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1. Recent progress of sulfide electrolytes for all-solid-state lithium batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Solid electrolytes are recognized as being pivotal to next-generation energy storage technologies. Sulfide electrolytes with high ionic conductivity represent some of the most promising materials to realize high-energy-density all-solid-state lithium batteries. Due to their soft nature, sulfides possess good wettability against Li metal and their preparation process is relatively effortless. High cell-level sulfide-based all-solid-state lithium batteries have gradually been realized in recent years. However, there are still several disadvantages that sulfide electrolytes need to overcome, including their sensitivity to humid air and instability to electrodes. Herein, the recent progress for sulfide electrolytes, with particular attention given to electrolyte synthesis mechanisms, electrochemical and chemical stability, interphase stabilization and all-solid-state lithium batteries with high cell-level energy density, is presented.

Keywords: Sulfide electrolytes, electrochemical stability, interphase stabilization, all-solid-state lithium batteries

2. Multi-dimensional correlation of layered Li-rich Mn-based cathode materials

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Lithium-rich manganese-based cathode materials are expected to promote the commercialization of lithium-ion batteries to a new stage by virtue of their ultrahigh specific capacity and energy density advantages. However, they are still restricted by complex phase transitions and electrochemical performance degradation caused by labile anion charge compensation. A deep understanding of the electrochemical properties contained in their intrinsic structures and the key driving factors of structural deterioration during cycling are crucial to guide the preparation and optimization of lithium-rich materials. Considering recent progress, this review introduces the intrinsic properties of Li-rich manganese-based cathode materials from interatomic interactions to particle morphology at multiple scales in the spatial dimension. The charge compensation mechanism and energy band reorganization of the initial charge and discharge, the structural evolution during cycling and the electrochemical reaction kinetics of the materials are analyzed in the temporal dimension. Based on the relationship between structure and electrochemical performance, preparation methods and modification methods are introduced to guide and design cathode materials. Effective characterization methods for studying anion charge compensation behavior are also demonstrated. This review provides important guidance and suggestions for making full use of the high specific capacity in these materials derived from anion redox and the maintaining of its stability.

Keywords: Li-ion batteries, Li-rich Mn-based cathodes, anion redox, structure-activity relationships, multiple dimensions

3. Recent advances in photocatalytic renewable energy production

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Chen X, Zhao J, Li G, Zhang D, Li H. Recent advances in photocatalytic renewable energy production. *Energy Mater* 2022;2:200001. <http://dx.doi.org/10.20517/energymater.2021.24>

Abstract

The development of green and renewable energy is becoming increasingly more important in reducing environmental pollution and controlling CO₂ discharge. Photocatalysis can be utilized to directly convert solar energy into chemical energy to achieve both the conversion and storage of solar energy. On this basis, photocatalysis is considered to be a prospective technology to resolve the current issues of energy supply and environmental pollution. Recently, several significant achievements in semiconductor-based photocatalytic renewable energy production have been reported. This review presents the recent advances in photocatalytic renewable energy production over the last three years by summarizing the typical and significant semiconductor-based and semiconductor-like photocatalysts for H₂ production, CO₂ conversion and H₂O₂ production. These reactions demonstrate how the basic principles of photocatalysis can be exploited for renewable energy production. Finally, we conclude our review of photocatalytic renewable energy production and provide an outlook for future related research.

Keywords: Photocatalysis, solar energy conversion, renewable energy, semiconductors

4. Evaluation of the electrochemical and expansion performances of the Sn-Si/graphite composite electrode for the industrial use

Article [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

The future development of lithium-ion batteries for electric vehicles requires significantly higher energy density and this is largely dependent on the application of novel active materials with high specific capacity. Recently, Sn-Si hybrid materials have been shown to exhibit both high specific capacity and good cycle stability. In practice, Sn-Si materials are mixed with graphite to form composite anodes to further improve the stability. However, detailed investigations of Sn-Si/graphite anodes are scarce. This study examines the electrochemical and expansion performance of Sn-Si/graphite anodes and features a morphological, structural and chemical analysis. The percolation and lattice expansion models are shown to fit well for the capacity and expansion evolution law of the composite anodes, respectively, as a function of Sn-Si hybrid content. Based on a comparison with a conventional graphite anode, efficient Sn-Si/graphite composite anodes could be formed that achieve a high reversible capacity (450 mAh g⁻¹), a promising 1st Coulombic efficiency (75%) and stable cycling (cycling coulombic efficiency > 98%), thereby making them some of the most promising Sn-based anodes for industrial applications.

Keywords: Lithium-ion batteries, Sn-Si-C composite anode, anode expansion modelling, capacity retention modelling, industrial application

5. Perspective of polymer-based solid-state Li-S batteries

Perspective [Full-Text](#) [PDF](#) [RIS](#)

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based solid-state Li-S batteries. *Energy Mater* 2022;2:200003.
<http://dx.doi.org/10.20517/energymater.2021.25>

Abstract

Li-S batteries, as the most promising post Li-ion technology, have been intensively investigated for more than a decade. Although most previous studies have focused on liquid systems, solid electrolytes, particularly all-solid-state polymer electrolytes (ASSPEs) and quasi-solid-state polymer electrolyte (QSSPEs), are appealing for Li-S cells due to their excellent flexibility and mechanical stability. Such Li-S batteries not only provide significantly improved safety but are also expected to augment the all-inclusive energy density compared to liquid systems. Therefore, this perspective briefly summarizes the recent progress on polymer-based solid-state Li-S batteries, with a special focus on electrolytes, including ASSPEs and QSSPEs. Furthermore, future work is proposed based on the existing development and current challenges.

Keywords: Solid-state Li-S batteries, polymer electrolytes, quasi-solid-state polymer electrolyte, energy-density estimations

6. Nanoscale redox reaction unlocking the next-generation low temperature fuel cell

Research Highlight [Full-Text PDF RIS](#)

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<http://dx.doi.org/10.20517/energymater.2021.26>

7. Atomistic engineering of Ag/Pt nanoclusters for remarkably boosted mass electrocatalytic activity

Communication [Full-Text PDF RIS](#)

Copy here to cite this article: Liu L, Zhu QY, Li J, Chen J, Huang J, Sun QF, Wen Z. Atomistic engineering of Ag/Pt nanoclusters for remarkably boosted mass electrocatalytic activity. *Energy Mater* 2022;2:200007.
<http://dx.doi.org/10.20517/energymater.2022.03>

Abstract

It is of vital importance to boost the intrinsic activity and augment the active sites of expensive and scarce platinum-based catalysts for advancing a variety of electrochemical energy applications. We herein report a mild electrochemical bottom-up approach to deposit ultrafine, but stable, Pt₈Ag₄ alloy clusters on carbon nanotubes (CNTs) by elaborately designing bimetallic organic cluster precursors with four silver and eight platinum atoms coordinated with μ,σ -bridged ethynylpyridine ligands, i.e., [Ag₄(C₂₄H₁₆N₄Pt)₈(BF₄)₄]. The Pt₈Ag₄ cluster/CNT hybrids present impressively high platinum mass activity that is threefold that of commercial Pt/C toward the hydrogen evolution reaction, as a result of the cooperative contributions from the Ag atoms that enhance the intrinsic activity and the CNT supports that increase the activity sites. The present work affords an attractive avenue for engineering and stabilizing Pt-based nanoclusters at the atomic level and represents a promising strategy for the development of high-efficiency and durable electrocatalysts.

