

Novel electrode boosts green hydrogen research

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ITM Power's hydrogen refuelling station, HFuel, generates hydrogen by electrolysis

Scientists from the National Physical Laboratory (NPL) have developed a novel reference electrode, and are working with hydrogen energy system manufacturer ITM Power to aid the development of hydrogen production technologies for renewable energy storage.

Polymer electrolyte membrane water electrolyzers (PEMWEs) convert electricity and water into hydrogen and oxygen using two electrodes separated by a solid polymer electrolyte. This promising technology could be coupled to intermittent renewable energy sources to generate hydrogen for efficient energy storage and low-carbon transportation.

PEMWEs are more efficient than currently-used alkaline electrolysis technologies, but require relatively expensive catalyst materials such as

iridium/ruthenium oxide (for oxygen evolution at the anode) and platinum (for hydrogen evolution at the cathode). Cost-effective design and extended lifetime are needed to boost competitiveness of PEMWEs, but development is currently being held back by poor understanding of the degradation of these catalysts.

Edward Brightman and Gareth Hinds from the Centre for Carbon Measurement at NPL have adapted their innovative fuel cell reference electrode for use in PEMWEs, allowing in situ measurement of the electrochemical processes at the anode and the cathode.

Conventional reference electrodes either connect to the edge of the cell under test, leading to significant measurement errors arising from edge effects, or require special modifications to be made to the PEMWE's design, making them difficult to incorporate. NPL's reference electrode avoids these problems by connecting directly to the active region of the cell through holes drilled into the end plates of the cell. This allows the reference electrode to determine the contributions of the anode and the cathode to the cell voltage, without affecting the cell's performance.

Commercial PEMWE systems commonly show a decay in open-circuit potential (the voltage at zero current) after the current is switched off. This has conventionally been attributed to changes in the redox state of the anode catalyst which can lead to degradation. But in new work published in *Electrochemistry Communications*, the NPL reference electrode has demonstrated that the decay in potential is in fact entirely due to the cathode. This is caused by oxidation of the platinum surface following shut-down, and large changes in potential were found to significantly reduce the electrochemical surface area of the platinum catalyst.

NPL is working with ITM Power, the UK's leading manufacturer of commercial PEMWE systems, to apply the technique to the study of

catalyst durability and the development of accelerated test protocols for new [catalyst materials](#). While internationally-recognised accelerated stress tests exist for PEM fuel cells, there are no equivalent protocols for PEM electrolyzers.

Nicholas van Dijk, Research Director at ITM Power and co-author of the publication, said: "This work has disrupted the conventional thinking in PEM electrolyser degradation and has paved the way toward the development of internationally-recognised accelerated stress tests. It has not only helped speed up innovation to market within ITM Power, but will benefit the industry as a whole."

More information: In situ characterisation of PEM water electrolyzers using a novel reference electrode, *Electrochemistry Communications*, Volume 52, March 2015, Pages 1–4.

Abstract

Polymer electrolyte membrane water electrolyzers (PEMWEs) are a promising technology for hydrogen production but catalyst degradation mechanisms are poorly understood, hampering informed catalyst design for extended lifetimes and the use of more economical loadings. Here we demonstrate the application of an innovative reference electrode to the study of catalyst degradation in an operating PEMWE. This approach enables separation of the relative contribution of anode and cathode to the overall water splitting reaction. It is shown that, in shut-down periods during power cycling, the cathode contributes more to changes in open circuit voltage than the anode. Changes in the electrochemical surface area of the platinum cathode as a result of power cycling are measured in situ for the first time using hydrogen underpotential cyclic voltammetry. The results demonstrate that degradation of the platinum cathode plays a more significant role than conventionally assumed by the electrolyser community, which has tended to focus more on the iridium/ruthenium oxide anode because it dominates the performance of the cell.

Provided by National Physical Laboratory

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