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Thermal and plasma-catalytic CO2 methanation over nanostrucured Ni/CeO2

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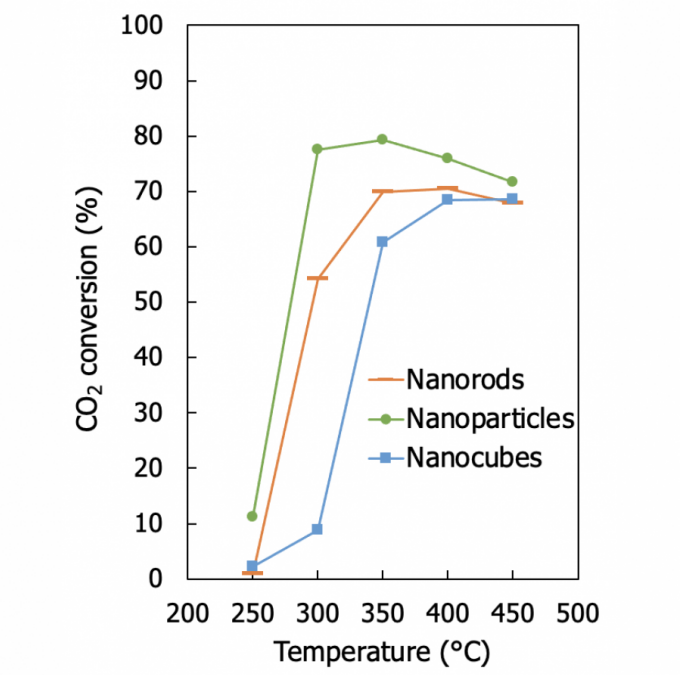
PURPOSE OF THE ABSTRACT

CO2 capture and utilization (CCU) is one of the main strategies to be developed in the direction of low-carbon budget and circular economy. With CCU, CO2 is no longer considered as a waste molecule but as a reservoir of carbon to be exploited as building block for added-value compounds, for instance vector molecules for harvest of energy in the Power-to-gas technology [1]. Power-to-gas concept is beneficial for the development of electricity generation from renewable sources, which are seasonal and unpredictable, and therefore need an energy carrier or buffer, such as hydrogen. Due to the current limitations in the storage and utilization of hydrogen as a fuel, the reaction between H2 and CO2 to produce recycled hydrocarbons can be advantageous to obtain more stable and efficient carriers. In this scenario, Sabatier's reaction of CO2 methanation is experiencing a renaissance for the development of Power-to-Methane and the production of synthetic fuels [2] . CO2 methanation is exothermic but kinetically hindered, hence it requires a suitable catalyst for activation and selective conversion. In thermal heterogeneous catalysis the reaction typically operates between 200°C and 450°C, at pressure between atmospheric and 100 bar. The increase of temperature improves the CO2 conversion but lowers the selectivity toward CH4 and in addition causes catalyst deactivation. Recently, besides the efforts done in the conventional thermal catalysis field, novel methods for CO2 hydrogenation have been investigated: electrocatalysis, photocatalysis, and plasma-assisted catalysis. It has been demonstrated that the use of a non-thermal plasma in combination with a Ni-containing catalysts results in an enhanced methane yield even at atmospheric pressure and mild reaction temperatures [3]. The study of synergy between plasma and catalytic materials represents a challenge but it is also very promising for the advancement of Power-to-gas technology.

In this study, Ni catalysts were prepared with nanostructured CeO2 supports and tested for CO2 methanation in a U-type tubular fixed bed reactor and in a packed dielectric barrier discharge (DBD) reactor in order to study the catalytic behaviour of Ni/CeO2 materials in thermal and plasma-assisted processes. The nanoscale morphologies of CeO2, namely nanoparticles (NP), nanorods (NR) and nanocubes (NC), were obtained through the modification of their hydrothermal synthesis conditions and the Ni phase (15% weight) was introduced via wet impregnation. The catalysts were characterized by means of XRD, XPS, SEM, H2 TPR, CO2 TPD, TGA, and N2 physisorption before the reaction as well as post mortem to assess their physicochemical properties and possible modifications. We report that the synthesis conditions of the CeO2 supports influence their catalytic performance and we observe that the key structural and chemical features for a good activity differ in thermal and plasma-assisted methanation. For instance, the support morphology has an impact on the properties of the catalysts and the yield in CO2 methanation. Figure 1 and 2 show the different conversion obtained over the Ni/CeO2 catalysts, ranking as NP>NR>NC in thermal and NR>NP>NC in plasma-assisted reaction.

FIGURES



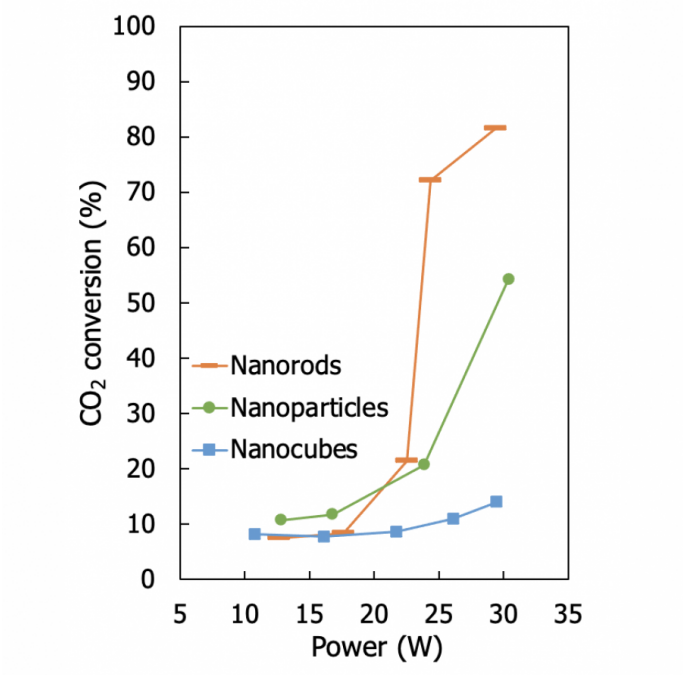


FIGURE 1

Catalytic performance in thermal CO2 methanation of Ni/CeO2 NC, Ni/CeO2 NR, and Ni/CeO2 NP.
CO2/H2/Ar 3/12/5
Total flow 100 mL/min
WHSV 30000 ml h-1 g-1

FIGURE 2

Catalytic performance in plasma-assisted CO2 methanation of Ni/CeO2 NC, Ni/CeO2 NR, and Ni/CeO2 NP.
21-24 kV, 12.3 kHz
CO2/H2 1/4
Total flow 100 mL/min
WHSV 30000 ml h-1 g-1

KEYWORDS

Power-to-gas | Plasma catalysis | CO2 capture and utilization | Cerium oxide

BIBLIOGRAPHY

[1] Artz, J., Chem. Rev. 2018, 118, 434–504.
[2] Rönsch, S., Fuel 2016, 166, 276–296.
[3] Mikhail, M., Catal. Sci. Technol., 2020, 10, 4532-4543