

# Ionic liquid integrated high-voltage polymer gel electrolyte to improve the capacitance and cyclic stability of supercapacitors

Apurba Ray, and Bilge Saruhan

German Aerospace Center (DLR), Institute for Frontier Materials on Earth and in Space, 51147 Cologne, Germany

With the rapidly increasing demand for the most promising electrical energy storage devices, supercapacitors (SCs) have attracted widespread interest due to their high capacity, specific power density and long cyclic performance. To date, symmetric electrodes made of various types of porous carbons such as activated carbon (AC), carbon nanofibers, carbon nanotubes (CNT), and graphene/reduced graphene oxide (rGO) are commonly used for commercial electrical double layer capacitors (EDLCs) or supercapacitors [1]. Electrolytes also play an important role for supercapacitor devices through their physical, thermal and electrochemical properties. Because of high ionic conductivity, simple processing, low cost and good interfacial (electrode/electrolyte) properties of aqueous electrolytes and organic liquid-based electrolytes have been widely used for SCs. However, lower voltage windows, lower cycle life, corrosion, leakage problem, flammability and safety issues limit their commercialization [2].

To address the above-mentioned issues, ionic liquids (ILs) integrated solid/semi-solid polymer electrolytes have attracted wide interest as an alternative electrolyte in electrochemical energy storage due to their wide potential windows ( $\geq 3V$ ), high ionic conductivity ( $10^{-4}\Omega^{-1}cm^{-1}$ ), leakage free, low flammability, good thermal stability, flexibility, tunable chemical functionalities and self-healing capabilities [3,4]. Significant efforts have also been devoted to integrating various ionic liquids (ILs) into solid/semi-solid polymer electrolytes for emerging SCs. In this work, 1-Ethyl-3-Methylimidazolium bis(trifluoromethylsulfonyl)imide [EMIM][TFSI] ionic liquid embedded in Polypropylene Carbonate (PPC) and Polycarbonate (PC) based polymer gel electrolyte has been developed by entrapping the IL in the polymer network for activated carbon (AC) electrode-based pouch cell SC and laser induced graphene (LIG) electrode micro-supercapacitors (MSCs) applications. The electrochemical performance of this [EMIM][TFSI]/ PPC/PC polymer gel electrolyte has been evaluated by cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) (Figure 1a), electrochemical impedance spectroscopy (EIS) and long cycle charge-discharge (CCD) analysis. Relying on the combined effect of IL, this novel semi-solid electrolyte improves the capacitance ( $0.94\text{ mF/cm}^2 @ 2V$ ),

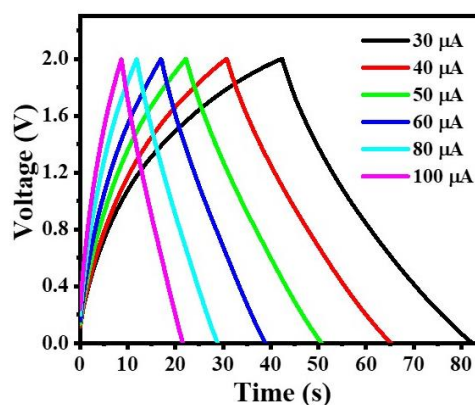


Figure 1. Galvanostatic charge-discharge (GCD) curves of [EMIM][TFSI]/PPC/PC polymer electrolyte integrated-laser induced graphene (LIG) electrode micro-supercapacitor (MSC).

electrode/electrolyte interface compatibility, voltage windows ( $\geq 2.0V$ ), ionic conductivity and long cycle stability ( $\geq 50000$  cycles) making it a potential electrolyte for next-generation supercapacitors.

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Dr. Apurba Ray is currently working as a Research Scientist at the Institute for Frontier Materials on Earth and in Space, German Aerospace Center (DLR) in Cologne. He accomplished his PhD in Jadavpur University, India in 2019 in the field of high-power supercapacitors. Afterwards, he was selected for the DLR-DAAD Post-doctoral Research Fellow in Germany. To date, he has published more than 45 research papers in various international journals. He was awarded the INSPIRE Scholarship in 2008 from the Department of Science and Technology (DST) and Senior Research Fellowship in 2018 from Council of Scientific and Industrial Research (CSIR), Govt. Of India.

Presenting author: Apurba Ray, e-mail: [Apurba.Ray@dlr.de](mailto:Apurba.Ray@dlr.de)

tel: +492203 601-4575