Reliability Study of Vanadium Redox Flow Batteries by Superior Stable DHE

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Introduction: To fundamentally understand the reliability and degradation mechanism is becoming a critical topic for large scaled energy storage systems in smart grid integration application. As a highly promising candidate for stationary energy storage, redox flow batteries (RFB) are mostly studied in a full cell with simply monitoring the cell voltage and current in varied operation conditions. Studies indicate that contributions from individual electrodes are hard to be separated especially for long-term cycling testing due to the lack of a stable reference electrode in RFB, however, it is in high demand and vital for the mechanistic investigation of RFB reliability.

Objectives and Approaches:
- Stable reference electrode development to decouple the cathode and anode during long-term testing of VRFB;
- Accelerated stressor lifetime testing (ASLT) protocol development for VRFB;
- Fundamental understanding of degradation mechanism of VRFB component and system.

Results and Discussion:

a) Dynamic hydrogen electrode (DHE) based reference electrode development
- Optimized design with adjustable resistor
- Sandwich between laminated membranes
- Validated resistor effect on the stability of DHE

b) In-situ monitoring single electrode potential for 100 cycles by extraordinarily stable DHE reference electrode

Summary and Perspective:
- A DHE based reference electrode has been developed for VRFB, which demonstrates a superior long-term stability by optimized design with adjustable resistor;
- In-situ monitoring single electrode potential has been achieved by the extraordinarily stable DHE throughout 100 cycles of cell charging-discharging;
- By DHE approach, the full cell performance decay (such as capacity, overpotential and impedance distribution) during long-term cycling is dissected into individual electrodes;
- The newly developed DHE approach in scaled commercial VRFB is under validation.

Future Work:
- Single or multi-stressors (including temperature, current density, SOC, DOD and anolyte and catholyte starvation) will be studied to accelerate the VRFB decay;
- ASLT protocol will be established and validated for VRFB with stressor selection;
- VRFB degradation mechanism will be identified by ASLT results.

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