La$_{1.7}$Sr$_{0.3}$NiO$_4$ layered perovskite: a potential electrocatalyst for metal-air batteries

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Rechargeable metal-air batteries have received significant attention in recent years owing to an increasing need for the high-energy density storage of electric vehicles and portable powers. Metal-air batteries are predicted to have several times higher energy densities compared to current lithium-ion batteries. However, for the realization of metal-air batteries, many obstacles should be overcome. The main challenge facing the metal-air batteries is the limited electrical efficiency resulting from the sluggish kinetics and irreversibility of electrochemical oxygen reactions on an air cathode during charge and discharge. As a result, it is of great importance to develop highly active and reversible bi-functional cathode catalysts.

Various types of catalysts have been developed to reduce potential hysteresis and thus to improve the round-trip efficiency. The catalysts include carbon-supported noble metals and transition metal oxides based on Mn and Co [1]. Mixed transition metal oxides with a perovskite structure are also of interest due to their structural and chemical stability. Perovskite structures can be doped with a wide range of cations, which allows control of their catalytic properties. Perovskite oxides have long been considered a promising material capable of catalyzing oxygen reduction and evolution in metal-air batteries with aqueous electrolytes [2].

In the present work, we report another class of mixed oxide, La$_2$NiO$_4$-based phase with a layered perovskite structure. The La$_2$NiO$_4$-based catalysts are fabricated by Pechini method and are applied as a cathode catalyst for aqueous metal-air batteries such as hybrid lithium-air and zinc-air cells. The crystal structure of the La$_2$NiO$_4$-based catalysts is characterized and their catalytic activity is evaluated. The air cathode with La$_2$NiO$_4$-based catalyst shows a remarkably enhanced power density compared to the catalyst-free cathode in the zinc-air cell (Fig. 1). This report suggests the possibility that La$_2$NiO$_4$ with layered perovskite can be used as an efficient catalyst to improve the round-trip efficiency of metal-air batteries with aqueous electrolytes.

Reference


Fig. 1. Discharge cell potential and power density profiles of Zn-air cell at various discharge current densities of 2 - 400 mA cm$^{-2}$. 