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Editorial

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Photocatalysts for Environmental Applications- a new horizon for Phase Change Materials

Environmental pollution is one of the significant challenges all around the world. This is because of the rapid industrialization and urbanization in big cities. Considering these significant challenges, providing a clean environment for humans and living animals is essential. Different nanostructured catalysts with unique physiochemical properties have the potential to solve many of the issues for a greener and cleaner society. In recent years, significant advances have been made in synthesizing and applying photocatalysts in different environmental applications.

These new photocatalysts have enabled wide applications from air purification to wastewater treatment, piezoelectric to energy conversion, thin-film to a supercapacitor, textiles to automotive industries, etc. The rapid development in photo-assisted catalysis science, nanotechnologies, and materials enabled significant advances in new and innovative strategies for the controlled preparation, and understanding of photocatalytic reaction mechanisms, including the structure-activity relationship of photocatalysts [1-3]. The structural features of photocatalysts can be further tuned to enhance their photocatalytic performance in environmental applications.

Photocatalysts can be used in medicine, especially orthopedic implants, in addition to efficiently degrading dyes, drugs, and hard-to-degrade pollutants through efficient utilization of sunlight. Tang et al. [4] studied the application of different types of TiO_2-based photocatalysts for pollutant degradation and orthopedic implants. These technologies provide technical support for the study of other semiconductor-based photocatalysts for orthopedic implants.

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Public Interest Statement

While many of the advances in materials science have been driven by breakthroughs in material design and fabrication, understanding the changes that occur in a material during its utilization or operation in devices is of immense importance for its successful integration. Considering these aspects and the continued growth in materials research, there is a clear need for new topical journals which can serve researchers to understand the phase transitions and exploit the phenomena to current, state-of-the-art research in the field of materials science, moreover with full accessibility.

Tang et al. also constructed ZnFe2O4-based heterojunction photocatalysts by sol-gel method, which showed high photocatalytic activity in photocatalytic degradation of dyes, refractory pollutants, and drugs. Chen et al. synthesized a variety of semiconductor composites using special preparation methods and investigated their photocatalytic activities in water splitting to produce hydrogen, and dye degradation[5]. The application of these techniques in the field of photocatalysis will promote the further development of photocatalysis for other environmental applications, including energy conversions as phase change materials.

The rapid development in catalysis science has inspired this exciting topic of Phase Change Materials. It is very much necessary to understand the critical problems of nanostructured photocatalysts. For the g-C_3N_4-based catalysts, researchers have already synthesized Ti_4O_7/g-C_3N_4 composites by low-temperature reactions. The enhanced photocatalytic activity for Ti_4O_7/g-C_3N_4 could be ascribed to its enhanced charge separation and photoabsorption efficiency. On the other hand, Yang et al. fabricated a monolithic g-C_3N_4/melamine sponge by a cost-effective ultrasonic-coating method. The monolithic g-C_3N_4/melamine demonstrated high photocatalytic activity for NO removal and CO_2 reduction. Ti4O7/g-C3N4-based photocatalysts can also be produced by the hydrolysis method. It has been observed that the Ti_4O_7/g-C_3N_4 catalyst has strong photocatalytic activity for hypophosphite oxidation, which can be ascribed to the heterojunction structure of Ti_4O_7/g-C_3N_4 that enhances charge carrier lifetime [5-6].

Another composite catalyst Ag_3PO_4/MoS_2 revealed its high activity for organic pollutant degradation under visible light [7]. The enhanced activity of the Ag_3PO_4/MoS_2 photocatalysts was ascribed to the efficient separation of photogenerated charge carriers and the stronger oxidation and reduction ability through the Z-scheme system composed of Ag_3PO_4, Ag, and MoS2, in which Ag particles act as the charge separation center. A two-step ZnO-modified strategy was also developed to immobilize the catalyst on rGO sheets and applied in photocatalytic degradation of Orange II dye under simulated solar light [8]. The photocatalytic activity of the ZnO core/rGO shell nanocomposite was demonstrated to originate from superoxide $O_2^{\bullet -}$ radicals due to the efficient trapping of photogenerated electrons in ZnO by rGO. Faceted hollow TiO_2 nanosheets of high specific surfaces were fabricated by calcinating $TiOF_2$ cubes and applied for Photocatalytic oxidation of acetone [9]. The high photocatalytic acetone removal activity of the TiO2 nanosheets was associated with the surface adsorbed fluorine. On the other hand, Kim et al. [10] fabricated nitrogen-doped TiO2 nanoparticles by a very novel plasma electrolysis method and evaluated their photocatalytic performance in the degradation of methyl orange organic dye. The 0.4 at.% N doped TiO_2 catalyst showed the highest photocatalytic performance, degrading about 91% MO degradation under visible light.

Another solar light absorbing metal oxide such as $BiVO_4$ has been utilized as a photocatalyst and photoelectrocatalyst for solar-light driven reactions such as water splitting [11]. The poor electron mobility and slow oxidation kinetics of the material could be overcome by fabricating its heterojunction with WO3. Ma et al. [12] fabricated $WO_3/BiVO_4$ heterojunction inverse opal photoanodes by swelling–shrinking mediated polystyrene template synthetic routes and utilized them as photoanodes in photoelectrochemical cells under simulated solar light for water oxidation.

Several research groups also studied the microbial decontamination process by photocatalysts and their possible mechanisms. In this regard, TiO2 has been utilized frequently due to its low cost, environmental friendliness, and high light-absorbing characteristics. The disinfection property of TiO_2 is primarily attributed to the surface generation of reactive oxygen species (ROS) as well as free metal ions formation. In this regard, Reddy et al. [13] made a comprehensive review of the performance of pure and modified TiO2 in microbial decontamination through the photocatalytic process. In fact, the utilization of semiconductor nanostructures, especially of metal oxides and their heterostructures in photocatalytic degradation of air and water-suspending organic pollutants and inactivation of microorganisms has been one of the attractive fields of research in recent times. The application of innovative techniques for synthesizing such nanostructures with desired size, shape, and functionalities remains the key to the success in these fields. The development of new photocatalysts in the coming years might stimulate us to apply them in several other fields, along with promoting our efforts for environmental remediation in a sustainable manner.

Prof. Umapada Pal and Dr. Sudip Chakraborty
Editor(s) in Chief

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