Photocatalytic water vapor dissociation using hydrophilic cocatalyst with β-Ga_2O_3

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Introduction

Ga_2O_3 is known as a photocatalyst for evolution of H_2 and O_2 by water splitting. Usually, photocatalytic water splitting is conducted in water liquid with the photocatalyst dispersed. However, photocatalytic activity often decreases since water absorbs UV light.[1] Recently, instead of water splitting, water vapor dissociation system is being developed. In water vapor, the number of H_2O molecules surrounding photocatalysts are limited, so the evolution amount of H_2 is limited too. In this research, we have employed the cocatalyst of MgO having a hydrophilic character mixed with β-Ga_2O_3 photocatalyst. We conducted photocatalytic water vapor dissociation and investigated the effects of MgO mixing methods and ratios on photocatalytic activity.

Experimental Procedures

Three types of photocatalyst samples were prepared. They were the simple mixture sample (MgO & β-Ga_2O_3), the supported samples (MgO/β-Ga_2O_3), and the composite sample ($MgGa_2O_4$).

The H_2 evolution from water vapor was conducted in the water-vapor system as follows. The photocatalyst sample of 0.2 g was inserted into a quartz reactor with 1 mL deionized water and dried at 353 K. Next, the water vapor was introduced by bubbling Ar gas through water with the frow rate of 5 mL/min. The UV light given by a Xe lamp through the UV cold mirror was illuminated with the light intensity of 23 mW/cm^2 at 254±10 nm. The reaction products were analyzed quantitatively by a TCD gas chromatograph.

Results and Discussion

XRD analysis showed that the simple mixture sample and the supported samples consisted of MgO and β-Ga_2O_3 without any other compounds, while the composite sample was converted to $MgGa_2O_4$ as each substances reacted.

In the reaction tests, the simple mixture and supported samples exhibited high photocatalytic activity, while the composite sample had poor activity. Among them, the supported sample mixed with 50 mol% MgO initially showed lower activity, but the activity increased with time and finally showed the highest activity.

Figure 1 shows Mg K-edge XANES spectra of 50 mol% MgO supported sample before and after the reaction, MgO and $Mg(OH)_2$. It was revealed that in 50 mol% MgO supported sample, most of the MgO phase was converted to $Mg(OH)_2$ phase. This result suggests that the hydroxyl groups generated by the hydroxylation of MgO adsorbed H_2O concentration surrounding β-Ga_2O_3 photocatalyst. Therefore, photocatalytic activity of the 50 mol% MgO supported sample is very likely promoted by the electron excitation in the β-Ga_2O_3 and the water vapor dissociation on $Mg(OH)_2$, showing the highest activity.

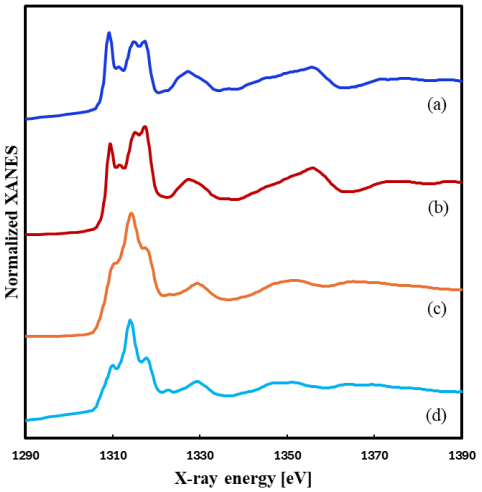

Figure 1 Mg K-edge XANES spectra of (s) MgO, (b) 50 mol% MgO supported sample, (c) 50 mol% MgO supported sample after the reaction, and (d) $Mg(OH)_2$.

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References

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