EDITORIAL OPEN ACCESS

Nanoscience and Nanotechnology

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Nanoscience and Nanotechnology are becoming the most interesting subjects because they have many applications in various fields. Nanoparticle is defined as a microscopic particle of matter that is measured on the nanoscale usually in the range of 1–100 nanometers. The properties of nanoparticles may be tuned by controlling the size of the nanoparticles. The size and surface characteristics of nanoparticles can be easily manipulated [1]. Nanoparticle is unique because it has large surface area and large surface energy. It is highly reactive and can be used as an excellent catalyst. Nanoparticles often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum size effects. We can reduce the dimension of nanoparticles to obtain thin films, quantum wires or quantum dots. These are the main reasons why we are using nanoparticles instead of bulk materials. Nanoparticles have extensive applications in biomedicine, optics and electronics. Nanoparticles are used in electrical batteries, filters, bio-labeling, optical receptors, sensors, drug delivery systems, detection of diseases, destruction of tumors, etc [2]. Although nanoparticles have many applications, it has some serious drawbacks also. Most of the nanoparticles are water insoluble and some of them are toxic to health. Due to highly reactive nature, they agglomerate into bulk within a short period of time. Their stability is very low. So, it is essential to give them kinetic stability. For example, cadmium sulfide (CdS) nanoparticles.

Cadmium sulfide nanoparticle is an important II-IV semiconductor nanoparticle with many excellent physical and chemical properties. This has promising applications in multiple technological fields including photochemical catalysis, gas sensor, detectors for laser and infrared, solar cells, light-emitting diodes, and in catalysis, etc [3]. Although cadmium sulfide have many uses for humans, it needs to be handled with care because it is harmful to the body. Due to its low solubility and toxic nature, CdS found limited use in various fields. The toxic effect of CdS nanoparticle is mainly due to the release of Cd^{2+} ions from the CdS core. To efficiently use this nanoparticle in medical area, the cytotoxicity of CdS must be reduced or it should be eliminated. Not only CdS nanoparticles many other nanoparticles are also facing the same problem. In order to overcome all these, researchers introduced a new scheme that is “introducing capping agent”. The most common route of stabilization is the attachment of organic molecules to the atoms on the surface of nanocrystals. These molecules not only avoid agglomeration, but also provide effective chemical passivation of surface atoms, which has significant influence on the optical and electrical properties of resulting nanocrystals.

A capping agent is a strongly adsorbed monolayer of usually organic molecules used to aid stabilization of nanoparticles. It is used to protect the surface of materials, commonly nanoparticles. It prevents degradation and can help preserve different properties of the material. Capping agent merely enclose the particle and does not react with the surface. For example, cadmium sulfide capped with L-Cysteine [4, 5] (a model is shown in Figure 1). This L-Cysteine is surrounding the CdS core. This makes the CdS nanoparticle water soluble and reduces the toxic nature of CdS. It also increases the stability of CdS nanoparticles. However, it also has a problem. When we take the capped nanoparticles in acidic or basic solutions there is a possibility of breaking the bond between core nanoparticles and the capping agent. So, this method is also not much useful.

Now scientists used the method of “surface coating” to solve this problem. Surface coatings or surface modification of nanoparticles protect the nanoparticle

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core and thus minimizes the toxicity. Shell growth and surface modification enhances the stability and increases photoluminescence of the core. This surface coating acts as a physical barrier between the core and the environment. Coated nanoparticles are essentially defined as the particles containing a core and a shell and have dimensions in the nanometer range. This core and shell nanomaterials can increase the luminescence quantum yield due to improved passivation of the surface and can be more physically robust than the bare organically passivated clusters. Encapsulation of nanoparticle cores in hollow spheres has attracted much attention because it is an effective means for preventing aggregation of core particles. Also, the void space between the core and shell is expected to be suitable as a reaction site for novel catalytic reactions and as a nanosized container for molecules [6].

These coated nanoparticles display superior luminescent properties including high photobleaching threshold, high quantum yield of fluorescence, broad excitation spectrum, narrow/symmetric emission spectrum, size and composition-tunable emission wavelength and excellent photostability. For example, CdS nanoparticles are coated with Silica [7], Zirconia [8], Alumina [9] or Titania etc. (a model for coated CdS nanoparticle is shown in Figure 2). The release of Cd^{2+} is reduced or eliminated by surface coating. Therefore, these nanoparticles have become ideal probes for signal generation and transduction in the fluorescent sensing of analytes. It can be used as a catalyst, fluorescence sensor, used for the detection of toxic materials like TNT, used to detect toxic metal ions such as mercury, lead, etc. They have applications in medical science such as drug delivery systems, detecting diseases, treatment of diseases, etc. [10]. It can be used as a sensor to detect adulterants in food materials like melamine, an organic compound which is added to the milk and milk products to increase the nitrogen level [11]. The researchers now plan to design particles containing cancer drugs and cancer-fighting coatings to see if they can effectively shrink tumors. Future research on nanotechnology and nanoscience will help a lot in human development, not only in industrial and medicinal fields but also in our day-to-day life aspects.

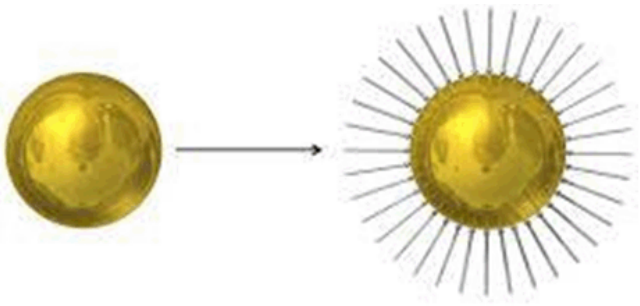

Figure 1: Capped CdS nanoparticle.

Figure 2: Coated CdS nanoparticle.

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Divya C. – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Muthuvinothini A. – Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

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Conflict of Interest

Authors declare no conflict of interest.

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