Fully Antioxidant Redox Flow Battery

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Overview

Flow batteries are one option for future, low-cost stationary energy storage. We present a perspective overview of the potential cost of organic active materials for aqueous flow batteries based on a comprehensive mathematical mo. Flow batteries are one option for future, low-cost stationary energy storage. We present a perspective overview of the potential cost of organic active materials for aqueous flow batteries based on a comprehensive mathematical model. The battery capital costs for 38 different organic active materials, as well as the state-of-the-art vanadium system.

With an increasing focus on renewable energy resources, the search for economic stationary energy storage systems is more important than ever1,2. One promising electrochemical storage technology is the redox flow battery (RFB) in which the charge carriers are stored in liquid electrolytes and pumped through an electrochemical cell referred to as flow cell. This open cell architecture allows to decouple the place of the electrochemical reaction from the place where the energy is stored; peak power and capacity can be scaled independently from each other3. Thus, RFBs are very versatile and can be applied in different ranges of applications4. Additionally, in the case where aqueous electrolytes are applied, safety concerns are low in comparison to other energy storage systems like the lithium-ion batter.

Based on the model described in the section Method we calculated the capital costs of 38 organic active materials. In the following, we present the obtained results and break down the individual factors that contribute to the overall costs of an RFB with the respective active material class.To adjust for possible changes in costs due to possible optimization states of the RFB system, we discuss the results for both the AqORFB and the VRFB by means of two self-defined scenarios (cf. Table 1), with: (a) “Present Case”, using state-of-the-art values as reported in literature or given by industry/companies. This choice implies that we apply an estimated material price at the present moment given by literature. The Nafion membrane is selected as separator material. Further semipermeable material.

The calculations for our study are based on a model proposed by Brushett et al.14, a further developed TE model by Dmello et al.35, which is an extension of the approach by Darling et al.36. Additionally, we combine the aforementioned studies with reasonable assumptions for the size and costs of redox flow stack components by Minke et al.5,37. Furthermore, we extend the TE model approach with a more detailed polarization model that incorporates kinetic as well as transport phenomena to account for individual differences in the physico-chemical properties of the active material. This section provides an overview of the calculation model used in our study. For an in-depth description, we refer the reader to section 1 in Supplementary Information.We.

All data generated in this study are included in the manuscript and Supplementary Information file. Source data are provided in this paper.

What are aqueous organic redox flow batteries?

Recently, aqueous organic redox flow batteries (AORFBs), utilizing water-soluble organic molecules as redox-active species, have garnered widespread attention [8, 9]. The conversion between electrical and chemical energy in organic molecules often involves electron transfer at active centers such as oxygen, nitrogen, sulfur, or radicals, etc.

Can organic redox-active materials be used for Advanced Flow batteries?

Organic redox-active materials offer a new opportunity for the construction of advanced flow batteries due to their advantages of potentially low cost, extensive structural diversity, tunable electrochemical properties, and high natural abundance.

Can redox flow batteries be used for energy storage?

Ye, R. et al. Redox flow batteries for energy storage: a technology review. J. Electrochem. Energy Convers. Storage 15, 10801–10802 (2018). Gregory, T. D., Perry, M. L. & Albertus, P. Cost and price projections of synthetic active materials for redox flow batteries. J. Power Sources 499, 229965 (2021).

Can redox flow batteries be membrane-free?

Nonaqueous redox flow batteries face challenges like costly membranes and unstable electrolytes. Here, authors develop a membrane-free battery using a polypropylene carbonate gel polymer electrolyte with Li anode and Tri-TEMPO catholyte, achieving a high voltage of 3.45 V, capacity retention of 96.8%, and efficiency of 98.4%.

Fully Antioxidant Redox Flow Battery

[Redox Flow Batteries: Fundamentals and ...]

Sep 6, 2017 · A redox flow battery is an electrochemical energy storage device that converts chemical energy into electrical energy through ...

Redox Flow Battery

The main difference with conventional batteries is that the energy and power of the redox-flow battery are fully independent: the energy is related to the electrolyte volume (tank size) and the ...

[Progress and prospects of pH-neutral aqueous organic redox flow]

Sep 1, 2024 · Aqueous organic redox flow batteries (AORFBs), which exploit the reversible electrochemical reactions of water-soluble organic electrolytes to store electricity, have ...

[Redox flow batteries for energy storage: their promise, ...]

Aug 1, 2019 · The deployment of redox flow batteries (RFBs) has grown steadily due to their versatility, increasing standardisation and recent grid-level energy storage installations [1]. In ...

[Towards a high efficiency and low-cost aqueous redox flow battery...]

