Dirty Water Electrolysis in Anion Exchange Membrane Systems

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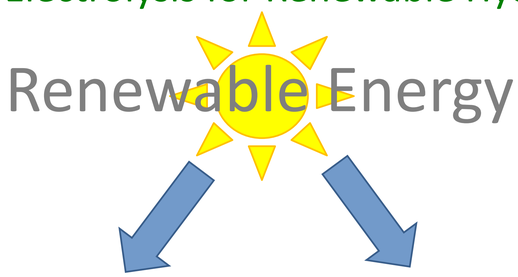
Water Electrolysis for Renewable Hydrogen



Water electrolysis in base

HER: $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$

OER: $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

Water electrolysis in acid

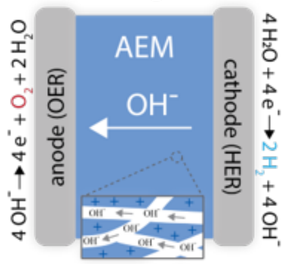
HER: $4H^+ + 4e^- \rightarrow 2H_2$

OER: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

The development of clean hydrogen fuel production is a necessary step towards increasing the effectiveness and scalability of renewable energy sources

Anion vs Cation Exchange Membrane

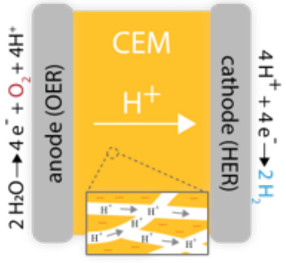
anion exchange membrane



Advantages:
-Greater impurity tolerance
-Less need for platinum-group metal (PGM) catalysts

Disadvantages:
-Underdeveloped
-Membrane instability
-No known baselines (under-researched)

cation exchange membrane

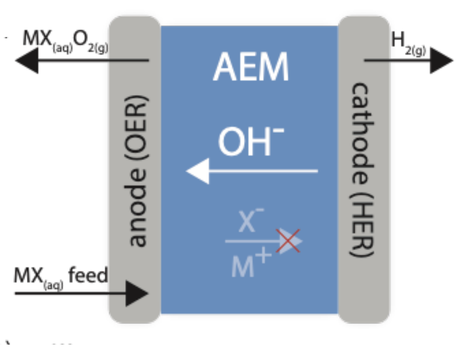


Advantages:
-Current industry standard
-High purity H_2

Disadvantages:
-Require ultra-pure water
-Harsh acidic conditions degrade all but PGM catalysts and hardware

Lindquist et al. *Joule*, **2020**, *4* (12), 2549-2561

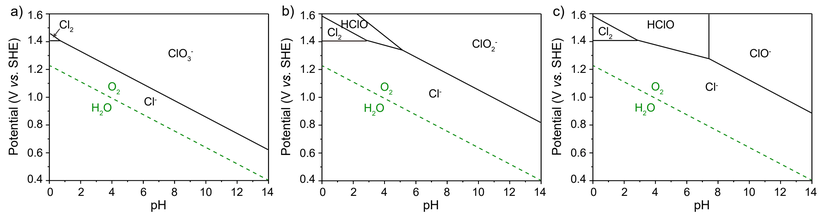
Dirty Water Electrolysis



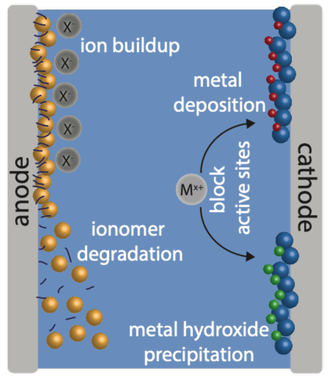
Developing an AEM system with resistance to contaminants from salt water, tap water, etc., will increase system durability and decrease risk of costly system damage or failure

Lindquist et al. *Joule*, **2020**, *4* (12), 2549-2561

Issues to Overcome



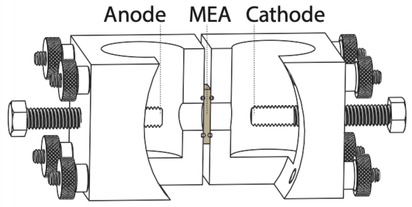
Chlorine gas evolution competing with oxygen evolution reaction



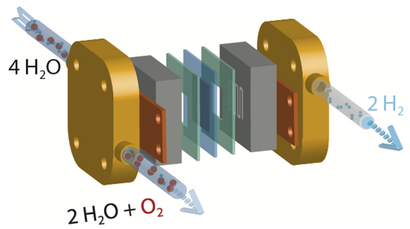
Various degradation pathways dependent on contaminants and ionomer

