

Application of multistep electrospinning method for preparation of electrical double-layer capacitor half-cells

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Investigation of the influence of the physical and electrochemical characteristics of the micromesoporous carbon electrodes and separator materials on the performance of the electrical double-layer capacitor (EDLC) is important, taking into account the need for higher power density EDLCs. The carbon electrode properties (thickness, density, specific surface area, micromesoporosity, ratio of micro/mesopores volume, etc.) have a noticeable influence on the ions adsorption/desorption rate at/in the charged micromesoporous carbon electrodes soaked into the non-aqueous electrolyte solution. It is well-known that in order to increase the EDLC performance the porous structure, thickness, wettability and the mass transfer rate of ions in micromesoporous carbon material, depending on the electrode preparation method, and separator, have to be optimized [1,2]. Thus, the new carbon electrodes with optimized hierarchical structure and enhanced mass transfer and adsorption rates have to be developed.

Electrospinning is a well-known method for processing of the flexible and highly porous nanostructured (fiber or porous layered) scaffolds by applying a high electric field strength to a droplet of polymer solution (or melt) [1,2].

Our aim was to study the influence of the electrospun carbon electrode micromesoporous structure (Fig. 1), specific surface area and ratios of micro- and mesoporous surface areas and volumes, on the performance of EDLC, deposited onto electrospun membrane. The supporting membrane material was prepared from 22.5% poly(vinylidene fluoride) (PVDF) solution in N,N-dimethylformamide (DMF) and acetone (AC) (8:2 w:w) mixture by electrospinning method. Thereafter the electrode material layer was deposited by the electrospinning method onto PVDF membrane from the mixture of commercial RP-20 (Kuraray Chemical Co.) carbon and PVDF in DMF + AC (8:2 w:w) solvent mixture to form the half-cell. For EDLCs the two half-cells have been completed together. The 1 M triethylmethylammonium tetrafluoroborate solution in acetonitrile has been used as an electrolyte.

The limits of ideal polarizability ($U \leq 3.2$ V), high specific capacitance (140 F g^{-1} (Fig. 2), being even higher than for carbide derived carbons [3-5]), equivalent series resistance, characteristic time constant, and high specific energy and power values (Fig. 3) have been calculated. It was established that there is a noticeable influence of the mesomacroporosity of the carbon electrodes on the EDLC high- and medium-frequency parameters.

Acknowledgements

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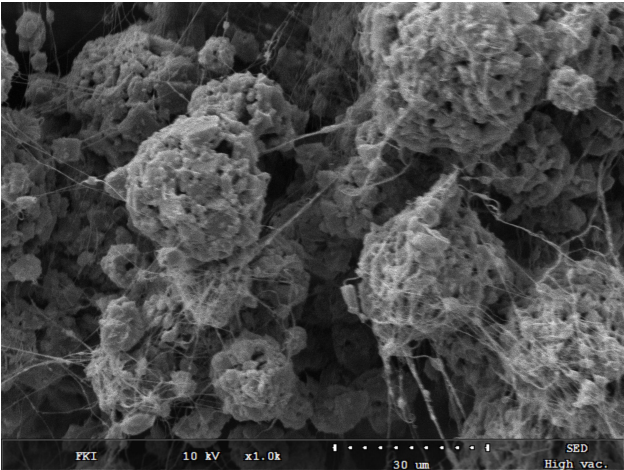


Fig. 1. Scanning electron microscopy image for RP-20/PVDF composite electrode prepared using the electrospinning method.

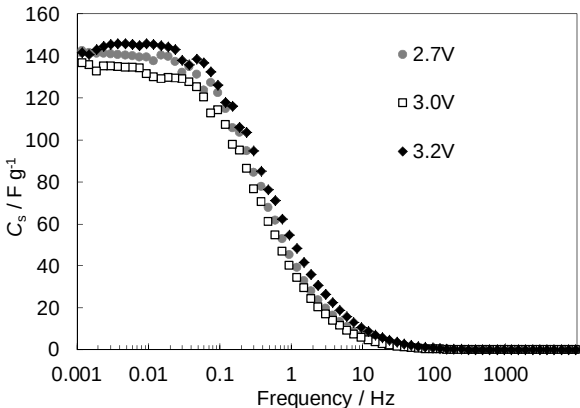


Fig. 2. Series capacitance vs. ac frequency plots for the EDLC cell at cell voltages 2.7, 3.0 and 3.2 V.

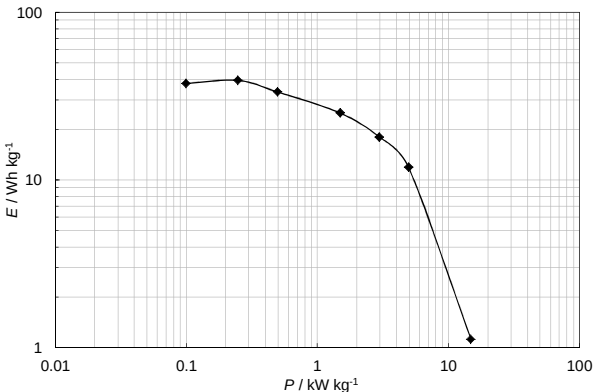


Fig. 3. Ragone plot for the completed EDLC.

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