Properties of different Iron/Iron redox flow batteries with recombination cell

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Due to the steadily increasing growth of renewable energies, the importance of stationary energy storage systems is growing significantly. A potentially very cheap alternative to lithium-ion and vanadium redox flow batteries are iron/iron redox flow batteries. Iron is an extremely inexpensive active material, thus enabling cheap energy storage solutions and perhaps batteries with very low investment costs while maintaining low toxicity and aggressiveness due to the moderate pH and relatively low potential of the positive electrode. An iron(II) salt solution serves as the initial solution and is oxidized to iron(III) at the positive electrode and reduced to elemental iron at the negative electrode during the charging process.

One of the biggest problems is the formation of hydrogen at the iron electrode during the charging process at low pH values and the precipitation of iron(II) hydroxides from slightly acidic pH values [1]. When operating this type of battery, the negative electrode must be kept within a narrow pH window where no precipitation occurs and as little hydrogen as possible is evolved, which in turn significantly reduces battery life and efficiency.

Figure 1: Picture of a laboratory scale Iron/Iron redox flow battery with recombination cell

As part of a feasibility, different iron/iron redox flow batteries were constructed and their electrochemical properties were investigated. One of the most important components of the battery was the recombination cell, which allows hydrogen evolution to be reversed, thus significantly increasing the number of cycles. Different substrates for iron deposition were investigated, different membranes as well as different charging and discharging parameters of the battery. With the recombination cell, it was possible to complete up to one hundred cycles with long cycle times of 1 h charging time, and to calculate and compare efficiencies and other performance values. A kynol fabric achieved the best performance and all membranes investigated showed potential applications. An optimized battery achieved up to 70% energy efficiency at 12.5 mA/cm² and max. 47 mW/cm² power density at 75 mA/cm².

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[1] [1]L. W. Hruska, J. Electrochem. Soc. 1981, 128, 18.