Activity comparison among Ru/α-Al$_2$O$_3$, Ru/γ-Al$_2$O$_3$, and Ru/Al@Al$_2$O$_3$ for selective CO oxidation in H$_2$

Tae Wook Kim[1], Jieun Kim[2], Doohwan Lee[2], Eun Duck Park[1,*]

[1]*Department of Chemical Engineering and Department of Energy Systems Research, Ajou University, Suwon, 16499, Republic of Korea*
[2]*Department of Chemical Engineering, University of Seoul, Seoul, 02504, Republic of Korea*

*E-mail: edpark@ajou.ac.kr

Selective oxidation of CO in H$_2$ is an important reaction to clean up the residual CO in the hydrogen feed for the polymer electrolyte membrane fuel cells (PEMFCs). When hydrogen is synthesized from various hydrocarbons in the fuel processor, even very small amount of CO can deteriorate the electrochemical performance of Pt anode in the PEMFCs. Until now, a variety of noble metals and metal oxides have been reported to be active for this reaction. Among them, supported Ru catalysts are unique because they can remove CO through selective CO oxidation as well as CO methanation over a wide temperature range. Since these are highly exothermic reactions, a facile removal of generated heat can be beneficial as a catalyst support, which can be accomplished using Al@Al$_2$O$_3$ support. In this study, Ru/Al@Al$_2$O$_3$ catalyst was compared with conventional Ru/α-Al$_2$O$_3$ and Ru/γ-Al$_2$O$_3$ catalysts [1] for selective CO oxidation in H$_2$.

α-Al$_2$O$_3$ and γ-Al$_2$O$_3$ were purchased and used as they are. Al@Al$_2$O$_3$ was prepared as described in the previous work [2]. All supported Ru catalysts were prepared using wet impregnation method from ruthenium nitrosyl nitrate solution and support. The catalysts were dried in an oven at 120 for 12 h and reduced in hydrogen at 300 for 1 h before a reaction. A typical fixed-bed reactor was utilized to obtain the activity data under different conditions.

In the absence of CO$_2$ and H$_2$O, Ru/α-Al$_2$O$_3$ showed the highest catalytic activity among tested Ru catalysts. However, Ru/Al@Al$_2$O$_3$ catalyst exhibited the widest temperature window achieving 100% CO conversion. In the presence of CO$_2$ and H$_2$O, the catalytic activity decreased significantly for all catalysts. Among them, Ru/Al@Al$_2$O$_3$ catalyst appears to be most promising to remove CO.
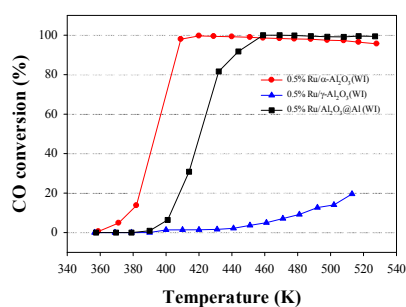

Fig. 1. Catalytic performance of supported Ru catalysts for selective CO oxidation in H$_2$. Reaction conditions: 1.0 mol% CO, 1.0% mol% O$_2$, 50.0 mol% H$_2$, and 48.0% mol% He, F/W = 1,000 mL/min/g$_{cat}$, 1 atm.
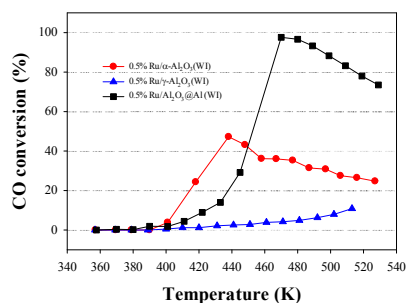

Fig. 2. Catalytic performance of supported Ru catalysts for selective CO oxidation in H$_2$. Reaction conditions: 1.0 mol% CO, 1.0% mol% O$_2$, 50.0 mol% H$_2$, 20.0 mol% CO$_2$, 10.0 mol% H$_2$O and 18.0% mol% He, F/W = 1,000 mL/min/g$_{cat}$, 1 atm.

REFERENCES

[1] Y.H. Kim and E.D. Park, Applied Catalysis B: Environmental, 2010. **96**(1-2): p. 41-50.

[2] J. Kim and D. Lee, Chemistry of Materials, 2016. **28**(8): p. 2786-2794.