Ionogel-based electrodes for non-flammable high-temperature operating electrochemical double layer capacitors

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Electrochemical double-layer capacitors (EDLCs) are a type of supercapacitors (SCs), which have garnered significant attention as suitable energy storage solution for several applications ranging from automotive, to smart grids, wind turbines, and power electronics [1]. However, their limited energy density (E_S) and narrow operating temperature range pose challenges for wider adoption, especially in harsh environments [2, 3]. This study introduces a novel approach for the fabrication of the SC electrodes using ionogels, improving the overall performances and overcoming the temperature limitations of conventional SCs. This study presents a novel strategy utilizing ionogel-based electrodes to improve the energy density of EDLCs, while expanding their operational temperature range. The ionogel electrodes were fabricated by formulating electrode slurries with an ionic liquid (1-ethil-3-methylimidazolium bis(fluorosulfonyl)imide (EMIMFSI)) and water as the liquid medium, avoiding the need for organic solvents and eliminating expensive drying procedures. The ionogel-electrode approach facilitates efficient contact between the porous electrode surface and the electrolyte, preventing gas entrapment in the pores, ensuring uniform wetting, and eliminating the need for time-consuming pre-conditioning steps. This simplifies industrial assembly processes significantly [4]. Ionogel-electrodes exhibited remarkable rate capability and capacity retention (~92 % over 100 h of floating time) due to the extended electrolyte penetration into the electrode pores, hardly achievable with conventional electrodes. At a power density of 12.96 kW kg^{-1}, the ionogel-based EDLC retains 33 Wh kg^{-1} which is ~83 % of the energy density measured at a low power of 0.14 kW kg^{-1} (40 Wh kg^{-1}). In contrast, conventional EDLCs retain 65 % of its energy density in the same specific power range. Moreover, the operating temperature window is enlarged thanks to the thermal stability of EMIMFSI-based electrolyte which enables to retain ~24 Wh kg^{-1} still at 100 °C while conventional SC are limited under 65 °C. Overall, this research presents a promising pathway for advancing EDLC technology through innovative electrode fabrication methods and IL-based electrolytes.

References

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Figures

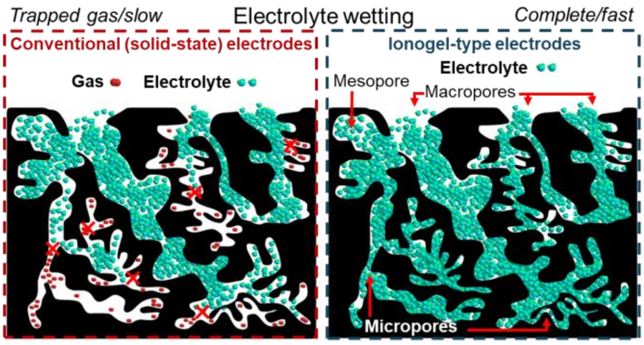

Figure 1. Sketch of the electrolyte wetting processes for conventional (solid-state) and ionogel-type electrodes.

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