

**PREPARATION, PROPERTIES AND  
PHOTOCATALYTIC ACTIVITY OF SOME DOPED  
AND UNDOPED METAL OXIDE NANOMATERIALS**

**ABSTRACT**

**of**

**THESIS**

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## Abstract

Titanium dioxide ( $\text{TiO}_2$ ), commonly known as Titania, is one of the most commonly used photocatalysts. Because of its high oxidative power, stability, and non-toxicity, it promises a broad range of uses as a photocatalysts. Advantages of using  $\text{TiO}_2$  as photo-catalyst are:

- (a) Using  $\text{TiO}_2$ , the process occurs under ambient conditions.
- (b) Using  $\text{TiO}_2$ , the oxidation of the substrate to  $\text{CO}_2$  is complete in most cases and
- (c) It is comparatively inexpensive and remains quite stable in contact with different substrate.

$\text{TiO}_2$  has also played a leading role in the active research for the utilization of solar energy. The  $\text{TiO}_2$  based, dye sensitized, photo-electrochemical cells are receiving a great deal of attention as a possible candidate for converting solar energy into electricity on a large scale. Titanium dioxide's photocatalytic characteristics are greatly enhanced due to the advent of nanotechnology. At nano-scale, not only the surface area of titanium dioxide particle increases dramatically but also it exhibits other effects on optical properties and size quantization. An increased rate in photocatalytic reaction is observed as the redox potential increases and the size decreases. In some cases energy from any ambient light source can be used effectively as the energy source of photo catalysis instead of UV light.

Photo catalyst of solarcoat not only have all the advantages of the traditional photocatalyst, but also can disinfect, purify air and eliminate harmful substance in the condition of visible light . Therefore, it has incomparable technology and quality advantages of fighting against pollution indoors and outdoors. The strong functions of solar coat photocatalysis will completely eliminate odours of newly-decorated houses and enable people to get rid of the danger caused by epidemic disease. Solar coat of photocatalyst has been widely applied in all kinds of fields and highly affirmed & appraised. The theory of photocatalyst: with the irradiation of light, the  $\text{TiO}_2$  on the surface of the ultra strong photocatalyst of solarcoat will take photocatalytic reaction the same as photosynthesis which can produce free radical and ozone with strong function of oxidization. And it can oxidize and decompose various organic compounds and some minerals.

A detailed study of the synthesis, characterization and photocatalytic activity of titania based nanocomposites have been carried out and presented in the thesis. The organization of whole thesis is given below:

**Chapter 1:** Introduction and Literature Review

**Chapter 2:** Photocatalytic degradation of Eriochrome Black-T by the Ni:TiO<sub>2</sub> Nanocomposites

**Chapter 3:** Photocatalytic Activity of Co:TiO<sub>2</sub> Nanocomposites and their Application in Photodegradation of Acetic Acid

**Chapter 4:** The photocatalytic degradation of Methyl Green in presence of Visible light using Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites as catalyst.

**Chapter 5:** Photocatalytic degradation of Rose Bengal and Thymol Blue dye under visible light by TiO<sub>2</sub>/PAni/GO nanocomposites

**Chapter 6:** Photocatalytic degradation of Victoria Blue and Rose Bengal dye in visible light by prepared TiO<sub>2</sub>/PPy/GO nanocomposite.

**Chapter 7:** Preparation and Photocatalytic activity of Co:La:TiO<sub>2</sub> nanocomposites for the degradation of Methyl Blue in Visible light

**Chapter 8:** Conclusion and Scope of Further Research Work

The study will broadly follow the scheme as given above. The Abstract of research work carried out is as follows:

In the first chapter, general introduction about the subject, historical background, theories, applications, literature review and objectives of the present study has been presented.

