# Renewable $CH_4$ production via $CO_2$ hydrogenation over mono- and bi-metallic Ru-Ni/MCM-41 catalysts.

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*TOPIC:* **Greenhouse gases mitigation by $H_2$**

## ABSTRACT

Since fossil fuels still remain the dominant source of energy in the industrial, commercial, residential, and transportation sectors, tremendous quantities of $CO_2$, the major greenhouse gas, are emitted into the atmosphere, raising its concentration from ~280 ppm before the industrial revolution to ~410 ppm nowadays. Predictions indicate a concentration of $CO_2$ ~570 ppm by the end of the century with the concomitant global warming and climate change to seem threatening, if no urgent mitigating actions implemented. Therefore, control of $CO_2$ emissions is a critical and urgent environmental issue. A possible solution for moderating $CO_2$ emissions can be provided by energy models with a reduced environmental footprint that can also be combined with the so-called *cyclic economy* strategies. $CO_2$ capture and utilization (recycling), through its conversion to added-value products and fuels, are nowadays among the approaches that receive intense research and technological interest. To this purpose, $CO_2$ hydrogenation toward methane production, the well-known Sabatier reaction, is a major topic, especially when the hydrogen demands for $CO_2$ methanation can be provided via a solar- or wind-powered water-splitting system, thus further expanding the eco-friendly and sustainability character the concept, often called the *power-to-gas* (P2G) process. P2G is also considered as a promising method for the storage of hydrogen, overcoming the safety difficulties of direct storage and transport of hydrogen. Here we report on $CO_2$ hydrogenation toward methane, investigated at 200–600 °C and $H_2/CO_2$ = 4/1 v/v, over mono- and bi-metallic Rh-Ni based catalysts supported on mesoporous silica MCM-41. Nickel was incorporated in-situ into the MCM-41 lattice (denoted as Ni-MCM-41 support), while the wet impregnation method was used as a second step for adding Ru on the Ni-MCM-41, using two different Ru precursors, namely $RuCl_3$ and Ru(III)-acetylacetonate. This enabled us to investigate in detail the effect of catalyst's design aspects (i.e., Ru precursor used, Ru/Ni molar ratio, the pre-incorporation of Ni into MCM-41 lattice), as well as reaction operational parameters (i.e., temperature, gas hourly space velocity, time-on-stream stability) on $CO_2$ methanation activity and selectivity performance. A plethora of characterization techniques, such as $N_2$ adsorption-desorption methods, isothermal $H_2$-chemisorption, hydrogen temperature programmed reduction ($H_2$-TPR), powder X-ray diffraction (pXRD), scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), and Fourier-transform infrared spectroscopy (FTIR), were applied in order to obtain well-documented structure-activity correlations for the investigated ($CO_2$+$H_2$)/Ru-Ni-MCM-41 catalytic system.

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