Cadmium sulphide based semiconducting Nano composites for visible light photocatalytic application

1.State of Art:

Cadmium sulphide is an important group of II-VI semiconducting nanomaterial with excellent physical properties and wide band gap energy, are successful in the utilization of photo catalytic application. The printing and dyeing materials with complex organic composition form the principal industrial wastewater contaminant by posing a serious issue for degradation.[1] Photocatalysis is one of important technology to solve environmental and energy issues. The most important quality of a good photocatalysts ineffective dye degradation is excellent adsorption in visible light regime, appropriate energy gap and flat band potential/energy levels.[2] Based on these criteria, CdS with a direct band gap of$\sim$2.4 eV at room temperature could be an excellent choice. [3] The main challenge in the development of photocatalysts based on CdS is to improve its efficiency required for the practical production of hydrogen. A fast recombination rate of the photogenerated electron/hole pairs hinders the commercialization of CdS nanomaterials. In order to effectively tune the optical absorption of CdS into the visible region with further improvement of charge carrier separation, it must be coupled with narrow bandgap semiconductors such as CdS/TiO_2,[3] Pt-PbS/CdS,[4] Ag_2O/ZnO [5] and Ag_2O/MnO_2.[6]

In recent years, the visible light induced photo degradation of dyes using nanoparticles is drawing more research interest to make the process more effective, green, and economical. Most of these researches are focused on enhancing the photo catalytic efficiency, by using different doped nanoparticles. In general, for the degradation of the organic dyes, the utilization of electron-hole pairs are playing an important role, on the other hand, the photo catalytic activity is suppressed due to the recombination of electron-hole pair. The best path to enhance the photo catalytic activity is by doping the CdS semiconductor with the transition metals, having magnetic property, such as Fe, Co and Ni. Because, when doping the magnetic transition metal ion like nickel to the host lattice, new defect locations are generated that act as an electron bond and restrains the photo generated hole-electrons pair recombination. In consequence, created electrons and holes are shifted towards catalyst surface where they contribute to degrading process with the organic pigment.

2.Objective:

- Achieving reproducibility in synthesis process.
- To standardise the nanostructures and composites synthesis and their detailed study
- Understanding the doping effect in the proposed application point of view
- Analysing the photo catalytic properties of CdS based semiconducting Nano composites.
- To improve the photocatalytic behaviour by analysing different degradation mechanism

3.Significance of work:

Cadmium sulphide, a visible-light-responsive photo catalyst with a band gap of 2.4 eV, is one of the most prominent semiconductor photo catalysts among the various sulphides for photo catalytic H_2 production. Various sulphides for photo catalytic H_2 production. CdS has been the subject of much research in the field of photo catalytic H_2 production. On the one hand, CdS has good performance for visible light absorption at wavelengths shorter than 516 nm. On the other hand, it has a good carrier transportation capacity, which can make photo generated electrons and holes mobile in a timely and efficient manner, extending the life of the photo generated carriers and leading to high photo catalytic activity. CdS photocatalysts have been of great significance for environmental and energy applications over the past few years. CdS-based compositions need to be further developed. On the other hand, a simple and facile synthetic method with low cost and high safety may provide a new direction to expand the areas of application of photo catalysts. There are some other factors that influence the performance of CdS and CdS-based photo catalysts during the photo catalytic process, such as the morphology, shape, crystal size and so on. Therefore, for further studies a better understanding of the reactive mechanism and theories are necessary and should be given more attention, since this has vital significance for designing and controlling CdS photocatalysts with excellent photocatalytic properties.

4.Methodology and Work Plan:

Experimental Method:

Several methods have been developed to synthesize CdS with divergent morphologies and cultures such as solvothermal method,[7] hydrothermal method,[8] photochemical method,[9] one pot synthesis method,[10] chemical precipitation method [11] etc. Among them, chemical precipitation method is a simple, clean and inexpensive technique to obtain CdS nano particles [12].

Characterization:

Synthesized photocatalysts have been characterized with the aid of diverse characterization techniques such as X-ray diffraction (XRD), FT-Raman, Fourier transform infrared spectroscopy (FT-IR), X-ray photoelectron spectroscopy (XPS), UV-visible and photoluminescence (PL) spectroscopy and transmission electron microscopy (TEM).

Preliminary Results:

We are the first to report on the photocatalytic activity of CdS/Ag_2O nanocomposites for the degradation of methylene blue (MB) dye. This work could facilitate a facile strategy to design highly efficient and stable photocatalyst. The photocatalytic activity of different ratios of CdS/Ag_2O nanocomposites under visible light is investigated towards the degradation of MB. The present research work demonstrates a simple and effective way to develop highly efficient, visible active photocatalyst based on nanotechnology for detoxification of MB.[12]

5.Future Perspectives and Scope:

In the future, more attention should be directed toward investigating the relationships between structures, functions, and the mechanism of photo catalytic reactions based on the CdS and CdS-based photocatalysts. Furthermore, it is expected that CdS and CdS-based photocatalysts will be the promotion of the solar-fuel applications and environmental protection.

Reference:

[1] N. Karamat, M. F. Ehsan, M. N. Ashiq, S. Ijaz, M. Najam-ul-Haq, S. Hamid, D. W. Bahnemann, *Appl. Surf. Sci.* 2019, *463*, 1019–1027.

[2] N. Soltani, E. Saion, M. Z. Hussein, M. Erfani, A. Abedini, G. Bahmanrokh, M. Navasery, P. Vaziri, *Inter. J. Mol. Sci.* 2012, *13*, 12242–12258

[3] S. S. Srinivasan, J. Wade, E. K. Stefanakos, *J. Nanomater.* 2006, *2006*, Article ID 87326

[4] H. Yan, J. Yang, G. Ma, G. Wu, X. Zong, Z. Lei, J. Shi, C. Li, *J. Catal.* 2009, *266*, 165–168.

[5] M. Wu, J.-M. Yan, M. Zhao, Q. Jiang, *ChemPlusChem* 2012, *77*, 931–935

[6] M. E. Assal, M. R. Shaik, M. Kuniyil, M. Khan, A. Al-Warthan, A. I. Alharthi, R. Varala, M. R. H. Siddiqui, S. F. Adil, *Arab. J. Chem.* 2019, *12*, 54–68

[7] A. Phuruangrat, T. Thongtem, and S. Thongtem, *J. Exp. Nanosci.* 4, 47 (2009).

[8] Z. Jinxin, Z. Gaoling, and H. Gaorong, *Chem. Chin.* 2, 98 (2007).

[9] M. Marandi, N. Taghavinia, A. Iraji, and S. M. Mahadavi, *Nanotechnology* 16, 334 (2005).

[10] H. Tong and Y. J. Zhu, *Nanotechnology* 17, 845 (2006).

15. V. Singh and P. Chauhan, *J. Phys. Chem. Solids* 70, 1074 (2009).

[11] A. Mercy, R. S. Selvaraj, B. M. Boaz, A. J. Anandhi, and R. Kanagadurai, *Indian Journal of Pure Applied Physics* 51, 448 (2013).

[12] P. Joice Sophia, D. Balaji, T. James Caleb Peters, D. Sathish Chander, S. Vishwath Rishaban, P. Vijaya Shanthi, K. R. Nagavenkatesh, and M. Rajesh Kumar *ChemistrySelect 5*, 4125 –4135(2000).