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ORIGINAL ARTICLE

Applications of nano-catalyst in new era

Shalini Chaturvedi [a], Pragnesh N. Dave [a,*], N.K. Shah [b]

[a] Department of Chemistry, Kachchh University, Kachchh 370001, India
[b] Department of Chemistry, School of Science, Gujarat University, Ahmedabad 380009, India

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Abstract In the era of nanoscience where all the devices and technologies are going to smaller and smaller in size with improved properties; catalysis is an important field of application. In this review article we are trying to summarize data reported in literature for application of nano sized catalyst in our daily life which are useful for human beings. Improvement in catalytic properties due size of catalyst reduced to nano scale is discussed here. Introductive points regarding nanoscience; their functional approaches; current research are also here.

Main applications of nanocatalysts in water purification; fuel cell; energy storage; in composite solid rocket propellants; bio diesel production; in medicine; in dye; application of carbon nano tubes and several other point of application are discussed here in detail.

1. Introduction

Nanoscience is the study of phenomena on a nanometer scale. Atoms are a few tenths of a nanometer in diameter and molecules are typically a few nanometers in size. The smallest structures humans have made have dimensions of a few nanometers and the smallest structures we will ever make will have the dimensions of a few nanometers. This is because as soon as a few atoms are placed next to each other, the resulting structure is a few nanometers in size. The smallest transistors, memory elements, light sources, motors, sensors, lasers, and pumps are all just a few nanometers in size like carbon nanotubes, grapheme etc.

Carbon nanotubes (CNTs) have exceptional mechanical properties, particularly high tensile strength and light weight. An obvious area of application would be in nanotube reinforced composites, with performance beyond current carbon-fiber composites. One current limit to the introduction of CNTs in composite is the problem of structuring the tangle of nanotubes in a well-ordered manner so that use can be made of their strength. Another challenge is generating strong bonding between CNTs and the matrix, to give good overall composite performance and retention during wear or erosion of composites. The surfaces of CNTs are smooth and relatively unreactive and so tend to slip through the matrix when it is

* Corresponding author. Tel.: +91 02832235002.
E-mail addresses: pragneshdave@gmail.com, pragnesh7@yahoo.com (P.N. Dave).

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stressed. One approach that is being explored to prevent this slippage is the attachment of chemical side-groups to CNTs, effectively to form 'anchors'. Another limiting factor is the cost of production of CNTs. However, the potential benefits of such light, high strength material in numerous applications for transportation are such that significant further research is likely (Bakunin et al., 2004; Edelstein and Cammarata, 1998).

Graphene is an allotrope of carbon, whose structure is one-atom-thick planar sheets of sp^2-bonded carbon atoms that are densely packed in a honeycomb crystal lattice. Graphene is most easily visualized as an atomic-scale chicken wire made of carbon atoms and their bonds. The crystalline or "flake" form of graphite consists of many graphene sheets stacked together.

The carbon–carbon bond length in graphene is about 0.142 nanometers. Graphene sheets stack to form graphite with an interplanar spacing of 0.335 nm, which means that a stack of 3 million sheets would be only one millimeter thick. Graphene is the basic structural element of some carbon allotropes including graphite, charcoal, carbon nanotubes and fullerenes. It can also be considered as an indefinitely large aromatic molecule, the limiting case of the family of flat polycyclic aromatic hydrocarbons. The Nobel Prize in Physics for 2010 was awarded to Andre Geim and Konstantin Novoselov "for groundbreaking experiments regarding the two-dimensional material graphene".

Besides the technological relevance of nanoscience (or perhaps because of the technological relevance) there is an enormous hype associated with it. Fantastic claims have been made about faster computers, cheap production of goods, and medical breakthroughs. Nanotechnology is expected to appear in products such as tennis rackets, self-cleaning cars, paint, food, and cosmetics.

It's a small, small, small, small world: Manufactured products are made from atoms. The properties of those products depend on how those atoms are arranged. If we rearrange the atoms in coal, we get diamonds. If we rearrange the atoms in sand (and add a pinch of impurities) we get computer chips. If we rearrange the atoms in dirt, water and air we get grass.

Nanoscience in physics, chemistry, biology, and medicine: Physics is the mother of the natural sciences. In principle, physics can be used to explain everything that goes on at the nanoscale. There is active physics research going on in nanomechanics, quantum computation, quantum teleportation, and artificial atoms. While physics can explain everything, sometimes it is more convenient to think of nanostructures in terms of chemistry where the molecular interactions are described in terms of bonds and electron affinities.

Chemistry is the study of molecules and their reactions with each other. Since molecules typically have dimensions of a few nanometers, almost all of nanoscience can be reduced to chemistry. Chemistry research in nanotechnology concerns C_{60} molecules, carbon nanotubes, self-assembly, structures built using DNA, and supermolecular chemistry. Sometimes the chemical description of a nanostructure is insufficient to describe its function. For instance, a virus can be described best in terms of biology.

Biology is sometimes described as nanotechnology that works. Biological systems contain small and efficient motors. There are more than 50 kinds of motors found in cells. Biological systems produce impressive control systems. The brain of a bee is tiny and consumes little power yet regulates complex flying behavioral patterns. A cell one micron in size can store 1 GB of information in DNA. They self reproduce. They construct tough and strong material. Biology is an important source for inspiration in nanotechnology. Copying engineering principles from biology and applying it to create new materials and technologies is called biomimetics.

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology. Current problems for nanomedicine involve understanding the issues related to toxicity and environmental impact of nanoscale materials.

1.1. Nanomaterials

Nanomaterials are those which have structured components with at least one dimension less than 100 nm. Materials that have one dimension in the nanoscale (and are extended in the other two dimensions) are layers, such as a thin films or surface coatings. Some of the features of computer chips come in this category. Materials that are nanoscale in two dimensions (and extended in one dimension) include nanowires and nanotubes. Materials that are nanoscale in three dimensions are particles, for example precipitates, colloids and quantum dots (tiny particles of semiconductor materials). Nanocrystalline materials, made up of nanometer-sized grains, also fall into this category. Some of these materials have been available for some time; others are genuinely new (Taniguchi, 1974; Lubick and Betts, 2008; Edelstein and Cammarata, 1998).

Two principal factors cause the properties of nanomaterials to differ significantly from other materials: increased relative surface area, and quantum effects. These factors can change or enhance properties such as reactivity, strength and electrical characteristics. As a particle decreases in size, a greater proportion of atoms are found at the surface compared to those inside. For example, a particle of size 30 nm has 5% of its atoms on its surface, at 10 nm 20% of its atoms, and at 3 nm 50% of its atoms. Thus nanoparticles have a much greater surface area per unit mass compared with larger particles. As growth and catalytic chemical reactions occur at surfaces, this means that a given mass of material in nanoparticulate form will be much more reactive than the same mass of material made up of larger particles (Taniguchi, 1974; Lubick and Betts, 2008; Edelstein and Cammarata, 1998).

1.2. Fundamental concepts

One nanometer (nm) is one billionth, or 10^{-9} of a meter. By comparison, typical carbon–carbon bond lengths, or the spacing between these atoms in a molecule, are in the range 0.12–0.15 nm, and a DNA double-helix has a diameter around 2 nm. On the other hand, the smallest cellular life-forms, the bacteria of the genus Mycoplasma, are around 200 nm in length. To put that scale in another context, the comparative size of a nanometer to a meter is the same as that of a marble to the size of the earth.

Two main approaches are used in nanotechnology. In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. In the "top-down" approach, nano-objects are constructed from larger entities without atomic-level control.