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Enhancement in Nanotechnology

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ABSTRACT

In recent years, nanotechnology has become one of the most important and exciting forefront fields in physics, chemistry, engineering, and biology. It shows great promise for providing us in the near future with many breakthroughs that will change the direction of technological advances in a wide range of applications. The present paper aims to review the previous work is done and recent enhancement in the field of nanotechnology. History of nanotechnology, methods of making nanomaterials, risks involved in using Nanotechnology have been reported. Various applications of nanotechnology are also discussed as this technology has enormous potential to contribute to significant advances over a wide range of technological areas.

Keywords— *Nanotechnology, Top- down approach, Bottom-up approach, Nanostructures, Nanosized materials, Fullerene, Nanotubes, Carbon-based nanomaterials, Metal based nanomaterials, Dendrimers, Composites*

1. INTRODUCTION

The prefix "Nano" in the word nanotechnology means a billionth ($1x10^{-9}$). Nanotechnology is the branch of applied science which deals with the various structures of matter having dimensions of the order of a billionth of a meter. A more generalized definition of the nanotechnology was subsequently established by the National Nanotechnology Initiative, which defines nanotechnology as the manipulation of matter with at least one dimension sized from 1 to 100 nm. This definition reflects the fact that quantum mechanical effects are important at this quantum mechanical realm scale and so the definition shifted from a particular technological goal to research category inclusive of all type [1] [2].

Compared with conventional technologies and sciences the development of Nanoscience and nanotechnology dealing with the synthesis and characterization of nanostructured materials has been quite rapid and intensive, while also unprecedented. Now the technologies based on Nanoscience and nanotechnology are exerting a profound and strong impact on every field of conventional technology and science [3].

2. HISTORY

The existence of functional devices and structures of nanometer dimensions is not new. In fact, such structures have existed on earth as long as life itself. It is not clear when humans first began to take advantages of nanosized materials. It is known that in the fourth century, A. D. Roman glassmakers were fabricating glasses containing nanosized metals. The great varieties of beautiful colours of the windows of medieval cathedrals are due to the presence of metal nanoparticles in the glass. Photography is an advanced and mature technology developed in the eighteenth and nineteenth centuries which depends on the production of silver nanoparticles sensitive to light. [2]

In 1959, the physicist Richard Feynman, Noble Prize winner for Physics in 1965, came up with the brilliant concept of the "Nano" when he said "there's plenty of room at the bottom" during a conference of the American Physical Society. Other work in this era involved making alkali metal nanoparticles by vaporizing sodium or potassium metal and then condensing them on cooler materials called substrates. Also, magnetic fluids called Ferro fluids were developed in 1960. In 1981, a method was developed to make metal clusters using a high-powered focused laser to vaporize metals into a hot plasma. In 1985, this method was used to synthesize the fullerene (C_{60}). [4] In 1990, the efforts were begun to make molecular switches and measure the electrical conductivity of molecules. In short, technology based on nanosized materials is really not that new.

3. SYNTHESIS OF NANOMATERIALS

There are two approaches used in the synthesis of nanomaterial's viz. top-down approach (size reduction from bulk materials) and bottom-up approach (material synthesis from atomic level) [5].

3.1 Bottom-up approach [6]
- Refers to build- up of material from bottom i.e. atom-by-atom, molecule-by-molecule, cluster-by-cluster
- More often used for preparing most of the nano-scale materials
- Has the ability to generate a uniform size, shape and distribution
- Plays an important role in the fabrication and processing of nanostructures and nanomaterial's

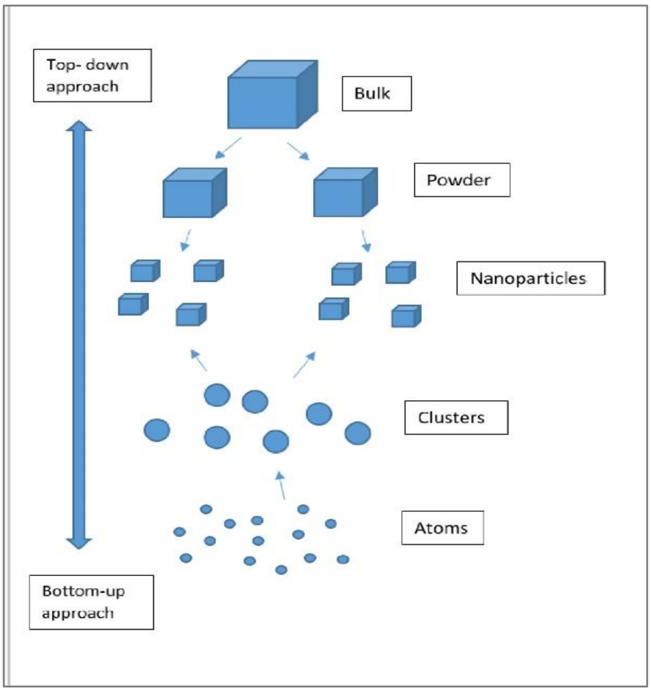

Fig. 1: Schematic representation of approaches used in the synthesis of nanomaterials

