NOVEL/GREEN SYNTHESIS AND CHARACTERIZATION OF HYBRID TITANIUM DIOXIDE PHOTOCATALYSTS FOR VISIBLE LIGHT PHOTODEGRADATION OF POLLUTANTS AND THE REACTIVE OXYGEN SPECIES INVOLVED

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by

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ABSTRACT

TiO_2 based visible light photodegradation is one of the amenable solution to the environmental problems especially the water pollution. However, various surface modifications has to done to make them visible light responsive. The reaction course and reactivity of these modified surfaces differ significantly from unmodified TiO_2. Deep insights and the photodegradation mechanistic views of these new systems are highly essential in designing an efficient visible light photocatalytic materials.

This thesis mainly focuses on the preparation methods of various TiO_2 modified composites, its characterization, to study its photodegradation properties and also to examine the reactive oxygen species (ROS) involvement in the photodegradation of rhodamine B (RhB) under visible light. In the (001) exposed facet TiO_2-graphene composite, the composite is prepared using photochemical reduction method using UV light. The composite is showing excellent selectivity towards the photodegradation of positive dyes and •OH and $^1O_2$ are the dominant ROS species (This work was published in Solar Energy Materials and Solar Cells, 2016).

Nitrogen doped TiO_2 (N-TiO_2) and TiO_2-MoS_2 (TMS) photocatalysts are prepared using one step solvothermal method lead and exhibit excellent visible light photodegradation properties. ROS O_2•− plays dominant role in the visible light photodegradation of RhB by N-TiO_2 and TMS photocatalysts (N-TiO_2 work was published in RSC Advances, 2016 and TMS photocatalyst work was published in New Journal of Chemistry, 2016). In N-TiO_2 photocatalyst, intra-band gap states is for visible light enhancement while in TMS composites few layered MoS_2 sensitized TiO_2 mechanism is the reason.

Modification of commercial P25 with carbon dot (C-dot) lead to the improved visible light absorption and the photodegradation properties. Here the composite is prepared from the physical mixing of P25 and C-dot. Up-converted photoluminescence is responsible for the dominant •OH ROS production. Scavenging studies reveal how ROS contributions alters the reaction pathway of the resulting intermediate especially the importance of •OH ROS in the mineralization of RhB dye.

Similarly the photochemical reduction is employed in the preparation of TiO_2-C_{60} (This work was published in Carbon, 2014) or TiO_2-reduced graphene oxide (rGO) (This work was published in Environmental Progress and Sustainable Energy, 2016) composites using cyclcodextrin as a linker molecule. Visible light absorption is achieved by ligand to metal charge transfer (LMCT) mechanism. ROS O_2•− and $^1O_2$ are dominant with TiO_2-CD-C_{60} and TiO_2-CD-rGO composites respectively.

In conclusion, this thesis presents an understanding of, how the various surface modifications of TiO_2 and the resulting photodegradation mechanism affects the contribution of ROS in the visible light photodegradation.