Chapter 1
Diverse Applications of Nanotechnology in Biomedicine, Chemistry, and Engineering

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ABSTRACT

This chapter introduces the basic concepts of nano science to readers. Some novel methodologies for synthesizing nano particles are discussed briefly. Since the book title suggests diverse applications of nano materials, this chapter also summarizes the applications of nano technology in medicine (nano medicine), where tissue engineering and regenerative medicine are discussed. Other applications DNA nanotechnology in living organisms are discussed briefly. Overall, this chapter introduces the readers to broad sections of nano science and its applications in chemistry, engineering, and medicine.

HISTORY

"There is plenty of room at the bottom" a famous quote by Richard Feynman which was inspirational to a new field of science called nanotechnology. Later in 1980 Eric Drexler proposed the idea of a nanoscale assembler, which can build a copy of itself and also of other items and finally become a complex system. Invention of scanning tunneling microscope led to the discovery of fullerens in 1985 and carbon nanotubes followed by it.

Nanotubes are the first well studied nano materials and belong to fullerene structural family. The name is derived from their long, hollow tube like structure formed by one atom thick sheets of carbon. These sheets are also rolled at specific chiral angles and these properties decide the nature of the nanotubes. (Figure 1) Coarse particles cover a range between 2,500 and 10,000 nanometers, fine particles are sized between 100 and 2,500 nanometers. Ultrafine particles, or nanoparticles, are between 1 and 100 nanometers in size. Nanoparticles are of great interest to scientific community as they form a bridge between bulk materials and atomic structures. A bulk material should have constant physical properties regardless of its size, but at the nano-scale size-dependent properties are often observed. Thus, the properties of materials

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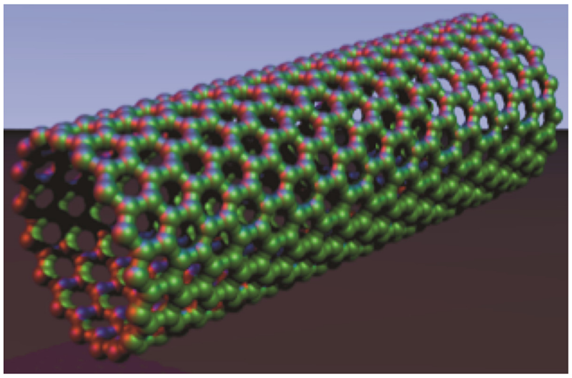
Figure 1. Carbon nanotube
Credit: Wiki:http://en.wikipedia.org/wiki/Carbon_nanotube



change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant. The interesting and sometimes unexpected properties of nanoparticles are therefore largely due to the large surface area of the material, which dominates the contributions made by the small bulk of the material.

SYNTHESIS

There are several methods reported to synthesis variety of nano materials. Depend on their application the synthetic method varies. Though the synthesis and organization of nanoparticles provide complementary tools for nanotechnology, processing of nanoparticles into bulk shapes while retaining their nanosize is a challenge as far as structural and engineering applications are concerned. Synthesis and assembly strategies of nanoparticles mostly accommodate precursors from liquid, solid or gas phase; employ chemical or physical deposition approaches; and similarly rely on either chemical reactivity or physical compaction to integrate the nanostructure building blocks within the final material structure. The variety of techniques that can be classified in top-down or bottom-up approaches. (Mijatovic, Eijkel, & van den Berg, 2005)

The bottom- up approach of nanomaterials synthesis first forms the nanostructured building blocks (nanoparticles). Build-up of a material from the bottom: atom-by-atom molecule-by-molecule. In organic chemistry and/or polymer science, we know polymers are synthesized by connecting individual monomers together. In crystal growth, growth species, such as atoms, ions and molecules, after impinging onto the growth surface, assemble into crystal structure one after another. Examples: Production of salt and nitrate in chemical industry, Growth of single crystals and deposition of films in electronic industry. For most materials, there is no difference in physical properties of materials regardless of the synthesis routes, provided that chemical composition, crystallinity, and microstructure of the material in question are identical. (Wegner et al., 2004)

In top down approaches, the source material is reduced from bulk size to nanoscale scale as in attrition processes (e.g., grinding). Grinding is a mechanical attrition process, which operates on the solid phase. (Heidenreich, Büttner & Ebert, 2003) An example of this approach is the formation of powder components through aerosol and sol-gel techniques and then the compaction of the components into the final material. Nanoparticles with diameters ranging from 1 nm to 10 nm with consistent crystal structure, surface derivatization, and a high degree of monodispersity can be processed by these techniques. (Lenggoro,Okuyama, de la Mora & Tohge, 2000). Gas phase synthesis or aerosol processing of nanoparticles is based on evaporation and condensation (nucleation and growth) in a sub atmospheric inert- gas environment; and the processing mainly is by combustion flame, laser ablation, chemical vapour condensation, spray pyrolysis, electro spray etc. (Iskandar, 2009) On the other hand, sol-gel processing is a wet chemical synthesis approach that can be used to generate nanoparticles by gelation, precipitation, and hydrothermal treatment.

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