3.2 Top-down approach [6]
- Included in the typical- solid-state processing of the materials
- Based with the bulk material and makes it smaller, thus breaking up larger particles by the use of physical processes like crushing, milling or grinding
- Not suitable for preparing uniformly shaped materials
- It is very difficult to realize very small particles even with high energy consumption
- Can cause significant crystallographic damage to the processed patterns.

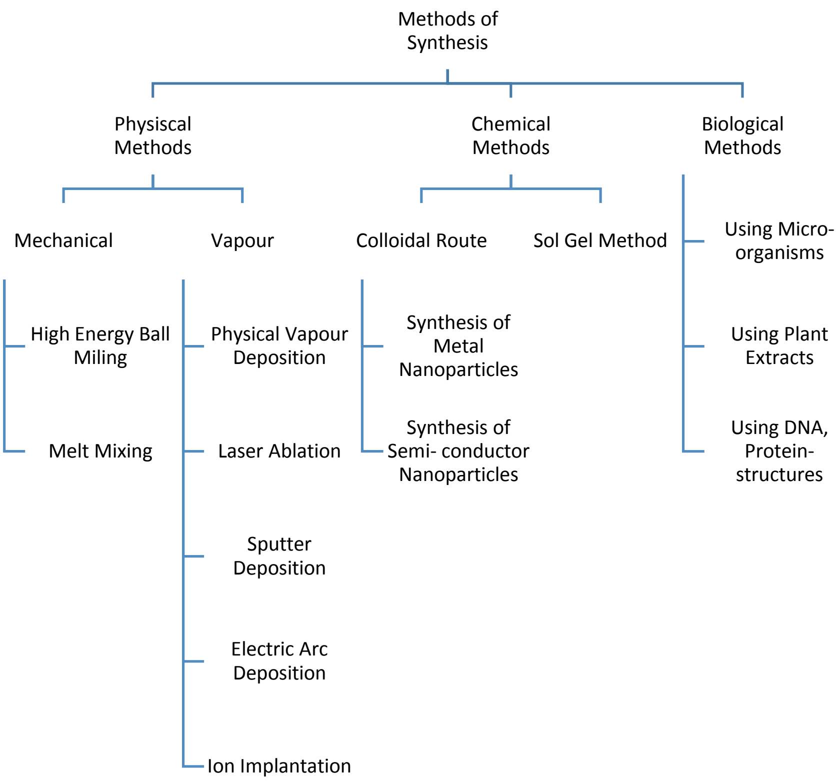

Fig. 2: Methods of synthesis of nanoparticles

Synthesis of nanoparticles to have better control over particle size distribution, morphology, purity, quality and quantity, by employing environment-friendly economical processes has always been a challenge for researchers. The choice of synthesis technique can be a key factor in determining the effectiveness of the photovoltaic as studies. There are three types of methods of synthesis viz. Physical methods, Chemical methods and Biological methods as shown in figure 2. [7]

4. CLASSIFICATION OF NANOPARTICLES

Most current nanomaterials could be organised into four types [8] viz.

- Carbon Based Materials
- Metal-Based Materials
- Dendrimers
- Composites

4.1 Carbon-Based Materials

These nanomaterials are composed mostly of carbon, most commonly taking the form of a hollow sphere, ellipsoid or a tube. Spherical and ellipsoidal carbon nanomaterials are referred to as fullerenes while cylindrical ones are called nanotubes.

4.2 Metal-Based Materials

These nanomaterials include quantum dots, nanogold, nanosilver and metal oxides, such as titanium dioxide. A quantum dot is closely packed semiconductor crystal comprised of hundreds or thousands of atoms and the whole size is on the order of a few nanometres. Changing the size of quantum dots changes the optical properties.

4.3 Dendrimers

These nanomaterials are nanosized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. Also, because three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery.

4.4 Composites

Composites combine nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles, such as nanosized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier and flame- retardant properties.

5. APPLICATIONS OF NANOPARTICLES

The unique properties of these various types of intentionally produced nanomaterials give them novel electrical, catalytic, magnetic, mechanical, thermal or imaging features that are highly desirable for applications in commercial, medical, military and environmental sectors. These materials also find their way into more complex nanostructures and systems. As new uses for materials with these special properties are identified, the number of products containing such nanomaterials and their possible applications continues to grow. Some of the applications are as follows [9]:

5.1 Medicines

Researchers are developing customized nanoparticles the size of molecules that can deliver drugs directly to diseased cells in your body. When it's perfected, this method should greatly reduce the damage treatment such as chemotherapy does to a patient's healthy cells. E.g. drug delivery, diagnosis technique, antibacterial treatments, wound treatment, cell repair, etc.

