Effects of Ultrasonication on Photocatalytic Reactions in Aqueous and Ionic Liquid Media

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INTRODUCTION

Particularly in heterogeneous processes in solid-liquid interfaces, high intensity shock waves generated by ultrasonic irradiation cause promotion of mass transport and/or activation of solid surface. From this point of view, irradiation of ultrasounds into a photocatalytic reaction system might enhance not only the mass transport but also the catalytic activity. In the present work, at first, we aimed to examine systematically ultrasonic effects on a photocatalytic reaction using the well-known oxidation of 2-propanol to acetone in aqueous suspension of TiO_2 powders [1].

Ionic liquids are room temperature molten salts and have many interesting properties as reaction media such as high ionic conductivity, thermal stability, non-flammability and non-volatility [2) 3)]. From this aspect, at the next stage of our investigation, we focused on ionic liquids as new media for the photocatalytic degradation of 2-chlorophenol under ultrasonication.

EXPERIMENTAL

A Pyrex glass cell equipped with an optical window, an ultrasonic stepped horn (Titanium alloy rod, 6 mm diameter, 20 kHz), a rotating magnetic stirrer, and a thermocouple was used for photocatalytic oxidation of 2-propanol (0.1 M) in aqueous suspension containing TiO_2 powder (Wako Pure Chem., anatase type; average size, 5 μm) and photo-catalytic degradation of 2-chlorophenol (0.1 mM) in 1-ethyl-3-methylimidazolium trifluoro-methanesulfonate containing TiO_2 powder (Degussa, P25) (See Fig. 1). The solutions magnetically stirred (1100 RPM) under Ar were irradiated at > 230 nm using an Hg-Xe lamp (500 mW cm^{-2} at 365 nm) under sonication. The reaction products were analyzed by GC and HPLC.

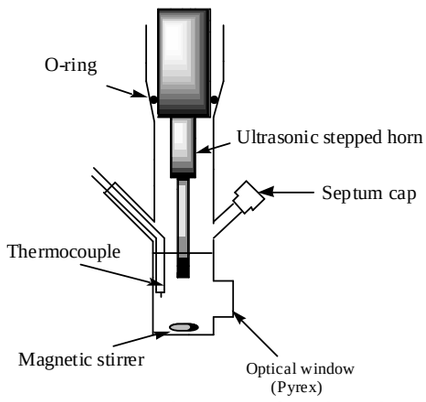

Figure 1 Experimental set-up for the photocatalytic reactions.

RESULT AND DISCUSSION

1.Photocatalytic Oxidation of 2-Propanol

In order to examine an ultrasonic irradiation effect on the formation rate of acetone, the photocatalytic reaction of 2-propanol was carried out using three different reaction modes such as under sonication with light, under nonsonication with light, under sonication without light. As shown in Fig. 2, the formation rate under sonication is higher than that under nonsonication. On the other hand, acetone was scarcely formed when the reaction was carried out under sonication without light. From these results, it was clarified that the photocatalytic oxidation was enhanced by ultrasound.

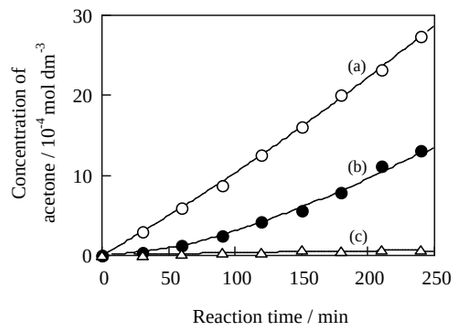

Figure 2 Concentration of acetone formed in the time cause of the oxidation of 2-propanol (a) under sonication and photo-irradiation, (b) under photo-irradiation and nonsonication, and (c) under sonication in the dark.

2.Photocatalytic Degradation of 2-Chlorophenol in Ionic Liquid

Fig. 3 shows the photocatalytic degradation rate of 2-chlorophenol in 1-ethyl-3-methylim-idazolium trifuoro-methnesulfonate under sonication and under nonsoni-cation. The degradation rate under sonication is higher than that under nonsonication. Moreover, it was also found that the rate was increased with an increase in the ultrasonic power. This result suggests that the application of ultrasound is effective means for enhancement of the photocatalytic degradation rate in a high viscosity medium such as the ionic liquid.

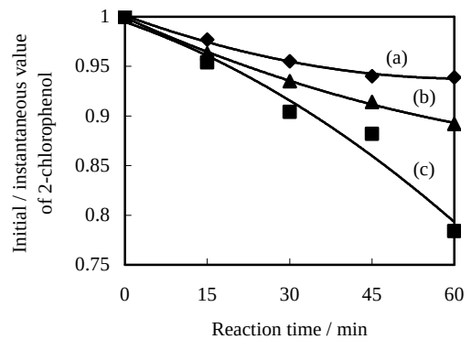

Figure 3 A ratio of initial / instantaneous value of 2-chlorophenol as a function of time. The reactions curried out (a) under nonsonication, (b) under sonication (power: 0.17 V_{p-p}) and (c) under sonication (power: 0.35 V_{p-p}).

REFERENCES

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