HIGH-CAPACITY REDOX FLOW BATTERY

IITM Technology Available for Licensing

Problem Statement

- The adoption of **renewable energy** sources like solar and wind is increasing, but their **intermittent nature** makes **reliable electricity storage and delivery** over long periods a significant challenge.
- **Redox flow batteries (RFBs) using quinone-based aqueous electrolytes**, particularly those with 2,6-dihydroxyanthraquinone (2,6-DHAQ) and potassium salt of iron hexacyanide ($K_4[Fe(CN)_6]$), **suffer from low capacity and high decay rates**, limiting their effectiveness for long-duration storage.
- Previous studies have shown that **capacity loss in these RFBs is caused by degradation mechanisms** such as dimer formation or hydrogen bonding, leading to irreversible changes in the anolyte and catholyte that **reduce performance over time.**
- There is a **need for a redox flow battery with high capacity and a low decay rate**, improving longevity and increasing the number of charge-discharge cycles, thus making it more suitable for reliable long-duration storage of renewable energy. This patent provides an easy route to achieve high capacity

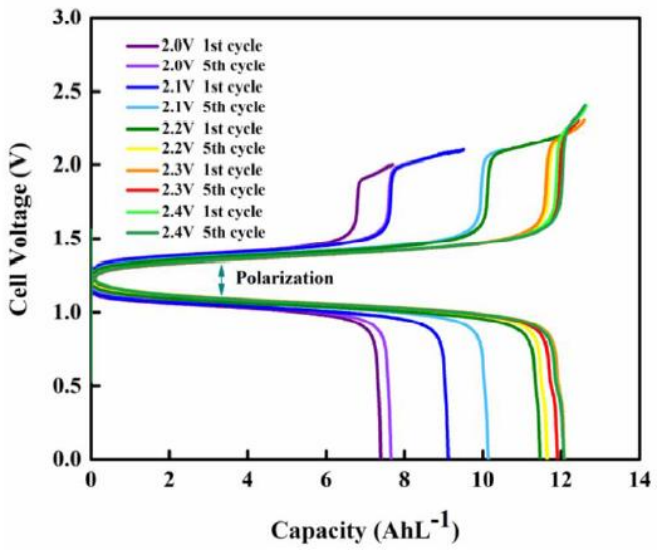

Figure: Charge discharge profile with different charging cutoff voltage 2.0 V to 2.4 V for the system 0.25 M 2,6-DHAQ and 0.5 M $K_4[Fe(CN)_6]$ in 1 M KOH at a current density of 80 $mAcm^{-2}$. The increase in capacity with cutoff voltage is attributed to the reduction of peroxo species

Intellectual Property

- IITM IDF Ref 2476
- **IN 553775 Patent Granted**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Energy, Energy Storage & Renewable Energy

Industry Classification:

NIC(2008)- 2720- Manufacture of batteries and accumulators

NAICS(2022)- 33591 Battery Manufacturing

Applications:

Manufacturing of Batteries for grid energy storage; Peak Shaving and Load Leveling; Battery Storage for Evs; Uninterruptible Power Supply (UPS); Microgrid Energy Storage; Energy Storage for Remote Communities; Long Duration Energy Storage (LDES); Energy Storage for Telecommunications and Data Centers

Market report:

The global Redox Flow Battery Market size was valued at USD 243.06 million in 2023 and is projected to grow to USD 1.71 billion by 2036, with a CAGR of 16.2%

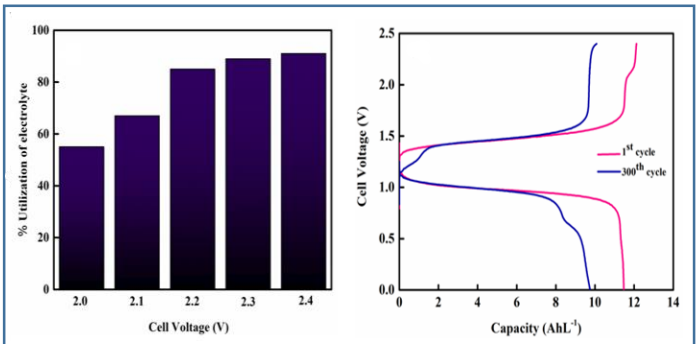

Figure: (a) Percentage of utilization of electrolyte at different charging cutoff voltage for first cycle; **(b)** Galvanostatic charge-discharge profile of 0.25 M anolyte in 1 M KOH at current density of 80 mA cm^{-2} for 1st and 300th cycle

Research Lab

Prof. Kothandaraman Ramanujan
Dept. of Chemistry

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
tto-mktg@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 8369

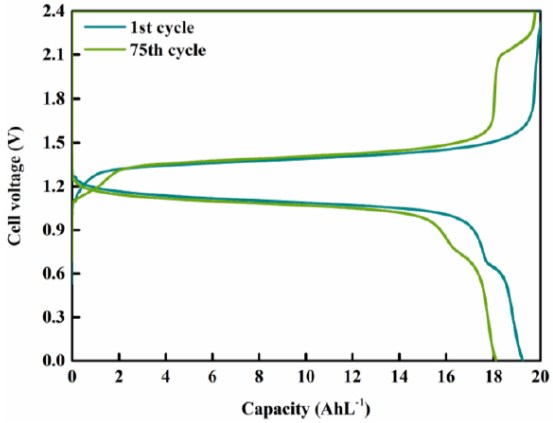

Figure: Galvanostatic charge-discharge profile of 0.45 M anolyte in 1 M KOH at current density of 80 mA cm^{-2} for 1st cycle and 75th cycle.

