Charge Transport in the Non-aqueous Li-O_2 Battery

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New science, including new electrochemistry and new materials, will play a crucial role in efforts to transform energy storage. Such a transformation is vital in order to reduce CO_2 emissions in the long-term and ensure energy security. The lithium-ion battery is one of the most successful technologies of the past 20 years. However, the maximum energy storage possible with lithium-ion batteries is too low for key applications in the long-term; such as electric vehicles and storing electricity from intermittent sources, e.g. wind, solar, tidal. To go beyond the horizon of lithium-ion is a formidable challenge; there are few options. Here we consider the non-aqueous Li-O_2 battery, especially the processes that occur at the cathode/electrolyte interface.

A typical non-aqueous Li-O_2 battery is shown in Figure 1. On discharge, O_2 from the atmosphere enters the porous cathode, where it is reduced and is supposed to form Li2O2, which can be then be oxidized on charging.

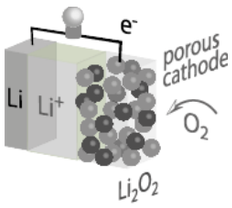

Fig. 1: Li-O_2 battery

There are many hurdles to be overcome if the Li-O_2 battery is ever to be realized in practice. These include, the voltage gap (charging potential greater than discharge), the achievable capacity, capacity fading on cycling, rate capability and lifetime.[1, 2]

The processes at the O_2 cathode are what distinguishes the non-aqueous Li-O_2 cell from other lithium batteries. Investigating and understanding these processes is essential to lay the foundations for technological progress. Reduced O_2 species presents an aggressive environment for the electrolyte and electrode materials, challenging their stability.[3-8] Notwithstanding stability, ensuring efficient and reversible electrode reactions involving gasses, liquids and solids presents its own challenges. Tackling these problems requires an understanding of the reactions taking place at the cathode using a combination of spectroscopic techniques allied with electrochemical measurements.[6, 9, 10] So far, these cells do not reach their theoretical capacity limit, and achieve only moderate rates due to the insulating nature of Li_2O_2.[11-14] We shall discuss processes and challenges imposed by charge transport in the non-aqueous O_2 cathode and strategies towards high performance cells.

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