ISSN: 0973-3469, Vol.19, No.(3) 2022, Pg.109-111

Material Science Research India

www.materialsciencejournal.org

Development of Visible Active Photocatalyst for the Environmental Remediation

K. M. GARADKAR

Nanomaterials Research Laboratory, Department of Chemistry, Shivaji University, Kolhapur, Maharashtra, India.

Article History

Published on: 20 January 2023

Today, the world is facing a lot of shortage of potable water due to the discharge of untreated industrial wastewater from the textiles, dying, pharmaceutical and paper industry into the natural resources that cause water pollution. This has led to a serious situationby reducing the quantity and quality of pure and potable water. Polluted water causes a long-lasting effect on aquatic biota as well as human health. According to World Health Organization (WHO), 80% of diseases are born with unhygienic water and 3.1% of death occurs due to polluted and poor-quality water. Therefore, pure water is a crucial requirement for a healthy world today and thus researchers are paying attention to the development and progress toward more effective methods for wastewater treatment.[1] Methyl Orange (MO) and similar dyes are important azo dyes, used as colouring agents in textiles, and leather industries. These dyes are toxic, mutagenic, and carcinogenic in nature while MO has LD50Acute: 60 mg/kg for Rat. It is hard to degrade; therefore, technologies should be designed for its degradation.[2] Many methods such as coagulation, osmosis, ultrafiltration and photodegradation are used to treat the pollutants. Asone such effective technology, photocatalysis is inexpensive, environmentally friendly and makes use of suitable light irradiation, therefore it can be applied worldwide. This process requires a material that can absorb the light to degrade the contaminants into CO_2 and H_2O (mineralization).[3] The degradation competence of a semiconductor photocatalyst is fundamentally dependent on its light-absorbing potential. Considerable progress has been made in the development of semiconductors, especially wide-bandgap semiconductors. A range of metal oxides such as TiO_2,SnO_2, CuO, WO_3 and ZnO NPsas photocatalysts have been explored to degrade the dye pollutants under UVand Vis. light. Among these ZnO isa justifiable photocatalyst because of its appropriate band gap (3.37 eV), large exciton binding energy (60 meV), high absorption coefficient, andsufficient electron-mobility (115–155

CONTACT K. M. Garadkar kmg_chem@unishivaji.ac.in Nanomaterials Research Laboratory, Department of Chemistry, Shivaji University, Kolhapur, Maharashtra, India.

Doi: http://dx.doi.org/10.13005/msri/190301

cm−2V−1s−1). ZnO NPs are central to various applications like gasand biosensors, solar and electrochemical cells, and ultraviolet photodetectors and are applicable in pigments, pharmaceuticals, cosmetics, metal protective coatings and antibacterial agents. On the other hand, ZnO shows a quick recombination rate of electron-hole pairs and a low quantum yield. The bandgap of ZnO can be triggered only by UV light and it is very essential to extend the visible light absorption and electron-hole (e--h+)separation to perform a proficient photocatalysis under the irradiation ofsolar light. To overcome these shortcomings, it is vital to modify ZnO semiconductors with suitable dopants. The metal ion doping changes the interfacial charge-transfer reaction and absorption spectrum of the ZnO to boost the photocatalytic activity. The way of achieving the desired properties is tocouple the metal oxide with plasmonic noble metal like Ag. Doping of Ag ionsinto ZnO NPs induces supplementary changes in the absorption, physical andchemical properties by modifying the crystal defects which helps to improve the photocatalytic activity of ZnO NPs. It inhibits the recombination rate by forming a Schottky barrier with ZnO and also produces intermediate energy states to reduce the band gap so as to minimize the energyto excite the electrons from the valence to the conduction band. Given this consideration, more attention was given on the synthesis of Ag-ZnO NPs with simple and effective methods. Microbial inhibition is also a severe issue in the healthcare and foodstuff industry. The development of antimicrobial agents has increased awareness in recent years. In particular, the Ag metal has a strong inhibitory effect on several microorganisms. It interacts with bacterial surfaces or may enter the cell, and subsequently exhibits a distinct bactericidal mechanism. The new strategy is developed anddesigned for further improvement in the photocatalytic activity by coupling ZnO with another semiconductor like gC_3N_4. Graphitic carbonnitride (g-C3N4) is a low-cost, metal-free organic polymer and stable allotrope of carbon that is mostly employed for the degradation of dyes. It absorbs visible light due to its low band gap (2.7 eV) and π- π, 2D layered electronic structure.[4] The coupling of g-C3N4 and ZnO forms a novel scaffold nanocomposite which is a sensible way to improve light absorptivity, better surface area and charge carrier separation. The studies show that the modified ZnO NPs by Ag doping coupled with g-C_3N_4(Ag-ZnO/gC_3N_4NCs) produce a composite that shows improved properties of the photocatalyst. Antibacterial materials are frequently used because they can protect human beings from many diseases that are initiated due to bacterial exposure or contact. The synthesized NCs produced considerable zones of inhibition which point towardtheir good antibacterial activity. The reactive oxygen species damage the cellular membrane, leading to cell death.The ZnO NPs and their nanocomposites of Ag and g-C_3N_4 are synthesized by a simple cost-effective co-precipitation method. This method provides a high yield with good purity of material and beneficial than other methods because the reagents are mixed at the molecular level so as to achieve the best stoichiometry and morphology with the desired size of thematerial.[5] The capping agent SDS is an anionic surfactant, it affects the morphology and aggregation ofmaterial which enhances the photocatalytic activity. The capping agent couldadsorb on nanoparticle surfaces and control the growth rate of crystallographic planes to limit the size and shape of nanoparticles. Boosting these activities of the ZnO NPs is the foremost goal of research. The research outcome will be helpful to different environmental remediation.The photocatalytic experiments showedthat the Ag-ZnO NPs (1.0 mol%) possessed excellent photocatalytic activity which exhibited a 26% increment in photodegradation of Methyl Orange (MO) compared to pristine ZnO under UV−Vis. the light within 90 min. These resultssuggest that Ag incorporated into ZnO will help to increase the rate offormation of O2•− and HO• reactive radicals,and simultaneously Ag-ZnO NPs facilitate the enhanced photo degradation of MO compared to pristine ZnO.[6] The individual semiconductor has its limitations like bandgap, absorption coefficient, photostability etc.These limitations are overcome by modification. The modification includes dopinf of noble metal ions ,or coupling with g-C_3N_4 so as to achieve desirable properties so as to utilise the photocatalyst in the visible region. For practical applications, it is essential to check the performance of the devices as pilot plants which may show entirely different performance than their in-lab counterparts. However, it is pertinent and the need of the day to focus the goal and concrete efforts towards the development of such methods and materials. The goal of achieving more potable water can only be achieved if material scientists join their hands for the development of materials like those mentioned above and engineers make pilot plants employing those materials for real use. Such collaborative efforts, worldwide, can only change the scenario of water challenges and make this earth livable to human beings and other members of the animal kingdom on this planet. These are the results of photocatalyst developed in the laboratory and shown the results[7-9]

Table 1: The various photocatalyst for the dye degradation

Sr. No	Material	Dyes	Time (Min)	Degradation (%)
				Sunlight
1.	Ag-ZnO Nanocomposite	MO	30	75
2.	E-waste derived $g-C_3N_4-Fe_2O3$ composite	TE	60	97
3.	Sn doped $N-TiO_2$ (Microwave Assisted)	MO	80	95
5.	Rust derived $g-C_3N4-Fe_2O_3$ composite	TE	90	98
8.	ZnO/Ag_2O (Thermal Decomposition)	MO	90	96

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