

Advances in Materials Development for Rechargeable Li-ion Batteries

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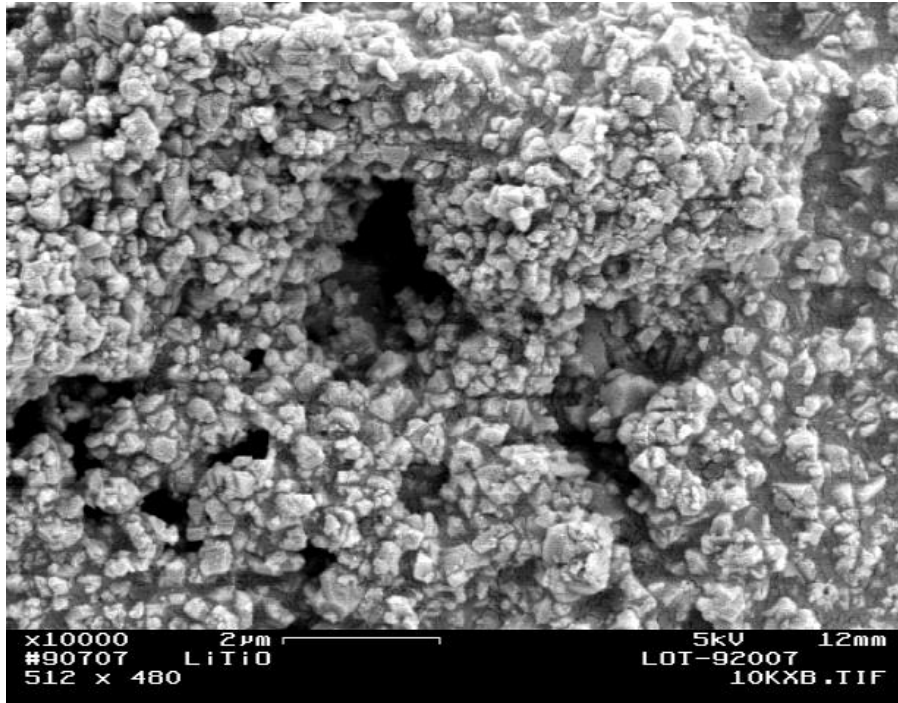
Introduction

The high energy density, power density, and fairly long cycle life render Li-ion batteries very promising for electric vehicles (EVs), hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs) [1]. For successful applications in vehicles, the current state-of-the-art lithium ion cells need to be improved in terms of cycle life, shelf life, and safety without sacrificing the energy density. Advanced electrode active materials will play a major role in the development of next generation Li-ion cells for all types of vehicle applications.

Electrode materials for Li-ion cells are a type of Li-ion intercalation compound that can undergo redox reaction while maintaining the basic crystal structure. To ensure high cyclability and Li-ion intercalation capacity, the material must be in the form of highly ordered crystal structure at the atomic level, while the ultrafine grain/particle size can lead to high specific power. In this paper, ultrafine $\text{Li}_4\text{Ti}_5\text{O}_{12}$ anode material (Nanomyte™ BE-10) and composite oxide cathode (Nanomyte™ BE-40) with a formula of $\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$ will be discussed. Additionally, a relatively new class of material, with the generic formula $x\text{Li}_2\text{MnO}_3 \cdot (1-x)\text{LiNi}_y\text{M}_z\text{Mn}_{1-y-z}\text{O}_2$ is under development at NEI Corporation. Preliminary results are presented here.

