

Potential Extended Ferrocyanide-based Aqueous Flow Batteries

Ali Tuna

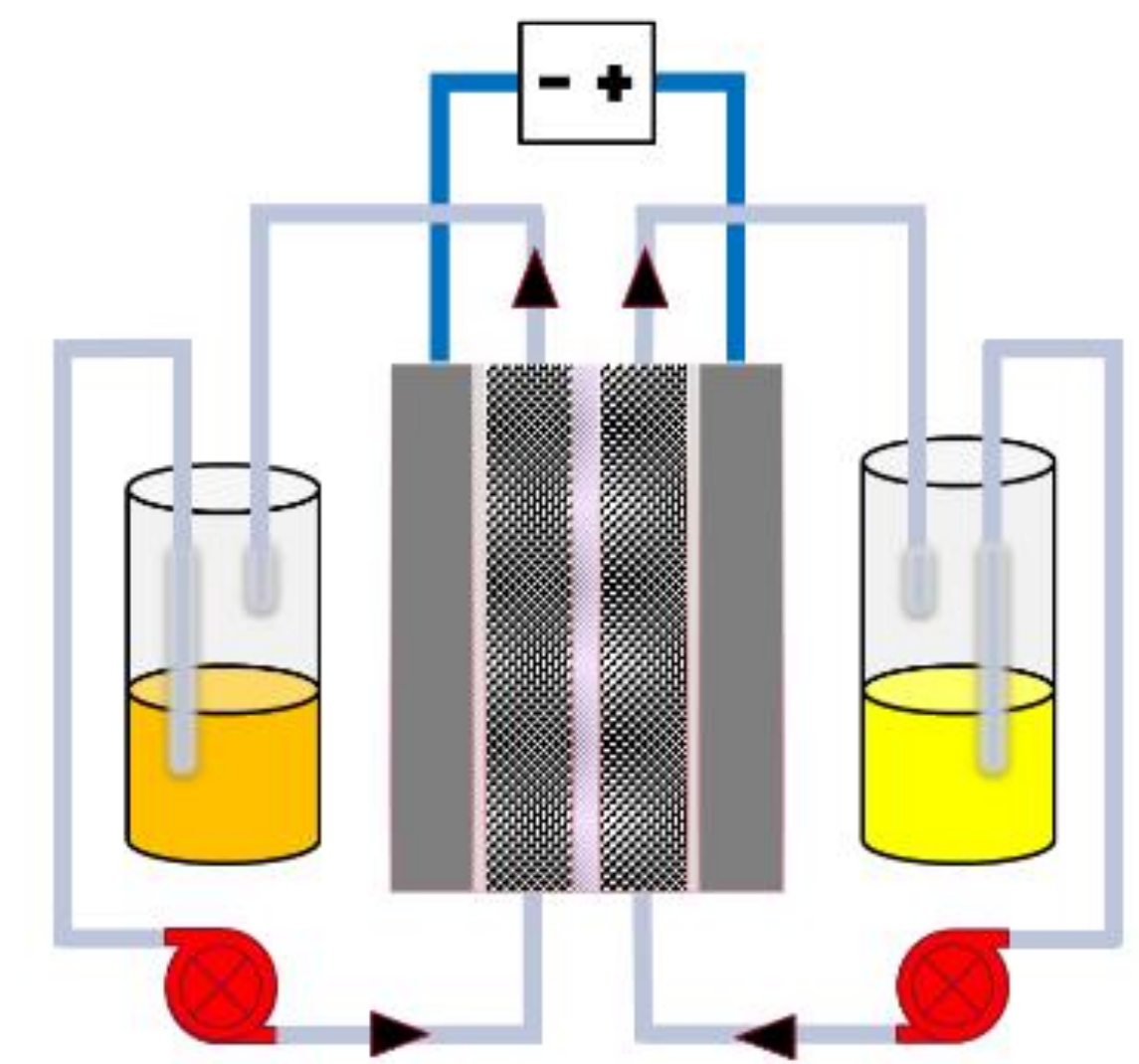
University of Turku, Department of Chemistry, Henrikinkatu 2, FI-20014 Turku, Finland

ali.tuna@utu.fi

Introduction

Flow batteries are emerging as a strong contender for large-scale energy storage, especially as the world moves toward cleaner power sources like solar and wind. Their design where energy is stored in separate liquid electrolytes, makes them ideal for flexible and long-duration storage. One of their biggest advantages is that the energy capacity and power output can be scaled independently by adjusting the tank size and the electrode area. However, current commercial systems mostly rely on vanadium, a costly and resource-limited material, which holds back broader deployment. To overcome this, researchers have been working on organic and inorganic, water-soluble substances that are more sustainable and easier to modify chemically. While many promising organic compounds have been found for the negative side (negolyte), finding stable and high-voltage materials for the positive side (posolyte) has proven much more difficult.

High-potential posolytes are crucial because they directly impact how much energy a flow battery can store and deliver. Yet, most organic molecules either break down when charged or simply don't reach the voltage levels needed for practical use. One exception is ferrocyanide, a well-known and stable compound that has been used successfully in various flow battery systems. In our study, we took this a step further by exploring what happens to ferrocyanide in acidic conditions. Looking ahead, the development of high-performing, oxygen-resistant, and high-potential posolyte materials will be key to unlocking the full promise of aqueous organic flow batteries.

