Cesium-Ion-Modified Vanadium Complex on Silica for Photocatalytic Decomposition of Acetaldehyde

Masako Tanaka,1 Fumiaki Amano1,2 and Bunsho Ohtani1,2

1Graduate School of Environmental Science and 2Catalysis Research Center, Hokkaido University

Photocatalytic decomposition of gaseous organic compounds into carbon dioxide (CO₂) is a useful technique for purification of indoor air. Recently, Ti-O-Ce complexes supported on mesoporous silica have been reported to be a visible-light-responsive photocatalyst for oxidation of gaseous 2-propanol [1]. The photocatalytic activity of such all-inorganic surface-complex photocatalysts can be tuned and manipulated in a molecular level, while it is rather difficult in the case of conventional semiconductor photocatalysts such as titanium(IV) oxide. It has been known that silica-supported vanadium(V) oxides (V₂O₅/SiO₂) exhibit photocatalytic activity for selective oxygenation of organic compounds under dehydrated conditions. Unfortunately, however, the activity is significantly reduced in the presence of water because of transformation of active vanadium complex on silica into inactive clusters like crystalline V₂O₅. In addition, vanadium complex on silica is less active for complete oxidation of organic compounds, since an exciton localized on vanadium complex seems to be unsuitable to drive multi-electron reactions. In the present study, we found that modification by alkali ion much enhanced the photocatalytic activity of vanadium complexes for complete oxidation of acetaldehyde (AcH) into CO₂ even in the presence of water in the atmosphere.

Cesium-ion-modified V₂O₅/SiO₂ (C-VS) was prepared by incipient-wetness method using amorphous silica (AEROSIL-380) and an aqueous solution of ammonium vanadate (NH₄VO₃) and cesium carbonate (Cs₂CO₃). The sample after evaporation to dryness was calcined at 773 K for 2 h. Photocatalytic decomposition of AcH was carried out using a cylindrical glass vessel under irradiation by a 300-W xenon lamp with and without a cut-off filter (Asahi Techno Glass L39, λ > 370 nm).

Figure 1 shows the effect of atomic ratio of cesium to vanadium (Cs/V ratio) on the photocatalytic activity for decomposition of AcH in air. Almost stoichiometric amount of CO₂ was liberated. C-VS with Cs/V ratio larger than 1.0 exhibited high level of activity for CO₂ liberation. It is considered that the photocatalytic active site is vanadium complexes interacted with cesium ions by one-to-one correlation. The activity of C-VS was a little larger than that of P25 when light of wavelength > 370 nm was irradiated.


![Fig. 1 Effect of Cs/V ratio on the amount of CO₂ liberation through decomposition of AcH (15 μmol) over 100 mg of C-VS photocatalysts (vanadium loading: 2 atom% V/(Si+V)).]
Name: Masako TANAKA

Position and Affiliation: Division of Environmental Materials Science, Graduate School of Environmental Science, Hokkaido University
Postal Address: North 21, West 10, Kita-ku, Sapporo 001-0021, Japan
Phone/Facsimile: +81-11-706-9130
Email: dolphin@cat.hokudai.ac.jp

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Biographical Sketch:
2008 March
   Bachelor of Engineering, Muroran Institute of Technology, Japan
2008 April
   Enter to Graduate School of Environmental Science, Hokkaido University