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The Impact of Milling Time and Rotation Speed on Li-NMC Cathode Performance

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Abstract. The Impact of Milling Time and Rotation Speed on Li-NMC Cathode Performance. Technological developments of electrical energy storage on this era are batteries. Many electronic devices using battery for energy storage, so the batteries in the future will be a strategic and economical source of energy storage. Li-ion battery comprises of anode, cathode and separator. The cathode is fully functional in the process of transferring lithium ions, during the charging and discharging processes. The particle size has a significant part within the electrochemical performance of the cathode for Li-ion battery. Milling could be a way to decrease particle size and improve electrochemical performance. Milling is a method that use the collision energy between grinding balls and the walls of the container (jar milling). X-rays characteristics are analytical signals that used in electron microscopy for chemical analysis. The results showed that longer milling time and a faster rotation speed, will give smaller size which increased the electrochemical performance of the battery cathode.

INTRODUCTION

Lithium ion battery is one type of secondary current source battery that can be recharged and does not contain hazardous materials such as batteries that developed earlier, namely NI-Cd batteries, large capacity, low cost, great cycling stability and safer. lithium ion can be charged at any time, short charging time (2-4 hours), and more durable (3 years life span) [1]. Li-NMC series, which combine image of $LiCoO_2$, $LiNiO_2$ and $LiMnO_2$, have attracted more attentions for their self. In the series, Ni gives a large capacity but bad thermal stability, while Mn gives a great cycling performance and safer and Co provides more electronic conductivity then resulting excellent rate capability [2]. Lithium ion batteries generally have four main components, namely a negative pole (anode), a positive pole (cathode), an electrolyte, and a separator.

On NMC synthesis, the composition of nickel, cobalt and manganese metals can be adjusted according to their respective functions. In this talk, we discuss about NMC 811. NMC 811 is the newest combination which the cobalt ratio is being reduced than for other materials and nickel which are cheaper and easier to get. High Ni content can increase the capacity, so NMC 811 is more 20% than NMC 622 and more 50% than NMC 111. For now, many say, the NMC 811 will dominate the battery industry [3].

Smaller particle sizes can decrease the lithium ion diffusion length and result in progressed rate capability. Milling is a way to decrease particle size and increase the electrochemical performance. The effects of spherical milling time, milling speed, and arrangement on the structure of the NMC cathode are highly decided. The research

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from [4] get a result of XRD analysis. The result showed that ball milling ease the primary particle size up to 29%, and the crystal size was related to milling time and milling speed. Apart from reducing the crystal size, ball milling was found to advance the interface charge transfer resistance, decrease the electrical conductivity, and provide aggregates that affect battery performance.

SEM is an instrument mostly used for observing the surface morphology of materials. These outgoing electrons / X-rays provide information about topography, morphology, composition, grain orientation, crystallographic information, etc. Morphology indicates shape and size, while topography shows the surface characteristic of an object, its texture, smoothness or roughness. Likewise, composition means the elements and compounds that form the material, while crystallography means the arrangement of atoms in the material. In this study, Scanning Electron Microscopy (SEM) was utilized to decide the changes in microstructure from the ball milling action.

METHODOLOGY

Four samples of NMC carbonate with 8.078 grams weight was mixed with 1.899 grams of Li_2CO_3 each. For time variation data, two samples of mixture was variated by one hour and three hours with the same rotation speed (2772 rpm). Furthermore, for speed variation, the remaining two mixture was variated by 2288 rpm (35 Hz) and 2772 rpm (42 Hz) with 3 hours long. Then, the samples or also called precursors enter to furnace for calcination. The precursors were calcined for 5 hours at a temperature of 500˚C and the temperature was raised again until 800˚C for 12 hours. For characterization, every NMC cathode was taken 1 gram each for SEM-EDX characterization to see its surface morphology.

