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Editorial

Nanomaterials Synthesis, Applications, and Toxicity 2012

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Nanotechnology presents new opportunities to create better materials and products. Nanomaterials find wide applications in catalysis, energy production, medicine, environmental remediation, automotive industry, and other sectors of our society. Nanomaterial-containing products are already available globally and include automotive parts, defense application, drug delivery devices, coatings, computers, clothing, cosmetics, sports equipment, and medical devices. This special issue includes emerging advances in the field, with a special emphasis given to nanomaterial synthesis and applications.

There is an increasing interest in identifying magnetically separable catalysts for the degradation of wastewater. In this issue, A. Perumal et al. report an investigation of temperature-dependent magnetic properties and photocatalytic activity of $CoFe_2O_4$–Fe_3O_4 magnetic nanocomposites (MNCs) synthesized by hydrothermal processes. These MNCs have saturation magnetization of 90 emu/g and coercivity (HC) of 530 Oe. The photocatalytic activity of the MNCs has been examined on the reduction of methyl orange (MO), a colored compound used in dyeing and printing textiles. The MNCs act as an excellent photocatalyst on the degradation of organic contaminants and degrade 93% of MO in 5 hours of UV irradiation. The photocatalytic activity of MNCs is attributed to remarkably high band gap energy and small particle size. Also, the MNCs with reproducible photocatalytic activity are easily separated from water media by applying an external magnetic field and they act as a promising catalyst for the remediation of textile wastewater.

Microwaves can play an important role in orchestrating nanomaterials for a wide range of technological applications. For example, J. W. P. Hsu et al. report on MoO_x nanoparticle suspensions for a promising route toward low-cost, large-area solution deposition of functional thin films for applications in energy conversion, flexible electronics, and sensors. They demonstrate that parameters such as size, stoichiometry, and electronic properties must be controlled to achieve the best results for the target application. Such control can be achieved via *in situ* chemical oxidation of MoO_x nanoparticles in suspensions using H_2O_2 as a mild oxidizing agent. The process starts with a microwave-synthesized suspension of ultrasmall ($d \sim 2$ nm) MoO_x nanoparticles in n-butanol, followed by systematically varying H_2O_2 concentration and reaction time. Moreover, they found that oxidation state and work function of MoO_x nanoparticle films was significantly affected. In particular, they achieved a continuous tuning of MoO_x work function from 4.4 to 5.0 eV, corresponding to the oxidation of synthesized MoO_x nanoparticle (20% Mo^{6+}) to essentially pure MoO_3. The synthesized particles can be applied in displays and optoelectronics.

In the last decade, carbon nanotubes played a significant role for a whole range of applications, and various methods were developed for their production of carbon nanotubes.

However, producing pure carbon nanotubes without impurities is still a challenge. In this issue, M. Rusop et al. report on the synthesis of single-wall carbon nanotubes (SWCNTs) and multiwall carbon nanotubes (MWCNTs) from palm oil precursor and ferrocene as catalyst source by single zone thermal CVD system at various depositions with the temperature ranging from 600 to 1000°C. Direct heat was used to vaporize both the fixed parameter of the precursor and the catalyst placed in the middle of quartz tube. They demonstrate how temperature influences the formation of varying thicknesses of carbon nanotubes.

Environmental applications of carbon nanotubes developed by S. M. Mukhopadhyay et al. open another window of opportunity. They demonstrate the effectiveness of a new type of hybrid nanocatalyst material that combines the high surface area of nanoparticles and nanotubes with the structural robustness and ease handling of larger supports. The hybrid material is made by fabricating palladium nanoparticles on two types of carbon supports: as received microcellular foam (Foam) and foam with carbon nanotubes anchored on the pore walls (CNT/Foam). Catalytic reductive dechlorination of carbon tetrachloride with these materials has been investigated, and they have shown that both palladium-functionalized carbon supports are highly effective in the degradation of carbon tetrachloride. The degradation is significantly increased with palladium on CNT/Foam.

Moreover, nanoparticles have been found to be used not only as catalysts, but also as materials for medicinal applications. Polymeric nanoparticles especially play a vital role. In this issue, V. Castaño et al. review a range of different applications of polymeric nanoparticles along with ceramic particles for biomedical application.

There is a need to better understand and apply information regarding nanomaterials in areas such as controlled synthesis, sustainability and environmental friendliness, characterization, and application. However, there are also unanswered questions about the impacts of nanomaterials and nanoproducts on human health and environment. The article by C. P. Huang et al. describes the toxicity of nanoparticles to unicellular green algae, exemplified by *Pseudokirchneriella subcapitata*. Three types of engineered nanoparticles (ENPs) were studied: Al_2O_3, SiO_2, and TiO_2. The effect of TiO_2, SiO_2, and Al_2O_3 with particle size of 11, 4, and 3 nm, respectively, on the responses of algal cells was examined. The change in pH, cell counts, chlorophyll *a*, and lipid peroxidation was used to measure the responses of the algal species to nanoparticles. The most toxic particle size of TiO_2 was 42 nm with an EC20 of 5.2 mg/L. On the contrary, the most critical size of Al_2O_3 was 14–18 nm, with an EC20 of 5.1 mg/L. SiO_2 was the least toxic with an EC20 of 318 mg/L compared to TiO_2 and Al_2O_3.

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