Evaluation of mayenite supported Ni-catalysts suitable for Sorption-Enhanced Reforming processes.

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Sorption-Enhanced Reforming (SER) has the potential, on a medium to long term perspective, to contribute to a more efficient and profitable hydrogen production with integrated CO_2-capture compared to the conventional Steam Methane Reforming process (SMR). In this process, reforming, water gas shift and carbonation take place simultaneously in a first reactor (reformer) in presence of a mixture of a reforming catalyst and a CO_2 solid sorbent, and in a second reactor (regenerator) the calcium carbonate formed is decomposed thermally by increasing the temperature to release CO_2. The key advantages of adding a solid sorbent are: an overall process simplification and intensification, a lower reforming temperature and a hydrogen yield in one single step ≥ 95 mol%, dry basis [1].

In the last years, extensive work has been carried out in the development of synthetic CaO-based sorbents showing a stable and higher sorption capacity than natural sorbents, as well as better mechanical properties. In particular, CaO-based sorbents using mayenite ($Ca_{12}Al_{14}O_{33}$) as a stable matrix have shown a very promising multi-cycle chemical and mechanical stability [2]. Recently, with the objective to reduce both capital and operation costs by reducing the amount of inert material in the system, but also by reducing the loss of material due to attrition, the material development has been focused on the production of a single particle that contains both the CaO sorbent and the reforming catalyst [3]. Following an agglomeration route, the two materials are combined in one particle creating a 1-particle system.

This work has been focused on the synthesis of Ni-based catalysts suitable for SER processes, using the same support as for the CaO-based sorbent, i.e. mayenite. The mayenite support has been produced using a hydrothermal method. The different catalyst materials have been prepared through impregnation methods, and present Ni-loads between 5 and 18wt. %. The materials have been characterised, and their catalytic activity has been tested in a micro fixed bed reactor. The effect of reaction temperature (600-750 ºC), Steam/Carbon (S/C) ratio (2-4) and the effect of regeneration conditions (high temperature 850 ºC, and dry and wet atmospheres) on the gas product composition has been assessed. The results indicate that the materials are able to produce equilibrium H_2 concentrations for temperatures close to 700 ºC and for S/C-ratios between 2 and 4, even for the lower Ni-loads tested. The materials also showed satisfactory operation after cyclic testing alternating between reforming and wet regeneration conditions.

References

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