

## Editorial

# Nanomaterials for Environmental Applications

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Environmental pollution and energy shortage are two current major global challenges faced by human beings. In the past two decades, the evolution of nanotechnology represents an ever improving process in the design, discovery, creation, and novel utilization of artificial nanoscale materials. To meet the major challenges in environmental sustainability, these nanomaterials in various hierarchical fashions are stimulating various important practical applications in the environmental sector. The rapid development in materials and catalysis science has led to significant advances in understanding the controlled synthesis and structure-activity relationship of the nanomaterials. The design, synthesis, and modification of novel nanomaterials allow for enhanced performance for environmental related applications.

This special issue contains 19 papers, which are mainly related to environmental materials synthesis, photocatalysis, and pollutant removal. The purpose of this special issue is to provide readers with current advances in the use of nanomaterials for environmental applications and apprise them of the progress, challenges, and promises. Among them, 11 papers are related to organic pollutant degradation, heavy metal removal, and NO reduction with  $\text{NH}_3$ . One paper is about biodiesel production through harvesting microalgae. Furthermore, there are 4 papers devoted to morphological control of environmental materials, 2 papers related to adsorption optimization, and 1 paper dealing with power transformer with nanomodified cellulose insulation paper. We would like to express our sincere thanks to all the authors

for submitting their interesting works to this special issue. A brief summary of all 19 accepted papers is provided below.

The paper entitled “*Removal of hazardous pollutants from wastewaters: applications of  $\text{TiO}_2$ - $\text{SiO}_2$  mixed oxide materials*” reviewed the different removal techniques employed for wastewater treatment and the factors that influence the degradation efficiency. The application of  $\text{TiO}_2$ - $\text{SiO}_2$  binary mixed oxide materials for wastewater treatment is extensively covered. This literature survey indicated that these mixed oxide materials have enhanced abilities to remove a wide variety of pollutants. This paper also pointed out that even though these binary mixed oxides show better activity than pure  $\text{TiO}_2$  materials in most instances, the utilization of these  $\text{TiO}_2$ - $\text{SiO}_2$  mixed oxides is limited for the mineralization of selected pollutants.

The review article entitled “*Chitosan and its derivatives applied in harvesting microalgae for biodiesel production: an outlook*” is aimed to describe and summarize current researches on the application of chitosan and chitosan-derived materials for harvesting microalgae. Biodiesel requires an efficient low-energy harvesting strategy so as to make biodiesel production economically attractive. Chitosan has emerged as a favorable flocculating agent in harvesting of microalgae. This offers a starting point for future studies able to invalidate, confirm, or complete the actual findings and to improve knowledge in this field.

In the review article entitled “*Study of modern nano enhanced techniques for removal of dyes and metals*,” a range

of wastewater treatment technologies have been introduced which can efficiently reduce both Cr(VI) and azo dyes simultaneously to less toxic form such as biodegradation, biosorption, adsorption, bioaccumulation, and nanotechnology. Rate of simultaneous reduction of Cr(VI) and azo dyes can be enhanced by combining different treatment techniques. As illustrated in this review, a range of nanomicrobiological techniques have been proposed or are under active development for treatment of polluted soil and wastewater, but many techniques are still at experimental or pilot stage. This review also evaluated the removal methods for simultaneous removal of Cr(VI) and azo dyes by surface engineered nanoparticles and nanophotocatalyst. Potential microbial strains capable of simultaneous removal of Cr(VI) and azo dyes have been summarized in some detail as well.

In the paper entitled “*The use of bioflocculant and bioflocculant-producing bacillus mojavensis strain 32A to synthesize silver nanoparticles*,” an organism was successfully used to produce more than one product at the same time. This study has investigated the ability of bioflocculant-producing *Bacillus mojavensis* strain 32A as a nanosilver synthesizer beside bioflocculant production. Three media, such as nutrient broth, bioflocculant-producing medium, and pure bioflocculant, were tested. The results emphasized that purified bioflocculant has the ability to produce anisotropy clusters of nanosilver ranging in size from 6 to 72 nm proving that the bioflocculant functioned as a reducing and stabilizing agent in nanosilver synthesis.

The paper entitled “*Preparation and characterization of lecithin-nano Ni/Fe for effective removal of PCB77*” described that a kind of combined material lecithin-nano-Ni/Fe is obtained by combining lecithin and nanoscale Ni/Fe bimetal via microemulsion method. The efficacy of such an original material was tested using PCB77 as target pollutant. A microemulsion system was optimized as template to prepare Ni/Fe nanoparticles, which was followed by an *in situ* loading process with the deposition of lecithin carrier. The Ni/Fe nanoparticles can be uniformly dispersed and closely combined with lecithin carrier. The constitution of lecithin-nano-Ni/Fe was a beneficial attempt to acquire the synergistic effect for intensified removal of environmental contaminants. It seems promising that the original system and the facile method described in this work will facilitate the development of the organic-inorganic hybrid materials.

