CO_2 reduction with H_2O over Ga_2O_3 photocatalysts prepared at various calcination temperatures

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Gallium oxide (Ga_2O_3) photocatalysts can reduce CO_2 with H_2O to produce CO, although the reaction rate of CO production is very low. It has been reported that the loading of Ag on Ga_2O_3 promoted CO production [1], on the other hand, improvement of Ga_2O_3 structure should be also essential. In our previous work [2], Ga_2O_3 loaded Al_2O_3 samples (Ga_2O_3/ Al_2O_3) were prepared to change coordination structures around Ga atoms, and we succeeded to enhance CO production rate. Recently, we found that the photocatalytic activity of Ga_2O_3 depended on the calcination temperature for a Ga_2O_3 precursor in the preparation stage. Therefore, in this study, we will discuss the reason why the CO production was enhanced by controlling calcination temperature.

Ga_2O_3 samples were prepared by calcination of $Ga(NO_3)_3 \cdot 8H_2O$ powder in the air at given temperatures (673 - 1173 K) for 4 h. We carried out photocatalytic CO_2 reduction with H_2O over the Ga_2O_3 samples. Fig.1 shows CO production rate for each Ga_2O_3 sample. Ga_2O_3 prepared by calcination at 823 K (Ga_2O_3(823 K)) showed a specifically high activity for CO production, although the H_2 production rate for this sample was comparable with those for Ga_2O_3 (673, 773, 873 K). It was found that the H_2 production rate increases with the surface area of the sample.

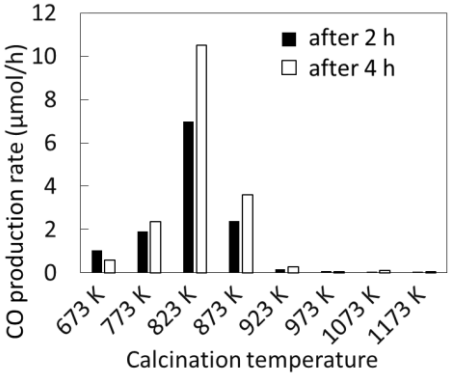

Fig. 1 CO production rates for Ga_2O_3 samples prepared by calcination at different temperarures.

In XRD measurement of Ga_2O_3(823 K), very weak and broad diffraction peaks were observed, suggesting the formation of low crystallinity β-Ga_2O_3. Taking into account that a low crystallinity photocatalyst has many defects to promote the recombination of excited electron-hole pairs, high CO production activity for Ga_2O_3(823 K) would be resulted from an improvement of CO_2 adsorption process rather than electrons and holes diffusion process. Therefore We performed FT-IR measurements for chemisorbed species on Ga_2O_3 samples after introduction of CO_2. It was revealed that adsorbed species on Ga_2O_3(823 K) are different from those on other Ga_2O_3 samples. The FT-IR spectrum of Ga_2O_3(823 K) indicated preferential formation of CO_2 species interacting with water adsorbed on Ga_2O_3 surface.

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[1] Yoshida H, Zhang L, Sato M, Morikawa T, Kajino T *et al*. Catal. Today **251**, 132(2015).

[2] M. Akatsuka, T. Yoshida *et al* Catal. J. Phys. Conf. Ser., conference 1, **712**, 012056 (2016).