Raney Nickel: Introducing the New High-Activity and Cost-Effective Catalyst for the Sabatier Reaction

Park, Junhyeok (School: Daegu-il Science High School)
Kim, Jinsong (School: Daegu-il Science High School)
Lee, Hyoungseok (School: Daegu-il Science High School)

As global carbon dioxide emissions increase worldwide, the research on carbon capture and utilization technologies has become increasingly important. The Sabatier reaction, which converts carbon dioxide into methane, has garnered significant attention as a future fuel. Researchers have investigated various catalysts for this reaction to reduce the reaction temperature. This study aims to evaluate the applicability of Raney Nickel, a cost-effective catalyst with high activity at low temperatures, for the Sabatier reaction. The characteristics of the catalyst were analyzed through XRD, SEM, BET, EPMA/WDS, TGA-DSC, XPS, and H2-TPD. The activity of the Raney Nickel catalyst was evaluated under atmospheric pressure with a H2/CO2 molar ratio of 4, and catalyst regeneration was performed at 365℃ using water for 1 hour. Raney Nickel showed 41.0% CO2 conversion at 250℃ and 83.2% CO2 conversion at 300℃. When the nickel content exceeded 90 wt%, the CO2 conversion increased to 87.5% at 250℃, demonstrating superior low-temperature activity compared to the previously used Ni/Al2O3 catalyst. Additionally, the used Raney Nickel recovered 90.8% of the initial CO2 conversion compared to a new catalyst. This study also identified the Bayerite formation mechanism and its role during the reaction and quantified the amount of coke on Raney Nickel's deactivation using TGA. Moreover, regeneration equipment was developed to continuously perform the reaction and regeneration process. These findings have important implications for the future of carbon utilization technology, as they offer a means of lowering the reaction temperature to 300℃ and price of the catalyst to 1/15 of the Sabatier reaction, and for the exploration of Mars, where methane and pure water can be produced using this process.

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