The paper entitled “*Quantitative fractal evaluation of herbicide effects on the water-absorbing capacity of superabsorbent polymers*” introduced that 100-mesh sieves, electron microscopy, and fractal theory can be used to study swelling and water absorption in SAPs in the presence of three common herbicides (atrazine, alachlor, and tribenuron-methyl). 2.0 mg/L atrazine reduces the capacity by 9.64–23.3% at different swelling points and no significant diminution was observed for the other herbicides or for lower atrazine concentrations. They also found that the hydrogel membrane pore distributions have fractal characteristics in both deionized water and atrazine solution. A linear correlation was observed between the fractal analysis and the water-absorbing mass. Multifractal analysis characterized

the membrane pore distribution, which is superior to single-fractal analysis that uses the fractal dimension.

In the paper entitled “*Application of a novel semiconductor catalyst, CT, in degradation of aromatic pollutants in wastewater: phenol and catechol*,” a novel semiconductor catalyst, CT, was for the first time employed in the present study to degrade phenol and catechol. The phenolic compounds (initial concentration of 88 mg L<sup>-1</sup>) were completely mineralized by the CT catalytic nanoparticles (1%) within 15 days under acidic condition and with the presence of mild UV radiation. The pollutants were adsorbed on the CT's surface and oxidized via charge-transfer and hydroxyl radical generation by CT. Given the low initial concentrations, a circumstance encountered in wastewater polishing, the current set-up should be an efficient and less energy- and chemical-consumptive treatment method.

The paper entitled “*Phenol removal by a novel non-photo-dependent semiconductor catalyst in a pilot-scaled study: effects of initial phenol concentration, light, and catalyst loading*” reported that a novel non-photo-dependent semiconductor catalyst (CT) was fabricated and employed to degrade phenol. The effect of operational parameters such as phenol initial concentration, light area, and catalyst loading on phenol degradation was investigated. CT catalyst exceeded titanium dioxide in treating and mineralizing low-level phenol, under both mild UV radiation and cloudy conditions. The results suggest that CT catalyst could be applied in circumstances when light is not easily accessible in pollutant-carrying media.

In the paper entitled “*A novel nanomodified cellulose insulation paper for power transformer*,” a novel cellulose insulation paper handsheet has successfully been modified with various contents of montmorillonite (MMT). Relative permittivity and breakdown strength were investigated. The microstructure of MMT in Kraft paper was investigated. The relative permittivity of the immersed oil Kraft-MMT handsheets (K-MMT) decreased with the increasing amount of MMT. For MMT concentration of 9 wt%, K-9% MMT possessed the lowest relative permittivity of approximately 2.3 at 50 Hz. The breakdown voltage of the paper-oil-paper composite insulation system increased from 50.3 kV to 56.9 kV.

In the paper entitled “*SO<sub>2</sub> poisoning behaviors of Ca-Mn/TiO<sub>2</sub> catalysts for selective catalytic reduction of NO with NH<sub>3</sub> at low temperature*,” the sulfur tolerance of Ca modified MnO<sub>x</sub>/TiO<sub>2</sub> catalysts was investigated in low-temperature selective catalytic reaction (SCR) process. Experimental results revealed that the durability of developed catalysts in the presence of SO<sub>2</sub> could be improved by Ca modification. After being subjected to a range of analytical techniques, it was found that the surface Ca species could act as a SO<sub>2</sub> trap by preferentially reacting with SO<sub>2</sub> to form bulk-like CaSO<sub>4</sub>, inhibiting the sulfation of active phase. Furthermore, the introduction of SO<sub>2</sub> had also preserved part of Lewis sites over the MnO<sub>x</sub>. Both of these are conducive to NH<sub>3</sub> adsorption and activation at low temperature, hence improving the sulfur tolerance of Ca doped catalysts.

In the paper entitled “*The poisoning effect of Na doping over Mn-Ce/TiO<sub>2</sub> catalyst for low-temperature selective*

*catalytic reduction of NO by NH<sub>3</sub>*,” sodium carbonate, sodium nitrate, and sodium chloride were chosen as the precursors to prepare the Na salts deposited Mn-Ce/TiO<sub>2</sub> catalysts through an impregnation method. The influence of Na doping on the performance of the Mn-Ce/TiO<sub>2</sub> catalyst for low-temperature selective catalytic reduction of NO<sub>x</sub> by NH<sub>3</sub> was investigated. Experimental results showed that Na salts had negative effects on the activity of Mn-Ce/TiO<sub>2</sub> and the precursors of Na salts also affected the catalytic activity. Significant changes in physical and chemical properties of Mn-Ce/TiO<sub>2</sub> were observed after Na was doped on the catalysts. The decreases in surface areas and NH<sub>3</sub> adsorption amounts were observed after Na was doped on the catalysts, which could be considered as the main reasons for the deactivation of Na deposited Mn-Ce/TiO<sub>2</sub>.

