Two electrodeposition strategies for the morphology-controlled synthesis of cobalt nanostructures

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The physicochemical properties of metal nanostructures are influenced by size and morphology. This has generated a considerable interest towards the development of techniques for the morphology-controlled synthesis of metal nanostructures. In numerous applications including, for example, electrocatalysis, the immobilization of metal nanostructures on a target substrate is required. Electrodeposition then becomes a competitive technological route to synthesize metal nanostructures.
Major advantages of electrodeposition if compared to alternative technologies, including, for example, lithography and chemical vapor deposition, are reduced costs and increased versatility. Reduced costs are mainly determined by the possibility to attain the deposition of the metal nanostructures in a unique step without any preparatory action, while versatility is determined by the large range of morphologies that can be generated by varying the operating parameters (mainly potential and precursor metal ion).
In this contribution, two different strategies are discussed to synthesize of cobalt nanostructures: direct cobalt electrodeposition on a planar aluminum electrode and cobalt electrodeposition into nanoporous alumina templates generated by aluminum anodization (template electrodeposition).
In the direct electrodeposition of cobalt on aluminum, cobalt nanoparticles are formed during the early stage of electrodeposition, which causes the depletion of cobalt ions near the electrode. Water reduction then takes place catalyzed by electrodeposited cobalt nanoparticles, which increases the pH near the electrode and can induce cobalt hydroxide precipitation. By varying the electrode potential and the cobalt ion concentration, the interplay between electrochemical growth of cobalt and water reduction could be controlled to induce transition from cobalt hexagonal nano-platelets to nanostructured films composed of cobalt nanoparticles and cobalt hydroxide nano-flakes.
Cobalt nanowires can be synthesized by electrodeposition into nanoporous alumina templates generated by aluminum anodization. This approach typically involves the application of alumina templates produced by a two-step anodization procedure: the alumina nanoporous layer generated by a first anodization is dissolved in a chromic acid solution while a very ordered alumina nanoporous layer is produced by a second anodization stage. In accordance with previous studies, this procedure is fundamental to achieve uniform filling of the nanopores in the subsequent electrodeposition stage. In the present study, uniform filling of the nanoporous alumina generated by one-step anodization could be achieved by the electrodeposition of cobalt nanowires. This result was made possible by the electropolishing of the aluminum foil employed to perform aluminum anodization and by the application of a novel pulsed electrodeposition strategy.