INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Investigation of Titania and Silica Based Inorganic Ionogels and Eutectogels as Electrolytes for Electrochemical Supercapacitors

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SHORT ABSTRACT

The doctoral thesis explores and compares three primary types of gel (ionogel and eutectogel) electrolytes obtained from a simple sol-gel physical confinement of ionic liquids (ILs), natural deep eutectic solvents (NADESs), or an IL-based hybrid DES into an inorganic matrix of titania or silica. The morphological, structural, and thermal properties of the gels are studied via different characterization techniques which primarily include field emission scanning electron microscopy (FESEM), field emission transmission electron microscopy (FETEM), rheology, Fourier transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), and thermogravimetric analysis (TGA). Furthermore, their compatibility with symmetric supercapacitors based on reduced graphene oxide (rGO) electrodes is investigated using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). All gels retain the structural integrity of their parent solvent whilst possessing porous and amorphous characteristics. An alteration in the thermal stabilities of the solvents is observed after gelation on account of non-bonded interactions between the solvent molecules and the matrix particles. Remarkably, the gels are able to deliver a double-layer capacitive behavior within a wide operating potential window (OPW) of 4 or 3 V, highlighting their suitability with electric double layer capacitors (EDLCs) and rGO electrodes. However, the overall electrochemical characteristics of the titania-tethered IL-based eutectogel, prepared using the hybrid DES comprising of the IL 1-butyl-3-methylimidazolium methanesulfonate ([BMIM][$MeSO_3$]) and *N*-methylacetamide (NMAc), are found to be at par with that of the ionogels and mostly superior to that of the NADES-based eutectogels. Nonetheless, the delivery of competent performance with the utilization of lesser quantity of IL as compared to that in ionogels renders the IL-based eutectogels more economical, thus offering the best trade-off between cost and performance among the three categories of gels studied in this work, supporting their utilization as cost-effective solid electrolytes in supercapacitors. The said eutectogel delivers a specific capacitance of 16.3 F g^{-1} (395.8 mF cm^{-2}) and specific energy (20.4 W h kg^{-1}) along with an equivalent series resistance of 39.6 Ω and an ionic conductivity (1.3 mS cm^{-1}), allowing the device to deliver a power of 3.3 kW kg^{-1}. The same gel is also observed to maintain its OPW and EDLC properties across controlled temperatures of 25, 50, and 80 °C, exhibiting notable improvement in specific capacitance and ionic conductivity by factors of 3 and 4.4 respectively, at 80 °C.