In the paper entitled “*The key role of pH value in the synthesis of titanate nanotubes-loaded manganese oxides as a superior catalyst for the selective catalytic reduction of NO with NH<sub>3</sub>*,” alkaline titanate nanotubes TNTs (TNTs-AL), acidic TNTs (TNTs-AC), and neutral TNTs (TNTs-NE) were synthesized by controlling the washing pH value. When these TNTs were utilized as the catalyst supports for manganese oxides (Mn/TNTs-AL, Mn/TNTs-AC, and Mn/TNTs-NE), the key role of pH value was found. Titanate nanosheets, titanate nanorods, and titanate nanotubes were dominated in Mn/TNTs-AL, Mn/TNTs-AC, and Mn/TNTs-NE, respectively. MnO<sub>2</sub> crystal was observed when using TNTs-AC or TNTs-NE as the support. By contrast, Mn<sub>3</sub>O<sub>4</sub> and NaNO<sub>3</sub> were observed when using TNTs-AL as the support. Mn/TNTs-NE showed the best selective catalytic reduction (SCR) of NO with ammonia due to the largest surface area, the best dispersion, and the most active redox property of manganese oxides.

The paper entitled “*The research of nanoparticle and microparticle hydroxyapatite amendment in multiple heavy metals contaminated soil remediation*” documented that a pot trial was conducted to evaluate the efficiency of two particle sizes of hydroxyapatite (HAP) induced metal immobilization in soils: nanometer particle size of HAP (nHAP) and micrometer particle size of HAP (mHAP). Both mHAP and nHAP were assessed for their ability to reduce lead (Pb), zinc (Zn), copper (Cu), and chromium (Cr) bioavailability in an artificially metal-contaminated soil. Furthermore, both mHAP and nHAP were efficient in covering Pb, Zn, Cu, and Cr from nonresidual into residual forms. The mHAP was superior to nHAP in the immobilization of Pb, Zn, Cu, and Cr in metal-contaminated soil and reducing the Pb, Zn, Cu, and Cr utilized by pakchoi. The results suggested that mHAP had the better effect on remediation of multiple metal-contaminated soils than nHAP and was more suitable for applying in *in situ* remediation technology.

In the paper entitled “*Effects of surfactants on high regularity of 3D porous nickel for Zn<sup>2+</sup> adsorption application*,” three-dimensional porous nickel (3D-PN) film with large specific surface area (As) and high porosity has been successfully prepared by hydrogen bubble dynamic template method. This work presents the effects of PEG 10000 and 1,4-butanediol as new additive combination on surface morphology of

the PN film. Meanwhile, the application of 3D-PN in Zn<sup>2+</sup> adsorption was investigated in the paper. The surface area is determined to be as large as 166.7 cm<sup>2</sup>/mg and the porosity is 0.762 cm<sup>3</sup>/g when the concentration of PEG 10000 and 1,4-butanediol was 0.3 g/100 mL and 0.1 g/100 mL, respectively. The adsorption capacity of PN for Zn<sup>2+</sup> is observed to be 9.145 mg/g.

In the paper entitled “*Photodegradation of methyl orange using magnetically recoverable AgBr@Ag<sub>3</sub>PO<sub>4</sub>/Fe<sub>3</sub>O<sub>4</sub> photocatalyst under visible light*,” a novel magnetically recoverable AgBr@Ag<sub>3</sub>PO<sub>4</sub>/Fe<sub>3</sub>O<sub>4</sub> hybrid was prepared by a simple deposition-precipitation approach. The results revealed that the photocatalytic activity and stability of AgBr@Ag<sub>3</sub>PO<sub>4</sub>/Fe<sub>3</sub>O<sub>4</sub> composite towards decomposition of methyl orange (MO) dye were superior to those of pure Ag<sub>3</sub>PO<sub>4</sub> under visible light irradiation. The photocatalytic activity enhancement of AgBr@Ag<sub>3</sub>PO<sub>4</sub>/Fe<sub>3</sub>O<sub>4</sub> is closely related to the efficient separation of electron-hole pairs derived from the matching band potentials between Ag<sub>3</sub>PO<sub>4</sub> and AgBr, as well as the good conductivity of Fe<sub>3</sub>O<sub>4</sub>. Moreover, the photocatalyst could be easily separated by applying an external magnetic field due to its magnetic property. The quenching effects of different scavengers proved that active holes (h<sup>+</sup>) and superoxide species (·O<sub>2</sub><sup>-</sup>) played the major role for the MO degradation. This work would provide new insight for the construction of visible light responsible photocatalysts with high performance, good stability, and recoverability.

