# Electrospray synthesis of porous cathode material for lithium ion batteries

S.W. Karuga[1], M.J. Gatari[1], J.C.M Marijnissen[1,3] and E.M. Kelder[2]

[1]Institute of Nuclear Science and Technology, University of Nairobi, Nairobi, Kenya
[2]Faculty of Applied Sciences, Delft University of Technology, Delft, 2600 GA, The Netherlands
[3]University of Florida, Gainesville, FL 32611, United States
Keywords: Electrospraying, cone-jet, lithium-ion batteries, lithium manganese nickel oxide.
Associated conference topic: 1.8
Presenting author email: swkaruga@yahoo.com

Over the decades, batteries have evolved from primary to secondary systems providing more compact and lighter power sources. Among them, lithium ion batteries (LIBs) standout because of their high energy density, zero memory effect and relatively long cycle life. However, their application is limited only to consumer electronics like mobile phones, laptops, digital cameras and other portable devices. With improved performance and cost, these batteries would be used in emerging applications like smart grids, implantable medical devices, sensors or electric vehicles. To meet these emerging energy needs, state-of-the-art LIBs that can offer the appropriate safety, size, cost, power and energy density are needed. Consequently, a lot of research is underway and different studies have embraced new materials and new ways of engineering them (Nitta et al., 2015).

Usually, the stored energy of a lithium ion battery can be enhanced by increasing the specific capacity of the cell, maximizing the potential difference between the electrodes and by reducing the amount of inactive material. For this reason, cathode materials are solely made from lithium metal oxides which provide a stable source of lithium in air and a relatively high potential. For instance, $LiCoO_2$ is widely used in commercial LIBs due to its outstanding stability and high operating voltage. However, it is considered expensive and toxic hence efforts to identify a safer and cheaper material have led to the investigation of different compounds like Li-Ni-Mn oxides. Though promising, the commercialization of these oxides is limited by the capacity fading during charge/discharge cycles, which is attributed to the resulting volume changes (Fujimoto et al., 2013).

To solve the above problem, studies have shown that hollow or porous structures can be effective. Such structures would offer more reaction sites, provide improved electron transport and create effective tolerance to the volume change during cycling (Pei et al., 2016). Therefore, ways of making the desired structures have been explored and among them are chemical solution routes and template-assisted synthesis. Nevertheless, the active materials are usually mixed with a conductive agent and a polymer binder, which interfere with the hollow and porous structure. Taking into account that the fabrication of batteries in thin film form is of great interest in making miniaturized electronic devices, electrospraying is expected to simplify the production of additive free electrodes (Hu et al., 2014). Therefore, this study uses electrospraying for the synthesis of $LiNi_{0.5}Mn_{1.5}O_4$ (LNMO) cathode material.

LNMO is synthesized from a precursor solution consisting of stoichiometric amounts of the respective nitrates in 2-propanol. Before spraying, the physical and chemical properties of the liquid precursor such as density, surface tension, conductivity, concentration and viscosity are determined. Since we are spraying in cone-jet mode, the scaling laws according to Yurteri et al. (2010) are applied to predict the droplet and particle sizes. As a result, it is possible to ensure that the final particles are very small and in the nano range. This is a great advantage since electrochemical performance has been reported to improve with reduction in particle size (Huang et al., 2001). Considering that the aim of this study is to tailor the surface morphology, experimental parameters like deposition temperature, deposition time, nature of the substrate, liquid flow rate and the applied voltage have been controlled to suite preference. The latest results on this study will be presented at the conference.

This work is supported by Delft University of Technology, Netherlands and the International Science Programme, Uppsala University, Sweden.

Fujimoto, K., Shimura, Y., Ito, S. (2013) *ACS Combinatorial Science* **15**, 626 – 630.

Huang, H., Yin, S.C., Nazar, L.F. (2001) *Electrochemical and Solid-State Letters* **4** (10), A170-A172.

Hu,T., Xin, G., Sun, H., Sun, X., Yu, M., Liua, C., Lian, J. (2014) *Royal Society of Chemistry Advances* **4**, 1521.

Nitta, N., Wu, F., Lee, J. T., Yushin, G. (2015) Materials Today **18**, 5.

Pei, Z., Li, Z., Zheng, X. (2016) *Journal of Nanoscience and Nanotechnology* **16**, 9028 – 9049.

Yurteri, C.U., Hartman, R.P.A., Marijnissen, J.C.M. (2010) *KONA Powder and Particle Journal* **28**, 91 – 115.