

PHOTOCATALYTIC DEGRADATION OF PYROGALLOL RED WITH COLLOIDAL ANTHRACENE IN FREE AND IMMOBILIZED STATE

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ABSTRACT

The photocatalytic degradation of pyrogallol red has been carried out in the presence of colloidal anthracene supported on polythene films. The photocatalytic reaction has been studied spectrophotometrically by observing absorbance at different time intervals. The effect of various parameters like pH, concentration of dye, light intensity, amount of semiconductor etc. on the reaction rate was observed. A tentative mechanism for the bleaching of the dye has been proposed.

Key words : Photocatalytic, Pyrogallol red, Anthracene

INTRODUCTION

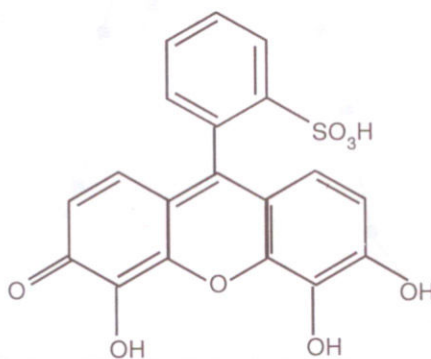
Photocatalytic degradation of organophosphorus pesticides using thin film of TiO_2 has been investigated by Mengyue et al¹. Photocatalytic mineralization of paraquat dissolved in water by TiO_2 supported on polyethylene and polypropylene films have been observed by Tennakone and Kottegoda². The photooxidation of organic impurities in water using a thin film of TiO_2 was investigated by Matthews³. Tennakone et al.⁴ reported photoextraction of silver from aqueous solution using anthracene colloid. Tennakone et al.⁵ studied a simultaneous reductive and oxidative photocatalytic nitrogen fixation in hydrous Fe_2O_3 loaded nafion films in aerated water. Photocatalytic degradation of organic contaminants in water with TiO_2 supported on polythene films has also been investigated by Tennakone et al⁶.

A great deal of literature survey reveals that negligible attention has been paid to photocatalytic reactions using anthracene colloid as a photocatalyst. Therefore, in the present work, colloidal anthracene in free and immobilised state has been used for the photocatalytic degradation of pyrogallol red. Immobilization of colloidal anthracene helped in combating against the problem of suspension of these particles in aqueous solutions.

EXPERIMENTAL

Pyrogallol red (S.D.Fine) and anthracene (BDH) were used in present work. 0.0400 g of pyrogallol red ($\text{C}_{19}\text{H}_{12}\text{O}_8\text{S}$) was dissolved in 100.0 mL of doubly distilled water so that the

concentration of dye solution was 1.0×10^{-3} M. It was used as a stock solution. The optical density of this dye solution was recorded with the help of spectrophotometer (Systronics Model 106) at $\lambda_{\text{max}} = 580$ nm. A polychromatic radiation source (200 W tungsten lamp) has been used for radiation throughout the experiment. The intensity of light was measured by Suryamapi (CEL Model 201). An effort has been made to use colloidal anthracene as a semiconductor. As it remains in the form of suspension and, it created problem in the correct measurement of optical densities, therefore to avoid this problem, an attempt has been made to use colloidal anthracene as a semiconductor supported on polythene films. Circular polythene films were cleaned and coated with adhesive (insoluble in water) and then colloidal anthracene powder was spread evenly on the surface of the polythene films. After air-drying, the films were washed with water to release loosely bound particles of colloidal anthracene and dried at room temperature. Colloidal anthracene was prepared using glacial acetic acid in place of propionic acid⁴.



Pyrogallol Red

RESULTS AND DISCUSSION

Effect of pH

The effect of pH on photocatalytic bleaching was investigated (Fig.1) in the pH range 6.5 to 9.0. It was observed that the rate of photocatalytic bleaching of dye increases with increase in pH. This can be explained on the basis that on increasing pH, the concentration of OH^- ions will increase at higher pH values. OH^- ions will generate more OH radicals by reacting with cationic form of the dye and these hydroxyl radicals are considered responsible for this photocatalytic bleaching. As the pH of the solution was further increased, more OH^- ions become available and these will make the surface of the semiconductor negatively charged and as a consequence of repulsive force between two negatively charged species (OH^- ion and dye anion) the approach of pyrogallol red anion to the semiconductor surface will be restricted. This will result into a decrease in the rate of photocatalytic bleaching of pyrogallol red.

