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When Halides Shape the Morphology and Electrocatalysis of Gold Nanoparticles Directly Grown onto Carbon Paper Electrodes

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During the last decade, several methods have emerged to engineer tunable metallic micro/nanostructures with specific sizes, shapes and hierarchies using nanoparticles (NPs) as elementary building blocks. The majority of the approaches occur physically separated from the electrodes, which are necessary for the final application. Thus, for their practical use in energy conversion, sensors or bioelectronic technologies, the implementation require further immobilization onto an electrode using various post-synthesis steps. Then, the support degradation and the loss of the binders lead to the aggregation and/or dissolution of NPs, which decreases significantly the overall performance. To address all these challenges, we recently developed a novel and versatile chemical method to grow anisotropic gold microstructures at the surface of carbon paper.^[1] The success of the approach for in situ growth relies on a tight control of the reaction time together with the use of halide anions as effective tools. It was observed that halides play a crucial role in the morphology, leading to either complex flower-like rough surfaces (exhibiting high catalytic activity) in the presence of Br⁻ or featureless smooth surfaces (exhibiting low catalytic activity) in the presence of I⁻ (Fig. 1). To date, this first proof of concept that Au particles can be directly grown onto large surface (5 cm × 5 cm) of conducting electrodes by means of a chemical reduction method yielded significant electrocatalysis. For glucose electrooxidation, the use of Br⁻ as regulator enables obtaining a record peak current density close to 10 milliamps per square centimeter of gold, which is higher than the conventional chemically synthesized AuNPs by an order of magnitude. Moreover, a designed glucose fuel cell has an outstanding open-circuit voltage (OCV) of 1.0 V and delivers a maximum power of 3.1 mW cm⁻² (at high cell voltage of 0.7 V without any fuel circulation at room temperature with metal loading of ~0.3 mg cm⁻²), which surpasses the relevant reported data as well as the commercial PtRu/C anode (1.4 mW cm⁻² at 0.5 V, OCV of 0.9 V using a high metal loading of 3 mg cm⁻²). The findings represent a decisive advance for the elaboration of structures with tunable size, morphology, and catalytic properties. These remarkable results greatly enhance our knowledge, add new strategies and pave new elegant approaches for the successful fabrication of low-cost, highly active and durable electrodes.

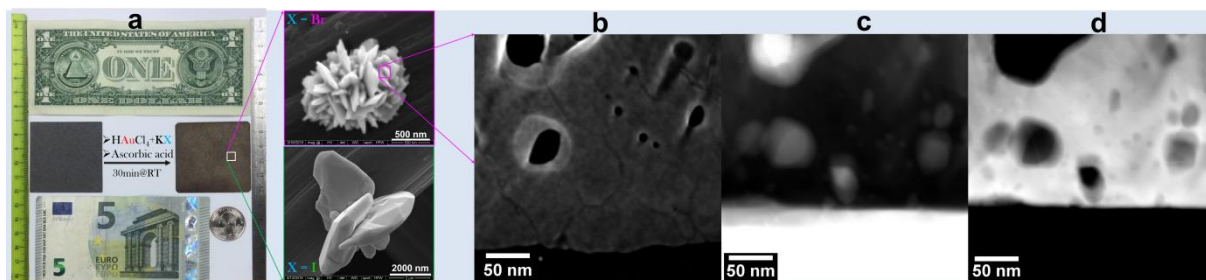


Figure 1. (a) Sketch illustrating the direct growth of metallic gold particles on carbon paper electrode (5 cm × 5 cm). Features of a particle (in the presence of bromide as regulator), sample prepared by focused ion beam dual beam microscope: (a) secondary electron (SE) tomography, (b) bright-field STEM image, (d) HAADF-STEM image

References

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