Study on Experimental Parameters Influence in Textile Wastewaters Treatment Using Degussa P25 Photocatalyst

Cristina Pastravanu[1,2], Igor Cretescu [2] , Eveline Popovici[1],

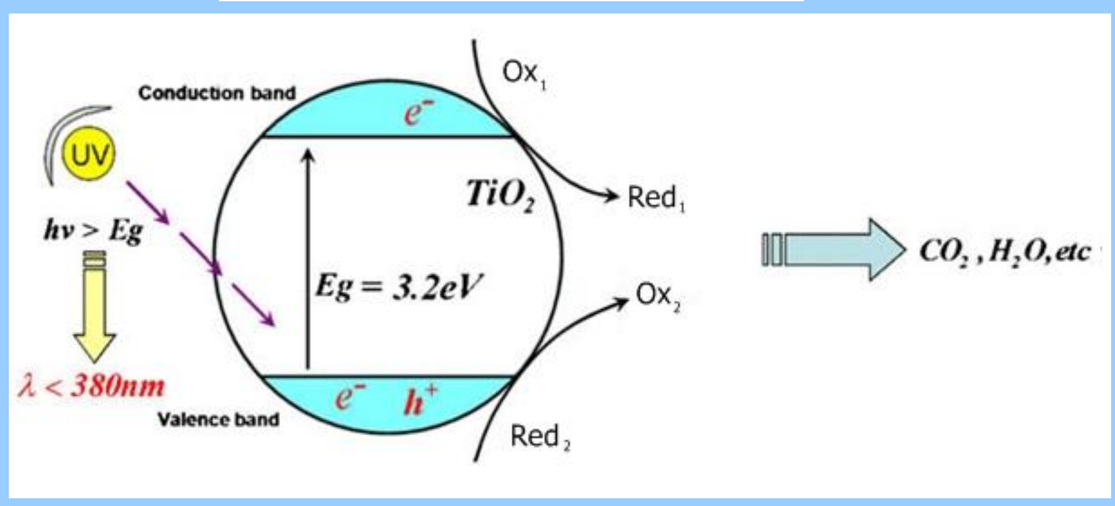
1. "Al. I. Cuza" University of Iasi
2. "Gh. Asachi" Technical University of Iasi

1. Introduction

Photocatalysis implies the acceleration of a photoinduced reaction by the presence of a catalyst. Photoinduced reactions are activated by absorption of a photon with sufficient energy, i.e., equal or higher than the band-gap energy (*Ebg*) of the catalyst. The absorption leads to a charge separation due to the promotion of an electron (e−) from the valence band of the semiconductor catalyst to the conduction band thus generating a hole (h+) in the valence band.

In order to have a photocatalyzed reaction, the e− –h+ recombination, subsequent to the initial charge separation, must be prevented as much as possible. Desired is the reaction of the activated electron with an oxidant (Ox1), yielding a reduced product (Red1), and the reaction of the generated hole with a reductant (Red2) to produce an oxidized product (Ox2), as indicated in the following equation:

$$Ox_1 + Red_2 \xrightarrow[light \geq E_{bg}]{semiconductor} Red_1 + Ox_2$$



The most widely used semiconductor catalyst in photoinduced processes is titanium dioxide (TiO_2), because it is chemically and biologically inert, photocatalytically stable, relatively easy to produce and to use, able to efficiently catalyse reactions, cheap and without risks to environment or humans.

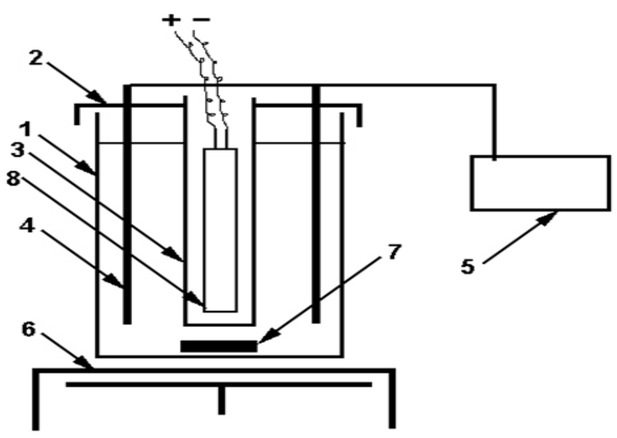
2. Experimental part

During this study the effect of different photocatalytic systems on the oxidation of Rose Bengal from the aqua solutions was investigated.

