the brain are impacted by the death of neurons. At the conclusion of Alzheimer's, widespread damage has occurred, and brain tissue has decreased dramatically.

CAUSES

Alzheimer's disease is incurable and has no recognised cause. But brain proteins fail fundamentally, affecting brain cell activity and setting off a chain of negative consequences. Neurons sustain damaged,

lose synapses, and perish. Alzheimer's disease is thought to be caused by a mix of genetic, behavioural, and environmental factors that slowly destroy the brain. Alzheimer's disease is caused by genetic abnormalities that affect less than 1% of people. Due to these rare occurrences, the disease generally presents around middle age. Brain injury often starts years before the first symptoms appear in the memory-controlling region of the brain. Neuronal death spreads to different parts of the brain in predictable ways. The brain has shrunk significantly during the disease's late stages. Plaques and tangles, two atypical structures, are suspected of causing injury to and degeneration of nerve cells. Researchers are examining the involvement of two proteins in their quest to determine what causes Alzheimer's disease:

Plaques are beta-amyloid protein [7, 8] particles that accumulate in the spaces between nerve cells. These fragments appear to disrupt neurons and impair cell-to-cell communication when clumped together. They create amyloid plaques, which contain extracellular debris.

Tangles are tau filaments [9] that tangle and clump together within cells. Tau proteins are required for the transportation of nutrients and other critical components within neurons' internal support and transport system. In Alzheimer's disease, tau proteins alter form and self-organize into aggregates known as neurofibrillary tangles [10, 11]. Tangles are damaging to cells and obstruct the passage of information.

RISK FACTORS

Alzheimer's illness is still unknown to scientists. There is no single reason, but rather a combination of circumstances that effect each individual.

- ✓ Age is the most well-known risk factor [12].
- ✓ Women appear to be at more risk than males, but overall, women have the condition because they live longer.
- ✓ Genetics may influence Alzheimer's progression [13, 14]. However, genes do not decide one's fate. Alzheimer's disease can be reduced by leading a healthy lifestyle. Regular exercise, a nutritious diet, limited alcohol use, and no smoking have been shown to help in two large-scale experiments. The apolipoprotein E gene is one better-understood genetic component (APOE) [15, 16]. Alzheimer's disease risk is increased by the APOE e4 gene variant. The APOE e4 gene is present in around 25%-30% of the population, but not everyone with this gene mutation becomes ill. Scientists have uncovered uncommon alterations in three genes that nearly guarantee Alzheimer's. But these mutations only affect 1% of Alzheimer's patients.
- ✓ A lack of sleep has been related to an increased risk of Alzheimer's.
- ✓ Those with significant brain injuries are more prone to Alzheimer's. Several important studies show that a traumatic brain injury raises the risk of dementia and Alzheimer's disease in older persons.
- ✓ Researchers are looking into how education, diet, and environment affect Alzheimer's disease. Poverty, stress, and prenatal viral or nutritional exposure are possible environmental contributors.

WARNING SIGNS

Alzheimer's is not a normal part of ageing. Memory loss is a hallmark of Alzheimer's and other dementias [17].

Table 1 showed Alzheimer's disease symptoms. Alzheimer's patients may also have one or more of the following symptoms:

Table 1: Warning Signs of Alzheimer’s disease

| | |
|--|---|
| Disruption of daily life due to memory loss | Forgetting events, repeating you, or using extra memory aides. |
| Problems with planning or solving | Having difficulty paying bills or preparing old favourites. |
| Difficulty performing routine duties at home, work, or leisure | Cooking, driving, using a phone, and going shopping are all difficult tasks. |
| Time or place ambiguity | Having problems understanding a subsequent occurrence or forgetting dates. |
| Trouble with visuals and spatial relations | More difficulties with balance or distance, more trips and falls at home, and more spills and drops. |
| Word issues in speaking or writing | Finding it difficult to follow or join a conversation (Instead of mentioning "watch," say "the thing on your wrist that displays time"). |
| Loss of memory and ability to retrace steps | Putting your car keys in the washer or dryer, or being unable to locate items. |
| Lack or bad judgement | A scam victim, poor money management, poor cleanliness, or difficulty caring for a pet. |
| Disruption from job or social life | Not wanting to do other things, being unable to follow games or keep track of events. Not wanting to do other things or keep up with what is going on. |
| Mood and personality shifts | Easily upset, apprehensive, or distrustful in everyday settings. |

