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Nanomaterials for Enhancement of Battery Cells

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Extended Abstract

There are continual efforts to improve lithium-ion batteries in terms of its capacity, rate performance and even cycle life, while driving the cost lower. While developments in areas like solid-state batteries [1] are pursuing the next evolutionary leap, traditional liquid electrolyte lithium batteries are by no means fully optimised [2, 3]. Some development work include application of nanomaterials like graphene in battery electrodes [4], which is also the focus of this study. This is due to the excellent thermal and electrical conductivity of graphene that have potential to improve the performance of the electrodes in batteries.

This study looks at the effects of adding different nanomaterials like carbon black, MWCNT (multi-walled carbon nanotubes) and graphene on the performance of lithium-ion cells. The objective is to demonstrate the different effects of each nanomaterial on the rate performance of the cell when added to the cathode. The nanomaterials were mixed as conductive additives together with Lithium Nickel Manganese Cobalt Oxide (NMC) active materials and a PVDF (Polyvinylidene Fluoride) binder as a slurry that was coated on an Aluminium current collector to produce the cathodes. They were then dried and cut to size before being assembled into CR2032 half-coin cells for testing. These coin cells were put through rate capability testing from 0.1C to 5C and the results compared. A number of formulations with different loadings of nanomaterials were considered. Some long-term tests of pouch cells are also carried out.

At a low current rate of 0.1C, the specific capacities of all formulations were quite similar. However, at high current rates of 2C and 5C, the variation among the formulations became more significant. Among the conductive additives, the general trend is that the rate performance at higher current rates improves over that of carbon black when replaced with MWCNT, which in turn further improves with the addition of graphene.

This study uniquely demonstrates that the synergistic effects of different nanomaterials can improve the performance of the cells in such a way that even a single nanomaterial would not achieve on its own. The different morphologies of MWCNT and graphene work together to create a better conductive additive for the cathode. The selection of material characteristics is also an important consideration.

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