Keywords: Pt₈Ag₄ clusters, electrocatalyst, high mass electrocatalytic activity, hydrogen evolution reaction

8. Two-dimensional nanofluidics for blue energy harvesting

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Blue energy harvesting based on the ion flow obtained from seas and rivers provides a clean, stable and continuous electric output that is highly dependent on ion-selective membranes (ISMs) that conduct single ions. In recent years, ISMs constructed based on two-dimensional (2D) nanofluidics have demonstrated promising application prospects in blue energy harvesting due to their facile fabrication, excellent ion selectivity and high ion flux. In this review, the principles of 2D nanofluidics in regulating ionic transport are firstly proposed and discussed, including ion selectivity and ultrafast ion transmission, which are considered as two critical factors for achieving highly efficient blue energy harvesting. The advantages of 2D nanofluidics towards blue energy harvesting are analyzed to reveal the necessity of this review. The construction of 2D nanofluidic membranes based on several typical materials and their recent research advances in salinity gradient- and pressure-driven blue energy harvesting are also summarized in detail. Finally, the existing challenges of 2D nanofluidic membranes regarding blue energy harvesting applications are discussed to provide new insights for the development of high-performance blue energy harvesting systems based on 2D nanofluidics.

Keywords: Blue energy harvesting, 2D nanofluidics, ion flow, osmotic energy, pressure-driven power generation

9. An overview of aqueous zinc-ion batteries based on conversion-type cathodes

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

The scarcity of lithium resources and the unsafety of organic electrolytes limit the further application of lithium-ion batteries (LIBs) in electric vehicles and grid-scale energy storage. Aqueous zinc-ion batteries (AZIBs) are potential complements for LIBs for large-scale grid energy storage because of their abundant resources, environmental friendliness, intrinsic safety and low cost. However, current AZIBs are mainly based on intercalation-type cathodes and their energy densities are not competitive with LIBs. Fortunately, conversion-type cathodes, with higher specific capacity and lower price, endow AZIBs with excellent potential for practical applications. In this review, the mechanism of energy storage and the progress in developing AZIBs based on conversion-type cathodes are summarized. Perspectives on critical scientific issues and the potential developmental directions of AZIBs are also proposed.

Keywords: Zinc-ion batteries, cathodes, conversion reaction, conductivity, shuttling effect

10. Strained carbon steel as a highly efficient catalyst for seawater electrolysis

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Cao X, Zhang L, Huang K, Zhang B, Wu J, Huang Y. Strained carbon steel as a highly efficient catalyst for seawater electrolysis. *Energy*

Abstract

In response to the global energy crisis, water splitting has become one of the most efficient methods to produce hydrogen as an excellent substitute for fossil fuels. The diffusion coefficient of hydrogen and its interaction with iron have granted carbon steel (CS) the susceptible nature to hydrogen, and therefore CS is considered a promising electrocatalyst in the hydrogen evolution reaction. Compared to many traditional alkaline electrolytes, simulated seawater exhibits reasonable performance that facilitates an effective hydrogen evolution reaction. In the electrolysis of simulated seawater, the lowest overpotential of strained CS samples (-391.08 mV) is comparable to that of Pt plate electrodes (-377.31 mV). This is the result of the plane strain introduced to CS samples by a hydraulic press and indentation, which help to facilitate mass transport through diffusion for hydrogen evolution. The susceptibility of CS is verified by the formation of nanoscale hydrogen blisters that form in the proximity of grain boundaries. These blisters are the result of hydrogen gas pressure that is built up by the absorbed atomic hydrogen. These hydrogen atoms are believed to accumulate along the CS {1 1 0} planes adjacent to grain boundaries. CS has so far not been studied for the catalysis of water splitting. In this study, CS is used as an electrocatalyst for the first time as a cost-effective method for the utilization of seawater that further contributes to the promotion of green energy production.

Keywords: Hydrogen evolution reaction, carbon steel, seawater electrolysis, strain engineering, hydrogen blistering, surface energy

11. Solidification for solid-state lithium batteries with high energy density and long cycle life

Review [Full-Text PDF RIS](#)

Copy here to cite this article: Bi Z, Guo X. Solidification for solid-state lithium batteries with high energy density and long cycle life. *Energy Mater* 2022;2:200011. <http://dx.doi.org/10.20517/energymater.2022.07>

Abstract

Conventional lithium-ion batteries with inflammable organic liquid electrolytes are required to make a breakthrough regarding their bottlenecks of energy density and safety, as demanded by the ever-increasing development of electric vehicles and grids. In this context, solid-state lithium batteries (SSLBs), which replace liquid electrolytes with solid counterparts, have become a popular research topic due to their excellent potential in the realization of improved energy density and safety. However, in practice, the energy density of SSLBs is limited by the cathode mass loading, electrolyte thickness and anode stability. Moreover, the crucial interfacial issues related to the rigid and heterogeneous solid-solid contacts between the electrolytes and electrodes, including inhomogeneous local potential distributions, sluggish ion transport, side reactions, space charge barriers and stability degradation, severely deteriorate the cycle life of SSLBs. Solidification, which converts a liquid into a solid inside a solid battery, represents a powerful tool to overcome the aforementioned obstacles. The liquid precursors fully wet the interfaces and infiltrate the electrodes, followed by in-situ conformal solidification under certain conditions for the all-in-one construction of cells with highly conducting, closely contacted and sustainable electrode/electrolyte interfaces, thereby enabling high energy density and long cycle life. Therefore, in this review, we address the research progress regarding the latest strategies toward the solidification of the electrolyte layers and the interfaces between the electrodes and electrolytes. The critical challenges and future research directions are proposed for the

solidification strategies in SSLBs from both science and engineering perspectives.

Keywords: Solid-state lithium batteries (SSLBs), solid electrolytes, interfaces, solidification, high energy density, long cycle life

12. Design of Zn anode protection materials for mild aqueous Zn-ion batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Zhang Y, Bi S, Niu Z, Zhou W, Xie S. Design of Zn anode protection materials for mild aqueous Zn-ion batteries. *Energy Mater* 2022;2:200012. <http://dx.doi.org/10.20517/energymater.2022.08>

Abstract

Rechargeable aqueous Zn-ion batteries (AZIBs) are considered alternative stationary storage systems for large-scale applications due to their high safety, low cost, and high power density. However, Zn anode issues including dendrite formation and side reactions greatly hinder the practical application of AZIBs. To solve the Zn anode issues, various strategies based on material designs have been developed. It is necessary to analyze and classify these strategies according to different materials, because different properties of materials determine the underlying mechanisms. In this review, we briefly introduce the fundamental issues in Zn anodes. Furthermore, this review highlights the material designs for the protection of Zn anodes in mild AZIBs. Finally, we also offer insight into potential directions in the material designs to promote the development of AZIBs in the future.

Keywords: Material design, Zn anode protection, aqueous Zn-ion battery, dendrites, hydrogen evolution reaction

13. Unraveling the doping mechanisms in lithium iron phosphate

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

As a result of the extensive research and application of LiFePO_4 (LFP) in the past > 20 years, there is now a relatively in-depth understanding of its structural stability, phase transition mechanism and electrochemical properties. However, the difficulties faced by further improving the performance of LFP due to its intrinsic low electronic and ionic conductivity have not yet been effectively solved. In order to unlock the effect of transition metal doping on the physicochemical properties of LFP, we establish doping models for all 3d, 4d and 5d transition metals in LFP and compare and analyze their structural properties, band gaps, formation energies, elastic properties, anisotropies and lithiation/delithiation voltages using ab-initio computational screening. According to our screening results, the V-, Mn-, Ni-, Rh- and Os-doped LFP structures have excellent electrochemical properties and can be used as high-performance cathode materials for Li-ion batteries.

