Novel ionic-liquid-based composite electrolytes for sodium-ion batteries

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Challenges associated with climate change and exhaustion of fossil fuels lead to increased interest in renewable energy. As renewable energy is gaining more and more traction, energy storage due to irregular patterns of energy generation and consumption require stationary energy storage. However, as growing price and demand for lithium motivates a search for alternatives to lithium ion batteries (LIBs), sodium ion batteries (SIBs) emerge as a good candidate for stationary energy storage. With sodium being 6th most abundant element in Earth's crust, the raw material costs are expected to be significantly lower. LIBs and SIBs with liquid electrolytes are considered to be a fire hazard. This has spun new ventures into developing ionic liquids (ILs), which are less flammable than the liquid electrolytes to the extent that they are being considered fire retardants. ILs display high chemical and electrochemical stability, low vapor pressure at room temperature and relatively good ionic conductivity[1].

Novel ether-functionalised imidazolium ILs with [TFSI]- anion were synthesised and tested for potential interactions with sodium salts. To elucidate the transport properties of neat ILs, viscosity, ion conductivity and density characterisations were conducted. The dynamic viscosity of ionic liquids as a function of temperature was determined using an Anton Paar oscillating cup microviscometer Lovis 2000 M/ME. For determination of resistance of the bulk electrolyte EIS method was used. All preparations and measurements were done in a glovebox EASYlab workstation 215182 (H_2O – 0,5 ppm, O_2 – 0,5 ppm). The unique feature of these IL structures lies in the linker length between the imidazolium ring and the ether side chain: In our series of ILs, only a single carbon atom separates the ring and the oxygen atom, thus limiting its rotation. Sulfonated polyetheretherketone (SPEEK) membranes with different parameters (geometry, degree of sulfonation) were synthesized. The prepared ionic liquids and mixes with sodium salt (sodium perchlorate, sodium bis(fluorsulfonyl)imide, sodium bis(trifluormethylsulphoninyl)imide) were used for composite membrane preparation. The membranes and IL`s were used to prepare and test the sodium-ion battery prototypes with a liquid electrolyte and all-solid ones. The propylenecarbonate was used as solvent.

Coin-cells assembled in a glove=box. The metallic sodium was used as an anode and $Na_2FeP_2O_7$ composite as a cathode. Neware BTS4000 battery tester was used for electrochemical measurements.

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References

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