

Hydrogen enriched fuel gas production, from the CO₂ capture and regeneration with CH₄, in a cyclic process technology

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Abstract

Concern over the increasing emissions of greenhouse gases into the atmosphere, mainly CO₂ and CH₄, has led to a growing interest in both new sustainable fuels and CO₂ capture and storage technologies (CCS). In this context, a catalytic CO₂ storage and *in situ* regeneration technology with CH₄ (CO₂-SR Cyclic Technology) has been developed [1]. This system requires Dual Function Materials (DFMs) which contribute to CO₂ capture [2] and whose chemical regeneration results in an enriched fuel gas stream.

Nickel-based catalysts combined with an alkali (K) or alkaline earth (Ba) metal with an atomic ratio of 1:1 were synthesized by a coprecipitation method. These catalysts were tested using a transient cyclic system of alternating stages of CO₂ and CH₄ pulses with a He purge, as shown in Figure 1a. Prior to the oxidation step, an activation of the catalysts with a 3% H₂ in He stream was carried out. Catalytic cyclic tests were performed isothermally at atmospheric pressure using *Transient Response Method* (TRM) in a fixed-bed reactor connected to a mass spectrometer. In addition, a thermogravimetric analysis was also performed to the catalysts under the same conditions.

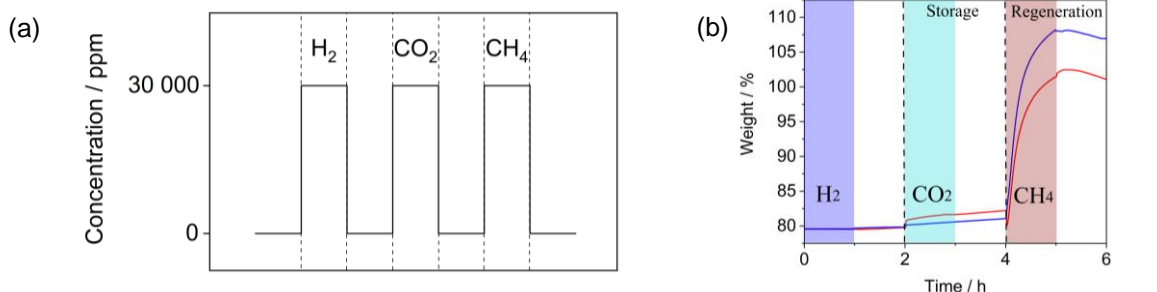


Figure 1. (a) Operation scheme of the experimental methodology of alternating CO₂-He-CH₄ cycles and (b) Profile of the thermogravimetric analysis.

Figure 1b shows the mass variation of the catalysts during the cycles. It was observed that both catalysts presented a high storage capacity. However, the regeneration capacity of the catalyst with incorporated K undergone a decrease as the catalytic cycles were performed. The novel concept, CO₂-SR technology, has been developed using a nickel-based catalyst with a high-capacity as CO₂ sorbent and methane conversion catalyst. The catalyst with alkaline earth metal provides a stream with higher proportion of hydrogen at the gas off during alternating catalytic cycles.

References

- [1] S. Molina-Ramírez, M. Cortés, C. Herrera, M.A. Larrubia & L.J. Alemany, (2020). CO₂-SR Cyclic Technology: CO₂ Storage and *in situ* Regeneration with CH₄ over a new dual function NiBa unsupported catalyst. *Journal of CO₂ Utilization*, Volume 40.
- [2] J. A. Onrubia-Calvo, A. Bermejo-López, S. Pérez-Vázquez, B. Pereda-Ayo, J. A. González-Marcos, J. R. González-Velasco, (2022). Applicability of LaNiO₃-derived catalysts as dual function materials for CO₂ capture and *in-situ* conversion to methane. *Fuel*, Volume 320.

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