NANOSTRUCTURED ENDO/EXO PARTICLE MATERIALS FOR ENERGY CONVERSION

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STEM for BRITAIN

Concept

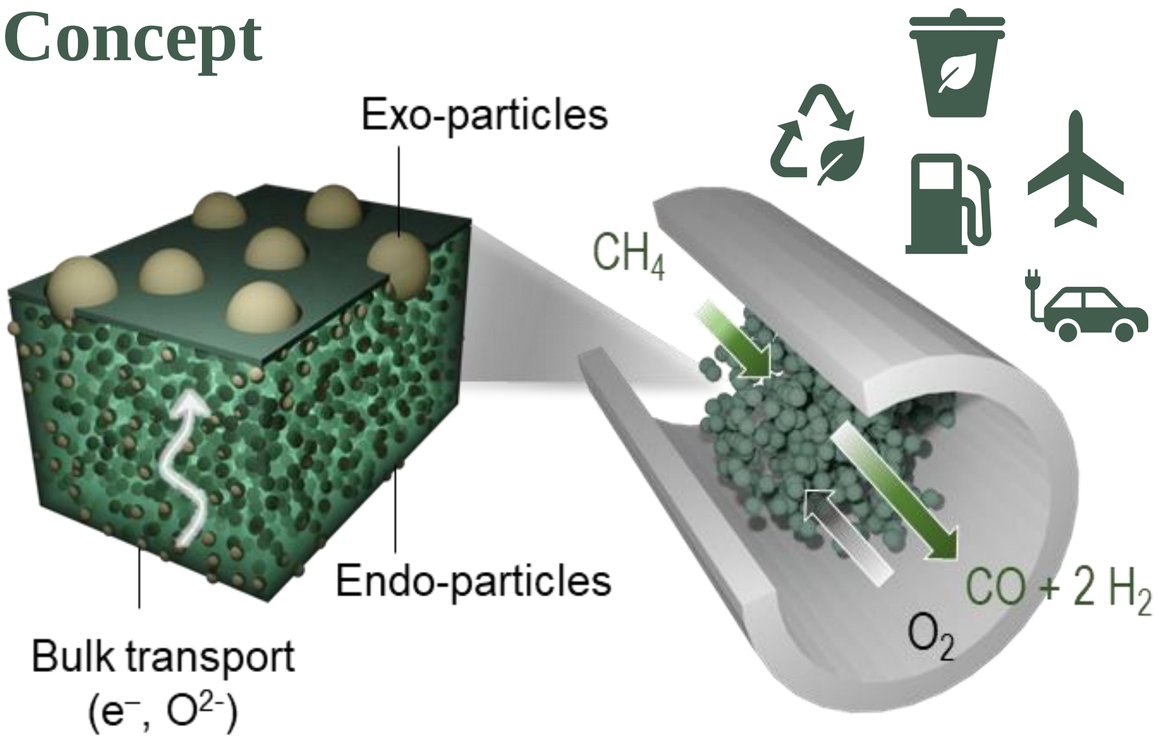


Fig. 1: Schematic of a system with endo/exo particles for cyclic CH_4 conversion to synthetic fuels.

