PHOTOADSORPTION OF DISSOLVED OXYGEN IN TITANIUM (IV) OXIDE SUSPENSIONS

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In recent years, extensive studies have been conducted on photocatalysis because of its applicability to treatments of pollutants and to chemical conversion of solar energy.[1] Since many harmful chemicals are decomposed by photocatalytic oxidation, it is important to understand the role of O_2 in the oxidation reaction. But the influences of O_2 are not fully understood. Few studies have been carried out on O_2 photoadsorption in a TiO_2 suspension.[2-3] Munuera et al. reported that the O_2 photoadsorption occurs in TiO_2 (P25) suspensions at pH 2 and pH 14.[2] On the contrary, Borgarello et al. reported that the O_2 photoadsorption do not occur in TiO_2 (P25 and other two powders) suspensions.[3] To explain the discrepancy between the results of the two groups and to understand the mechanism of O_2 photoadsorption in TiO_2 suspension, we have measured the concentration of dissolved O_2 (DO) in different TiO_2 suspensions with and without UV irradiation.

The TiO_2 powders used were P25 (Nippon Aerosil), AMT600 (Tayca), and ST01 (Ishihara Sangyou). They were used as received. To confirm whether the effect of organic compounds adsorbed on the TiO_2 powder on the O_2 photoadsorption is negligible, the TiO_2 powders were exceptionally heated at 673 K for 2 hours in air with a furnace before the DO measurement. Water used was purified to a resistivity of > 18 MΩcm by filtration through a Milli-Q reagent water system. The TiO_2 suspensions used were aqueous suspensions containing 1.0 g/l of the TiO_2 powders. Each 100 ml of the TiO_2 suspensions was stirred in a flask during the DO measurement. The concentrations of DO in the TiO_2 suspensions were measured with a DO meter at room temperature. The neck of the flask was closed with the electrode of the DO meter and there was no gas space in the flask, so that the amount of O_2 in the TiO_2 suspension is regarded as constant throughout the DO measurement. In the DO measurement the TiO_2 suspensions were irradiated with black lights. The irradiation intensity was 2.2 mW/cm^2 at the position of the flask.

Figure 1 shows the effect of UV irradiation on DO concentration in the P25 suspension. The UV irradiation was done 3 times for 5 minutes at 5 minutes intervals and was done for a few minutes. Then the DO concentration reached 0 mg/l and was unchanged even for 1 hour after the UV irradiation. The DO concentration decreased during the UV irradiation, while that was unchanged during the interval and after the UV irradiation. Similar results were obtained for the AMT600 and ST01 suspensions. These results suggest that DO concentration in a solution can be controlled from 0 to 7 mg/l using a TiO_2 photocatalyst and a UV light.

The decrease in the DO concentration by the UV irradiation could be caused by the consumption of DO in an oxidation of organic compounds adsorbed on the TiO_2 powder. Nevertheless, this explanation for the DO decrease is denied by considering the results that under the UV irradiation the concentrations of DO in the suspensions of the previously heated P25 and AMT600 decreased similar to those in the suspensions of P25 and AMT600 as received. Consequently, the decrease in the DO concentration by the UV irradiation is most likely caused by the DO photoadsorption on the TiO_2 powder.

The amount of photoadsorbed DO on the surface of TiO_2 powder in its suspension is thought to depend on the specific surface area of the powder. The BET surface area of ST01 is approximately 6 times of those of P25 and AMT600 (Table I). Thus, the amount of photoadsorbed DO in the ST01 suspension is expected to be much larger than those in the P25 and AMT600 suspensions. In contrast, the decrease in the DO concentration under the UV irradiation in the ST01 suspension was smaller than those in the P25 and AMT600 suspensions. This result suggests that another factor except specific surface area strongly influences the DO photoadsorption. By considering the fact that the particle size of ST01 is much smaller than those of P25 and AMT600, it seems that the low efficiency of charge separation of photogenerated electron-hole pair in ST01 particle reduces the amount of electron on the particle surface under UV irradiation and results in the decrease in the amount of photadsorbed DO. This explanation is consistent with the reported results that DO in the suspensions of Pt loaded TiO_2 powders, which have higher efficiencies of the charge separation than unloaded TiO_2 powders, is photoadsorbed while that of unloaded TiO_2 powders is not photoadsorbed.[3]

For the detail discussion, we are going to examine the photoadsorption of DO on Pt loaded ST01 in the suspension and show the results in the presentation.

References

1. A. Fujishima et al., *J. Photochem. Photobiol. C,* **1**, 1 (2000).
2. G. Munuera et al., *Studies in Surf. Sci. Catal.*, **19**, 335 (1984).
3. E. Borgarello et al., *Inorg. Chim. Acta,* **91** 295 (1984).

Table I. The BET surface areas of the TiO_2 powders and the pH of their suspensions.

TiO_2 powder	BET surface area (m^2/g)	pH of the suspension
P25	48	5.3
AMT600	56	5.2
ST01	319	6.3

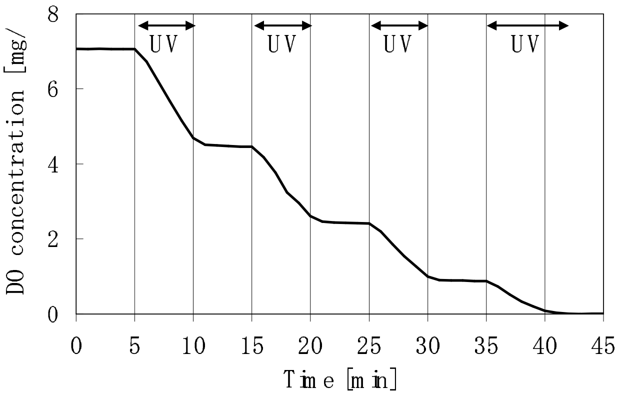

Figure 1. Typical time-course of dissolved oxygen (DO) concentration in the TiO_2 (P25) suspension with and without the UV irradiation.