Alzheimer's causes loss of memory. For example, forgetting recent events or discussions is a symptom. As the condition advances, cognitive problems and other symptoms increase. Alzheimer’s disease patients may initially experience memory loss and trouble organising their ideas. A family member or friend may notice a worsening of symptoms. As seen in Table 2, the brain alterations linked with Alzheimer's disease resulted in increasing difficulty with:

Table 2: Brain changes associated with Alzheimer's disease

| | |
|---------------|--|
| Memory | <p>Alzheimer's causes progressive memory loss that impairs ability to work or live independently.</p> <p>Alzheimer's disease patients may exhibit the following symptoms:</p> <ul style="list-style-type: none"> • Repetition of comments and queries • Forget about encounters, appointments, and events. • Frequently misplace personal belongings, frequently in awkward locations • Become disoriented in familiar locations • Forget familiar faces and daily stuff • Difficulty recognising objects, expressing ideas, or participating in conversations |
|---------------|--|

| | |
|---|---|
| Thinking and reasoning | Alzheimer's disease hampers concentration and reasoning, especially when it comes to numbers. Multitasking, as well as managing funds, checking accounts, and paying bills on time, are all demanding tasks. Alzheimer's patients may lose number recognition and manipulation skills. |
| Making judgments and decisions | Alzheimer's disease hampers daily judgement and decision-making. For instance, someone may make unconventional social choices or misappropriate clothing. Routine issues like cooking on the stove or driving may be more difficult. |
| Planning and performing familiar tasks | Routine tasks, such as meal preparation or favourite game becomes more difficult as the condition progresses. Advanced Alzheimer's sufferers commonly lose basic skills like dressing and washing. |
| Changes in personality and behaviour | Alzheimer's brain changes can affect mood and behaviour. Among the issues: <ul style="list-style-type: none"> • Depression • Apathy • Social retach • Spiral Moods • Doubt in others • Angry & irritable • Sleeping habits change • Wandering • Inhibition loss • Delusions |
| Preserved skills | Many critical skills are kept even as symptoms deteriorate. Reading, listening to music, dancing, drawing, and making crafts are all examples of abilities that have been passed down through the generations. Because these skills are governed by later impacted brain areas, they may last longer. |

DIAGNOSIS

Alzheimer's disease must be identified when a person exhibits memory loss, cognitive decline, or behavioural abnormalities that limit everyday functioning. Alzheimer's disease does not have a single diagnostic test. If a doctor detects the disease, he or she should inquire about the patient's overall health, medication use (prescription and OTC), food, previous medical problems, capacity to perform everyday activities, and changes in behaviour and personality [18,19]. Additionally, the doctor may perform the following tests:

- ✓ Neurological tests are used to check a person's balance, senses, and reflexes, while brain and memory tests are used to measure a person's memory and cognition.
- ✓ Conduct routine medical examinations, such as blood and urine testing, to rule out other probable reasons.
- ✓ Brain scans, such as CT, MRI, or PET, can assist confirm or rule out an Alzheimer's diagnosis.

There are a variety of techniques available for evaluating cognitive function. Alzheimer's disease symptoms, for example, can be associated with genetic illnesses such as Huntington's disease. Certain

APOE e4 gene variations have been associated with an elevated risk of Alzheimer's disease. Genetic tests performed early in life may aid in predicting the chance of having or developing the illness. In any event, the findings are not totally trustworthy.

TREATMENT

Alzheimer's has no known cure [20-22]. Brain cell death is irreversible. Treatments can alleviate symptoms and improve the standard of living for the patient as well as their family members.

Important elements of dementia care include:

- ✓ Co-occurring disorders and Alzheimer's disease management
- ✓ Activities & day care programmes
- ✓ Support groups and services engaged

MEDICATIONS AND TREATMENTS FOR BEHAVIOURAL CHANGES

MEDICATIONS FOR COGNITIVE SYMPTOMS

Although Alzheimer's disease is incurable, many therapies can help alleviate symptoms and improve overall quality of life. Cholinesterase inhibitors [23, 24] may be beneficial in the treatment of memory loss, disorientation, altered mental processes, and impaired judgement. They enhance brain connections and help symptoms progress more slowly.