RESULTS AND DISCUSSION

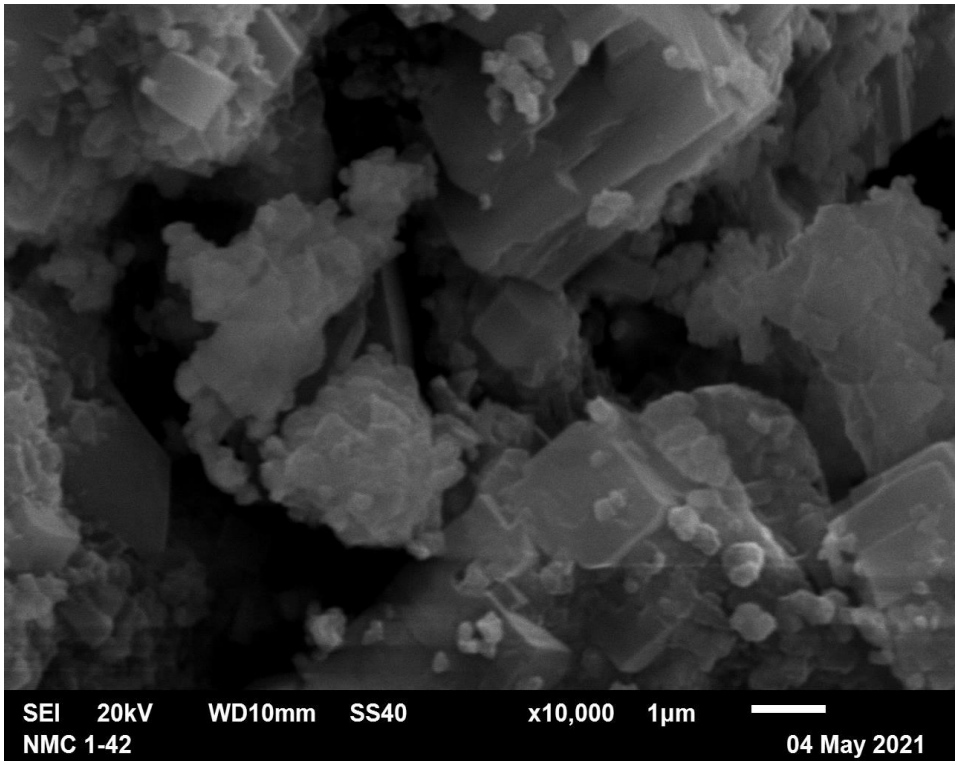

FIGURE 1. NMC cathode (one-hour milling)

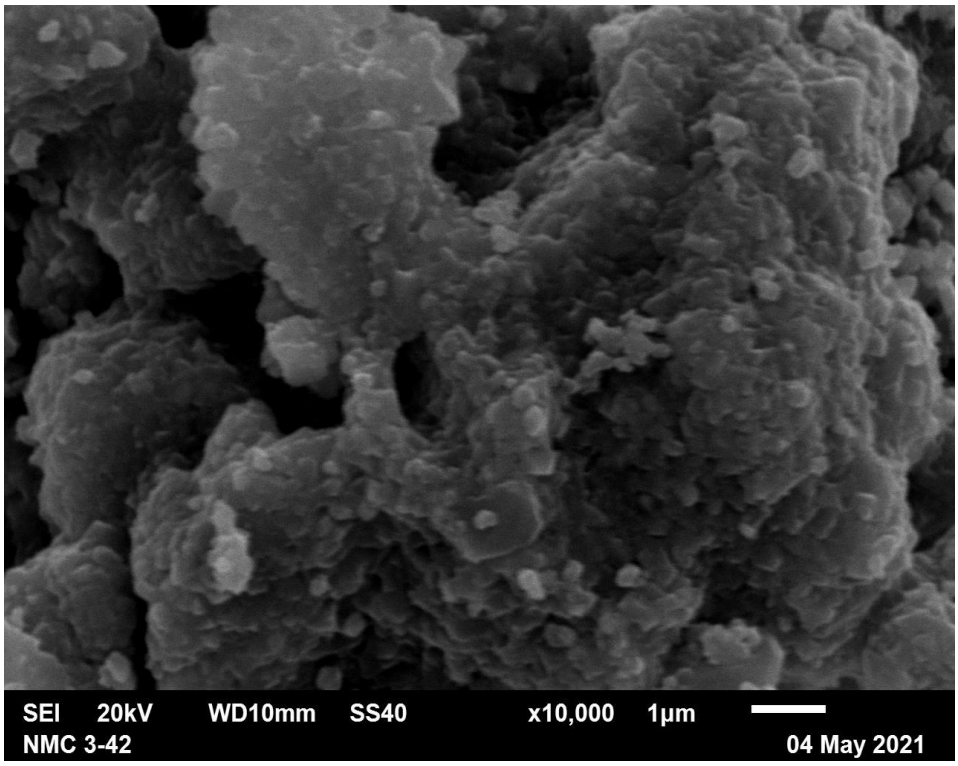

FIGURE 2. NMC cathode (three hours milling)

When the time variation of 1 hour, it has a thick layered beam structure with big grains around it. While the time variation of 3 hours, the structure of the beam has disappeared and has been mixed with the grain structure, also the grains have the smaller size. After being analyzed in EDX, the NMC cathode with a milling time of 3 hours was more evenly mixed with lithium than the milling time of only 1 hour. The NMC cathode which is mix well and has a uniform and smaller size, can affect the distance of the lithium ion diffusion path so that it becomes shorter and the conductivity value of the battery will be optimum.

