Catalytic activity of $PrNi_xCo_{1-x}O_3$ - graphene nanocomposites for sustainable energy application

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Cobalt-containing perovskites ABO_3 with praseodymium in A-site have been investigated as a possible candidate for cathode material for intermediate temperature solid oxide fuel cells. It was found that the conductivity of these compounds does not change significantly with temperature. At close to room temperatures they have conductivity similar to that at high temperatures (1580 $S \cdot cm^{-1}$ at 50°C and 1031 $S \cdot cm^{-1}$ at 1000°C).[1] This could be favorable for the oxygen reduction reaction/oxygen evolution reaction (ORR/HER) catalytic activity while considering energy storage and generating devices, such as fuel cells or metal air batteries.

Pt catalysts are the leading catalysts for use in ORR. However, Pt is an expensive catalyst and with limited supply cannot be considered a sustainable material for feasible application that is scalable in the economy. This calls for new solutions for catalyst materials that either mitigate the amount of Pt used in catalysts by developing hybrid catalysts, or to replace Pt altogether with a material with similar or better catalytic activity.[2]

Praseodymium based pyrochlores ($PrNi_xCo_{1-x}O_{3-\delta}$) with three concentration of Co ranging from x=0.1, 0.5, and 0.9 have been synthesized using a modified nitrate-glycine Pechini method and sintered at different temperatures, specifically 900°C and 1200°C. The XRD pattern (Fig. 1) of the $PrNi_{0.5}Co_{0.5}O_{3-\delta}$ sintered at 1200°C for 2hr represents cubic perovskite structure (space group Pm-3m). [1]

The electrochemical performance of the perovskites sintered at 1200°C and tested in KOH (0.1M) demonstrated that $PrNi_{0.9}Co_{0.1}O_{3-\delta}$ has the highest ORR activity in comparison to the two other perovskites. This activity gradually increases with an increasing ratio of cobalt to nickel at the B site.

Additional experimental data will be presented for these materials in combination with a small addition of Pt or Pt alloys with Co, Ir, or Ru to reveal possible synergistic effect from electron level interaction between molecular orbitals of perovskite and Pt.

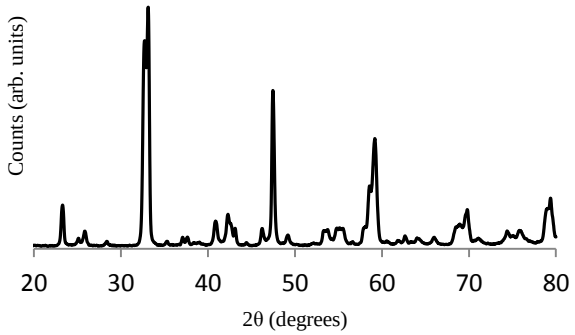

Fig. 1: XRD data $PrNi_{0.5}Co_{0.5}O_{3-\delta}$ after 1200°C sintering.

The electrochemical performance for the samples with and without graphene in acidic ($HClO_4$) and basic (KOH) solutions will be presented and discussed in terms of mass and catalytic activity in comparison to Pt/graphene as a baseline.

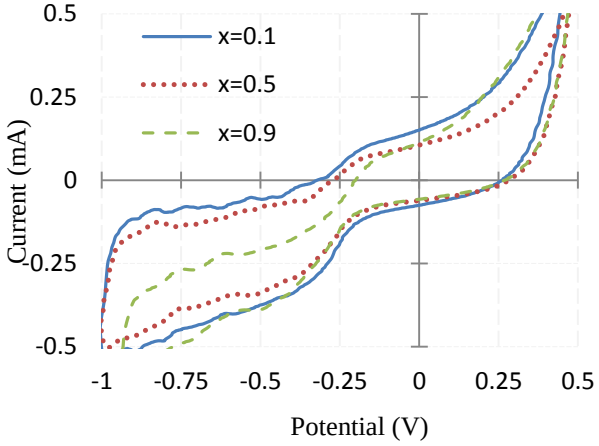

Fig. 2: Cyclic voltammetry of $PrNi_xCo_{1-x}O_{3-\delta}$ for x = 0.1 (solid line), 0.5 (dotted line), 0.9 (dashed line) in an oxygen purged KOH (0.1 M) solution.

References:

[1] S. Huang, Q. Lu, S. Feng, G. Li, C. Wang, J. of Power Sources, **199,** 150 (2012).
[2] J. Suntivich, H. A. Gasteiger, N. Yabuuchi and Y. Shao-Horn, J. Electrochem. Soc., **157**, B1263 (2010).