Photodegradation of Textile effluent by Cr^{3+}: ZnO

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Abstract

Semiconducting material like TiO_2 and ZnO plays a promising role in the photodegradation of toxic organic materials present in water. In the present case the author reports the photodegradastion of textile effluent using Cr^{3+}: ZnO, where the photodegradation of textile effluent was carried out under both sunlight and UV light. The effect of various parameters such as catalyst loading, intensity of illumination was investigated on photocatalytic degradation of textile effluent. The degradation efficiency of these compounds was calculated by knowing the % Decomposition, Chemical Oxygen Demand (COD) and % Transmission (%T) of textile effluent before and after exposing to light. The increase in %T, % Decomposition and reduction in COD of treated effluent reveales the destruction of organics present in textile waste.

***Keywords**: Photodegradation, Photocatalysis, Textile effluent*

1. Introduction

Zinc oxide (ZnO) is a multi functional material with a wide range of applications. Zinc Oxide (ZnO), a wide band gap (3.37 eV) semiconductor, is a potentially important for laser diode [1] optical waveguides [2, 3], optical switches [4, 5], transparent ultraviolet (UV) protection conducting film [6] and acousto-optic and surface acoustic application. Moreover, this material is characterised by high transmittance in the visible spectrum region, high electric conductivity and good chemical stability in comparison with traditionally used commercial luminescent materials [7-11]. ZnO has been widely used in optical applications as it has a wide band gap of 3.37 eV. It is transparent and has a large excitation binding energy of 60 meV. Apart from the various optical and optoelectronic applications, ZnO is also used as a cosmetic, antibiotic and as a photocatalytic material. However, for this particular application, the recombination radiation near 385 nm is a deterrent. To eliminate the effect of this recombination radiation in the UV region, it is necessary to dope transition metal ions in ZnO in order to envisage the possibility of shifting the recombination wavelength to higher wavelengths. In the present case the author reports the doping of Cr^{3+} in ZnO using hydrothermal route and the application of the synthesized compound in the photodegradation of industrial effluent.

II. Experimental Method

In the synthesis of Cr: ZnO a known amount of commercially available ZnO was taken in the in a Teflon liner to which 2% of Cr_2O_3 was doped. The chemical ingredients were weighed in stoichiometric proportions and a required amount of suitable mineralizer (HCl 1N) was added into this Teflon liner maintaining 40% of fill. The Teflon liner was then placed inside the autoclave. The autoclave was then placed inside the oven and the temperature of the oven was set to 150°C for 24 hrs. After the experimental run, the autoclave was quenched and the sample was taken out. The sample inside the liner was separated from the solution and washed with the double distilled water till the pH become neutral, and then ultrasonicated. The product extracted was centrifuged to remove undesired components and dried at a temperature of 35-40°C in a dust free environment. The compound so prepared was used for the photodegradation of textile effluent in order to know the efficiency of the compound synthesized.

In the photocatalytic degradation of the textile effluent a known volume of the effluent (50ml) was taken in a beaker. To this a known amount of catalyst was added. The experiment was carried out under both UV and sunlight. For UV source the sample was kept in UV chamber (Sankyo, Denki, Japan, 8W) the distance between the UV and effluent was 18 cm. The intensity of sunlight and UV was estimated by

photolysis of Uranil Oxalate (Steven1973). It was estimated that the intensity of sunlight was 6.728 X 10^{16} quanta/sec and the intensity of UV was 2.375 X 10^{15} quanta/s. 2-3 ml of the sample exposed to light was taken and centrifuged for 4-5 min at 1000rpm and then used to measure the percentage transmission (%T) at 540nm using spectrophotometer (Model: Minispec SL 171, Elico, India). Chemical oxygen demand (COD) was estimated before and after the treatment (using the $K_2Cr_2O_7$ oxidation method). The photodegradation of the Textile effluent was calculated using the equation,

$$\text{Photodegradation} = \text{Initial}_{COD} - \text{Final}_{COD} / \text{Initial}_{COD} \text{ X100}$$

III. Result and Discussion

3.1 Effect of Cr^{3+}: ZnO on photodegradation of textile effluent

In order to obtain an optimum condition with respect to amount of catalyst used at which photodegradation is maximum the experiment was carried out for the degradation of textile effluent using different amount of Cr^{3+}: ZnO. Figure.1 illustrates the effect of different amount of catalyst (10- 30 mg) on the decomposition of organic present in textile effluent. It was observed that the rate of decomposition increases with respect to catalyst loading and the intensity of illumination. The decomposition rate was high under sunlight when compared to UV light.

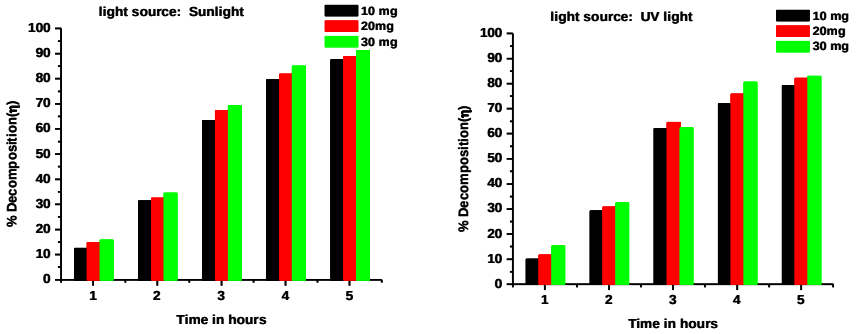

Fig 1 Graphical representation of %Decomposition reading on exposure to sun & UV light

