ASYMMETRIC LEAD DIOXIDE - CARBON ELECTROCHEMICAL CAPACITOR

Susannah M. Butler and John R. Miller

JME, Inc.
17210 Parkland Drive
Shaker Heights, OH 44120
Phone/Fax 216-751-9537
jmecapacitor@att.net

INTRODUCTION

Electrochemical capacitors, often called supercapacitors or ultracapacitors, have numerous performance advantages over other charge storage components. In the past several years this technology has advanced on many fronts including higher voltage per cell, larger devices, improved power performance, and higher energy densities. The uses for electrochemical capacitors have expanded steadily, but the market for products have not taken off at the growth rates once predicted. The main reason for the slow growth in this area is product cost. In order to see market growth, electrochemical capacitors will have to maintain product performance at more reasonable and lower costs.

One approach for lowering costs is to use an aqueous electrolyte, which is less costly in bulk and also allows reduced manufacturing costs. Another approach is to reduce or eliminate costly materials such as activated carbon cloth, expensive separator materials, or expensive non-carbon materials like ruthenium oxide. Aqueous asymmetric capacitors based on NiOOH/KOH/C have been offered and reduce costs over some symmetric carbon organic electrolyte devices. However, even the cost of nickel may also be too high for a low-cost, mass marketed electrochemical capacitor product. MnO_2 and MoO_3, for example, have also been investigated as low cost alternatives to ruthenium oxide or nickel oxyhydroxide for this application.[1,2]

We chose the asymmetric $PbO_2/H_2SO_4/C$ capacitor because it combines low cost electrode materials with an aqueous electrolyte. The technology of the battery-like lead electrode is mature because of the lead acid battery industry and there is a well-developed recycling program in place for this component. The operating voltage is anticipated to be ~ 2 V, higher than with the nickel-carbon capacitor system.

An $PbO_2/H_2SO_4/C$ capacitor was used as a specific example of an asymmetric capacitor in the ESMA asymmetric capacitor patent.[3] This type of capacitor has been reported in several patents.[4-6] Our purpose was to evaluate the properties and performance capabilities of this asymmetric capacitor system.

TEST DEVICES

$PbO_2/H_2SO_4/C$ devices were fabricated using a positive electrode with the integral lead current collector that was extracted from a lead acid battery. The negative electrode was fabricated from particulate activated carbon formed into a sheet. The negative electrode was sandwiched between a glass mat separator and the negative current collector. The devices were fabricated with a great excess of capacity in the positive electrode compared to the negative electrode.

RESULTS

Evaluations were performed using beaker experiments with an excess of electrolyte and a Ag/AgCl reference electrode to evaluate positive and negative electrode behavior individually. The potential of each electrode and the voltage of the full device, during 10 mA discharge, are shown in Figure 1. While the full capacitor was discharged from ~2.1 V to 0.9 V, the potential of the positive electrode changed very little.

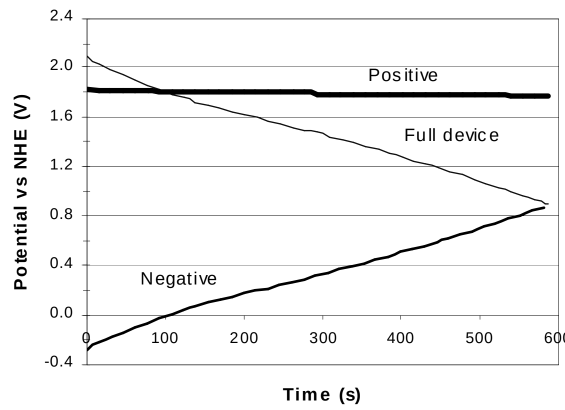

Figure 1. Potentials for the full capacitor and each electrode during 10 mA discharge.

After initial forming of the positive electrode, the discharge behavior of the capacitor during charge/discharge cycling, exhibited stable performance during 60 cycles. This is shown in Figure 2.

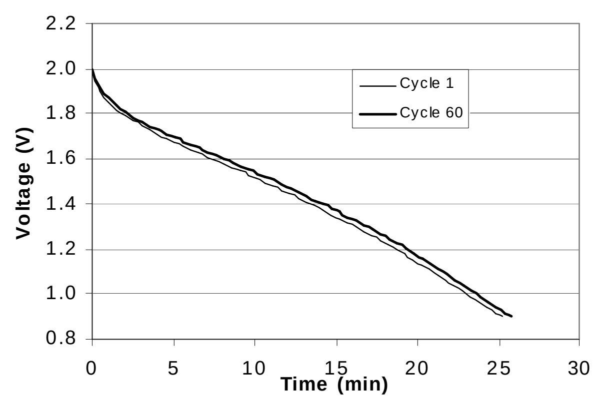

Figure 2. Discharge behavior of a second, larger $PbO_2/H_2SO_4/C$ capacitor during the first and the 60th cycles.

A full range of test results for single cell $PbO_2/H_2SO_4/C$ capacitors will be presented.

REFERENCES

1. D. Reisner, The 9th International Seminar on Double Layer Capacitors and Similar Energy Storage Devices, Deerfield Beach, FL, Dec. 6-8, 1999.
2. Y. Takasu, et al., 201st Meeting of the Electrochemical Society, Philadelphia, PA, May 12 – 17, 2002.
3. Rozoumov, et al. US Patent 6,222,723, Apr. 24, 2001.
4. Belyakov, et al. US Patent 6,195,252, Feb. 27, 2001.
5. Vasechkin et al. US Patent 6,426,862, July 30, 2002.
6. Volfkovich et al. US Patent 6,466,429, Oct. 15, 2002.