Study of intensified and electrified reactors for low-carbon hydrogen production

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This research project aims to contribute to the decarbonisation of hydrogen production by testing and modelling a novel reactor configuration for intensified and electrified steam biogas reforming. This system maximises the H_2 yield from a renewable C-feedstock and allows its distributed production due to the wide availability of biogas. The reactor is based on the use of conductive (Cu) periodic open cellular structures (POCS) in thermal contact with heating wires and packed with highly active Rh-based catalyst particles. The enhanced heat transfer provided by the copper matrix ensures almost flat radial temperature profiles and therefore optimal catalyst usage. This concept has been demonstrated by performing steam biogas reforming in a laboratory scale reactor, see Figure 1 A-C. The system was able to achieve thermodynamically controlled conditions at 3x Gas Hourly Spaced Velocity (GHSV) compared to the reference industrial process and was operated at volumetric heat duties greater than 5 MW/m^3. Finally, the specific power demand of the electrified reformer is ¼ that of the state-of-the-art electrolyzers [1].

The reactor will be scaled up and experimentally tested in a multi-wire configuration able to reach a productivity of 8 Nm^3H_2/h, see Figure 1D; and an engineering mathematical model will be coupled with detailed CFD simulations of the unit to optimize the heating wire pattern. The further development of industrial units will be useful for the design of intensified reactors for other endothermic reactions relevant to the hydrogen economy, e.g. NH_3 cracking.

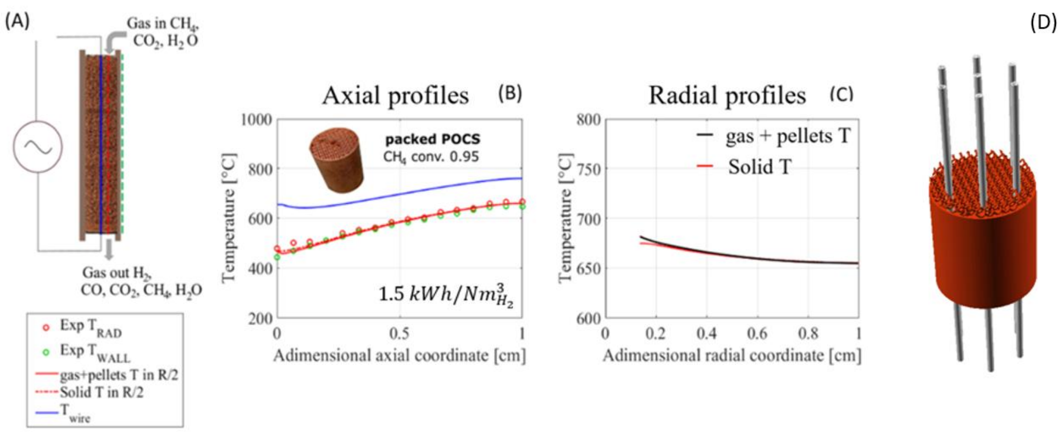

Figure 1 *(A) Scheme of the lab-scale electrified reactor for biogas reforming with packed POCS; (B) Axial temperature profiles: experimental (dots) and model predictions (lines); (C) Radial temperature profiles in steam biogas reforming; (D) Scaled up multi-wire tubular unit.*

References

[1] G. Ferri, M. Ambrosetti, A. Beretta, G. Groppi, E. Tronconi, *Low-carbon H_2 production via electrified biogas steam reforming in conductive structured reactors,* submitted to Chemical Engineering Journal

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