5th European Symposium on Super Capacitors & Hybrid Solutions
April 23-25, 2015

THE EFFECT OF TEMPERATURE VARIATION ON THE PERFORMANCE OF SUPERCAPACITORS BASED ON PHOSPHONIUM IONIC LIQUIDS

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Abstract

Ionic liquid electrolytes are of interest for advanced supercapacitors because of their ability to provide increased cell operating voltages [1]. The advantage of this can be seen from the Equation 1, which describes the amount of "useful" energy contained in supercapacitors:

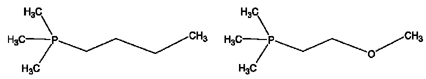
$$P = \frac{1}{4}\frac{V_{max}^2}{R} \qquad \text{E1}$$

V_{max} is governed by the breakdown potential of the electrolyte and V_{min} is governed by operation applications e.g. interface with power electronics. Since V_{min} is fixed, there are clear advantages in increasing V_{max}. The main problem is that ionic liquids gave higher viscosities than organic liquid or aqueous electrolytes. This is manifested as increased cell resistance (R) and reduces the power handling capabilities of supercapacitors, as can be seen from Equation 2:

$$P = \frac{1}{4}\frac{V_{max}^2}{R} \qquad \text{E2}$$

This is a clear disadvantage because supercapacitors are generally used because of their power handling properties. One method of ameliorating this is to operate the supercapacitors at elevated temperatures. This should have the effect of decreasing viscosity, and therefore R, thus allowing higher temperature operation. To date there has been very little published on the effects of temperature variation on the performance of supercapacitors [2].

Two phosphonium based ionic liquids were selected. The common anion was bis(trifluoromethanesulfonyl)imide, while the cations were (labeled as P1114 and P111(201) respectively):



These cations were chosen because P1114 has a higher operating voltage than P111(201) (3.4 v 2.7V). Conversely, P111(201) has a lower viscosity than P1114 (85 vs 48 mPaS at room temperature).
Table 1 presents the energy and power densities for supercapacitors made from a mesoporous resorcinol formaldehyde carbon [3] using the P1114 and P111(201) electrolytes. The capacitances and ERSs are also given and were derived from Electrochemical Impedance Spectroscopic measurements of the supercapacitors [3].

Table 1. Capacitor measurements from EIS

Temperature (°C)	Capacitance (F g^{-1})		ESR (Ohms)		Energy density (J g^{-1})		Power density (W g^{-1})	
	P1114	P111(201)	P1114	P111(201)	P1114	P111(201)	P1114	P111(201)
25	14.1	15.1	44.0	55.6	81.3	55.0	0.066	0.033
40	16.0	15.9	45.8	50.8	92.4	58.0	0.063	0.036
60	18.0	17.1	48.1	48.6	104.2	62.2	0.060	0.038

Table 1 reveals some interesting and unexpected results. Firstly, the energy density of the P1114 supercapacitors is greater than the corresponding P111(201) supercapacitors. This is an expected result because of the higher operation potential of the P1114. What is unexpected is that the P1114 also exhibits consistently higher power densities, despite having a higher viscosity. However, the carbon chosen for this study is not optimized for capacitor performance and has mesopores that are considered as being too narrow to maximize power density. The second unexpected result is that the P111(201) capacitors exhibit an (expected) increase in power density with increasing temperature where as the P111 capacitors show the completely opposite behavior.

REFERENCES (SELECTION)

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