Physicochemical and electrical characterization of a CeO_2-based nanostructured catalysts for plasma-assisted CO_2 methanation in a DBD reactor

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Among the different processes for the chemical utilization of CO_2, its methanation stands as a promising technology allowing both the synthesis of a carbon-neutral fuel and the storage of off-peak renewable electricity (power-to-gas concept). The methanation reaction is exothermic but strongly hindered by kinetics. It has been recently demonstrated that the use of a non-thermal plasma in combination with a Ni-containing catalyst results in an enhanced methane yield even at atmospheric pressure and mild reaction temperatures (around 200°C) [1]. Plasma-catalyst coupling still represents one of the biggest challenges. Two different efforts for catalyst optimization should be developed side by side to improve performance and energy efficiency: first, tailoring the physicochemical properties, such as area and basicity of the surface; secondly, considering the conductivity and electrical behaviour of the material packed in the dielectric barrier discharge (DBD) reactor when in contact with plasma. In the present study, different Ni catalysts supported on synthesised nanostructured CeO_2, were used to pack a DBD reactor and tested for plasma-assisted CO_2 methanation. The focus was on the contribution of physicochemical properties and conductivity of the packing material to the electrical behaviour in plasma characterized by Q-V Lissajous figure analysis and plasma current amplitude. The catalyst selection paradigm in plasma catalysis changes compared to thermal CO_2 methanation. The Ni/CeO_2 catalyst that possesses optimized surface area (70 m^2/g), basic sites (medium strength), and particle size (smallest Ni and CeO_2 particle), which are the ideal properties for thermal catalysis according to literature, is not the most efficient in the plasma-assisted reaction. This is due to the electrical behaviour and conductivity properties, as this packing material leads to higher capacitance and larger charge transferred, conditions that are unfavourable for the reaction in plasma.

References

[1] R. Dębek et al., Renewable Sustainable Energy Reviews **116** 109427 (2019)

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