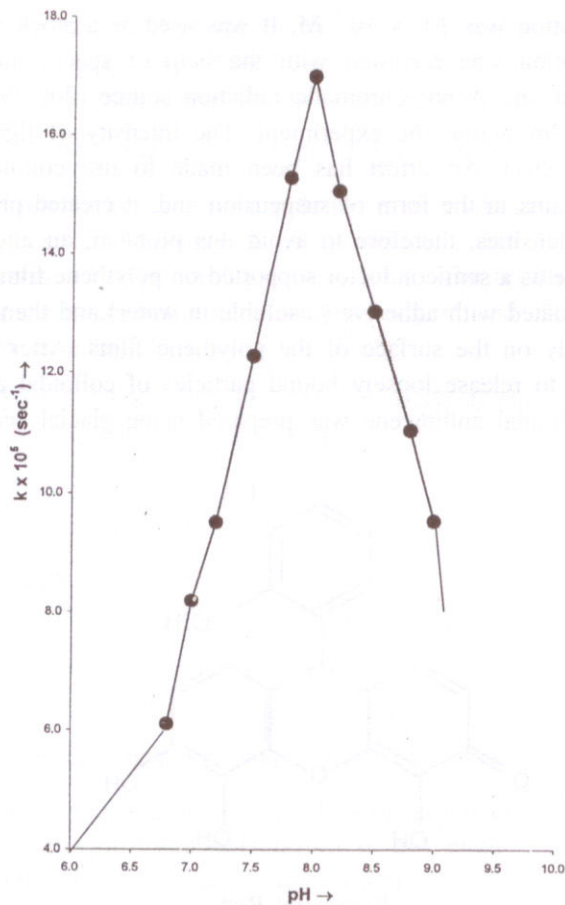


Fig. 1: EFFECT OF pH

Effect of pyrogallol red concentration

The effect of dye concentration on the rate of photocatalytic bleaching was investigated (Fig.2). It was observed that the rate of photocatalytic bleaching increases with an increase in the concentration of the dye. These changes can be explained on the basis that as the concentration of pyrogallol red was increased, more dye molecules were available for excitation and energy transfer and hence, an increase in the rate. After particular concentration of dye, the rate of photocatalytic bleaching was found to decrease with an increase in the concentration of the dye. This may be attributed to the fact that at the higher concentrations, dye will start acting as a filter for the incident light and it will not permit the desired light intensity to reach the semiconducting particles; thus, decreasing the rate of photocatalytic bleaching of dye.

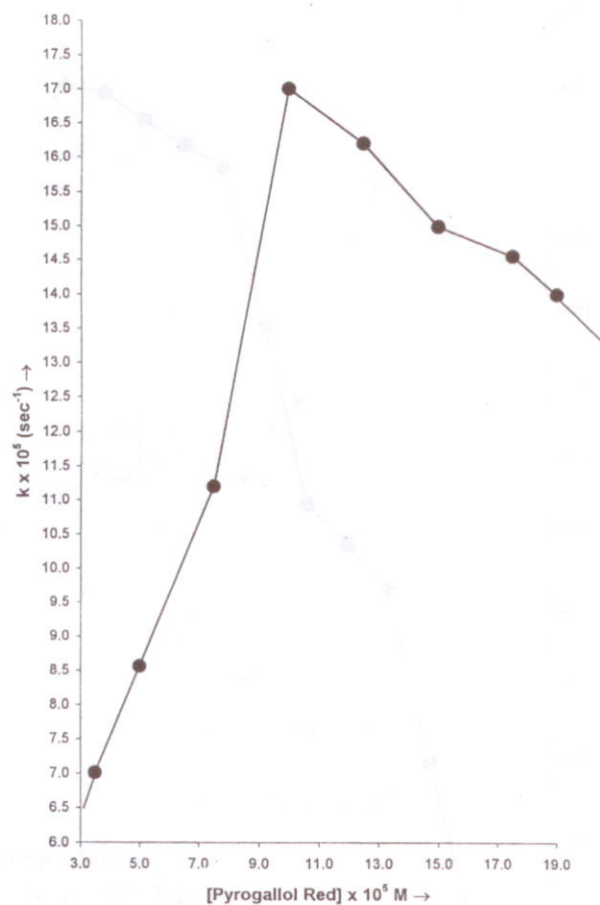


Fig. 2: EFFECT OF PYROGALLOL RED CONCENTRATION

Effect of amount of semiconductor

The effect of amount of semiconductor on the rate of photocatalytic reaction was also observed (Fig.3). It was found that an increase in the amount of semiconductor increases the rate of photocatalytic reaction up to a certain amount of semiconductor, which is like a saturation point. This can be attributed to the fact that with an increase in the amount of semiconductor, the surface area of the semiconductor will also increase and hence, a corresponding rise in the rate of reaction was observed. But after a certain limiting amount of semiconductor, if the amount of semiconductor was further increased, then it will not contribute to an increase in the surface area. On the contrary, it will increase only the thickness of the layer at the polythene film and thus a saturation point like behaviour was observed.

