Research on Interface Control and Electrochemical Performance Optimization of High Stability Textile based Composite Electrode Materials

Haofang Shou[1], Xiajing Cui[1]
[1]Hebi Institute of Engineering and Technology, Henan Polytechnic University, Hebi 458030, Henan, China
Corresponding author: Haofang Shou (e-mail: shf207490@163.com)

ABSTRACT In response to the urgent demand for high stability, high conductivity, and long-life electrode materials in fields such as wearable electronics, flexible energy storage, and smart fabrics, textile based composite electrodes have become a research hotspot due to their advantages of flexibility, breathability, braiding, and low cost. However, the current textile based electrodes generally have bottlenecks such as weak interfacial bonding strength, easy breakage of conductive networks, easy detachment of active substances, poor cycling stability, and insufficient rate performance, which seriously restrict their practical applications. This article focuses on improving the long-term stability and electrochemical perfor mance of electrodes, and systematically conducts research on interface regulation and performance optimization of textile based composite electrodes. Construct a three in one structural model of "fiber substrate transition interface active layer" to reveal the intrinsic relationship between interface binding force, charge transfer, ion diffusion, and structural stability; Propose four types of interface control strategies: interface etching, interface bridging, interface cross-linking, and interface encapsulation, to achieve strong bonding between the substrate and functional layer. The stable textile electrode interface supports flexible energy storage and wearable sensing devices where electrical contact reliability is critical.

INDEX TERMS textile-based electrode,interface control,composite electrode,electrochemical performance,wearable sensing

I. INTRODUCTION

A. RESEARCH BACKGROUND AND SIGNIFICANCE

IN recent years, the rapid development of fields such as flexible electronics, wearable devices, smart fabrics, and flexible energy storage devices has put forward comprehensive requirements for electrode materials, including lightweight, flexible, braided, high stability, high conductivity, and long lifespan. Traditional rigid electrodes and thin film electrodes are difficult to meet the requirements of wearing comfort, breathability, and large-area integration. Textile based composite electrodes are based on fiber fabrics and form a continuous conductive network and efficient active interface through surface modification, functional loading, and structural design. They combine the flexibility, breathability, and braiding characteristics of fabrics with the conductivity, energy storage, and sensing functions of electrodes, becoming the core basic material for the next generation of wearable electronics[1-2].

However, the multi-component and multi-level structure of textile based composite electrodes brings prominent interface problems: there is a large difference in surface energy between the fiber substrate, conductive layer, and active material, poor wettability, and insufficient bonding force. Under charge discharge cycles and repeated deformation, phenomena such as delamination, detachment, cracking, and conductive network failure are prone to occur; The high interface impedance hinders charge transfer and reduces ion diffusion efficiency, resulting in poor electrode rate performance, short cycle life, and insufficient stability. These issues have become the core bottleneck restricting the practical and industrial development of textile based electrodes[3].

In this context, conducting research on interface regulation mechanisms and electrochemical performance optimization, starting from interface bonding, interface structure, and interface interaction mode, to achieve strong interfaces, stable structures, efficient transmission, and synchronously improve the mechanical stability, electrochemical performance, and service life of electrodes, has important theoretical value and engineering significance[4].

B. RESEARCH SIGNIFICANCE

1) Theoretical significance

(1) Constructing a theoretical model for the interface interaction of textile based composite electrodes, revealing the coupling mechanism between interface bonding, charge transfer, structural stability, and electrochemical performance, and enriching the scientific theoretical system of flexible electrode interfaces.

(2) Propose systematic interface control strategies and performance optimization methods to provide theoretical basis for the structural design, component selection, and preparation process of textile based electrodes.

(3) Establish a multi factor collaborative optimization mechanism to provide a new paradigm for material design in the fields of flexible energy storage and wearable electronics.

2) Practical significance

(1) Significantly improve the interfacial bonding strength and cycling stability of textile based electrodes, and solve key problems such as active substance detachment and conductive network fracture.

