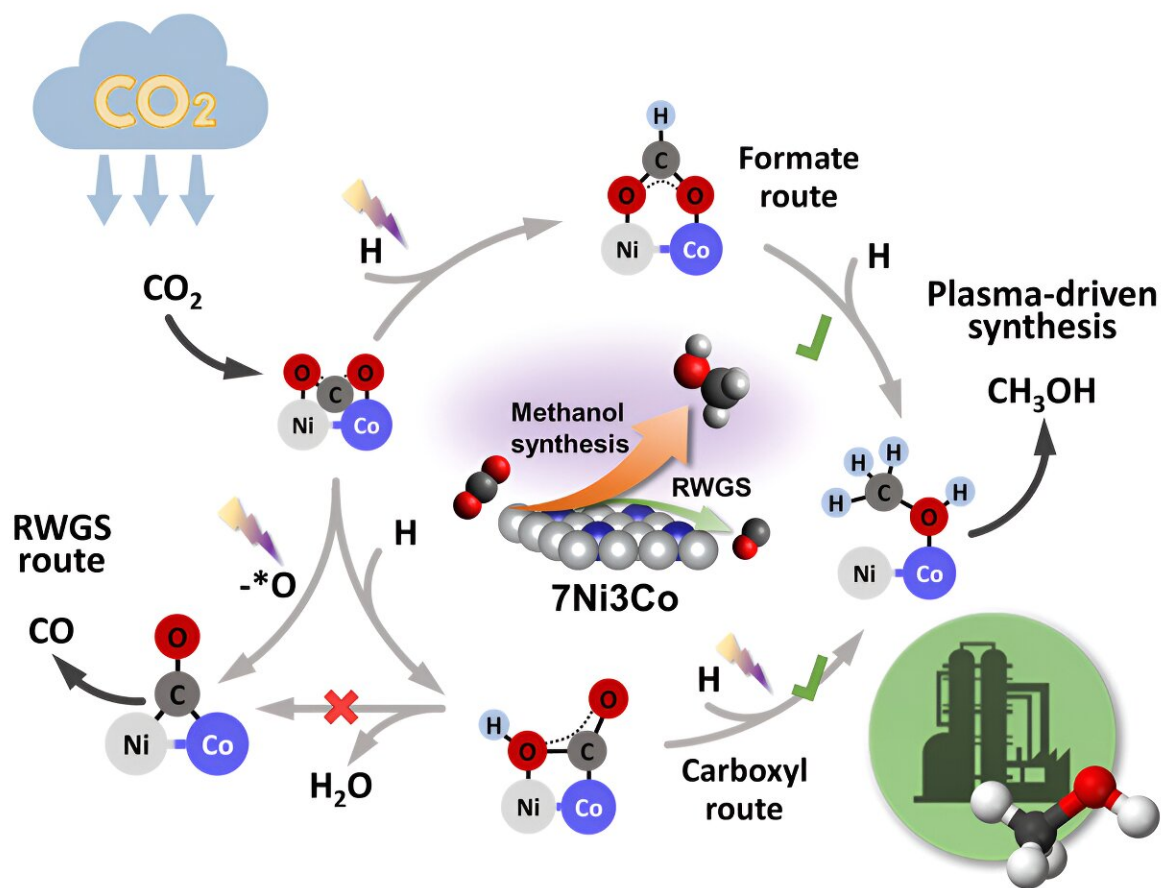


Pioneering plasma-catalytic process for CO₂ hydrogenation to methanol under ambient conditions

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Credit: *Chem* (2024). DOI: 10.1016/j.chempr.2024.06.022

Researchers at the University of Liverpool have achieved a significant milestone in the conversion of carbon dioxide (CO₂) into valuable fuels and chemicals, marking an important step towards a sustainable net-zero economy.

In a [paper](#) published in the journal *Chem*, the team reports a pioneering [plasma](#)-catalytic process for the hydrogenation of CO₂ to [methanol](#) at room temperature and atmospheric pressure.

This breakthrough addresses the limitations of traditional thermal catalysis, which often requires high temperatures and pressures, resulting in low CO₂ conversion and methanol yield.

The novel process utilizes a bimetallic Ni-Co catalyst within a non-thermal plasma reactor to achieve an impressive single-pass 46% selectivity for methanol and 24% CO₂ conversion at 35 °C and 0.1 MPa.

Non-thermal plasma, an ionized gas containing energetic electrons and reactive species, can activate strong chemical bonds of inert molecules like CO₂, facilitating [chemical reactions](#) under [mild conditions](#).

In addition, plasma-based modular systems can be turned on and off instantly, offering great flexibility to use intermittent renewable electricity for decentralized production of fuels and chemicals.

Professor Xin Tu, Chair in Plasma Catalysis at the University of Liverpool, said, "Our work demonstrates that plasma catalysis offers a

flexible and decentralized solution for CO₂ hydrogenation to methanol under ambient conditions.

"Our recent techno-economic assessment also shows that this process can significantly reduce the [capital costs](#) compared with traditional thermal catalytic CO₂-to-methanol processes, providing a viable route for utilizing renewable energy sources in the production of synthetic fuels."

In situ plasma-coupled Fourier transform infrared (FTIR) characterization and density functional theory (DFT) calculations revealed that the bimetallic Ni-Co interface is the primary active center for methanol synthesis, with CO₂ adsorption and hydrogenation occurring via the Eley-Rideal (E-R) mechanism to produce a variety of intermediates.

Additionally, both the formate and carboxyl routes play a critical role in the formation of methanol, while the reverse water-gas shift (RWGS) and CO hydrogenation pathways were found to be less favorable on the Ni-Co sites.

The precise control of Ni-Co sites in bimetallic catalysts holds significant promise for tailoring the weight of each reaction pathway by promoting asymmetric adsorption of CO₂ molecules at the bimetallic interfaces, thereby effectively modulating the distribution of products.

This research underscores the significant potential of plasma catalysis as an emerging electrification technology for sustainable CO₂ conversion and fuel production. The ability to perform these reactions at [ambient conditions](#) using a modular and scalable plasma system presents an attractive alternative for the chemical industry.

Furthermore, plasma-based systems can be powered by intermittent

renewable electricity, enhancing the feasibility of decentralized fuel and chemical production.

This pioneering work is a major step forward in the field of catalytic CO₂ conversion and offers promising avenues for future research and industrial applications to meet the challenge of a sustainable future.

The University of Liverpool research team is a leader in plasma catalysis and has also made pioneering advances in plasma catalytic conversion of CO₂ to other fuels and chemicals. For example, they have developed promising plasma processes for CO₂ methanation and single-step biogas [conversion](#) to methanol and have filed three PCT patents in this area.

More information: Yaolin Wang et al, Engineering Ni-Co bimetallic interfaces for ambient plasma-catalytic CO₂ hydrogenation to methanol, *Chem* (2024). [DOI: 10.1016/j.chempr.2024.06.022](https://doi.org/10.1016/j.chempr.2024.06.022)

Provided by University of Liverpool

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