5.2 Electronics

Nanotechnology holds some answers for how we might increase the capabilities of electronic devices while we reduce their weight and power consumption. E.g. flexible electronic circuits, silicon nanophotonics, nanomagnets as switches, silver nanoparticle ink, laser that uses nanopatterned silicon surface, transistors from carbon nanotubes, integrated circuits built with nanotube transistors, integrated circuits using carbon nanotubes, developing a lead free solder reliable enough for space missions and other high stress environments using copper nanoparticles.

Also, using electrodes made from nanowires that would enable flat panel displays to be flexible as well as thinner than current flat panel displays; using nanowires to build transistors without p-n junctions; using buckyballs to build dense, low power memory devices, etc.

5.3 Food

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food but also in food safety and the health benefits that food delivers. E.g. clay nanocomposites are being used to provide an impermeable barrier to gasses such as oxygen or carbon dioxide in light- weight bottles, cartons and packaging films; storage bins are being produced with silver nanoparticles embedded in the plastic; spraying of carbon nanotubes onto flexible plastic surfaces to produce sensors which could detect the spoiled food.

5.4 Fuel cells

Nanotechnology is being used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuels such as methanol and to improve the efficiency of membranes used in fuel cells to separate hydrogen ions from other gases such as oxygen. E.g. nanoplate catalyst to reduce the high level of oxygen.

5.5 Solar cells

Companies have developed nanotech solar cells that can be manufactured at a significantly lower cost than conventional solar cells. E.g. a solar cell that uses a copper indium selenide sulphide quantum dots to reduce the cost; a combination of silver nanocubes scattered over a thin gold layer to reduce the losses due to reflection.

5.6 Batteries

Companies are currently developing batteries using nanomaterials. One such battery will be as good as new after sitting on the shelf for decades. Another battery can be recharged significantly faster than conventional batteries. E.g. a catalyst made from nitrogen-doped carbon nanotubes could be used in Lithium-air batteries, which can store up to 10 times as much energy as lithium-ion batteries.

5.7 Space

Nanotechnology may hold the key to making space- flight more practical. Advancements in nanomaterials make lightweight spacecraft 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. E.g. using carbon nanotubes to build lightweight solar sails that use the pressure of light from the sun reflecting on the mirror-like solar cell to propel a spacecraft; working with nanosensors to monitor the levels of trace chemicals in spacecraft to monitor the performance of the life support systems.

5.8 Fuels

Nanotechnology can address the shortage of fossil fuels such as diesel and gasoline by making the production of fuels from making the production of fuels from low-grade raw materials economical, increasing the mileage of engines and making the production of fuels from normal raw materials more efficient. E.g. nanotechnology in the form of genetic engineering, can also improve the performance of enzymes used in the conversion of cellulose into ethanol.

5.9 Better air quality

Nanotechnology can improve the performance of catalysts used to transform vapours escaping from cars or industrial plants into harmless gases. That's because catalysts made from nanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalysts simultaneously, which makes the catalysts more effective.

5.10 Chemical sensors

Nanotechnology can enable sensors to detect very small amounts of chemical vapours. Various types of detecting elements, such as carbon nanotubes, zinc oxide nanowires or palladium nanoparticles can be used in nanotechnology-based sensors. Because of the small size of nanotubes, nanowires or nanoparticles, a few gas molecules are sufficient to change the electrical properties of sensing elements. This allows the detection of a very low concentration of chemical vapours.

5.11 Sporting goods

Even sporting goods has wandered into the nano realm. Current nanotechnology applications in the sports arena include increasing the strength of tennis racquets, filling any imperfections in club shaft materials and reducing the rate at which air leaks from tennis balls.

5.12 Fabrics

Making composite fabric with nanosized particles or fibres allows improvement of fabric properties without a significant increase in weight, thickness or stiffness as might have been the case with previously used techniques.

5.13 Cleaner Water

Nanotechnology is being used to develop solutions to three very different problems in water quality. One challenge is the removal of industrial wastes, such as a cleaning solvent called TCE, from groundwater. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at a much lower cost than methods which require pumping the water out of the ground for treatment.

6. CONCLUSION

The role of nanotechnology in advanced modern technologies is to provide materials as a break through and to materialised technology. These materials have been considered the unique and sole solution to the limitations of other technologies and the means of widening their applications. With the continuous use of nanotechnology, global life styles change radically.

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