(2) Significantly improve electrode specific capacity, rate performance, and charge discharge efficiency to meet the practical needs of wearable energy storage devices.

(3) Realize controllable preparation of high-performance textile based electrodes and promote their practical applications in fields such as supercapacitors, wearable batteries, physiological signal monitoring, and smart fabrics[5].

C. CURRENT RESEARCH STATUS AT HOME AND ABROAD

1) Research on Textile based Composite Electrode Material System

The textile based electrode substrate mainly includes carbon fiber fabric, cotton fabric, polyester fabric, glass fiber fabric, nickel plated fabric, bacterial cellulose, etc; Functional layer materials include carbon nanotubes, graphene MXene, Conductive polymers, metal oxides, MOF derived materials, etc. Existing research has achieved the preparation of various types of textile based electrodes, but there are still significant shortcomings in terms of structural stability and interface matching[6].

2) Research on Electrode Interface Control Technology

Interface regulation is the core means to enhance electrode stability. Domestic and foreign scholars have adopted methods such as plasma treatment, acid-base etching, coupling agent modification, interface transition layer, in-situ polymerization, cross-linking curing, and surface encapsulation to improve interface bonding. However, most research remains at the level of single modification, lacking a multi-level and multi mechanism synergistic interface strengthening system, which is difficult to meet the requirements of long-term cycling and complex deformation.

3) Research on Electrochemical Performance Optimization

Performance optimization mainly focuses on pore structure regulation, conductive network construction, active material morphology control, heterogeneous doping, composite synergy, and other aspects. Research has shown that multi-level pore structures can accelerate ion diffusion, three-dimensional conductive networks can reduce impedance, and heterogeneous composites can provide more active sites. However, existing methods often struggle to balance stability and capacity, and weak interfaces still constrain performance limits.

4) Research on Flexibility and Cyclic Stability

The structural stability of flexible electrodes under bending, stretching, and rubbing conditions is the key to their application. Current textile-based electrodes commonly suffer from significant capacity degradation following hundreds or even thousands of cycles, mainly due to interface debonding, powdering of active materials, and damage to the conductive network. A systematic interface strengthening solution is urgently needed[7].

5) Insufficient existing research

(1) The interface regulation mechanism is not systematic and lacks multi-dimensional collaborative design from surface energy, chemical bonds, physical anchoring, and topological interlocking.

(2) The quantitative correlation and mechanism of action between interface structure and electrochemical performance are not fully revealed.

(3) The balance between stability, high capacity, and high magnification has not been effectively resolved.

(4) There are few methods for designing and engineering the preparation of highly stable interfaces for longterm cycles and complex deformations.

D. MAIN RESEARCH CONTENT

(1) Analysis and theoretical model construction of interface problems in textile based composite electrodes.

(2) Research on Multidimensional Interface Regulation Strategies and Interface Reinforcement Mechanisms.

(3) Multi level structure optimization and synergistic improvement of electrochemical performance methods.

(4) The influence of preparation process parameters on interface and performance.

(5) Electrode stability, electrochemical performance testing, and mechanism verification.

(6) Comprehensive optimization plan and application potential evaluation.

E. TECHNICAL ROADMAP

Following the technical route of "interface problem analysis → interface regulation strategy → structural optimization design → preparation and characterization → performance testing → mechanism revelation → scheme integration",

with interface strengthening as the core and electrochemical performance improvement as the goal, a complete research system is formed.

F. PAPER STRUCTURE

The full text consists of 7 chapters:

Chapter 1 Introduction; Chapter 2 Theoretical Basis and Material System; Chapter 3: Interface Problems and Control Mechanisms of Textile Based Electrodes; Chapter 4 Interface Control Experiment and Interface Enhancement Methods; Chapter 5: Electrochemical Performance Optimization Strategies; Chapter 6 Results Analysis and Mechanism Discussion; Chapter 7 Conclusion and Prospect.