Lindquist et al. *Joule*, **2020**, *4* (12), 2549-2561

Methods



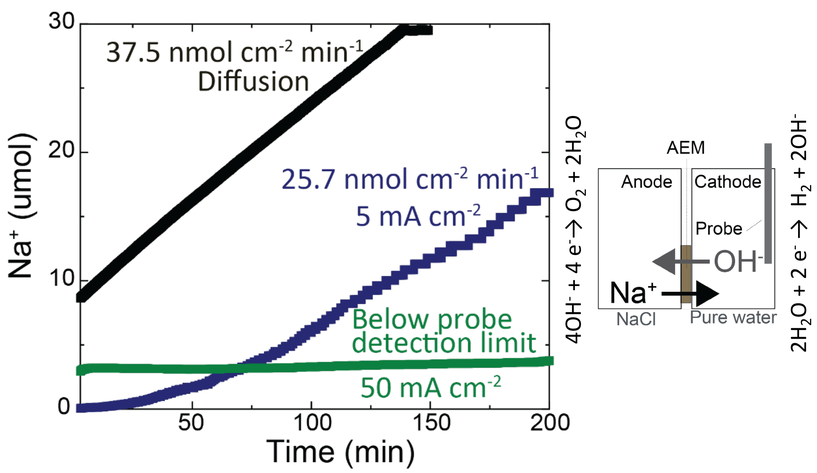
H-Cell - used for ion crossover measurements



membrane electrode assembly (MEA) - used for electrochemical measurements

Oener et al. *Science* **2020,** *369* (6507), 1099-1103.

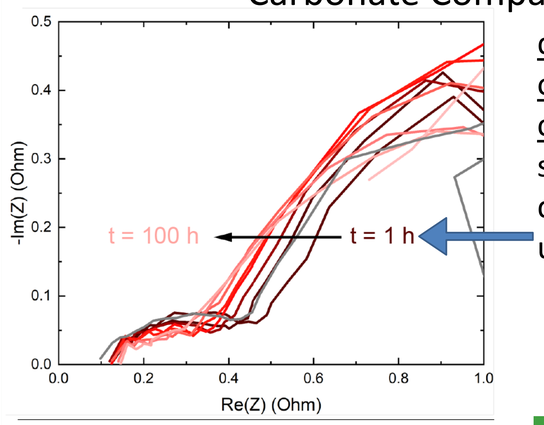
Results



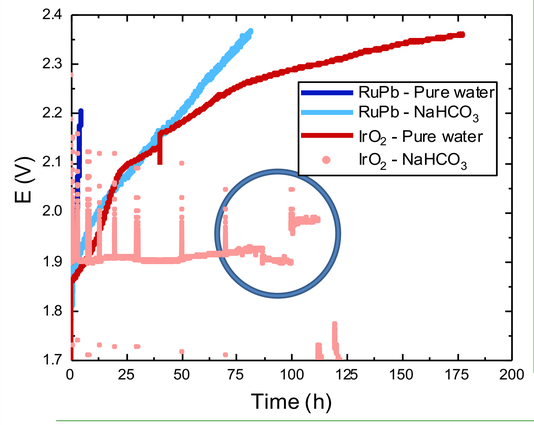
1. Sodium cation crossover is blocked under sufficient current density
2. Crossover may be current-density dependent

Results

Carbonate Comparison

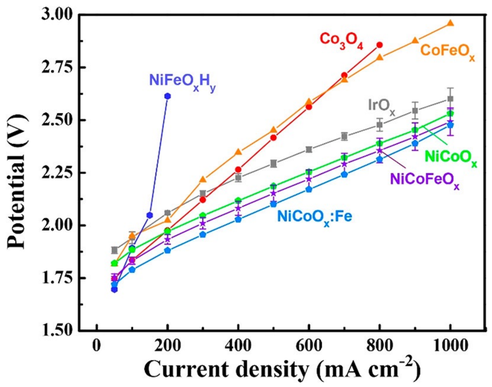


decreasing resistance over time before cell short indicates system is degenerating slowly until failure



Hypothesis: ionomer is degrading in both systems, but voltage increase (efficiency loss) is not observed with $NaHCO_3$ due to increased conductivity masking degradation

Future Directions



Further research on the use of non-PGM catalysts for the oxygen evolution reaction will provide crucial baseline data and reduce capital costs for industry electrolysis

Xu et al. *ACS Catal.* 2019, 9, 1, 7–15

Summary

- AEM show promise for greater system impurity tolerance but require further development
- Cation crossover is mitigated at sufficiently high current density
- Carbonate appears to affect long-term durability, testing of alternate electrolytes is needed
- Future work will study changes in performance and degradation using non-PGM anode catalysts

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