Effects of Na on CO and CO_2 methanation over Na-Ni/SiO_2 and Na-Ni/CeO_2

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CO methanation is an important catalytic reaction to convert syngas, which can be synthesized from coal or biomass through gasification, into synthetic natural gas (SNG) [1]. CO_2 methanation is also considered to be one of ways to utilize surplus power to realize the Power-to Gas technology [2]. Until now, supported Ni catalysts have been reported to be active for these reactions [1-3].

During biomass gasification, various metal compounds including alkali metals can be involved in the syngas and cause the side effect on the catalytic activity as well as product selectivity in the downstream process even through most of them are removed in the clean-up process after a gasifier. In this study, the effect of Na on the catalytic activity for CO and CO_2 methanation over Ni/SiO_2 and Ni/CeO_2 catalysts.

Ni/SiO_2 and Ni/CeO_2 catalysts were prepared by wet impregnation method from an aqueous $Ni(NO_3)_2$ solution and SiO_2 (Zeochem, ZEOprep 60, S_{BET} = 542 m^2/g) or CeO_2 (Rhodia, S_{BET} = 230 m^2/g). The impregnated catalysts were calcined in air at 500 ℃ and reduced in hydrogen at 500 ℃. The addition of Na onto supported Ni catalysts were made with an aqueous solution of $NaNO_3$ and calcined supported Ni catalysts. These supported Na-Ni catalysts were also calcined in air and reduced in hydrogen both at 500 ℃. Various techniques including N_2 physisorption, H_2 chemisorption, hydrogen temperature-programmed reduction, CO_2 chemisorption, temperature-programmed desorption of CO_2, X-ray diffraction, and transmission electron microscopy were employed to characterize the catalysts.

The negative effect of Na on CO methanation was confirmed even over Na-Ni/SiO_2 and Na-Ni/CeO_2 catalysts containing 0.1 wt% Na. This can be explained that Na can block the active site on the metallic Ni. A facile formation of higher hydrocarbons was observed over supported Na-Ni catalysts.

In the case of CO_2 methanation, the positive and negative effect of Na was observed over Na-Ni/SiO_2 and Na-Ni/CeO_2 catalyst, respectively. This is closely related to the amount of CO_2 chemisorbed on the catalyst.

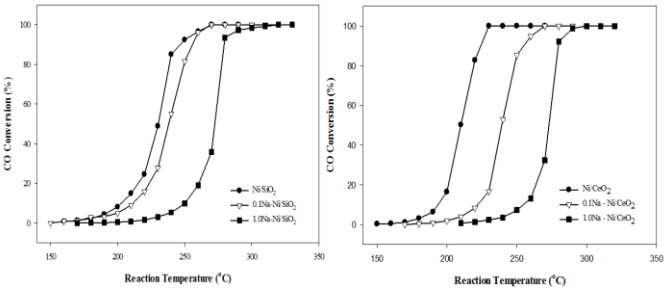

Fig.1 CO methanation over Na-Ni/SiO_2 and Na-Ni/CeO_2 catalysts with different Na contents. Reaction conditions: 1.0 mol% CO, 50.0 mol% H_2, and 49.0 mol% He, F/W=1000 mL/min/$g_{cat.}$, 1 atm.

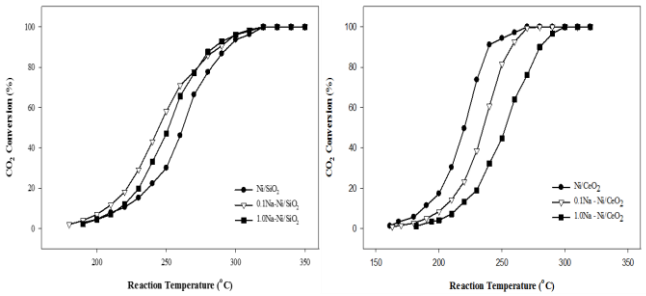

Fig. 2 CO_2 methanation over Na-Ni/SiO_2 and Na-Ni/CeO_2 catalysts with different Na contents. Reaction conditions: 1.0 mol% CO_2, 50.0 mol% H_2, and 49.0 mol% He, F/W=1000 mL/min/$g_{cat.}$, 1 atm.

REFERENCES

[1] B. Mao, S.S.K. Ma, X. Wang, H. Su, S. H. Chan, Catal. Sci. Technol. 6 (2016) 4048.
[2] M.A.A. Aziz, A.A. Jalil, S. Triwahyono, A. Ahmad, Green Chem., 17 (2015) 2647.
[3] J. Gao, Q. Liu, F. Gu, B. Liu, Z. Zhong, F. Su, RSC Adv., 5 (2015) 22759.