# $CO_2$ methanation as a strategy for green $H_2$ storage and distribution: experimental optimisation and process design

M. Tommasi[1], A. Gramegna[1,2], S. Romegialli[1,2], G. Ramis[3], I. Rossetti[1,2]
[1] Chemical Plants and Industrial Chemistry Group, Dip. Chimica, Università degli Studi di Milano and CNR-SCITEC, Milan, Italy.
[2] INSTM Unit Milano-Università, Dip. Chimica, Università degli Studi di Milano, Milan, Italy
[3] Dip. DICCA, Università degli Studi di Genova and INSTM Unit-Genova, Genoa, Italy

## Abstract

The aim of this work was to synthesise, characterise and test catalysts for $CO_2$ methanation with the final aim of deigning a $CO_2$ methanation plant offering a strategy for green $H_2$ storage and distribution.
Ni-based catalysts were prepared with different composition. The supports were $Al_2O_3$, $SiO_2$, ZSM5, $CeO_2$, $TiO_2$, $ZrO_2$ and MgO, with different Ni loadings (6%, 16%, 25%, 36%, 45% and 94%). The samples were synthesised using various procedures. Comparisons were also made on the same support from different manufacturers and with different specifications.
The catalysts were characterised using different techniques. BET, XRD, FT-IR, SEM EDS, DRS, XRD, Raman and *operando* DRIFTS. All the catalysts were first screened in an ambient pressure continuous plant and the products were analysed with an on-line GC. For each catalyst, $CO_2$ conversion and $CH_4$ selectivity were assessed over a temperature range from 200 to 550°C. The most promising samples were also tested at higher pressure and under widely variable reaction conditions.
The experiments confirmed the superior activity and selectivity of $CeO_2$ over the other supports tested, in particular achieving 86% conversion and 100% methane selectivity at 345°C ambient pressure.
The results allowed the sizing of a pilot and a commercial scale plant through Aspen Plus process simulator.

GR and IR are grateful to NextGenerationEU and to the Italian ministry MASE (ex MITE bando A) through the PNRR, Missione 2 Componente 2 investimento 3.5 measure funding the project “Stoccaggio e distribuzione di idrogeno attraverso una strategia “power-to-gas/gas-to-power” con cattura ed utilizzo completi del carbonio - Hydrogen storage and distribution through power-to-gas strategy, with full carbon capture and utilization”.
The authors gratefully acknowledge the financial contribution of Tasks 8.2.3 and 8.4.1 of the Agritech National Research Center, funded from the European Union NextGenerationEU - PNRR – Missione 4 Componente 2, Investimento 1.4 – D.D. 1032 17/06/2022, CN00000022.
IR acknowledges Università degli Studi di Milano for support through the grant PSR 2021 - GSA - Linea 6 “One Health Action Hub: University Task Force for the resilience of territorial ecosystems”.