

Studies on the Iron-Chloride Redox Flow Battery for Large-Scale Energy Storage

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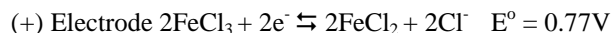
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Large scale energy storage systems that are inexpensive, robust, and highly efficient are necessary for the integration of renewable energy sources like solar and wind into the electricity grid [1]. Electrochemical energy storage systems, especially batteries offer a very promising solution for grid scale applications [2]. The present study focuses on studying the performance of an iron – chloride redox flow battery for grid-scale applications.

The iron-chloride redox flow battery is based on inexpensive and abundant materials and is also eco-friendly. The earliest report on such a flow battery based only on iron species was by Hruska and Savinell in 1981 [3]. While a significant amount of research is in progress on other redox-flow systems for grid scale storage, there has not been a significant development of the iron-chloride redox flow battery in spite of its advantages.

In an iron-chloride redox flow battery, during discharge, iron (III) chloride is converted to iron (II) chloride at the positive electrode and metallic iron is converted to iron (II) chloride at the negative electrode, as noted in the equations below:



One of the major technical issues limiting the performance of the iron chloride redox flow battery is the low charging efficiency of the negative electrode. The reversible potential of the iron deposition reaction is more negative to the reversible potential for hydrogen evolution in the same electrolyte. As a result, during charging, in addition to the deposition of iron, the evolution of hydrogen also occurs, resulting in a low charging efficiency. This problem of low charging efficiency has also been reported by Hruska and Savinell [3]. In addition, due to the evolution of hydrogen, the pH of the electrolyte increases causing the precipitation of Fe^{3+} and Fe^{2+} ions from the electrolyte solution. Therefore, in addition to suppressing hydrogen evolution, the electrolyte pH must be maintained below 4. The charging efficiency of the negative electrode and the battery performance are dependent on the concentration of Fe (II) species in the electrolyte, electrolyte pH and presence of any Fe^{3+} ions [3, 4].

The goal of our research is to optimize the composition of the electrolyte and the charging conditions to achieve high charging efficiency on the negative electrode.

Half-cell experiments were performed using a glassy carbon rotating disc electrode (RDE) to identify the optimal electrolyte pH and additives to maximize the faradaic efficiency of electro-deposition of iron.

A flow cell consisting of reticulated vitreous carbon structures as positive and negative electrodes has been designed and tested. These electrode structures provide good distribution of electrolyte flow and also provide a large volume for storing the electrodeposited iron during charging. An anion exchange membrane permeable to chloride ions separated the positive and negative electrode compartments.

Electrochemical characterization of the flow battery under different operating conditions along with charge-discharge cycling data (Figure 1) will be presented.

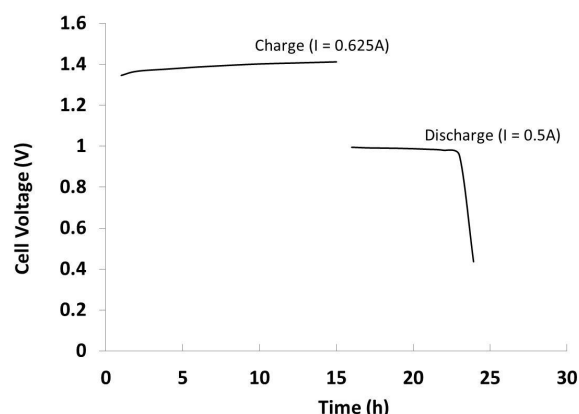


Figure 1: Cell voltage - time curves measured during charging and discharging of an iron-chloride redox flow battery.

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