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Electrochemical Top-Down Synthesis of Nanostructured Support and Catalyst Materials for Energy Applications

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Abstract : Functional nanostructures such as nanoparticles are a promising class of materials for energy applications due to their unique properties. Bottom-up synthetic routes for nanostructured materials often involve multiple synthesis steps and the use of surfactants, reducing agents, or stabilizers. This results in complex and extensive synthesis protocols. In recent years, a novel top-down synthesis approach to form metal nanoparticles has been established, in which bulk metal wires are immersed in an electrolyte (primarily alkali earth metal based) and subsequently subjected to a high alternating potential. This leads to the generation of nanoparticles dispersed in the electrolyte. The main advantage of this facile top-down approach is that there are no reducing agents, surfactants, or precursor solutions. The complete synthesis can be performed in one pot involving one main step with consequent washing and drying of the nanoparticles. More recent studies investigated the effect of synthesis parameters such as potential amplitude, frequency, electrolyte composition, and concentration on the size and shape of the nanoparticles. Here, we investigate the electrochemical erosion of various metal wires such as Ti, Pt, Pd, and Sn in various electrolyte compositions via this facile top-down technique and its experimental optimization to successfully synthesize nanostructured materials for various energy applications. As an example, for Pt and Pd, homogeneously distributed nanoparticles on carbon support can be obtained. These materials can be used as electrocatalyst materials for the oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER), respectively. In comparison, the top-down erosion of Sn wires leads to the formation of nanoparticles, which have great potential as oxygen evolution reaction (OER) support materials. The application of the technique on Ti wires surprisingly leads to the formation of nanowires, which show a high surface area and demonstrate great potential as an alternative support material to carbon.

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