

**Development of Cathode Material for Lithium Ion  
Rechargeable Batteries Based on the System  
 $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$   $x = 0.02, 0.06$**

A dissertation submitted to the  
Faculty of Science and Technology, Uva Wellassa  
University in partial fulfilment of the requirements for the  
award of the Degree of Bachelor of Science and Technology

by

**WARSAPPERUMA  
ARACHCHIGE MANEESHA  
HASANJALEE  
WARSAPPERUMA**

**Faculty of Science and Technology  
Uva Wellassa University, Sri Lanka**

**January 2017**

## Abstract

Expensiveness of electrode materials, such as  $\text{LiCoO}_2$ , is recognized as one of the main barriers that prevents the development of the rechargeable Lithium Ion Batteries (LIB) from reaching the common masses. Therefore, layered transition metal oxides such as  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3})\text{O}_2$  are presently being investigated as an alternative cathode material. Moreover, substitution of Na in transition metal oxides of Ni, Mn and Co (NMC) has been identified as an effective strategy to improve their electrochemical performance. The present work attempted to synthesize  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$   $x = 0.02$  and  $0.06$  through substituting expensive Co by cheaper Na, using Glycine Nitrate Combustion (GNC) method. The GNC is an effective method to synthesize sub-micron size particles formed by agglomerating primary nano scale particles. This particle morphology is chemically stable and provides greater rate capability and electrochemical performance.  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$ ,  $x = 0.02$  and  $0.06$ , oxide powders were synthesized by GNC method keeping the Glycine:Nitrate ratio as 0.6, by calcining at  $900^\circ\text{C}$  for two hours. This process is a simple and single step process with a low calcination period. Scanning electron microscopy showed that the synthesized powder consists of quasi-spherical, secondary particles formed by aggregating nano-scale primary particles. Chemical analyses of synthesized powders reveal that the composition of these synthesized samples was close to stoichiometric ratio given by its empirical formula. Fourier transform infrared spectra of  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$   $x = 0.02$  and  $0.06$  are characterized by IR absorption bands in three distinct regions. These bands represent the characterized chemical bonds in layered metal oxides with  $\alpha\text{-NaFeO}_2$  structure. The four probe D.C. electrical conductivity measurements performed on the dense sintered pellets showed enhanced electrical conductivity in these novel materials compared that of base material,  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3})\text{O}_2$ . Hence this study revealed the possibility of preparing cheaper  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$  by GNC method, for the intended LIB cathode applications.