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Nanotechnology: A Growing Field in Science and Technology

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ABSTRACT

In recent decades nanotechnology has gained attention of all the branches of science due to its applicability in different areas and connectivity with other branches of science. In this paper a brief introduction of nanotechnology along with methods of synthesis of nanoparticles, their characterization techniques and applications in different areas are being enlightened.

Keywords: applications, nanoparticles, nanotechnology, synthesis, top down and bottom up.

I. INTRODUCTION

Innovation is necessary to help address challenges at global level like sustainable development, climate change, competition and national progress determination. Energy and environment, food and nutrition, water and sanitation, habitat, affordable health, skill building and unemployment are the main well-known areas that require new structural mechanisms, while the advancement of scientific temper and skill for application of new ideas among the youth, creating careers in science, making research interesting are some of the other fields required for connecting science with the people and increasing the number of skilled manpower in Science & Technology (S&T) sector. Recently nanotechnology is an emerging field due to its applicability in different fields.

1.1 What is nanotechnology?

Nanotechnology is the designing and exploitation of materials, devices and systems on the nanometer scale [1]. In general, the most important things in the field of nanotechnology are: small size in the range of 1-100 nm and large surface area of the nanoparticles.

1.2 Classification of nanomaterials

Nanomaterials exist in zero, one, two or three dimensional nanostructures in isolated or combined forms having different shapes like spherical, cubic, tubular, rod, flower and irregular as shown below in Fig. 1 which can be used for different functions.

1.3 Approaches in nano technology

There are two approaches in synthesis of nanoparticles as shown in Fig. 2 and defined below in tabulated form in Table 1.

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Table 1: Top-Down and Bottom –up approach

Top down Approach	Botom up Approach
Bulk materials or large sized particles converted into small size (in nm range) by using grinder or laser.	Very small sized particles or true solution (in pm or fm) aggregate or combine to form big particles in nano dimension This uses the principle of molecular recognization and self assembly.

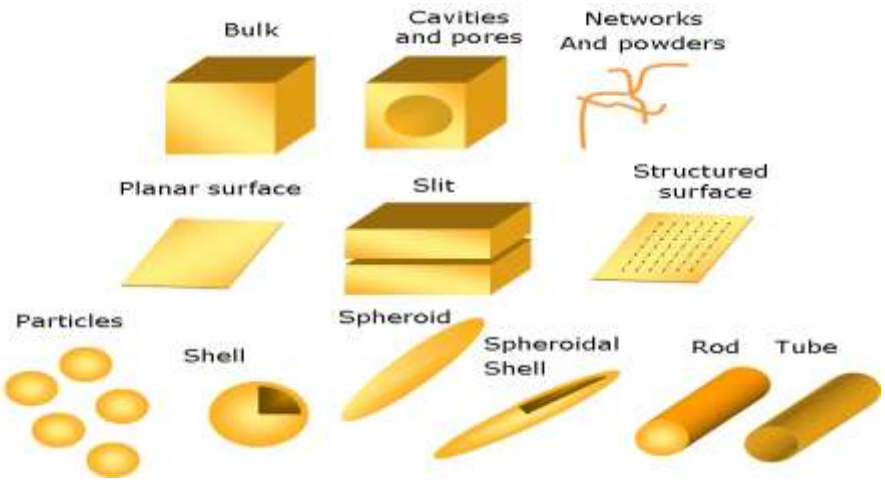

Figure 1: Classification of nanomaterials

(source: https://simple.wikipedia.org/wiki/Nanotechnology)

