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Editorial | Open Access

Preparation and Applications of Titanium Dioxide and Zinc Oxide Nanoparticles

Majeed A Shaheed and Falah H Hussein*

Chemistry Department, College of Science, University of Babylon, 51002 Hilla, Iraq

***Corresponding author**: Falah H. Hussein, Chemistry Department, College of Science, University of Babylon, 51002 Hilla, Iraq, Tel: 00964 - 780 – 1006256; E-mail: abohasan_hilla@yahoo.com

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Editorial

Nanotechnology represents one of new sciences that promise to provide a broad range of novel uses and improved technologies for numerous applications. One important reason behind the intense interest is that nanotechnology permits the controlled preparation of nanomaterials where at least one dimension of the structure is less than 100 nm [1]. It is the study and design of machines or devices on the molecular and atomic level. To be considered in nanotechnology, structures must be anywhere from 1 to 100 nm in size.

The first studies on the use of titanium dioxide nanoparticles (TiO_2-NPs) in microbiology for photoelectrochemical sterilization of microbial cells dates back to 1985 [2,3]. Recently, studies have appeared devoted on the possibility of using TiO_2-NPs in oncology [4].

In the past decade, the developments in the area of preparation and application of different nanostructured titanium dioxide (nanowires, nanotubes, nanofibers and nanoparticles) and zinc oxide have been tremendous. This work briefly describes the production, properties, and applications of nanostructured titanium dioxide and zinc oxide. Special emphasis is placed on photocatalytic activity as well as on some requirements for efficient photocatalysts [5].

In the past thirteen years, those nanomaterials have different toxicity profiles compared with larger materials because of their small size and also their high reactivity. Capping is the coating of one semiconductor or metal nanomaterial on the surface of another semiconductor or metal nanoparticle [6].

Our work focused on the preparation of the TiO_2 and ZnO nanoparticles (NPs), and analyzing the prepared nanoparticles using X-ray diffraction (XRD) and scanning probe microscope (SPM). The adsorption capability and photocatalytic activity of synthesized TiO_2 and ZnO samples were quantified in terms of the adsorption capacity and photocatalytic degradation of aqueous solution of reactive black 5 (RB 5). Ultimately, this study demonstrated the quality of all the prepared catalysts and recommends the optimum semiconductor to be used for different applications in future.

This research consists of three main parts. In the first part, synthesis of thirty one samples of TiO_2 and ZnO nanoparticles using sol-gel and direct precipitation method were carried out.

Structural, morphological and chemical properties of synthesized TiO_2 and ZnO nanoparticles were investigated by XRD and SPM. Photocatalytic activity and combining effect were also performed.

Adsorption capacity of aqueous solution of reactive black 5 on the surface of the synthesized TiO_2 nanoparticles was investigated, particularly focused on the influence of experimental parameters on the kinetics adsorption at conditions constant, such as initial concentration, dosage, pH, contact time and temperature.

The photocatalytic activity for all synthesized catalysts was studied and compared with reference to catalysts (TiO_2 Hombikat UV100 and ZnO Merck). The UV light photocatalytic activity was evaluated by photocatalytic degradation of RB 5 dye in aqueous solution. Combining effect had been studied by using different RB 5 concentrations at different light intensities.

Types of Semiconductor Nanomaterials

The structural dimensionality has a significant impact on the properties of TiO_2 materials. A spherical TiO_2 with zero dimensionality has a large specific surface area, resulting in a higher rate of photocatalytic decomposition of organic pollutants [7].

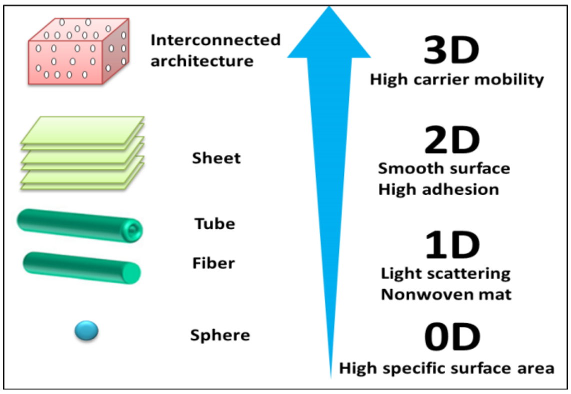

Figure 1: Schematic illustration of structural dimensionality of nanomaterials with expected properties.

