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CARBON AEROGEL AND LIGNIN-MODIFIED SUPPORTED METAL OXIDE CATALYSTS FOR SUSTAINABLE ENERGY APPLICATIONS

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Although the oxygen reduction reaction (ORR) is important in variety of electrochemical processes and technologies such as sensors and metal-air batteries, the application of the ORR in fuel cells is of particular interest. The ORR slow kinetics in metal air batteries and PEM fuel cells requires novel approaches for the development of catalytically active nanostructures with a final goal of commercialization[1]. Platinum and platinum alloys are the most efficient ORR catalysts, but they are expensive.

Current study is focused on ceria based metal oxides and lanthanum based perovskites as ORR catalysts. These materials have been extensively studied as catalysts (perovskites) or promoters (gadolinia doped ceria oxide) in high temperature catalysis and solid oxide fuel cells. Recently ceramic–based catalysts have demonstrated improved ORR activity in acidic and alkaline media applicable to the metal air battery and PEMFC cathodes(1, 2) .

The synthesis of complex metal oxides, such as $Gd_{0.1}Ce_{0.9}O_{3-\delta}$ fluorite and two ABO_3 perovskites with different chemical composition and iron-cobalt ratio on B-site ($La_{0.6}Sr_{04}Co_{0.8}Fe_{0.2}O_{3-\delta}$ and $La_{0.6}Sr_{04}Co_{0.6}Fe_{0.4}O_{3-\delta}$) was performed using modified Pechini method followed by heat-treatment at 900°C and 1200°C in air. Their crystal structure identification and morphological characterization was performed by XRD, BET, and HRSEM. The electrochemical catalytic activity in acidic and alkaline media was studied with rotating disc electrode in 3-cell configuration with Ag/AgCl, 0.1 M KCl reference electrode.

The XRD spectra of the materials sintered at 900°C in air show well defined crystal structure (Fig.1). The electrochemical studies indicate that in N_2 saturated acidic media (Fig.2) $Gd_{0.1}Ce_{0.9}O_{3-\delta}$, $La_{0.6}Sr_{04}Co_{0.8}Fe_{0.2}O_{3-\delta}$, and $La_{0.6}Sr_{0.4}Co_{0.6}Fe_{0.4}O_{3-\delta}$ demonstrate hydrogen oxidation activity with the highest values for $La_{0.6}Sr_{04}Co_{0.8}Fe_{0.2}O_{3-\delta}$ and the highest hydrogen adsorption defined by the Co-Fe ratio on B-site. ORR catalytic activity (Fig.3) demonstrates similar trend that is sensitive to the type of the material (fluorite or perovskite) and the B-site Fe-Co relative doping.

The results for lignin-modified carbon aerogel supported complex oxides, e.g. $Gd_{0.1}Ce_{0.9}O_{3-\delta}$, $La_{0.6}Sr_{04}Co_{0.8}Fe_{0.2}O_{3-\delta}$, $La_{0.6}Sr_{04}Co_{0.6}Fe_{0.4}O_{3-\delta}$ will be discussed in terms of ORR, methanol oxidation and stability in acidic and alkaline environment.

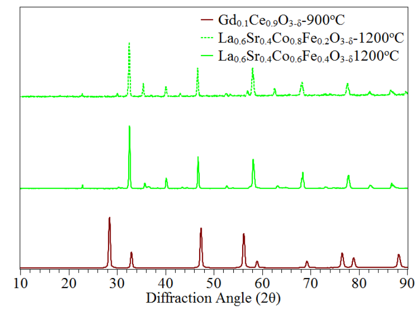

Fig.1 XRD pattern of single phased fluorites (red) and perovskite (green)

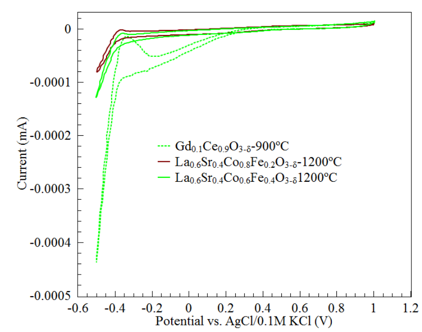

Fig. 2: Cyclic voltammogram (20mV/s) for complex metal oxides sintered at 900°C in O_2 saturated 0.1M $HClO_4$

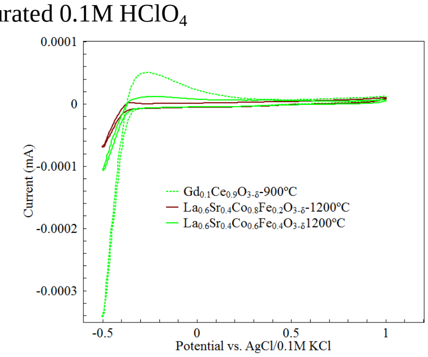

Fig. 3: Cyclic voltammogram (20mV/s) for complex metal oxides sintered at 900°C in N_2 saturated 0.1M $HClO_4$

References:

1. J. Suntivich, H. A. Gasteiger, N. Yabuuchi, H. Nakanishi, J. B. Goodenough and Y. Shao-Horn, *Nat Chem*, **3**, 546 (2011).

2. J. Suntivich, H. A. Gasteiger, N. Yabuuchi and Y. Shao-Horn, *Journal of The Electrochemical Society*, **157**, B1263 (2010).