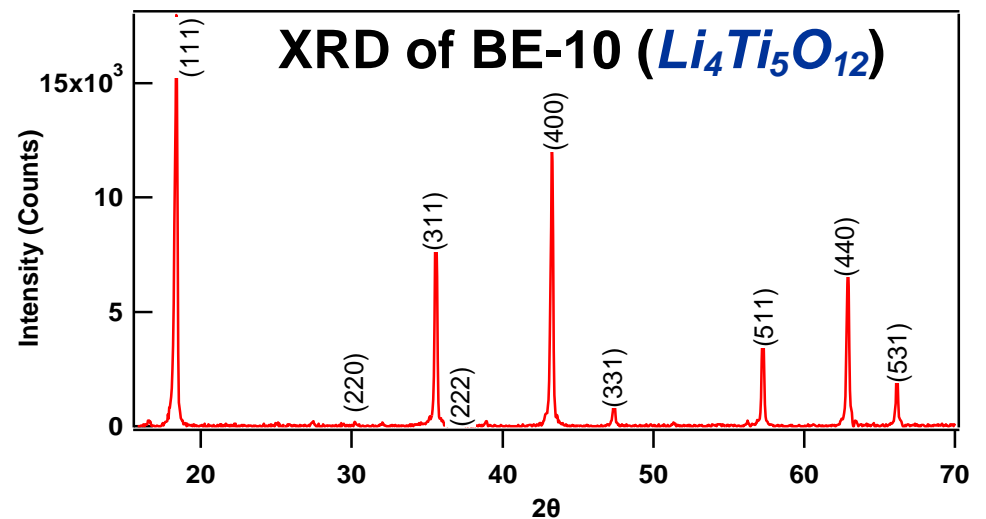
Lithium Titanium oxide (LTO, $\text{Li}_4\text{Ti}_5\text{O}_{12}$)-“Nanomyte™ BE-10”.

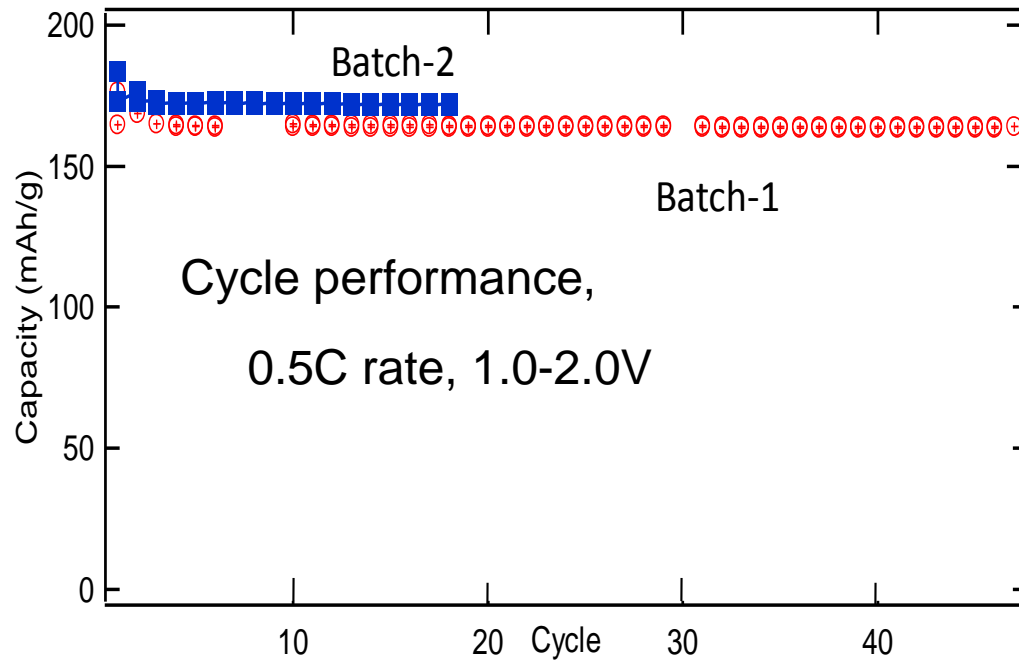
SEM of Nanomyte™ BE-10 (LTO)



