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Characterization of $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ prepared by a sol-gel method using table sugar as chelating agent for Li-ion batteries

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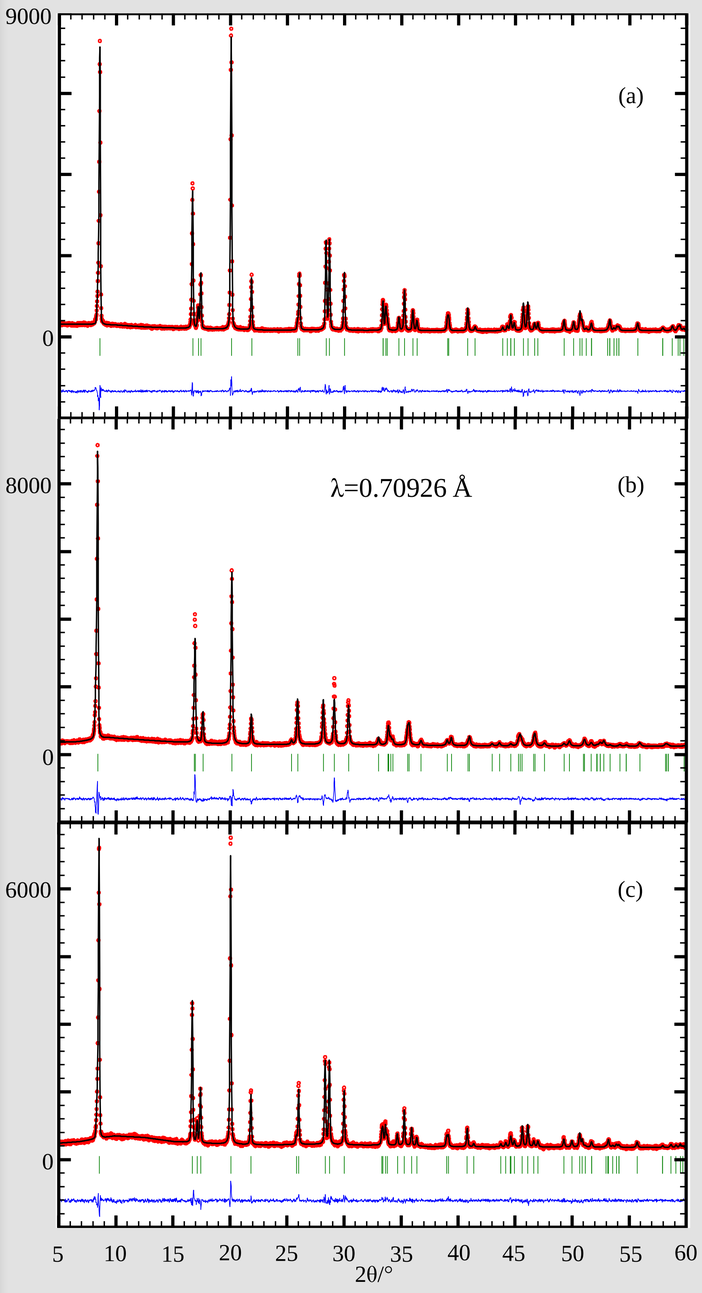
Introduction

Recently, $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$, a layered structure material with an improved cycling performance, good thermal stability, lower cost and less toxicity, has been extensively studied as an attractive candidate of a next-generation cathode material in lithium ion batteries. However, the severe capacity fading and relatively poor rate capability limit its use in lithium ion batteries for electric and hybrid electric vehicles. In $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$, Ni, Co and Mn are in 2+, 3+ and 4+ oxidation states, respectively. Ni^{2+} is responsible for most of the cycling capacity and can result in detrimental effects to the electrochemical properties [1, 2]. It is well known that this layered structure can be synthesized by various methods [3, 4]. The table sugar is a new and cheap chelating agent for the sol-gel synthesis. The observed results show that the table sugar is suitable and it can be used to synthesize $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ material for application in lithium ion batteries.