In the second chapter, TiO<sub>2</sub> and Ni:TiO<sub>2</sub> nanoparticles (NPs) were prepared and their photocatalytic activity was measured against Eriochrome Black T (EBT). The Photo-degradation of Eriochrome Black T was investigated at different condition of concentration and pH in presence of TiO<sub>2</sub> and Ni:TiO<sub>2</sub>. The prepared nanoparticles of photocatalyst are characterized by XRD, SEM, EDX, UV-Vis and BET. The photocatalyst activity was measured by varying pH and concentration of dye solution. Kinetics study of photodegradation was found first order kinetics. The photocatalytic activity of Titania has been enhanced by the doping of Ni.

In the third chapter, TiO<sub>2</sub> and Co-TiO<sub>2</sub> nanoparticles (NPs) were prepared and their photocatalytic activity was measured against Acetic Acid. The prepared material was subjected to XRD analysis which gives the rutile and Anatase both phases were

present in the prepared sample. It is found that, in samples sintered at 400 °C both Anatase and rutile phases were presented and rutile phase was more dominant, while in samples without sintered the exclusive formation of polycrystalline Anatase and rutile phase separately was occurred. Applying the Scherrer's calculations through which particle size was found 35 and 80 nm in case of Cobalt titania and pure titania respectively. The prepared sample of titania and Cobalt titania were subjected to photocatalytic degradation of acetic acid was done. The degradation of acetic acid occurs efficiently. The prominent degradation was found in case of Acetic acid in the presence of nanocomposites Co-TiO<sub>2</sub>.

In the fourth chapter, the photodegradation of Methyl green dye has been done in presence of prepared Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites. The nanocomposites of Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> was prepared by the solution impregnation method. The characterization of Synthesized TiO<sub>2</sub> and Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites were done by X-Ray Diffractometer, SEM, TEM, UV- Vis, FT-IR, Band gap energy and BET. The photocatalytic degradation of Methyl Green has been done in presence of TiO<sub>2</sub> and Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites. The presence of anatase and rutile phase in the nanocomposites has been confirmed by XRD analysis. The photocatalysts particle was found in nanodimension in morphology. The surface area was observed 34.72 and 96.58 m<sup>2</sup>/g for the TiO<sub>2</sub> and Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites. The band gap energy was observed 3.2 and 3.0 eV for the TiO<sub>2</sub> and Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> nanocomposites. The photocatalytic degradation behaviour of photocatalysts was investigated by considering different parameters such as effect of concentration, effect of amount of photocatalyst, effect of pH, effect of temperature, adsorption and kinetics. The 90-98 % photodegradation of Methyl Green has been found at 7 pH, 25 ppm concentration of dye, 800 mg/L amount of photocatalyst and 50 min illumination of visible light in presence of Ni<sub>0.10</sub>:La<sub>0.05</sub>:TiO<sub>2</sub> while 10-18 % in presence of neat TiO<sub>2</sub> . The photodegradation of Methyl Green was following the first order kinetics.

In the fifth chapter, Nanocomposites of TiO<sub>2</sub>, TiO<sub>2</sub>/PAni and TiO<sub>2</sub>/PAni/GO were prepared by in situ oxidation polymerization method. The prepared TiO<sub>2</sub>, TiO<sub>2</sub>/PAni and TiO<sub>2</sub>/PAni/GO Nanocomposites were characterized by the XRD, SEM, TEM, BET, UV-Vis, FTIR, Band gap energy and Photoluminescence. The XRD confirmed the presence of Anatase and rutile phase in the prepared photocatalysts. The average particle size was found 68, 15 and 12 nm for TiO<sub>2</sub>, TiO<sub>2</sub>/PAni and