In order to study the decolorisation of Rose Bengal during the photocatalytic processes different solutions of different concentrations were prepared. One solution of 400 ppm was correspondingly diluted to obtain the needed concentrations.

The oxidation process was monitored using a spectrophotometrical method for measuring the decolorization rate. For this type of investigation, the equipment used was a Shimadzu UV – 1700 Pharma – Spec, UV – Visible spectrophotometer.

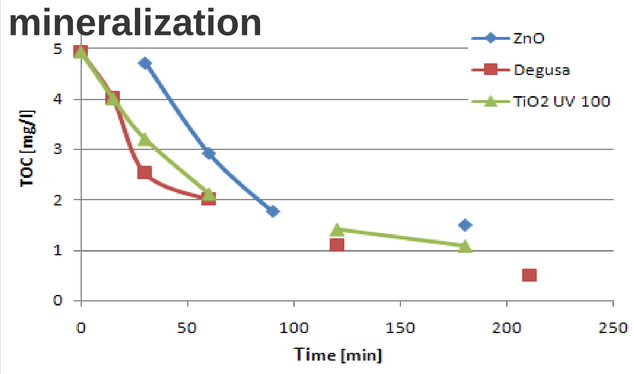
In order to point out the mineralization of the organic dye during the oxidation process, the TOC method was applied using the Shimadzu TOC Analyser.



1 – photochemical reactor
2 – pierced cap
3 – quartz glass tube
4 – plastic tubes
5 – compressor
6 – magnetic range
7 – magnetic agitator
8 – UV lamp
Black cover

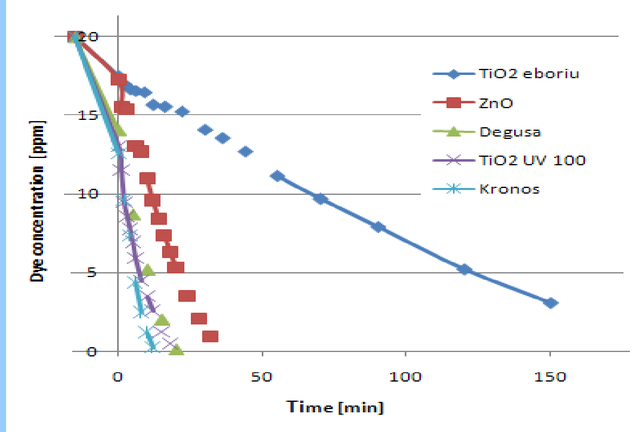
3. Results and discussions

A. Dye mineralization



The mineralization process (measured by TOC) was realized for the same values of the experimental factors and the reaction time corresponded to 210 min for Degussa (TOC reduction rate = 90%), 180 min for TiO_2 UV 100 (TOC reduction rate = 78%), 180 min for ZnO (TOC reduction rate = 68%).

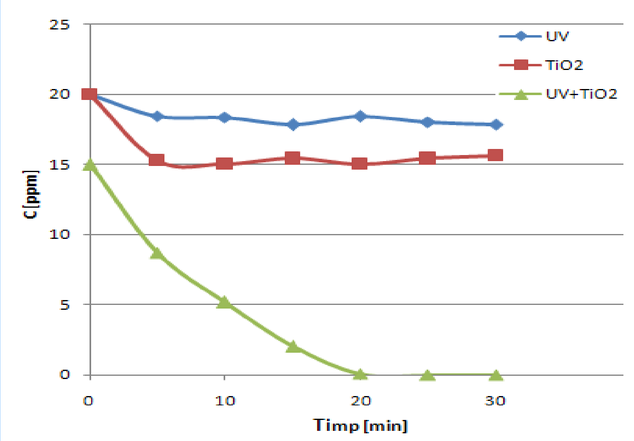
B. Catalyst type influence



Keeping the optimal experimental factors constant (pH = 5.6, Ccat = 0.25 g/L, C0 dye = 20 ppm), the following results concerning the decolorization rate were obtained:

Kronos > TiO_2 UV 100 > Degusa P25 > ZnO > TiO_2 Eborium

C. Initial TiO_2 measurements

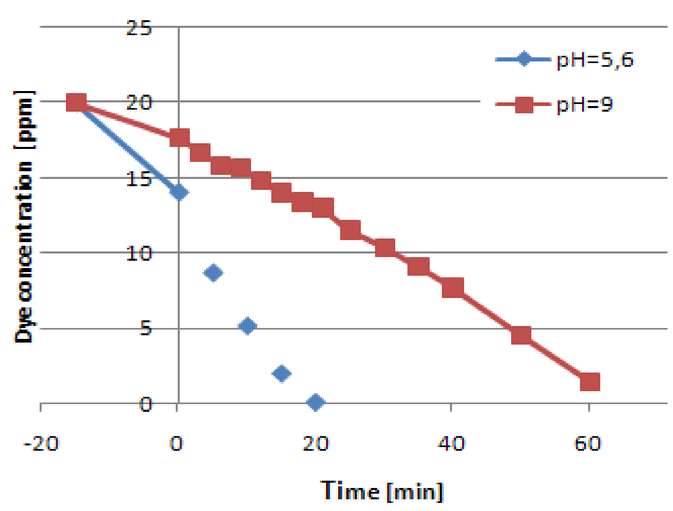


Even if TiO_2 alone reduces the dye concentration (due to adsorption), the combined photocatalytic system is more efficient.

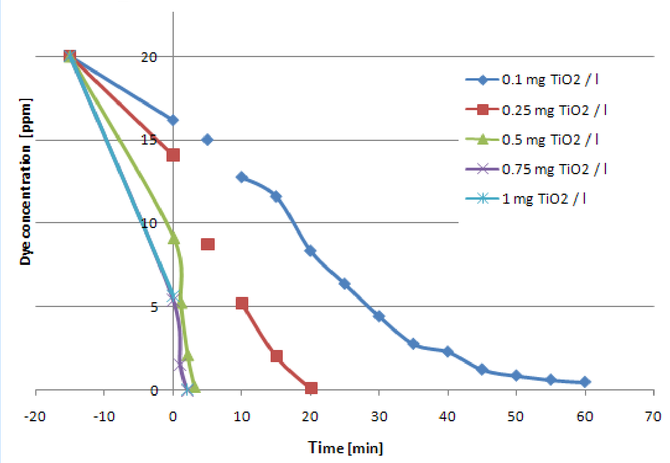
D. pH influence

In order to study the solution's pH influence on Rose Bengal decolorisation, 2 experiments were conducted using the same catalyst concentration (0.25 g/L), the same dye concentration (20ppm) and two different pH values.

It was noticed that the decolorisation was faster when the pH value was 5.6. This is because 5.6 is the natural pH value for the prepared solutions.



E. TiO_2 concentration influence



During the experiments, the pH value was kept constant at 5.6 and the concentration of the dye solutions was 20ppm.

It was concluded that increasing the photocatalyst concentration over 0.5 mg/L conducted to no improvement of the decolorisation. But there can be noticed a great difference for lower TiO_2 concentrations.

4. Conclusions

The influence of different experimental factors (pH, catalyst concentration, catalyst type, dye concentration) on the process of photocatalytical degradation and decolorization of the dye Rose Bengal was studied.

The first tests concerning the decolorization were conducted using the catalyst Degussa P25 when the optimal values of the experimental factors were obtained: pH = 5.6, Ccat = 0.25 g TiO_2 / l, $C_{0\ dye}$ = 20 ppm, which correspond to a reaction time of aproximately 20 min.

The mineralization (measured by TOC) was realised for the same values of the experimental factors, which correspond to 210 min for Degussa (TOC reduction rate = 90%), 180 min for TiO_2 UV 100 (TOC reduction rate = 78%), 180 min for ZnO (TOC reduction rate = 68%)

5. References

1. C. Betianu, F. Caliman, M. Gavrilescu, I. Cretescu, C. Cojocaru, I. Poulios, Response surface methodology applied for Orange II photocatalytic degradation in TiO_2 aqueous suspensions. J. of Chemical Technology & Biotechnology, Vol 83, No 11, Oct 2008 , pp. 1454-1465(12)

2. M.S. Secula, G.D. Suditu, I. Poulios, C. Cojocaru, I. Cretescu, Response surface optimization of the photocatalytic decolorization of a simulated dyestuff effluent. Chemical Engineering Journal 141 (2008) 18–26

3. A. Mills, S. Le Hunte, An overview of semiconductor photocatalysis, J. Photochem. Photobiol. A: Chem. 108 (1997) 1–35.

4. O. Carp, C.L. Huisman, A. Reller, Photoinduced reactivity of titanium oxide, Progr. Solid State Chem. 32 (2004) 33–177.

5. H. de Lasa, B. Serrano, M. Salaices, Photocatalytic Reaction Engineering, Springer, New York, 2005.

6. A. Stankiewicz, Energy matters, alternative sources and forms of energy for intensification of chemical and biochemical processes, Trans IChemE: A Chem. Eng. Res. Des. 84 (2006) 511–521.

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