FMRI RET 2017-Perovskite Oxides as an Alternative Electrocatalyst in Oxygen Evolution Reaction

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Abstract

Electro-catalytic water splitting is a clean approach to efficiently synthesize H_2 and O_2. There has been an ongoing search for a more sustainable, cost effective, and clean energy source to supply the world's energy demands. There is a constant search for alternate anode materials, inexpensive but effective electrocatalysts, with low onset potentials and good current densities. In our approach, we synthesize perovskite oxides with the general formula $LaCo_xNi_{1-x}O_3$ and test the electrochemistry in alkaline medium for each sample to determine the efficacy as an OER catalyst in future technologies.

Background

Fossil fuels have been the primary source of energy in the world for centuries, but have recently been looked down upon due to the negative environmental effects. The use of oxygen evolution reaction (OER) in fuel cells is a great contender for lowering the Earth's carbon footprint because it splits water into hydrogen and oxygen (Fig. 1). However, the cost of fuel cells is expensive due to the platinum catalyst used. It has been found that various perovskite oxides can be used as cheaper alternatives to platinum. Perovskite oxides serve as great catalysts on the anode and have a general molecular formula of ABO_3. The "A" site is usually an alkaline earth or rare earth element, while the "B" site could be a transition metal which is responsible for the catalytic activity. Here, we use an additional A-site cation transition metal, A', which has been known to stabilize the cation within the B-site. The A site chosen is lanthanum because of its thermal stability of B-sites. $LaCo_xNi_{1-x}O_3$ perovskite oxides were synthesized to test the electrocatalytic activity towards OER.

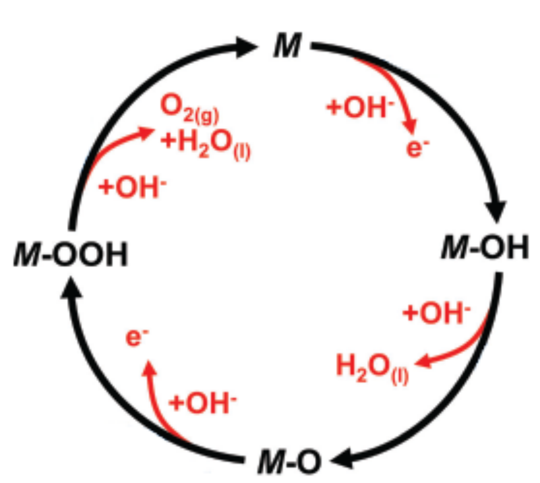

Figure 1: Mechanism of oxygen evolution reaction in an alkaline solution at the anode (M = Ni or Co).

Objectives

Synthesize quaternary pure phase perovskite oxides nanoparticles with prospects in OER/HER and ORR.

Approach

Synthesis of Perovskite Oxides

- Precursors: $La(NO_3)_3$, $Co(NO_3)_3$, $Ni(NO_3)_3$
- 4 mL of DI H_2O

- Slowly add citric acid
- 2 hrs @ Room Temp.
- With condenser for 3 hrs @ 70°C

- 110°C for 8 hours
- 650°C for 9 hours

Characterization of Perovskite Oxides

- X-ray diffraction (XRD) Analysis
- Scanning electron microscopy (SEM)-imaging
- Color mapping-EDS

Figure 2: Gel product formed after stirring step.

