$Ni_{50}Co_{50}$ NANOPARTICLES SUPPORTED ON γ-Al_2O_3 FOR INDUCTION HEATED REFORMING REACTIONS

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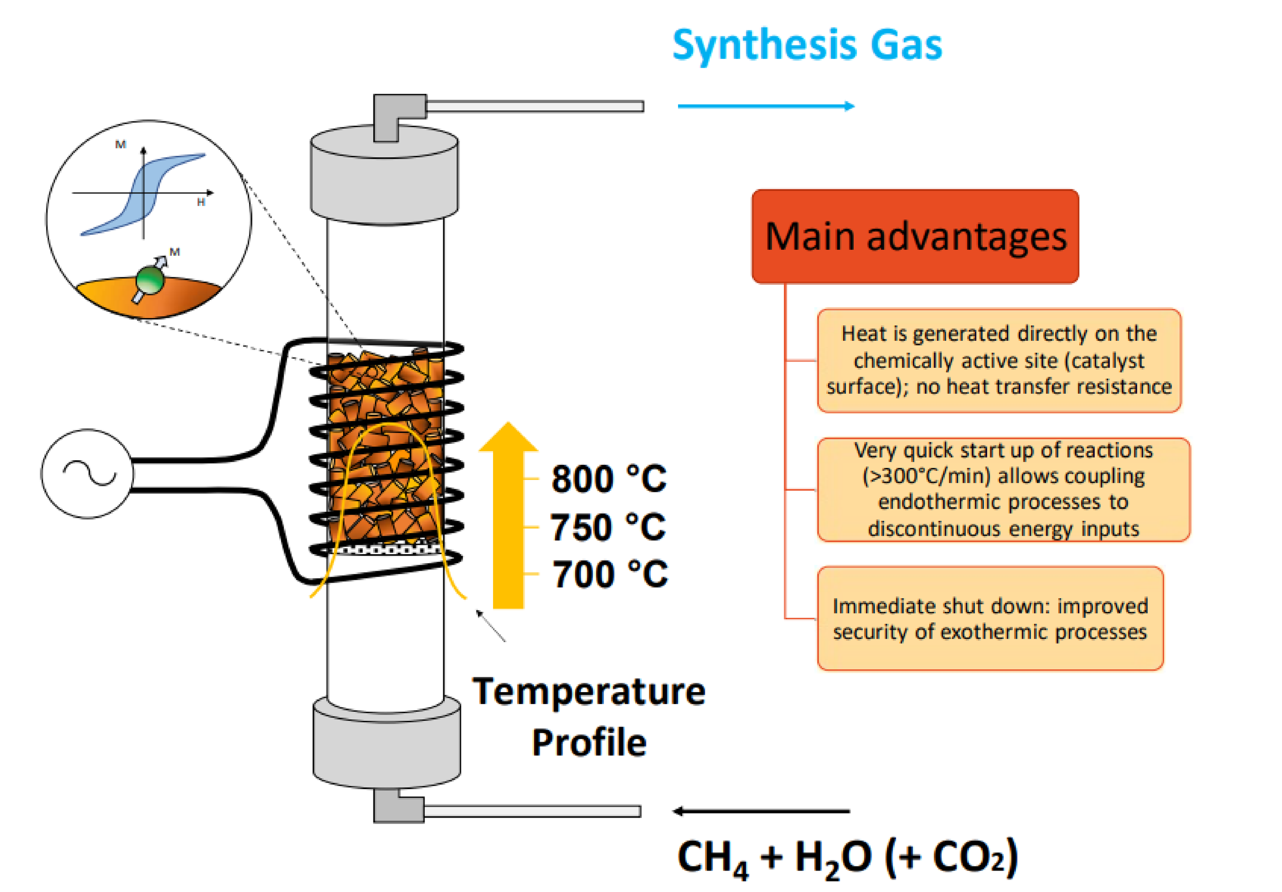
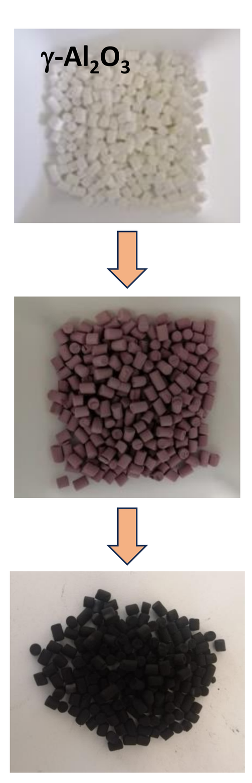
Reforming reactions are presently the main route to hydrogen production. Due to thermodynamic constraints, temperatures higher than 750°C are commonly utilized to achieve high equilibrium conversions. It follows that the productivity of reforming plants is very dependent on how efficiently heat can be transferred to the catalytic bed.
Among the different energy transfer options, induction heating is a technology well known for its high efficiency. Magnetic materials immersed in a r.f. field convert electromagnetic energy into heat that can be utilized to power endothermic chemical processes.
At the scope, a catalyst composed by NiCo nanoparticles supported on commercial γ–Al_2O_3 pellets was developed. **The metallic nanoparticles act at the same time as heating agents and catalysts for the reforming processes**. In such a way the heat of reaction is provided instantaneously and remotely on the chemically active site limiting dissipation due to inefficient transfer from outside the reactor.



