Effect of various Metal Ions on Photocatalytic Degradation of Rhodamine B by TiO_2 Nanoparticles

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***Abstract*: Present study deals with the photocatalytic degradation of Rhodamine B dye in presence of TiO_2 nanoparticles. The photocatalytic activity investigation has been carried out by performing the decomposition of rhodamine-B dye under UV illumination over as- synthesized TiO_2 Nanoparticles. In this work the progress of the reaction has been studied kinetically by measuring absorbance of the reaction mixture at various time intervals using Spectrophotometer. The control experiments have also been performed in different conditions. Control experiments confirm the necessity of light, semiconductor catalyst and oxygen to follow the photocatalytic path to proceed the photobleaching of dye. Kinetic analysis of degradation indicates that the degradation follows the first order kinetics. Effect of various metal ions (Zn^{+2}, Fe^{+2},Cu^{+2}) has also been studied. result ravels that addition of various metal ions reduce the photocatalytic efficiency of the rhodamine B dye.**

***Keywords*: Photocatalytic degradation, Rhodamine-B, TiO_2 Nanoparticles**

Introduction

Among the various techniques, heterogeneous photo- catalysis is a popularly employed process to eliminate hazardous waste materials especially organic compounds which are degraded to less toxic or less harmful materials [1]. Recently, the metal oxide semiconductors have shown good photocatalytic activity toward the degradation of harmful organics into less harmful molecules under light illumination [2]. Many attempts have been made to study the photocatalytic activity of different semiconductors such as SnO_2, ZrO_2, Fe_2O_3, CdS and ZnO[3]. Titanium dioxide (TiO2) is one of functional metal oxide semiconductor that performs high efficiency in photocatalytic activities because of non-toxicity, excellent energy conversion efficiency and long-term chemical stability [4,5]. Rhodamine B (Rh-B) represents one of the most important dyes, extensively used in thetextile industry due to its high stability. Its release into the environment is dangerous for aquatic life as in many cases; it is carcinogenic andmutagenic for both humans and animals. Thus, decomposition of such organic dyes is significantly important for the purification and conservation of water [6-10].

Experimental

To study photocatalytic degradation stock solution has been prepared. For the stock solution dye Rhodamine B has been dissolved in of double distilled water so that the concentration of dye solution become 1×10^{-3} M . This solution has been further diluted as per requirement. The absorbance of the dye solution has been determined with the help of spectrophotometer. Control experiments confirm that both light and semiconductor photocatalyst are necessary for the photodegradation and oxygen increases the rate of photodegradation. Photocatalytic degradation of Rhodamine B has been carried out by taking 100 ml of 3×10^{-5} M dye solution in round bottom flask and 0.15 gm of TiO_2 nanoparticles have been added to it. The pH of the reaction mixture has been made alkaline (9.0) by adding 0.1 N NaOH. The mixture has been then irradiated under visible light source (2 x 200 W, Tungsten lamps). A water filter has been placed between light source and reaction vessel to cut off thermal radiations. Air has been purged continuously through reaction mixture with the help of an aerator for stiring purpose and availability of oxygen.

Results and discussion

About 3 ml of dye solution has been taken after a specific time interval (40 min) and its absorbance has been measured using spectrophotometer at 554 nm after removing TiO_2 . The rate of change in absorbance of the reaction mixture with time has been continuously measured. The result of photocatalytic degradation of Rhodamine B has been given in table 1.

Table 1 Typical Run

Time (Min)	Absorbance (Abs)	1+log Abs
0	0.211	0.324
40	0.169	0.227
80	0.143	0.155
120	0.125	0.096
160	0.113	0.053
200	0.103	0.012

It has been observed that absorbance of rhodamine B decreases with increase in time of irradiation. A plot of (1+ log absorbance) with irradiation time has been shown in Fig 1. It has been observed by fig 1 that the plot between absorbance and time is linear, which indicates the photocatalytic degradation of rhodamine B follows the first order kinetics. The rate constant of this reaction can be determined using the expression:

Rate constant K = 2.303 x Δ [log Abs/time] [1]

Rate constant of photocatalytic degradation of rhodamine B has been calculated using equation 1 and it is found as **6.4×10^{-5} sec^{-1}**.