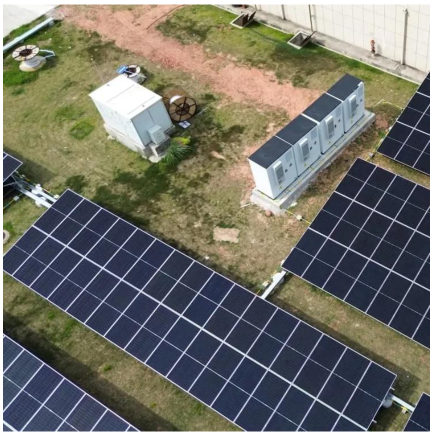
May 1, 2024 · The aqueous redox flow battery (ARFB), a promising large-scale energy storage technology, has been widely researched and developed in both academic and industry over ...

[Membraneless-architectured redox flow batteries]

Nov 1, 2025 · This comprehensive review critically explores the latest advancements and innovative strategies in the development of membraneless architectures for redox flow ...

[Aqueous Organic Redox-Targeting Flow Batteries with ...]

Nov 5, 2023 · Aqueous organic redox flow batteries (AORFBs) represent innovative and sustainable systems featuring decoupled energy capacity and power density; storing energy ...



[Aqueous Organic Redox Flow Batteries , SpringerLink]

Among them, redox flow battery (RFB) is a new electrochemical energy storage technology with the unique structure proposed by Thaller [10]. It can store and release energy through the ...

[Aqueous Organic Redox-Targeting Flow ...]

Nov 5, 2023 · Aqueous organic redox flow batteries (AORFBs) represent innovative and sustainable systems featuring decoupled energy capacity ...

[Benchmarking organic active materials for aqueous redox flow ...]

Oct 21, 2023 · To guide research and implementation of aqueous organic redox flow batteries it is essential to estimate their potential costs. In this perspective, the authors present an overview ...

[A Triphasic Membrane-Free Redox Flow Battery in a Total ...]

Nov 28, 2024 · The membrane-free redox flow battery (RFB) represents an innovative design philosophy that encompasses reduced costs, flexible design schemes, and enhanced overall ...

[Long-Life Aqueous Organic Redox Flow ...]

Jul 25, 2022 · Highly ion-selective robust membranes are developed from a series of amidoxime-functionalized Polymers of Intrinsic Microporosity ...

[Long-Life Aqueous Organic Redox Flow Batteries Enabled by ...]

Jul 25, 2022 · Highly ion-selective robust membranes are developed from a series of amidoxime-functionalized Polymers of Intrinsic Microporosity (AO-PIMs), which enable long lifetime ...

[Reversible Reduction of the TEMPO Radical: ...]

Dec 2, 2020 · Nitroxide radicals are considered as ideal redox species in all-organic redox flow batteries due to their redox potential of ~2 V. These ...

[A Triphasic Membrane-Free Redox Flow ...]

Nov 28, 2024 · The membrane-free redox flow battery (RFB) represents an innovative design philosophy that encompasses reduced costs, flexible ...

Prospective life cycle assessment of organic redox flow ...

Abstract Redox flow batteries (RFBs) are considered a promising technology for stationary energy storage. Organic redox flow batteries (OFBs) are emerging as alternatives to vanadium redox ...

Development of organic redox-active materials in aqueous flow ...

Mar 20, 2023 · Aqueous redox flow batteries, by using redox-active molecules dissolved in nonflammable water solutions as electrolytes, are a promising technology for grid-scale energy ...

Perspectives on aqueous organic redox flow batteries

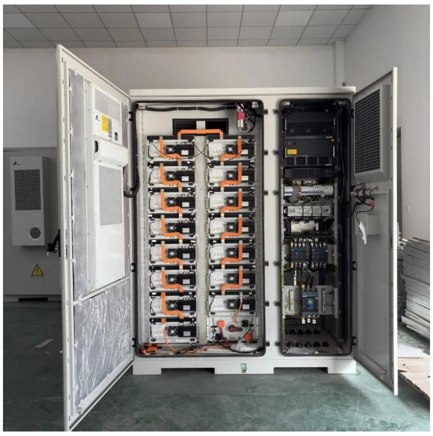
Nov 1, 2024 · Recently, aqueous organic redox flow batteries (AORFBs), utilizing water-soluble organic molecules as redox-active species, have garnered widespread attention [8, 9]. The ...

Redox Flow Battery

10.17.3 Redox flow batteries The redox flow batteries are flow batteries that employ two fully soluble redox couple solutions in each half-cell. Unlike the Zn/Br flow battery, the redox flow ...

[Reduced Flow Battery Capacity Fade from Mixed Redox ...]

Jul 30, 2025 · Abstract Aqueous organic redox flow batteries offer a sustainable approach to long-duration energy storage but suffer from molecular degradation. Here, we present a mixed ...



[Prospective life cycle assessment of organic ...]

Abstract Redox flow batteries (RFBs) are considered a promising technology for stationary energy storage. Organic redox flow batteries (OFBs) are ...

[Membrane-free redox flow battery with polymer electrolytes]

Oct 3, 2025 · Nonaqueous redox flow batteries face challenges like costly membranes and unstable electrolytes. Here, authors develop a membrane-free battery using a polypropylene ...

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