One-dimensional fibers or tubes make the short distance for charge carrier diffusion and therefore, they have advantages like less recombination, light-scattering properties and fabrication of self-standing nonwoven mats.

Zero-and one-dimensional structures have been well developed and previously discussed in higher details [8].

It is well known nanosheets have two-dimensional and smooth surfaces with high adhesion [9], whereas three-dimensional quantum dotes may have high carrier mobility as a result of their interconnecting structure and can be used in environmental decontamination.

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It is possible to take full advantage of the unique properties offered by TiO_2 nanomaterials by choosing the appropriate dimensionalities of TiO_2 materials. Figure 1 shows types of nanomaterials.

Synthetic Methods of Nanoparticles Semiconductor

Several different methods can be used to control the size distribution of semiconductor and metal nanoparticles to obtain monodisperse samples. These methods fell into two broad fields, although there is considerable overlap among them. Monodisperse nanoparticles may be obtained by:

(1) The kinetics of nucleation could be controlled for subsequent crystal growth.

(2) Synthesizing polydisperse particles and selecting a portion of that distribution, or limits adjusting synthetic conditions so that a monodisperse size distribution corresponds to a thermodynamic minimum [10]. Common synthetic methods of TiO_2 and ZnO nanostructures shown in Figures 2 and 3.

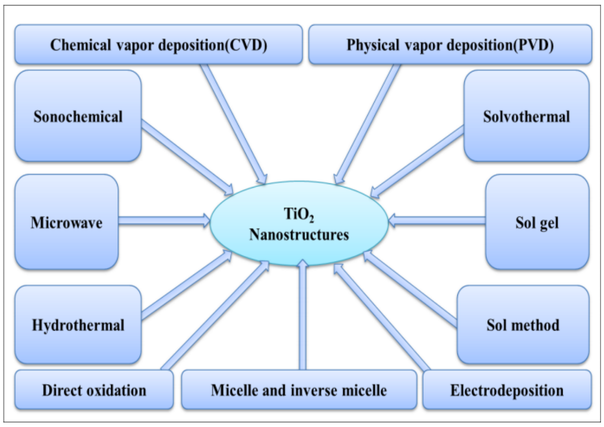

Figure 2: Common synthetic methods of TiO2 nanostructures.

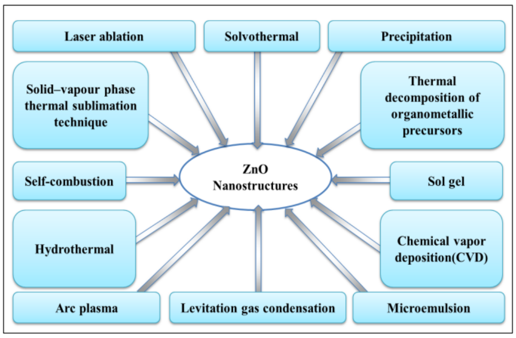

Figure 3: Common synthetic methods of ZnO nanostructures.

Applications of Nanomaterials

Many researches nowadays focus on the applications of nanomaterial in devices because of their unique properties. Nanomaterials can be used for a number of applications in different fields due to their novel properties. It has been demonstrated that novel electrical, mechanical, chemical and optical properties are significantly different from their bulk counterpart, which are greatly believed to be the results of the large increase of surface area to volume ratio [11] and quantum confinement effect [12] as their sizes are reduced therefore, they can be utilized in many applications. Figure 4 shows Applications of TiO_2 photocatalysis.