Chemical processes powered by magnetic induction

Synthesis of NiCo nanoparticles supported on γ–Al_2O_3 catalyst support

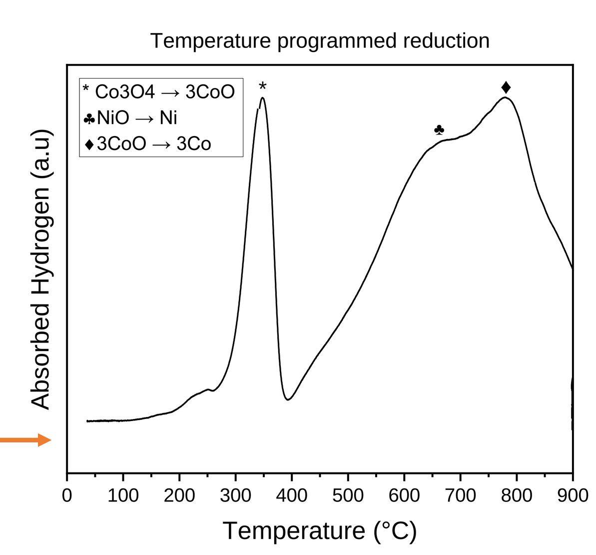


Wet impregnation: Ni and Co nitrates solution (5M) and metal ratio 50:50

Calcination: T= 600 °C, 1h, in air flow

Reduction:T= 900 °C, 5h, in Ar- H_2 (3%)

