Corrosion of aluminium anodes in chloroaluminate electrolytes for secondary batteries

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Lithium battery technology faces challenges of safety, limited resources and high cost.[1] Currently, this drives tremendous efforts to replace lithium in secondary batteries by safer chemistry, based on more abundant and significantly cheaper materials. One candidate that fulfils these criteria is aluminium, which is the most abundant metal in the earth's crust and hence a cheap resource with high recycling rate. Moreover, its theoretical value of volumetric capacity of 8046 Ah/l is superior and its specific capacity of 2980 Ah/g is similar to that of lithium metal. In combination with either insertion cathodes made from graphitic carbon[2] or conversion cathodes based on e.g. sulphur[3] or oxygen[4], aluminium anodes could yield a highly promising battery chemistry, provided a suitable electrolyte can be found. Mainly chloroaluminate ionic liquids[5] and deep eutectic solvents (DESs)[2] have been reported as electrolytes for these types of batteries.

Similar to lithium, however, aluminium is prone to dendritic growth, which can ultimately lead to device failure.[6] The native oxide layer on the aluminium anode also poses a challenge to an efficient battery discharge/charge performance. It has been reported that soaking the aluminium anode in a suitable electrolyte has a positive effect on its electrochemical performance.[7] Accordingly, the discharge/charge characteristics of the aluminium anode were tested by galvanostatic cycling in symmetric cells with a $AlCl_3$:urea DES after various periods of soaking. The surface morphology of the aluminium anodes was then studied with scanning electron microscopy and energy dispersive X-ray spectroscopy. It turned out to be essential analysing the compositional changes of the native oxide layer during soaking in order to understand its effects on the aluminium growth morphology. This has been achieved with a combination of transmission electron microscopy and energy dispersive X-ray spectroscopy, secondary neutral mass spectrometry, as well as X-ray photoelectron spectroscopy.[8] The consistent results provide the basis for a reliable interpretation of electrochemical impedance data recorded during soaking.

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