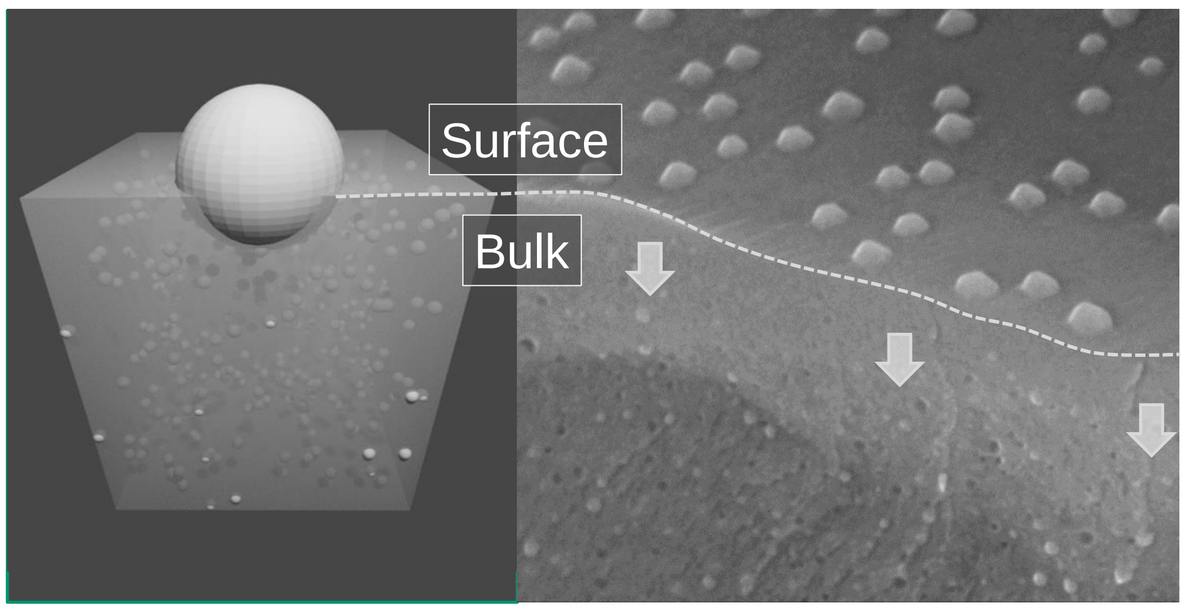
Abstract

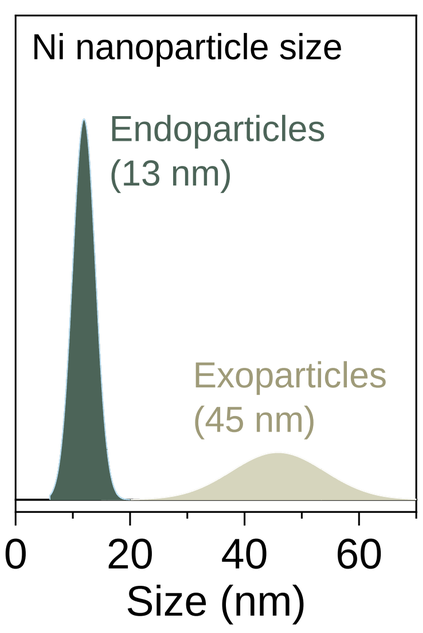
Methane (CH_4), the main component of natural, shale gas and biogas, is predominantly used to produce hydrogen (H_2) generating significant amounts of carbon dioxide (CO_2). An **efficient and environmentally-friendly alternative** is its **conversion to syngas ($CO+H_2$)**, making **synthetic fuels production a viable alternative to crude oil**[1] via a Fischer-Tropsch process.

The conversion of CH_4 to syngas at low temperatures, with no CO_2 (selectivity) or carbon deposition (deactivation) has been a long-standing challenge[2] and has recently been identified as a strategic target in the race for 2050 decarbonisation[3].

We rethink not only **how materials should be nanostructured**, but also **how they should also operate in a reactor**. We use **metallic nanoparticles** as **catalytic centres** at the surface and as **oxygen exchange reservoirs** within oxide supports, buried and **protected against deactivation**, to carry out a cyclic conversion of CH_4 to syngas, 300 ^oC lower than conventionally possible. We combine **operando synchrotron X-ray diffraction** with **gas analysis and electron microscopy** to reveal the nanoscale processes that make this remarkable advance possible[4].