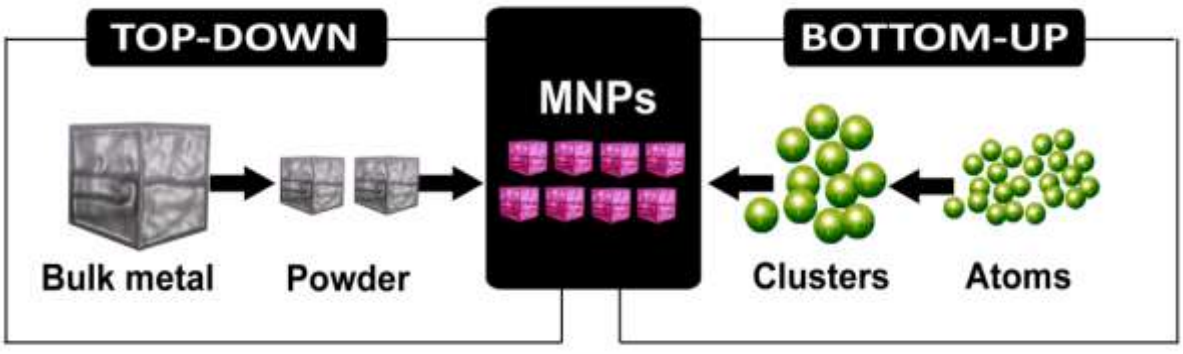

Figure 2: Top down and Bottom up approach in nanotechnology

(source: http://nanotechnologyjd.weebly.com/uploads/2/1/9/2/21920428/6500290_orig.png)

1.4 Methods of preparation

There are different methods of synthesizing nanostructures, macromolecules, nanoparticles, buckyballs, nanorods or nanotubes. Some of these are: Mechanical grinding, Hydrothermal method, Sol-gel technique, Co-precipitation method, Solid state route, Laser abalation, Microwave synthesis and Plasma processing.

1.5 Characterization techniques

Various techniques used for characterization of nanoparticles are: X-ray diffraction (XRD), Fourier transform infra-red spectroscopy (FTIR), Ultra-violet absorption spectroscopy (UV), Scanning electron microscopy (SEM), Tunneling electron microscopy (TEM) or High Resolution HRTEM, Brunauer-Emmett-Teller (BET), Thermo-Gravimetric/Differential Thermal Analyzer (TG/DTA), Static Light Scattering Technique (SLT), Dynamic light scattering (DLS), Electron Energy Loss Spectroscopy (EES), Energy Dispersive X-ray Spectroscopy (EDS or EDX), Photoluminescence (PL) *etc*.

II. PROPERTIES OF NANO MATERIALS

Nanomaterials are having different properties than bulk materials due to larger surface area, high surface energy, spatial confinement, reduced imperfection. They have large surface area to volume ratio due to small size which enhance the surface dependent properties. Various properties of nanoparticles are physical properties, Optical properties and magnetic properties.

Physical properties of nanoparticles include size, shape, surface area, structure *etc.* Optical properties of nanomaterials include optical detector, laser, sensor,imaging, phosphor, display, solar cell, photocatalysis, photoelectrochemistry and biomedicine. The optical properties depend on structural properties such as size, shape, surface characteristics, and other variables like doping and interaction with the surrounding environment.

III. APPLICATIONS OF NANOMATERIALS

Nanomaterials have several applications in the field of electronics, catalysis, sensors, dye degradation, fuel cells, batteries, agriculture, food industry, medicines *etc*.

3.1 Catalysis

Higher surface area of nanomaterials help them to act as catalysts. Nano-catalysts tend to have extraordinary surface activity. For example, reaction rate at nano-aluminum can go so high, that it is utilized as a solid-fuel in propulsion of rockets, whereas the bulk aluminum is widely used in making utensils. Nano-aluminum being highly reactive supplies the required thrust to send vehicles in space. Catalysis assisting or retarding the reaction rates depend on the surface area of catalysts and can very well be utilized in influencing the rate-controlling step.

3.2 Photocatalysis or Dye degradation

Due to release of certain poisonous chemicals from industries, water pollution is a key problem in current periods. The major constituents of the pollutants are mainly chlorophenols, arsenic, heavy metals, pesticides, aliphatic and aromatic detergents, degreasing agents, volatile organics, and dyes [2]. Dyes are a significant class

of man-made organic compounds used in the fabric industry. But these are common industrial pollutants. Due to the stability of these pollutants or dyes, conservative biological treatment methods are not suitable. Heterogeneous photocatalysis is an encouraging technology for the decline of global environmental pollutants. Inorganic photocatalysts like TiO_2, g-CN are very cheap and effective route of eradicating organic compounds and pollutant gases [3].

