A study of electrical double-layer characteristic of activated carbon electrode in spiro-(1, 1’)-bipyrrroldinium tetrafluoroborate electrolyte

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Electric double layer capacitors (EDLCs), have received much attention recently because their excellent performance. However, the drawback of low energy density limits their application. According to the equation E=1/2CV^2, it is obviously that the energy density increases with the capacitance and the voltage. When the specific surface area of the porous carbon increases to a certain value, the mass ratio of the capacitance tends to saturate. Furthermore, the oxygenated functional groups on porous carbon electrode surface serve as active site, which can catalyze the electrochemical oxidation or reduction of the carbon, or the decomposition of the electrolyte components. Besides, the safe working voltage of electric double layer capacitors based on organic electrolyte (quaternary ammonium salt represented in TEMA-BF_4 electrolyte) is generally lower than the 2.7 V. Therefore, it is necessary to develop a novel electrolyte with good electrochemical stability and higher than 2.7 V working voltage to increase the energy density of supercapacitors.

Spiro-(1, 1’)-bipyrrroldinium tetrafluoroborate (SBP-BF_4), which is a spiro-type quaternary ammonium salt, has received much attention for its excellent electrochemical properties in recent years. The smaller SBP cations relative to TEMA cations can easily diffuse into the micro pore and has a higher mobility in PC than TEA-BF_4 and TEMA-BF_4, which contribute to high electrical conductivity. Therefore, novel electrolytes at the 1.5 M in PC has wide work potential and high electrical conductivity, about 5.2 V and 16.96 mS·cm^-1, respectively. The SBP-BF_4/PC has high specific conductivity can be explored to improve the electrochemical stability at electrode/electrolyte interface. When the charging voltage increase to 3.5 V, the charge-discharge curves of SBP-BF_4/PC based EDLCs remain linear and symmetrical, while the curves of TEMA_4/PC become a little asymmetrical. Furthermore, when the charging voltage continues to increase, the charge-discharge curves of SBP-BF_4/PC based EDLCs become a little asymmetrical, while that of TEMA-BF_4/PC electrolyte based EDLCs become seriously asymmetrical. The withstand voltage of SBP-BF_4/PC electrolyte is higher than that of TEMA-BF_4/PC electrolyte, about 3.2 V. The SBP-BF_4/PC electrolyte own well upper voltage hold feature and higher discharge capacitance than that of TEMA-BF_4/PC which can be a promising high voltage electrolyte for the energy type EDLCs.