TiO<sub>2</sub>/PAni/GO respectively. The SEM and TEM images also confirmed the formation of nanocomposites in the range of ~ 100 nm. The surface area 37.52, 76.68 and 96.24 m<sup>2</sup>/g were observed for TiO<sub>2</sub>, TiO<sub>2</sub>/PAni and TiO<sub>2</sub>/PAni/GO Nanocomposites respectively. The Band gap energy of TiO<sub>2</sub>, TiO<sub>2</sub>/PAni and TiO<sub>2</sub>/PAni/GO were calculated by talc plot and obtained 3.0, 2.86 and 1.76 eV respectively. The Photocatalytic degradation of Rose Bengal dye was done at different condition viz concentration of dye, time of illumination, pH and dose of photocatalyst. The maximum photodegradation were found at neutral pH, 6.25 ppm concentration of dye solution, 800 mg/L amount of photocatalyst and 120 min irradiation of visible light. Kinetics of photodegradation was investigated for Rose Bengal dye and found first order kinetics. The coating of PAni and GO were enhanced the photocatalytic activity of Titania. Hence TiO<sub>2</sub>/PAni and TiO<sub>2</sub>/PAni/GO are the efficient photocatalyst for the degradation of Rose Bengal B dye than pure TiO<sub>2</sub>.

In the sixth chapter, describes a proficient method for synthesis of TiO<sub>2</sub>/PPy and TiO<sub>2</sub>/PPy/GO nanocomposites. These nanocomposites were prepared by one-step *in situ* deposition oxidative polymerization of pyrrole hydrochloride using Ammonium per sulphate (APS) as an oxidant in the presence of ultra fine grade powder of TiO<sub>2</sub> nanoparticles cooled in an ice bath. The obtained nanocomposites were characterized by XRD, TEM, SEM, UV-Vis, FTIR, techniques. The obtained results showed that TiO<sub>2</sub> nanoparticles have been encapsulated by PPy with a strong effect on the morphology of TiO<sub>2</sub>/PPy and TiO<sub>2</sub>/PPy/GO nanocomposites. The Photocatalytic degradation of Rose Bengal and Victoria blue dye was done at different condition viz concentration of dye, time of illumination, pH and dose of photocatalyst. The maximum photodegradation were found at 7 pH, 20 ppm concentration of Victoria blue and 25 ppm of Rose Bengal dye solution, 800 mg/L for VB and 1600 mg/L for RB amount of photocatalyst and 120 min irradiation of visible light. Kinetics of photodegradation was investigated for Victoria blue and Rose Bengal dye and found first order kinetics. The coating of PPy and GO were enhanced the photocatalytic activity of Titania. Hence TiO<sub>2</sub>/PPy and TiO<sub>2</sub>/PPy/GO are the efficient photocatalyst for the degradation of Rose Bengal and Victoria Blue dye than pure TiO<sub>2</sub>.

In the seventh chapter, prepared the nanocomposites of Co:La:TiO<sub>2</sub> by the wet chemical method. Synthesized TiO<sub>2</sub> and Co:La:TiO<sub>2</sub> were characterized by X-Ray

Diffractionmeter, SEM, TEM, UV- vis, FT-IR, Band gap energy and BET. The  $\text{TiO}_2$  and  $\text{Co:La:TiO}_2$  were used as photocatalyst for the degradation of Methyl Blue. The XRD pattern confirmed the presence of anatase and rutile phase in the catalyst. The particle size was estimated by the Scherrer's and found 68 and 32 nm for  $\text{TiO}_2$  and  $\text{Co:La:TiO}_2$  respectively. The particle morphology of the photocatalysts was found in nanodimension. The surface area of the photocatalysts were found 37.52 and 106.68  $\text{m}^2/\text{g}$  for  $\text{TiO}_2$  and  $\text{Co:La:TiO}_2$  respectively . The band gap energy of  $\text{TiO}_2$  and  $\text{Co:La:TiO}_2$  were 3.2 and 3.0 eV. The FT-IR spectra of  $\text{Co:La:TiO}_2$  were recorded and found Co bonded with Titania. The photodegradation of Methyl Blue has been found maximum at 5 pH, 25 ppm concentration of dye, 800 mg/L amount of photocatalyst and 180 min illumination of visible light. The photodegradation was following the first order kinetics.

In the eighth chapter, conclusion and some important results of all chapters have been discussed and also describe the future trends.