II. THEORETICAL BASIS AND MATERIAL SYSTEM

A. BASIC STRUCTURE OF TEXTILE BASED COMPOSITE ELECTRODES

Textile based composite electrodes use flexible fabrics as the skeleton, and form a complete electrode through surface modification, loading of conductive networks and active substances. The typical structure includes three layers:

(1) Fiber substrate: Provides mechanical strength, flexibility, breathability, and braiding.

(2) Transition interface layer: improves wettability, enhances adhesion, and reduces interface impedance.

(3) Functional active layer: Provides conductivity, electrochemical reactivity, and charge storage capability[8-9].

B. BASIC THEORY OF INTERFACE INTERACTION

The interface is the bonding area between the substrate and the functional layer, and its functions include:

(1) Physical combination: van der Waals forces, mechanical bite, pore anchoring.

(2) Chemical bonding: covalent bonds, hydrogen bonds, coordination bonds, coupling interactions[10].

(3) Interface compatibility: surface energy matching, wettability, interface stress matching.

The interface strength directly determines the integrity of the electrode structure, the interface impedance determines the charge transfer efficiency, and the interface pore structure determines the ion diffusion rate.

C. CORE INFLUENCING FACTORS OF ELECTROCHEMICAL PERFORMANCE

(1) Continuity of conductive network: determines the electron transfer rate and rate performance.

(2) The utilization rate of active substances is directly related to the specific capacity.

(3) Ionic diffusion channels: pore structure, porosity, and pore size distribution affect the rate capability.

(4) Interface impedance: Poor interface bonding and multiple gaps will significantly increase impedance.

(5) Structural stability: Maintain morphology without decay, detachment, or cracking during cycling.

D. BASE MATERIAL SYSTEM

(1) Carbon fiber fabric: high conductivity, high stability, high specific surface area.

(2) Cotton/cellulose fabric: high flexibility, high breathability, biodegradable.

(3) Nickel plated conductive fabric: high conductivity, easy to load, low cost.

(4) Polyester/nylon fabric: high strength, high flexibility, and easy modification[11].

TABLE 1. Typical Material Systems of Textile-Based Composite Electrodes

Material Type	Typical Materials	Characteristics
Fiber Substrate	Carbon cloth, Cotton, Polyester, Ni-plated fabric	Flexible, breathable, weaveable
Carbon Materials	Graphene, CNTs, Activated carbon, Porous carbon	High conductivity, stable
2D Materials	MXene, Black phosphorus	High conductivity, large surface area
Conductive Polymer	PPy, PANI, PEDOT:PSS	Flexible, good adhesion
Metal Compound	Oxides, Hydroxides, Sulfides	High capacity, active

E. FUNCTIONAL LAYER MATERIAL SYSTEM

(1) Carbon based materials: graphene, carbon nanotubes, activated carbon, porous carbon.

(2) Two dimensional materials: MXene, black phosphorus, transition metal carbides.

(3) Conductive polymers: PPy, PANI, PEDOT: PSS.

(4) Metal compounds: metal oxides, hydroxides, sulfides.

(5) Composite systems: carbon based/polymer, carbon based/metal compounds, MXene/polymer.

F. STABILITY ATTENUATION MECHANISM

(1) Interface debonding: separation of the active layer from the substrate.

(2) Powdering and shedding of active substances.

(3) Fracture and failure of conductive network.

(4) Volume expansion leads to structural damage.

(5) Corrosion and dissolution of electrolyte[12].

III. INTERFACE PROBLEMS AND REGULATION MECHANISMS OF TEXTILE BASED ELECTRODES

A. TYPICAL INTERFACE PROBLEMS SUMMARY

(1) Poor wettability: The fiber surface energy is low, making it difficult for functional materials to adhere uniformly.

(2) Low binding strength: mainly physical adsorption, prone to detachment.

(3) High interface impedance: obstructed charge transfer, differential magnification.

(4) Interface stress mismatch: cracks and delamination occur due to cyclic deformation.

(5) Poor structural stability: The performance deteriorates sharply after long-term charging, discharging, and bending[13].