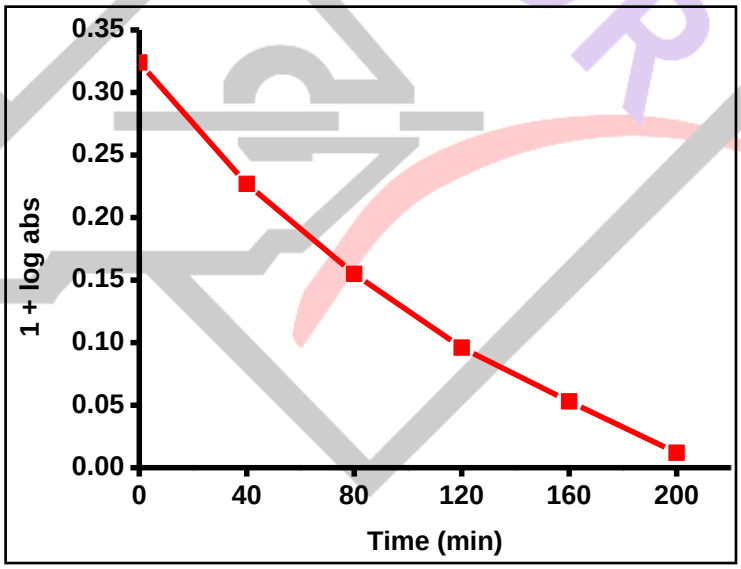

Fig 1: A plot showing typical run of photocatalytic degradation of Rhodamine B dye under optimum conditions

Effect of various transition metal ions

Effect of addition of various transition metal ions (**Zn^{+2}, Fe^{+2},Cu^{+2}**) on photocatalytic degradation of Rhodamine B dye by TiO_2 has been studied. Results have been reported in table 2 and fig. 2

Table 2: Effect of various transition metal ions

M^{n+}	Rate constant K x 10^{-5} (sec^{-1})
TiO_2	6.46
Zn^{+2}	5.72
Fe^{+2}	5.08
Cu^{+2}	4.85

Result reveals that the addition of Zn^{+2},Fe^{+2},Cu^{+2} in TiO_2 nanoparticles reduce the photocatalytic efficiency of the rhodamine B dye with TiO_2 nanoparticles and the rate constant also decreses with addition of metal ion Zn^{+2},Fe^{+2},Cu^{+2} respectively.

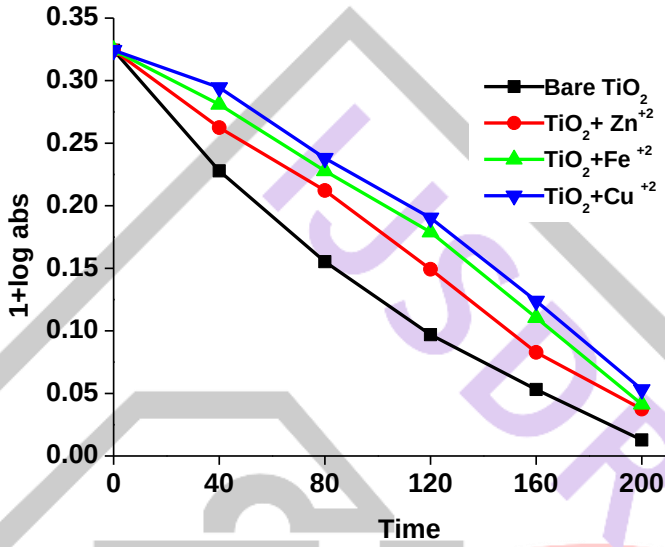

Fig 2: Effect of different metal ions on photocatalytic degradation of Rhodamine B dye (A) Bare (B) Zn^{2+} (C) Fe^{2+} (D) Cu^{2+}

Conclusion

Photocatalytic degradation of Rhodamine B dye in presence of TiO_2 nanoparticles has been studied. the progress of the reaction has been studied kinetically. Absorbance of the reaction mixture has been measured at various time intervals. The control experiments have also been performed in different conditions. Control experiments confirm the necessity of light, semiconductor catalyst and oxygen to follow the photocatalytic path to proceed the photobleaching of dye. Kinetic analysis of degradation revels that the degradation follows the first order kinetics. Addition of metal ions (Zn^{+2}, Fe^{+2},Cu^{+2}) effects the photocatalytic degradation. It has been observed that addition of various metal ions reduce the photocatalytic efficiency of the rhodamine B dye.

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