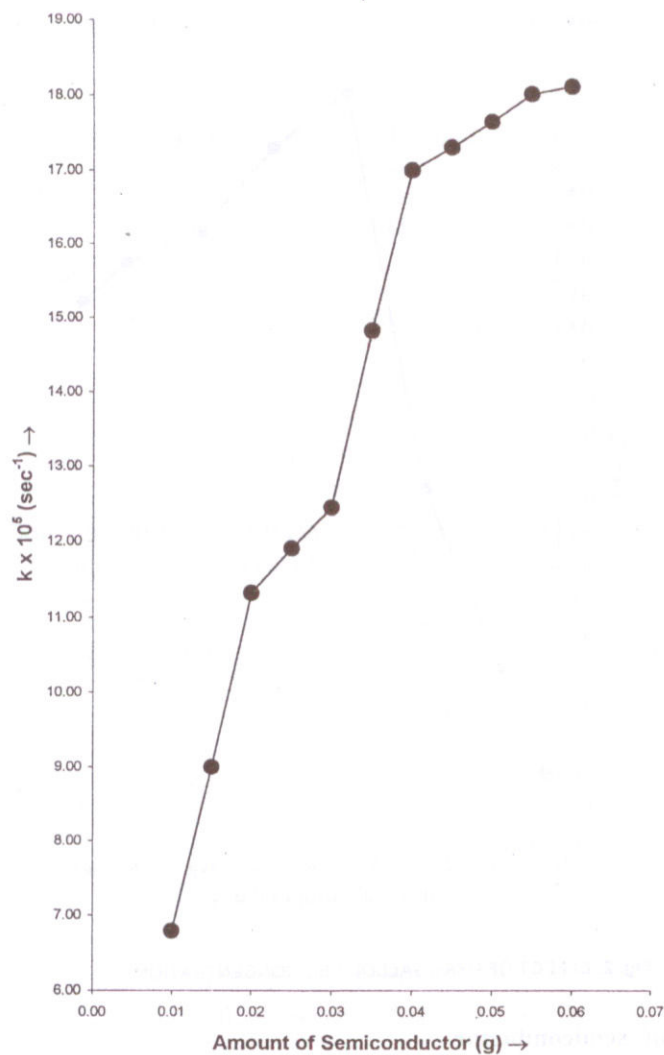


Fig. 3: EFFECT OF AMOUNT OF SEMICONDUCTOR

Effect of light intensity

Effect of variation of light intensity on the photocatalytic bleaching of dye was also investigated (Fig.4). It has been observed that increase in the light intensity increase the rate of reaction. It is because of the fact that increase in the light intensity will increase the number of photons striking per unit area of the semiconductor powder. A linear behaviour between light intensity and rate of reaction was observed.

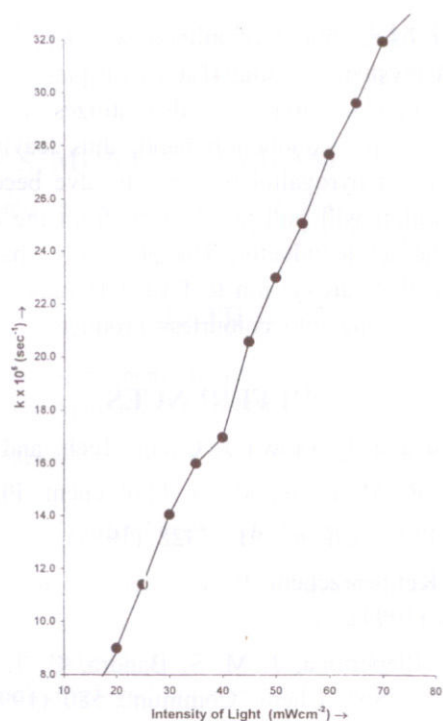
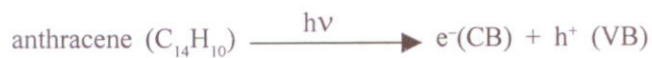
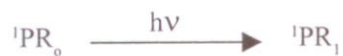


Fig. 4: EFFECT OF LIGHT INTENSITY

MECHANISM

On the basis of these observations, a tentative mechanism for photocatalytic degradation of pyrogallol red may be proposed as -



Pyrogallol red (PR) absorbs radiations of suitable wavelength and it is excited to its singlet state. Then it undergoes intersystem crossing (ISC) to triplet state of the dye^{7,8}. On the other hand, the semiconducting colloidal anthracene also utilizes the radiant energy to excite its electron from valence band to the conduction band, thus leaving behind a hole. This hole abstracts an electron from triplet pyrogallol red and the dye becomes positively charged. The dissolved oxygen of the solution will pull an electron from the conduction band of semiconductor; thus, regenerating the semiconductor. The positively charged molecules of pyrogallol red will immediately react with hydroxyl ion to form OH radicals and these OH[•] radicals will oxidize the pyrogallol red molecule into colourless products.

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