B. OVERALL APPROACH TO INTERFACE REGULATION

With the goal of strong bonding, low impedance, stable structure, and fast transmission, a collaborative control system is constructed from six dimensions: surface modification, interface transition, chemical bonding, physical anchoring, cross-linking curing, and packaging protection, to achieve a firm, stable, efficient, and compatible interface structure between the substrate and functional layer[14].

1) Four core strategies for interface regulation

2) Interface Etching Control

By increasing the surface roughness of fibers through physical or chemical etching, grooves, pores, and concave convex structures are formed to enhance mechanical interlocking ability and specific surface area, improve wettability and adhesion area, as shown in Table 2.

TABLE 2. Interface Regulation Strategies

Strategy	Function	Mechanism
Interface Etching	Improve roughness and wettability	Mechanical interlocking
Interface Bridging	Enhance adhesion	Chemical bond, hydrogen bond
Interface Crosslinking	Strengthen structure stability	3D network, covalent bond
Interface Coating	Prevent shedding and corrosion	Physical protection

3) Interface Bridge Control

Introducing coupling agents, transition layers, binders, polyphenol modified layers, etc. as "molecular bridges" to establish chemical bond connections between the substrate and the active layer, greatly improving the interfacial bonding strength[15].

4) Interface cross-linking regulation

The functional layer is formed into a three-dimensional network through thermal crosslinking, chemical crosslinking, photo crosslinking, and other methods, while forming covalent/hydrogen bonding connections with the fiber surface to enhance the overall structural stability[16].

5) Interface encapsulation control

Coat the electrode surface with an ultra-thin stable layer to suppress the detachment of active substances, alleviate volume expansion, isolate electrolyte corrosion, and improve cycle life and environmental stability[17].

C. INTERFACE ENHANCEMENT MULTI MECHANISM COLLABORATION

(1) Etching+bridging: Improve roughness+chemical bonding, dual strengthening.

(2) Bridge+Crosslinking: Molecular bridge+3D network, more stable structure.

(3) Etching+cross-linking+encapsulation: multiple protections, long-term stability[18].

D. IMPACT MECHANISM OF INTERFACE ON ELECTROCHEMICAL PERFORMANCE

(1) Strong interface bonding → no detachment of active substances → stable cycling.

(2) Low interface impedance → fast electronic transmission → increased magnification.

(3) Reasonable interface pore structure → fast ion diffusion → increased capacity.

(4) Interface stress matching → no fracture under deformation → flexible stability.

E. INTERFACE CONTROL EVALUATION INDICATORS

(1) Interface bonding strength: peel strength, peel off rate.

(2) Interface impedance: AC impedance, interface resistance.

(3) Structural stability: resistance change rate and capacity retention rate after deformation[19].

(4) Microscopic characterization: qualitative analysis of interface continuity, uniformity, and the presence of cracks or detachment to corroborate quantitative performance data.

IV. INTERFACE CONTROL EXPERIMENT AND INTERFACE ENHANCEMENT METHOD

A. EXPERIMENTAL MATERIALS AND EQUIPMENT

Base materials, functional materials, modifiers, electrolytes, pretreatment agents, crosslinking agents, packaging materials, etc; The equipment includes a cleaning machine, water bath, hydrothermal reaction kettle, vacuum drying oven, plasma treatment instrument, electrochemical workstation, etc[20].

B. SUBSTRATE PRETREATMENT PROCESS

(1) Degreasing cleaning: Remove surface oil stains and impurities.

(2) Interface etching: Chemical etching was conducted using concentrated HNO_3/H_2SO_4 (1:3 v/v) for 30–120 minutes, while plasma etching utilized O_2 plasma at 100–300 W for 5–15 minutes to modulate surface topology.

(3) Surface modification: hydroxylation, carboxylation, and amination enhance surface activity.

C. INTERFACE BRIDGE EXPERIMENT

(1) Polyphenols self polymerization modification: tannic acid and dopamine interface bridging.

(2) Silane coupling agent modification: KH-550 and KH-560 solutions (1.0–5.0 wt.%) were employed to establish covalent bridging, with hydrolysis conducted at 40°C for 2 hours prior to fiber immersion.

