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Photocatalytic Degradation of Methylene Blue Dye using TiO_2 Nanoparticles

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ABSTRACT

TiO_2 nanomaterials were prepared by using sol-gel, hydrothermal and dispersion method. These nanomaterials were characterised by XRD. The photocatalytic activity of all three prepared samples were demonstrated for the degradation of methylene blue dye under sun light irradiation. The degradation rate of methylene blue dye degradation has been significantly enhanced with TiO_2 prepared by hydrothermal method.

Key words: TiO_2, Hydrothermal, Sol-gel, Titanium tetra-isobutoxide, Urea, Methylene blue

INTRODUCTION

Titanium dioxide (TiO_2) is an important semiconductor, having properties such as non- toxicity, photo and chemical stability, water insolubility under most conditions and low production cost [1-5]. TiO_2 is highly promising agent to be used in electronic, photo catalysis, water purification, as well as antibacterial and self-cleaning materials [6-11]. The history of TiO_2 started in 1972 from the discovery Fujishima and co-worker [1-3].

Different preparation procedure can change the morphology of TiO_2 catalyst. This can results in change in photocatalytic activity of TiO_2. In this study, we have prepared three TiO_2 catalysts by different methods and compare the photocatalytic activity for degradation of methylene blue.

METHODOLOGY

2.1 Synthesis of Catalyst by Sol-Gel Method:

The 5 ml of acetic acid was added in to 50 ml of ethanol under continuous stirred for 30 min, to this 5 ml of titanium tetra-isobutoxide was also added to obtained clear solution. To this solution, dilute ammonia was added slowly to achieve the pH 10. The obtained precipitate was washed with distilled water & ethanol, dried at 110 °C & finally, calcined at 450 °C for 4 hours.

2.2 Synthesis of Catalyst by Hydrothermal Method:

Titanium *tetra*-isopropoxide added in distilled water under continuous stirring for 30 min at room temperature followed by addition of urea diluted separately with about 10 ml of distilled water stirred for 15 min at room temperature. Then the mixture was transfer in to a Teflon-lined stainless steel autoclave and maintain at 160 °C for 20 hours. After the autoclave was cooled, the formed white precipitate was filtered, washed with distilled water, dried in the oven at 80 °C and finally, calcined for 4 hours at 450 °C.

2.3 Synthesis of Catalyst by Dispersion Method:

Bulk TiO_2 powder was added in a beaker having solution of NaOH. This solution was vigorously stirred for 6 hour, and then this dispersed solution was filtered, washed with distilled water, dried at 80°C and finally calcined at 450°C.

RESULTS AND DISCUSSIONS

3.1 X-Ray Diffraction:

Figure 1 shows XRD pattern of the prepared TiO_2 samples prepared by sol-gel and hydrothermal method. Both the sample shows the formation of anatase phase of TiO_2. From, the Debye–Scheerer's formula, the average crystallite sizes observed to be 09 nm and 19 nm for sample prepared by sol-gel and hydrothermal method respectively.

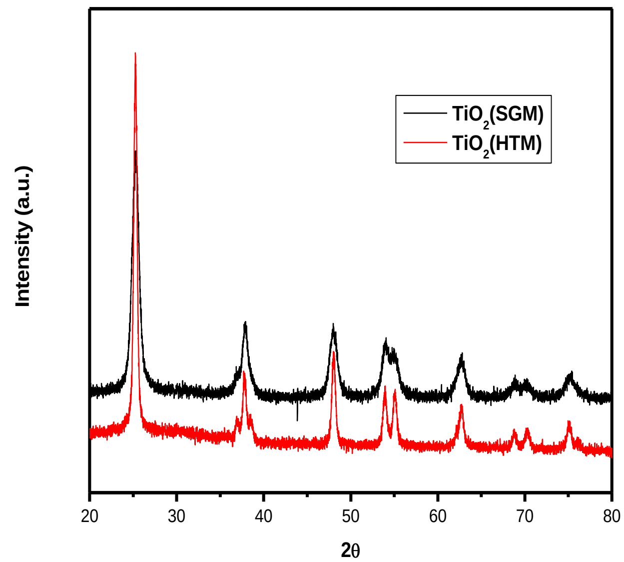

Fig.1. XRD patterns of the TiO_2 samples.

