A Hybrid Electrochemical Capacitor with Asymmetric Electrodes and Aqueous Electrolyte

Jong H. Kim,[a]* Jong H. Park,[b]
Chang S. Jin,[a] and Kyung H. Shin[a]

[a]Energy Storage Research Center, Korea Institute of Energy Research, 71-2 Jang-dong, Yusong-gu, Taejon, 305-343, Korea

[b]Department of Chemical Engineering, Korea Advanced Institute of Science and Technology, Taejon, 305-701, Korea

Activated carbon(AC) as an electrode material of electrochemical capacitors(ECs) has been contributed to improve the specific capacitance of electric double layer capacitors(EDLCs). Authors have ever reported that highly increased specific capacitance up to 300 F/g had been obtained from AC-based EDLC with KOH electrolyte by using a nickel foam current collector.[1] The AC has some advantageous points of not only material properties but also practical applicability such as accessibility, easy process ability and relatively low cost.

Some kinds of conducting polymers and metal oxides have been interested in applying to 'pseudo-capacitance' types of ECs which have comparatively higher specific capacitances up to several hundreds F/g. Among these types of capacitors, named as 'pseudo-capacitor' or 'redox capacitor', a hydrous RuO_2-based EC is well known one due to its quite distinctive characteristics of highly reversible and very fast faradaic reaction mechanism, high specific capacitance, and very good conductivity.

Nevertheless, it seems that the RuO_2-based ECs are not able to be popular to commercialize since its raw material price is extremely expensive. In addition, since its thickness of RuO_2 electrode layer is limited as to be a thinner layer under several microns, its specific capacitance with respect to apparent electrode area is rather smaller than that of AC-based ECs. Lots of studies on conducting polymer as another electrode material for redox capacitors have been conducted, however, some weaknesses of its performance characteristics on working temperature and cycle-life time are remaining so far.

As another attempt to overcome technical barriers of EDLCs or pseudo-capacitors, asymmetric electrode in ECs have being investigated recently. We, authors, have also presented a brief result on asymmetric electrodes with the positive electrode of $Ni(OH)_2$ and AC composite material and the negative electrode of AC-based examined up to 1.4 V in KOH electrolyte.[2] The examined asymmetric electrode unit-cell with nickel foam current collectors has shown a hybrid characteristic of both EDLC and pseudo-capacitor.

In this paper, some more progressed results for the hybrid EC of EDLC/pseudo-capacitor would be presented. By optimizing mass balance of electrode material between positive and negative electrodes, the maximum operating voltage of unit-cell has been widened up to 1.6 V maintaining electrochemically stable cyclic behavior. Around 580 F/g of the specific capacitance for half-cell at 10 mA/cm^2 of charge-discharge current density, which is corresponding to the energy density of 38 Wh/kg with respect to the total active material weight of unit-cell, has been evaluated. Until 2,000 cycles of charge-discharge tests at 10 mA/cm^2 in the voltage range from 0.8 to 1.6 V, less than 20% of the capacitance degradation has been observed. The specific resistance measured by ac impedance method without bias voltage has been observed as about 0.6 Ω·cm^2.

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References

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2. J. H. Park, O. O. Park, K. H. Shin, C. S. Chin, and J. H. Kim, *Electrochem. Solid State Lett., in printing(2002)*

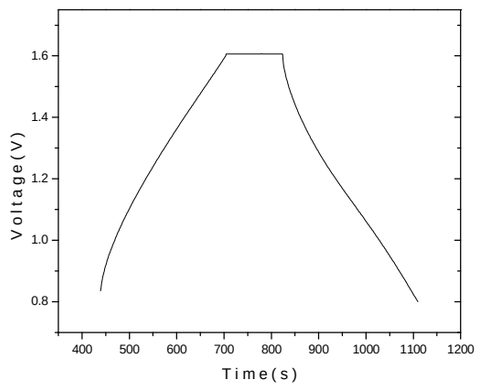

Figure 1. Charge-discharge cycle at 10 mA/cm^2 of current density.

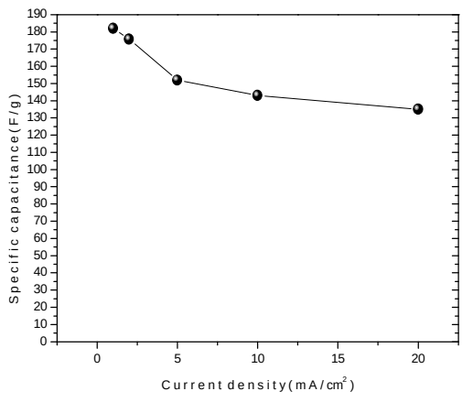

Figure 2. Specific capacitances of unit-cell on current densities.

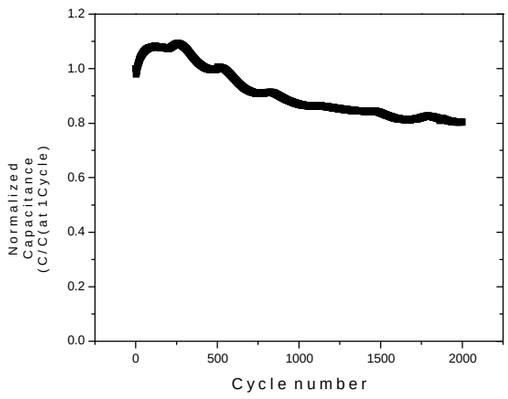

Figure 3. Cycle-life performance at 10 mA/cm^2 of current density.