Keywords: LiFePO_4 , doping, computational screening, stability, cathode materials, lithium-ion batteries

14. Electroactive organics as promising anode materials for rechargeable lithium ion and sodium ion batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

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Electroactive organics as promising anode materials for rechargeable lithium ion and sodium ion batteries. *Energy Mater* 2022;2:200014.
<http://dx.doi.org/10.20517/energymater.2022.11>

Abstract

Electroactive organics have attracted significant attention as electrode materials for next-generation rechargeable batteries because of their structural diversity, molecular adjustability, abundance, flexibility, environmental friendliness and low cost. To date, a large number of organic materials have been applied in a variety of energy storage devices. However, the inherent problems of organic materials, such as their dissolution in electrolytes and low electronic conductivity, have restricted the development of organic electrodes. In order to solve these problems, many groups have carried out research and remarkable progress has been made. Nevertheless, most reviews of organic electrodes have focused on the positive electrode rather than the negative electrode. This review first provides an overview of the recent work on organic anodes for Li- and Na-ion batteries. Six categories of organic anodes are summarized and discussed. Many of the key factors that influence the electrochemical performance of organic anodes are highlighted and their prospects and remaining challenges are evaluated.

Keywords: Rechargeable batteries, organic anode materials, energy storage mechanism, structural regulation

15. Carbon-supported single-atom catalysts for advanced rechargeable metal-air batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Xia Q, Zhai Y, Zhao L, Wang J, Li D, Zhang L, Zhang J. Carbon-supported single-atom catalysts for advanced rechargeable metal-air batteries. *Energy Mater* 2022;2:200015.
<http://dx.doi.org/10.20517/energymater.2022.13>

Abstract

To address the fossil energy crisis and environmental problems, the urgent demand for clean energy has promoted the rapid development of advanced rechargeable metal-air batteries based on the redox reaction couples of gases, such as the oxygen reduction, oxygen evolution, carbon dioxide reduction and carbon dioxide evolution reactions. High-efficiency electrocatalysts are highly desirable to enhance the conversion efficiency of these reactions for enhancing battery performance. Significant advances in single-atom catalysts (SACs) on carbon matrices have been witnessed in recent years as attractive and unique systems to improve the electrocatalytic activities for high-performance rechargeable Zn- and Li-air batteries. This review summarizes the latest achievements in the applications of carbon-supported SACs in metal-air batteries, with a particular focus on the rational design of SACs and their fundamental electrocatalytic mechanism at the atomic level. The future development and perspectives of SACs in the field of metal-air batteries are also discussed.

Keywords: Single-atom catalysts, carbon supports, electrodes, electrocatalysis, Zn- and Li-air batteries

16. Accelerating perovskite materials discovery and correlated energy applications through artificial intelligence

Review [Full-Text](#) [PDF](#) [RIS](#)

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applications through artificial intelligence. *Energy Mater* 2022;2:200016.
<http://dx.doi.org/10.20517/energymater.2022.14>

Abstract

Perovskites are promising materials applied in new energy devices, from solar cells to battery electrodes. Under traditional experimental conditions in laboratories, the performance improvement of new energy devices is slow and limited. Artificial intelligence (AI) has recently drawn much attention in material properties prediction and new functional materials exploration. With the advent of the AI era, the methods of studying perovskites have been upgraded, thereby benefiting the energy industry. In this review, we summarize the application of AI in perovskite discovery and synthesis and its positive influence on new energy research. First, we list the advantages of AI in perovskite research and the steps of AI application in perovskite discovery, including data availability, the selection of training algorithms, and the interpretation of results. Second, we introduce a new synthesis method with high efficiency in cloud labs and explain how this platform can assist perovskite discovery. We review the use of perovskites in energy applications and illustrate that the efficiency of energy production in these fields can be significantly boosted due to the use of AI in the development process. This review aims to provide the future application prospects of AI in perovskite research and new energy generation.

Keywords: Perovskite solar cells, machine learning, artificial intelligence, new perovskite prediction, accelerated synthesis

17. Recent progress and perspective of multifunctional integrated zinc-ion supercapacitors

Mini Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Li Y, Yang W, Han L, Li H, Wen Z, Li Y, Wang X, Sun H, Lu T, Xu M, Pan L. Recent progress and perspective of multifunctional integrated zinc-ion supercapacitors. *Energy Mater* 2022;2:200018.
<http://dx.doi.org/10.20517/energymater.2022.15>

Abstract

Zinc-ion supercapacitors (ZISCs) are recognized as one of the most promising types of energy storage devices with the advantages of high theoretical capacity and safety, nontoxicity, low cost, abundant resources (~300 times higher than lithium), and lightweight. So far, multifunctional integrated ZISCs have greatly broadened their application scenarios. In addition to enhancing the electrochemical performance via the design of advanced electrodes and electrolytes, the complex application scenarios and in-depth development of energy storage devices have resulted in higher requirements for ZISCs with multifunctional integrated applications. However, to the best of our knowledge, there is no relevant review about summarizing advanced multifunctional ZISCs. In this review, various advanced multifunctional ZISCs, including micro, self-powered integrated, antifreezing, and stretchable ZISCs, are comprehensively presented to fully understand the advanced evolution of multifunctional ZISCs. The working principles and challenges of ZISCs are analyzed and the future development directions and expectations of advanced multifunctional ZISCs are discussed. This review provides significant guidance for the multifunctional development of ZISCs for future studies.

Keywords: Zinc-ion supercapacitors, energy storage devices, multifunctional integrated applications

18. A bimetallic-activated MnO₂ self-assembly electrode with a dual heterojunction structure for high-performance rechargeable zinc-air batteries

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Yin Z, He R, Xue H, Chen J, Wang Y, Ye X, Xu N, Qiao J, Huang H. A bimetallic-activated MnO₂ self-assembly electrode with a dual heterojunction structure for high-performance rechargeable zinc-air batteries. *Energy Mater* 2022;2:200021. <http://dx.doi.org/10.20517/energymater.2022.17>

Abstract

A major challenge in developing zinc-air batteries (ZABs) is to exploit suitable cathodes to efficiently accelerate the key electrocatalytic processes involved. Herein, a bifunctional oxygen catalytic self-supported MnO₂-based electrode is designed that displays superior oxygen reduction and evolution reaction performance over noble metal electrodes with a total overpotential of 0.69 V. In addition, the as-synthesized NiCo₂O₄@MnO₂/carbon nanotube (CNT)-Ni foam self-supported electrode can be directly used as an oxygen electrode without externally adding carbon or a binder and shows reasonable battery performance with a high peak power density of 226 mW cm⁻² and a long-term charge-discharge cycling lifetime (5 mA for 160 h). As expected, the rapid oxygen catalytic intrinsic kinetics and high battery performance of the NiCo₂O₄@MnO₂/CNTs-Ni foam electrode originates from the unique three-dimensional hierarchical structure, which effectively promotes mass transfer. Furthermore, the CNTs combined with Ni foam form a unique “meridian” conductive structure that enables rapid electron conduction. Finally, the abundant Mn³⁺ active sites activated by bimetallic ions shorten the oxygen catalytic reaction distance between the active sites and reactant and reduce the surface activity of MnO₂ for the O, OH, and OOH species. This work not only offers a high-performance bifunctional self-supported electrode for ZABs but also opens new insights into the activation of Mn-based electrodes.

