

Copper plating of LiCoO₂ particles for water friendly electrodes in Li-ion batteries

M. Spreafico¹, P. Cojocar², F. Triulzi²,
M. Apostolo², L. Magagnin¹

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.Cojocar@solvay.com

Lithium cobalt oxide (LiCoO₂) is the most widespread used active material in conventional cathodes for lithium-ion batteries. Its structural and electrochemical properties have been extensively studied [1-3].

The value of LiCoO₂ charge capacity, 150 mA h g⁻¹, is one of the reasons that prompted research in seeking for alternatives to be used at the positive electrode. Plenty of cathode materials have been studied, for example spinels [2,4] and LiFePO₄ [2,5] amongst the others. Moreover, modification of lithium cobalt oxide properties has been achieved by coatings of the active material with different materials and with various techniques [6,7].

In commercial grade lithium batteries, electrodes are produced by mixing the active material and additives with a polymeric binder in an organic solvent, and then applying the resulting slurry onto a metallic current collector. The solvent is then removed from the electrode via evaporation with an annealing treatment. The use of an organic solvent is necessary since LiCoO₂ undergoes chemical decomposition in an aqueous environment [8].

In this work, copper coating has been applied on LiCoO₂ particles in order to allow the use of water as solvent in the manufacturing process of the cathodes for Li-ion batteries. The deposition was done with electroless technique, which is made of two distinct steps: (i) Pd-activation of the particles and (ii) the growth of the coating on the particles with the reduction of Cu ions. The treatment allowed the deposition of a homogeneous copper layer on the particles as shown by SEM analysis, fig. 1.

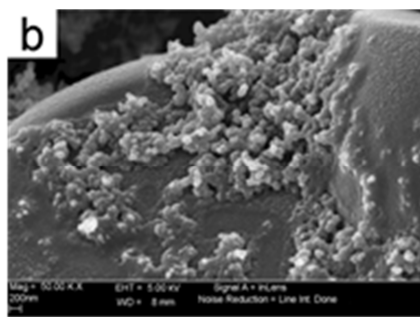


Figure 1. SEM images of the cathodes containing coated LiCoO₂ particles.

The electrodes manufactured with the coated powders of active material showed an increased electrical conductivity. Electrochemical characterization has been carried out to investigate the nature of the coating, and performances of the obtained cathodes have been evaluated by means of galvanostatic cycling in coin cells. Table 1 summarizes the outcome of the measurements

after the first 50 cycles at 0.33 C.

Table 1. Electrochemical performances for the coin cells after 50 cycles with a cycling rate of 0.33C. RC: reversible capacity. RC1 cycle: reversible capacity measured after 1 cycle. Capacity retention is the ratio between RC50 cycles and RC1 cycles.

| | RC _{1 cycle} (mAh g ⁻¹) | RC _{50 cycles} (mAh g ⁻¹) | Capacity Retention |
|--------------|-------------------------------------------------|---------------------------------------------------|--------------------|
| LCO/Water | 81.8 | 37.2 | 45.5 % |
| LCO/NMP | 140.1 | 102.8 | 73.4 % |
| Cu-LCO/Water | 115.8 | 101.9 | 88 % |

The presence of copper on the particles of active material has shown its effectiveness under more severe cycling conditions. The coating allows using water as solvent in the preparation of the cathodes, leading to NMP-free manufacturing process of lithium-ion batteries.

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.
- [4] M. M. Thackeray, W. I. F. David, P. G. Bruce, J. B. Goodenough, *Mater. Res. Bull.* 18 (1983) 461.
- [5] A. K. Padhi, K.S. Nanjundaswamy, J.B. Goodenough, *J. Electrochem. Soc.* 144 (1997) 1188.
- [6] F. T. Quinlan, R. Vidu, L. Predoana, M. Zaharescu, M. Gartner, J. Groza, P. Stroeve, *Ind. Eng. Chem. Res.* 43 (2004) 2468.
- [7] C. Li, H.P. Zhang, L.J. Fu, H. Liu, Y.P. Wu, E. Rahm, R. Holze, H.Q. Wu, *Elect. Acta* 51 (2006) 3872.
- [8] R. Ruffo, C. Wessells, R. A. Huggins, Y. Cui, *Electr. Comm.* 11 (2009) 247.