# REMARKABLE LOW-TEMPERATURE $CO_2$ METHANATION ACTIVITY OF Ni/$CeO_2$-NANOROD CATALYSTS WITH TUNABLE PARTICLE SIZE

**E. Mandela*[1], G.Varvoutis[1], A.A. Dabbawala[2,3], A.G.S. Hussien[2,3], M. Lykaki[4], A. Lampropoulos[1], K. Polychronopoulou[2,3], G.E. Marnellos[5,6], M. Konsolakis[4]**

[1] Department of Mechanical Engineering, University of Western Macedonia, Kozani, Greece

[2]Department of Chemical Engineering, University College London, London, United Kingdom

[3]Department of Mechanical Engineering, Khalifa University of Science and Technology, Abu Dhabi, United Arab Emirates

[4]School of Production Engineering and Management, Technical University of Crete, Chania, Greece

[5]Department of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

[6]Chemical Process and Energy Resources Institute, CERTH, Thessaloniki, Greece

(*e.mandela@uowm.gr)

## ABSTRACT

During the last decades, $CO_2$ hydrogenation towards methane stands out as a promising strategy, with the dual purpose of utilizing captured industrial $CO_2$ emissions and excess RES-powered electrolytic $H_2$. Consequently, the produced synthetic $CH_4$ is considered as a carbon neutral energy carrier, effectively harnessing the intermittence of renewable energy sources, such as solar and wind[1]. Among the most explored catalysts for this process, nickel-ceria systems are characterized by many advantageous characteristics, such as their enhanced redox properties, abundant oxygen vacancies, thermal stability and are easily tuned, while their low-cost compared to noble metal based catalysts facilitates their further scalability[2]. Recently, it has been demonstrated that nanostructured ceria, namely ceria nanorods, exhibit superior catalytic behavior due to their exposed crystal facets that comprise various beneficial redox and electronic properties[3]. On the other hand, although modifications in the metallic phase could lead to higher dispersions and more active centers, it could also favour the CO production through the rWGS reaction [4]. Therefore, a balance between the particle size and optimal metal-support interactions should be achieved to develop highly active and selective catalysts for $CO_2$ methanation. In this work, the remarkable low-temperature $CO_2$ methanation activity of Ni/$CeO_2$-nanorod catalysts with variable particle size induced by the citric acid concentration during their synthesis is reported. Various complementary characterization techniques, namely $N_2$ physisorption, XRD, Raman spectroscopy, HR-TEM, $H_2$-TPR, $CO_2$-TPD, $H_2$-TPD, and XPS, were employed to assess the structure sensitivity of the developed catalysts for the $CO_2$ methanation reaction.

**KEYWORDS:** $CO_2$ Hydrogenation, Ni/$CeO_2$, Citric acid assisted synthesis, Ni Dispersion

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## REFERENCES

[1] Götz M, Lefebvre J, Mörs F, McDaniel Koch A, Graf F, Bajohr S, Reimert R, Kolb T. (2016). *Renew. Energy*, 85, 1371–1390.

[2] Han F, Liu Q, Li D, Ouyang J. (2023). *J. Environ. Chem. Eng*., 11, 110331.

[3] Konsolakis M, Lykaki M, Stefa S, Carabineiro S A C, Varvoutis G, Papista E, Marnellos G E. (2019). *J. Nanomater*, 9(12):1739.

[4] Varvoutis G, Lykaki M, Stefa S, Binas V, Marnellos G E, Konsolakis M. (2021). *Appl. Catal., B*, 297, 120401.