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XAFS Study of Nano-sized Pt Metal Catalyst Prepared by the Photo-Assisted Deposition Method Using Ti-Containing Mesoporous Silica Thin Film Photocatalyst

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Introduction

Platinum is one of the most efficient catalyst metals in an industrial area [1]. Particularly, nano-sized Pt particles have attracted a wide range of scientific and practical interests because of their unique properties [2].

In this study, nano-sized Pt metals can be highly deposited on the photo-excited Ti-containing mesoporous silica (TMS) thin films using a photo-assisted deposition (PAD) method [3,4]. The structure of Ti species in TMS thin films and nano-sized Pt metals were observed by XAFS analysis. The benefits of combination of the PAD method and the TMS thin films as support to prepare the active nano-sized Pt metal catalysts were demonstrated. XAFS measurement is one of the effective methods to clarify the local structure at an atomic level.

Experimental

The TMS thin film was prepared by the spin-coating sol-gel method. The mixture of precursor was dripped onto a quartz substrate and spin-coated. The obtained thin film was calcined in air to remove the template.

The Pt loaded on TMS (Pt/TMS) thin films were prepared by the PAD method with H_2PtCl_6 solution. The scheme of this method is shown in Fig. 1.

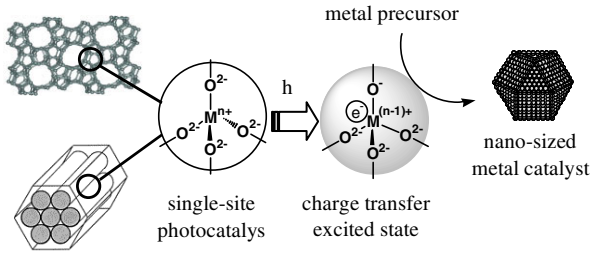

Fig. 1. The scheme of the PAD method.

Results and Discussion

The prepared TMS thin films and Pt/TMS thin films were transparent and well-fixed on the substrate of quartz plate. XRD patterns indicate the presence of hexagonal mesoporous structure in the prepared TMS thin films.

Ti K-edge XANES spectra of prepared TMS thin films exhibit an intense single preedge peak, which are different from that of bulk TiO_2 showing several preedge peaks. FT-EXAFS spectra showed only one strong peak at around 1.6 Å due to the Ti-O bond for all TMS samples. This observation suggests that the titanium oxide moieties in TMS thin films exist in a highly dispersed tetrahedral coordination geometry.

Pt L_{III}-edge XANES spectra (Fig. 2) show that the Pt nano particles exist as Pt metal, not platinum oxide.

TMS and Pt/TMS thin films show photo-induced super-hydrophilic property. Interestingly, the water contact angles on TMS and Pt/TMS thin films are much smaller than on mesoporous silica thin film even before UV-light irradiation.

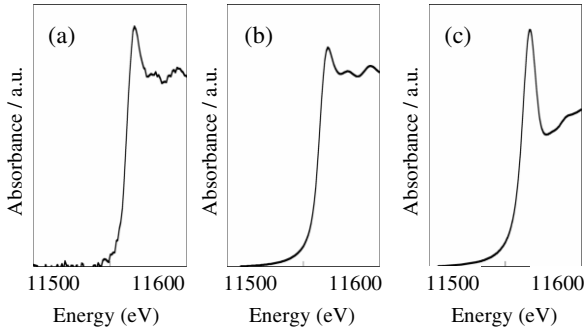

Fig. 2. Pt L_{III}-edge XANES spectra of (a) Pt / TMS thin films, (b) Pt metal, and (c) PtO_2.

Conclusion

The synthesis of the TMS thin films was carried out by using the spin-coating sol-gel method. Using the PAD method, nano-size Pt metal can be highly deposited on TMS thin films under UV-light irradiation. These thin films are colorless transparent and well-fixed on the substrate of quartz plate. The Ti-oxide in the TMS thin films species were present as tetrahedrally-coordinated titanium oxide moieties. Nano-sized Pt metals were highly deposited on the photo-excited tetra-Ti-oxide moieties of TMS.

References

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