X-ray diffraction pattern of $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ powder as prepared (a), in the charged state after 10 complete cycles (b) and redischarged after 10 cylces (c)

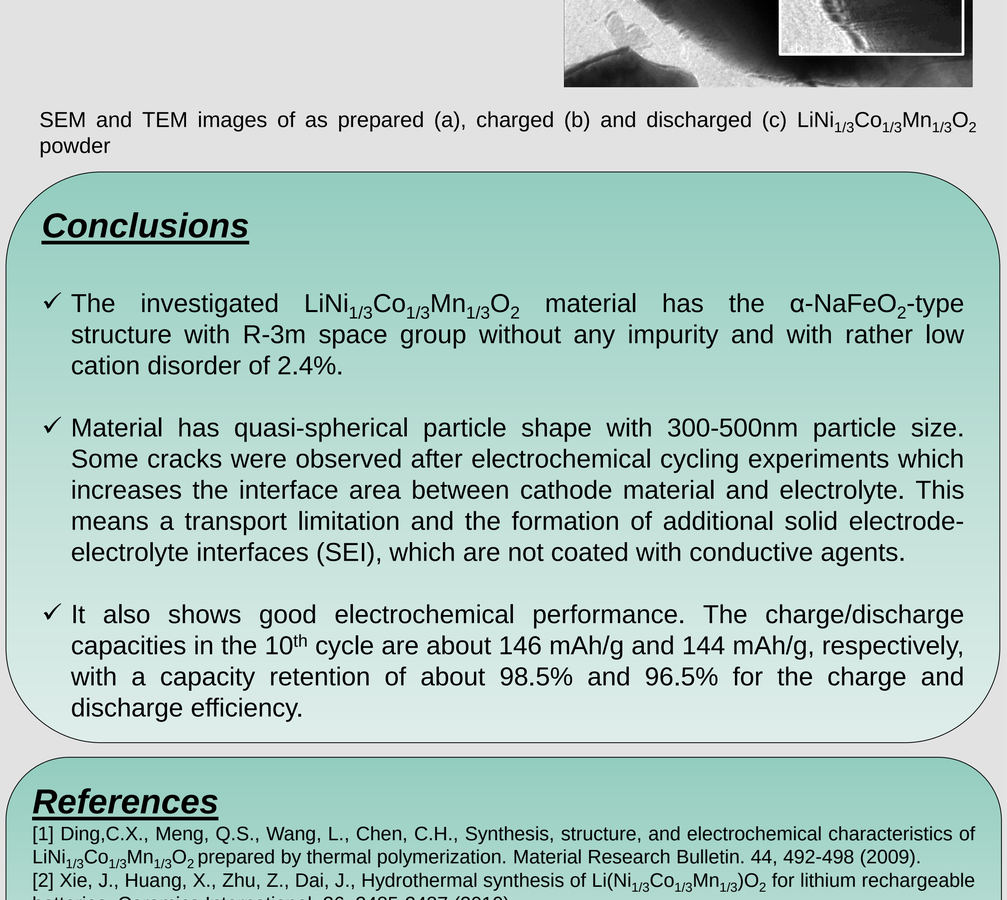
Experimental Details

Synthesis: $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ material was synthesized by a wet-chemical method using table sugar as polymeric agent and metal acetates as precursors. The final product is obtained at 900 °C for 12 h in air.