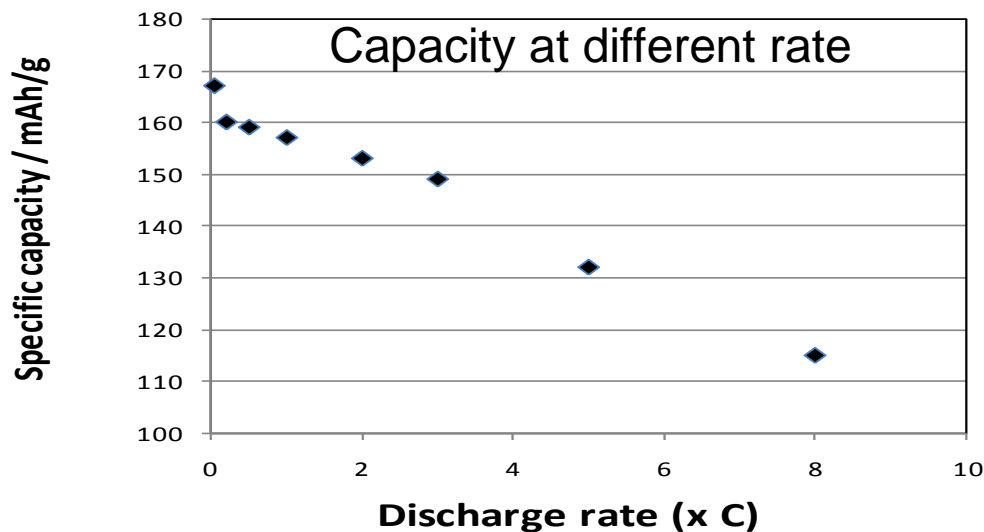
Grain size of BE-10 is in range of 0.1-0.3 μm. They are agglomerated into different particle sizes to enable fabrication of electrodes

BE-10 is a highly ordered crystalline $\text{Li}_4\text{Ti}_5\text{O}_{12}$ with high phase purity, which insures high specific capacity and cycle stability



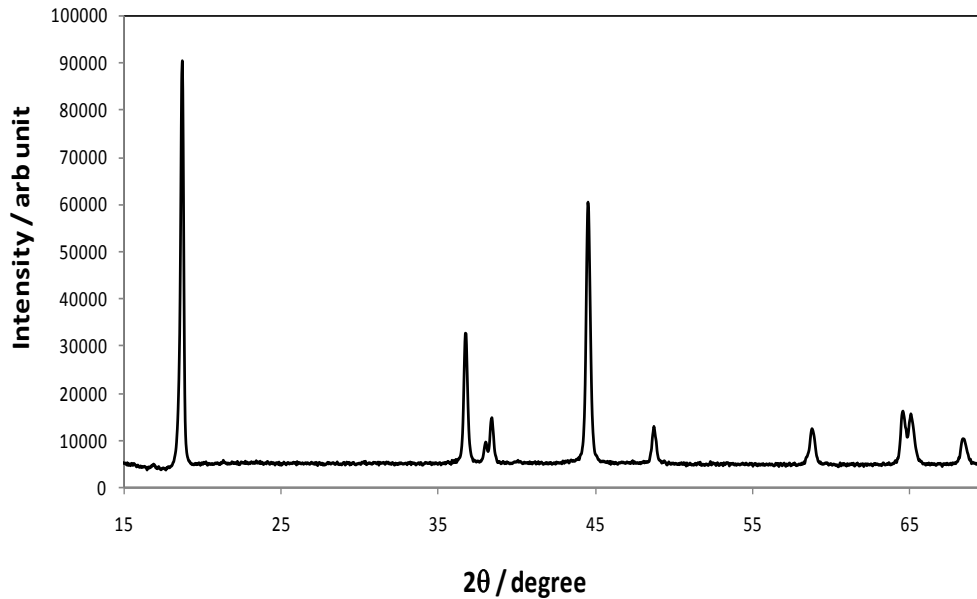


BE-10 ($\text{Li}_4\text{Ti}_5\text{O}_{12}$) is very stable in cycle test and long cycle life is expected.