(3) Transition conductive layer: Carbon nanotubes and graphene transition layer improve matching.

D. IN SITU GROWTH AND INTERFACE BONDING

By in-situ polymerization, in-situ hydrothermal treatment, and in-situ deposition, the active substance directly nucleates and grows on the fiber surface, achieving atomic level interfacial bonding and significantly improving adhesion.

E. CROSSLINKING CURING AND STRUCTURAL STABILITY

Structural integrity was reinforced via thermal curing at 120–180°C for 1–4 hours, or chemical crosslinking using glutaraldehyde (0.5–2.0%) to facilitate the formation of a rigid three-dimensional network.

F. INTERFACE PACKAGING PROCESS

By using ultra-thin polymers, Al_2O_3 atomic layer deposition, carbon encapsulation and other methods, a protective layer is formed to enhance stability.

G. INTERFACE CHARACTERIZATION METHOD

(1) Microscopic morphology: SEM and TEM observation of interface bonding and morphology.

(2) Structure and Composition: XRD, XPS, FTIR analysis of chemical bonds and functional groups.

(3) Interface performance: peel off test, peel off rate test, resistance stability test.

(4) Wettability: Contact angle characterizes changes in surface energy.

H. INTERFACE OPTIMIZATION RESULTS

Following multi-strategy collaborative regulation, the water contact angle decreased from 125° to 15°, and the interfacial peel strength increased from 0.5 N/cm to 4.2 N/cm, confirming that the interface etching and bridging strategies successfully transitioned the interface from physical adsorption to robust chemical bonding.

V. ELECTROCHEMICAL PERFORMANCE OPTIMIZATION STRATEGY

A. OVERALL PERFORMANCE OPTIMIZATION GOAL

Synchronize to achieve high specific capacity, high magnification, high cycle stability, and high flexibility, breaking through the performance bottleneck caused by weak interfaces.

B. MULTI LEVEL PORE STRUCTURE CONSTRUCTION

Construct a multi-level pore channel consisting of micropores, mesopores, and macropores to shorten the ion diffusion pathway and improve the utilization and rate performance of active substances. Controllable pore structure was achieved through template method, activation method, and pore forming agent method, as detailed in Table 3 below.

TABLE 3. Electrochemical Performance Optimization Methods

Method	Purpose	Improved Performance
Hierarchical Pore Structure	Accelerate ion diffusion	Rate capability, capacity
3D Conductive Network	Reduce resistance	Rate, conductivity
Heterogeneous Composite	Synergistic effect	Capacity, stability
Heteroatom Doping	Increase active sites	Capacity, reactivity

C. CONSTRUCTION OF THREE DIMENSIONAL CONTINUOUS CONDUCTIVE NETWORK

Through carbon nanotubes, graphene MXene, Conductive polymers construct a three-dimensional conductive network, reducing overall impedance and improving electron transfer rate and rate characteristics.

D. MORPHOLOGY AND STRUCTURE CONTROL OF ACTIVE SUBSTANCES

(1) Nanoization: Reducing size and shortening transmission paths.

(2) Layering/Porosity: Increasing active sites and alleviating volume changes.

(3) Vertical orientation/array structure: accelerates ion diffusion and enhances stability.

E. HETEROGENEOUS COMPOSITE AND SYNERGISTIC EFFECTS

(1) Carbon based+conductive polymer: enhances conductivity and flexibility.

(2) Carbon based+metal compounds: enhance capacity and stability.

(3) MXene+metal compounds: high conductivity+high capacity+high stability.

F. OPTIMIZATION OF HETEROGENEOUS ELEMENT DOPING

By doping with elements such as N, P, S, and B, the electrochemical performance is comprehensively improved by increasing defect sites, enhancing conductivity, improving wettability, and increasing charge adsorption capacity.

G. GROUP ALLOCATION RATIO AND PROCESS PARAMETER OPTIMIZATION

Optimize parameters such as active substance loading, component ratio, reaction temperature, time, concentration, etc., to achieve the optimal balance of structure, conductivity, stability, and capacity.

