Impact of Particle Wiring on Performance of Insertion Cathodes

R. Dominko, M.Gaberscek, J. Drofenik, M. Bele, and J. Jamnik

National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia

Distribution of carbon black (or alternative electron conductor) in cathode composites is crucial for electrode performance. Only at spots where carbon black is available, electrochemical insertion of ions together with electrons can take place (Fig. 1). So, ideally, carbon black should be distributed homogeneously around each active particle.[1,2] In practice, it turns out that it is very difficult to control and design the carbon black arrangement in cathode composites. Actually, the problem seems to be underestimated or even ignored. Recently, as the particles size is decreasing to sub-micron dimensions, these problems are becoming even more relevant.

It is almost impossible to achieve homogeneous distribution of carbon black around active particles using conventional techniques of cathode preparation. Namely, simple mixing of cathode constituents (active particles, carbon black, binder) leads to considerable phase agglomeration[1]. In order to control the mutual particle arrangement, we have introduced a special technique (Novel Coating Technology – NCT)[1,2] in which gelatin takes care for homogeneous distribution around cathode active particles ( ). Even more, by appropriate selection of processing parameters, it has been possible to tailor the distribution of carbon black around active particles. The distribution of carbon black in the composite catthodes was checked by various techniques: scanning electron microscopy, microelectrode impedance spectroscopy and element mapping analysis. We have been able to show a direct correlation between carbon black distribution and reversible capacity of cathodes (Fig. 2). It is necessary to stress that this correlation has been observed regardless of the type of cathode material tested, i.e., $LiMn_2O_2$-spinel, $LiCoO_2$, or $LiFePO_4$.

The importance of carbon black distribution in practical cathode composites can be illustrated by the following example (Fig. 2b): if one does not care about carbon black distribution and simply mixes the constituents together, he will need about 5 times more carbon black than in the case where carbon black is deposited uniformly around active particles – to achieve the same reversible capacity (the same average electrode polarisation).

Acknowledgements

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References

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2. R. Dominko, M. Gaberscek, J. Drofenik, M. Bele, S. Pejovnik, J. Jamnik, accepted for publ. in J. Power Sources.

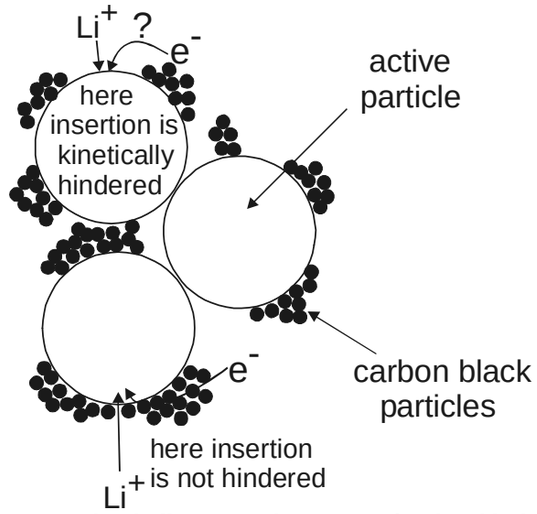

Figure 1. A sketch illustrating the impact of carbon black distribution on insertion kinetics in cathode materials.

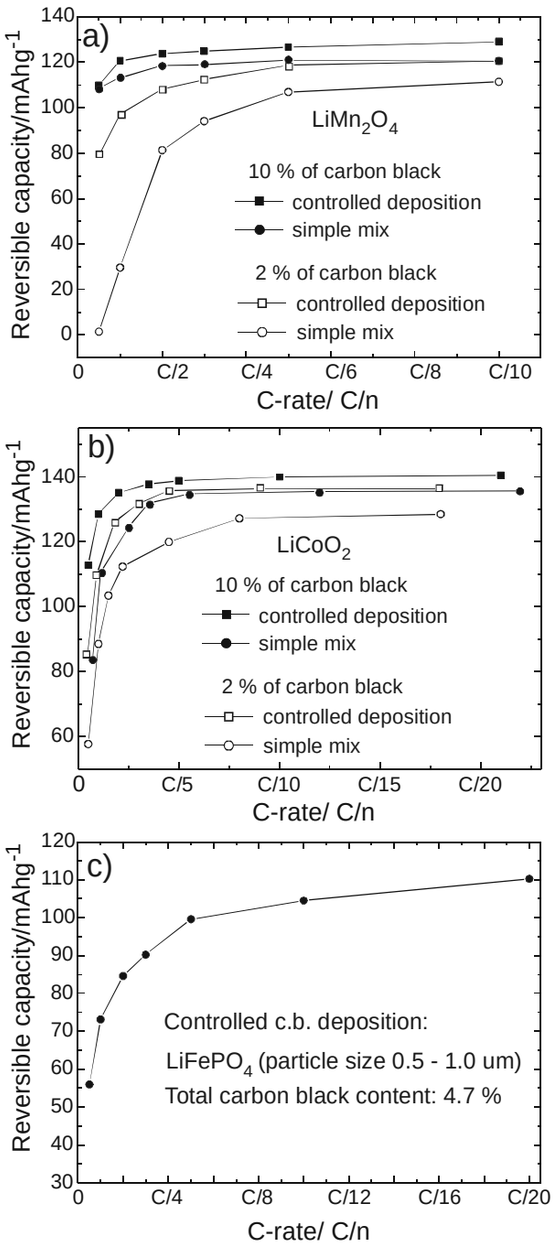

Figure 2. Cathode performance as a function of carbon black content and carbon black distribution.