Sodium-ion battery negative electrode: investigation of carbon-carbon composites

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Abstract

The current energetic and environmental situation of the world calls for an increased use and storage of renewable energies, which could be achieved by rechargeable batteries. Today, lithium-ion batteries lead the battery market, thanks to their high energy density and long cycle life [1]. However, most of their basic components (lithium, cobalt, and copper) are critical materials and their future unavailability is likely to limit their development. The transition to sodium-ion batteries could partially solve this problem, as sodium is much more abundant than lithium throughout the world. In addition, the use of cobalt can be avoided in sodium-ion battery cathodes, and copper current collectors can be replaced by aluminum [2, 3].

Extensive research on positive electrode materials and electrolytes of sodium-ion batteries has been conducted recently [4] but the negative electrode remains a critical challenge. The use of graphite, the classical negative electrode material of commercial lithium-ion batteries, is not possible because sodium ions intercalate poorly within its structure [4], pointing to the need to investigate alternative materials. Among carbonaceous materials, hard carbons (*i.e.* non-graphitizable) synthesized by pyrolysis of organic precursors are promising: reversible capacities over 300 mAh/g have been reported in the literature [2]. However, these carbons present disadvantages such as their low energy densities and significant irreversibility in the first electrochemical cycle, due to their high specific surface area causing important electrolyte degradation at the electrode surface and thus solid electrolyte interphase (SEI) formation [5].

In this work, which follows a first study [6], carbon xerogels (*i.e.* micro-mesoporous hard carbons with a controllable pore texture [7]) were synthesized by pyrolysis of phenolic resins. A secondary soft (*i.e.* graphitizable) carbon layer, which allows to limit SEI formation by masking the micropores of the carbon xerogel [7], was then deposited using Chemical Vapor Deposition (CVD) to obtain carbon-carbon composites. To determine the influence of pore texture and secondary carbon layer thickness on the battery electrochemical performance, the synthesized carbon-carbon composites underwent comprehensive physicochemical characterization. Electrodes were then produced by spray-coating an aqueous ink onto current collectors [8] and evaluated through various electrochemical measurements in half-cell and supercapacitor configurations. These characterizations clearly show that the CVD carbon layer improves the Initial Coulombic Efficiency by modifying the carbon-electrolyte interface and reducing the specific surface area of the carbon.

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