TOPIC 3

Testing of solid oxide fuel cells fed with dry and steam reformed biogas with hydrogen sulfide and dimethyl sulfide contaminants

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Solid Oxide Fuel Cells (SOFC) use O^{2-} transporting ceramic as the electrolyte and operate at high temperatures. This technology provides higher fuel flexibility, enabling the direct use of biogas as a fuel. However, when used directly, the biogas is endothermically reformed into hydrogen and carbon monoxide which leads to localized cooling of the cell. Moreover, and more critical, the carbon-rich mixture shows high risk of coking on the nickel-yttria stabilized zirconia fuel electrode. To mitigate these risks, biogas is usually converted in an external reformer, e.g., by using a fraction of the anode off-gas as a supply of steam and additional carbon dioxide, pushing the mixture away from the carbon deposition region.

Another important concern when using biogas in SOFC is the amount and chemical nature of contaminants. Sulfides are among the most concerning ones. Even short exposures lead to the deactivation of active sites. Although this deactivation is partly reversible, prolonged exposures at levels as low as 5 ppm may induce irreversible degradation of the cell performances.

For that reason, a biogas-integrated SOFC system requires a thorough and reliable cleaning of the raw biogas. Such a requirement increases the cost of the installation and it becomes important to identify the highest sulfide trace amounts that could tolerate the fuel cell. Being able to identify the signature of sulfur poisoning would allow early detection and mitigation strategies that would improve the SOFC lifetime.

In this work, two commercially available SOFC (i.e., 750°C anode supported and 850°C electrolyte supported) were studied. Their performances were assessed in dry reformed and mixed reformed biogas compositions. Under these compositions, hydrogen sulfide and dimethyl sulfide contaminants were added in several ppm levels. The cell performance losses and recovery abilities were investigated by current-voltage behavior and electrochemical impedance spectroscopy. Among other results, the electrolyte-supported cell showed lower initial performances (due to higher ohmic resistance) but better sulfide tolerance (sulfide adsorption unfavored by the higher temperature).