BOOSTED SUPERCAPACITORS FROM FORESTRY RESIDUES (285196)

a. Brief introductory summary

Supercapacitors are energy storage devices bridging the gap between Li-ion batteries (LiB) and traditional capacitors. They possess attributes such as high specific power, long life cycles, fast charge and discharge, enabling them to function ideally in power intensive applications such as regenerative braking in automobiles, load levelling in wind turbines, cranes, marine and heavy transport. However, they suffer from low specific energy in comparison to LiB which has hindered their utilization.

The specific energy of a supercapacitor is determined by half the product of its specific capacitance and square of its maximum operating potential window (OPW). By widening its maximum OPW, a significant increase can be achieved.

Activated carbon used as electrodes in supercapacitors possess several defects and functional groups which affects its stability at high potentials, accelerating electrolyte decomposition, and thus narrows the OPW.

b. Main purpose

The purpose of this project was to improve the specific energy of supercapacitors by widening its OPW (from Fig1B to D). This was achieved by both reducing the defect level of activated carbon via non-destructive activation, functional group stabilization and optimization of initial electrode potential by ion adsorption.

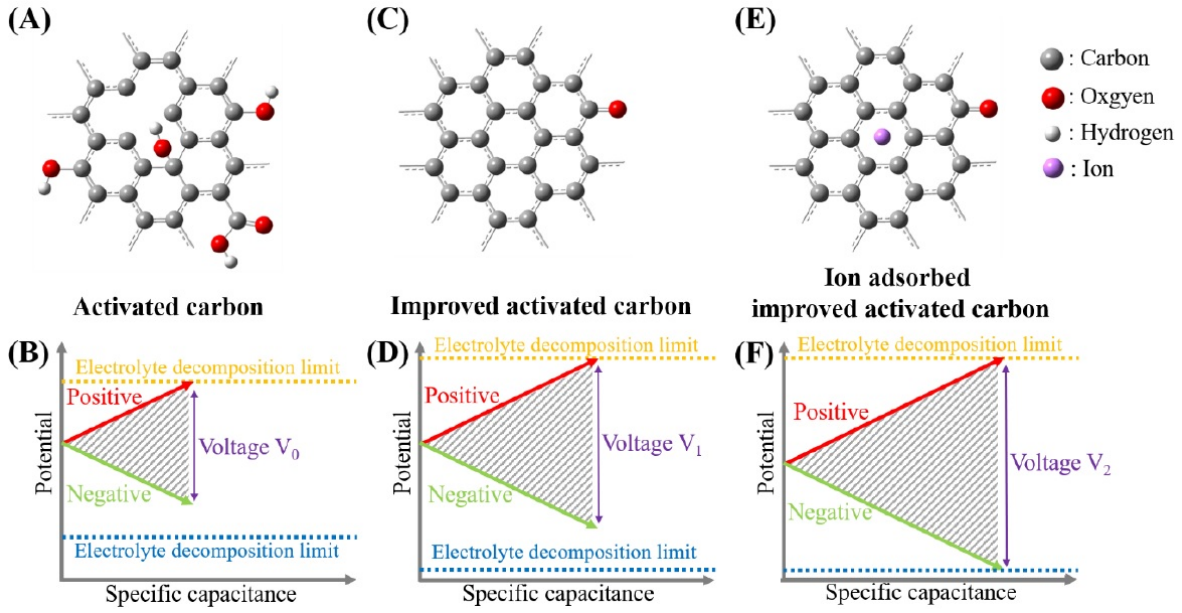

Figure 1. Approaches to widen supercapacitor operating voltage window by activated carbon modification

The key research questions answered by this project included:

- How can the defect level in activated carbon be reduced via non-destructive activation?
- What kind of additive can convert destructive activation into nondestructive activation?
- What kind of functional groups are present on the activated carbon surface and how can they be stabilized?
- How can the initial electrode potential of activated carbon be optimized by ion adsorption to extend its OPW?

c. Present and evaluate results

In this project, a series of modifications were made to the activated carbon which resulted in widening the OPW and enhancement of the specific energy of an assembled supercapacitor. In work package 1, the defect level of the activated carbon was decreased via non-destructive activation through the incorporation of a metal additive (Al) in the activation process. A 53% increase in the specific energy was obtained after the OPW was extended by 0.25V. In work package 2, the oxygen functional groups present in the activated carbon samples responsible for electrolyte decomposition were isolated and removed via heat treatment under an atmosphere of Ammonia gas. An increase in Nitrogen functional groups present, most especially the pyridinic bands was responsible for widening the potential window by 0.5V. In work package 3, the operating potential window was widened via ion adsorption. The initial electrode potential of the activated carbon was regulated by tuning which enabled ion adsorption unto the surface. The ion adsorbed electrode was then used to assemble coin cells with a fresh electrode. Upon analysis, the operating potential window was extended by 0.25V with no signs of decomposition or rapid rise in current at high potentials (Voltage).

d. Project evaluation

The projects main purpose and objectives in the various work packages were met as presented in the previous section. The different techniques employed were able to modify the properties of the activated carbon and upon application as electrodes for supercapacitor, an increase in the specific energy was observed.

e. Considerations about future work

The different methods highlighted in this report, were able to produce modified activated carbons with expanded operating potential windows and excellent properties which resulted in an increase in the specific energy of the supercapacitor.

The potential for scale up to produce pristine activated carbon with excellent properties on a large scale would be investigated using one of the methods in subsequent projects.