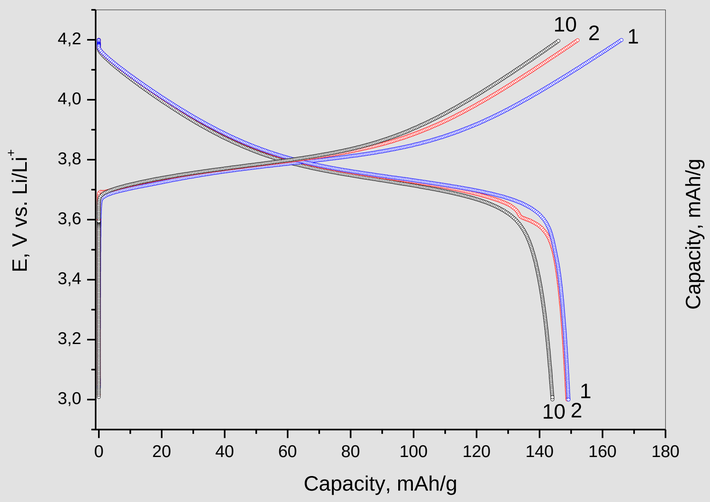
Characterization: XRD experiments were carried out with a STOE STADIP diffractometer (Mo-Kα1-radiation, λ=0.70926Å) in Debye-Scherrer mode. The morphology of the particles was studied with Gemini 1530 (Zeiss) SEM (Scanning Electron Microscope) with primary energy of 10 keV, working distance of 5 mm and inlense - SE – detector. Images with higher magnification were taken with a CM 20 (FEI/Philips) TEM (Transmission Electron Microscope) in bright field at 200 kV acceleration voltage.

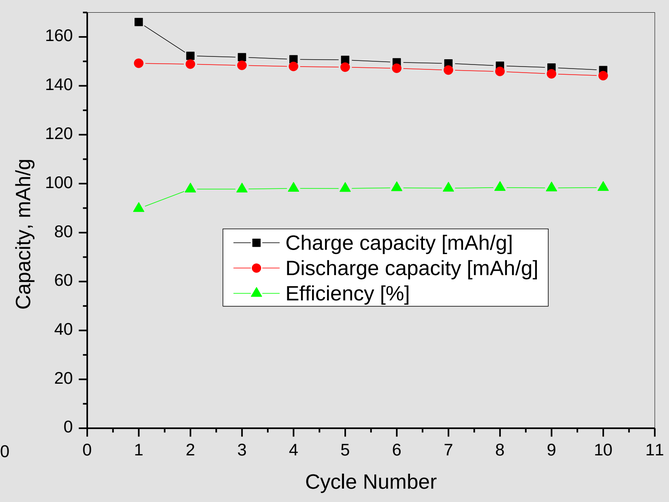
Electrochemical Experiments: The positive electrode was prepared as a mixture of 80:10:10 (%w/w) of active material, polyvinylidene difluoride (PVdF) as a binder and super P carbon as a conduction material, respectively. The mixture was pressed on Al mesh. The electrochemical cell including lithium foil as anode and 1M $LiPF_6$ in EC-DMC (1:1) as electrolyte were galvanostatically cycled at C/10 rate.

Sample	a/Å	c/Å	z(oxygen)	Refined Li-content x
a) as prepared	2.862(4)	14.2403(3)	0.2419(2)	1
b) charged after 10 cycles	2.818(1)	14.5201(9)	0.2360(5)	0.38(5)
c) discharged after 10 cycles	2.858(5)	14.2736(4)	0.2414(3)	0.96(3)



SEM and TEM images of as prepared (a), charged (b) and discharged (c) $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ powder





Electrochemical behavior of as-prepared $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ at 0.1C-rate over the voltage range 3.0-4.2 V vs. Li/Li^+.

Conclusions

- ✓ The investigated $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ material has the α-$NaFeO_2$-type structure with R-3m space group without any impurity and with rather low cation disorder of 2.4%.
- ✓ Material has quasi-spherical particle shape with 300-500nm particle size. Some cracks were observed after electrochemical cycling experiments which increases the interface area between cathode material and electrolyte. This means a transport limitation and the formation of additional solid electrode-electrolyte interfaces (SEI), which are not coated with conductive agents.
- ✓ It also shows good electrochemical performance. The charge/discharge capacities in the 10th cycle are about 146 mAh/g and 144 mAh/g, respectively, with a capacity retention of about 98.5% and 96.5% for the charge and discharge efficiency.

References

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*Nilüfer Kızıltaş Yavuz, Markus Herklotz, Ahmed M. Hashem, Hanaa M. Abuzeid, Björn Schwarz, Christian M. Julien, Helmut Ehrenberg, Synthesis, structural, magnetic and electrochemical properties of $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ prepared by a sol-gel method using table sugar as chelating agent (in preparation).