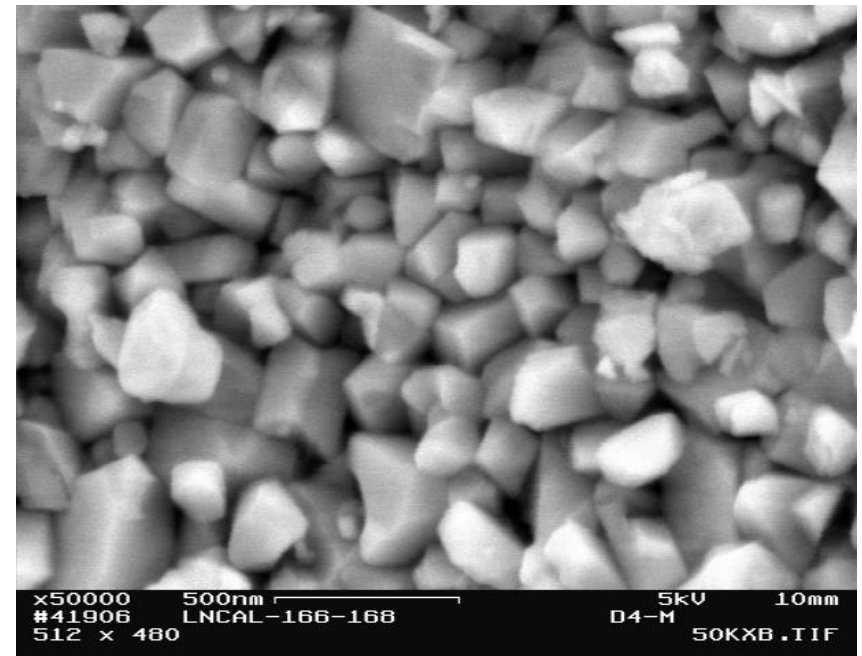
BE-10 ($\text{Li}_4\text{Ti}_5\text{O}_{12}$) works well at high discharge rate. The specific capacity at 8C is >110mAh/g.

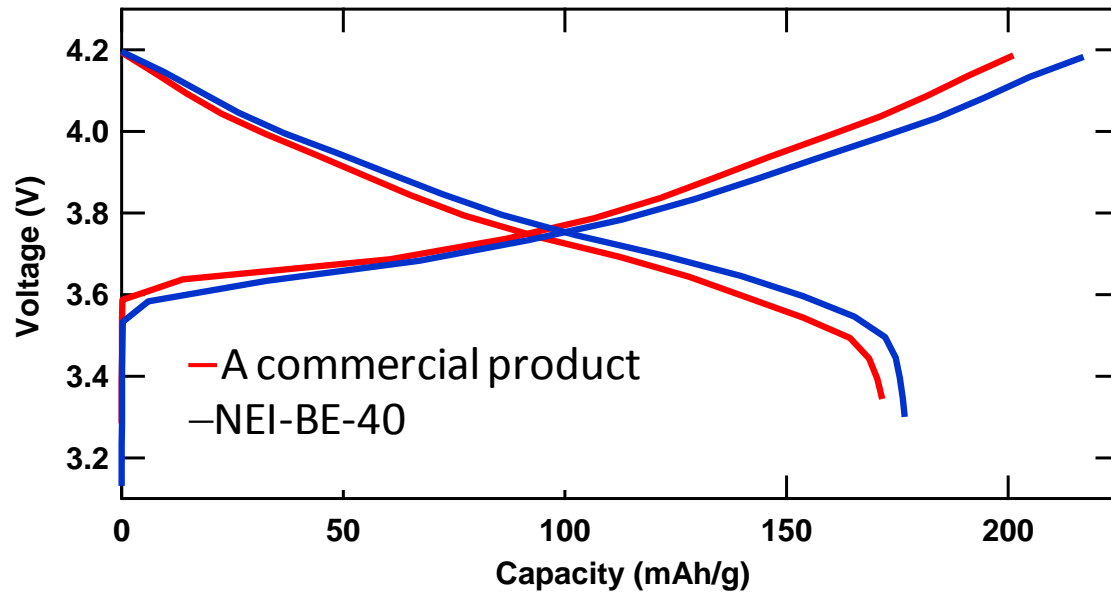
Nanomyte™ BE-40 ($\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$) cathode materials



