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Effect of Conductive Additives in LiFePO₄ Cathode for Lithium-Ion Batteries

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LiFePO₄ has been studied as the cathode-active material for Li rechargeable batteries because of low-cost, low toxicity and relatively high theoretical specific capacity of 170mAh/g [1,2]. However, one of major problem to prevent the commercialization of LiFePO₄ is poor rate capability because of low electrical and ionic conductivity. Recently, Huang *et al* reported that nanocomposites of LiFePO₄ and conductive carbon prepared by coating a carbon gel could approach theoretical capacity at room temperature and high rate [3]. However, as Chen and Dahn have already reported [4], small particle size needs more carbon coating. Therefore, the energy density of material decreases with decreasing grain size because of inactive and bulky carbon. However, they did not report the variation for volumetric and gravimetric energy densities of LiFePO₄ electrode by the amount of conductive additive, which is added during electrode preparation. It is very important to find the optimum content of conductive additive, which affects on utilization and energy density of LiFePO₄ electrode.

In this study, we investigate the effect of different conductive additives, carbon black and graphite, in LiFePO₄ electrode. This work is a part of BATT (Batteries for Advanced Transportation Technologies) program that is studying cell chemistry under constant cycling regimes with standard test protocols and diagnostic techniques to determine cycle performance and capacity fade mechanisms [5].

LiFePO₄ electrodes were supplied from Hydro-Québec and Université de Montréal. LiFePO₄ cathodes consist of active material, LiFePO₄, carbon black, graphite, PVdF and carbon-coated Al current collector. All electrodes were supplied from Hydro Quebec. Table 1 shows the electrode composition in detail. Before electrochemical test, electrodes were dried at 120°C under vacuum and then transferred to an Ar-filled glovebox. These electrodes were tested in Swagelok type half-cell with Li reference and counter electrodes and Celgard separator. The electrolyte was 1M LiBF₄ in EC/DEC (1/1) solvent. All cells were assembled in an Ar-filled glovebox and tested at room temperature. The cut-off voltage of these cells was 2.5V to 4.0V. To measure the rate capability, the cell was charged to 4.0V at C/2 and then discharge to 2.5V at specific rates from C/5 to 5C. Constant cycling was carried out 80 times at C/2 to evaluate capacity fade rate.

Fig. 1 shows the apparent electrode density, active material loading and theoretical capacity based on electrode volume. The apparent electrode density was calculated by the weight and thickness of electrode. As carbon black content increased, apparent electrode density

and active material loading of electrode decreased. When same amount of conductive additives was added in electrode, the use of only graphite or the mixture of carbon black and graphite produce higher active material loading and thinner electrode than the addition of only carbon black.

Fig. 2 shows specific capacity on conductive additive content and specific current. This shows that the capacity increases when the amount of conductive additive increases. The addition of 3% carbon black did not give capacity improvement. But, above 6%, capacity increases as the conductive additives content increases.

Acknowledgement

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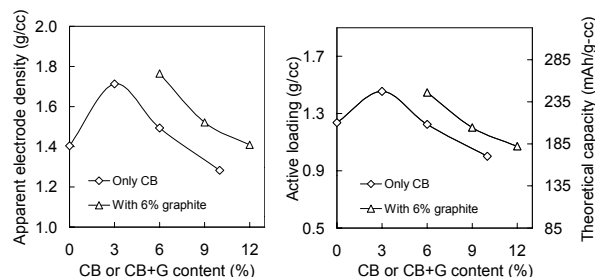


Fig. 1. Apparent electrode density, active loading and theoretical capacity based on electrode volume as function of conductive additive content

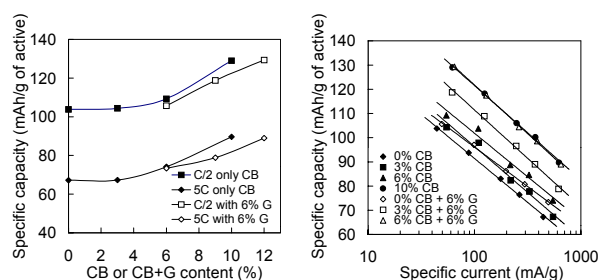


Fig. 2. Specific capacity (mAh/g of active material) of LiFePO₄ electrodes on conductive additive contents and specific current