# γ-$Ga_2O_3$ supported by α-$Ga_2O_3$ as a photocatalyst for $CO_2$ reduction with water

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## Introduction

$Ga_2O_3$ has been attracting attention as a photocatalyst for the reduction of $CO_2$ with water. In most of previous studies, Ag has been employed as a co-catalyst [1, 2]. In our previous works, we have successfully synthesized $Ga_2O_3$ photocatalysts consisting of mixed phases of α and γ [3], and β and γ [4] which exhibit high activity without the co-catalyst. However, the cause of their high activity remains unclear partly because the mixing ratio of the two phases is difficult to control. Here, we have synthesized γ-$Ga_2O_3$ supported by α-$Ga_2O_3$ (γ-$Ga_2O_3$/α-$Ga_2O_3$) with different ratios of α and γ phases and evaluated their photocatalytic activity to investigate the cause of the high activity.

## Experimental Procedures

γ-$Ga_2O_3$/α-$Ga_2O_3$ photocatalysts were synthesized by the impregnation method. $Ga(NO_3)_3 \cdot 8H_2O$ was dissolved in distilled water, and α-$Ga_2O_3$ powder was dispersed in the solution. The mixture was heated with stirring to dryness and then calcined at 723 K for 4 h. The ratio of α and γ phases was controlled by varying the amounts of α-$Ga_2O_3$ and $Ga(NO_3)_3 \cdot 8H_2O$. The photocatalytic $CO_2$ reduction with water was conducted using these catalysts and the generated gases were quantified by gas chromatography. The catalysts were characterized by XRD, TEM, and XAFS.

## Results and Discussion

Fig. 1 shows the XRD patterns of (a) γ-$Ga_2O_3$/α-$Ga_2O_3$ with the γ phase content of 60%, (b) α-$Ga_2O_3$, (c) the difference pattern obtained by subtracting (b) from (a), and (d) the reference pattern of γ-$Ga_2O_3$. The difference pattern exhibits broad peaks corresponding to the reference pattern of γ-$Ga_2O_3$ without contributions from other phases. This indicates that γ-$Ga_2O_3$/α-$Ga_2O_3$ consists of well-crystallized α phase and poorly-crystallized γ phase.

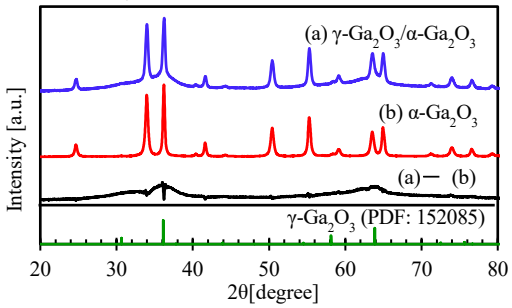

Figure 1 XRD patterns of samples.

Fig. 2 shows changes in $H_2$ and CO production rates as a function of γ phase content. $H_2$ production rate decreased with increasing the γ phase content, indicating that the $H_2$ production was dominated by the α phase. High CO production rates were observed for samples containing 60%-80% of the γ phase, while the production rate decreased in the γ phase-dominated samples. Although γ phase has been reported to adsorb $CO_2$ effectively [3], the observed higher CO production rate could not be attributed to high $CO_2$ adsorption alone.

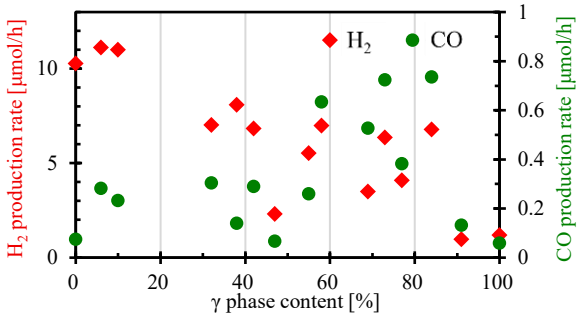

Figure 2 Production rates of $H_2$ and CO plotted against the γ phase contents of the γ-$Ga_2O_3$/α-$Ga_2O_3$.

Considering our previous work on mixed phases of α-$Ga_2O_3$ and γ-$Ga_2O_3$ photocatalysts, this work clarifies that CO production proceeds via a mechanism in which H predominantly generated on the α phase migrates to the γ phase and reduces the adsorbed $CO_2$.

## Acknowledgement

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## References

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