Cost reduction of water electrolyzers via insights into anode current collector corrosion

Dr Gareth Hinds FREng
NPL Fellow & Science Area Leader
Electrochemistry Group

Tel. + 44 20 8943 7147  E-mail: gareth.hinds@npl.co.uk
- UK’s national standards laboratory
- Founded in 1900
- 1000 scientists/engineers
- Research and consultancy focused on measurement, testing and standards
Role of measurement

Confidence for innovators, investors, and customers

- Validating performance
- Providing confidence
- Driving productivity
- Underpinning standards
Hydrogen – not a hype cycle this time round?

Source: David Hart (E4Tech)
NPL Hydrogen Refuelling Station
Measurement needs for the hydrogen industry

Material development for fuel cells and electrolysers

Impact assessment of added odorant to hydrogen to aid leak detection

Determination of the blend ratio when hydrogen is mixed with natural gas in the gas grid

Measurement of the combustion properties of hydrogen

Assessment of the suitability of existing gas infrastructure and materials for hydrogen transportation

Validated techniques for hydrogen storage

https://www.npl.co.uk/resources/energy-transition/hydrogen-industry
How an electrolyser works
PEM water electrolyser stack cost breakdown

Today’s cost
€1,400/kW

EU target (2030)
€500/kW

Source: E4Tech and Element Energy (2014)

Bertuccioli et al., Development of Water Electrolysis in the European Union, 2014
Bipolar plates and current collectors are typically made from platinum-coated titanium, which is expensive to source and manufacture.

**WHY?**

Perceived need for corrosion resistance at high potentials (~2 V)

Particularly at anode (oxygen) electrode

Today's cost

€1,400/kW

Source: E4Tech and Element Energy (2014)
What is the corrosion potential of the current collector?
In situ reference electrode measurements

Driving force for corrosion
In situ reference electrode measurements

![Graph showing the relationship between electrode potential (E) and current density (j)]

- **Cell**: Represents the overall driving force for corrosion.
- **Cathode CC**: Indicates the cathode current collection point.
- **Anode CC**: Indicates the anode current collection point.

The graph illustrates the corrosion driving force as a function of current density and electrode potential.
In situ reference electrode measurements

![Graph showing in situ reference electrode measurements with E/V on the y-axis and j/A cm^2 on the x-axis. The graph includes data for Cell, Anode CC, and Cathode CC. The driving force for corrosion is indicated by an arrow.]
Ex situ reference electrode measurements

Dilute $\text{H}_2\text{SO}_4$, pH 4.5, 60 °C
In situ reference electrode measurements

- **Cell**
  - $1 \text{ A cm}^{-2}$

- **Anode carbon CC**
Anode catalyst layer

\[ [H^+]_{\text{water}} < [H^+]_{\text{ionomer}} \]

Piston

Mesh

Sinter

Polymer electrolyte membrane (PEM)

0.85 V

1.9 V

\( R_{\text{ionic}} \)
Summary & Implications

- Corrosion potential at the current collector during PEMWE operation is effectively **decoupled** from that of the nearest electrode due to the large potential drop in deionised water.

- Opens up possibility of using **lower cost** materials than Pt and Ti for anode current collectors, e.g. carbon or carbon-coated stainless steel, with potential to reduce stack cost by up to ~ 50%.

- NPL is now supporting investigation of feasibility of design modifications to PEMWE stacks to incorporate this new perspective.