Keywords: Zinc-air batteries, bimetallic activation, self-supported electrode, heterojunction, hierarchical structure

19. Research progress on the surface/interface modification of high-voltage lithium oxide cathode materials

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Lithium oxides are the most promising cathode candidates for high-performance lithium-ion batteries (LIBs), owing to their high theoretical capacity and average working voltage, which are conducive to achieving the ultimate goal of upgrading energy density. By raising the upper limit of the cutoff voltage, we may be able to further improve both the practical capacity and average voltage of lithium oxide cathodes. Unfortunately, the high-voltage operation of these cathodes results in significant challenges, namely, reduced surface structural stability and interfacial stability with electrolytes, thus degrading the electrochemical performance. Accordingly, surface/interface modification strategies, including surface coating, electrolyte regulation, binder design, and special surface treatments, are systematically summarized and comprehensively analyzed for high-voltage lithium oxide cathode materials in this review. Furthermore, the corresponding modification mechanisms are

discussed in detail to better grasp the internal mechanisms for the enhanced electrochemical performance. Based on recent progress, we further propose predictable development directions for high-performance LIBs in future practical applications. This review provides new insights into various high-voltage lithium oxide cathodes and their universal surface/interface modification strategies towards advanced next-generation LIBs with high energy and power density and long cycle life.

Keywords: Lithium-ion batteries, oxide cathodes, high-voltage operation, stability, surface/interface modification strategies

20. Dealloying-derived Fe-doped Ni(OH)₂/Ni foils as self-supported oxygen evolution reaction catalysts

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Abstract

Dealloying has been an essential technique for developing nanostructured catalysts for the oxygen evolution reaction (OER). Self-supported active catalysts can be fabricated through an alloying-dealloying process on metal foil surfaces. This study uses a Ga-assisted alloying-dealloying strategy combined with electrooxidation and heteroatom doping to fabricate a Fe-doped Ni(OH)₂/Ni self-supported OER catalyst. We find that the surface phase compositions and dealloyed structures can be adjusted by controlling the reaction-diffusion temperature and time. The optimized O-Ni-Fe/200-3 catalyst shows an overpotential of 318 mV to activate a 10 mA cm⁻² current density with a Tafel slope of 60.60 mV dec⁻¹. *Ex-situ* characterization of the catalyst proves that Fe doping promotes the formation of active NiOOH, which contributes to the excellent OER activity. This study extends the Ga-assisted alloying-dealloying strategy and demonstrates the possibility of controlling the microstructure of dealloyed materials by changing the reaction-diffusion conditions.

Keywords: Dealloying, reaction diffusion, oxygen evolution reaction, Ni(OH)₂

21. Predicting a novel two-dimensional BN material with a wide band gap

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Fan Q, Zhou H, Zhao Y, Yun S. Predicting a novel two-dimensional BN material with a wide band gap. *Energy Mater* 2022;2:200022. <http://dx.doi.org/10.20517/energymater.2022.21>

Abstract

Based on density functional theory, a new two-dimensional boron nitride, *Pmma* BN, is proposed and studied in detail for the first time. The stability of *Pmma* BN is demonstrated using phonon spectra, ab initio molecular dynamics simulations at 300 and 500 K, and in-plane elastic constants. The orientation dependences of the Young's modulus and Poisson's ratio show that *Pmma* BN has large mechanical anisotropy. *Pmma* BN is an indirect band gap semiconductor material with a band gap of 5.15 eV and the hole and electron effective masses have high anisotropy. The electron carrier mobilities of *Pmma* BN along the *x* and *y* directions are similar, while the hole carrier mobility along the *y* direction is more than double that along the *x* direction. The band gap of *Pmma* BN remains indirect under the effect of uniaxial tensile strain and its adjustable range reaches 0.64 eV when the uniaxial strain is applied along the *x* direction. When uniaxial strain is applied along the *y* direction, the positions of

the conduction band minimum and valence band maximum change. *Pmma* BN under uniaxial strain shows strong optical absorption capacity in the ultraviolet region. To explore its potential clean energy applications, the thermoelectric properties of *Pmma* BN are also investigated.

Keywords: Two-dimensional boron nitride, band gap engineering, uniaxial strain, thermoelectric properties

22. Recent advances and perspectives of micro-sized alloying-type porous anode materials in high-performance Li- and Na-ion batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Li G, Guo S, Xiang B, Mei S, Zheng Y, Zhang X, Gao B, Chu PK, Huo K. Recent advances and perspectives of micro-sized alloying-type porous anode materials in high-performance Li- and Na-ion batteries. *Energy Mater* 2022;2:200020. <http://dx.doi.org/10.20517/energymater.2022.24>

Abstract

Alloying materials (e.g., Si, Ge, Sn, Sb, and so on) are promising anode materials for next-generation lithium-ion batteries (LIBs) and sodium-ion batteries (SIBs) due to their high capacity, suitable working voltage, earth abundance, environmental friendliness, and non-toxicity. Although some important breakthroughs have been reported recently for these materials, their dramatic volume change during alloying/dealloying causes severe pulverization, leading to poor cycling stability and safety risks. Although the nanoengineering of alloys can mitigate the volumetric expansion to some extent, there remain other drawbacks, such as low initial Columbic efficiency and volumetric energy density. Porous microscale alloys comprised of nanoparticles and nanopores inherit micro- and nanoproperties, so that volume expansion during lithiation/sodiation can be better accommodated by the porous structure to consequently release stress and improve the cycling stability. Herein, the recent progress of porous microscale alloying-type anode materials for LIBs and SIBs is reviewed by summarizing the Li and Na storage mechanisms, the challenges associated with different materials, common fabrication methods, and the relationship between the structure and electrochemical properties in LIBs and SIBs. Finally, the prospects of porous microscale alloys are discussed to provide guidance for future research and the commercial development of anode materials for LIBs and SIBs.

Keywords: Alloy-type materials, micro-sized porous materials, lithium-ion batteries, sodium-ion batteries

23. An interpenetrating network polycarbonate-based composite electrolyte for high-voltage all-solid-state lithium-metal batteries

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Copy here to cite this article: Chen J, Wang C, Wang G, Zhou D, Fan LZ. An interpenetrating network polycarbonate-based composite electrolyte for high-voltage all-solid-state lithium-metal batteries. *Energy Mater* 2022;2:200023. <http://dx.doi.org/10.20517/energymater.2022.25>

Abstract

The exploration of solid polymer-based composite electrolytes (SCPEs) that possess good safety, easy processability, and high ionic conductivity is of great significance for the development of advanced all-solid-state lithium-metal batteries (ASSLMBs). However, the poor interfacial compatibility between the electrode and solid electrolyte leads to a large interfacial impedance that weakens the electrochemical performance of the battery. Herein, an interpenetrating network polycarbonate (INPC)-based composite

electrolyte is constructed via the *in-situ* polymerization of butyl acrylate, $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$ (LLZO), Lithium bis(trifluoromethanesulphonyl)imide, succinonitrile and 2,2-azobisisobutyronitrile on the base of a symmetric polycarbonate monomer. Benefiting from the synergistic effect of each component and the unique structure features, the INPC&LLZO-SCPE can effectively integrate the merits of the polymer and inorganic electrolytes and deliver superior ionic conductivity ($3.56 \times 10^{-4} \text{ S cm}^{-1}$ at 25°C), an impressive Li^+ transference number [$t(\text{Li}^+) = 0.52$] and a high electrochemical stability window (up to 5.0 V vs. Li^+/Li). Based on this, full batteries of $\text{LiFePO}_4/\text{INPC\&LLZO-SCPE}/\text{Li}$ and $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2/\text{INPC \&LLZO-SCPE}/\text{Li}$ are assembled, which exhibit large initial capacities of 156.3 and 158.9 mAh g^{-1} and high capacity retention of 86.8% and 95.4% over 500 and 100 cycles at 0.2 and 0.1 C, respectively. This work offers a new route for the construction of novel polycarbonate-based composite electrolytes for high-voltage ASSLMBs.

