Upcycled Bio-Derived Carbons and Bio-Based Frameworks for Sustainable Electrochemical Energy Storage

Amrita Jain[1*]

[1]Institute of Fundamental Technological Research, Polish Academy of Sciences, Pawińskiego 5B, 02-106 Warsaw, Poland

*Email: ajain@ippt.pan.pl

The global transition toward renewable energy necessitates electrochemical storage technologies that are not only high-performing but also ecologically sustainable. Traditional supercapacitor and battery components rely heavily on energy-intensive synthetic carbons and non-recyclable polymer matrices, presenting critical end-of-life environmental challenges. This presentation highlights strategies for upcycling biowaste feedstocks and bio-derived precursors into tailored, high-surface-area porous carbon architectures and functional biopolymer gel frameworks. By utilizing sustainable chemical activation and structural templating techniques, bio-derived carbons exhibit hierarchical porous networks optimized for rapid ion transport and high charge accumulation. Furthermore, integrating these bio-carbons with sustainable electrolytes and 2D functional materials yields hybrid electrode-electrolyte interfaces with exceptional structural stability, enhanced ionic conductivity, and reduced environmental footprint. The talk will demonstrate how converting agricultural and biopolymer waste into functional electrochemical components addresses key circular economy principles—reducing raw material extraction, minimizing processing toxicity, and enabling closed-loop lifecycle management. These developments pave the way for next-generation, eco-friendly energy storage devices that reconcile high volumetric/gravimetric power densities with environmental stewardship.

Keywords: Bio-derived materials, Sustainable sources, Porous Carbon, Electrochemical Energy Storage, Supercapacitors.