UGC Minor Research Project Summary

Photocatalytic Degradation of Organic Pollutants using TiO_2 Catalysts

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Advanced Oxidation Processes (AOPs) appears as an emerging technology for the complete mineralization of the organic pollutants. Among AOPs, heterogeneous photocatalysis using semiconductor nanomaterials for the waste water purification appears to be the most promising technology, because the photoactivated semiconductors can completely decompose (mineralize) various kinds of pollutants that are refractory, toxic, and non-biodegradable, to CO_2, water and mineral acids under mild conditions. Photocatalysis is a reaction which uses light to activate a substance which modifies the rate of a chemical reaction without being involved itself and the photocatalyst is the substance which can modify the rate of chemical reaction using light irradiation. The common photo catalysts are TiO_2, ZnO_2, Fe_2O_3, CdS, ZnS, etc.

When the semiconductor is illuminated with light of greater energy than that of band gap, an electron is promoted from the VB to the CB and produces a positive hole in the valance band and an electron in the conduction band. The electron and hole may migrate to the catalyst surface, where they participate in redox reactions with absorbed species. Specially, hole may react with surface-bound H_2O or OH^- to produce the hydroxyl radical and e^- is picked up by oxygen to generate superoxide radical anion. The hydroxyl radical and superoxide anions are the primary oxidizing species in the photocatalytic oxidation processes. These oxidative reactions results in the degradation of pollutants. Among different photocatalysts ,titania is most suitable for environmental applications because of its biological and chemical inertness, stability against photocorrossion and cost effectiveness.

TiO_2 anatase plays a central role in energy and environmental research. A major bottleneck towards photocatalysis with TiO_2 is that it only absorbs ultraviolet light, owing to its large band gap of 3.2e.V. If one could reduce the band gap of anatase to the visible region, TiO_2 based photocatalysis could become a competitive clean energy source

In this project ,titania was prepared by solgel route and it was modified by doping with metals like Cr, Mo, Ag and nonmetals. Different doped catalysts were prepared using titanium isopropoxide as precursor. Sol gel method was selected because of its advantages of high purity ,homogeneity, improved thermal stability and large surface area at comparatively low temperatures.

All the prepared catalysts were characterized using different techniques such as X-ray Diffraction Analysis(XRD), BET surface Area, UV-Vis Diffuse Reflectance Spectroscopy(UV-Vis.DRS), CHNS Elemental analysis, Scanning Electron Microscopy(SEM), Energy Dispersive X-ray Analysis(EDX), Transmission Electron Microscopy(TEM) and Fourier Transform Infrared Spectroscopy(FTIR).

XRD results showed that all particles are highly crystalline with fully anatase phase which is promising since nanocrystalline anatase found to be most effective for photocatalytic applications. The BET surface area of all the doped catalysts were analysed and found that the surface area of doped catalysts are much higher than that of pure titania. The presence of nitrogen and sulphur was studied using CHNS analysis and found that the dopaants are incorporated in the catalyst. Surface morphology was studied using SEM analysis and found that most of the particles are spherical in shape. EDAX analysis was used to study the presence of elements Cr, Mo and Ag in the doped catalysts. The TEM analysis indicated that particles are spherical in shape and are highly ordered. The selected area electron diffraction pattern of catalysts showed well distinct spots due to the high crysallinity of titania. UV DRS was used to record the absorbance and band gap was calculated . Extending the absorption to visible light is the main objective of this study. The presence of small amount of dopants in the catalyst give rise to a red shift in its absorbance wavelength and decreases its band gap and increases the utility of catalyst in sunlight. The FTIR spectra showed peaks correspond to OH groups which are considered to play a key role in photocatalytic mechanism.

With the emergence of environmental problems, environmental cleanup is an issue of highest priority. In this context a few dyes Acid Red 1, Congo Red , Rhodamine B and pesticides dazomet and aldicarb were selected. The photocatalytic degradation of the pollutants in water was studied. Both artificial light source and sunlight were used to study the degradation. After irradiation the absorbance of dyes was recorded using colorimeter and percentage degradation was studied .In the case of pesticides the percentage mineralization was studied using TOC analysis. Effect of different operational parameters like time, catalyst concentration, dye concentration and effect of dopants were studied .As time increases the amount of light falling on the surface increases and enhances the photoactivity. The increased activity at higher catalyst concentration can be attributed to the increased number of active sites. In all cases the doped catalysts showed higher percentage degradation compared to undoped titania, maybe due to the high efficiency of dopants in trapping charge carriers and also due to their increased visible light absorption. Negligible degradation of pollutants was observed in the absence of light and catalyst suggesting that the degradation of pollutants take place through photocatalytic mechanism. The antibacterial activity of the TiO_2 and Ag-TiO_2 were investigated against 10 types bacteria. The results from all experiments showed that the nanoparticles exhibit antibacterial activity against all pathogens. The greatest enhancement of antibacterial activity was observed for Ag-TiO_2. During the study the antibacterial property of three nanoparticles evaluated at different concentration of bacteria The gram positive bacteria strains showed higher antibacterial effect than the gram negative bacteria strains.. When the concentration of bacteria increases, percentage of viability decreases.

The present method adopted is a good route for the preparation of catalyst with high visible light activity and they showed better antibacterial effect. The work can be extended for the degradation of other harmful organic pollutants.