Three commonly used medications approved by the FDA to treat these Alzheimer's disease symptoms include donepezil [25-27] for all stages, galantamine [28-30] and rivastigmine [31-33] for mild-to-moderate stages. Another medication, memantine, has been licenced for the treatment of mild-to-moderate Alzheimer's disease. Additionally, there is a memantine/donepezil combo [34].

EMOTION AND BEHAVIOUR TREATMENTS

Alzheimer's disease patients may exhibit emotional and behavioural abnormalities. Irritability, anxiety, sadness, restlessness, and sleep problems may all worsen. The factors that contribute to these alterations can be addressed. Several are adverse effects of medications, other medical disorders, or hearing or vision problems. Identifying triggers and avoiding or altering them might assist individuals in coping with change. Triggers may include changes in the surroundings, caretakers, or demands to bathe or dress. Often, it is possible to alter one's environment in order to increase one's comfort, security, and mental health. The Alzheimer's Association provides caregivers with a list of helpful coping mechanisms. A doctor may give antidepressants to treat depression, antianxiety medications to treat anxiety, and antipsychotic medications to treat hallucinations, delusions, or violence.

ALTERNATIVE THERAPIES

Professionals may prescribe alternative therapy to treat some behavioural issues associated with Alzheimer's disease. Table 3 represented alternative therapies for Alzheimer's disease some examples are:

Table 3: Alternative Therapies for Alzheimer's disease

| | |
|--------------------|---|
| Validation Therapy | It is founded on acceptance of one's reality. Reminiscence Therapy involves talking about past events in a group or individually. |
| Aromatherapy | In aromatherapy, essential oils are used to promote health. Commonly used oils include orange, lemon, rosemary, and lavender. |

| | |
|----------------------|--|
| Simulation Therapy | Based on attachment theories, the Alzheimer's patient can listen to recordings of loved ones' voices. |
| Bright Light Therapy | Because Alzheimer's disease affects the circadian rhythm portion of the brain, it can interrupt a person's wake and sleep cycle. This can disrupt sleep. Intense bright light therapy can help re-establish the sleep and wake cycle. |
| Acupuncture | Component of traditional Chinese medicine used for centuries to treat a variety of diseases. Most studies on its advantages for Alzheimer's disease patients are positive. |
| Herbal Treatments | Herbal supplements may help Alzheimer's patients. One highly recommended choice is Gingko Biloba, a supplement with antioxidant effects. Common natural therapies include coconut oil and omega 3 fatty acids. |
| Massage | This form of therapy is effective for many ailments. A few research show it helps Alzheimer's patients. Massage may also help reduce agitation, roaming, and hostility. Alternative Alzheimer's disease treatments are currently undergoing extensive research. Herbal supplements and vitamins are rarely subjected to the same rigorous government scrutiny as pharmaceutical medications. As a result, people with Alzheimer's disease should use alternative treatments with caution. Despite the fact that many respectable researchers are investigating these methods, unfounded claims abound. The disabled person should discuss the dangers and benefits with their doctor. A person should also consult their doctor before taking any vitamin or herbal supplement because some may negatively interact with medications. |

PREVENTING ALZHEIMER'S

Medical management can help Alzheimer's patients and caregivers live better lives. Alzheimer's has no known cure. Treatment aims to maintain brain health, manage behavioural symptoms, and slow or delay disease symptoms. Healthy lifestyle habits are being studied as a way to prevent cognitive decline. A plant-based diet may help as well as quitting smoking and exercising regularly [35]. Eating a diet rich in fresh fruits and vegetables, healthy oils, and low-fat foods, follow treatment guidelines for hypertension, diabetes, and cholesterol, eat more antioxidants, and socialise. Some believe vitamin E can help prevent mental decline, but studies show more research is needed. As with any supplement, consult your doctor first. It may interact with some Alzheimer's medications.

