Application of Ionic Liquids as electrolytes for safe and sustainable lithium ion batteries

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To be adequate, the new batteries must offer performances, in terms of safety, cost, cycle and calendar life and environmental compatibility, superior than those of the presently available lithium ion batteries. Batteries of this type are presently requested as ideal power sources for portable electronic devices (e.g., lap top computers and cellular phones) and, particularly, for electric or hybrid cars. Indeed, safety and environmental respect are nowadays two major concerns, and one typical problem is linked to internal pressure build-up, that can follow to (i) solvents vaporization if heat is inefficiently dispersed, or to (ii) solvents electrochemical decomposition and gas products formation. The increase of internal pressure can turn into cell rupture and venting, but sometimes violent side reactions can occur with flame development.

Ionic liquids (ILs), i.e., molten salts at temperatures approaching room conditions, are of great actual interest for their unique characteristics, which include: (1) a liquid state over a wide temperature range; (2) nonvolatility, which assures thermal stability and nonflammability; (3) high ion content, which results in high ionic conductivity; and (4) great chemical and electrochemical stability. All these features, responding to the requirements of environmental compatibility and safety, ideally connote ILs as a suitable constituent of a battery.

In this study, we present some of the most recent results obtained in our laboratory, on the application of ionic liquids to lithium ion batteries.

The study of intrinsic characteristics of several ionic liquids carried us to the choice of N-butyl-N-ethylpyrrolidinium bis(trifluoromethanesulfonyl)imide, $Py_{24}TFSI$. The properties of a LiTFSI solution have been deepened in terms of thermal behaviour, conductivity and electrochemical stability. Then, tests in batteries have been performed.

A combination of a $Li_{4/3}Ti_{5/3}O_4$ anode and a $LiFePO_4$ cathode has already been proved to be a valid choice to realize a lithium ion battery. Both electrodes are cheap and not toxic; their potential profile upon the two-phase lithium acceptance-removal processes is flat, and minor structural modifications occur upon cycling. In addition, for both electrodes, the electrochemical process develops within the stability window of the ionic liquid solution, thus further granting the intrinsic safety and stability of the system.

As a matter of fact, the assembly $Li_{4/3}Ti_{5/3}O_4$ / LiTFSI $Py_{24}TFSI$ / $LiFePO_4$ proved to be stable and well performing.