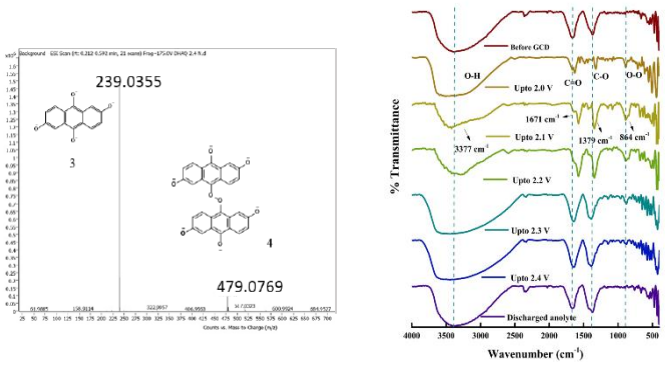

Figure: In order to confirm the presence of peroxo species (or dimer), HRMS and FT-IR measurements were done. A peak at around m/z value of 479.0769 in HRMS confirms the formation of dimer, where as a peak at 864 cm-1 in FT-IR shows the formation of dimer via peroxo linkage.

Technology

The invention involves increasing the charging cutoff voltage above conventional limits (more than 1.5 V, typically in the range of 2.0-2.4 V) to improve the performance of the anolyte in RFBs, specifically for 2,6-DHAQ.

At higher voltages, the peroxo species (dimer 4) formed during the reduction of DHAQ is converted into the tetra-anion (3), which is electroactive and capable of storing more energy during charging.

By adjusting the charging voltage, the capacity decay of the anolyte is minimized, and long-term cycling stability is achieved, with performance sustained even after 300 charge-discharge cycles.

The higher charging cutoff voltage results in a significantly higher percentage of the theoretical capacity being utilized (e.g., 91% at 2.4 V), leading to better overall battery performance.

The invention ensures that the anolyte remains stable throughout many charge/discharge cycles, with minimal degradation, and provides high capacity and low decay rate in the resulting RFB system, making it highly efficient for long-term use.

Key Features / Value Proposition

- When compared to literature data, the conditions were optimized in the invention to obtain higher capacity i.e., 12 Ah L^{-1} and lower the decay rate to 2.5% per day at 0.25 M concentration of anolyte.
- The system's decay rate is only 2.5% per day, outperforming systems with decay rates up to 8% per day
- The invented cell was assembled with higher concentration of $DHAQ^{2-}$ (0.45 M) and demonstrated a discharge capacity of up to ~20 Ah L^{-1}
- Aqueous alkali (KOH) ensures stable, safe, and non-toxic electrolytes, unlike other systems with more corrosive or hazardous materials.
- Robust testing with CV, NMR, IR, and EPR ensures stable performance and verifies no electrolyte crossover or anolyte degradation, making it more reliable than prior technologies under real-world cycling conditions.
- The system's decay rate is only 2.5% per day, outperforming systems with decay rates up to 8% per day.
- By optimizing charging cutoff voltage, the system achieves up to 19 Ah L^{-1}, comparable to conventional VRFB systems.

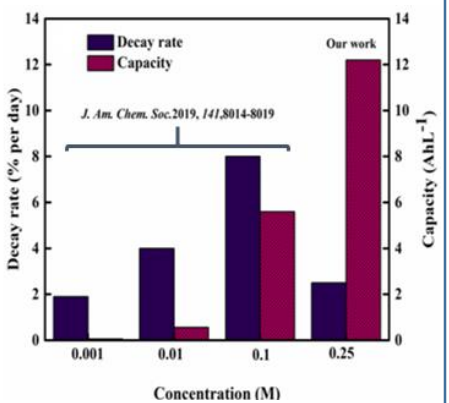

Figure: Dependence of decay rate and discharge capacity of first cycle with concentration of anolyte comparison with literature data.

CONTACT US
Dr. Dara Ajay, Head TTO
Technology Transfer Office,
IPM Cell- IC&SR, IIT Madras

IITM TTO Website:
https://ipm.icsr.in/ipm/

Email: headtto-icsr@icsrpis.iitm.ac.in
tto-mktg@icsrpis.iitm.ac.in
Phone: +91-44-2257 9756/ 8369