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Exploring the photocatalytic behavior of TiO_2:Mn films under UVA illumination compared to TiO_2 Degussa P25

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***Abstract*— In this work we investigate the photocatalytic behaviour TiO_2:Mn thick films, as in Optisol™ , in comparison with Degussa P25 for the photodegradation of Basic Blue-41, which is an azo dye. The films were calcinated at 500°C providing a nanostructured substrate, with a high active surface area. The system was tested using a round-shaped Pyrex glass photoreactor illuminated by a 400W UVA lamp. The results show that the TiO_2:Mn based films have almost no effect on the Basic Blue-41 dye after exposure for 2.5h, while the concentration of the dye was reduced by over 50% when using the Degussa P25 substrate. This demonstrated very convincingly that the TiO_2:Mn material is much less photoactive than the TiO_2 Degussa P25 paste.**

Keywords—titania; manganese; photocatalysis; Degussa P25

I. INTRODUCTION

Degradation of various organic pollutants by photocatalysis, using wide band gap semiconductors under UV or solar light, has been extensively studied [1-3]. Among them, TiO_2 is an inexpensive semiconductor, which exhibits high photocatalytic activity, is non-toxic and has good stability in aqueous solutions with applicability in environmental remediation, such as the degradation of azo dyes [4]. Azo dyes are a large class of synthetic organic dyes that contain nitrogen as the azo group -N=N- as part of their molecular structure [5]. In particular, the use of Degussa P25 has been routinely immobilized as a thick film paste in order to remove organic dyes from water samples successfully under UV illumination. This work, shall compare the degradation of Basic Blue-41 (BB-41), an organic azo dye (*Fig.1*), using both Degussa P25 and TiO_2:Mn as in Optisol™ thick films, in order to gauge the ambient nature of TiO_2:Mn.

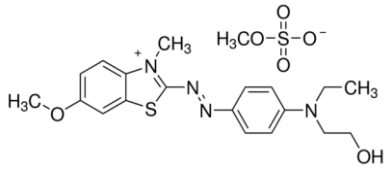

Fig. 1 Molecular structure of BB-41 [6]

II. EXPERIMENTAL

A. Materials

Unless otherwise indicated, reagents were obtained from Sigma-Aldrich and were used as received. commercial nanocrystalline titania Degussa P25 and TiO_2:Mn as in Optisol™ were used in all reactor constructions and millipore water was used in all experiments.

B. Description of the reactor

The reactor was a made of pyrex glass filled with 100ml of 2x10^-5M of the BB-41 azo dye and then exposed to a 400W UVA lamp, 30cm away. The photocatalyst, ie. Degussa P25 and TiO_2:Mn, was immobilized each time on a microscope glass as thick films. The measurements were obtained by initially allowing the samples to absorb BB-41 in the dark for 30 minutes taking the first measurement of the absorption spectrum at t=0. Then the sample in solution was illuminated and subsequent measurements were taken in 30 minute intervals for 150 mins. The same measurements were repeated both for the TiO_2-Degussa P25 and the TiO_2:Mn, Optisol™ thick films.

C. Deposition of the photocatalyst as a film

The TiO_2-Degussa P25 paste was deposited on microscope glass using doctor blading upon a compact sol-gel anatase layer to facilitate better attachment to the substrate. The sol-gel was prepared using 3.5 g of the non-ionic surfactant Triton X-100 mixed with 19 mL ethanol. Then 3.4 mL glacial acetic acid and 1.8 mL of Titanium Tetraisopropoxide were added under vigorous stirring. The film was deposited by dip coating and left to dry in air for a few minutes. Finally, it was calcined at 500°C for about 10 min. The above procedure was repeated once more to obtain a final compact film. On the top of this, commercial TiO_2-Degussa P25 was deposited to provide an open structure for better BB-41 dye adsorption, by dispersion of nanocrystalline Degussa P25 in aqueous carbowax solution [7]. Two such layers were applied on the microscope glass and then calcined at 500°C in order to create an open structure to encourage dye

adsorption. A similar open structure was prepared using Optisol™.

