Advance Physics Letter

Nanotechnology: A Review

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Abstract— Nanotechnology deals with the engineering of functional systems at the molecular level and is focused on controlling and exploiting the structure of matter below 100 nanometers. It is involved with everything today from clothes to foods. In this paper, we have discussed the concept of Nanotechnology along with its history and various applications. The purpose of this paper is to look into the present aspects of "Nanotechnology" and its applications in various fields viz. computing, medicine, food technology, Robotics, Solar cells etc. It also deals with the future perspectives and risks in advanced nanotechnology.

Keywords: Nanotechnology, nanomaterial, Top-Down Approaches, Bottom-Up Approaches, NanoFilms, Grey Goo, Nanoelectronics, Nanomedicine.

I. INTRODUCTION

Nanotechnology is a new emerging theoretical and experimental field of applied science and technology with systems at the molecular level. It is focused on controlling and exploiting the structure of matter on a large scale below 100 nanometers [1]. It has significant impact on almost all industries and all areas of society [2]. It deals with the fabrication of materials with novel and improved properties. It has considerable impact on physical and chemical sciences, biological and health sciences. This technology leads to better materials which are longer lasting, cleaner, safer and smarter and cost effective solutions for home, communications, medicine, transportation etc. Nanotechnology provides a new foundation for knowledge, innovation, and integration of technology [3].

Nanoparticles

Particles whose sizes range from 1-100 nm is called a nanoparticle, whether it is dispersed in gaseous, liquid or solid medium. These are number of atoms or molecules bonded together and intermediate in size between individual atoms and bulk material. They can be built by assembling individual atoms or subdividing bulk materials. Size of nanoparticles is less than wavelength of light. Critical characteristics are their very high surface-to-volume ratio, quantum confinement effect etc. Van der Waal forces or magnetic forces play more important role than gravitational forces in case of nanomaterials[4].

II. SYNTHESIS METHODS

A. Top-Down and Bottom-Up Approaches

The methods of synthesis of nanoparticles are classified into 'top-down' and 'bottom-up' approaches. Top-down approach involves breaking of larger materials into fine particles of nanometer dimensions. The miniaturization of components for the construction of useful devices and machines has been and still is pursued by the top-down approach [5]. In this method the bulk is machined down to the nanometer length scale by lithographic or laser ablation-condensation techniques.

For mass production of metal nanoparticles, the chemical methods are more effective than the physical ones. Fig. 1 shows the Schematic illustration of preparative methods of metal nanoparticles.

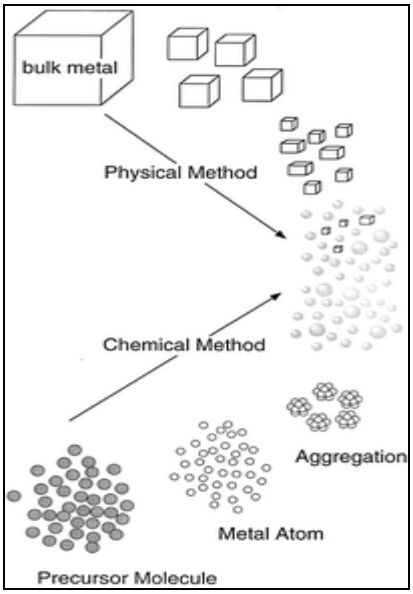

Fig 1: Schematic of methods of preparation of metal nanoparticles

In the bottom-up approach, the nanoparticles are built up from atoms or molecules. Nano- or sub Nano-scale objects contribute to build up nanostructures [5]. In the synthesis of metal colloids, controlling the size and shape is done by adjusting the ratio of the concentration of the precursors and the capping material (e.g., polymers, micelles, surfactants, or dendrimers).

III APPLICATIONS

A. Nanotechnology in Paints and Coatings

Paints or coatings beautify and protect valuable metals and buildings from corrosion. Nanotechnology in paint and coatings promises to fulfill all desired properties [6]. New paint technology fights bacterial and fungal growth with Nano scale silver. Silver Nanoparticles in wall paint prevent the formation of mould inside buildings and the growth of algae on outside walls. Silver interferes with various stages of cell metabolism; it can destroy a wide range of germs and make it difficult for microbes to develop resistance [7]. Nanoparticles in paints offer better surface appearance, good chemical resistance, easy to clean, anti-fogging, anti-fouling, anti-reflective, anti-fingerprints, scratch resistance, UV resistance, hydrophobic & oil repellent in nature, fire resistant etc.

B. Nanotechnology in Textiles and Clothing

Nanotechnology also has real commercial potential for the textile industry. Coating is a common technique used to apply Nano-particles onto textiles. Nano-particles have a large surface area-to-volume ratio and high surface energy which provides high durability for fabrics [8]. Nanotechnology favours various textile properties like process ability,flexibility, wash ability and softness. The use of nanotechnology produces fabrics with special functions like antibacterial, UV-protection, easy clean, water & stain repellent and anti-odor.