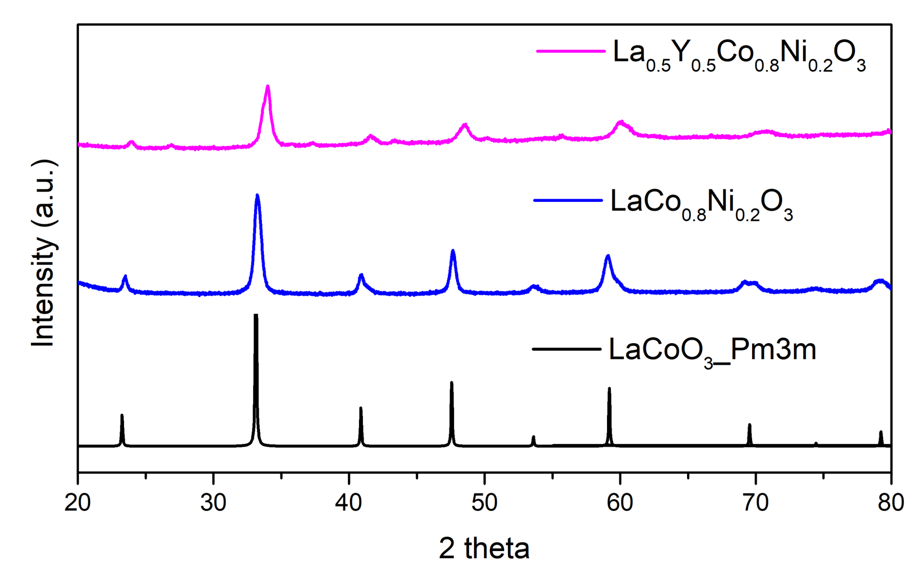

Figure 3: XRD patterns of Y-doped $LaCo_{0.8}Ni_{0.2}O_3$. The patterns show the diffraction peaks match those of the reference ones. These results suggest that yttrium was successfully doped into the A site of $LaCo_{0.8}Ni_{0.2}O_3$.

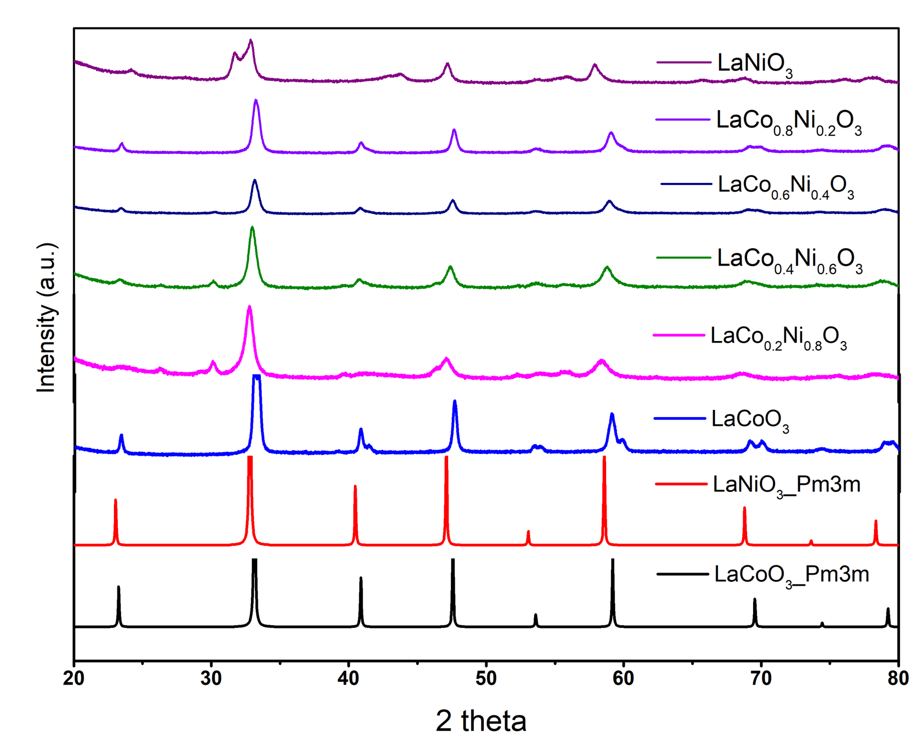

Figure 4: XRD patterns of various ratios of nickel to cobalt compared to the references. These results indicate the formation of $LaCo_xNi_{1-x}O_3$ by showing the same peaks in comparison. This also confirms the formation of cubic perovskite phase.

