
Tailoring Ni-based catalysts for Dry Reforming of Methane and Hydrogen Production: The Forefront of Sustainable Energy

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Dry reforming of methane (DRM) is an endothermic catalytic process that converts greenhouse gases (GHGs) into clean hydrogen (H₂) fuel and synthesis gas (syngas, CO/H₂), positioning it as a key player in sustainable energy solutions. The syngas produced can be utilized for fuel production and high-value chemicals. Despite its potential in mitigating global warming, DRM has not yet been industrialized due to economic challenges.



In this keynote talk, I will present the main challenges facing DRM and highlight the crucial role of catalyst design in developing robust and stable catalysts to enhance reaction performance and stability. Additionally, I will explore advanced methodologies for catalyst evaluation, particularly transient isotopic isothermal experiments (TIIE), which is powerful tool for understanding catalytic mechanisms.

The economic viability of Ni-based catalysts has spurred numerous studies on these systems for DRM. However, high operating temperatures and competing side reactions, such as methane decomposition and CO disproportionation, lead to sintering of active sites and carbon deposition on the catalyst surface. Factors such as metal-support interaction, preparation methods, porosity, and metal dispersion significantly influence catalyst performance.

Various catalyst carriers namely doped ceria and SBA-15, alongside unsupported metal-organic frameworks (MOFs) are discussed in details. Doping ceria with other trivalent rare-earth metals (La⁺³) increases lattice oxygen mobility and basicity which improved coke resistance. The improved stability and carbon inhibition were correlated to the labile oxygen that gasified the carbon formed during the reaction. In another study, SBA-15 was used to combine the benefits of doped ceria and mesoporosity. The high surface area of SBA-15 was used to improve the interaction between Ni active sites and CeLa₁₀Cu promotor and confinement of the Ni in its channels (dispersion). Whereas, in the case of coalesced Ni- and La-MOFs, negligible carbon formation and high CH₄ conversion rates under DRM conditions at 800 °C were used. The use of terephthalic acid (BDC) as an organic linker achieved strong metal-support interactions (SMSI) and produced highly active and stable catalysts towards DRM reaction.

In conclusion, while DRM holds significant promise for the future of hydrogen energy, challenges remain for its commercialization. Through continued research and advanced characterization techniques, we can deepen our understanding and overcome these hurdles, paving the way for the effective commercialization of the DRM process.

References

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