Facile Electrochemical Template Synthesis of CoPt Alloyed Mesoporous Nanorods from Microemulsions Using an Ionic Liquid

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Abstract

The developments of nano-size materials (nanoparticles, nanorods, nanospheres, among others) are undeniable, reaching applications from catalysis to biomedicine or information storage due to their unique chemical and physical properties [1]. Nanomaterials provide an enormous challenge in energy conversion and storage devices due to their effectiveness as electrocatalysts for methanol (DMFCs) or ethanol (DEFCs) fuel cells. Nowadays, the major advances in the fabrication of nanocatalysts are focused on enhancing durability and electrocatalytic activity by increasing both the surface –volume ratio and the catalytic performance [2]. In this direction, one of the challenges of the synthesis methods is the preparation of controlled nano or mesoporous nanostructures as a consequence of their high porosity and surface-volume ratio.

Mesoporous nanomaterials can be prepared by several methodologies including the traditional hard-templating, phase separation, and alloy-dealloying approaches, among others [3]. Recently, soft template systems have been proposed as a new approach [4]. Therefore, a facile and generalizable synthesis pathway to produce ordered and controlled mesoporous is a new burgeoning challenge.

Herein we propose a new, facile, versatile, environmentally friendly, simple, inexpensive procedure for the synthesis (Figure 1) of porous nanostructures (nanorods) of metals or alloys, from confined electrodeposition using microemulsions containing aqueous solution (W), Ionic Liquid (IL) and Surfactant (S). This method allows producing alloyed nanorods of variable porosity as a function of the microemulsion structure (ionic liquid-in-water (IL/W), bicontinuous or water-in-ionic liquid (W/IL)). This original method successively permits the growth of nanorods with extremely porosity. The prepared nanorods (of CoPt alloy) present a very high value of the effective area for mass unity, significantly higher than that corresponding to other platinum nanostructures (compact nanorods, Pt nanoparticles), which makes them very catalytic for methanol oxidation. The proposed approach is obviously non-restricted to the CoPt system. However, we select CoPt because bimetallic platinum alloys with less expensive 3d-transition metals (Fe, Co, and others) enhance the electrochemical activity for methanol oxidation (reduction of poisoning by adsorbed intermediates) and reduces costs [5]. Therefore, it's a general method, able to prepare very porous nanostructures of different metals or alloys, by preparing stable microemulsions with ionic liquids in which the aqueous component can be any classic electrolytic bath. Moreover, the nanorods present a very good corrosion resistance and stability, as the manner that they can be presented as very promising electrocatalysers.

The obtained nano or mesoporous nanorods exhibit high electrocatalytic activity and corrosion stability, a facile recyclability by the anchoring or recollecting due to their magnetic behavior and a relatively good poison tolerance in the methanol oxidation, which make them highly promising electrocatalysts in the future.

References

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Figures

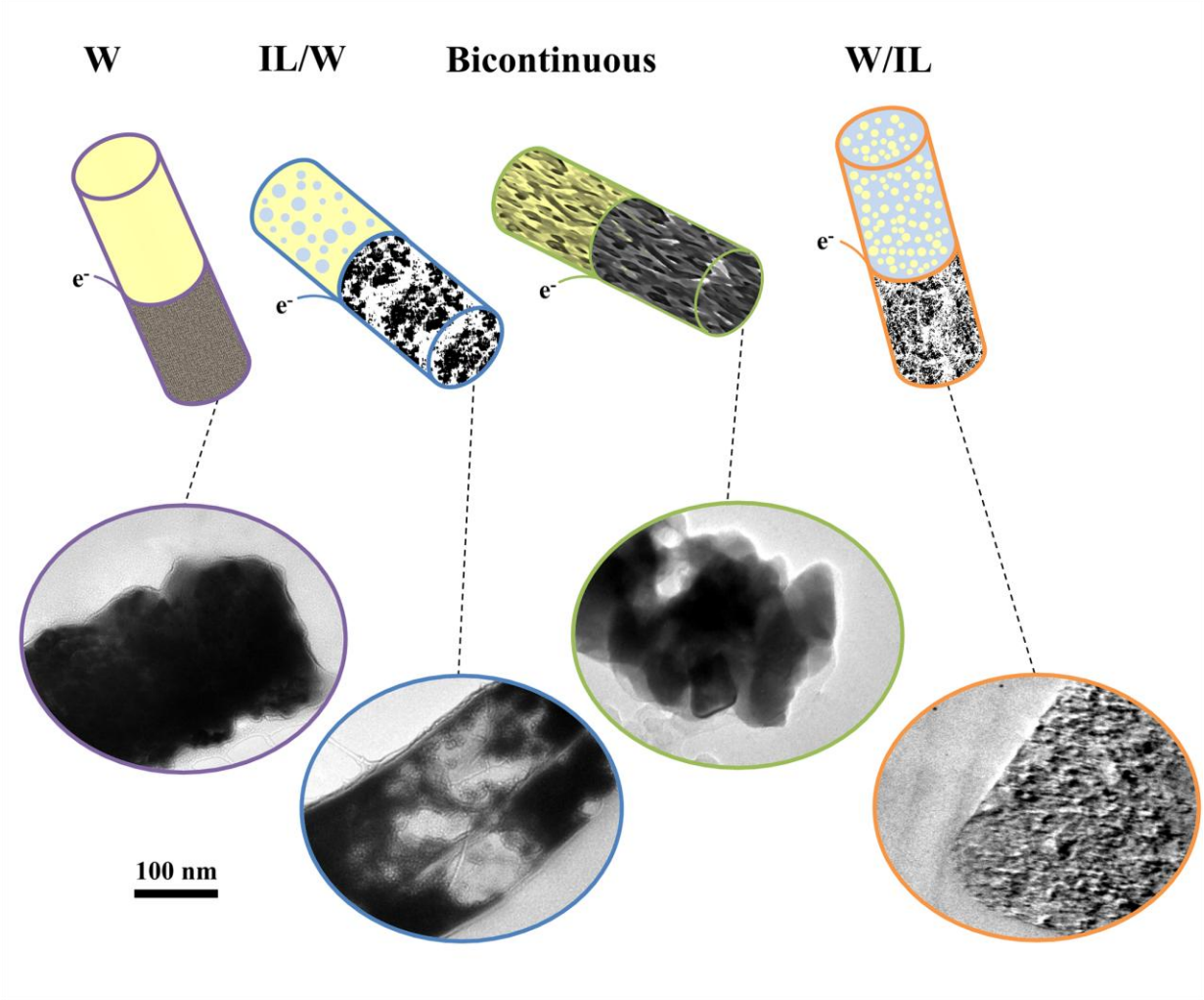

Figure 1: Schematic representation of the different selected systems (aqueous solution and ionic liquid-in-water, bicontinuous or water-in-ionic liquid microemulsions) and HRTEM micrographs.