3.3 Hydrogen generation through photoelectrochemical cells

Hydrogen has numerous probable applications, like used as a fuel for powering of nonpolluting vehicles, domestic heating, and in aircrafts. Hydrogen acts as an energy transporter, is anticipated to link photovoltaic electricity as the basis of sustainable energy system. It has been found that hydrogen can be generated from water by using solar energy through the help of high efficiency photo-electrochemical cells (PECs). PEC technology is the most favorable technology for hydrogen production because this is based on solar energy, which is a huge source of energy, environmentally safe, with no undesirable side products, may be used on both large as well as small scales relatively in an easier way [4].

3.4 Phosphors for high-definition TV

The pixel used for the resolution of a television, or a monitor made up of materials called "phosphors". The resolution increases with a decrease in the size of the pixel, or the phosphors. Nanocrystalline zinc selenide, Cadmium sulphide, Zinc sulphide, and lead telluride *etc.* are used for refining the resolution of monitors. The use of Nano phosphors reduces the cost of displays.

3.5 Sun-screen lotion

UV exposure for a long time causes skin-burns, skin rashes and cancer. Sun-screen lotions containing nano-TiO_2 afford improved sun protection factor (SPF) which protects the skin by sitting onto it than penetrating into the skin. Hence, they block the exposure of UV radiation effectively for a longer duration, transparent, and helps to retain natural skin color.

3.6 Sensors

Nanosensors are chemical or mechanical sensors used to detect numerous chemicals in gases for pollution monitoring, for medical diagnostic purposes. Top-down and bottom-up techniques are used to make nanosensors. Nanosensors are more specific and sensitive over sensors because of high surface area to volume ratio. To sense ionization of gaseous molecules, carbon nanotubes can be used whereas titanium nanotubes can be used to detect atmospheric concentrations of hydrogen respectively [5]. We can use ZnO nanotubes to measure the concentration of hydrogens or ethanol. Platinum and gold nano-wires are used as biosensors for food analysis [6].

3.7 Drug delivery

Drug delivery means, the drug will be carried out by blood to the target. Conventional drug delivery methods are not suitable because they lead to the damage of normal cells and organs due to toxicity. Targeted drug delivery is better because in this method the drug is delivered to specific cells or organs. Different morphological structures of nanomaterials like nanoparticles, nanospheres, nanoencapsules, nanoemulsions,

nanotubes can be used for drug delivery because these can be dissolved, adsorbed, attached or captured into the nanoparticle matrix. Antineoplastic agents, Antibiotics, and various CNS-active drugs, especially neuropeptides cannot pass the Blood Brain Barrier (BBB) alone [7]. But it has been found that some drugs in nano form can now cross the BBB with lower toxicity and less adverse effects.

3.8 Food processing

Food processing is a process of conversion of raw food materials into cosumable form. Various nanomaterials cn be used for processing of food. Some of the examples of nanomaterials used as food processing agents are:
Zinc and its oxide in nm are used as nutritional additives as well as antimicrobial agents in food packaging [8]. Titanium dioxide nanoparticles are usually used as food additive and antimicrobial agent for food packaging and storage containers with minimum toxic effects on rats [9]. Silicon dioxide and carbon particles in the range of 100 nm used as food additives and for food packaging [10]. Silver nanoparticles (AgNps), are good antimicrobial agents in food packaging, storage containers and health supplements [11].

3.9 Local Anaesthesia

To increase the effectiveness of local anaesthesia in pain relief, various biomaterials in different forms (liposomes, nanospheres, nanoparticles, nanocapsules, nanorod, cyclodextrins and hydrogels) have successfully been developed [12].

