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Investigation of a solid state redox capacitor based on polypyrrole electrodes

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Conducting polymers (CPs) have received a great attention as a class of potential candidates for diverse applications including batteries, electro chromic devices and redox capacitors. They surpass the carbon based materials in many applications due to their fascinating properties such as easy synthesis, low cost and good stability. In this study, it is reported about the application of a conducting polymer in a redox capacitor fabricated with a gel polymer electrolyte (GPE) of which the ionic conductivity is similar to a liquid electrolyte but having a mechanical stability like a solid electrolyte. Conducting polymer, Polypyrrole (PPy) was polymerized on to Fluorine doped tin oxide (FTO) glass galvanostatically using a three electrode set up. Sodium Dodecylsulfonate (SDS) was used as the salt. Thickness of PPy film was maintained at 1 μm. GPE was prepared using polyvinylidenefluoride (PVdF), zinc trifluoromethanesulfonate (Zn $(CF_3SO_3)_2$ – ZnTF) (Aldrich), ethylene carbonate (EC) and propylene carbonate (PC). The starting materials were magnetically stirred, heated and the hot mixture was pressed in between two glass plates. Thereby, it was possible to obtain a bubble free thin film. Redox capacitor was fabricated using two PPy : DS films having an area of 1 cm^2 as electrodes and a GPE having same area as the electrolyte. Configuration of the redox capacitor was in the form of PPy : DS / PVdF : EC : PC : ZnTF / PPy : DS. Electrochemical Impedance Spectroscopy (EIS) measurements of the redox capacitors were carried out within the frequencies ranging from 400 kHz to 0.01 Hz using a frequency response analyzer (Metrohm AUTOLAB 101). Cyclic Voltammetry (CV) measurements were carried out in the potential window of 2.5 V - (-2.5) V at the scan rate of 10 mV/s by means of a computer controlled potentiostat / galvanostat. For, Galvanostatic Charge Discharge (GCD) test, redox capacitor was first galvanostatically charged to 0.5V, immediately subjected to a galvanostatic discharge up to 0.0 V. The maximum charge and discharge currents were set to $1.0x10^{-4}$ A. In the electrochemical impedance plot, high-frequency intercept of the semicircle on the real axis provides the resistance of the bulk electrolyte, the diameter of the semicircle gives the value of the charge transfer resistance. At the low frequency range electrodes exhibit a nearly straight line of a limiting diffusion process which is a characteristic feature of pure capacitive behaviour. The specific capacitance was obtained from the bode plot and the value obtained was 8 F/g. The calculated specific capacitance from the CV test was 22 F/g. The difference between the capacitance values may be that the value obtained in CV method depends on the scan rate. Galvanostatic charge-discharge test showed that the specific capacitance reduction after 500 cycles was about 3%. Even though the capacitance values are little bit lower, the selected combination of PPy and PVdF based gel polymer electrolyte is seemed to be suitable for redox capacitors

Keywords: Conducting polymers, Redox capacitors, Electrochemical impedance spectroscopy, Cyclic voltammetry

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