Carbon nanostructures decorated with Cerium Oxide as multi-functional electrocatalysts for CO2 conversion

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The electrocatalytic reduction of CO_2 is a captivating strategy for the conversion of CO_2 into fuels, to realize a close loop for carbon footprinting. The research has focused on the development of new materials and technology capable of capturing and converting CO_2 into useful products.[1] Among all reduction products, formic acid is particularly attractive for its high volumetric hydrogen density, low toxicity, and liquid state, that make it a valuable hydrogen storage vector.

The design of new electrocatalysts that reduce CO_2 in a selective and efficient fashion is a key step for future exploitation of this technology.

Here we present how the combination of different building blocks in a single nanostructure might be a good strategy to achieve a good selectivity in the CO_2 reduction process.

Combining the unique physico-chemical properties of functionalized nanomaterials (such as carbon nanotubes and carbon nanohorns) and nanocrystalline cerium dioxide (CeO_2) we revealed faradaic efficiency for formic acid production as high as 55% at an overpotential as low as 0.02V in acid solutions. These performances have been possible by the formation of partially reduced ceria ($Ce^{4+/3+}O_{2-x}$) responsible of an increased CO_2 adsorption and a more efficient electron transfer at the surface.[2] In the nanocomposite, the carbon nanostructures are used as support and they have a fundamental role in to counteracting the insulating effect of oxide nanoparticles and promoting the generation of Ce^{3+} sites. Their elevated surface area and high electrical conductivity guarantee a greater process efficiency.[3] In particular, the nanohorns have a unique conical geometric, where the nano-tips terminals act as "electron collector", increasing the charge mobility.[4]

We demonstrated that the interconnections between various components are fundamental for the efficient CO_2 reduction to formic acid and opens new possibilities in the design of optimized electrocatalytic materials.

References

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Figures

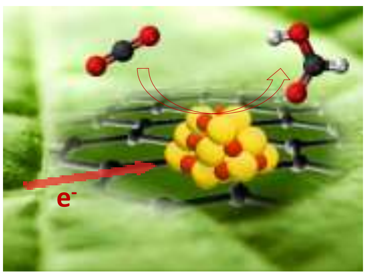

Figure 1: Schematic CO_2 reduction into formic acid on MWCNT@CeO_2