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Comparison of Acid and Alkaline Hydrogen-Bromine Fuel Cell Systems

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Abstract

The hydrogen bromine (H_2-Br_2) 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 H_2-Br_2 fuel cell system are as follows:

Bromine Electrode:

$$Br_{2\,(aq)} + 2e^- \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2Br^-_{(aq)},\ \boldsymbol{E^o = +1.09\ V}$$

Hydrogen Electrode:

$$H_{2\,(g)} \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2H^+_{(aq)} + 2e^-,\ \boldsymbol{E^o = +0.0\ V}$$

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:

$$H_{2\,(g)} + Br_{2\,(aq)} \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2HBr_{(aq)},\ \boldsymbol{E^o = +1.09\ V}$$

The charge and discharge electrode reactions in an alkaline H_2-Br_2 fuel cell system are as follows:

Bromine Electrode:

$$Br_{2\,(aq)} + 2e^- \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2Br^-_{(aq)},\ \boldsymbol{E^o = +1.09\ V}$$

Hydrogen Electrode:

$$H_{2\,(g)} + 2OH^-_{(aq)} \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2H_2O + 2e^-,\ \boldsymbol{E^o = +0.83\ V}$$

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:

$$H_{2\,(g)} + Br_{2\,(aq)} + 2KOH_{(aq)} \underset{Charge}{\overset{Discharge}{\longleftrightarrow}} 2H_2O + 2KBr_{(aq)},$$
$$\boldsymbol{E^o = +1.92\ V}$$

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 H_2-Br_2 fuel cell systems and compare the discharge and charge performance of both systems.

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