



PAPER

Effects of lithium excess and Ni content on the electrochemical performance of $\text{Li}_{1+x}(\text{Ni}_{0.45-x}\text{Mn}_{0.4}\text{Co}_{0.15})\text{O}_2$ lithium-ion cathode materials in stoichiometric stateRECEIVED
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24 May 2019A Tolouei¹, A Kafilou¹  and S K Sadrnezaad² ¹ Iranian Research Organization for Science and Technology, Iran² Sharif University of Technology, IranE-mail: ali.kafilou@irost.ir**Keywords:** lithium-ion batteries, lithium excess, cathode material, electrochemical performance, nickel-manganese-cobalt**Abstract**

In Li-ion batteries, application of active materials can enhance the kinetics of the charge-discharge process, reduce the costs and improve the safety of the system. In this work, the effect of nickel content and lithium excess in $\text{Li}_{1+x}(\text{Ni}_{0.4-x}\text{Mn}_{0.5}\text{Co}_{0.1})\text{O}_2$ compounds on the electrochemical performance of the lithium-ion battery cathode have been studied. For this purpose, three compounds of NMC in the stoichiometric state were synthesized via co-precipitation as the cathode active material. XRF and EDS analyses indicate that precursors and oxide compounds are well synthesized. The final compound of synthesized cathodes was obtained by ICP analysis. XRD results also suggest that the hydroxide and oxide phases are formed appropriately. SEM results show that the particle size of the synthesized samples ranges from 1–2 μm . As the content of nickel increases (sample 3), particle sizes also increase. The battery charge-discharge test results (at rates of 0.1–5 C) show that when the nickel content is 0.45, the cycle life of the sample 3 is lower than the other two (154 mAh g^{-1} at discharge rate 1 C). While the discharge capacity for the sample 1 at 1 C and 5 C rates after 30 cycles is 176.9 mAh g^{-1} and 101.4 mAh g^{-1} , respectively. Therefore, as a result, to increase the cathode capacity, the amount of lithium can be increased as well as the amount of nickel can be reduced in a stoichiometric state.

Introduction

Among the components of the lithium-ion batteries, cathode-active materials limit their oxidation-reduction reactions due to their low capacity for the anode. Hence, in the recent decade, most efforts were focused on improving cathode performance [1–3]. In the three primary functional components of the lithium-ion battery, cathode material plays a decisive role in its electrochemical properties [4]. The selection of suitable materials for this purpose has been of significant concern to the researchers and because of the new applications defined for this category of storage, has found special significance [5–7].

The basis of the active cathode material is the entry of the guest or the lithium ion into their structure. The cathode is a host network that can store guest ions. Guest ions can provide a reversible transfer of electrical charge by entering and leaving the network [3, 8, 9].

To raise the kinetics of ion release, achieving higher capacity storage, high charge/discharge rates, and increasing cyclic life, altering the physical properties of cathode material is essential. The proposed strategies in recent years include: improving the morphology of the cathode surfaces, reducing the particle size [8, 10, 11], coating and enhancing the absorption of lithium at the cathode surface by surface modification methods and doping elements within the structure [9, 12, 13].

One of the main challenges for accepting guest ions in the cathodic structure is the acceptor sites conditions. If the number of suitable sites for lithium is low (from the perspective of physical structures), the number of ions which are capable of reducing, decreased, and reduction cannot complete. One of the best arrangements for accepting guest ions is layered structures, and so, these structures have been a great deal of research. Also, if the