Analysis of Electrochemical Properties of Zn-Br Flow Battery

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Introduction: A redox flow battery represents an electrochemical system which produces energy when reversible oxidation and reduction reactions occur simultaneously between two active materials [1, 2]. These active materials constitute the redox system and the redox reactions takes place on the surface of inactive electrodes. Two separate electrolytes (catholyte and anolyte) are used which are stored separately and this makes it unique from conventional batteries. The Zn-Br redox flow battery contains two half-cells at which the reversible electrochemical reactions take place [3, 4]. The reaction at the negative electrode can be written as:

$$Zn^{2+} + 2e- = Zn \text{ and } E^\circ = -0.76V \text{ w.r.t. SHE}$$

Similarly the reaction at the positive electrode is:

$$3Br^{-} - 2e- = Br^{3-} \text{ and } E^\circ = +1.09V \text{ w.r.t. SHE}$$

Experimental techniques focused on the characterization of the different parts of this flow cell and studying the operational parameters.

Experiments: The electrolyte used is $ZnBr_2$ with an excess of bromine on the negative side to help in the flow. The electrolytes consisted of 1M $ZnBr_2$ for the negative electrode (anolyte) and 1M $ZnBr_2$ and 0.05M Br_2 for the positive electrode (catholyte). To improve the conductivity, 2 M KCl solutions were added to both the anolyte and the catholyte. Preliminary experimentation was done with the help of two vials containing the two electrolytes and a salt bridge acting as the connection between the two.

Figure 1. Experimental set up of the Zn-Br flow battery system for preliminary data.

As can be seen from **Figure 1**, preliminary experimentation was done with the help of two vials containing the two electrolytes and a salt bridge acting as the connection between the two.

Cyclic voltammetry (C.V.) is done to study the preliminary electrochemical parameters of the system and the results have been shown in **Figure 2.** The CV from 2000mV and go to 0, and then back from 0 to 2000mV. A scan rate of 2mV/s. A very fast scan rate will produce a large non-Faraday current between the electrodes and the solution and to reduce it the optimum scan rate of 2mV/s is chosen.

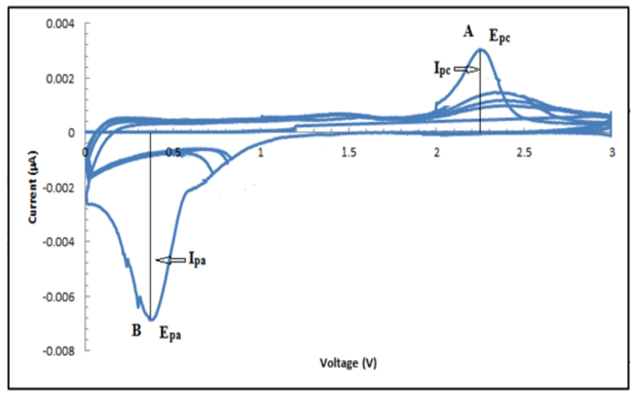

Figure 2. Cyclic Voltammetry data of Zn-Br redox couple.

As can be seen from **Figure 2,** the reduction process produces a cathodic peak. The peak cathodic potential (Epc) is the **point A** in the plot and the resultant current is the cathodic current (ipc) which are 2.205V and 0.0028A respectively. Similarly, during the reverse scan, the reaction is this is the anodic current and the peak anodic potential (Epa) is given by the **point B**, and the corresponding anodic current is the peak anodic current (ipa) which are 0.41V and 0.064 A respectively.

Study: A detailed further study of the Zn-Br flow battery system was done under different conditions so as to better understand the operation of the system and optimize it for power generation purposes. Some of the conditions that are to be studied are as follows:

a) Effect of Molar Concentration: Effect of concentration is important, so the concentration of the electrolytes was studied from a range of 1M to about 10M. Concentration less than 1M was too dilute to give sufficient output. Also increased concentration decreased the resistivity of the system and reduced polarization values.

b) Effect of Temperature: Effect of temperature is important in the Zn-Br flow battery as increasing temperature has a positive effect in that improves both the diffusivity of the gaseous and the liquid species. Cell performance tested at 30, 40 and 50 °C. Bromine vaporized at around 59 °C and so the cell should not be operated above 55 °C.

c) Effect of pH: pH is very important as it affects the conductivity of the solution; lower pH (more acidic) solution indicates greater protons than a higher pH which indicates more hydroxyl ions. Low pH (pH < 3) tends to produce more hydrogen at the Zn electrode because of the reaction's nature. The system tested at different pH from 4-8.

Reference:

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