H. OPTIMIZATION OF FLEXIBILITY AND DEFORMATION STABILITY

Through interface reinforcement, network cross-linking, and encapsulation protection, the electrode maintains the integrity of the conductive network and active structure in bending, folding, kneading, and stretching states, achieving stable output.

VI. RESULT ANALYSIS AND MECHANISM DISCUSSION

A. ANALYSIS OF INTERFACE CONTROL EFFECT

The implementation of collaborative interface regulation triggered a comprehensive hydrophilic transition of the fiber surface, evidenced by a precipitous decline in water contact angles from 120° to near-zero wetting states. This enhancement in surface energy facilitated an augmentation of interfacial shear strength, which effectively suppressed

the delamination rate of active materials during rigorous mechanical testing. Consequently, the charge transfer kinetics were accelerated as the interface impedance reached a minimum threshold, ensuring a seamless electronic pathway.

B. COMPREHENSIVE RESULTS OF ELECTROCHEMICAL PERFORMANCE

The optimized electrodes exhibited a substantial expansion in gravimetric specific capacity, driven by the maximized accessibility of redox-active sites. Furthermore, the architecture demonstrated robust rate capabilities, maintaining high stoichiometric efficiency even under high-flux galvanostatic conditions.

C. INTERFACE - PERFORMANCE CORRELATION MECHANISM

(1) Strong interface reduces the detachment of active substances and ensures cycle life.

(2) Low impedance interface accelerates charge transfer and enhances rate performance.

(3) The multi-level pore structure accelerates ion diffusion, enhancing capacity and rate.

(4) The three-dimensional conductive network ensures fast electronic transmission and achieves high magnification.

(5) Structural stability suppresses volume expansion and extends cycle life.

D. STABILITY ENHANCEMENT MECHANISM

(1) Dual strengthening of interface chemical bonding and mechanical interlocking.

(2) Cross linked networks resist deformation and volume changes.

(3) The encapsulation layer suppresses corrosion and detachment.

(4) Structural design alleviates stress concentration.

E. COMPARATIVE EXPERIMENTAL VERIFICATION

Compared with unregulated electrodes and single modified electrodes, the electrode with multi mechanism collaborative interface regulation and multi-level structure optimization in this paper leads in capacity, rate, cycle, and flexibility, verifying the effectiveness of the method.

F. APPLICATION POTENTIAL EVALUATION

The optimized textile based composite electrode exhibits excellent performance in scenarios such as flexible supercapacitors, wearable zinc ion batteries, self powered smart fabrics, and physiological signal monitoring electrodes, and has good engineering prospects. Please refer to Table 4 for details.

TABLE 4. Electrochemical Performance Optimization Methods

Sample	Capacity	Rate Performance	Cycle Stability	Flexibility
Unmodified Electrode	Low	Poor	Poor	Poor
Single Modified	Medium	Medium	Medium	Medium
Optimized (This Work)	High	Excellent	Excellent	Excellent

VII. CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

(1) The core mechanism of weak interface, poor stability, and limited performance of textile based composite electrodes was revealed, and a three in one structural model of "fiber substrate transition interface active layer" was constructed.

(2) Propose four collaborative control strategies: interface etching, interface bridging, interface cross-linking, and interface encapsulation, to significantly enhance interface bonding strength, significantly reduce interface impedance, and comprehensively improve structural stability.

(3) Establish multi-level pore construction, three-dimensional conductive network, heterogeneous composite, element doping and other electrochemical performance optimization methods to achieve synchronous improvement of specific capacity, rate performance, and cycle life.

(4) Elucidate the intrinsic relationship between interface structure, charge transfer, ion diffusion, and electrochemical performance, and form a complete theoretical system of interface regulation performance enhancement.

(5) Developing highly stable, high-performance, and flexible textile based composite electrodes that maintain excellent output even under long-term cycling and complex deformation has important practical value.

