SiC-based structured catalysts for a high-efficiency electrified dry reforming of methane

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INTRODUCTION

The process of dry reforming of methane (DRM) can allow the conversion of CH_4 and CO_2, the two main greenhouse gases, into syngas. However, the heat required for the reaction is obtained by combustion of fossil fuels, so CO_2 footprint of the process is significant. One more issue of the process concerns the heat transfer to the catalytic volume: for allowing the catalytic bed to reach and maintain the reaction temperature, the heating medium outside the tubes containing the catalyst must have a temperature higher than 1000°C. This work proposed the intensification of DRM process by combining (i) the use of electrification for the energy supply (microwave heating, MW, and ohmic electrification, OE) and (ii) the adoption of Ni-based structured catalysts with high thermal conductivity, prepared starting by a Silicon carbide (SiC) honeycomb monolith and a Si-SiC open-cell foam.

EXPERIMENTAL/THEORETICAL STUDY

In this work, Ni-based catalysts, were prepared starting by a Silicon carbide (SiC) honeycomb monolith and a Si-SiC open-cell foam. The catalysts were characterized by means of several techniques and tested in the MW-assisted methane steam reforming reaction. Furthermore, the energy balance of the entire process was performed to calculate the energy efficiency, making a preliminary evaluation of its feasibility in distributed hydrogen production also possible.

RESULTS AND DISCUSSION

The results of the experimental tests (Figure 1), performed at different space velocity values, have shown that the SiC monolith is more suitable than the Si-SiC foam for a MW-assisted catalytic test, with a higher energy consumption of the latter (8.29 kWh/Nm^3 H_2 and 4.2 kWh/Nm^3 H_2, for the foam and the monolith respectively). Moreover, the monolith-based catalyst approached the thermodynamic equilibrium values in terms of CH_4 conversion (X_{CH4}) in all the investigated temperature range, while in the same tests the foam-based catalyst reached these values only at the higher temperatures. Conversely, the foam-based catalyst has shown the best performance in the OE tests: the CH_4 conversion approached the equilibrium values in the investigated temperature range and, more important, the energy consumption value was of 2.6 kWh/Nm^3 H_2. This value is lower than that of other electrified processes in literature, as well as than that of the commercial electrolysers.

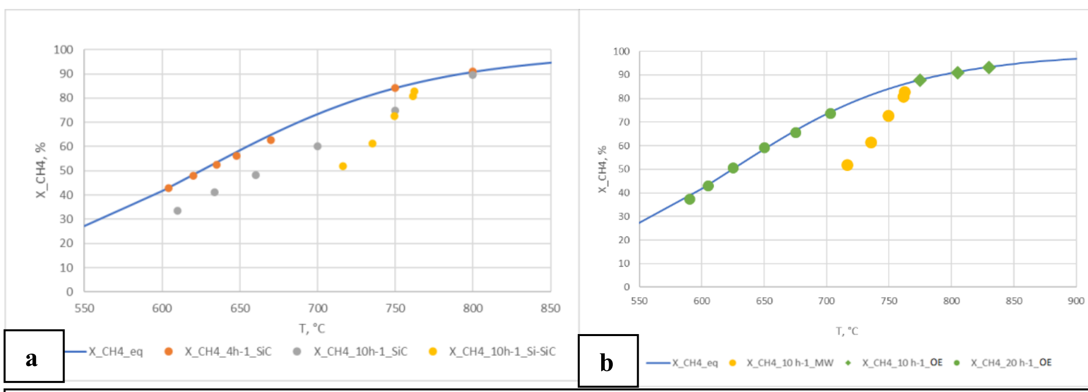

Figure 1. a) X_{CH4} vs T in MW-assisted experimental tests, b) Comparison in terms of X_{CH4} vs T for MW and OE experimental tests performed by using the Si-SiC based catalyst

CONCLUSION

These results highlighted how an effective and feasible process intensification is possible with this innovative system, in particular for a distributed hydrogen production. Future studies will deal with the microwave reactor optimization, aiming at the increase of the energy efficiency of the system, as well as to obtain a higher CH_4 conversion at lower temperatures and increase the H_2 yield and selectivity.

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