Stabilized Ni-Mo at the edges of single-crystalline MgO for CO₂ reforming

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The search for a known chemical process to utilize the huge quantities of CO₂ emissions generated mainly by the energy sector via the oxidation of carbon in fuels, remains an unending task. CO₂ reforming of methane is seen as a suitable alternative to the generally proposed carbon capture and storage. Furthermore, it has been suggested as a potential chemical process to handle the excess CO₂ emissions without much modification to the current infrastructure.

CO₂ reforming of methane should have been the chemical process to solve the excess CO₂ emissions, but the rapid catalyst deactivation is a major bottleneck. Several catalysts have been developed for decades to tackle catalyst sintering, carbon formation and deposition on the surface of the catalyst which result in deactivation, but most of the catalysts have failed to deliver the required catalytic performance necessary for commercialization. Now, Youngdong Song, Cafer Yavuz, and colleagues at the Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology, succeeded in developing a stable molybdenum-doped nickel (Ni-Mo) nanocatalysts stabilized at the edges of a single-crystalline magnesium oxide (MgO) for the reforming reaction.

In order to develop a stable reforming catalyst, the authors used a highly crystalline MgO as the support because they suspected that a defective MgO support will alter the expected redox reaction. They produced the near-single crystalline MgO by the reduction of CO₂ with Mg chips via autothermal reaction. Knowing fully well that Ni catalyst particle size of greater than 7 nm enhance carbon formation, the authors utilized a polyol-mediated reduction method in the polyvinylpyrrolidone to control the size of Ni particles. Although it has been generally reported that molybdenum (Mo) is not active of CO₂ reforming, they found out that addition of ~2% Mo enhance the catalytic conversion. The durability and stability of the catalysts was confirmed for up to 850 hrs at 60 Lg_{cat}⁻¹ hour⁻¹ with ~100 % conversions for both CH₄ and CO₂ with no deactivation.

In conclusion, carefully designed nanocatalysts on single MgO crystal edges is seen as potential solid catalyst for CO₂ reforming of methane and other coke-prone catalytic reactions. A locking mechanism in which particulates move to the high energy step edges of the crystalline MgO (111), is believed to be the key

to the coke- and sintering-resistance performance exhibited by the Ni-Mo/MgO catalyst. Reduction of CO₂ with Mg chips to synthesize the near-single-crystalline MgO instead of a defective MgO, also played a major role in the superior catalytic activity and stability exhibited by the Ni-Mo/MgO catalyst.

Reference

[1] Song, Y., Ozdemir, E., Ramesh, S., Adishev, A., Subramanian, S., Harale, A., Albuali, M., Fadhel, B. A., Jamal, A., Moon, D., Choi, S. H., Yavuz, C. T., **2020**, Dry reforming of methane by stable Ni-Mo nanocatalyst on single-crystalline MgO, *Science*, 367, 777.

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