Effects of electrode density on the safety of NCA positive electrode for high capacity Li-ion batteries

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Many companies manufacturing commercial Li ion batteries have started to use $Li[Ni_{0.8}Co_{0.15}Al_{0.05}]O_2$ (NCA) as an alternative positive electrode material for high capacity Li ion batteries because the attainable capacity of $LiCoO_2$ is less than that of NCA. The companies also have tried to make positive and/or negative electrodes thicker and denser to reach higher capacity. As the capacity of Li ion cells, such as 18650 size, increases, however, cell safety characteristics become worse[1]. No fundamental reports about the relation between electrode density and safety have been previously reported.

Accelerating rate calorimetry (ARC) studies of NCA positive electrodes with various electrode densities were made. The ARC tests also probed the effects of $LiPF_6$ and lithium bis(oxalato)borate (LiBOB) salts on safety using charged-NCA powder.

Table 1 shows some physical properties of the electrodes compressed with 0 atm, 1020 atm, and 2078 atm. The electrode compressed with the highest pressure showed the highest electrode density (2.3 g/cc) and the least amount of electrolyte (10 mg) contained within the coin-cell electrode.

Figure 1 shows ARC results for the various electrodes. The electrolyte used was 1M $LiPF_6$ EC:DEC (1:2 v/v). The ARC starting temperature was 150°C. Figure 1 shows that the denser electrode (compressed with 2078 atm) shows higher reactivity with the electrolyte in the temperature range from 150°C to 250°C than the other electrodes. This result suggests that the differences of the ARC result of these electrodes are caused by a different amount of $LiPF_6$ contained within the electrodes. The $LiPF_6$ in electrolyte plays an important role in reducing the rate of reaction and enhancing safety because polymeric reaction products generated by decomposition of $LiPF_6$ hinder the release of the oxygen from the cathode material at an elevated temperature[2,3,4]. On the other hand, additions of LiBOB could not suppress the rate of reaction between electrodes and electrolyte at all.

The results of this work suggest that the reactivity between NCAs and electrolyte will be slowed when electrolytes with high $LiPF_6$ concentration (≈ 1.5M) are employed. This result may be helpful to researchers and engineers who desire to design and develop highly safe Li-ion batteries having high capacity.

Table 1. Basic physical properties of the NCA electrodes. The electrodes have an area of 1.27 cm^2.

	electrode weight (mg)	electrode thickness (um)	electrode density (g/cc)	an amount of electrolyte in electrode (mg)
0 atm sample	48.2	226	1.6	20
1020 atm sample	48.6	183	2.0	13
2078 atm sample	49.3	163	2.3	10

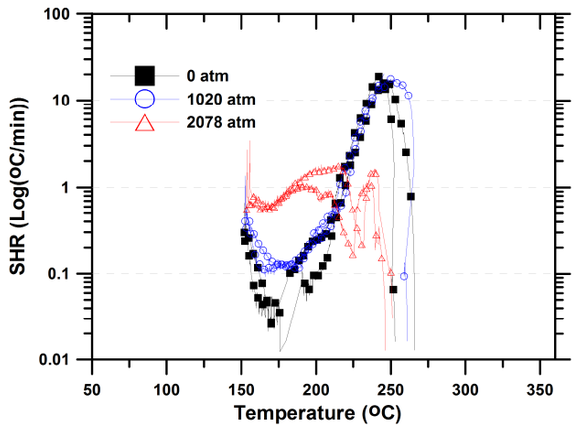

Figure 1. ARC results for the 0 atm, 1020 atm, and 2078 atm electrodes in 1.0M $LiPF_6$ EC:DEC (1:2 v/v ratio) electrolyte with starting temperatures of 150°C.

References

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