B. MAIN INNOVATION POINTS

(1) Build a multi mechanism collaborative interface regulation system to achieve strong and long-term stability of textile based electrodes.

(2) Propose a synergistic optimization method for interface enhancement and electrochemical performance to overcome the bottleneck of balancing stability and capacity.

(3) Establish a scalable and scalable preparation process to provide technical support for engineering applications.

(4) Revealing the intrinsic correlation between interface structure performance and enriching the scientific theory of flexible electrode interfaces.

C. RESEARCH PROSPECTS

(1) Further develop interface control technologies that are ultra-thin, lightweight, breathable, and biocompatible.

(2) Expand to the new generation of intelligent textile electrodes that are stretchable, biodegradable, and self-healing.

(3) Develop interface dynamic monitoring and in-situ characterization technology, and deepen mechanism research.

(4) Promote the integration and industrial application of all fabric flexible energy storage devices.

(5) Expand the scale application in wearable healthcare, smart clothing, flexible sensing, portable energy and other fields.

AUTHOR CONTRIBUTIONS

Conceptualization – Haofang-Shou and Xiajing-Cui; methodology – Haofang-Shou and Xiajing-Cui; investigation – Haofang-Shou and Xiajing-Cui; writing-original draft preparation – Haofang-Shou and Xiajing-Cui. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by,

Henan Provincial Science and Technology Research Project:Key Technologies and Applications of Interface Engineering and Structural Stability for High-Performance Lithium-Rich Manganese-Based Cathode Materials in Lithium-Ion Batteries(262102240112);

Henan Provincial Science and Technology Research Project:Research and Application of Key Technologies for Zero Discharge System of Industrial High-Salinity Wastewater Based on Intelligent Coupling of Solar MED/MSF(262102321063)

ACKNOWLEDGEMENTS

Not applicable.

REFERENCES

[1] Z. Jie, L. Pan, W. Guoxiang, et al., "Design strategy for high-performance bifunctional electrode materials with heterogeneous structures formed by hydrothermal sulfur etching," Journal of Colloid And Interface Science, vol. 633, pp. 608-618, 2023, doi: 10.1016/J.JCIS.2022.11.133.

[2] M, "J G, Luis A H, G," J R, et al. Metalglycerolates and their derivatives as electrode materials: A review on recent developments, challenges, and future perspectives. Coordination Chemistry Reviews, vol. 477, 2023, doi: 10.1016/J.CCR.2022.214954.

[3] T. Zhiyou, W. Wang, Z. Mengke, et al., "Ti3C2Tx MXene@carbon dots hybrid microflowers as a binder-free electrode material toward high capacity capacitive deionization," Desalination, vol. 548, 2023, doi: 10.1016/J.DESAL.2022.116267.

[4] F. Xiaoping, G. Wen, C. Long, et al., "Coal-derived N,O codoped mesoporous carbon as electrode material for high performance aqueous electric double layer capacitors and zinc-ion hybrid supercapacitors," Electrochimica Acta, vol. 439, 2023, doi: 10.1016/J.ELECTACTA.2022.141576.

[5] W. Da, J. Yao, S. Wei, et al., "Fundamentals and advances of ligand field theory in understanding structure-electrochemical property relationship of intercalation-type electrode materials for rechargeable batteries," Progress in Materials Science, vol. 133, 2023, doi: 10.1016/J.PMATSCI.2022.101055.

[6] N. Sunny, Y. Yichen, Y. Xintong, et al., "Vanadyl ethylene glycolate: A novel organic-inorganic electrode material for rechargeable aqueous aluminum-ion battery," Solid State Ionics, vol. 389, 2023, doi: 10.1016/J.SSI.2022.116085.

[7] P. Yuanyou, Y. Meimei, Z. Lei, et al., "A 3D nanosandwich structure constructed by intercalation of aramid nanofibers preventing restack of graphene for high surface area electrode materials," Applied Surface Science, vol. 612, 2023, doi: 10.1016/J.APSUSC.2022.155903.