% wt Me tot (AAS)	% wt Ni (AAS)	% wt Co (AAS)
25	12,5	12,5



Catalytic perfomances

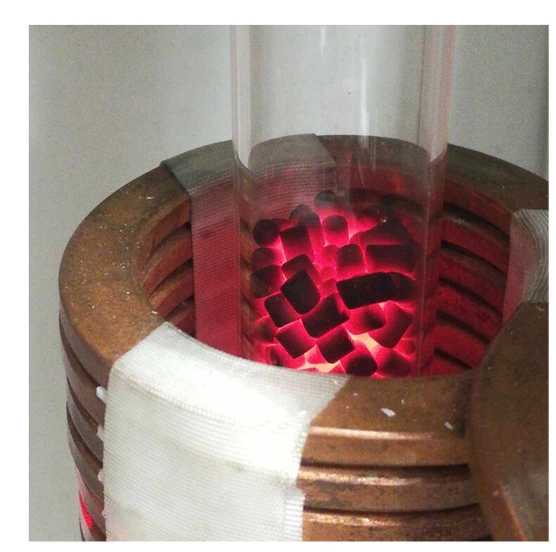
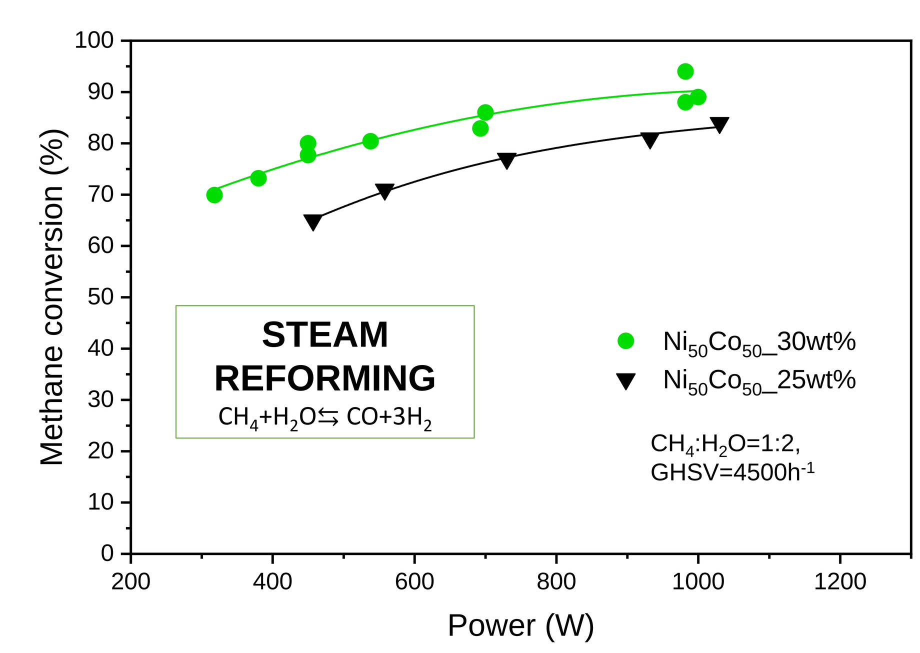
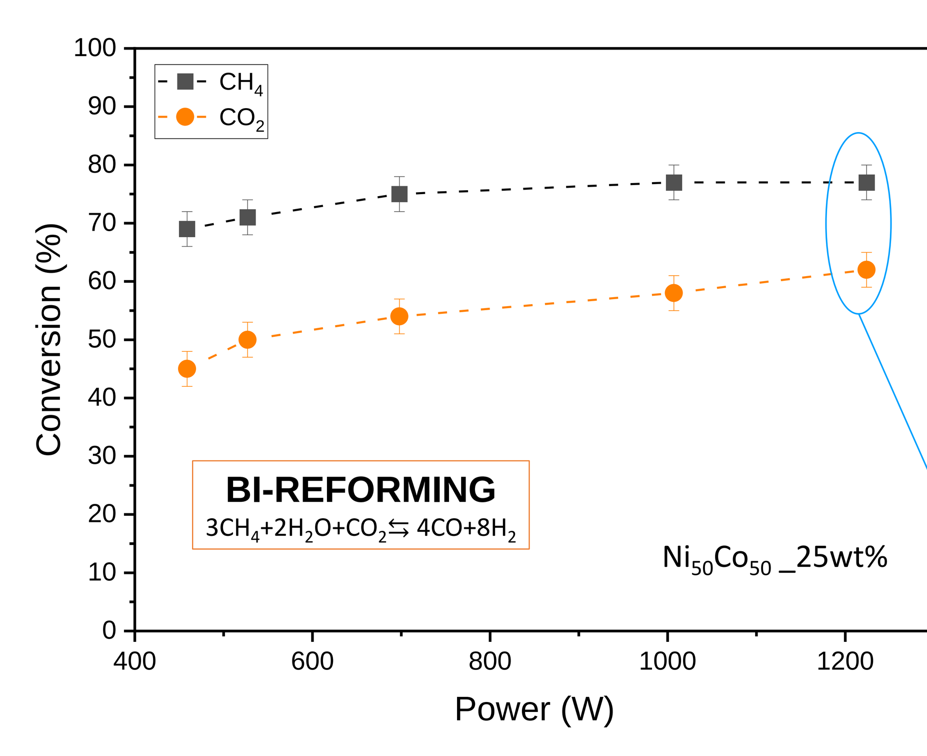


