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Towards high energy storage supercapacitor: combining in-situ and operando techniques

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Supercapacitors are power systems that charge-discharge in seconds with moderate energy density (3-10 Wh/kg). We have been working on increasing this energy density but keeping essential supercapacitor qualities such as high power (10k W/kg), highly cyclability (1million cycles ~15 years lifespan), charge-discharge temperature (-40^{o}C to 65^{o}C), and cell voltage (≥2.7V).

We have explored several electrolytes widening the cell voltage (V), which is fundamental to increasing energy density (E), i.e., $E \sim V^2$. Here we will discuss how to continue improving the cell voltage with research, exploring green chemistry ionic liquids, organic electrolytes, and deep eutectic solvents. Also, we have developed in-house an activated carbon (AC) material with outstanding electrode features such as high capacitance (C), which is also fundamental to increasing energy density (E), i.e., $E \sim C$. This novel AC has a low carbon footprint, low cost and can be quickly produced from the abundant biomass we have here in this country (sugarcane bagasse and/or coconut shell). Our results with AC decorated with metal oxides also had a promising performance at the coin cell level.

We have been developing and using *operando* FTIR, Raman, and mass spectroscopy to better understand the energy storage and failure mechanisms.

We already produced pouch cells with 100F and 3V in our group. Now we are looking for 3000F and 5V with an increase of 14k% in 5 years to be closer to the applications.

Keywords: energy density, voltage window, electrolytes, ionic liquids, *operando*, nonflammable

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