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<td>Author(s)</td>
<td>Nguyen, TV; Yarlagadda, V; Lin, G; Weng, G; Li, VCY; Chan, KY</td>
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<tr>
<td>Citation</td>
<td>The 224th ECS Meeting, San Francisco, CA., 27 October-1 November 2013.</td>
</tr>
<tr>
<td>Issued Date</td>
<td>2013</td>
</tr>
<tr>
<td>URL</td>
<td><a href="http://hdl.handle.net/10722/199359">http://hdl.handle.net/10722/199359</a></td>
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Comparison of Acid and Alkaline Hydrogen-Bromine Fuel Cell Systems


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Abstract

The hydrogen bromine (H2-Br2) fuel cell system is an attractive system for electrical energy storage because of its high round-trip conversion efficiency, high power density capability, and anticipated low costs.

The hydrogen-bromine fuel cell system can be operated in the acid or alkaline modes. The charge and discharge electrode reactions in an acid H2-Br2 fuel cell system are as follows:

**Bromine Electrode:**

\[
\text{Br}_2(aq) + 2e^- \overset{\text{Discharge}}{\longleftrightarrow} 2\text{Br}^-(aq), \quad E^o = +1.09 \text{ V}
\]

**Hydrogen Electrode:**

\[
\text{H}_2(g) \overset{\text{Discharge}}{\longleftrightarrow} 2\text{H}^+(aq) + 2e^- , \quad E^o = +0.0 \text{ V}
\]

The H+ ions migrate from the hydrogen side across a proton conducting membrane to the bromine side during discharge to combine with the Br- ions to form hydrobromic acid.

**Overall Reaction:**

\[
\text{H}_2(g) + \text{Br}_2(aq) \overset{\text{Discharge}}{\longleftrightarrow} 2\text{HBr}(aq), \quad E^o = +1.09 \text{ V}
\]

The charge and discharge electrode reactions in an alkaline H2-Br2 fuel cell system are as follows:

**Bromine Electrode:**

\[
\text{Br}_2(aq) + 2e^- \overset{\text{Charge}}{\longleftrightarrow} 2\text{Br}^-(aq), \quad E^o = +1.09 \text{ V}
\]

**Hydrogen Electrode:**

\[
\text{H}_2(g) + 2\text{OH}^-(aq) \overset{\text{Discharge}}{\longleftrightarrow} 2\text{H}_2\text{O} + 2e^- , \quad E^o = +0.83 \text{ V}
\]

The cations (e.g., K+), associated with the OH- ions, migrate from the hydrogen electrode across a cation (K+) conducting membrane to the bromine side and combine with the Br- ions to form KBr as shown in the overall reaction.

**Overall Reaction:**

\[
\text{H}_2(g) + \text{Br}_2(aq) + 2\text{KOH}(aq) \overset{\text{Discharge}}{\longleftrightarrow} 2\text{H}_2\text{O} + 2\text{KBr}(aq), \quad E^o = +1.92 \text{ V}
\]

Based on the reactions shown above the alkaline system offers a higher cell voltage, which is an advantage because of potentially higher power output. However, the hydrogen reactions in this system are two-phase reactions involving gaseous hydrogen and liquid-phase hydroxide ion reactants and will require more complex electrode structure and fuel cell design. The other advantages of this system include the fact that non-noble catalysts can be used for the hydrogen reactions and lower corrosiveness.

This presentation will discuss the advantages and disadvantages of the alkaline and acid H2-Br2 fuel cell systems and compare the discharge and charge performance of both systems.

Acknowledgements

This work was funded in part by the National Science Foundation through grant number EFRI-1038234 and the Research Grants Council of Hong Kong through a General Research Fund (GRF HKU 700210P). A Visiting Professorship to Trung Nguyen was provided by the Initiative on Clean Energy and Environment (ICEE), University of Hong Kong.