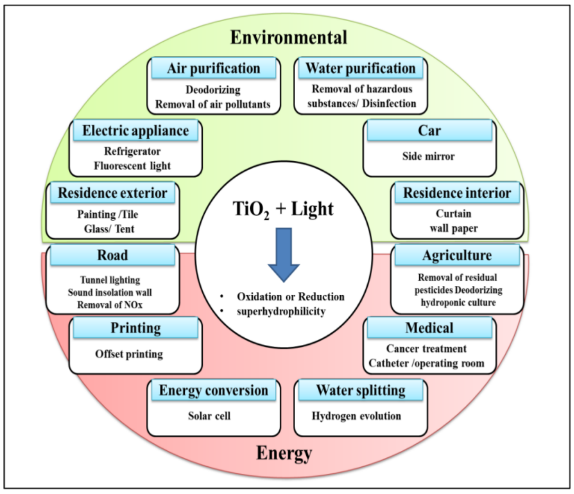

Figure 4: Applications of TiO2 photocatalysis.

Besides, other applications have appeared for the performance of ZnO-NPs in degradation of some organic compounds [13], antibacterial effect [14], killing human cancer cells, and potential biological applications as efficient antimicrobial agents, drug carriers, bioimaging probes and possessing cytotoxic behaviour [15].

References

1. McNeil SE (2005) Nanotechnology for the biologist. Journal of Leukocyte Biology 78; 585–594.
2. Kim B, Kim D, Cho D, Cho S (2003) Bactericidal effect of TiO2 photocatalyst on selected food-borne pathogenic bacteria. Journal of Chemosphere 52: 277–281.
3. Suketa N, Sawase T, Kitaura H, Naito M, Baba K, et al. (2005) An antibacterial surface on dental implants, based on the photocatalytic bactericidal effect. Journal of Clinical Implant Dentistry 7: 105–111.
4. Fujishima A, Cai R, Otsuki J, Hashimoto K, Itoh K, et al. (1993) Biochemical application of photoelectrochemistry: photokilling of malignant cells with TiO2 powder. Journal of Electrochima. Acta 38: 153–157.
5. Khataee A, Mansoori G A (2012) Nanostructured titanium dioxide materials properties, preparation and application. 1 st ed, World Scientific Publishing Co. Pte. Ltd, 5, USA.
6. Brayner R, Dahoumane SA, Yepremian C, Djediat C, Meyer M, et al. (2010) ZnO nanoparticles: synthesis, characterization, and ecotoxicological studies. Journal of American Chemical Society 26: 6522–6528.
7. Liu B, Nakata K, Sakai M, Saito H, Ochiai T, et al. (2011) Mesoporous TiO2 core shell spheres composed of nanocrystals with exposed high-energy facets: facile synthesis and formation mechanism. Journal of American Chemical Society 27: 8500–8508.
8. Nakata K, Liu B, Ishikawa Y, Sakai M, Saito H, et al. (2011) Fabrication and photocatalytic properties of TiO2 nanotube arrays modified with phosphate. Journal of Chemistry Letters 40: 1107–1109.

9. Yao L, Haas TW, Guiseppi-Elie A, Bowlin GL, Simpson DG, et al. (2003) Electrospinning and stabilization of fully hydrolyzed poly (vinyl alcohol) fibers. Journal of Chemistry of Materials; 15: 1860–1864.

10. Ramamurthy V, Schanze KS (2003) Semiconductor photochemistry and photophysics. Marcel dekker, Inc; 10, USA.

11. Habishi A, Yahya R, Shafie N, Ismail MSE, Waje I, et al. (2005) Preparation and characterization of aluminum substitute yttrium iron garnet nanoparticles by sol-gel technique. Int. Advanced Tech. Congress (ATCI) 577–583.

12. Yahya N, Masoud RAH, Zaid M (2009) Synthesis of Al 3 Fe 5 O 12 cubic structure by extremely low sintering temperature of Sol Gel technique. American Journal of Engineering and Applied Science 2: 76–79.

13. Wang H, Xie C, Zhang W, Cai S, Yang Z, et al. (2007) Comparison of dye degradation efficiency using ZnO powders with various size scales. Journal of Hazardous Materials 141: 645-652.

14. Padmavathy N, Vijayaraghavan R (2008) Enhanced bioactivity of ZnO nanoparticles-an antimicrobial study. Journal of Sci. Technol. Adv. Mater 9: 035004.

15. Hanely C, Thurber A, Hanna C, Punnose A, Zhang J, et al. (2009) The influences of cell type and ZnO nanoparticle size on immune cell cytotoxity and cytokine induction. Journal of Nanoscale Res Lett 4: 1409–1420.