3.2 Effect of Cr^{3+}: ZnO on the chemical oxygen demand (COD) of the textile effluent

The COD of the effluent was estimated before and after the treatment. The reduction in the COD value of the effluent depicts the destruction of the organics present in the effluent. A maximum of 91.5 % of degradation efficiency was obtained with in duration of 5hrs in the present study. Figure.2 represents the reduction of COD using Cr^{3+}: ZnO under both sunlight and UV light. Tables 1 and 2 represent the effect of Cr^{3+}: ZnO weight on COD, decomposition (ŋ) and % transmission (%T) of textile effluent under both sunlight and UV light. Figure.3 represents the increase in %T of the effluent with respect to time.

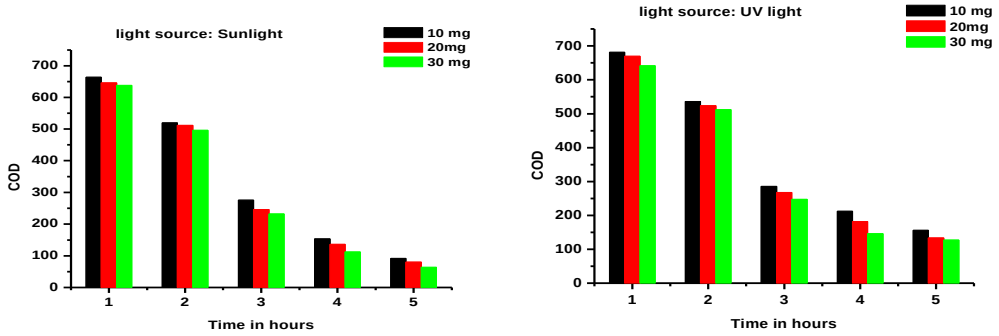

Fig .2. Graphical representation of COD reading on exposure to sun & UV light

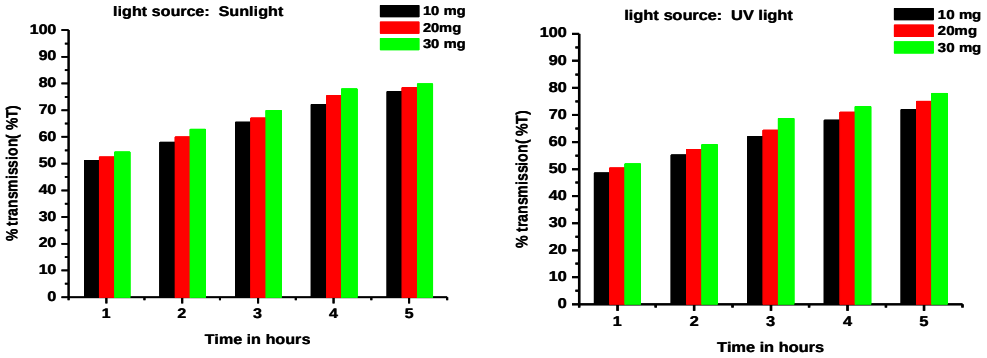

Fig .3. Graphical representation of %Transmittance reading on exposure to sun & UV light

Time in Hrs	10 mg			20 mg			30 mg		
	COD	ŋ	%T	COD	ŋ	%T	COD	ŋ	%T
1	664	12.6	51.3	646	15	52.7	638	16	54.5
2	520	31.5	58.2	512	32.6	60.2	496	34.7	63
3	276	63.6	65.7	246	67.6	67.3	232	69.4	70.1
4	153	79.8	72.3	136	82.1	75.6	112	85.2	78.2
5	92	87.8	77.2	80	89	78.6	64	91.5	80

Table 1. Effect of Photocatalytic degradation efficiency (ŋ) and Decolorization (%T) on Textile effluent under sunlight using Cr^{3+}:ZnO

Time in Hrs	10 mg			20 mg			30 mg		
	COD	ŋ	%T	COD	ŋ	%T	COD	ŋ	%T
1	682	10.2	48.5	670	11.8	50.4	642	15.5	51.9
2	536	29.4	55.2	524	31.0	57.3	512	32.6	59
3	286	62.3	62	268	64.7	64.3	248	62.6	68.7
4	212	72.1	68	182	76	71	146	80.7	73
5	156	79.4	72	134	82.3	75	128	83.1	78

Table 2. Effect of Photocatalytic degradation efficiency (ŋ) and Decolorization (%T) on Textile effluent under UV light using Cr^{3+}: ZnO

III. Conclusion

The photo-catalytic degradation of textile effluent using the prepared materials is an efficient and environmentally benign technique, because it facilitates the complete mineralization of the complex organics into simpler non-toxic products. The study of various parameters like initial concentration of the organics, catalyst amount, % Decomposition, %T and COD test has helped in finding out the optimum reaction conditions. Moreover the use of sunlight as the source of light in the photodegradation reaction could be a safe and highly cost effective source. The textile effluent was treated successfully using the prepared compound. The decrease in the COD values from 740 to 64 demonstrated the destruction of the organics present in the effluent and increase in the % transmittance. COD reduces and degradation efficiency increases as the time increases. The proposed degradation showed that the final products of the degradation are less toxic and environmental friendly and further work is been carried out for the use of these compound in the degradation of organics present in municipal waste.

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