A system with endo/exo particles





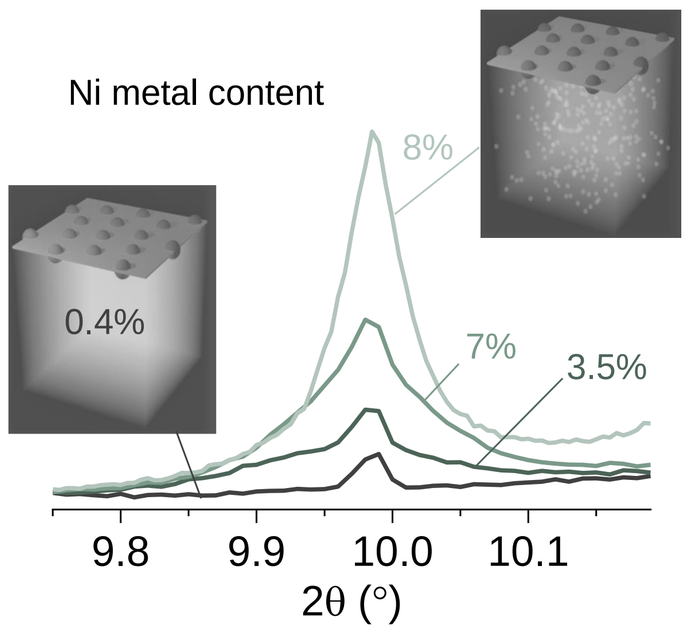
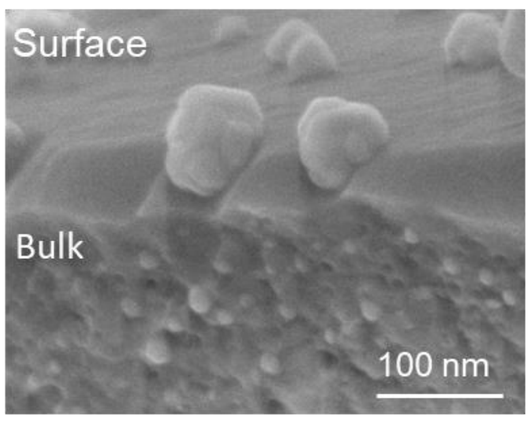
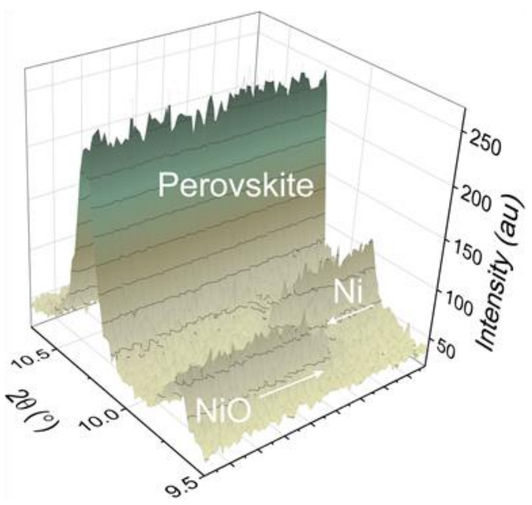


Fig. 2: Creating a system with endo/exo particles, particle size and control of metallic content.

CH_4 to Syngas Operando





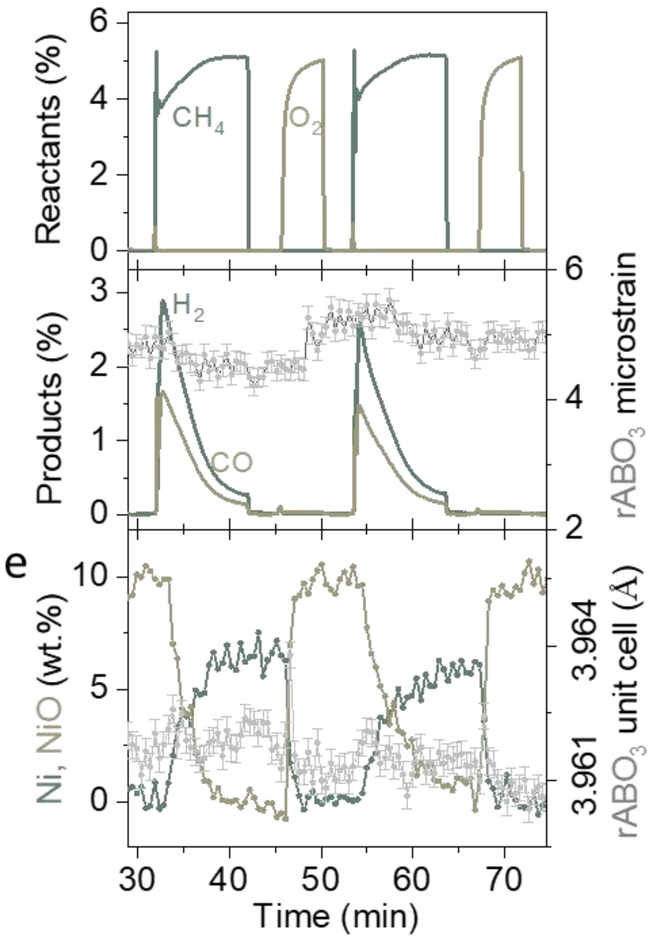


Fig. 3: Monitoring CH_4 conversion to syngas in a cyclic process operando through gas analysis, Ni-NiO wt% and perovskite unit cell.