C. Nanotechnology in Cosmetics

The applications of nanotechnology and nanomaterial's can be found in many cosmetic products including moisturizers, hair care products, make up & sunscreen. Almost all the major cosmetic manufactures use nanomaterial in their products. Nanomaterials are mainly used as UV filters and for delivery. Titanium dioxide (TiO2) and zinc oxide (ZnO) are the main compounds used in these applications. Liposomes and noisome, they both are used in the cosmetic industry as delivery vehicles. Nano crystals, Nano emulsions, solid lipid nanoparticles are being investigated for cosmetic applications [9].

D. Nanotechnology in Food Science

Nanotechnology may be used in agriculture and food production in the form of Nano sensors for monitoring crop growth and pest control by early identification of plant diseases[10]. A Nano composite coating process could improve food packaging by placing anti-microbial agents directly on the surface of the coated film. They can also improve the mechanical and heat-resistance properties and lower the oxygen transmission rate.

E. Nanotechnology in Catalysis

Catalysis is the essential application of metal nanoparticles. As catalysts, nanomaterials show a great potential because of the large surface area of the particles. There are different types of nanomaterials which are used as a catalysts e.g. metals or metal oxide & sulfides or silicates [11]. There are two types of catalyst: heterogeneous catalysis & homogeneous catalysis. Heterogeneous catalysts act in a different phase than the reactants whereas homogeneous catalysts function acts in the same phase as the reactants.

F. Nanomaterials for Drug-Delivery

Dendrimers are a type of nanostructures that can be precisely designed and manufactured for a wide variety of applications, including the treatment of cancer and other diseases. Dendrimers can recognize diseased cells, can do drug delivery to respective location, and report outcomes of therapy [12].

G. Nanotechnology in Electronics: Nanoelectronics

Nanoelectronics increase the capabilities of electronics devices and reduce their weight and power consumption. E.g. Improving display screens on electronics devices. This involves reducing power consumption while decreasing the weight and thickness of the screens, increasing the density of memory chips. Researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch or greater. Reducing the size of transistors used in integrated circuits[13].

Environmental issue

In free form nanoparticles can be released in the air or water during production.In fixed form, where they are part of a manufactured substance or product, they will ultimately have to be recycled or disposed of as waste. Nanomaterials may constitute a completely new class of non-biodegradable pollutant [14].

Health issue

Health and environmental issues combine in the workplace of companies engaged in producing or using nanomaterials and in the laboratories engaged in

nanoscience and nanotechnology research and may be show severe results.

IV FUTURE SCOPE

Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight solar sails and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and travelling in space. In addition, new materials combined with nanosensors and nanorobots could improve the performance of spaceships, spacesuits, and the equipment used to explore planets and moons, making nanotechnology an important part of the 'final frontier' [15].Nanotechnology thus has a very bright future not only in space technologies but also in various other fields such as military, medicine, cosmetics, solar photovoltaics, food industry, fibers and textiles, construction etc.

REFERENCES

[1] Nanotechnology (2005),"Enabling technologies for Australian innovative industries", [Online] Available: http://www.innovation.gov.au/Science/PMSEIC/Documents/Nanotechnology.pdf

[2] Jeremy J. Ramsden (2005),"What is Nanotechnology", Collegium Basilea", [Online] Available: http://pages.unibas.ch/colbas/ntp/N03RA05.pdf

[3] Handbook on Nanoscience, Engineeering and Technology, 2nd Ed., Taylor and Francis, 2007.

[4] Charles P. Poole Jr., Frank J. Owens,"Introduction to Nanotechnology", May 2003, Wiley, John & Sons, Incorporated.

[5] Vincenzo Balzani, "Nanoscience and nanotechnology: The bottom-up construction of molecular devices and machines", 2008, IUPAC [Online] Available: http://pac.iupac.org/publications/pac/pdf/2008/pdf/8008x1631.pdf

[6] A S Khanna,"Nanotechnology in High Performance Paint Coatings", Vol. 21, No. 2, 2008: 25-32, [Online] Available: http://ajes.in/PDFs/08-2/2.%20 Nanotechnology-A%20 boon.pdf

[7] [Online] Available: http://www.nanovations.com.au/Press%20Release/Paint%20technology%20from%20 Nanovations.pdf

[8] Understanding Nano, Nanotechnology Applications, [Online] Available: http://www.understandingnano.com/nanotech-applications.html

[9] New paint technology fights bacteria and fungal growth with Nano scale silver, [Online] Available: http://freewebs.com/jayaram-co/doc/Selected_Appz_of_Nanotechnology_in_Textiles.pdf

[10]Nano Bio-Raise, Nanotechnology and Food, [Online] Available: http://files.nanobio-raise.org/Downloads/Nanotechnology-and-Food-fullweb.pdf

[11] Bharat Bhushan,"Handbook of Nanotechnology", 2nd Edition, Springer.

[12] National Nanotechnology Initiative. http://www.nano.gov.

[13] Nanoelectronics:Nanotechnology in electronics. http://www.understandingnano.com

[14] Nanotechnology Risks-the real issues. http://www.nanowerk.com

[15] NASA Institute for Advanced Concepts report: The Space Elevator. http://www.nanotech-now.com