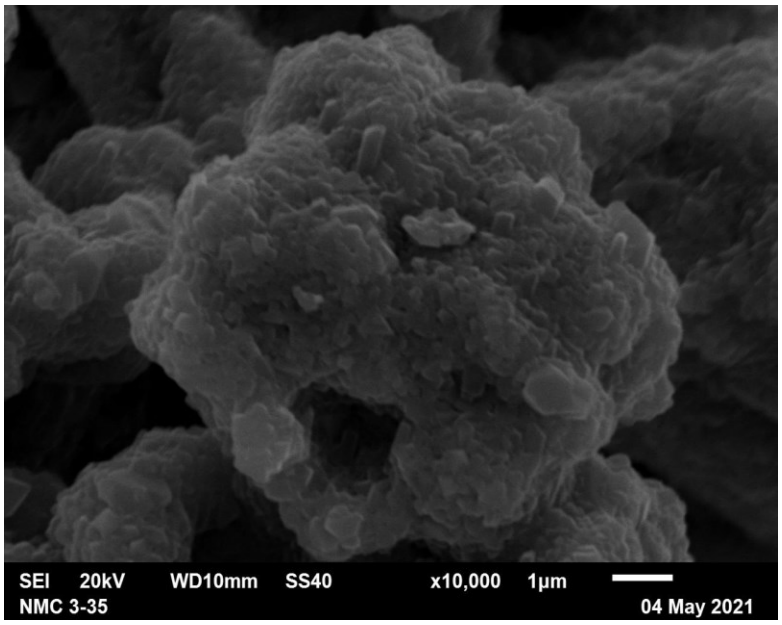

FIGURE 3. NMC cathode (35 Hz)

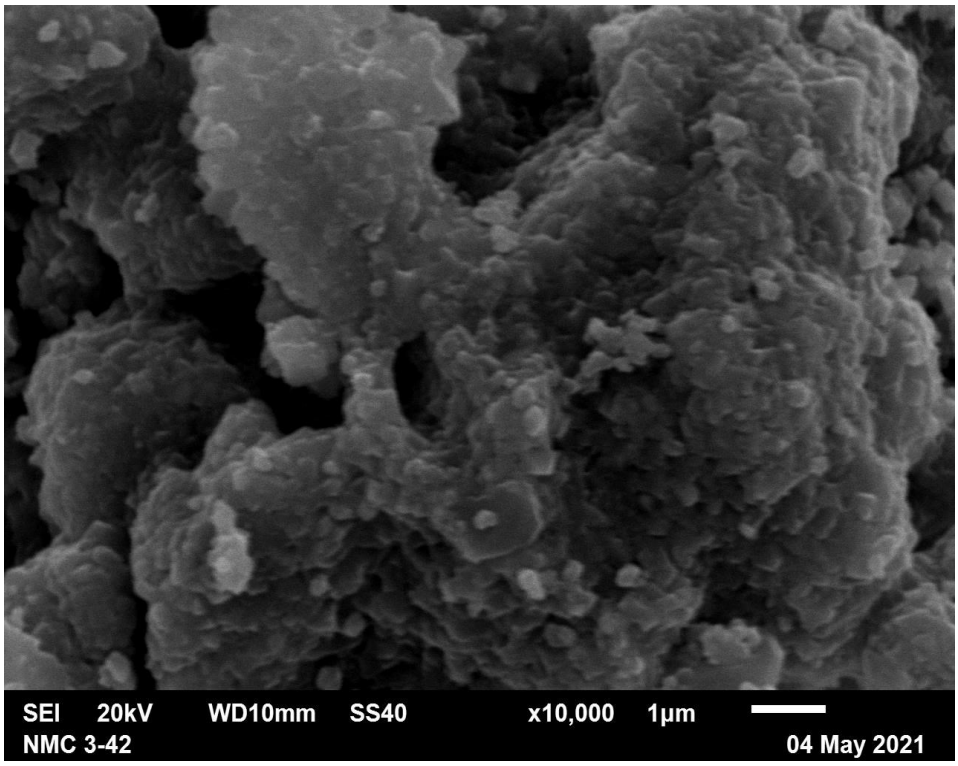

FIGURE 4. NMC cathode (42 Hz)

The surface morphology of the NMC cathode was obtained when the rotation speed variation of 35 Hz was still a large form and big grains. While the 42 Hz rotation speed variation has an irregular and smaller grain structure. The NMC cathode with a longer rotation speed will produce a smaller particle size as well and it will be easier to increase the electrochemical work of the battery cathode.

CONCLUSION

Milling time variation and rotation speed variation of NMC cathode to see its performance was successfully done through milling process. When the time variation of 1 hour, it has a thick layered beam structure with big grains around it. While the time variation of 3 hours, the structure of the beam has disappeared and has been mixed with the grain structure, also the grains have the smaller size. When the rotation speed variation of 35 Hz, the figure still has a large form and big grains. While the 42 Hz rotation speed variation has an irregular and smaller grain structure. For an analytical balance and SEM instrument, to give an accurate reading, the instruments must be calibrated. Calibration is important because it defines the accuracy and quality of the measurements.

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