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Effects of Humidified Gas Environments on the Electrode Behavior of $La_{0.6}Sr_{0.4}CoO_{3-\delta}$.

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Understanding degradation of Solid Oxide Fuel Cell (SOFC) electrodes is an important aspect of SOFC commercialization. However, many causes of degradation remain poorly understood. Recent work has indicated a high rate of degradation for SOFC cathodes when exposed to humidified gas environments [1-2]. For electrodes incorporating $La_{1-x}Sr_xMnO_{3-\delta}$ (LSM) this has been attributed to decomposition [2], yet the phenomenon remains unclear for electrodes comprising mixed conducting perovskites such as $La_{1-x}Sr_xCoO_{3-\delta}$.

$La_{0.6}Sr_{0.4}CoO_{3-\delta}$ electrodes were studied using Electrochemical Impedance Spectroscopy (EIS) and found to exhibit enhanced degradation in the presence of ~2.5% humidity (Figure 1), as well as a transition from co-limitation of transport and kinetics to primarily kinetically limited at specific conditions (Figure 2). Non-Linear Electrochemical Impedance Spectroscopy (NLEIS) was used to gain further insights in the underlying phenomena by examining changes in the nonlinear *i-V* response of electrodes (Figure 3).

NLEIS has been used previously to study oxygen reduction reaction on $La_{1-x}Sr_xCoO_{3-\delta}$ electrodes [3-4]. The primary contributions to nonlinear response were attributed to bulk and surface transport of oxygen ions and oxygen reduction on the electrode surface. Harmonics measured by the NLEIS technique were found to be sensitive to the specific kinetic mechanism, thermodynamic behavior of the bulk and surface of the electrode, and the relative rates of surface transport, bulk transport, and oxygen reduction kinetics.

In the present work, we have examined surface-specific effects of a humidified gas environment on NLEIS characteristics, yielding insights into both the isolation of individual effects on electrode behavior as well as the likely underlying phenomena for humidity-driven degradation.

References

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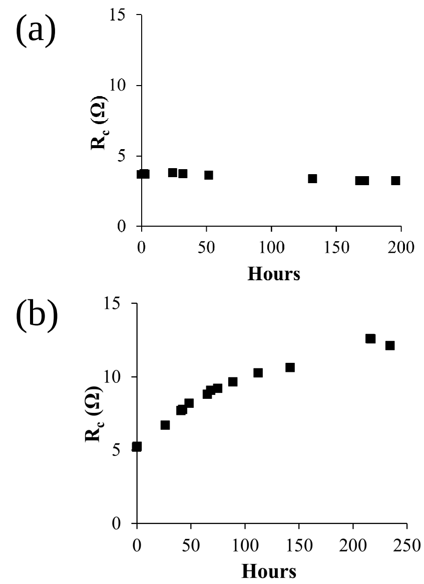

Figure 1. Comparison of changes in characteristic resistances of electrode behavior for dry (a) and humidified (b) gas enviromnets (as measured by impedance spectroscopy), for LSC-64 electrodes at 550°C and 1 atm O_2.

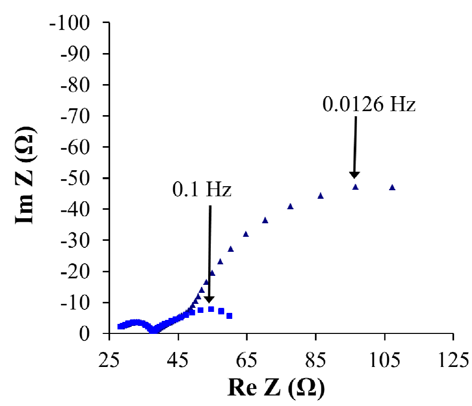

Figure 2. Impedance response of a $La_{0.6}Sr_{0.4}CoO_{3-\delta}$ electrode at 550°C, 0.01 atm O_2, and under dry (squares) and humidified (triangles) conditions. Dry conditions exhibit a Gerischer shape for the low frequency arc attributed to co-limitation of transport and kinetics, while humidified conditions exhibit a semi-circular shape attributed to primarily kinetic limtations.

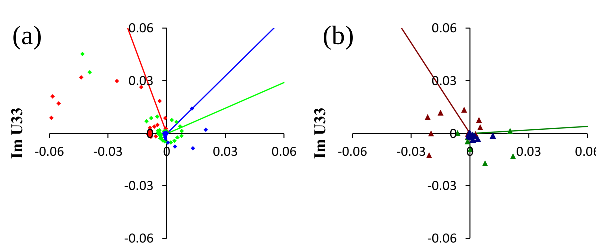

Figure 3. 3^{rd} order harmonic response of a $La_{0.6}Sr_{0.4}CoO_{3-\delta}$ electrode at 550°C, 0.01, 0.1, and 1 atm O_2, and under dry (a) and humidified (b) conditions. Humidified conditions cause significant changes in the magnitude and low frequency intercept of the measured harmonics.