Novel Printed Sensor for Detection of Dissolved Mn Ions in Li-ion Battery

Tina Paljk\textsuperscript{a,b}, Victoria Bracamonte\textsuperscript{c}, Tomáš Syrový\textsuperscript{d}, Sara Drvarič Talian\textsuperscript{a}, Samo Hočevar\textsuperscript{a}, Robert Dominko\textsuperscript{a,b}

\textsuperscript{a}National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia
\textsuperscript{b}Faculty of Chemistry and Chemical Technology, Večna pot 113, 1000 Ljubljana, Slovenia
\textsuperscript{c}Universidad Nacional de Córdoba, Av. Haya de la Torre s/n, Córdoba, Argentina
\textsuperscript{d}Faculty of Chemical Technology, Doubravice 41, 53353 Pardubice, Czech Republic

Transition metals as the repaid redox reaction centres are essential in the Li intercalation cathode compounds. At the same time, they are directly connected to a major source of overall performance fade of the battery related to the transition metal dissolution. The dissolved metal cations migrate through the separator to the anode surface, which can lead to the formation of undesired degradation products, thus altering the properties of the passive film on the surface of the anode. Therefore is extremely important to monitor and understand transition metals dissolution.

Among all the metals, manganese is the most detrimental. To investigate the amount of dissolved manganese from the spinel cathode material LiMn$_2$O$_4$, several half cells with the same configuration were prepared and cycled for different numbers of cycles. Using ICP-MS analysis, we were able to determine the amount of dissolved manganese in the disassembled cycled cells.

Monitoring transition metal dissolution in a battery has proved to be either impossible or impractical without significantly changing the battery cell set-up. The aim of this research was to develop a sensor to easily integrate into a battery cell. We propose an electrochemical sensor printed on the battery cell separator as an \textit{in situ} analytical tool for detecting manganese dissolution from the cathode material of a fully operational battery cell. The sensor is capable of detecting manganese dissolution during battery operation: the impedance response of the sensor was measured \textit{in situ} during cycling of a LiMn$_2$O$_4$||Li cell.

The printed sensor can be scaled-up to the roll-to-roll process, thus opening the possibility for commercialization and potential improvement of the quality, reliability, safety and cycle life of Li-ion cells.

\textbf{Ključne besede}: Li-ion, battery, electrolyte, sensor, transition metal.