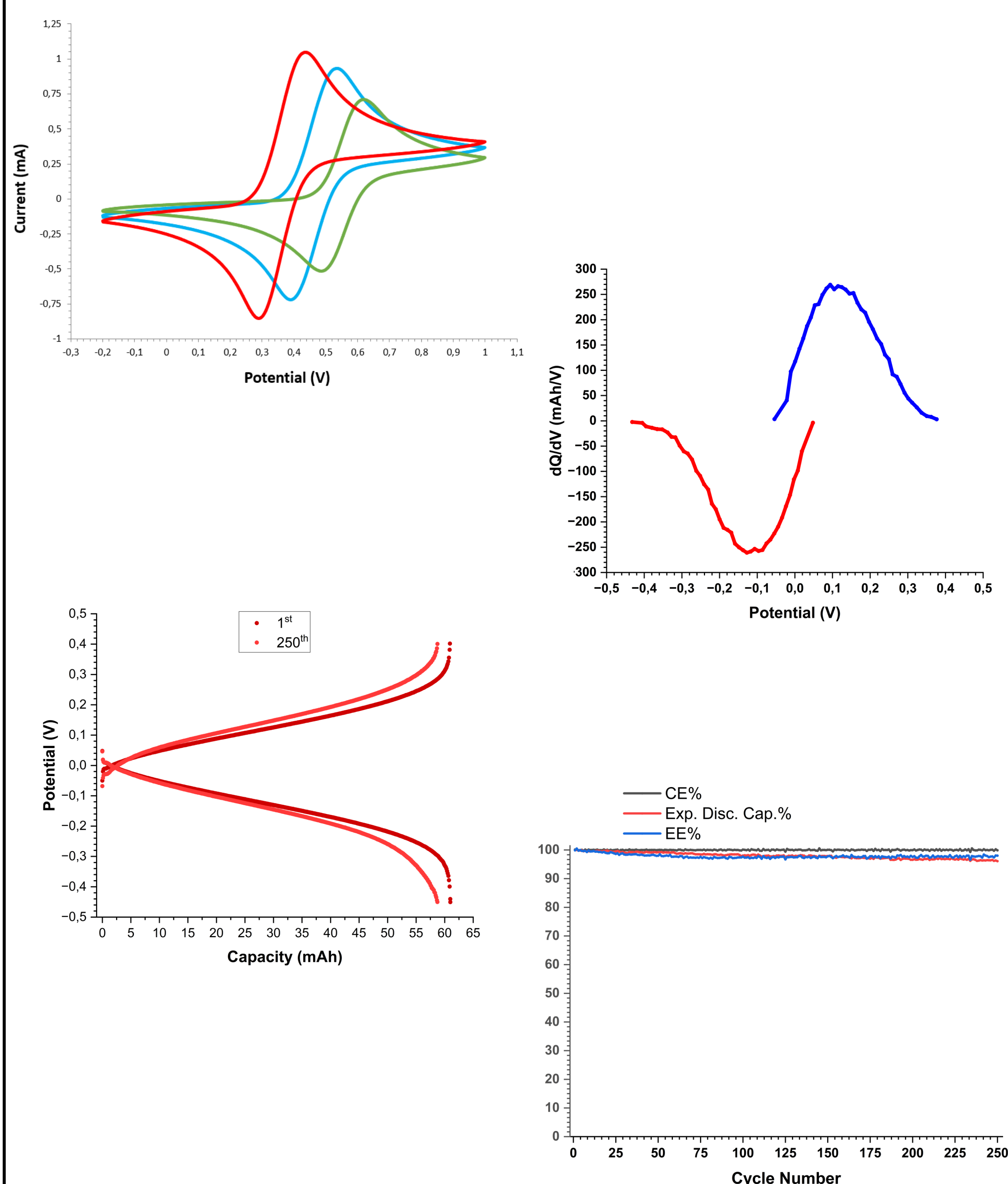


Abstract

In this study, potential extensions in ferrocyanide-based aqueous flow batteries was explored and conducted comprehensive electrochemical examinations of the resulting systems. Our experiments revealed that in acidic media, the ferrocyanide structure undergoes protonation, leading to the formation of an isocyanide structure without the release of free cyanide. This transformation resulted in a notable potential shift, and the new protonated specie was identified using ^{13}C -NMR spectroscopy. The flow cell experiments focused on the charging and discharging operations, demonstrating that the chemical structure of the formed isocyanide complex exhibited stable properties and excellent cyclability. These findings suggest that the isocyanide structure could significantly enhance the performance and stability of ferrocyanide-based aqueous flow batteries. The stable and cyclable nature of this isocyanide complex indicates its potential for improving the efficiency and longevity of these batteries, making them more viable for practical high-potential battery applications. This research provides valuable insights into the chemical behavior of ferrocyanide in acidic media without deforming and opens up new avenues for the development of advanced energy storage systems.

Results

Symmetric Battery



vs 2,7-AQDS