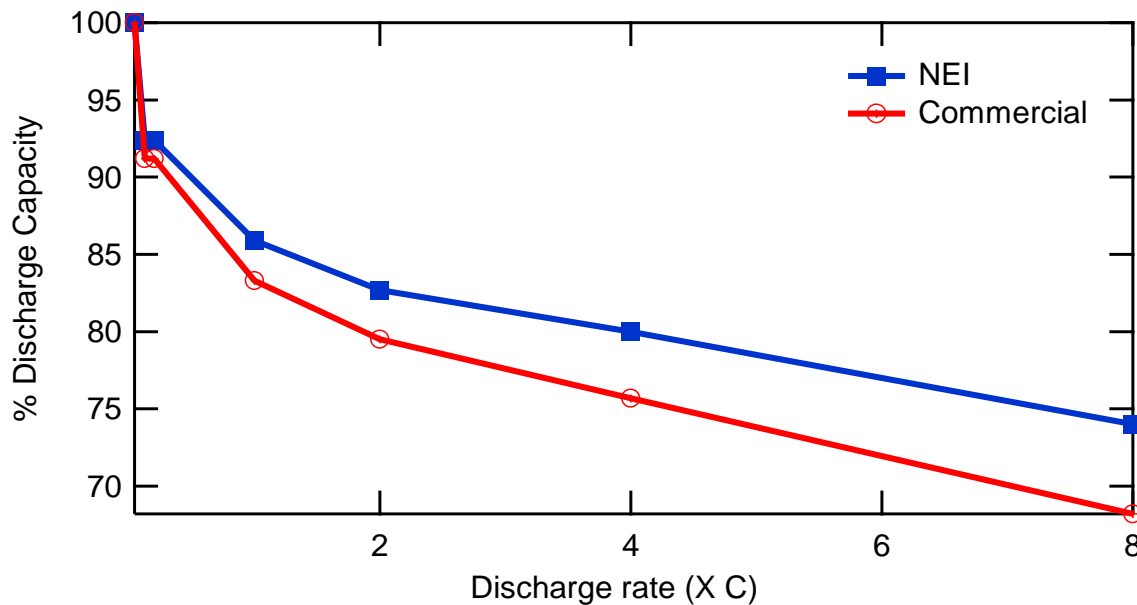
XRD shows that the BE-40 is a high orderd crystalline structure. The percentage of Li/Ni ion mixing determined by Rietveld refinement is <1%.

Ultrafine particles (< 0.5 μm) offer high rate capability and high utilization.

