Active cathode copper coated powder for improving Lithium Ion Battery performances

M. Spreafico[1], P. Cojocaru[2], F. Triulzi[2], M. Apostolo[2], L. Magagnin[1]

[1] Politecnico di Milano, Dip. Chimica, Materiali e Ing. Chimica Giulio Natta
Via Mancinelli, 7 – 20131 Milano, Italy
luca.magagnin@polimi.it
[2] Solvay Specialty Polymers, Alternative Energy R&D
V.le Lombardia 20/a, 20021 Bollate (Milan), Italy
Paula.Cojocaru@solvay.com

The research presented in this abstract is concerned with a major step improvement in current Li-ion technology intended to make it greener, with increase battery capacity and reduced cost.
The state of the art production process for the Li-ion battery manufacturers entails anode material (i.e. graphite) and the cathode material (Li oxide or equivalent) being coated – in the form of fluid slurries - onto metal foils current collectors, sandwiched together with an electrolyte filling and separator and rolled or folded into compact shapes suitable for packaging (cylinder, pouch or coin) [1-3].
The anode material is made from a carbon powder mixed with a small percentage of binder material, certain additives and a solvent to keep it liquid during manufacturing. Carbon is not reactive with water and hence the binder solvent can be water-based.

The cathode materials are generally sensitive to moisture/humidity, negatively affecting final electrode performance so special provisions must be made to assure that water is kept out of the process. For the cathode therefore, a highly stable binder, the thermoplastic fluoropolymer PVDF, is used as the binder dissolved in the organic solvent N-Methyl-2-pyrrolidone (NMP). During the coating process approximately 40% of the slurry mix is comprised of NMP which is evaporated off in the drying process. NMP or similar toxic solvents are no longer needed.
The innovative concept at the basis of this research is to employ an electrochemical process to coat the active cathode material powder in a barrier which will prohibit contact with water and hence enable the use of aqueous binder mixes.
The active electrode powder material ideally makes up 96% of the finished electrode material. An electro conductivity additive such as carbon black, graphene or carbon nanotubes may be included up to 10% of the weight. Thickeners may also be added to reduce the tendency to separate of the different materials in the fluid mix.
The polymer binder is introduced in the form of aqueous latex of polymer obtained from emulsion polymerization. The mix is performed in an apparatus such as, for example, a roll kneader, mixer or bead mill. The mix is then applied to at least one surface of a metal current collector by a wet coating process such as screen printing or roll coating. The drying may be performed at temperatures ranging from 50°C to 150°C.
Preliminary evaluation of electrochemical properties of manufactured cathodes with coated active materials using a new process was done.
During this research lithium coin cells (CR2032 type) were prepared in laboratory tests in a glove box under Ar gas atmosphere by punching a small disk of the electrode prepared with Lithium metal as counter and reference electrode. The electrolyte was 1 M $LiPF_6$ in ethylene carbonate (EC)/dimethylcarbonate (DMC) (1:1 vol/vol) and a Whatman® glass-fiber paper was used as separator.
After initial charge and discharge cycles at low current rate, cells were galvanostatically cycled at a constant current rate of 0.33 C to show capacity fade over cycling. The electrochemical results confirm that the Cu coating can greatly increase the stability of $LiCoO_2$ in the presence of water based binders, thus enabling a capacity retention strongly improved over electrodes made from uncoated $LiCoO_2$ powders, and substantially similar, or even better, than results obtained from traditional solvent-borne electrode-forming compositions: After 50 charge/discharge cycles the electroless coated version retained an impressive 89.3% of reversible capacity compared to 82.4% for conventional NMP technology and to a very poor 23% for cells with an aqueous binder and uncoated cathode material.
What this points to is not only a greener production process but the potential for battery life to be extended by a significant amount, i.e. potentially substantially more than 10%. Extended battery life results in reduced battery replacement rates and a consequent reduction in spent battery disposal and recycling and new battery manufacturing, all of which result in a cleaner more resource efficient economy.

References

[1] J. Shu, M. Shui, F. Huang, Y. Ren, Q. Wang, D. Xu, L. Hou, J. Phys. Chem. C 114 (2010) 3323.
[2] M. S. Whittingham, Chem. Rev. 104 (2004) 4271.
[3] Y. Gu, D. Chen, X. Jiao J. Phys. Chem. B 109 (2005) 17901.