

Lithium-Oxygen Battery Chemistry for High Pressure O₂ Cells

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Since it was first put forward in 1996, research on lithium oxygen battery chemistry has received considerable interest from both the industrial and academic world for energy storage applications. Terrestrial applications have typically focused on air-breathing systems for organic electrolyte cells. However, using air as an oxygen source presents several difficulties, such cleaning water and CO₂ from the intake gas, the limitation of slow diffusion of oxygen from the outside, and the low concentration of O₂ in air. In addition, an easy air supply is lacking for many applications such as under water, in space, or for any sealed compartment.

This work concerns the chemistry of the lithium –oxygen battery in an enclosed, high pressure system. In addition to controlling the quality of O₂ in the cell, it allows for a much higher O₂ concentration in solution. While the necessity of carrying an O₂ supply as well as a vessel to contain the higher pressure will reduce the cell level energy density, there are several performance improvements. This study uses microcavity electrodes faster materials screening. Increasing the O₂ pressure up to 10 atm can increased the capacity of the cell by a factor of 2x for moderate rates (C/2), and up to 5x for high rates (25C), by improving the rate of diffusion of O₂ to the electrode. Figure 1 shows fixed depth of discharge (DOD) galvanostatic cycles of carbon black microelectrodes in 1 and 10 atm O₂ cells. The high (10 atm) O₂ pressure induced a Nertstian increase in the discharge voltage of up to 100 mV for 1 mA/cm². The high O₂ supports a much higher rate due to increased oxygen diffusion.

Also, increasing the effective O₂ pressure at the electrode surface can induce a lowering of the charge overpotential by forming interfacial Li₂O₂. This leads a higher round trip efficiency for cycling and leads to greater cyclability due to fewer oxidative side reactions, as seen in the lowered charge plateaus in Figure 1. Thus, transitioning to a high pressure system can increase the rate capability, the discharge voltage, and the charge overpotential, making this version of Li-O₂ chemistry very promising for a more practical cell.

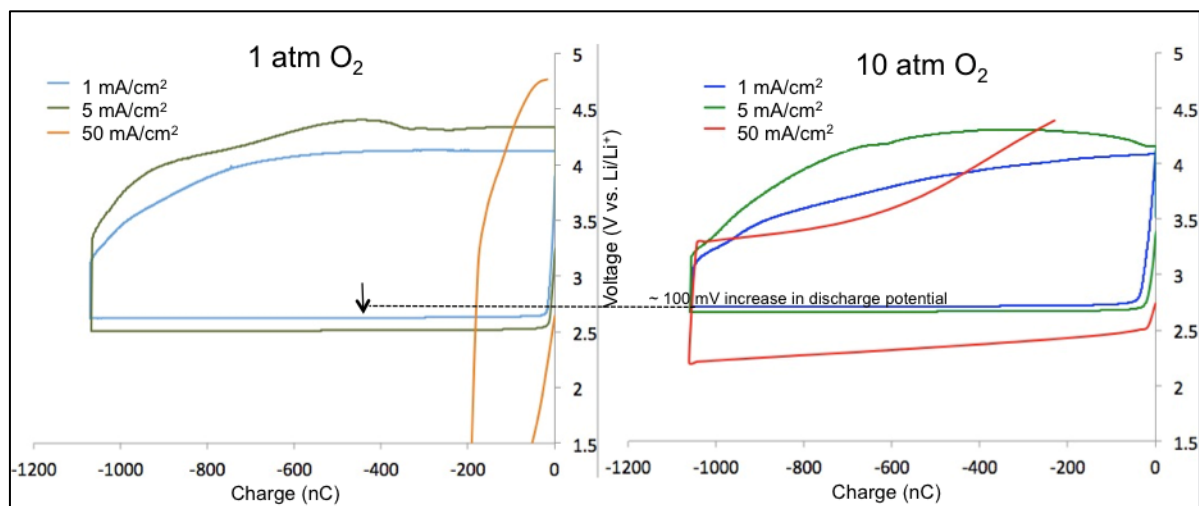


Figure 1. Galvanostatic cycles for carbon black microelectrodes at 1 and 10 atm O₂.