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Hotspot Formation and Its Impact on Hydrogen Production in Proton Exchange Membrane Water Electrolysers (PEMWEs)

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ABSTRACT

PEMWE systems are vital for sustainable hydrogen production; however, their efficiency is often hindered by the formation of hotspots, which can lead to performance degradation and shortened cell lifetimes. A comprehensive literature review of key factors contributing to hotspot formation in PEMWE, including bubble behaviour, uneven current distribution, and non-uniform temperature gradients. These factors are shown to not only affect local electrochemical reactions but also impede hydrogen production efficiency. In particular, bubble dynamics within the flow field disrupt gas-liquid interfaces, leading to irregular current densities. Concurrently, localised temperature variations exacerbate these effects, further intensifying hotspot formation. To gain deeper insights into this phenomenon, we present preliminary experimental results comparing bubble behaviour with temperature distribution in a single PEM cell, utilising infrared (IR) thermography to map thermal variations. The initial findings suggest a direct correlation between bubble formation, stagnation, and localised temperature spikes. Additionally, uneven current distribution across the membrane electrode assembly (MEA) is a significant concern, as regions of higher current density tend to experience higher rates of heat generation, further exacerbating temperature gradients within the cell. These phenomena are intricately linked, and when combined, they can cause irreversible damage to the MEA and lower overall hydrogen production rates. These results aim to uncover the underlying mechanisms of hotspot formation, aiming to optimise PEMWE operation to mitigate hotspots and enhance hydrogen production efficiency

KEYWORDS

Hotspot formation

Non Uniform Current density distribution

Bubble management

Uneven Temperature distribution

Water Starvation

BIOGRAPHY

I am Anie Shejoe Justin Jose Sheela, and I am pursuing a PhD in Chemical and Materials Engineering (CHEMMAT) at the University of Auckland (UOA). My research interests lie in Proton Exchange Membrane Water Electrolysis (PEMWE) and Proton Exchange Membrane Fuel Cells (PEMFC), focusing on developing innovative materials to enhance the efficiency and durability of these systems.
A passion for experimental work and modelling has driven my academic journey. I have designed and modelled my lab-scale PEM cell to optimize its performance and prevent degradation. I aim to contribute to sustainable hydrogen production, aligning with broader efforts in clean energy technologies.
With a chemistry and materials science background, I strive to advance sustainable hydrogen production and clean energy technologies. I am committed to advancing research that supports a sustainable future. My work reflects my dedication to innovation and practical solutions in the energy sector.

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