Photo-Assisted Deposition of Nano-Sized Pt Metal on Ti-Containing Mesoporous Silica Thin Film Photocatalyst

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INTRODUCTION

Along with the photocatalysis of powdered TiO_2 nano-particle photocatalysts [1], another interesting and useful phenomenon has been observed and developed, i.e. the photo-induced super-hydrophilicity of TiO_2 thin films. Although the super-hydrophilicity of TiO_2 thin film has already been observed under the UV-light irradiation, the photo-induced surface properties of Ti-containing mesoporous silica films are also of special interest. The design of Ti-containing mesoporous silica embedded onto the transparent quartz plate is desired strongly for utilization as the efficient photocatalyst and unique photo-functional materials [2].

In this study, Ti-containing mesoporous silica thin films have been prepared on quartz plate by the spin-coating sol-gel method and have been investigated on their hydrophilic property. Furthermore, Ti-containing mesoporous silica thin films having nano-sized Pt metal catalysts for various catalytic reactions have been synthesized by the photo-assisted deposition method.

RESULTS AND DISCUSSION

Fig. 1 shows the X-ray diffraction patterns of the as-coated mesoporous silica (MS) and Ti-containing mesoporous silica (TMS) thin films prepared at various Ti/Si ratios. The TMS films with Ti/Si ratio of 0.01, 0.02, and 0.05, exhibit a diffraction peak at around

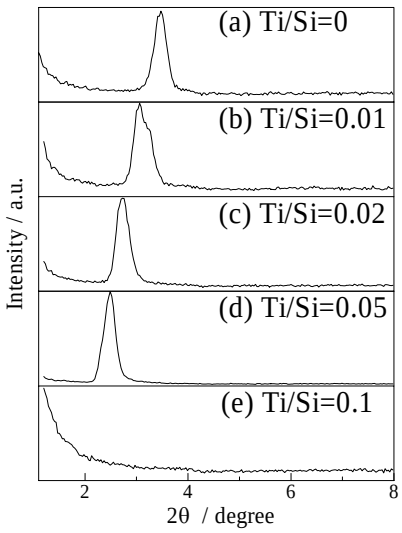
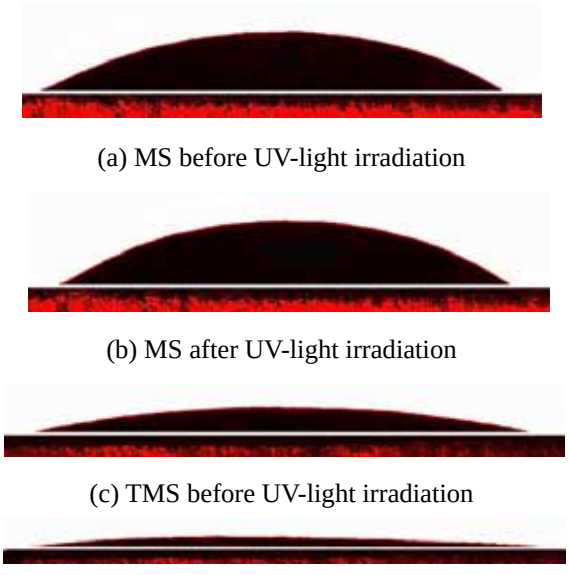


Fig.1 XRD patterns of the (a) MS and TMS. Ti/Si ratio was (b) 0.01, (c) 0.02, (d) 0.05, (e) 0.1.



(a) MS before UV-light irradiation

(b) MS after UV-light irradiation

(c) TMS before UV-light irradiation

(d) TMS after UV-light irradiation

Fig. 2. The images of water droplets observed before and after UV-light irradiation on the MS and TMS (Ti/Si=0.01).

2-3 degree indicating the presence of hexagonal mesoporous structure. The pore size of TMS changes depending on the Ti/Si ratios.

From the spectroscopic characterization (UV-vis and XAFS), it has been revealed that the Ti-containing mesoporous silica thin films involve isolated and tetrahedrally-coordinated titanium oxide moieties in the frameworks.

Fig. 2 shows the images of water droplets on the MS and TMS thin films deposited on quartz plate. The water contact angles on TMS were much smaller than on MS even before UV-light irradiation. After UV-light irradiation, the water contact angle on TMS becomes very small, while the water contact angle on MS does not make any changes. These observations indicate that TMS can perform the super-hydrophilic properties under UV-light irradiation.

Fig. 3 shows the XANES spectra at the Pt L_{III}-edge of Pt species photo-deposited on TMS, together with Pt foil and PtO_2 as references. The spectrum of Pt species photo-deposited on TMS was similar to that of Pt metal, but differed from PtO_2, indicating the formation of nano-sized Pt metal on TMS.

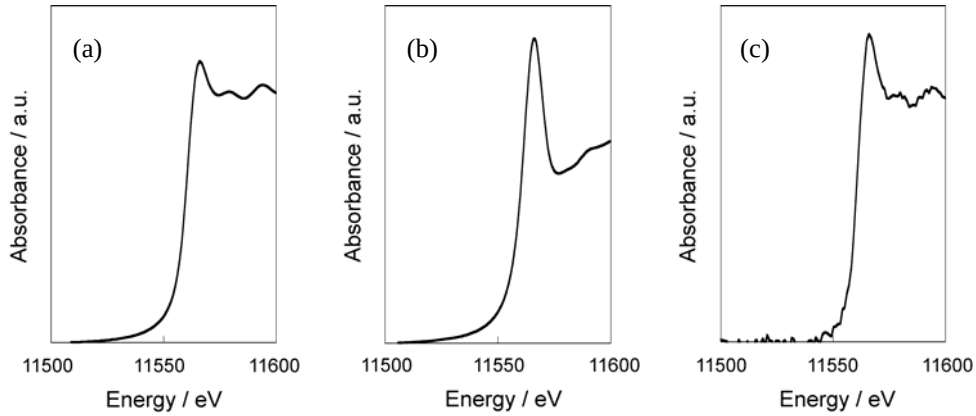


Fig. 3. XANES spectra at the Pt L_{III}-edge of the (a) Pt foil, (b) PtO_2 and (c) nano-sized Pt metal photo-deposited on TMS.

CONCLUSIONS

These Ti-containing mesoporous silica thin films are colorless transparent and have hexagonal mesostructures. Compared with the mesoporous silica thin films, these Ti-containing mesoporous silica thin films have demonstrated a strong hydrophilic surface property even before UV-light irradiation. After UV-light irradiation on the Ti-containing mesoporous silica thin films, the contact angle of water became lower to indicating the appearance of the super-hydrophilic property. Furthermore, the nano-sized Pt metal with well-controlled size can be deposited on the photo-excited tetrahedrally coordinated titanium oxide moieties of Ti-containing mesoporous silica thin films under UV-light irradiation.

REFERENCES

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[2] H. Yamashita, S. Nishio, I. Katayama, N. Nishiyama, H. Fujii, *Catal Today*, **111**, 254 (2006).