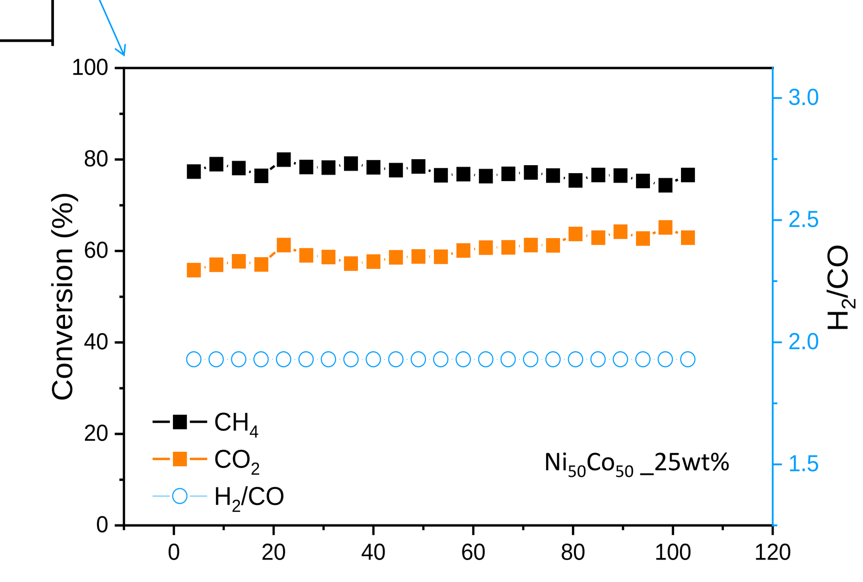
Image of the magnetic catalytic bed during steam methane reforming process powered by induction heating. Temperature (measured by IR pyrometer) exceeds 750°C. Sample:180 pellets (~5g)



Methane conversion increases as a function of the power applied to generate the magnetic field. Under the same magnetic field condition, a higher metal loading favors the attainment of higher temperatures, and therefore higher conversion, as the number of dissipating agents increases.

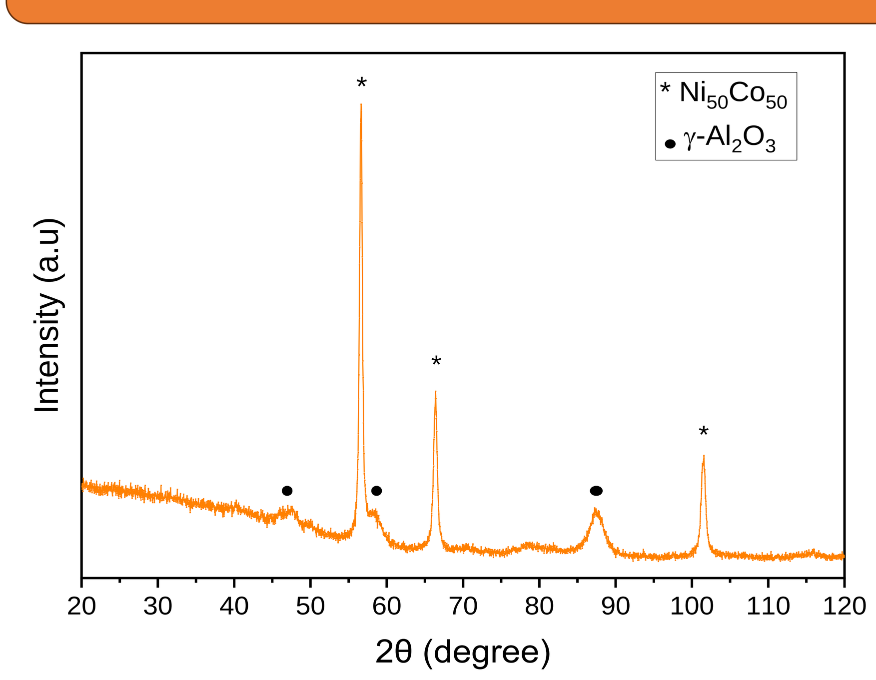


Methane and carbon dioxide conversion reach 75% and 55% at 700W (23mT). Further increase of the applied power does not appear to have marked effect on conversion due to limit in the achievable temperature (755°C) in this experimental conditions.H2/CO approaches 2