Keywords: All-solid-state batteries, composite electrolyte, polycarbonate, interpenetrating network, high voltage

24. Recent advances in earth-abundant first-row transition metal (Fe, Co and Ni)-based electrocatalysts for the oxygen evolution reaction

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Chen X, Liu J, Yuan T, Zhang Z, Song C, Yang S, Gao X, Wang N, Cui L. Recent advances in earth-abundant first-row transition metal (Fe, Co and Ni)-based electrocatalysts for the oxygen evolution reaction. *Energy Mater* 2022;2:200028. <http://dx.doi.org/10.20517/energymater.2022.30>

Abstract

The oxygen evolution reaction (OER) is of fundamental importance as a half reaction and rate-controlling step that plays a predominant function in improving the energy storage and conversion efficiency during the electrochemical water-splitting process. In this review, after briefly introducing the fundamental mechanism of the OER, we systematically summarize the recent research progress for nonprecious-metal-based OER electrocatalysts of representative first-row transition metal (Fe, Co and Ni)-based composite materials. We analyze the effects of the physicochemical properties, including morphologies, structures and compositions, on the integrated performance of these OER electrocatalysts, with the aim of determining the structure-function correlation of the electrocatalysts in the electrochemical reaction process. Furthermore, the prospective development directions of OER electrocatalysts are also illustrated and emphasized. Finally, this mini-review highlights how systematic introductions will accelerate the exploitation of high-efficiency OER electrocatalysts.

Keywords: OER, catalytic mechanism, catalytic performance, first-row transition metal-based electrocatalysts, structure-function correlations

25. Insights into the electrochemical performance of metal fluoride cathodes for lithium batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Ma D, Zhang R, Hu X, Chen Y, Xiao C, He F, Zhang S, Chen J, Hu G. Insights into the electrochemical performance of metal fluoride cathodes for lithium batteries. *Energy Mater* 2022;2:200027.

Abstract

In recent years, energy storage and conversion have become key areas of research to address social and environmental issues, as well as practical applications, such as increasing the storage capacity of portable electronic storage devices. However, current commercial lithium-ion batteries suffer from low specific energy and high cost and toxicity. Conversion-type cathode materials are promising candidates for next-generation Li metal and Li-ion batteries (LIBs). Metal fluoride materials have shown tremendous chemical tailorability and exhibit excellent energy density in LIBs. Batteries based on such electrodes can compete with other envisaged alternatives, such as Li-air and Li-S systems. However, conversion reactions are typically multiphase redox reactions with mass transport phenomena and nucleation and growth processes of new phases along with interfacial reactions. Therefore, these reactions involve nonequilibrium reaction pathways and significant overpotentials during the charge-discharge process. In this review, we summarize the key challenges facing metal fluoride cathode materials and general strategies to overcome them in cells. Different synthesis methods of metal fluorides are also presented and discussed in the context of their application as cathode materials in Li and LIBs. Finally, the current challenges and future opportunities of metal fluorides as electrode materials are emphasized. With continuous rapid improvements in the electrochemical performance of metal fluorides, it is believed that these materials will be used extensively for energy storage in Li batteries in the future.

Keywords: Metal fluorides, cathodes, Li-ion batteries, conversion reaction

26. Challenges and prospects of Mg-air batteries: a review

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Mg-air batteries, with their intrinsic advantages such as high theoretical volumetric energy density, low cost, and environmental friendliness, have attracted tremendous attention for electrical energy storage systems. However, they are still in an early stage of development and suffer from large voltage polarization and poor cycling performance. At present, Mg-air batteries with high rechargeability remain difficult to achieve, mainly because the discharge products [$\text{Mg}(\text{OH})_2$, MgO and MgO_2] are thermodynamically and kinetically difficult to decompose at moderate voltage ranges. Therefore, it is crucial to optimize the reaction paths and kinetics from the electrodes to the batteries via the combination of materials design and first-principles calculations. In this review, remarkable progress is highlighted regarding the currently used materials for Mg-air batteries, including anodes, electrolytes, and cathodes. In addition, the corresponding reaction mechanisms are comprehensively surveyed. Finally, future perspectives for rechargeable Mg-air batteries with decreased voltage polarization and improved cycling performance are also described for further practical applications.

Keywords: Mg-air batteries, rechargeability, anode, electrolyte, cathode, application

27. Lithium molybdate composited with carbon nanofibers as a high-capacity and stable anode material for lithium-ion batteries

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Copy here to cite this article: Wang J, Yao J, Li W, Zhu W, Yang J, Zhao J, Gao L. Lithium molybdate composited with carbon nanofibers as a high-capacity and stable anode material for lithium-ion batteries. *Energy Mater* 2022;2:200026. <http://dx.doi.org/10.20517/energymater.2022.22>

Abstract

Transition metal molybdates have been studied as anode materials for high-performance lithium-ion batteries, owing to their high theoretical capacity and low cost, as well as the multivalent states of molybdenum. However, their electrochemical performance is hindered by poor conductivity and large volume changes during charge and discharge. Here, we report lithium molybdate (Li_2MoO_4) composited with carbon nanofibers ($\text{Li}_2\text{MoO}_4@\text{CNF}$) as an anode material for lithium-ion batteries. Li_2MoO_4 shows a shot-rod nanoparticle morphology that is tightly wound in the fibrous CNF. Compared with bare Li_2MoO_4 , the $\text{Li}_2\text{MoO}_4@\text{CNF}$ composite demonstrates superior high specific capacity and cycling stability, which are attributed to the reversible Li-ion intercalation in the $\text{Li}_x\text{Mo}_y\text{O}_z$ amorphous phase during charge and discharge. The capacity of the $\text{Li}_2\text{MoO}_4@\text{CNF}$ anode material can reach 830 mAh g^{-1} in the second cycle and 760 mAh g^{-1} after 100 cycles at a charge/discharge current density of 100 mA g^{-1} , which is much better than the bare Li_2MoO_4 . This work provides a simple method to prepare a high-capacity and stable lithium molybdate anode material for lithium-ion batteries.

Keywords: Li_2MoO_4 , carbon nanofibers (CNFs), anode material, lithium-ion batteries

28. An azobenzene-based photothermal energy storage system for co-harvesting photon energy and low-grade ambient heat via a photoinduced crystal-to-liquid transition

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Dong L, Zhai F, Wang H, Peng C, Feng Y, Feng W. An azobenzene-based photothermal energy storage system for co-harvesting photon energy and low-grade ambient heat via a photoinduced crystal-to-liquid transition. *Energy Mater* 2022;2:200025. <http://dx.doi.org/10.20517/energymater.2022.26>

Abstract

Ambient heat, slightly above or at room temperature, is a ubiquitous and inexhaustible energy source that has typically been ignored due to difficulties in its utilization. Recent evidence suggests that a class of azobenzene (Azo) photoswitches featuring a reversible photoinduced crystal-to-liquid transition could co-harvest photon energy and ambient heat. Thus, a new horizon has been opened for recovering and regenerating low-grade ambient heat. Here, a series of unilateral para-functionalized photoinduced liquefiable Azo derivatives is presented that can co-harvest and convert photon energy and ambient heat into chemical bond energy and latent heat in molecules and eventually release them

in the form of high-temperature utilizable heat. A straightforward crystalline-to-liquid phase transition achieved with ultraviolet light irradiation (365 nm) is enabled by appending a halogen/alkoxy group on the para-position of the Azo photoswitches, and the release of thermal energy is triggered by short-wavelength visible-light irradiation (420 nm). The phase transition properties of the trans- and cis-isomers and the energy density, storage lifetime and heat release performance of the cis-liquid are investigated with differential scanning calorimetry, ultraviolet-visible absorption spectroscopy, and an infrared (IR) thermal camera. The experimental results indicate a high energy density of 335 J/g, a long lifetime of 5 d and a heat release of up to 6.3 °C due to the coupled photochemical-thermophysical mechanism. This work presents a new model for utilizing renewable energy, i.e., the photoinduced conversion of ambient thermal energy.

