# $NH_3$ decomposition of $Al_2O_3$ bead surface modified Ru catalysts to produce carbon-free hydrogen

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**Significance and Relevance**

Developing highly active catalysts with low noble metal content is essential for reducing catalyst costs and making them commercially viable. We have developed a coating method on bead supports to fabricate $NH_3$ decomposition catalysts with reduced Ru content, providing a pathway to more economical catalysts for industrial applications.

*Preferred and 2nd choice for the topic: "Ammonia decomposition and Carbon-free hydrogen production"*
*Preferred presentation*: "Poster"

**Introduction and Motivations**

Ammonia is one of the promising hydrogen carriers because of high hydrogen content (17.7 wt.% $H_2$), carbon-free conversion to hydrogen and nitrogen, and mild liquefaction condition ( - 33.4 °C at 1 atm, or 8.5 atm at 20 °C) [1]. At the end of the $NH_3$ transport, the $NH_3$ gas should be converted to $H_2$ and $N_2$ using $NH_3$ decomposition catalyst, of which should have outstanding catalytic performance and low cost. Therefore, we developed the Ru based catalysts, which used surface-modified $Al_2O_3$ bead support to enhance catalytic performance and reduce Ru content.

**Results and Discussion**

The purpose of the $Ru/LaCeO_x/Al_2O_3$ bead catalyst synthesized by our method is to increase in catalytic activity for $NH_3$ decomposition while decreasing Ru content, simultaneously, our method was also concerned for ease to be commercialized.

**Fig. 1** shows the $NH_3$ conversion of the commercial (pellet and bead coating catalysts) and synthesized Ru based catalysts at 3,000 mL $g_{cat.}^{-1}$ $h^{-1}$ under 100 % $NH_3$. The $Ru/LaCeO_x/Al_2O_3$ catalyst, which we have made with our method, exhibited better $NH_3$ decomposition performance than the other commercial Ru based catalysts (A – C co.) and Ru catalyst, which $LaCeO_x$ layer was formed by normal impregnation method (Ru cat. normal method).

In addition, the $Cs\text{-}Ru/LaCeOx/Al_2O_3$ bead catalyst had the promoted catalytic activity more than the no Cs-promoted $Ru/LaCeO_x/Al_2O_3$ bead catalyst.

**Fig. 2** shows the elemental mapping image of the $Ru/LaCeO_x/Al_2O_3$ bead (cross-section) and elemental composition analyzed by ICP-OES. In this catalyst, the main metal species including Ru and promoting support materials, La and Ce oxide were evenly formed onto the thin sub-surface of $Al_2O_3$ bead, indicating that expensive material, such as Ru, La, and Ce were dispersed on the bead catalyst's surface and could be saved for the $Ru/LaCeO_x/Al_2O_3$ bead catalyst. Especially, the Ru content was 0.66 wt%, which is very low Ru content compared to the other commercial catalysts. It indicates that our shaped catalyst developed in this work, the $Ru/LaCeOx/Al_2O_3$ bead catalyst, has excellent catalytic activity although Ru and the other expensive element, such as La and Ce contents were very low.

Conclusively, we have developed the low cost and high active Ru bead catalyst for $NH_3$ decomposition, and it was better than the other commercialized Ru based pellet and bead coating catalysts even it had low Ru content.

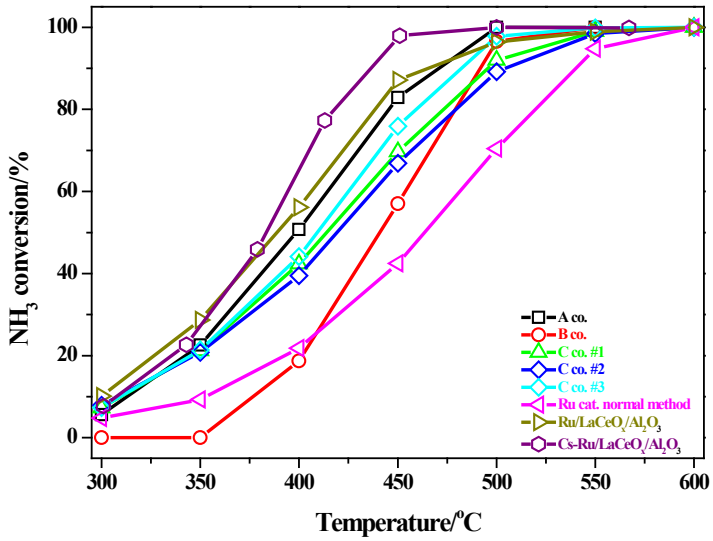


**Figure 1**. $NH_3$ conversion of Ru based catalysts; commercial and synthesized $Ru/LaCeO_x/Al_2O_3$ bead catalysts with normal impregnation (Ru cat. normal method) and our methods ($Ru/LaCeO_x/Al_2O_3$ and $Cs\text{-}Ru/LaCeO_x/Al_2O_3$) (SV: 100 % $NH_3$ 3000 mL $g_{cat.}^{-1}$ $h^{-1}$)

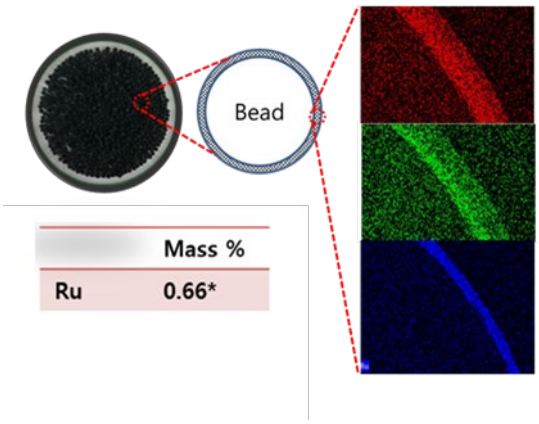


**Figure 2**. Elemental mapping image (cross-section) and Ru content of $Ru/LaCeO_x/Al_2O_3$ bead catalyst analyzed by SEM-EDS and ICP-OES of $Ru/LaCeO_x/Al_2O_3$ bead catalyst (Red: Ce, Green: La, Blue: Ru)

## References

1. S. Sun, *Renewable and Sustainable Energy Reviews, **2022**,* 169, *112918*.

## Acknowledgements

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