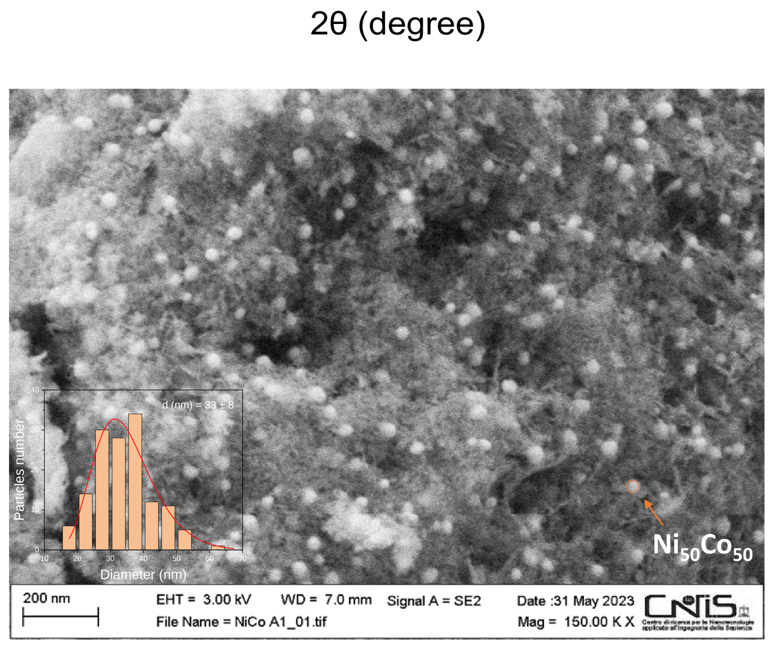


Experimental conditions: Sample 180 pellets (~5g). GHSV= 5870 h^{-1}. Applied field B ~ 22,6 mT, P= 1200W, Measured temperature **755°C**. **CH_4:H_2O:CO_2=3:2:1**

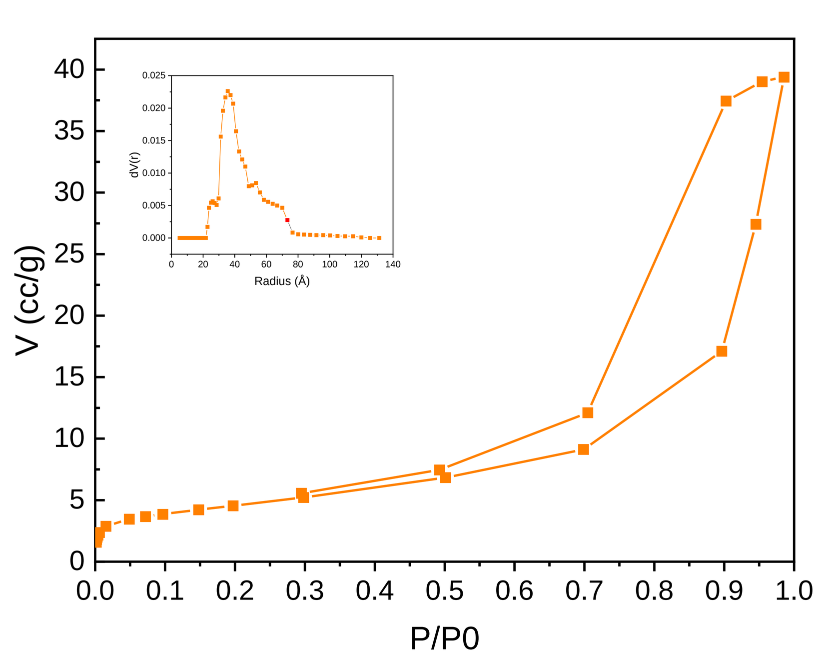
Characterization of supported NiCo nanoparticles



XRD pattern shows only the peaks belonging to a single fcc metallic phase, corresponding to NiCo alloy, and the γ–Al_2O_3 support.



The SEM image shows that, despite the high loading (25 wt%), the metal nanoparticles are uniformly distributed within the porous structure of the alumina. The average particle diameter, evaluated from the size distribution histogram, is in line with the crystallite size calculated from the XRD data, an indication that the metal particles are mostly a single crystalline domain.



Nitrogen adsorption/desorption isotherm at 77K exhibits a type-IV (IUPAC) shape, typical of mesoporous materials (γ–Al_2O_3).
The specific surface of the supported catalyst reduced at 900°C calculated by BET method is 135 m^2g^{-1}.

$Ni_{50}Co_{50}$ nanoparticles have been successfully synthesized and evenly dispersed on γ–Al_2O_3 catalyst support. Ferromagnetic nanoparticles have proven to be an active catalyst to produce H_2 via steam reforming and bi-reforming processes powered by magnetic induction. **Magnetic catalysis** has been applied to high-temperature endothermic processes (T>750°C). From a perspective aimed at the sustainability of production processes and widespread generation of hydrogen which avoids its transport as much as possible, an agile technology is proposed, easy to switch on/off and therefore with increased safety, which allows the production of hydrogen on-demand in small-sized plants.

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C. Scarfiello et al. Int J Hydrogen Energy 46 (2021) 134
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