



Use of PEM Fuel Cell Stack as power supply in French Guiana: mitigation of poisoning from coastal tropical environments.

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Introduction

Fuel cells have gathered growing interest in the recent years due to their potential as a clean, efficient, and scalable energy solution. With their minimal environmental impact of operation, fuel cells are being explored across diverse applications, from transportation to stationary power generation. This rising attention is driven by global efforts to transition towards renewable energy sources and reduce greenhouse gas emissions. As a result, understanding and addressing the challenges associated with the deployment of fuel cells in unique and demanding environments has become increasingly critical in advancing their broader adoption.

Proton Exchange Membrane (PEM) fuel cells are a particularly promising type of fuel cell due to their high efficiency, fast start-up time, and suitability for a wide range of power applications. PEM fuel cells operate by converting chemical energy directly into electricity through an electrochemical reaction between hydrogen and oxygen. The key components of a PEM fuel cell include the anode, the cathode, and a proton-conducting polymer membrane. At the anode, hydrogen splits into protons and electrons by means of a catalyst. The protons pass through the membrane to the cathode, while the electrons travel through an external circuit, generating an electric current. At the cathode, the protons, electrons, and oxygen from the air combine to form water as the only byproduct, making PEM fuel cells a clean energy converter for various application, including off-grid electricity production.

This thesis project aims to investigate the viability of Proton Exchange Membrane (PEM) fuel cell stacks as a primary power supply for Base Transceiver Stations (BTS) in remote areas of French Guiana that cannot be connected to the grid.

Situated in a tropical climate, close to the sea, fuel cells of the stack will be exposed to coastal contaminants such as NaCl, chlorides, nitrates, ammonium and sulfates aerosols [1], [2], [3], as well as some halogens (*i.e.* chlorine, bromine and iodine) and ozone (O₃) [4], [5]. These compounds are identified as factors that accelerate degradation processes, especially at the catalyst layer level for most of them. As an example, chlorine has three negative impacts on the oxygen reduction reaction (ORR): (i) it poisons Pt active sites, (ii) it increases the energy barrier for the ORR, and (iii) it decreases the contact between Nafion® and Pt metal particles [6]. This is also confirmed and investigated for other halogens, indeed, bromine and iodine were found to form covalent bond with the catalyst [7]. In the case of NaCl, and in addition to chlorine ions, sodium ions tend to supplant H⁺ in the proton-conducting polymer membrane [8]. Finally, ozone has been explored as a mean to improve fuel cell performance [9], given that it is a strong oxidant but a later study indicated that ozone may also induce Pt dissolution and accelerate degradation of the membrane-electrode assembly (MEA) [10]. All those observations call for specific investigations of the performance of PEM fuel cell of such a harsh environment.

Methodology

The goal of this PhD project is thus to study the functioning of PEM fuel cell stacks in conditions mimicking those of French Guiana. To that aim, a stack test bench is now developed to evaluate and characterize the performance of the stacks, and in particular, evaluate the lifespan of PEM fuel cell stacks under these harsh conditions. The objective is to identify the degradation causes and mechanisms, and to quantify the impact of the degradation processes on performance and reliability. Degradation and regeneration will be inspected at various operating conditions, and compared using EIS, Cyclic Voltammetry, Step Response and Polarization curve of intact, poisoned and regenerated FC stacks.

Discussion

Given that the PhD thesis just started, no results can be present yet.

Insights from degradation and regeneration cycles shall highlight operating conditions to mitigate negative effects on FC stack lifetime, evaluate special treatments to optimize regeneration efficiency, or discuss threshold values for air purification methods to ensure minimal or inconsequential poisoning. The overall target is to determine how ageing can be prevented so as to implement the stack cells in the best possible working configuration.

Conclusions

The research seeks to explore mitigation strategies and regenerative solutions that could extend the operational life of PEM fuel cells working in harsh environment, ensuring low occurrence of heavy maintenance.

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