FAMILY EDUCATION AND SUPPORT

Many individuals with Alzheimer's disease are being cared after at home by family members. Caring for another person has a number of advantages for both the caregiver and the person being cared for. It may provide personal fulfilment for the caregiver by allowing them to assist a family member or friend, as well as strengthen family bonds. While the majority of individuals are ready to assist friends and family members, caring for someone who has Alzheimer's disease at home can be challenging and overwhelming. Each day presents a new set of obstacles as the caregiver adjusts to the caregiver's

changing abilities and behaviours. As Alzheimer's disease advances, people frequently require more extensive care.

CONCLUSION

Alzheimer's disease is a progressive disease that results in brain atrophy and cell death. Medical management has the potential to significantly enhance the lives of Alzheimer's patients and caretakers. Drugs and other treatments, on the other hand, can help alleviate cognitive, emotional, and behavioural symptoms and enhance overall quality of life. Medications can temporarily ease or slow symptoms. These treatments may improve the ability of persons with Alzheimer's disease to function and keep their independence for a while. Numerous programmes and services are available to aid Alzheimer's disease sufferers and caregivers.

REFERENCES

- [1] Dubois B., Hampel H., Feldman H.H., Scheltens P., Aisen P., Andrieu S., Bakardjian H., Benali H., Bertram L., Blennow K., et al. (2016). Preclinical Alzheimer's disease: Definition, natural history, and diagnostic criteria. *Alzheimer's Dement. J. Alzheimer's Assoc.* 12, 292–323.
- [2] De-Paula V.J., Radanovic M., Diniz B.S., Forlenza O.V. (2012). Alzheimer's disease. *Sub-Cell. Biochem.* 65, 329–352.
- [3] Cipriani G., Dolciotti C., Picchi L., Bonuccelli U. (2011). Alzheimer and his disease: A brief history. *Neurol. Sci. Off. J. Ital. Neurol. Soc. Ital. Soc. Clin. Neurophysiol.* 32, 275–279;
- [4] Blass J.P. (1985). Alzheimer's disease. *Dis. A Mon. Dm.* 31, 1–69.
- [5] Zeinab Breijyeh, Rafik Karaman. (2020). Comprehensive Review on Alzheimer's disease: Causes and Treatment. *Molecules.* 25(24), 5789
- [6] Armstrong R.A. (2009). The molecular biology of senile plaques and neurofibrillary tangles in Alzheimer's disease. *Folia Neuropathol.* 47, 289–299.
- [7] Li N.M., Liu K.F., Qiu Y.J., Zhang H.H., Nakanishi H., Qing H. (2019). Mutations of beta-amyloid precursor protein alter the consequence of Alzheimer's disease pathogenesis. *Neural Regen. Res.* 14, 658–665.
- [8] Tcw J., Goate A.M. (2017). Genetics of beta-Amyloid precursor protein in Alzheimer's disease. *Cold Spring Harb. Perspect. Med.* 7, a024539.
- [9] Spires-Jones T.L., Hyman B.T. (2014). The intersection of amyloid beta and tau at synapses in Alzheimer's disease. *Neuron.* 82, 756–771.
- [10] Brion J.P. (1998). Neurofibrillary tangles and Alzheimer's disease. *Eur. Neurol.* 40, 130–140.
- [11] Metaxas A., Kempf S.J. (2016). Neurofibrillary tangles in Alzheimer's disease: Elucidation of the molecular mechanism by immunohistochemistry and tau protein phospho-proteomics. *Neural Regen. Res.* 11, 1579–1581.
- [12] Guerreiro R., Bras J. (2015). The age factor in Alzheimer's disease. *Genome Med.* 7, 106. doi: 10.1186/s13073-015-0232-5.
- [13] Bekris L.M., Yu C.E., Bird T.D., Tsuang D.W. (2010). Genetics of Alzheimer disease. *J. Geriatr. Psychiatry Neurol.* 23, 213–227.
- [14] Khanahmadi M., Farhud D.D., Malmir M. (2015). Genetic of Alzheimer's disease: A narrative review article. *Iran. J. Public Health.* 44, 892–901.
- [15] Riedel B.C., Thompson P.M., Brinton R.D. (2016). Age, APOE and sex: Triad of risk of Alzheimer's disease. *J. Steroid Biochem. Mol. Biol.* 160, 134–147.

