Understanding the influence of conductive carbon additives surface area on the rate performance of $LiFePO_4$ cathodes for lithium ion batteries

Xin Qi [a], Berislav Blizanac [b], Jie Li [a], Martin Winter [a]

a MEET Battery Research Center, Institute of Physical Chemistry, University of Muenster

Corrensstraße 46, 48149 Muenster, Germany

b Cabot Corporation

5401 Venice Avenue NE, Albuquerque, USA

Performance of the cathode active materials in lithium ion batteries is strongly influenced by their poor electronic conductivity, particularly the case for lithium iron phosphate ($LiFePO_4$, LFP), which conductivity below 10^{-9} S cm^{-1} [1, 2]. Conductive carbon additives with different surface area and particle size, alone or in different combinations, were tested as conductive additives for $LiFePO_4$ cathode materials in lithium ion batteries. Their influence on the conductivity, rate capability as well as the structure of the resulting electrodes was investigated.

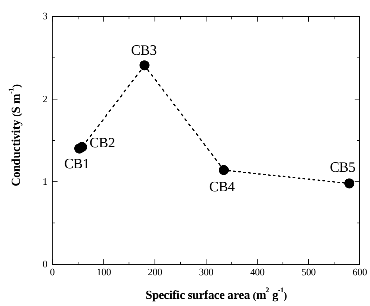

Fig. 1: Conductivity of LFP electrodes with the different carbon blacks.

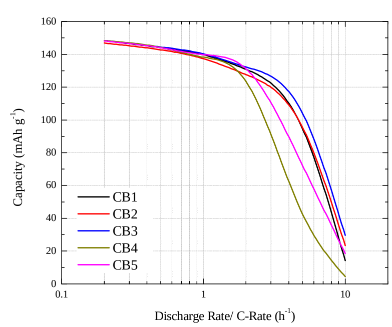

Fig. 2: Discharge capacity as a function of discharge rate for electrodes utilizing different conductive carbon additives.

By comparing the discharge capacity, especially at higher rates, it can be concluded that the conductivity and electrochemical performance of $LiFePO_4$ cathode is significantly affected by the surface area, particle size and morphology of the used carbon additives.

Mercury porosimetry was carried out to define the porosity and pore size distribution of electrodes.

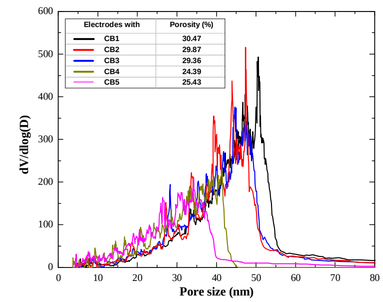

Fig. 3: Porosity and pore size distribution of LFP electrodes with 5 different carbon blacks.

Carbon additives with higher surface area (smaller particle size) create more contact points between the active material particles and thus have a potential to form a better conductive network in the electrode. However, if the particle size is too small it becomes more difficult to properly incorporate conductive additive into the electrode structure in addition to challenges with dispersion and agglomeration. This deteriorates the conductive network and increases electrode resistivity. The electrode porosity is strongly affected by the dimensions of the carbon black: small carbon black in electrode leads to smaller pores and lower porosity, thus is negatively affecting the electrolyte accessibility. The results indicate that an optimum electrode structure and thus performance can be obtained by selecting a suitable combination of carbon additive and active material.

References:

[1] S. Y. Chung et al. Nature Materials 2 (2002) 123.
[2] A. K. Padhi et al. J. Electrochemical Society 144 (1997) 1188.