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Development of NMC622 / graphite hybrid polymer lithium battery

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Li-ion batteries are considered as the most suitable electrochemical energy storage systems for a wide range of applications including stationary applications, when combined with renewable energy harvested systems, and automotive applications with the electrification of transportation, in order to contribute to the reduction of CO₂ emissions responsible for climate change¹.

Indeed, Li-ion batteries combine high specific energy and power, long cycle life, high efficiency, high charge/discharge rate capability and low self-discharge. In addition, it is a versatile technology easily adaptable to the application by playing with the electrode materials and electrolyte composition.^{2,3}

However, most commercial Li-ion batteries widely use organic carbonates electrolyte containing Li salt which is volatile, flammable and can induce thermal runaway in case of inner short-circuit.⁴ In order to make the battery safer, CEA-Liten and Solvay have developed a new technology based on hybrid polymer lithium battery, where the organic carbonates electrolyte is confined in a hybrid polymer membrane as well as in gelled electrodes from their manufacturing.

Hybrid polymer membrane is prepared by using a non-aqueous sol-gel route. A new Solvay proprietary functionalized PVdF is able to react and create a stable network able to trap fully the organic carbonate electrolyte. The membrane elaborated by a two-step cross-linking method and implemented by using roll-to-roll coating machine, shows homogeneous structure coupled with high ionic conductivity and high flexibility when LiPF₆ (1M) in a carbonate mix is used.

The gelled electrodes are prepared by using a second Solvay proprietary functionalized PVdF as binder, which is able to trap the organic carbonate electrolyte in the electrode microstructure. Gelled electrodes are produced according to conventional electrode manufacturing process (i.e using mixing, coating and calendaring machines). Thus, gelled graphite based anode and gelled NMC622 based cathode are produced at the pilot line scale in anhydrous atmosphere, using LiPF₆ (1M) in a carbonate mix. In addition, the technology allows producing high loading electrodes (5mAh/cm² typically for the gelled cathode) with suitable mechanical properties adapted for winding. No damage was observed regarding the integrity of the gelled electrodes at each manufacturing step.

Proof of concept of the technology was carried out by assembling the gelled electrodes with the hybrid polymer membrane (without any addition of additional electrolyte) in various cell sizes and formats: from single layer pouch to 1 Ah stacked cell, prismatic cell or even 18650 cylindrical cell, leading to relevant electrochemical performances. In addition, the retention of the organic carbonate electrolyte has shown unequivocally a benefit effect on the safety, highlighted by calorimetry analysis and some abusive tests.

New process is today under investigations in order to manufacture the hybrid polymer membrane as well as the gelled electrodes without the any process solvent, than those used in the organic carbonate electrolyte. This way allows simplifying considerably the cell manufacturing process, increasing the safety and reducing the cost and the environmental footprint because no solvent is evaporated and recovered, as it is the case with conventional Li-ion batteries.

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