- [16] Filippini N, Rao A, Wetten S, Gibson RA, Borrie M, Guzman D, Kertesz A, Loy-English I, Williams J, Nichols T, Whitcher B, Matthews PM. (2009). Anatomically-distinct genetic associations of APOE epsilon4 allele load with regional cortical atrophy in Alzheimer's disease. *Neuroimage*. 44(3), 724-8.
- [17] Terry R.D., Davies P. (1980). Dementia of the Alzheimer type. *Annu. Rev. Neurosci.* 3, 77-95.
- [18] Monczor M. (2005). Diagnosis and treatment of Alzheimer's disease. *Curr. Med. Chem. Cent. Nerv. Syst. Agents*. 5, 5-13.
- [19] Neugroschl J., Wang S. (2011). Alzheimer's disease: Diagnosis and treatment across the spectrum of disease severity. *Mt. Sinai J. Med. N. Y.* 78, 596-612.
- [20] Rathmann K.L., Conner C.S. (1984). Alzheimer's disease: Clinical features, pathogenesis, and treatment. *Drug Intell. Clin. Pharm.* 18, 684-691.
- [21] Yiannopoulou K.G., Papageorgiou S.G. (2020). Current and future treatments in alzheimer disease: An update. *J. Cent. Nerv. Syst. Dis.* 12, 1-12.
- [22] Livingston G., Huntley J., Sommerlad A., Ames D., Ballard C., Banerjee S., Brayne C., Burns A., Cohen-Mansfield J., Cooper C., et al. (2020). Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *Lancet*. 396, 413-446.
- [23] Sharma K. (2019). Cholinesterase inhibitors as Alzheimer's therapeutics (Review) *Mol. Med. Rep.* 20, 1479-1487.
- [24] Eldufani J., Blaise G. (2019). The role of acetylcholinesterase inhibitors such as neostigmine and rivastigmine on chronic pain and cognitive function in aging: A review of recent clinical applications. *Alzheimers Dement.* 5, 175-183.
- [25] Cacabelos R. (2007). Donepezil in Alzheimer's disease: From conventional trials to pharmacogenetics. *Neuropsychiatr. Dis. Treat.* 3, 303-333.
- [26] Kumar A., Sharma S. (2020). StatPearls. StatPearls Publishing; Treasure Island, FL, USA. [(Accessed on 8 December 2020)]. Donepezil.
- [27] Dooley M., Lamb H.M. (2000). Donepezil: A review of its use in Alzheimer's disease. *Drugs Aging*. 16, 199-226.
- [28] Scott L.J., Goa K.L. (2000). Galantamine: A review of its use in Alzheimer's disease. *Drugs*. 60, 1095-1122.
- [29] Prvulovic D., Hampel H., Pantel J. (2010). Galantamine for Alzheimer's disease. *Expert Opin. Drug Metab. Toxicol.* 6, 345-354.
- [30] Kim J.K., Park S.U. (2017). Pharmacological aspects of galantamine for the treatment of Alzheimer's disease. *Excli J.* 16, 35-39.
- [31] Annicchiarico R., Federici A., Pettenati C., Caltagirone C. (2007). Rivastigmine in Alzheimer's disease: Cognitive function and quality of life. *Ther. Clin. Risk Manag.* 3, 1113-1123.
- [32] Muller T. (2007). Rivastigmine in the treatment of patients with Alzheimer's disease. *Neuropsychiatr. Dis. Treat.* 3, 211-218.
- [33] Khoury R., Rajamanickam J., Grossberg G.T. (2018). An update on the safety of current therapies for Alzheimer's disease: Focus on rivastigmine. *Ther. Adv. Drug Saf.* 9, 171-178.
- [34] Briggs R., Kennelly S.P., O'Neill D. (2016). Drug treatments in Alzheimer's disease. *Clin. Med.* 16, 247-253.
- [35] Crous-Bou M., Minguillon C., Gramunt N., Molinuevo J.L. (2017). Alzheimer's disease prevention: From risk factors to early intervention. *Alzheimer's Res. Ther.* 9, 71. doi: 10.1186/s13195-017-0297-z

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