Tailoring the charge storability of commercial activated carbon through surface treatment

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ABSTRACT

Sustainability concerns in the electrochemical charge storage realm revitalized research on the electrochemical capacitors (ECs), or synonymously, supercapacitors (SCs), because of the renewability of their electrode materials and environmental benignity thereby, longer life cycle to improve materials circularity, and their inherent superior rate charging/discharging than batteries. As SCs store energy via the reversible adsorption of electrolyte ions on the electrode pores, maximizing the number of pores to accommodate the ions is the most desired way to improve the charge storability. In this regard, we report herewith a simple and facile approach for engineering the porosity of commercial activated carbon by refluxing it in nitric acid as a function of time; the BET surface area of the 72 h refluxed samples increased by 75 %. Charge storage properties of the modified electrodes are evaluated in a three-electrode system configuration in 1 M Na_2SO_4 electrolyte; a 75 % increase in the surface area led to an increase in specific capacitance over 110 % following a significant reduction in Warburg impedance. Besides, symmetric SC full cells were fabricated by varying the electrode mass between 3 and 14 mg·cm^{-2} in five steps. All the fabricated devices achieved a potential window of 1.8 V in 1 M Na_2SO_4. The highest mass loaded (~14 mg·cm^{-2}) device fabricated using the prepared material has delivered a maximum capacitance of ~990 mF, the maximum areal capacitance of ~494 mF·cm^{-2}, an energy density of ~13 mWh·cm^{-3}, and a maximum power density of ~2189 mW·cm^{-3}. The device also maintained ~97 % retention in capacitance with a remarkable coulombic efficiency of ~97 % after 5000 cycles. The performance of the device is comparable with the commercial SCs used for low voltage DC hold-up applications such as embedded microprocessor systems. The procedure developed herewith supports easy recycling and reusing of the activation agent, and thereby reduces the release of toxic chemicals into the environment.

KEYWORDS

Electrochemical Double Layer Capacitors (EDLC); Porosity tailoring; Activated carbon; Acid refluxing; Electrode mass loading

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