Intensified methanation (SEsSaR) with Ni-Fe based catalysts for biogas upgrading

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ENERGY CHALLENGE

Reducing carbon emissions is more critical than ever, but at same time renewable energies are still strongly limited by the difficulties of ensuring the capacity of supplying the energy demand, or how to store the surplus electricity to solve the intermittence of renewables. Moreover, it has been shown the need of reducing the European energy model dependency of international providers (e.g., natural gas).

ALTERNATIVES

Power to Gas technologies (PtG) can transform methane, renewable H₂ using surplus electricity from renewable origin [1]. Through methanation reaction (Sabatier reaction, r.1), a high purity synthetic natural gas (close to 100%) can be obtained from concentrated CO₂ streams (i.e., biogas -ca. 30% CO₂+70% CH₄). The upgraded biogas could fulfill all the regulatory parameters imposed by codes and normative. Moreover, methane (Synthetic Natural Gas, SNG) is an energy vector easier to transport and storage than hydrogen. In fact, the technology required to adapt the preexisting natural gas network to SNG is relatively simple, being an interesting substitute of natural gas. On the contrary, H₂ admissible for preexisting natural gas is limited to a maximum concentration of 10% in the total flow [2].

INTENSIFICATION

Sorption Enhanced Sabatier Reactor (SEsSaR) with zeolites incorporates the use of water adsorbent solids in order to in situ remove the water produced by (r.1), trying to push up its thermodynamical equilibrium (i.e., Chatelier’s principle). Thus, reaction shift to products, increases the CO₂ conversion and warily the selectivity to CH₄.

FEASIBILITY CASE STUDY

CREG group has developed a feasibility case study for methanation technology of the resulting biogas from a waste management plant for ca. 84000 inhabitants [3]. The study was based on CAPEX/OPEX analyses in order to obtain the breakeven point price of the synthetic natural gas produced. Simulation showed a breakeven point of 69 €/MWh in 2021. In October 2021, the average price for importing natural gas in the Iberian market was 89.25 €/MWh [4], and during the first trimester of 2022, natural gas in the Iberian gas market exceeded 100 €/MWh.

RESULTS AND DISCUSSION

- The Ni-Fe catalyst showed a good conversion to CH₄ allowing to decrease the operational cost in comparison with a conventional nickel catalyst.
- An important improvement in the CO₂ conversion has been shown by replacing the inert solid in the packed bed with 5A LTA zeolite.
- Increasing temperature on the desorption steps (e.g., D2) has been observed as a feasible way in the recovery of the adsorption capacity of the zeolite.
- The highest conversion enhancing effect is observed at 400 °C.
- Feasibility case study showed a breakeven point €9/MWh when the importing natural gas price market for the same time period was 89.25 €/MWh.

ACKNOWLEDGEMENTS

This work has been carried with financing of the project P12019-20000988-000 by Xunta de Galicia, Spain, through FEDER.

Also VMR expresses his gratitude for the grant PRE2020-035679