

XAFS study on TiO₂ photocatalyst prepared on zeolite synthesized from steel slag

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Introduction

The combination of zeolite and nano-sized TiO₂ has been attractive for its adsorption and photocatalytic degradation of organic pollutant diluted in liquid or gaseous phases [1].

In the present study, Y-zeolite was synthesized utilizing the pretreated steel slag and applied as the support of TiO₂ photocatalyst. The local structure of titanium oxide species was investigated by X-ray absorption fine structure (XAFS) and other spectroscopy techniques. The influences of zeolite composition and the crystallization of TiO₂ against photocatalytic activity for degradation of organic pollutants in liquid phases were investigated.

Experimental

The HCl treated powdered slag sample was heated with NaOH tablets and proper amount of NaAlO₂ to gain SlagY-zeolites with desired SiO₂/Al₂O₃ ratio (2.5, 5, and 10) at 623 K, followed by adding deionized water to fuse, aging for 24 h. The hydrothermal treatment was carried out at 373 K for 6 h to prepare Y-zeolite. The Na⁺ ions contained in the prepared Slag Y-zeolites were exchanged with NH₄⁺ by stirring in aqueous NH₄OH solution, followed by calcination at 773 K for 5 h. The preparation of TiO₂ on Y-zeolite samples were carried out by an impregnation method.

Results and discussions

In the preparation processes of Y-zeolite from steel slag materials, acid treatment is essential. After hydrothermal treatment for 6 h, well-crystallized Na type Y-zeolite could be obtained as confirmed by XRD.

Fig. 1 shows the results of Ti K-edge XAFS analysis of TiO₂ loaded on zeolite supports. One sharp pre-edge peak at around 4970 eV observed in the XANES spectrum is derived from the existence of isolated titanium oxide species surrounded by four oxygen atoms in the zeolite framework. And the peak at around 2.5 Å in the FT-EXAFS spectrum is derived from the existence of Ti-O-Ti bond which is due to the formation of titanium oxide crystal [2]. The former pre-edge peaks were observed in all TiO₂ loaded on Y-zeolite and the latter Ti-O-Ti peaks were not detected, suggesting that the uniform structure of Y-zeolite might restrict crystallization of titanium oxide.

TiO₂ loaded on the Y-zeolite with SiO₂/Al₂O₃=40, which exhibited higher hydrophobicity compared to other samples, showed the highest photocatalytic activity for

the decomposition of 2-propanol diluted in water. It is considered that high hydrophobic surface property of Y-zeolite derived from the SiO₂/Al₂O₃ ratio of the zeolite framework components can allow a smooth adsorption of pollutants into zeolite pores to achieve efficient photocatalytic degradation.

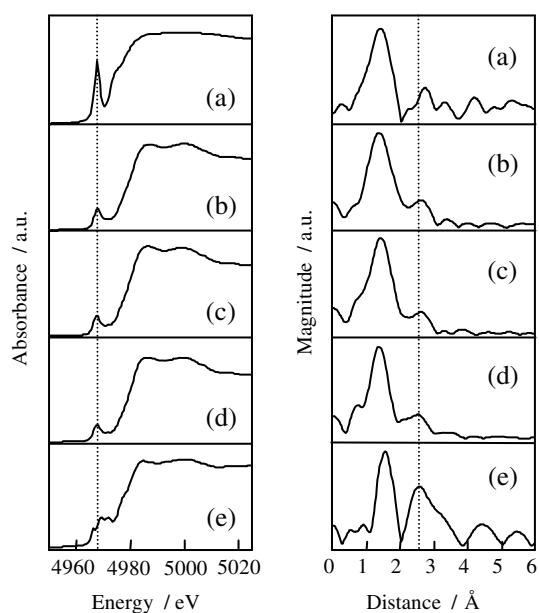


Figure 1. Ti K-edge XANES and FT-EXAFS spectra of (a) Ti(O⁻Pr)₄, (b) TiO₂-SlagY, (c) TiO₂-Y(5), (d) TiO₂-Y(40), (e) TiO₂ (Anatase)

Conclusions

The formation of titanium oxide species incorporated in zeolite porous structure was investigated by XAFS analyses, which suggests that all TiO₂-loaded zeolites contains isolated and tetrahedrally-coordinated titanium oxide species in the framework and the zeolite porous structure might restrict the crystallization of TiO₂ particles. Photocatalytic degradation of organic pollutants depends on the zeolite chemical composition and the structure of titanium oxide species.

References

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