An Introduction to Nanotechnology

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ABASTRACT: *Nanotechnology is the booming technology and has numerous applications. However, applications in medicine are especially promising in the longer term. These can be expected to enable drug delivery, detect tumor cells, make hip-joint from biocompatible materials, lead to stronger and longer-lasting implants and sensors that can be used to monitor aspects of human health; and improved artificial cochleae and retinas. Nanotechnology is also enabling the development of smaller, cheaper sensors, which will have a wide range of applications from monitoring the pollution in the environment, the freshness of food, or the stresses in a building or a vehicle. Nanotechnology can also be used to produced sun creams, computer disk drives to improve storage, Organic Light Emitting Diodes (OLEDs) for displays, photovoltaic film that converts light into electricity, fabrics coated to resist stains and control temperature, intelligent clothing to measures pulse and respiration, light but very strong bucky-tubeframe, nano-particle paint to prevent corrosion, thermo-chromic glass to regulate light, magnetic layers for compact data memory, carbon nanotube fuel cells to power electronics and vehicles. It also has applications in construction mainly in binding the cracks, controlling pore size, increasing strength & durability of construction materials. The various applications of nanotechnology from medicine to construction as well as the synthesis, structure and thermophysical properties of calcium silicate h}tlrate (C-S-H) and C-S-H- polymer nanocomposite (C-S-HPN) nanomaterials have been discussed in this work.*

Keywords: Nanotechnology, nanoparticles, nanotube, nano-composites, TEM, SEM, FTIR, NMR, applications of nanomaterials.

I. Introduction

Nanotechnology continues to attract a great deal of attention because of their potential impact on an incredibly wide range of industries and markets. Nanotechnology is the design, characterization, production, and application of structures, devices, and systems by controlling shape and size on the nano scale. Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular, and macromolecular scales, where properties differ significantly from those at a larger scale. Nanocomposites are a new class of composites that are particle-filled polymers for which at least one dimension of the dispersed particles is in the nanometer range. Three types of nanocomposites, depending on how many dimensions of the dispersed particles are in the nanometer range can be distinguished. Particles with three dimensions in the order of nanometers are typically is odimensional, such as spherical silica nanoparticles obtained by in situ sol-gel methods or by polymerization promoted directly from their surface. They also include semiconductor nanoclusters and others. Nanotubes or whiskers (with two dimensions in the nanometer scale and the third forming a larger elongated structure), for example, carbon nanotubes or cellulose whiskers, are extensively studied as reinforcing phases yielding materials with exceptional properties. The third type of nanocomposites is characterized by only one dimension in the nanometer range. In this case the material is present in the form of sheets of one to a few nanometers thick and hundreds to thousands nanometers long. This family of composites is referred to as polymer-layered crystal nanocomposites.

Much interest is also focused on quantum dots, which are semiconductor nanoparticles that can be 'tuned' to emit or absorb particular colors of light for use in solar energy or fluorescent biological labels. This work is the combination of a comprehensive review and experimental findings.

II. Material and Methods

Synthesis of C-S-H and C-S-HPN material

Synthesis of C-S-H and C-S-HPN materials is described.

Scanning Electron Microscopy (SEM) images were acquired on a Hitachi S4800 Field Emmission Scanning Electron Microscope. Surface structure images were taken using a beam current of 2.0 keV at 10 µa. Images were acquired using an integrated frame capture with 32 frames to reduce random noise. Images were acquired at a working distance of 8 mm and each area of interest was captured a series of field magnifications from 5000 to 80,000x magnification.

Samples for Transmission electron microscopy (TEM) imaging were prepared by suspending the particles in acetone followed by sonication for several minutes. One drop of the particle/acetone suspension was placed onto a holey carbon grid and was dried in air. The dried grid was then loaded into a double tilt sample holder. The sample was thus examined with a Philips CM20 STEM equipped with a Gatan UltraScan 1000 CCD camera and an energy dispersive x-ray spectrometer: INCA Energy TEM 200. Both BF and HRTEM images were taken at 200 kV.

Fourier transform infrared (FTIR) spectra were collected on a Bomem MB 100 spectrometer in direct transmission mode between 4000 and 400 cm^{-1} as the average of 50 scans and a 4 cm^{-1} resolution. Samples were grounded to a fine powder with KBr and pressed into a disk with a 10-ton ring press. Air was used as a background for all measurements.

III. Results and Discussion

Nanotechnology and Concrete: Small Science for Big Changes: Nanotechnology is usually associated with high-profile biomedical, telecommunications and military applications. But for most people, one of the main ways this science at nanometer-level is revolutionizing our daily lives is right under our feet: concrete.

Single Molecule Electrical Circuit:

Researchers at the National Institute for Nanotechnology (NINT) in Canada are discovering how to build the computer of the future one1molecule at a time. A breakthrough in creating a single molecule electrical circuit was published in Nature on June 2, 2005. This discovery could pave the way to miniaturizing computers and creating sensors fine enough to detect single molecule interactions. Computer miniaturization is currently limited by the size constraints of transistors. Each transistor has three electrodes, or electron conducting devices, which must be in physical contact to allow electricity to flow. Having three electrodes touching a single molecule is almost physically impossible. Therefore, a research team at NINI' did the next best thing - they made two electrodes serve as three.

Bionanotechnology:

A study suggests that it may be possible to control the contact resistance of nanotube-metal interfaces. "The main technical problem in such nanotube based electronic devices is the high Schottky energy barrier at the metal-nanotube contact, which hinders electrons entering the nanotube from a metal connecting wire," Calculations perlormed using the first-principles pseudopotential plane wave method within the density functional theory and the generalized gradient approximation indicate that the electronic energy structure and self- consistent-field electronic potential of a semiconducting singlewalled nanotube side-contacted on metal electrodes (as shown) depend strongly on the metal type. The contact is simulated in a super cell approach, consisting of a zigi.ag (8, 0) carbon nanotube and five layers of metal (Mo or Au). For the Au (100) surface, a weekly bonded system is formed with a large potential barrier, of 3.9 eV. The contact has a minimal effect on the electronic properties and charge density, which explains why Au electrode devices have high contact resistance, says Yildirim. For the Mo (110) surface, the interaction is very strong (0.4 eV). The nanotube site at the interface is conducting, while the opposite ite remains semiconducting.

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