

SANS study of electrolyte accessibility into Novel Heteroatom-Loaded Activated Carbons used for supercapacitor electrodes

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Electrochemical capacitors are devices capable of absorbing and delivering energy over short time-scales ideal for high-power/low energy applications such as automotive acceleration and braking. They are considered as one of the most promising energy storage technologies owing to their distinct properties such as exceptionally high power capabilities, excellent cycle-ability and efficiency as compare to other electrochemical devices such as fuel cells and batteries[1-3]. Their capacitive performance is achieved by storing energy at a surface double-layer on electrodes with surface areas of several hundred m². This high power handling comes from two features: i) Energy is stored electrostatically with no internal redox chemical reactions and ii) they have very low internal impedance. Electrode and electrolyte materials are the key components affecting the performance of electrochemical capacitors. Variety of carbon based materials and also a range of aqueous, organic and ionic solutions have been adopted as electrode and electrolytes for electrochemical applications respectively. To avoid the volatility and flammability issues associate with organic electrolytes and also low power handling and diffusional issues of ionic liquid based electrolytes, aqueous electrolyte based supercapacitors are developed at much lower manufacturing costs. However the main disadvantage of these devices is that they operate at much lower cell voltages (~1.2V) and consequently have lower energy densities ($E=1/2mV^2$). In order to overcome this restriction we have developed new polymer based carbons specially activated to have a larger working surface area and that are loaded with heteroatoms such as O and N. These heteroatoms induce an element of pseudocapacitance and may make the carbon surface more hydrophilic. Contrast Matching SANS (CM-SANS) has been used to understand the accessibility of the electrolyte into the carbon porosity. Neutron scattering from “dry” samples is from all of the carbon porosity regardless of whether it can be accessed by the electrolyte or not. However, when the electrolyte is contrast matched to the carbon, SANS from these “wet” samples is solely from porosity that the contrast matched electrolyte cannot access. This is shown for different carbons in Figure 1.

SANS from carbons loaded with nitrogen heteroatoms in Figure 2 also suggests increased porosity and the significant decreased scattering for the CM N-loaded sample suggests increased accessibility of the electrolyte with nitrogen doping. This result strongly supports our hypothesis about heteroatoms increasing electrolyte accessibility.

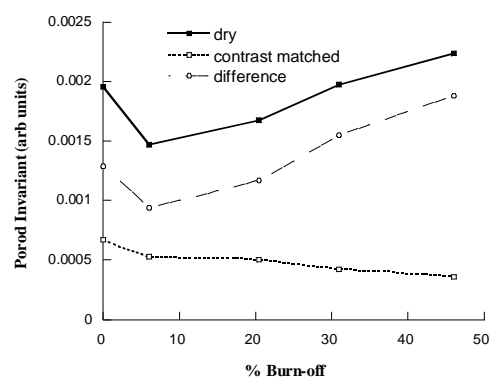


FIGURE 1

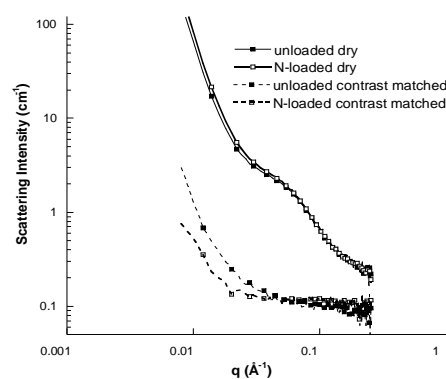


FIGURE 2