



## Colloidal chemistry for controlled and tunable catalysis

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Chemical transformations often require the catalytic material to possess multiple functionalities in order to be efficient and selective. Our group develops novel synthetic schemes to achieve an exquisite control and tunability of multi-component nanomaterials, including metal oxides, quantum dots and metals. To achieve the desired precision, we use colloidal chemistry as our preferred synthesis approach and we strive towards understanding and manipulating the nucleation and growth kinetics through in-situ studies.

In this talk I will focus on our most recent work on building catalytic platforms to advance studies in conversion of CO<sub>2</sub> into value added chemicals.

At this time, copper is the only catalyst which can produce high-energy dense hydrocarbons in the electrochemical CO<sub>2</sub> reduction reaction (CO<sub>2</sub>RR). Yet, the activity and selectivity of polycrystalline copper still need improvement to move towards technological implementation. We have revealed that the size and shape of copper catalysts plays an important role. In particular we have found that copper nanocubes with an edge length of 44nm are highly selective catalysts to convert CO<sub>2</sub> to ethylene, which is a key feedstock for petrolchemicals.<sup>1</sup> We have also shown that Cu octahedral nanocrystals are highly selective for methane and that such selectivity is promoted by smaller sizes.<sup>2</sup> A recent group effort has resulted in a very nice study focusing on the morphological evolution and degradation mechanism of these catalysts during electrolysis, something which is of the uttermost importance to understand in order to develop proper mitigation strategies for working stability.<sup>2</sup>

While size and shape can modify the activity and selectivity of single metal catalysts, bifunctionality is needed to further promote the CO<sub>2</sub> conversion towards longer chain hydrocarbons. To this aim, we are developing the synthetic routes to access hybrid catalysts wherein pure metals are interfaced with domains of different chemical nature (i.e. different metals, metal oxides, molecular moieties). To date, we have learned that Ag-Cu nanodimers increase further the selectivity towards ethylene as a result of tandem and electronic effects arising at their interface.<sup>4</sup> In a second example, the coupling of Cu NCs with ceria has allowed to indentify the stabilizazion of oxygen-containing intermediates as the main reason for increased methane production in these catalysts.<sup>5</sup>

Finally, our work on atomically-defined tunable material platforms tested under technologically relevant conditions aims at providing theorists with those activity/selectivity/stability descriptors which will allow them to ultimately predict better catalysts for CO<sub>2</sub>RR and beyond.

### References

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