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Carbon Aerogels with Tailored Porosity as Cathode in Li-Ion Capacitors

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Abstract : The constant demand of electrical energy, as well as the increase in environmental concern, lead to the necessity of investing in clean and eco-friendly energy sources that implies the development of enhanced energy storage devices. Li-ion batteries (LIBs) and Electrical double layer capacitors (EDLCs) are the most widespread energy systems. Batteries are able to storage high energy densities contrary to capacitors, which main strength is the high-power density supply and the long cycle life. The combination of both technologies gave rise to Li-ion capacitors (LICs), which offers all these advantages in a single device. This is achieved combining a capacitive, supercapacitor-like positive electrode with a faradaic, battery-like negative electrode. Due to the abundance and affordability, dual carbon-based LICs are nowadays the common technology. Normally, an Active Carbon (AC) is used as the EDLC like electrode, while graphite is the material commonly employed as anode. LICs are potential systems to be used in applications in which high energy and power densities are required, such us kinetic energy recovery systems. Although these devices are already in the market, some drawbacks like the limited power delivered by graphite or the energy limiting nature of AC must be solved to trigger their used. Focusing on the anode, one possibility could be to replace graphite with Hard Carbon (HC). The better rate capability of the latter increases the power performance of the device. Moreover, the disordered carbonaceous structure of HCs enables storage twice the theoretical capacity of graphite. With respect to the cathode, the ACs are characterized for their high volume of micropores, in which the charge is storage. Nevertheless, they normally do not show mesoporous, which are really important mainly at high C-rates as they act as transport channels for the ions to reach the micropores. Usually, the porosity of ACs cannot be tailored, as it strongly depends on the precursor employed to get the final carbon. Moreover, they are not characterized for having a high electrical conductivity, which is an important characteristic to get a good performance in energy storage applications. A possible candidate to substitute ACs are carbon aerogels (CAs). CAs are materials that combine a high porosity with great electrical conductivity, opposite characteristics in carbon materials. Furthermore, its porous properties can be tailored quite accurately according to with the requirements of the application. In the present study, CAs with controlled porosity were obtained from polymerization of resorcinol and formaldehyde by microwave heating. Varying the synthesis conditions, mainly the amount of precursors and pH of the precursor solution, carbons with different textural properties were obtained. The way the porous characteristics affect the performance of the cathode was studied by means of a half-cell configuration. The material with the best performance was evaluated as cathode in a LIC versus a hard carbon as anode. An analogous full LIC made by a high microporous commercial cathode was also assembled for comparison purposes.

Keywords : li-ion capacitors, energy storage, tailored porosity, carbon aerogels
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