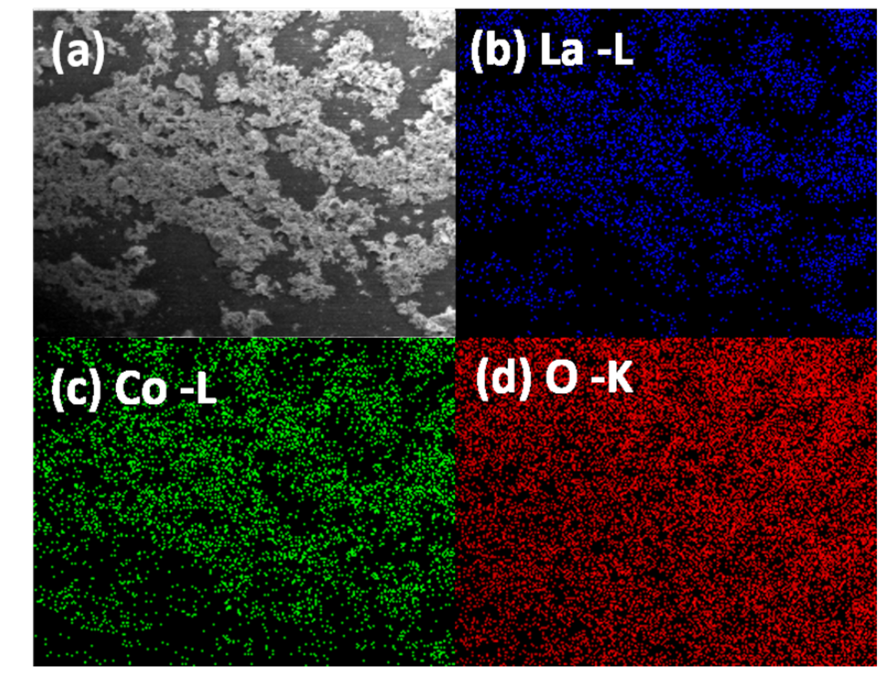

Figure 5: SEM images showing (a) $LaCoO_3$,(b) with lanthanum atoms in blue, (c) cobalt atoms in green, and (d) oxygen atoms in red.

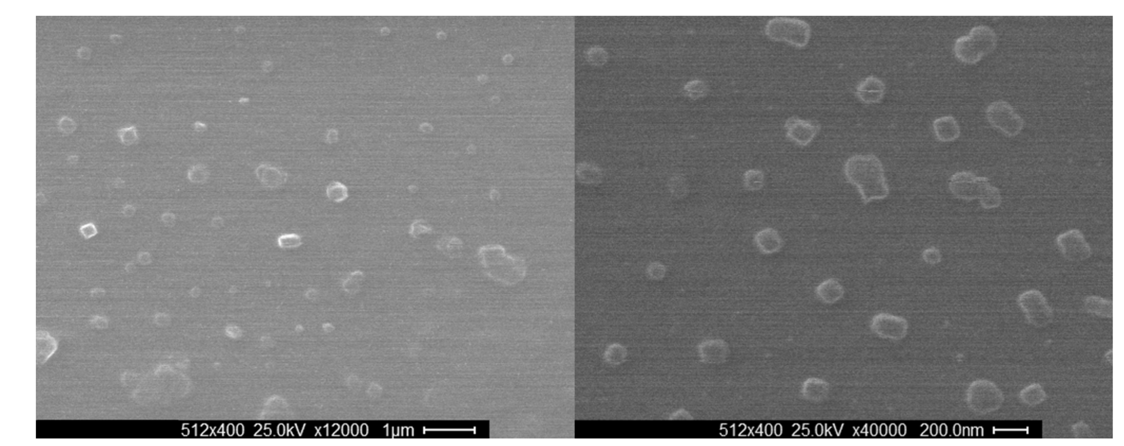

Figure 6: SEM images of $LaCoO_3$ showing cubic morphology with magnification of 12,000 times on the left and 40,000 times on the right.

Future Work

Synthesis of $LaCo_xNi_{1-x}O_3$ through our method proved to create perovskite oxides that can be used as a catalyst. However, in order to better understand the activity and applications of $LaCo_xNi_{1-x}O_3$ perovskites, they should be considered under oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER).

Referenced Resources

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