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ADVANCED DOUBLE LAYER CAPACITORS

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There is a need for large amounts of power to be delivered rapidly in a number of airborne and space systems. Conventional, portable power sources, such as batteries, are not suited to delivering high peak power pulses. The charge stored at the electrode-electrolyte double layer is, however, much more accessible on a short time scale. Devices exploiting this concept have been fabricated using carbon (SOHIO) and metal oxides (Pinnacle Research) as the electrodes and sulfuric acid as the electrolyte.

One problem with using a solid electrode and a liquid electrolyte module is the possibility of leakage of the electrolyte because of the rupture of seals due to pressure external changes, overcharge, and other factors. The sulfuric acid electrolyte is highly corrosive, and leakage would be expected to lead to premature failure of the module. The approach reported here replaces the liquid sulfuric acid electrolyte with a solid ionomer electrolyte. The challenge is to form a solid electrode-solid ionomer electrolyte composite which has a high capacitance per geometric area.

The approach to maximize contact between the electrode particles and the ionomer has been to impregnate the electrode particles using a liquid ionomer solution and to bond the solvent-free structure to a solid ionomer membrane. Ruthenium dioxide is the electrode material used and is prepared in powder form by thermal decomposition of RuCl_3 in the presence of a fluxing agent. The ionomer solution chosen for the initial phase of the work contains Nafion 117 (Nafion ionomers are perfluorosulfonated ionomers made by E. I. DuPont). It is purchased as a 5% solution in alcohol-water solvent. Three strategies are being pursued to provide for a high area electrode-ionomer contact: (1) mixing of the RuO_x with a small volume of ionomer solution followed by evaporation of the solvent, (2) mixing of the RuO_x with a large amount of ionomer solution followed by filtration to remove the solvent, and (3) impregnation of the ionomer into an already formed RuO_x electrode.

After impregnation and solvent removal, electrodes are bonded to a Nafion 117 membrane and their electrochemical behavior is examined by cyclic voltammetry and AC impedance techniques. The reference (Hg/HgSO_4) and counter electrodes are in 1M H_2SO_4 . Voltammograms showed the beginning of voltammetric waves at -0.275 V and $+0.65$ V vs. Hg/HgSO_4 . The cathodic wave is due to the reduction of RuO_x while the anode wave is limited to the beginning of oxygen evolution. The 0.925 V window between these reactions represents the usable voltage range. Capacitances were derived by plotting current density vs. sweep rate at 0.1 V vs. Hg/HgSO_4 . Capacitances of up to $60 \text{ mF}/\text{cm}^2$ have been observed.

RuO_x powder and electrodes have also been examined by non-electrochemical techniques. X-ray diffraction has shown that the material is almost pure RuO_2 . BET surface area of the powder is approximately $50 \text{ m}^2/\text{g}$. The electrode structure depends on the processing technique used to introduce the Nafion. Impregnated electrodes have Nafion concentrated near the surface. Electrodes prepared by the evaporation method show large aggregates of crystals

surrounded by Nafion. Research is focusing on methods to make more uniform electrode-electrolyte contact.

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