Synthesis and Characterization of Inorganic Materials for Photocatalysis and other Environmental Applications

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Abstract

In the past decades rapid industrial and population growth have increased the environment pollution especially contamination of water bodies by industrial wastes. It is necessary to develop a sustainable method for detection and remediation of water pollutants. Among various physical, chemical or biological methods, advanced oxidation process (AOP) using heterogeneous photocatalysis have become effective and widely used. Semiconductor oxides or sulfides (TiO_2, CdS etc.) have been used for the cause, though they suffer from limitation like restricted use of solar spectrum with broad band gap or fast recombination of charge carriers towards enhanced efficiency. In this work a number of hybrid semiconductor composites were synthesized to overcome the limitations and applied for the photocatalysis under visible light.

The thesis work contains six chapters including a general introduction in **Chapter 1**. In **Chapter 2** a ternary hybrid MoNiCdS was synthesized with optimization of reaction condition for their structural and surface properties. The optimized catalyst was utilized for photocatalytic degradation of pollutant (complete degradation of 20 ppm 2,4-DCP in 90 min) and photocatalytic water splitting. The advantage of the components in ternary hybrid was discussed in detail. **Chapter 3** is presented with organic acid modified TiO_2 to avail carbon and self Ti^{3+} doping along with mixed phases (anatase/rutile). The importance of facets in the catalytic activity was discussed with results, and the photocatalytic activity of modified TiO_2 was studied towards degradation of 2,4-DCP (k = 2.7 x 10^{-2} min^{-1}). **Chapter 4** presents dye sensitization of TiO_2 with a small fluorescent benzimidazole derivative and applied for photocatalytic degradation of an emerging water pollutant, bisphenol A. The same benzimidazole derivative was used for anion (sulfide ion) sensing through fluorescence turn-off with a low detection limit (54 nM). The **Chapter 5** describes a carbon modified TiO_2 with magnetic Fe_3O_4 core, which was synthesized through optimization of synthetic parameters, and its employability for enhanced visible light photodegradation of bisphenol A (k = 1.3 x 10^{-2} min^{-1}). The role of carbon in the hybrid catalyst and charge separation were investigated in detail. In **Chapter 6** a Si-functionalized polymer was synthesized to form a hybrid structure with MFe_2O_4 (M = Ni, Mn). The hybrid was found to act as adsorbent for dyes depending on surface charges, and offer effective degradation of methylene blue (95% removal in 120 min) after strategic thermal treatment. Here, the role of reactive oxygen species and surface modification were investigated. Overall, thesis work is describing the synthesis various materials and their utilization for sustainable environmental applications (visible light photocatalysis) and sensing of pollutants.