Innovative Polymeric Materials for Sodium-ion Batteries

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Large-scale energy storage systems are becoming fundamental for the modern society, particularly to fully exploit major advantages from renewable energy sources, such as wind and solar light. In this respect, secondary sodium-based batteries may represent the key technology since they possess high-energy density, low-cost, simple design and easiness in maintenance. Nevertheless, the state of art of the current materials is rather far from a mass commercialization. Beside electrodic materials, an essential role is also played by electrolytes and separators, which are deepened in this work. Indeed, a large number of factors must be considered while selecting the best separator, including electronic insulation, low ionic resistance, mechanical stability, chemical resistance to degradation, wettability and uniform thickness [1].

In this context, we prepared polyurethane-based membranes starting from polyviniyl butyral (PVB) and diisocyanate, by means of a coagulation bath as [2,3]. The choice of PVB as polymer is related to the European project *SUNRISE*, which aims to find different recycling pathways for this material, normally used as polymeric interlayer into laminated glasses for construction and automotive. At the moment, the PVB fraction collected after consume, that lacks of optical and mechanical requirements for its original purpose, is incinerated or landfilled, causing tons of losses every year, even though it could find a second life within the energy storage panorama [4].

After preparation, our PVB-based membranes were tested as polymer electrolyte separating membranes, swelled in combination with different solvents, inside sodium-metal cells. Firstly, they were used as standard separating electrolytes soaked in mixtures of sodium salts (sodium perchlorate, $NaClO_4$ or sodium exafluorophosphate, $NaPF_6$) in 1M carbonate based mixtures. Successively, they are also used as gel polymer electrolyte separators in different formulations with room temperature ionic liquids and sodium salts, namely N-butylpyrrolidinium bis(fluorosulfonyl)imide ($Pyr_{14}FSI$) and sodium bis(fluorosulfonyl)imide (NaFSI). Lastly, the performances of the membrane were investigated with glyoxylic-acetal-based solvents, specifically 1,1,2,2-tetramethoxyethane (also known as tetramethoxyglyoxal, TMG) and 1,1,2,2-tetraethoxyethane (also known as tetraethoxyglyoxal, TEG). Ionic conductivity, plating and stripping processes, galvanostatic and potentiostatic cycling were evaluated, to demonstrate the practical application of the developed electrolyte materials in laboratory scale Na-based electrochemical cells at various conditions of current rate, temperature and aging. Preliminary results are highly encouraging and pave the way to the development of more sustainable electrolytes separators for safe, low cost energy storage devices.

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