Development of electrospun fibrous activated carbon based electrodes for supercapacitor application

Summary

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In this work fibrous electrodes were prepared for supercapacitor's application. These were done using electrospinning process, which involves formation of fibers from a solution using high voltage. The electrodes for supercapacitors need to have high specific surface area and the electrospun membranes show great promise regarding that. As the polymer matrix for fibers, polyacrylonitrile (PAN) was used and the solvent was dimethylsulfoxide (DMSO). To give the electrodes capacitance, porous carbons were added to the electrospinning mixture, namely activated carbon (AC) made from coconut shell, which was preliminarily grinded to ensure the particles to be in nanoscale. For the purpose of increasing the conductivity of membranes conductive carbon conductivity enhancers were added together with AC. In this work commercially available carbon black (CB) and conductive carbon nanotubes composite (CNTs) were tested and compared. To prevent the AC pores from blockage by polymer and to increase the conductivity of solution ionic liquid was added to the electrospinning solution. Mainly two different solution preparation methods were used in this work. Both of them used ultrasonication technique, which helps to disperse carbon materials in the mixture. Obtained electrospun nanofiber membranes were measured for their conductivity, analyzed by scanning electron microscopy (SEM) and the most promising ones were tested in the electrochemical double-layer capacitors (EDLC) cells.

SEM analysis showed that almost all samples prepared via electrospinning had fibrous structure with fibers being in nanoscale. The carbon materials were also well dispersed. From the two methods tested, the one where 1/3 of PAN was added to the mixture prior ultrasonication gave the better results regarding the conductivity of membrane and also capacitance, so this method was further used. The addition of conductive additives (CB or CNTs) increases the electric conductivity and improves general fibrous morphology of the membrane. As a result, the specific capacitance of electrodes improves twice or thrice (up to 64 F/g) compared to the electrode with no conductive additives (20 F/g). Comparison of two additives shows that CB work better − both the capacitance and conductivity of membranes is bigger.

In this work the capacitance of fibrous electrode has reached the value (64 F/g) that is comparable with capacitance of conventional EDLC electrode material (78 F/g).