

## SUSTAINABLE SUPERCAPACITOR FABRICATION USING BIOWASTE-DERIVED ACTIVATED CARBON FROM *Mimosa pigra*

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The global energy crisis, driven by the rising demand and dependence on non-renewable sources, has intensified the search for sustainable energy storage technologies. Among these, electric double-layer capacitors (EDLCs) have gained considerable attention due to their high-power density, long cycle life, and rapid charge-discharge capabilities. In this study, activated carbon derived from *Mimosa pigra* (*Yodha Nidikumba*; YN), a highly invasive and carbon-rich biowaste, was investigated as a low-cost and eco-friendly electrode material for EDLC applications. The raw material was carbonised at 400 °C, chemically activated using 2.5 mol L<sup>-1</sup> KOH, and further treated at 750 °C to produce porous *Mimosa pigra* derived activated carbon (YN-AC). The synthesised material was mixed with poly(vinylidene difluoride) binder to fabricate carbon ink, which was drop-casted onto current collectors. Symmetric EDLCs were then assembled using YN-AC electrodes and 6.0 mol L<sup>-1</sup> KOH as the liquid electrolyte. Material characterisation revealed that YN-AC exhibited significantly enhanced adsorption properties and porosity compared to its non-activated form. The methylene blue adsorption capacity increased from 48.50 mg g<sup>-1</sup> to 70.13 mg g<sup>-1</sup>, and Raman spectroscopy showed a higher I<sub>D</sub>/I<sub>G</sub> ratio of 0.94 indicating increased structural disorder. Scanning electron microscopic analysis confirmed the development of well-distributed micropores and mesopores, improving ion accessibility. Cyclic voltammetric measurements demonstrated a maximum specific capacitance of 44.86 F g<sup>-1</sup> at a scan rate of 2 mV s<sup>-1</sup>. Galvanostatic charge-discharge (GCD) tests showed stable performance, achieving an energy density of 0.17 W h kg<sup>-1</sup> and a power density of 8.53 W kg<sup>-1</sup> at 1.0 mA cm<sup>-2</sup>. Long-term cycling tests exhibited strong capacitance retention with 110% retention after 1000 cycles, confirming its durability and reliability. These findings highlight the potential of YN-AC as an electrode material for sustainable supercapacitors, with its excellent cycling stability and high capacitance retention demonstrating its viability and contributing to both energy storage and the management of an invasive species.

**Keywords:** Activated carbon, Electrode material, *Mimosa pigra*, Specific capacitance, Supercapacitors