Supporting Information for

A Molten Salt Lithium-Oxygen Battery

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**Figure S1.** TGA-MS analysis of a Super P carbon:PTFE/Li$_2$O$_2$/(Li,K)NO$_3$ mixture (1/1/3 mass ratio). Sample is heated up (5 °C/min) and kept at 200 °C first under Ar then under O$_2$ (both for 60 hours). Mass fragments 28 (CO), 30 (NO), 32 (O$_2$), 40 (Ar) and 44 (CO$_2$) are monitored (right y-axis). Note that the baseline for mass 28 (CO, light blue), 30 (NO, green) and 44 (CO$_2$, dark blue) varies depending upon the carrier gas (Ar or O$_2$).

**Figure S2.** TGA-MS analysis of a (Li,K)NO$_3$/Li$_2$O$_2$ mixture (85/15 wt.%) heated up to 150 °C at 2 °C/min, held at 150 °C for 2.5 hours then heated up to 400 °C at 2 °C/min. 2Li$_2$O$_2$ → 2Li$_2$O + O$_2$ thermal decomposition typically observed around 250 °C. Expected weight loss (95% pure Li$_2$O$_2$): 33.1%.

**Figure S3.** Levich plot derived from linear sweep voltammograms recorded at various rotation rates for Li$_2$O$_2$ bulk oxidation in (Li,K)NO$_3$ molten salt electrolyte. Working electrode: Pt RDE ($A= 0.196$ cm$^2$), T= 150 °C, sweep rate= 1 mV/s. The limiting current increases linearly with the square root of the rotation rate, and the line intercepts the vertical axis at zero, as predicted by the Levich equation ($i_L = 0.620 n F AD^{2/3} \nu^{-1/6} C_o^{1/2}$). Kinematic viscosity $\nu$ of LiNO$_3$-KNO$_3$ eutectic at 150 °C: 5.82x10$^{-2}$ cm$^2$/s.

**Figure S4.** a) SEM analysis of a Super P carbon:PTFE air cathode following the 1$^{st}$ cycle (battery was fully charged to 3.0 V cutoff), confirming complete removal of Li$_2$O$_2$ (500 nm to several microns in diameter hexagonal prisms). Left image: amorphous carbon nanoparticles; right image: Li$_2$CO$_3$ particles covering the electrode surface. b) Elemental analysis performed on the area covered by Li$_2$CO$_3$. 
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