

High capacity magnesium batteries using solvent-controlled charge storage

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The increased demand for portable as well as stationary energy storage has in the last few decades lead to heavy research efforts into a variety of battery chemistries. Li-ion batteries is still dominating the market for small-scale electronics as well as electric vehicles. However, as more and more devices are electrified and the demand for tailored batteries increase, new chemistries become significantly more important. One of the more promising new technologies is the Mg-ion battery (MIB) due to higher safety, chemical stability and a high natural abundance in the Earth's crust (13.9% as compared to $7 \cdot 10^{-4}$ % for Li). In addition, Mg has a theoretical volumetric capacity of 3833 mAh/cm³, nearly twice that of Li (2061 mAh/cm³), indicating the potential of MIB to reach a high volumetric energy density.^{1,2} There are however, several issues hampering a fast development of MIBs, including finding suitable electrolytes as well as good cathode materials capable of providing high specific capacity and power density, good rate performance, and long-term stability. And one of the main issues for the cathode materials is poor diffusion of the divalent Mg ion in the host material.

Here, we present a Mg battery using Mn₃O₄ as the electrode material and Mg metal as the counter electrode in a Mg organohaloaluminate electrolyte. The material has been investigated both as cathode and anode, simply by changing the cut-off voltages during electrochemical testing. The reversible capacity when Mn₃O₄ was used as cathode reached ~ 580 mAh g⁻¹ at a current density of 15.4 mA g⁻¹, whereas a reversible capacity of ~ 1800 mAh g⁻¹ was obtained in an anode configuration. As a cathode, the Mn₃O₄ showed excellent cycling stability with no loss of capacity after 500 cycles at a current density of 770 mA g⁻¹. As an anode, the stability was not as good and Mn₃O₄ retained 86% of its initial capacity after 200 cycles. By careful investigation using quantitative kinetics analysis in addition to TEM with EDX and EELS it was found that these exceptional charge storage properties and high cycling stability are attributed to highly reversible interfacial reactions involving the electrolyte solvents. Density functional theory calculations were also conducted, which support these findings.

Acknowledgements

Norwegian Research Council for funding (Grant Number 221785). Computational resources were provided by the Norwegian Metacenter for Computational Science (NOTUR) through the project NN9264K and NTNU243.

References:

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