III. RESULTS AND DISCUSSION

From the Cary 1E Varian UV-Vis the following graphs were obtained revealing the changes in the absorption spectrum of the BB-41 dye (*Fig. 2*) for the Degussa P-25 based sample and for Optisol™.

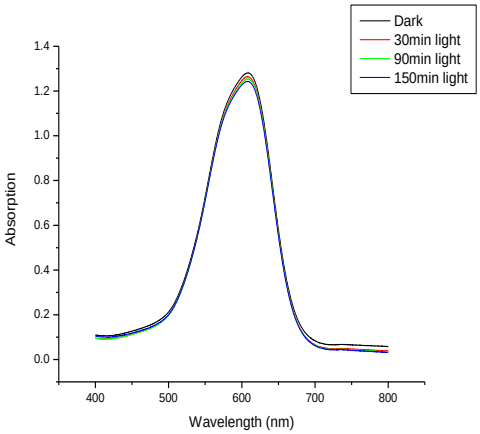

Fig.2.a Changes in the absorption spectrum of the Basic Blue 41 Dye using the TiO_2:Mn paste on microscope glass after illumination

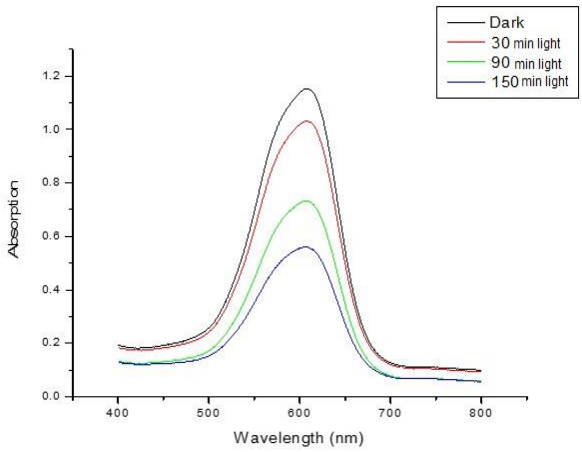

Fig. 2b Changes in the absorption spectrum of the Basic Blue 41 Dye using the TiO_2-Degussa P25 paste on microscope glass after illumination

Below the drop in concentration of the Basic Blue 41 Dye is plotted after UVA illumination using the TiO_2:Mn and TiO_2-Degussa P25 pastes on microscope glasses in comparison (*Fig. 3*). This demonstrated very convincingly that the TiO_2:Mn material is much less photoactive than the TiO_2-Degussa P25 paste.

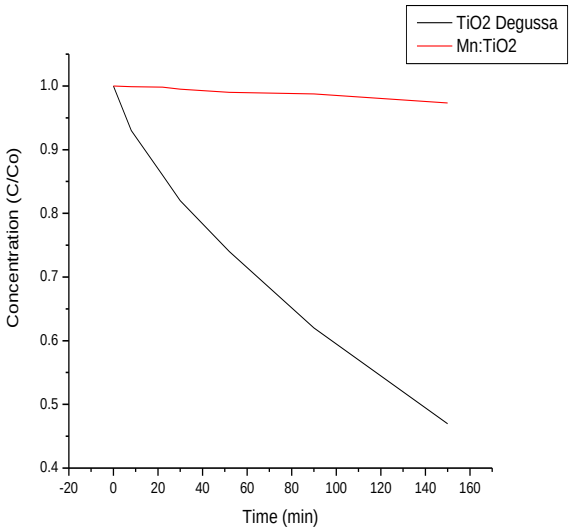

Fig. 3. Drop in concentration of the Basic Blue 41 Dye after illumination on using TiO_2:Mn and TiO_2-Degussa P25

IV. CONCLUSIONS

In this work, the ambient nature of TiO_2:Mn in comparison to Degussa P25 is confirmed. In particular, the study of the photodegradation of the azo dye BB-41 was tested using a round-shaped Pyrex glass photoreactor illuminated by a 400W UVA lamp. The results show that while the Degussa P25 substrate leads to over 50% reduction in the concentration of the BB-41 dye, the TiO_2:Mn based films have almost no effect on it, even after exposure for 2.5h. This demonstrated very convincingly that the TiO_2:Mn material is much less photoactive than the TiO_2 Degussa P25 paste.

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