Keywords: Azobenzene, photoinduced crystal-to-liquid phase transition, photoisomerization, ambient heat conversion, light energy

29. A low-concentration sulfone electrolyte enables high-voltage chemistry of lithium-ion batteries

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Lv L, Zhang H, Lu D, Yu Y, Qi J, Zhang J, Zhang S, Li R, Deng T, Chen L, Fan X. A low-concentration sulfone electrolyte enables high-voltage chemistry of lithium-ion batteries. *Energy Mater* 2022;2:200030. <http://dx.doi.org/10.20517/energymater.2022.38>

Abstract

Commercial carbonate electrolytes with poor oxidation stability and high flammability limit the operating voltage of Li-ion batteries (LIBs) to ~4.3 V. As one of the most promising candidates for electrolyte solvents, sulfolane (SL) has received significant interest because of its wide electrochemical window, low flammability and high dielectric permittivity. Unfortunately, SL-based electrolytes with normal concentrations cannot achieve highly reversible Li^+ intercalation/deintercalation in graphite anodes due to an ineffective solid electrolyte interface, thus undermining their potential application in LIBs. Here, a low-concentration SL-based electrolyte (LSLE) is developed for high-voltage graphite|| $\text{LiNi}_{0.8}\text{Co}_{0.1}\text{Mn}_{0.1}\text{O}_2$ (NCM811) full cells. A highly reversible graphite anode can be achieved through the preferential decomposition of the dual-salt LiDFOB-LiBF_4 in the LSLE. The addition of fluorobenzene further restrains the decomposition of SL, endowing uniform, robust and inorganic-rich interphases on the electrode surfaces. As a result, the LSLE with improved thermal stability can support the MCMB||NCM811 full cells at 4.4 V, evidenced by an excellent cycling performance with capacity retentions of 83% after 500 cycles at 25 °C and 82% after 400 cycles at 60 °C. We believe that the design of this fluorobenzene-containing LSLE offers an effective routine for next-generation low-cost and safe electrolytes for high-voltage LIBs.

Keywords: Electrolyte, sulfone, fluorobenzene, interphase, lithium-ion batteries (LIBs)

30. ZnO/MgZnO heterostructure membrane with type II band alignment for ceramic fuel cells

Article [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Semiconductor membrane fuel cells are a new promising R&D for solid oxide fuel cells and proton ceramic fuel cells. There is a challenge of the electronic short circuit issue by using semiconductor to replace conventional electrolyte membrane. In this work, type II band alignment of the semiconductor heterostructure based on Mg-doped ZnO and ZnO can, on one hand, block electrons passing through the junction, and on the other hand, trigger the ionic properties of membrane to boost the fuel cell performance. The Mg doping into ZnO creates more oxygen vacancies at the surface of ZnO, leading to enhanced ionic transport, and meaningful fuel cell performance of 673 mW/cm²; while the Mg-doped ZnO/ZnO heterostructure fuel cell has delivered 997 mW/cm² and OCV 1.04 V at 520 °C. It is worth highlighting that the constructed heterostructure interface, especially the band bending and constituted build-in electric field, plays a pivotal role in enhancing the ionic transport and suppressing the electron passing through the internal device. First principal calculations using density functional theory confirmed the doping of Mg and the formation of heterostructure with ZnO to help for enhancing charge carriers and separations. This work suggests that the constructed type II band alignment or the semiconductor heterostructure is useful for developing advanced fuel cells.

Keywords: Type-II semiconductor heterostructure, ZnO/Mg-ZnO, ceramic fuel cells, high ionic conductivity

31. Photo-coupled electrocatalytic oxygen reduction to hydrogen peroxide using metal-free CNT-threaded oxidized g-C₃N₄

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Copy here to cite this article: Zhu Q, Fan J, Tao Y, Shang H, Xu J, Zhang D, Li G, Li H. Photo-coupled electrocatalytic oxygen reduction to hydrogen peroxide using metal-free CNT-threaded oxidized g-C₃N₄. *Energy Mater* 2022;2:200029. <http://dx.doi.org/10.20517/energymater.2022.33>

Abstract

Hydrogen peroxide (H₂O₂) has been widely used in environmental cleaning, hospital disinfecting and chemical engineering. Compared to the traditional anthraquinone oxidation method, the electrocatalytic two-electron oxygen reduction reaction (2e-ORR) to produce H₂O₂ has become a promising alternative due to its green, safety and reliability. However, its industrial application is still limited by the slow reaction kinetics and low selectivity due to the competitive reaction of the 4e-ORR to H₂O. Herein, we prepare a novel photoresponsive metal-free electrocatalyst based on oxidized g-C₃N₄/carbon nanotubes (OCN/CNTs) and introduce an external light field

to realize the high-performance electrocatalytic 2e-ORR to produce H₂O₂. Impressively, the OCN/CNT electrocatalyst exhibits an outstanding H₂O₂ productivity of 30.7 mmol/gcat/h with a high faradaic H₂O₂ efficiency of 95%. The oxygen-containing groups of the OCN/CNTs promote the adsorption of oxygen intermediates and the photo-coupled electrocatalysis simultaneously improves the electron transport efficiency and enhances the electrocatalytic selectivity.

Keywords: Electrocatalytic oxygen reduction reaction (ORR), polymeric carbon nitride, carbon nanotubes, photo-coupled electrocatalysis, H₂O₂ production

32. A cigarette filter-derived nitrogen-doped carbon nanoparticle coating layer for stable Zn-ion battery anodes

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Guo Y, Liu C, Xu L, Huang K, Wu H, Cai W, Zhang Y. A cigarette filter-derived nitrogen-doped carbon nanoparticle coating layer for stable Zn-ion battery anodes. *Energy Mater* 2022;2:200032. <http://dx.doi.org/10.20517/energymater.2022.45>

Abstract

Despite the low cost, safety and high theoretical capacity of metallic zinc, zinc anodes face chronic problems, including zinc dendrites, corrosion and side reactions in aqueous zinc-ion batteries (ZIBs). Herein, a nitrogen-doped carbon nanoparticle coating layer derived from discarded cigarette filters is constructed to suppress parasitic side reactions and zinc dendrite growth. The dense coating layer isolates water from the zinc anode, effectively inhibiting side reactions. Furthermore, the special micro-mesoporous structure and sufficient zincophilic groups guarantee uniform Zn stripping/plating. Consequently, durable cycle stability (2400 cycles at a current density of 1 mA cm⁻²) with a stable polarization potential is achieved for symmetrical cells. The coating layer derived in this study therefore has the potential to improve the electrochemical performance of ZIBs.

