

An Inorganic Molten Salt Supercapacitor

D.W.Kirk and J.W. Graydon

*Dept. Chemical Engineering & Applied Chemistry
University of Toronto
200 College Street, Toronto, ON Canada M5S 3E5*

INTRODUCTION

Supercapacitors are energy storage devices. They have the ability to be charged and discharged rapidly and thus in general have excellent power densities. This rapid charge-discharge capability is based primarily on a physical rather than chemical mechanism for charge storage and is a characteristic which distinguishes supercapacitors from batteries or fuel cells.

Despite the physical nature of the energy storage mechanism there are energy loss mechanisms which under heavy load or repeated cycling will result in heat generation. Neither aqueous nor organic based supercapacitors are suitable for operation at temperatures above 80°C. In addition, there are many environments in which the ambient temperatures routinely exceed 60°C such as in a vehicle engine compartment. Thus a supercapacitor which could operate at higher temperatures would be useful.

This work describes the behavior of a inorganic molten salt supercapacitor capable of operating in the 100-160°C range. This range is practical for some specific applications and because there is no water involved nor organic solvents, the system is interesting from a fundamental perspective of understanding charge storage with only simple anions and cations present.

EXPERIMENTS AND RESULTS

The activated carbons used in this work were from fluid coke. The activation process for fluid coke has been described earlier¹ but basically involves treating the carbon to a caustic soak followed, by a high temperature bake under nitrogen at 850 °C for 1 hour. The treated carbon is washed to removed any soluble inorganic species. A dough is made by adding 4% Teflon resin and 6% carbon black with isopropyl alcohol as a mixing fluid. The dough is rolled into an electrode sheet and then is cured at 100 °C for 24 h to remove all solvent.

Surface area was measured using BET, while micro pore distribution area was determined by CO₂ adsorption and mesopore/macropore by N₂ adsorption. Quenched Solid Density Functional theory, QSDFT was used for modeling adsorption isotherms on carbon materials with various degrees of pore wall roughness and surface defects.

The surface area of the electrodes in this paper ranged from 850 to 1200 m²/g.

The electrolyte was prepared from a eutectic mixture of nitrate salts. Despite the fluidity of the molten salt, wetting of the activated carbon was a challenge. Pretreating the activated carbon electrodes with an aqueous solution was required before the molten salt would fully wet the electrodes.

RESULTS

The capacitance behavior was determined using a symmetrical cell with both galvanic charge discharge and cyclic polarization techniques. This behavior was compared with electrodes from the same batch of activated carbon but using a 4 M KOH electrolyte at 25 °C. A typical response for the molten salt electrolyte based supercapacitor is shown in Figure 1.

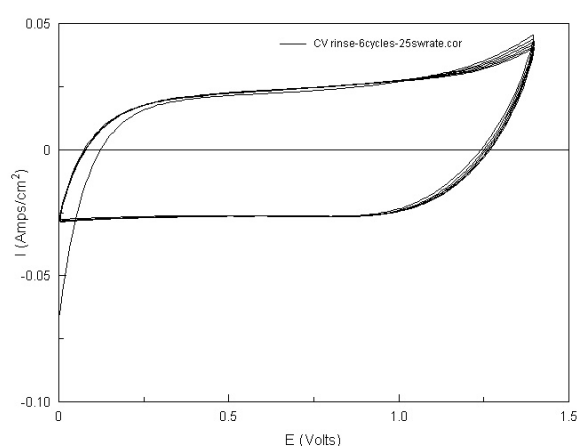


Figure 1 Cyclic Voltammetric response of a symmetrical activated carbon supercapacitor at 25 mV/s for 6 cycles at 140°C

After the initial sweep cycle seen starting at 0V and -0.07A/cm², the CV response became reproducible with no change after the 6th cycle. The molten salt electrolyte provided a larger voltage window than the alkaline electrolyte, but otherwise showed almost the same characteristics of capacitance and response. The similarities will be discussed in detail in the paper

ACKNOWLEDGEMENT

The authors would like to acknowledge the support from the NSERC Discovery program.

REFERENCES

1. Kirk D.W. and Jia C.Q. "Activated Carbon in Double Layer Capacitors" ECS Transactions 16[1] 49-56, 2008.
2. Kirk D.W. and Graydon J.W. "Electrochemical Double Layer Capacitance in Activated Carbon: Ion Size Effects", ECS Transactions 25 [35] 163-171 2010.