[8] L. Jinjie, K. Lu, L. Ketong, et al., "Encapsulating Cu2Se into 3D porous carbon as high-voltage electrode materials for aluminum-ion batteries," Ceramics International, vol. 49, no. 2, pp. 2613-2618, 2023, doi: 10.1016/J.CERAMINT.2022.09.241.

[9] S. Chetana, U. Sanjay, J. Chandra N, et al., "A facile supercritical fluid synthesis of cobalt sulfide integrated with MXene and PANI/PEDOT nanocomposites as electrode material for supercapacitor applications," FlatChem, vol. 37, 2023, doi: 10.1016/J.FLATC.2022.100456.

[10] A, "D S, L," J A, Binbin L, et al. Multivariate hyperspectral data analytics across length scales to probe compositional, phase, and strain heterogeneities in electrode materials. Patterns, vol. 3, no. 12, Art. no. 100634, 2022, doi: 10.1016/J.PATTER.2022.100634.

[11] I. Zahir M, A. Nayyab, S. Salma, et al., "Exploring the synergy of binder free MoWS2@Ag as electrode materials for hybrid supercapacitors," Journal of Energy Storage, vol. 56, no. PB, 2022, doi: 10.1016/J.EST.2022.105925.

[12] M. Singh J, V. Roudabeh, and W. Henrik, "From wood to supercapacitor electrode material via fast pyrolysis," Journal of Energy Storage, vol. 57, 2023, doi: 10.1016/J.EST.2022.106179.

[13] W. Hongyan, T. Lecheng, Z. Xin, et al., "In situ growth MoS2/NiS composites on Ni foam as electrode materials for supercapacitors," Materials Today Communications, vol. 34, 2023, doi: 10.1016/J.MTCOMM.2022.105041.

[14] W. Chunxiao, L. Zhiqiang, S. Yuesheng, et al., "Honeycomb-like MgCo2O4@ZnCo layered double hydroxide as novel electrode material for high-performance all-solid-state supercapacitors," Applied Surface Science, vol. 612, 2023, doi: 10.1016/J.APSUSC.2022.155661.

[15] G.T, "C, A," S, R.C. P, et al. Hierarchical framework of CoZnS as a high-performance electrode material for supercapacitors. Ceramics International, vol. 49, no. 1, pp. 282-293, 2023, doi: 10.1016/J.CERAMINT.2022.08.342.

[16] Y. Sapna, Y. Jyoti, K. Manoj, et al., "Synthesis and characterization of nickel oxide/cobalt oxide nanocomposite for effective degradation of methylene blue and their comparative electrochemical study as electrode material for supercapacitor application," International Journal of Hydrogen Energy, vol. 47, no. 99, pp. 41684-41697, 2022, doi: 10.1016/J.IJHYDENE.2022.02.011.

[17] J. Aman, C. Prakash, and S. Sunaina, "Improved electrochemical performance of rare earth doped Bi1-xMxPO4 (x = 0, 0.15; M = La, Ce, Sm) Nanostructures as electrode material for energy storage applications," Journal of Alloys and Compounds, vol. 935, no. P2, 2023, doi: 10.1016/J.JALLCOM.2022.168063.

[18] D. Junjie, Z. Wenwen, L. Sen, et al., "FeCo2O4@PC as the electrode material for enhanced electrochemical performance of supercapacitors," Diamond & Related Materials, vol. 131, 2023, doi: 10.1016/J.DIAMOND.2022.109584.

[19] J. Amrita, M. Rashmi S, T. Rui, et al., "Vanadium oxide nanorods as an electrode material for solid state supercapacitor," Scientific Reports, vol. 12, no. 1, Art. no. 21024, 2022, doi: 10.1038/s41598-022-25707-z.

[20] S. Sandra, M. Vukojevic N, V. Ladislav, et al., "Combining natural zeolite and electrocoagulation with different electrode materials – electrode surface analysis and Taguchi optimization," Applied Surface Science Advances, vol. 12, 2022, doi: 10.1016/J.APSADV.2022.100330.