Perovskite Composite Bifunctional Catalyst for Rechargeable Lithium-Oxygen Batteries

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The rechargeable Li-O_2 battery is an attractive energy storage device for the application in electric vehicles due to the high theoretical energy density of the battery. However, the asymmetry in the discharging and charging behaviors in the battery induces the large difference between discharging and charging voltages, which further degrades the efficiency of electrical energy storage in a Li-O_2 battery. The use of an active cathode catalyst would reduce both discharging and charging overvoltages by facilitating the oxygen reduction reaction (ORR) during discharging and the oxygen evolution reaction (OER) during charging.

From a rational design point of view, an ideal cathode catalyst in the Li-O2 battery should have highly active catalytic centers, which is densely distributed over the carbon support surface, by maintaining minimum separation between individual sites to achieve maximum interaction with the solid precipitates such as a Li_2O_2. The active sites should also be easily accessible to the electrons necessary to complete the electrochemical reactions. A potential candidate catalyst is the perovskite type composite prepared by the soft chemical oxidation of ingredient materials.

The cathodes were prepared by rolling the paste including bi-functional catalyst (perovskite composite), ketjen black and PVDF. The perovskite composite was prepared using the soft chemical oxidation of La, Co and Ni ions. Various ratios of the composite materials were prepared by merely adjusting the concentration of the constituent elements in the experimental solutions. The spherical and rectangular particles with connected morphology were evidenced from the surface morphology analysis. The TEM analysis confirmed the particle size of 70 nm ~ 100 nm for all the compositions of the composite. Figure 1 shows the XRD plot for the perovskite composite. The plot clearly indicates the peaks related to the two distinct phases of $LaCoO_3$ and $LaNiO_3$ simultaneously in the synthesized material.

Furthermore, the Li-O_2 cell was assembled with Li electrode, glass fiber separator and air electrode. This cell was used to investigate the electrochemical impedance and the oxygen reduction mechanism on the catalyst surface. To examine the effect of applied current on the capacity retention of the Li-O_2 cell, the cell were tested at various current densities (0.2 ~1mA). The composite oxide accelerated the ORR and helped to catalyze the non-redox Li_2O_2 decomposition process efficiently. The discharge capacity higher than 2500 mAh·g$^{-1}_{carbon}$ for all the composite catalyst was observed. The power density

possessed by the Li-O_2 cell containing the composite catalyst was 2.5 kW·kg^{-1}. The gap between the charging and discharging voltage was found to be less than one volt. The XPS analysis showed that the discharge products in Li–O_2 cells were Li_2O_2 and got decomposed during charging process. The discharge products of Li–O_2 cells were systematically analyzed using XRD, SEM, FTIR and RAMAN spectroscopy.
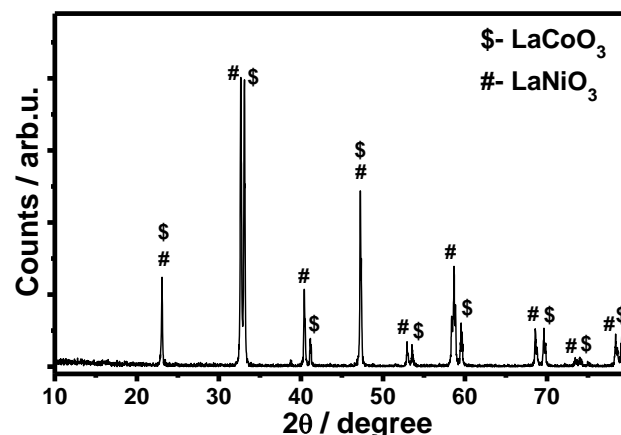

Figure 1 XRD plot of the perovskite composite prepared by the soft chemical oxidation method.