Keywords: Zinc dendrites, nitrogen-doped carbon nanoparticle coating layer, micro-mesoporous structure, zinc affinity

33. Facile synthesis of platinum-copper aerogels for the oxygen reduction reaction

Communication [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Although carbon-supported platinum (Pt/C) has been generally used as a catalyst for the oxygen reduction reaction (ORR) in fuel cells, its practical application is limited by the corrosion reaction of the carbon support. Therefore, it is essential to develop new self-supported catalysts for the ORR. Noble metal aerogels represent highly promising self-supported catalysts with large specific surface area and excellent electrocatalytic activity. Classic sol-gel processes for aerogel synthesis usually take days due to the slow gelation kinetics. Here, we report a straightforward strategy to synthesize

platinum-copper (PtCu) aerogels by reducing the metal salt solution with an excess of sodium borohydride at room temperature. The PtCu aerogels are formed in a relatively short time of 1 h through a rapid nucleation mechanism. The obtained PtCu aerogels have a highly porous structure with an appreciable topological surface area of 33.0 m²/g and mainly exposed (111) facets, which are favorable for the ORR. Consequently, the PtCu aerogels exhibit excellent ORR activity with a mass activity of 369.4 mA/mg Pt and a specific activity of 0.847 mA/cm², which are 2.6 and 3.3 times greater than those of Pt/C, respectively. The PtCu aerogels show remarkable ORR catalysis among all the noble metal aerogels that have been reported. The porous morphology and outstanding electrocatalytic activities of the PtCu aerogels illustrate their promising applications in fuel cells.

Keywords: Noble metal aerogels, platinum-copper alloy, rapid nucleation, electrocatalysis, oxygen reduction reaction

34. Constructing stable lithium metal anodes using a lithium adsorbent with a high Mn³⁺/Mn⁴⁺ ratio

Article [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Lithium (Li) metal batteries (LMBs) have emerged as the most prospective candidates for post-Li-ion batteries. However, the practical deployment of LMBs is frustrated by the notorious Li dendrite growth on hostless Li metal anodes. Herein, a protonated Li manganese (Mn) oxide with a high Mn³⁺/Mn⁴⁺ ratio is used as a Li adsorbent for constructing highly stable Li metal anodes. In addition to the Mn³⁺ sites with high Li affinity that afford an ultralow Li nucleation overpotential, the decrease in the average Mnⁿ⁺ oxidation state also induces a disordered adsorbent structure via the Jahn-Teller effect, resulting in improved Li transfer kinetics with a significantly reduced Li electroplating overpotential. Based on the mutually improved Li diffusion and adsorption kinetics, the Li adsorbent is used as a versatile host to enable dendrite-free and stable Li metal anodes in LMBs. Consequently, a modified Li||LiNi_{0.8}Mn_{0.1}Co_{0.1}O₂ (NMC811) coin cell with a high NMC811 loading of 4.3 mAh cm⁻² delivers a high Coulombic efficiency of 99.85% over 200 cycles and the modified Li||NMC811 pouch cell also achieves a remarkable improvement in electrochemical performance. This work demonstrates a novel approach for the preparation of highly efficient Li protection structures for safe LMBs with long lifespans.

Keywords: Lithium metal batteries, lithium metal anodes, dendrites, protonated lithium manganese oxide

35. Ternary organic solar cells featuring polythiophene

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Qi Q, Ke H, Ye L. Ternary organic solar cells featuring polythiophene. *Energy Mater* 2022;2:200035.

Abstract

Benefiting from the creation of new photovoltaic materials and innovations in device architectures, organic photovoltaic (OPV) cells are booming. Nonetheless, their prosperity is also accompanied by challenges, such as tedious synthetic routes, increasing costs and insufficient operational stability under practical stresses. Polythiophene, with a simple chemical structure, high scalability and excellent charge transport ability, is expected to be the most promising candidate among all kinds of polymer donors. Ternary mixing, as a simple and effective method for improving the efficiency and stability of OPVs, has attracted significant attention in recent decades. This review provides an overview of the recent advances in ternary OPVs based on polythiophene and discusses the role of various third components in three types of OPV active layers, where polythiophene serves as either the host material or additive, and also clarifies how the third component plays a role in determining morphology and device performance, and finally proposes future research directions for ternary OPVs featuring polythiophene. In short, this review provides insights into polythiophene-based multicomponent systems and helps readers better understand the relationships between morphology, efficiency and stability.

Keywords: Ternary organic solar cells, third components, polythiophene, morphology, efficiency, stability

36. Enabling 4.6 V $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ cathodes with excellent structural stability: combining surface LiLaO_2 self-assembly and subsurface La-pillar engineering

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<http://dx.doi.org/10.20517/energymater.2022.42>

Abstract

Although Ni-rich layered materials with the general formula $\text{LiNi}_{1-x-y}\text{Co}_x\text{Mn}_y\text{O}_2$ ($0 < x, y < 1$, NCM) hold great promise as high-energy-density cathodes in commercial lithium-ion batteries, their practical application is greatly hampered by poor cyclability and safety. Herein, a $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ (NCM622) cathode modified with a surface self-assembling LiLaO_2 coating and subsurface La pillars demonstrates stabilized cycling at 4.6 V. The LiLaO_2 -coated NCM622 benefits from the suppression of interfacial side reactions, which relieves the layer-to-rock salt phase transformation and therefore improves the capacity retention under high voltages. Moreover, the La dopant, as a pillar in the NCM622 lattice, plays a dual role in expanding the c lattice parameter to enhance the Li-ion diffusion capability, as well as suppressing Ni antisite defect formation upon cycling. Consequently, the dual-modified NCM622 cathode exhibits an initial Coulombic efficiency of over 85% and a high capacity of over 200 mAh g^{-1} at 0.1 C. A specific capacity of 188 mAh g^{-1} with a capacity retention of 76% is achieved at 1 C after 200 cycles within a voltage range of 3.0–4.6 V. These findings lay a solid

foundation for the materials design and performance optimization of high-energy-density cathodes for Li-ion batteries.

Keywords: $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ cathode, surface coating, La pillars, high energy density, Li-ion batteries

37. Understanding the role of interfaces in solid-state lithium-sulfur batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Although All-solid-state lithium-sulfur batteries (ASSLSBs) exhibit huge potential applications in electrical energy storage systems due to their unique advantages, such as low costs, safety and high energy density. However, the issues facing solid-state electrolyte (SSE)/electrode interfaces, including lithium dendrite growth, poor interfacial capability and large interfacial resistance, seriously hinder their commercial development. Furthermore, an insufficient fundamental understanding of the interfacial roles during cycling is also a significant challenge for designing and constructing high-performance ASSLSBs. This article provides an in-depth analysis of the origin and issues of SSE/electrode interfaces, summarizes various strategies for resolving these interfacial issues and highlights advanced analytical characterization techniques to effectively investigate the interfacial properties of these systems. Future possible research directions for developing high-performance ASSLSBs are also suggested. Overall, advanced in-situ characterization techniques, intelligent interfacial engineering and a deeper understanding of the interfacial properties will aid the realization of high-performance ASSLSBs.

Keywords: All-solid-state lithium-sulfur batteries, interfacial issues, advanced strategies, solid-state electrolytes, sulfur-based cathodes

38. Anodization fabrication techniques and energy-related applications for nanostructured anodic films on transition metals

Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Nanostructured anodic films on transition metals prepared using the electrochemical anodization method have recently attracted particular attention owing to their extraordinary properties and potential use in a variety of applications. Herein, we provide a thorough review of the anodization fabrication of anodic films with different nanostructures, including nanopores, nanotubes, nanoflowers, nanoneedles and nanowires on transition metals, focusing on the growth processes of nanostructured anodic films on three representative transition metals, namely, iron, copper and zinc.

