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Furfuryl alcohol derived high-end carbons for ultrafast dual carbon lithium ion capacitors

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Abstract

In this work, a lithium ion capacitor (LIC) based on carbon electrodes prepared from furfuryl alcohol-derived polymers is presented. While furfuryl alcohol is not a new carbon precursor, it has been evaluated in the past mainly for negative electrodes with Li-ion insertion. Here we describe both an activated carbon (AC) and a hard carbon (HC) made from the same furfuryl alcohol-derived polymers, for both electrodes of the LIC. The polymerization technique used to make carbon from the furfuryl alcohol precursor is different from all the methods described earlier, and is flexible enough to make soft, high surface area AC, as well as a denser, low surface area HC. The HC and the HC-based negative electrode used in this study are targeted at a high-energy and high-power LIC application by specifically reducing the carbon particle size to sub-micrometric levels, using a HC with a specific surface area of ~300 $m^2\ g^{-1}$ and keeping the electrode mass loading to <2 mg cm^{-2}. The HC delivers a stable capacity of ~400 mAh g^{-1} *vs.* Li^+/Li at C/10, with excellent capacity retention of 50% at 10C (>200 mAh g^{-1}) and 25% at 50C (~100 mAh g^{-1}). The AC used for the capacitor-type positive electrode was activated to a specific surface area of ~1670 $m^2\ g^{-1}$. For comparison purposes, a symmetric electric double layer capacitor (EDLC) using the same AC, in a 1.5 M Et_4NBF_4 (acetonitrile) electrolyte, was also fabricated. Overall, the LIC showed considerably higher energy density over its EDLC counterpart, delivering a maximum energy density (based on the total electrode active mass weight) of 150 Wh $kg^{-1}{}_{AM}$ at a power density of 150 W $kg^{-1}{}_{AM}$, with a 66% retention of the initial energy at the highly demanding 10,000 W $kg^{-1}{}_{AM}$ power peak point. Additionally, long cycle life was measured, with 83% capacitance retention after 10,000 cycles.