The paper entitled “*Tuning the morphological structure and photocatalytic activity of nitrogen-doped (BiO)<sub>2</sub>CO<sub>3</sub> by the hydrothermal temperature*” described that various nitrogen-doped hierarchical (BiO)<sub>2</sub>CO<sub>3</sub> nanosheets architectures were synthesized by a facile one-step template-free hydrothermal method through controlling the hydrothermal temperature (HT). It was found that HT acted as a crucial factor in determining the morphology of the samples. The *Rosa chinensis*-like, red camellia-like, and lamina-like of nitrogen-doped (BiO)<sub>2</sub>CO<sub>3</sub> (N-BOC) micro-/nanostructures can be selectively fabricated under hydrothermal temperatures of 150, 180, and 210°C. The thickness of the nanosheets was in direct proportion to the increasing HT. The red camellia-like N-BOC-180, especially, exhibited the highest photocatalytic performance, superior to the well-known visible light photocatalyst C-doped TiO<sub>2</sub> and N-doped TiO<sub>2</sub>.

The paper entitled “*Photocatalytic degradation of 2-chlorophenol using Ag-doped TiO<sub>2</sub> nanofibers and a near-UV light-emitting diode system*” reported the photocatalytic degradation of 2-chlorophenol using TiO<sub>2</sub> nanofibers and Ag-doped TiO<sub>2</sub> nanofibers synthesized using the sol-gel and electrospinning techniques. The crystallite size of the Ag-doped TiO<sub>2</sub> nanofibers was smaller than that of the TiO<sub>2</sub> nanofibers because silver restrained phase transformation not only controls the phase transformation but also inhibits the growth of anatase crystallites. The photocatalytic degradation rate followed a pseudo-first-order equation. The rate constants (*k*) of the TiO<sub>2</sub> nanofibers and the Ag-doped TiO<sub>2</sub> nanofibers were 0.056 and 0.144 min<sup>-1</sup>, respectively.

In the paper entitled “*Mechanical and morphological properties of poly-3-hydroxybutyrate/poly(butyleneadipate-co-terephthalate)/layered double hydroxide nanocomposites*,” the nanocomposites of poly-3-hydroxybutyrate/poly(butyleneadipate-co-terephthalate)/layered double hydroxide (PHB/PBAT/LDH) were prepared from a binary blend of PHB/PBAT and stearate- $Zn_3Al$  LDH via a solution casting method using chloroform as solvent. The pristine  $Zn_3Al$  LDH was synthesized from nitrate salts solution using coprecipitation technique and then was modified by stearate anions surfactant *via* ion exchange reaction. As a result, the basal spacing of the LDH was increased from 8.77 to 24.94°. The infrared spectrum of stearate- $Zn_3Al$  LDH exhibited the existence of stearate anions in the synthesized  $Zn_3Al$  LDH. Mechanical properties with 2 wt% stearate- $Zn_3Al$  LDH loading nanocomposites showed 56 wt% improvements in elongation at break compared to those of the blend.

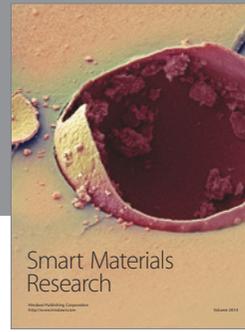
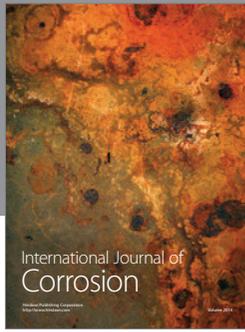
In the paper entitled “*A novel synthesis method of porous calcium silicate hydrate based on the calcium oxide/polyethylene glycol composites*,” a novel method was developed to prepare porous calcium silicate hydrate (CSH) using the calcium oxide/polyethylene glycol ( $CaO/PEG_{2000}$ ) composites as precursors. The reactivity of silica materials ( $SiO_2$ ) was enhanced by increasing the pH value.  $Ca^{2+}$  could not sustain the release from  $CaO/PEG_{2000}$  and reacted with  $SiO_3^{2-}$  caused by silica to form CSH until the hydrothermal temperature reached 170°C, avoiding the hardly dissolved intermediates formation efficiently. The as-prepared CSH, due to the large specific surface areas, exhibited excellent release capability of  $Ca^{2+}$  and  $OH^-$ . This porous CSH has potential application in reducing the negative environmental effects of continual natural phosphate resource depletion.

We hope that these papers provide the reader with knowledge in this topical area and directions for future research.

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