Specific consideration is given to the anodization behavior and formed film nanostructures of these transition metals. We conclude that electrolyte composition plays a key role in influencing the final morphologies of anodic films. Fluoride-containing solutions represent universal electrolytes for forming nanostructured anodic films on transition metals. The main applications of the resulting nanostructured anodic films, especially in energy-related fields, such as photoelectrochemical water splitting and supercapacitors, are also presented and discussed. Finally, we indicate the main challenges associated with the fabrication of anodic films with highly ordered nanostructures and the potential future directions of this field are indicated.

Keywords: Anodization, transition metals, anodic films, nanostructures, applications

39. Metal nitride heterostructures capsulated in carbon nanospheres to accommodate lithium metal for constructing a stable composite anode

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Abstract

Although various hosts have been proposed to accommodate the Lithium (Li) metal to solve the uneven Li deposition and infinite volume change, the pulverization of the host or lithiophilic modification layer easily leads to structural damage and the poor cycling stability of the composite anode. Herein, we design a host of metal nitrides (Mo_2N and WN heterostructures) nanoparticles capsulated in the hollow carbon nanospheres, which can accommodate Li metal to form a stable composite anode. The lithiophilic Mo_2N guides uniform infusion and reduces the nucleation barriers of Li metal during electrochemical process. Note that the rigid WN matrix is uniformly composited with Mo_2N , which can suppress the pulverization of Mo_2N during the repeat Li plating/stripping, ensuring the stability of regulated deposition during long cycling. High mechanical strength, uniform surface potential distribution and good electrolyte wettability of the Li metal-based composite anode guarantee the rapid Li plating/stripping kinetics. Thus, the obtained composite anode can stably cycle 1400 h at 1 mA cm^{-2} and 1 mA h cm^{-2} in the symmetric battery. The assembled full cells with $\text{LiNi}_{0.8}\text{Mn}_{0.1}\text{Co}_{0.1}\text{O}_2$ (NCM811) also deliver high capacity retention under the high loading (8.6 mg cm^{-2}) or lean electrolyte ($2 \text{ } \mu\text{L mg}^{-1}$) condition. This work suggests a promising host structure design to construct a highly stable lithium metal anode for practical applications.

Keywords: Lithium metal anode, matrix structural modification, anode structure design

40. Design of manganese dioxide for supercapacitors and zinc-ion batteries: similarities and differences

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manganese dioxide for supercapacitors and zinc-ion batteries: similarities and differences. *Energy Mater* 2022;2:200040.

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Abstract

Energy storage devices, e.g., supercapacitors (SCs) and zinc-ion batteries (ZIBs), based on aqueous electrolytes, have the advantages of rapid ion diffusion, environmental benignness, high safety and low cost. Generally, SCs provide excellent power density with the capability of fast charge/discharge, while ZIBs offer high energy density by storing more charge per unit weight/volume. Although the charge storage mechanisms are considered different, manganese dioxide (MnO₂) has proven to be an appropriate electrode material for both SCs and ZIBs because of its unique characteristics, including polymorphic forms, tunable structures and designable morphologies. Herein, the design of MnO₂-based materials for SCs and ZIBs is comprehensively reviewed. In particular, we compare the similarities and differences in utilizing MnO₂-based materials as active materials for SCs and ZIBs by highlighting their corresponding charge storage mechanisms. We then introduce a few commonly adopted strategies for tuning the physicochemical properties of MnO₂ and their specific merits. Finally, we discuss the future perspectives of MnO₂ for SC and ZIB applications regarding the investigation of charge storage mechanisms, materials design and the enhancement of electrochemical performance.

Keywords: Aqueous energy storage devices, manganese dioxide, zinc-ion batteries, supercapacitors, mechanisms

41. An industrial pathway to emerging presodiation strategies for increasing the reversible ions in sodium-ion batteries and capacitors

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Abstract

Sodium-ion batteries (SIBs) and capacitors (SICs) have been drawing considerable interest in recent years and are considered two of the most promising candidates for next-generation battery technologies in the energy storage industry. Therefore, it is essential to explore feasible strategies to increase the energy density and cycling lifespan of these technologies for their future commercialization. However, relatively low Coulombic efficiency severely limits the energy density of sodium-ion full cells, particularly in the initial cycle, which gradually decreases the number of recyclable ions. Presodiation techniques are regarded as effective approaches to counteract the irreversible capacity in the initial cycle and boost the energy density of SIBs and SICs. Their cyclic stability can also be enhanced by the slow release of supplemental sodium and high-content recyclable ions during cycling. In this review, a general understanding of the sodium-ion loss pathways and presodiation process towards full cells with high Coulombic efficiency is summarized. From the perspectives of safety, operability and

efficiency, the merits and drawbacks of various presodiation techniques are evaluated. This review attempts to provide a fundamental understanding of presodiation principles and strategies to promote the industrial development of SIBs and SICs.

Keywords: Na-ion batteries, presodiation, recyclable ions, full cells, commercialization

42. Air-exposed lithium metal as a highly stable anode for low-temperature energy storage applications

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Abstract

The demand for cryogenic applications has resulted in higher requirements for the low-temperature performance of energy storage systems. Lithium-metal batteries are the most promising energy storage systems. Lithium-metal anodes have the merits of high capacity and low potential. However, at low temperatures, especially sub-zero, the formation of lithium dendrites seriously hinders their applications. Herein, distinct from the traditional strategies of separating lithium metal from oxygen substances, we propose a new strategy to suppress dendrites by exposing lithium metal to air for short periods to generate a controlled oxidative protective layer in situ that is compact, homogeneous and mainly composed of Li_3N , Li_2O , LiOH and Li_2CO_3 . Symmetrical and full cells are assembled. The air-pretreated Li metal symmetrical cell exhibits an excellent lifespan of up to 4500 h (1 mA cm^{-2}) at 30°C and also shows a smaller voltage polarization of 20 mV at 1.0 mA cm^{-2} at -20°C . Importantly, the full cell using the air-pretreated Li metal as an anode and NCM811 as a cathode can charge-discharge normally at -20 and -40°C . This work provides an efficient and facile approach for developing superior lithium-metal batteries for future utilization at a wide range of temperatures.

Keywords: Lithium-metal batteries, lithium dendrites, in-situ self-assembly, air-pretreated layer, protective layer

43. Advances in lithium-ion battery materials for ceramic fuel cells

Mini Review [Full-Text](#) [PDF](#) [RIS](#)

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Abstract

Lithium-ion batteries (LIBs) and ceramic fuel cells (CFCs) are important for energy storage and conversion technologies and their materials are central to developing advanced applications. Although there are many crosslinking research activities, e.g., through materials and some common scientific fundamentals employed for both LIB and CFCs, crosslinking scientific aspects to achieve a comprehensive understanding are missing. There is a lack of such a review to promote and guide further research and

development in the crosslinking of LIBs and CFCs. Herein, we review the existing application of LIB materials in CFCs to discover the scientific advances of lithium-ion and proton transport cooperation and identify the new directions of Li-CFCs in the future. This review is the first to propose CFC advances, especially at low temperatures (300-600 °C) by applying LIB materials to practical devices and highlight the material properties and new device functions with enhanced performance, as well as the scientific mechanisms and principles. Furthermore, we seek to deepen the scientific understanding of materials science, ion transport mechanisms and semiconductor electrochemistry to benefit both the battery and fuel cell fields.

Keywords: Lithium-ion batteries, ceramic fuel cells, built-in electric field, semiconducting materials