Electrocatalysis from two-dimensional materials

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Electrochemical reactions can afford hydrogen gas (H_2) and small organic molecules from water and CO_2, respectively and therefore offers promise for the production of fuels. Catalytic properties are indeed largely dictated by the electronic structure because the performance of catalysts follows the Sabatier principle, which predicts that interactions between reactants (and intermediates) and the catalyst surface must be ideally balanced[1]. Owing to their reduced dimensionality, two-dimensional (2D) materials have emerged as interesting platforms for studying electrocatalysis. In addition, their properties can largely be tuned by changing their elemental composition, their thickness and their atomic structure.

By developing engineering strategies, we aim at investigating the electrocatalytic properties of 2D materials including transition metal dichalcogenides and 2D transition metals[2,3]. To do so, we have recently reported the fabrication of electrochemical microcells using microfabrication techniques. This device architecture allows testing individual nanosheets in order to precisely quantify the activity from the edges and the basal planes. We notably observed the strong influence of the electronic coupling between the 2D nanosheets and the conducting support. More recently we have explored the influence of the defects, the crystal structure and the electronic properties on the catalytic performance towards the reduction of CO_2 and the oxidation organic sulfur compounds. The activity from the different sites of the 2D materials were estimated by combining electrochemical measurements and precise quantification of the reaction products, which opens avenues for the rational design of novel 2D electrocatalytic materials. In this talk, I will present how the engineering of exfoliated 2D nanosheets can be used for fine tuning the properties of the 2D TMDs with enhanced activity.

References:

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