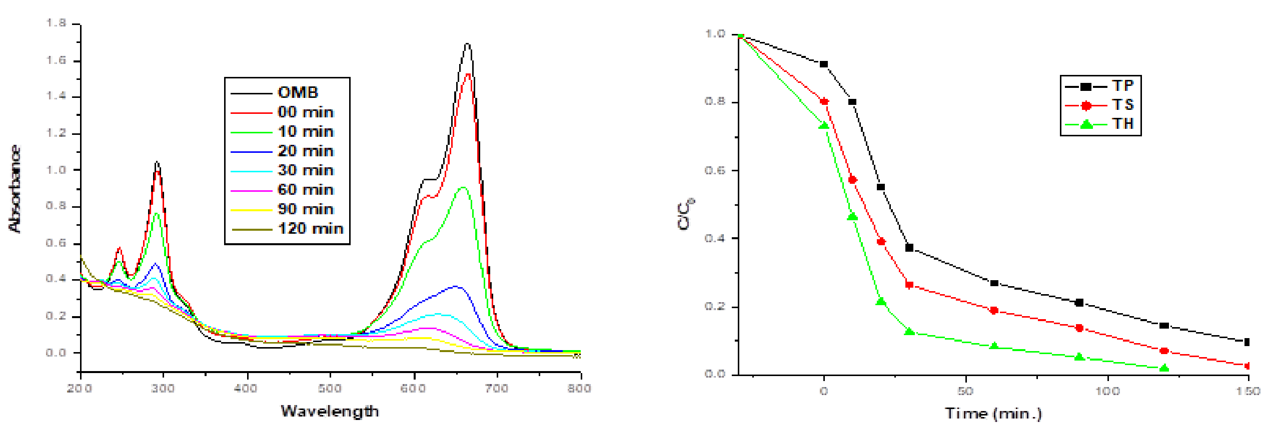

Fig. 2. Photocatalytic degradation of MB by TiO_2 sample (HT method) and Kinetic parameter study of degradation of MB by different TiO_2 samples.

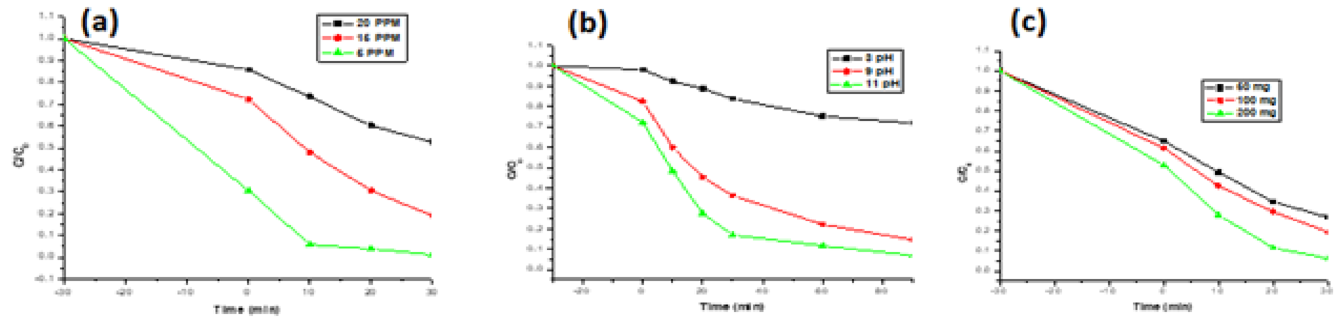

Fig. 3. (a) Effect of concentration of MB; (b) Effect of different pH on depredation of MB; (c) Effect of different wt. of catalyst on degradation of MB

3.2 Photo catalytic Degradation of Methylene Blue:

To find out the best catalyst from these three, we have carried out the degradation of methylene blue dye. The results obtained are shown in Fig. 2. Among these three catalysts, the catalyst prepared by hydrothermal method is working more efficiently. Further studies, like change in concentration, effect of pH and catalyst content have been carried out by using hydrothermal method prepared TiO_2.

3.2.2 Effect of pH of Methylene Blue and Weight of Catalyst:

Fig. 3(b) shows that the degradation efficiency of MB increases with the increasing solution pH. This may be due to formation of OH radical, which will increase the rate of degradation. On increasing weight of catalyst, the degradation becomes faster [Fig, 3(c)].

3.2.3 Effect of different weight of catalyst:

The results [Fig. 3(c)] show that an increase in the catalyst loading from 50 to 200 g/L increases the dye degradation sharply. This is due to the fact that an increase in catalyst loading increases the active sites on the surface of the catalyst, which in turn, increases the adsorption of number of MB species and, hence, the proportion of the excited species by the incoming photons. Therefore, the rate of degradation increases with higher catalyst loading for this amount of MB (20 mg/L).

CONCLUSION

Prepared catalysts (by hydrothermal and sol-gel method) have shown the formation of catalytically active anatase TiO_2 phase. The catalyst prepared by hydrothermal method shown higher efficiency than other prepared catalysts for degradation of MB. Also, this catalyst found to be active at different pH of the solution.

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