Corn Cob Biochar Use in Supercapacitors

Supercapacitors are made of layers of rolled carbon nanosheets, which is usually made from activated carbon. While activated carbon is not too expensive, its source is typically from carbonaceous materials – such as wood, nutshells, peat, or coal – which can take anywhere from a decade to a millennium to produce. More recently, nanosheets have been made of graphene (2D sheet of pure carbon atoms) which can be very expensive to make. Junhua Jiang and colleagues (Matthew Genovese and Keryn Lian from University of Toronto and Nancy Holm from ISTC) have discovered a way to make the low-cost carbon nanosheets out of agricultural waste which is readily available in mass quantities.

An LED light is lit by the corn cob biochar supercapacitor. (Photo by L. Brian Stauffer - U. of I. (University of Illinois) News Bureau)

Known as “agricultural residue,” corn cobs are typically left on the field after harvest and wasted. But if farmers collected corn cobs to sell as a carbon source, the farmer would earn a little extra income and the tech industry would have a low-cost carbon source for supercapacitors.

For the corn cobs to make effective carbon nanosheets, they need to undergo a process called pyrolysis where the raw carbon is turned into a charcoal-like product called biochar. When biochar is made through conventional pyrolysis methods the specific surface area is much lower (7.9 $m^2\ g^{-1}$) than activated carbon (~500 $m^2\ g^{-1}$). However, Jiang and his collaborators discovered a novel synthesis strategy involving biomass pre-treatment, nitrogen pyrolysis, and a high temperature thermal-chemical flash exfoliation. This new process resulted in porous carbon nanosheets with specific surface areas that are much closer to those of activated carbon (543.7 $m^2\ g^{-1}$).

When the corn cob biochar nanosheets were made into a supercapacitor, they demonstrated high capacitance (100 times greater than natural biochar), and they showed outstanding high rate capability for fast discharge. This combination of high capacitance and fast charge-discharge capability distinguishes this material from most other high surface area activated carbons; in fact, the electrochemical behavior more closely resembles that of designer nanomaterials such as graphene and carbon nanotubes.

The biochar electrodes were also extremely durable showing only a 3% reduction in capacitance after 5000 successive potential cycles. The exfoliation strategy developed here could provide a novel route for the low cost production of high performance energy storage materials from a variety of waste biomass feedstocks.

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