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Specific performance of supercapacitors based on different micro/mesoporous membrane materials

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Electric double layer capacitors (EDLCs) (so-called supercapacitors) are known to have the characteristics such as high specific power, excellent high-rate capability and long lasting cycle life. The performance specifications for EDLC in terms of the relations between the achieved specific power and corresponding specific energy depend noticeably on the total high frequency series resistance. Thus, on the internal distribution of electrolyte resistance in the porous matrix of the electrodes, as well as in porous membrane filled with electrolyte [1]. In literature there are no systematic studies analysing influence of separator materials properties on the EDLC performance. However, our experiments showed that there is a crucial influence of the commercially available separator materials (Celgard, Nippon Kodoshi) on the EDLC characteristics (i.e. the high frequency series resistance, characteristic time constant, mass transfer limiting stage parameters, specific energy and power (i.e. Ragone plot) values [1]). To increase EDLC performance, the porous structure, thickness, wettability and limiting molar conductivity values of ions in micro/mesoporous membrane have to be optimized and developed.

First objective of this work was to use electrospinning method for preparation of the various micro/mesoporous and nanofibrous polymeric membranes for EDLCs. Electrospinning has the unique ability to produce nanofibers from different materials in various fibrous assemblies. A variety of nanofibers can be made for applications in energy storage, healthcare, biotechnology, environmental engineering, defense and security [2].

Second objective of this work was to study the influence of the membrane characteristics (chemical composition, lyophility, surface area, density, average pore radius and volume) on the performance of EDLCs [1, 3]. Various commercially available mesoporous membrane materials, prepared from cellulose (TF4425, TF4530, TF4030), polypropylene (Celgard 2400) and prepared by electrospinning method from poly(vinylidene fluoride, PVDF) (noted as TUX1, TUX2, TUX3, TUX4, TUX5) with different thickness, specific surface area, pore size distribution, micro- and mesopore volume values, have been used between the identical nanoporous carbide-derived carbon electrodes, prepared from TiC at chlorination temperature T=950°C.

The electrochemical characteristics of the EDLCs based on the different micro/mesoporous membranes in 1 M $(C_2H_5)_3CH_3NBF_4$ acetonitrile solution have been studied using the cyclic voltammetry, constant current charge/discharge and the electrochemical impedance spectroscopy methods. The limits of ideal polarizability, low-frequency limiting capacitance and series resistance, phase angle, characteristic time constant, complex power components and other parameters, dependent on the polymeric membrane properties, have been obtained.

References:

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