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Nano-perovskite oxide prepared *via* inverse microemulsion mediated synthesis for catalyst of lithium-air batteries

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ABSTRACT

Perovskite oxides have received considerable attention as useful electro-catalysts for Li-air batteries due to their properties of excellent catalytic activity, electrical conductivity, and durability. The nanostructure can enhance the electrochemical performance of perovskite oxides by enlarging the catalytic active sites. In this study, nano-size $Nd_{0.67}Sr_{0.33}CoO_{3-\delta}$ (NSC) perovskite particles with a particle size of 20–50 nm and a specific surface area of 12.759 $m^2 g^{-1}$ were successfully synthesized by a microemulsion method. The NSC perovskite particles exhibit excellent electrocatalytic activity particularly in the oxygen evolution reaction (OER) with a high limiting current density of 33.68 mA cm^{-2} at 0.9 V *vs.* (Hg/HgO). This excellent catalytic activity can be ascribed to the existence of Co^{3+} and the enlarged surface area. Co^{3+} provides catalytically active site by forming $Co^{3+/4+}$ redox couple and the enlarged surface increases active sites for reactants and catalyst particles. In this regard, nano-size NSC particles prepared by the microemulsion route provide excellent and stable electrochemical performance in the hybrid Li-air battery.

1. Introduction

Li-air batteries are receiving significant attention due to their higher theoretical energy density (11,140 Wh kg^{-1}) compared to other rechargeable batteries such as Li-ion polymer (387 Wh kg^{-1}) and Li-S (1086 Wh kg^{-1}) batteries [1–4]. However, the practical use of Li-air batteries is hampered by poor performance and low energy efficiency during cycling, mainly because of the high overpotential at the air electrode [5,6]. For this reason, Li-air batteries need new air-electrode catalysts with high catalytic activity and stability. At present, precious metal catalysts such as Pt/C and IrO_2 are considered as the most effective air electrode catalyst for Li-air batteries because of their excellent catalytic activity in oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) [7,8]. However, the development of alternative catalysts is required due to high cost and instability of those catalysts. Some candidate materials have been viewed as alternatives for air electrode of Li-air batteries. e.g., carbon-based materials [9], spinel structured oxides [10], and perovskite structured oxides [11–15]. Among these alternatives, the perovskite structured oxides are attracting attention owing to their high electrical conductivity, electro-catalytic activity, and redox stability [16–20]. On the other hand, despite these excellent properties, the high synthesis temperature (1000–1500 °C) of the perovskite structured oxides decreases the specific surface area, thereby degrading the electrochemical performance. The main challenge to the perovskite structured oxides is, therefore, to increase the surface area for sufficient electrochemically active sites. In this regard, many researchers have studied various methods such as microemulsion [21], hydrothermal [22], co-precipitation [23], and electro-spinning [24] to increase the surface area. Among them, the microemulsion is one of the simplest and most effective ways of constructing nanostructures because it can prevent particle agglomeration through the encapsulation of a precursor [21]. The microemulsion can also reduce the synthesis temperature by

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