3.10 Pesticide removal from aqueous solutions

To protect plants from pests, fungi, insects and weeds, pesticides are extensively used in agricultural production all over the world. Therefore, residues of pesticides are widely distributed in drinking waters, groundwaters, and soils and creating environmental problems. Adsorption, filtration and degradation are three main phenomena which are currently in trend to overcome this problem [13]. Maliyekkal *et al.* studied graphene can be used for the adsorption of pesticides [14].

IV. CONCLUSION

Nanotechnology plays an important role in medical science, agricultural science, IT sector, food processing *etc.* Scientists are working in the field of nanotechnology throughout the world to discover new applications. Although this field has some disadvantages also, but still it finds lot of applications due to its size and surface area.

REFERENCES

[1] https://www.ugc.ac.in/mrp/paper/MRP-MAJOR-CHEM-2013-2346-PAPER.pdf.

[2] Hegde M. S., Nagaveni K. and Roy S., Synthesis, structure and photocatalytic activity of nano TiO_2 and nano $Ti_{1-x}M_xO_{2-\delta}$ (M= Cu, Fe, Pt, Pd, V, W, Ce, Zr), *Pramana, 65(4),* 2005, 641-645.

[3] Rashed M. N. and El-Amin A. A., Photocatalytic degradation of methyl orange in aqueous TiO_2 under different solar irradiation sources, *International Journal of Physical Sciences, 2(3),* 2007, 73-81.

[4] Bak T., Nowotny J., Rekas M. and Sorrell C. C., Photo-electrochemical hydrogen generation from water using solar energy. Materials-related aspects, *International Journal of hydrogen energy, 27(10),* 2002, 991-1022.

[5] Modi A., Koratkar N., Lass E., Wei B. and Ajayan P. M., Miniaturized gas ionization sensors using carbon nanotubes, *Nature, 424(6945),* 2003, 171-174.

[6] Amil Usmani, M., Khan, I., H Bhat, A., S Pillai, R., Ahmad, N., K Mohamad Haafiz, M., and Oves M., Current trend in the application of nanoparticles for waste water treatment and purification: a review, *Current Organic Synthesis, 14(2),* 2017, 206-226.

[7] Kreuter J., Nanoparticulate systems for brain delivery of drugs, *Advanced drug delivery reviews, 47(1),* 2001, 65-81.

[8] Alfadul S. M. and Elneshwy A. A., Use of nanotechnology in food processing, packaging and safety–review, *African Journal of Food, Agriculture, Nutrition and Development, 10(6),* 2010, 2719-2739.

[9] Higashisaka K., Yoshioka Y. and Tsutsumi Y., Applications and Safety of Nanomaterials Used in the Food Industry, *Food Safety, 3(2),* 2015, 39-47.

[10] Chen, M. and Von Mikecz A., Formation of nucleoplasmic protein aggregates impairs nuclear function in response to SiO_2 nanoparticles, *Experimental cell research, 305(1),* 2005, 51-62.

[11] Aigbogun I. E., Mohammed S. S. D., Orukotan A. A. and Tanko J. D., The Role of Nanotechnology in Food Industries-A Review, *Journal of Advances in Microbiology, 7(4),* 2017, 1-9.

[12] Moradkhani M. R., Karimi A. and Negahdari B., Nanotechnology application to local anaesthesia (LA), *Artificial cells, nanomedicine, and biotechnology, 46(2),* 2018, 355-360.

[13] Taghizade Firozjaee T., Mehrdadi N., Baghdadi M. and Nabi Bidhendi G. R., Application of Nanotechnology in Pesticides Removal from Aqueous Solutions-A review, *International Journal of Nanoscience and Nanotechnology, 14(1),* 2018, 43-56.

[14] Maliyekkal S. M., Sreeprasad T., Krishnan D., Kouser S., Mishra A. K., Waghmare U.V. and Pradeep T., Graphene: a reusable substrate for unprecedented adsorption of pesticides, Small, 9, 2012, 273-283.