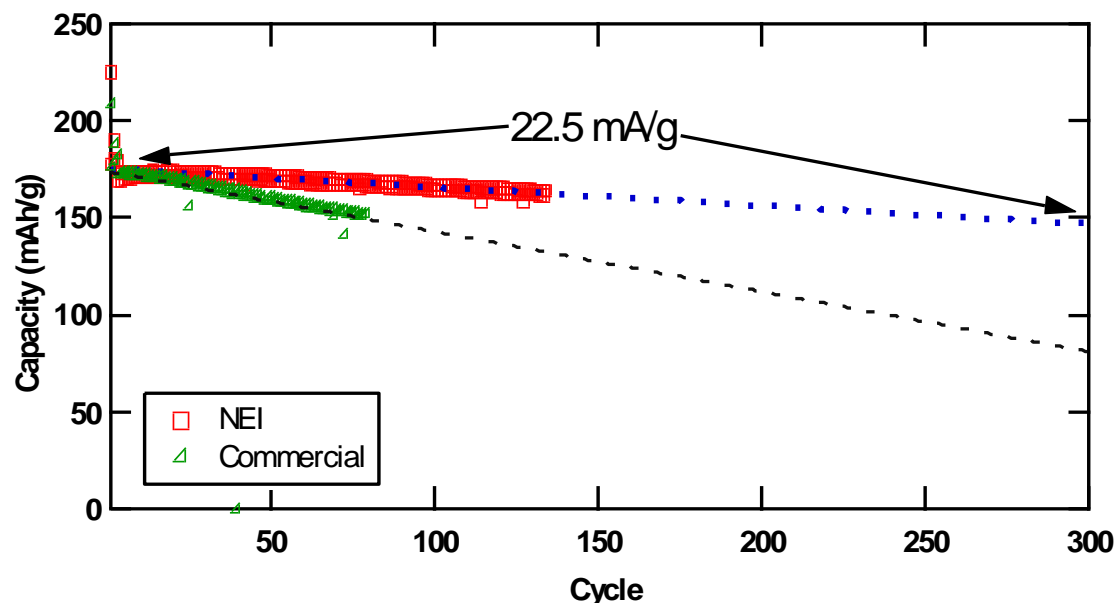




BE-40 ($\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$) has higher specific capacity and lower polarization compared to a well known commercial product.

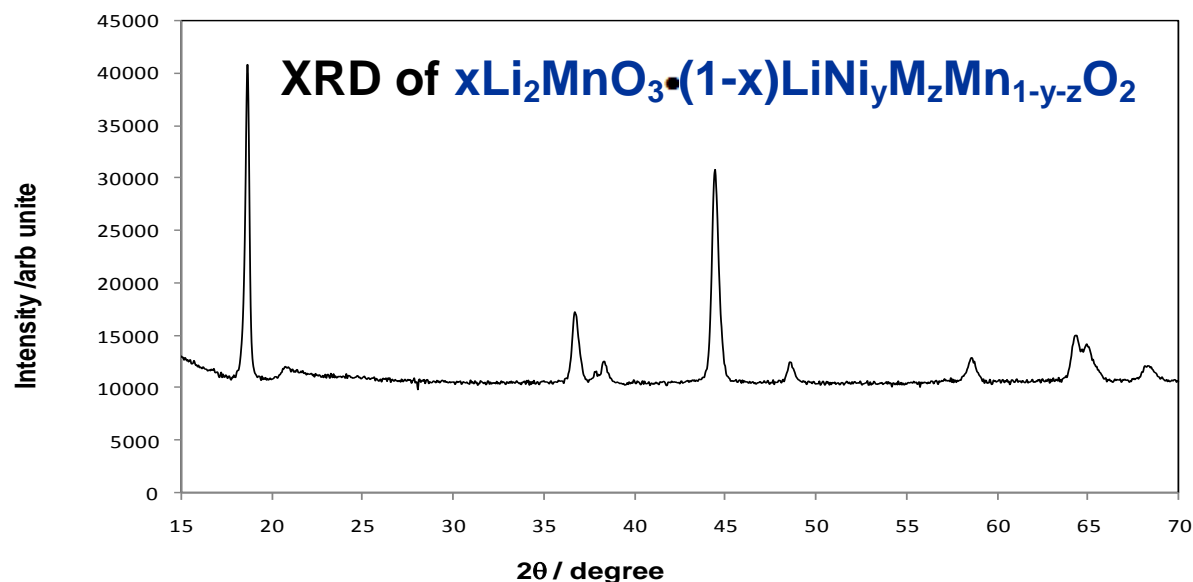


BE-40 ($\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$) has better performance at high rate. At 8C rate, it can get 74% capacity of that at low rate.



BE-40 ($\text{LiNi}_{1-x-y}\text{Co}_x\text{Al}_y\text{O}_2$) has better cycle performance.

$x\text{Li}_2\text{MnO}_3 \cdot (1-x)\text{LiNi}_y\text{M}_z\text{Mn}_{1-y-z}\text{O}_2$ composite cathode material



The powder synthesized at NEI is highly ordered and phase pure. Initial tests in a non-optimized cell gives 175 mAh/g capacity. It is possible to deliver > 200mAh/g capacity.

Acknowledgments

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Cell tests and structure analysis have been performed by Prof. Shirley Ying Meng at University of Florida, Energy Storage Group at Rutgers University, and Lithium Technology Corporation.

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