Stability in operation

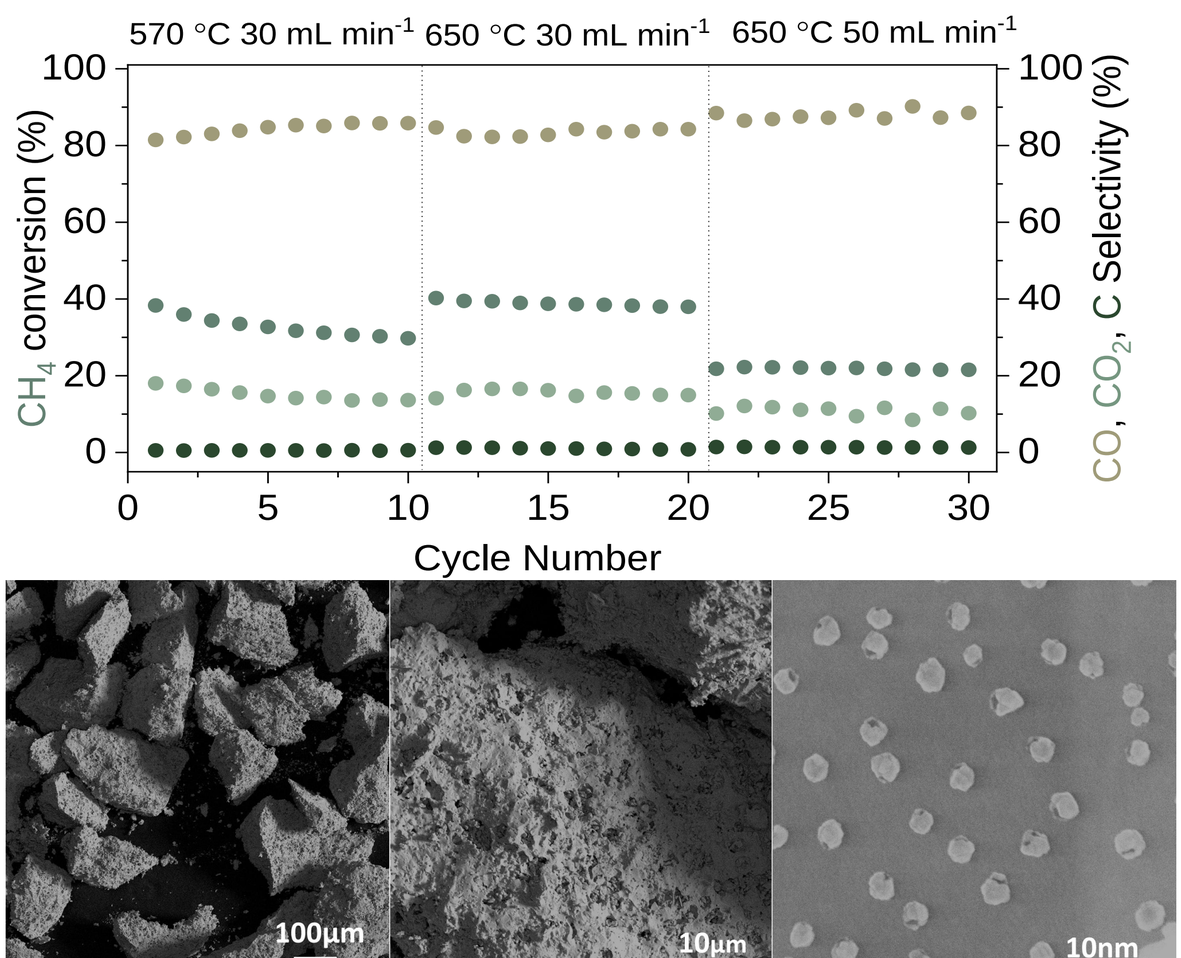


Fig. 4: Long term activity and micro and nano structural stability of a system with endo/exo particles for selective cyclic CH_4 conversion to syngas.

Acknowledgements

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References

1. Nørskov, J. K., et al, Research needs towards sustainable production of fuels and chemicals.
2. Datye, A. K. & Votsmeier, M. Nature Materials 1–11 (2020)
3. M4ET-Roadmap, (2020).
4. Kousi, K et al., Angew. Chem. 59, 2510–2519 (2020)