Experimental study of the application of a NiO/NiAl$_2$O$_4$ catalyst and a CaO-based synthetic sorbent on the Sorption Enhanced Reforming process

Ana L. García-Lario, María Aznar, Isabel Martínez, Gemma S. Grasa, Ramón Murillo
Environmental Research Group, Instituto de Carboquímica, CSIC, C/Miguel Luesma 4, E-50018 Zaragoza, Spain

HIGHLIGHTS

- Joint performance of a Ni-catalyst and a CaO-based synthetic sorbent was demonstrated.
- No interaction between the catalyst and the synthetic sorbent was observed.
- 650 °C was the most appropriate temperature value during the tests.
- Equilibrium concentrations were reached at steam/CH$_4$ ratios as low as 1.6.
- A steam/CH$_4$=1.6 allowed a self-sustained plant according to simulation work.

KEYWORDS:
Hydrogen; Nickel; Synthetic sorbent; Nickel aluminate; Sorption Enhanced Reforming; Self-sustained plant

ABSTRACT:
A CaO-based synthetic sorbent and a NiO/NiAl$_2$O$_4$ catalyst are synthesized and tested under Sorption Enhanced Reforming (SER) conditions in a fixed bed reactor. The effect of temperature, steam-to-methane ratio (S/C) and sorbent-to-catalyst proportion (Z) are studied. A SER based plant simulation model is implemented to evaluate if the operating conditions chosen allow for a self-sustained plant from a thermal energy consumption standpoint. The most
appropriate temperature for SER test is 650ºC. At 600ºC the catalyst seems to be not sufficiently active, while at 700ºC, a longer breakthrough period results. SER equilibrium is reached even at the lowest S/C ratio of 1.6, obtaining H₂ purity of 82vol.% (dry basis). For the SER based plant simulation developed, the low S/C ratio of 1.6 allows a self-sustained plant where the energy required in the calciner for CaCO₃ decomposition is supplied by burning the off-gas from the H₂ purification unit.