Activated Carbon Electrode Structure Properties Related to the Performance of UHMWPE-bonded Double Layer Capacitors

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Supercapacitors, also known as ultracapacitors and electric double-layer capacitors, are gaining interest as energy storage devices to supplement or replace batteries in hybrid electric and fuel cell powered vehicles. While the amount of energy stored per unit mass or volume is lower than for any battery type, the power delivered is immensely greater. Furthermore, supercapacitors are capable of hundreds of thousands (100,000's) of charge/discharge cycles without significant degradation of performance. New, advanced designs of automotive electrical systems will take advantage of the high power density of the supercapacitor and the higher energy density of the battery to result in greater performance, longer life, and lower cost for the vehicle overall.

The principal components of the capacitor, the ones that drive both cost and performance, are its activated carbon electrodes. Amtek Research International (ARI) has developed a process for the manufacture of activated carbon electrode films that promises the large reductions in manufacturing cost that are essential to the large scale use of supercapacitors in hybrid electric and fuel cell powered vehicles. This process is based on the continuous extrusion and extraction of porous films filled with activated carbon and is made possible by gel-processing of ultrahigh molecular weight polyethylene (UHMWPE).

The structural properties of the activated carbon and the resulting electrode film have been investigated with respect to their effect on the performance of UHMWPE-bonded electrodes. Nitrogen adsorption behavior has been used to characterize the microstructure of different activated carbons and correlated with the double-layer capacitance behavior (figure 1).

The physical structure of the electrode (pore volume and structure) and its impact on performance have also been investigated. Densification of the electrode results in improved conductivity (figure 2) and volumetric capacitance (figure 3). There is, however, a slight decrease in specific capacitance (F/g).

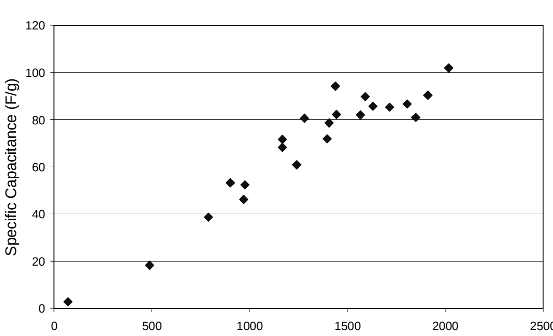

Figure 1: Specific capacitance of activated carbons in UHMWPE-bonded electrode films as a function of BET surface area.

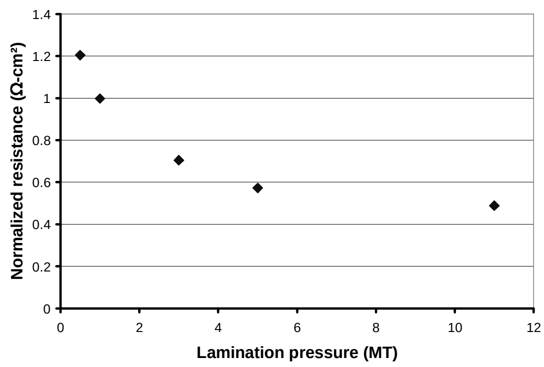

Figure 2: Normalized electrode resistance as a function of lamination pressure to aluminum foil collector.

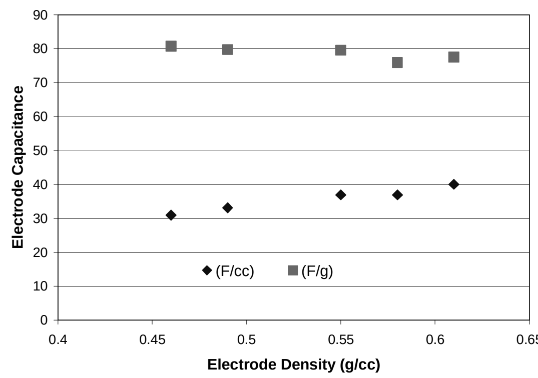

Figure 3: Gravimetric (F/g) and Volumetric (F/cc) electrode capacitance as a function of densification during lamination.