Photocatalytic Methanol Dehydrogenation by Platinum-loaded Titania Particles Prepared from Evonik P25

Kunlei Wang[1], Bunsho Ohtani[1,2] and Ewa Kowalska [1,2]
[1]*Graduate School of Environmental Science and* [2]*Institute for Catalysis, Hokkaido University, Sapporo, Japan*

*E-mail: kowalska@cat.hokudai.ac.

Evonik P25 titania (P25) is widely used as a photocatalyst and contains anatase and rutile crystalline phases as well as an amorphous. Co-existence of anatase and rutile makes discussion on photocatalytic performance complex, e.g., contrary reasons of its high-level activity of mixed phases has already been proposed: i) transfer of charge carriers between different crystalline phases [1] and/or ii) intrinsic high activity of single phases in different reactions [2]. The latter has been confirmed in our previous study, in which separated phases showed higher photocatalytic activities than P25, with the exception of methanol dehydrogenation reaction, in which P25 showed slightly higher activity than single isolated crystalline phases. However, it should be pointed that this reaction requires the presence of metallic co-catalyst (usually platinum (Pt) nanoparticles (NPs)), and thus the properties (size and distribution) of those deposited NPs influence the resultant activity. Therefore, present study focuses on clarification of influence of Pt-loading on resultant photocatalytic activity. Anatase (ANA) and rutile (RUT) particles were isolated from P25 by selective chemical dissolution [2], and then purified by thermal-treatment and washing with an alkali solution (RUT only). To minimize heterogeneity of P25, an original sample was homogenized by suspending in water, then centrifugally separated and finally freeze dried (Homo-P25). Photocatalytic activity was evaluated for methanol (50vol% in water) dehydrogenation under irradiation by a mercury lamp (> 290 nm) at 298 K in the presence of various concentrations of chloroplatinic acid for in-situ platinum photodeposition (0.005–2.0wt%).

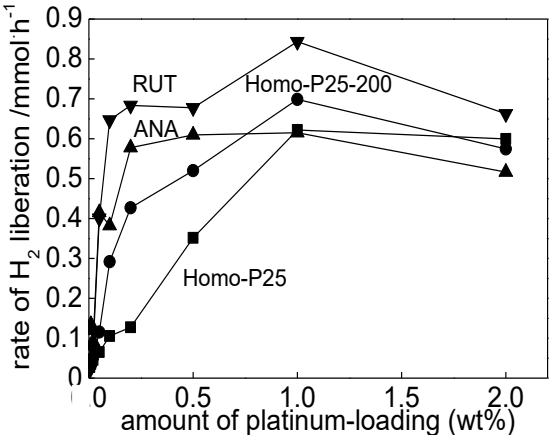

Fig. 1 Influence of platinum amount on rate of H_2 liberation.

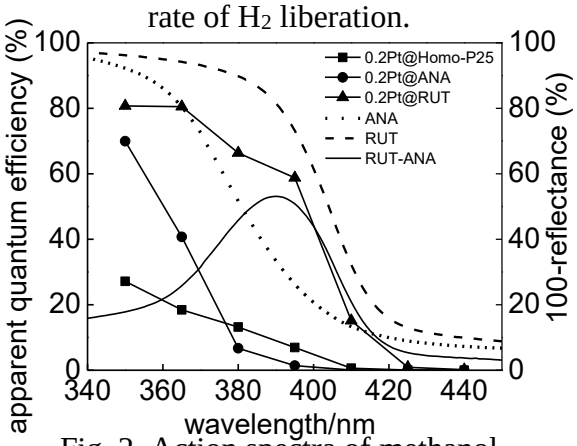

Fig. 2 Action spectra of methanol dehydrogenation on platinized (0.2 wt%)

It was found that the rate of hydrogen liberation increased with loaded-Pt amount, reaching a plateau at the amount which was strongly depended on titania samples, as shown in Fig. 1. Platinized RUT exhibited higher photocatalytic activity than the other platinized samples, i.e., ANA, Homo-P25, Homo-P25-200 (Homo-P25 heated at 473 K), even with lower amount of deposited Pt, possibly due to ability of light absorption at broader wavelength range, as was confirmed by action spectrum analyses (Fig. 2). It is presumed that in the case of mixed titania photocatalysts, Pt is deposited firstly on rutile phase, and thermal treatment (used for sample purification) results in particle aggregation which causes the lowering of necessary amount of Pt, i.e., large particle (aggregates) can be activated by one Pt deposit, due to interparticle electron transfer.

REFERENCES

[1] T. Ohno, K. Tokieda, S. Higashida, M. Matsumura, Appl. Catal. B, 244 (2003) 383.
[2] B. Ohtani, O.-O. P.-Mahaney, D. Li, and R. Abe, J. Photochem. Photobiol. A Chem., 216 (2010) 179.