Abstract

Despite the rapid expansion of the organic cathode materials field, we still a face shortage of materials obtained through simple synthesis that exhibit stable cycling and high energy density. The large-scale deployment of battery technology is driving the research towards the use of more sustainable and less scarce anode materials, with zinc metal being recognized as one of the most promising alternatives. The thesis focuses on the development of novel organic cathode materials with increased energy density derived from facile synthesis procedures, which were applied in lithium and zinc batteries. Apart from the performance evaluation, we show additional in-depth analysis of the redox reaction and degradation mechanisms with the use of ex-situ FT-IR spectroscopy, ex-situ SEM analysis, and three-electrode cyclic voltammetry experiments.

The first part of the thesis is dedicated to small organic cathode materials derived from the reaction between aromatic diamines and sodium rhodizonate or hexaketocyclohexane octahydrate. In lithium battery configuration the derived materials showed high energy density (up to 860 Wh kg^{-1}) and excellent cycling stability (up to 82 % capacity retention after 400 cycles at 50 mAg^{-1}). Although the high energy density (up to 280 Wh kg^{-1}) was retained in zinc battery configuration employing aqueous electrolytes, the cycling stability was compromised with the best-performing material showing 88 % capacity retention after 100 cycles at 100 mAg^{-1}.

The second part of the thesis encompasses the development of novel Schiff base polymers. The design of materials mitigated the use of redox inactive linkers, which limit the capacity of the polymer cathode materials. We explored a Schiff base polymer derived from reaction between 2,5-dihydroxybenzene-1,4-dicarbaldehyde (DHDC) and 2,6-diaminoanthraquinone. The synthesized polymer SBP1 exhibited a maximum capacity of 240 $mAhg^{-1}$ and stable performance in lithium battery with a capacity retention of 83 % after 140 cycles at 50 mAg^{-1}.

Keywords: lithium battery, zinc battery, cathode, pyrazine, quinone