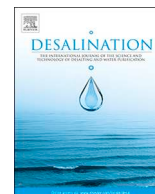


# 能源化工专业学生参与科研在国际期刊上发表论文

## 首页/录用通知

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# Highly conductive and permselective anion exchange membranes for electrodialysis desalination with series-connected dications appending flexible hydrophobic tails

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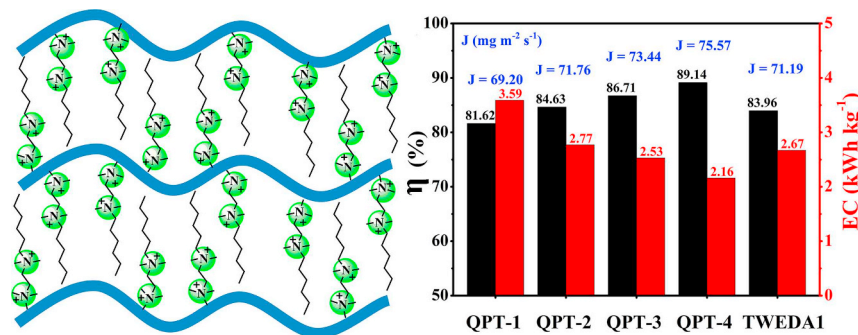
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## GRAPHICAL ABSTRACT

A series of series-connected dication anion exchange membranes appending flexible hexyl tails (QPTs) were tailored successfully for electrodialysis desalination (ED). The QPTs membranes have good conductivity and permselectivity simultaneously and display superior ED performances to that of commercial TWEDA1.



## ARTICLE INFO

### Keywords:

Anion exchange membrane  
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High permselectivity  
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## ABSTRACT

A series of series-connected dication ionic ionomers with flexible hydrophobic tails (QPTs) designed for electrodialysis desalination (ED) anion exchange membranes have been synthesized successfully from a monoionic quaternization agent *N*-(2-(dimethylamino)ethyl)-*N,N*-dimethylhexan-1-aminium bromide and brominated poly(2,6-dimethyl-1,4-phenylene oxide). The properties of QPTs membranes were evaluated in terms of ion exchange capacity (IEC), water uptake (WU), swelling ratio (SR), thermal stability, membrane area resistance ( $R_m$ ), permselectivity ( $P$ ) and ED experiments. The results confirm that the coaction of the series-connected dications linking by a short chain of two methylene groups and the middle length aliphatic tails offers QPTs excellent conductivity and permselectivity simultaneously. Especially, QPT-4 membrane has an excellent permselectivity of 94.0% and the lowest  $R_m$  of 1.60 Ω cm<sup>2</sup> at the highest IEC of 2.33 mmol g<sup>-1</sup>. Moreover, QPT-4 membrane shows the best ED performances with current efficiency of 89.14%, salt flux of 75.57 mg m<sup>-2</sup> s<sup>-1</sup> and energy consumption of 2.16 kWh kg<sup>-1</sup> in the mostly reported NaCl ED system, which are much higher than those of commercial TWEDA1 (the corresponding values of

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# Flexible free-standing SnS<sub>2</sub>/carbon nanofibers anode for high performance sodium-ion batteries

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## ABSTRACT

To solve the problems of insufficient conductivity and volume expansion of SnS<sub>2</sub> during cycling when applied as anode for sodium-ion batteries (SIBs), we designed flexible and self-standing SnS<sub>2</sub>/carbon nanofibers (SnS<sub>2</sub>/CNFs) film by electrospinning technology and post sulfuration, in which the ultrafine SnS<sub>2</sub> nanoparticles (~5 nm) are preganated in the carbon nanofibers. The three-dimensional carbon nanofibers serve as flexible scaffold with high electrical conductivity to buffer the aggregation and pulverization of SnS<sub>2</sub> particles. The obtained flexible SnS<sub>2</sub>/CNFs film can be directly used as anode for SIBs without adding binder and carbon additive, and exhibits excellent electrochemical performance. The SnS<sub>2</sub>/CNFs delivers a high capacity of 570.8 mAh g<sup>-1</sup> at 0.2 A g<sup>-1</sup>. Even at a high rate of 5 A g<sup>-1</sup> a high capacity of 247.1 mAh g<sup>-1</sup> is still achieved. It also maintains 378.9 mAh g<sup>-1</sup> after 100 cycles at 0.5 A g<sup>-1</sup>.

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## 1. Introduction

With increased demand of high energy density and long cycling life for mobile electrical equipment, limiting lithium sources leads to high cost, which restricts the application of lithium ion batteries (LIBs) in energy storage equipment [1,2]. To meet the progressive requirement of low-cost and large-scale energy storage applications, many researchers show renewed interest in SIBs due to the abundant sodium resources. It's pivotal to develop high performance electrode materials and stimulate the commercial development of high-efficiency and low-price devices during sodium-ion batteries system [2–5].

Metal sulfides (e.g. SnS<sub>2</sub> [6–9], SnS [10], FeS<sub>2</sub> [11], FeS [12], etc.) have attracted much attention used as anode for SIBs due to high energy-density and high-rate performance [13,14]. Among metal sulfides, SnS<sub>2</sub> is a promising anode for SIBs owing to high theoretical capacity (1137 mAh g<sup>-1</sup>) and better reversibility than SnO<sub>2</sub> due to weaker M–S ionic bonds [15]. However, the insufficient conductivity and the serious volume change (420%) during cycling lead to the poor electrochemical performance [16]. In order to improve the electronic conductivity and buffer the volume change of the SnS<sub>2</sub>, carbon materials are used to integrate with the nanostructured SnS<sub>2</sub> [7–9]. Jiang et al. developed ultrasmall SnS<sub>2</sub> nanocrystals

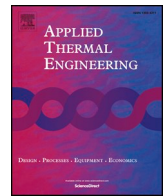
grown on the nitrogen-doped graphene sheets (SnS<sub>2</sub>-NGS), exhibiting excellent electrochemical properties due to the synergistic function between NGSs and SnS<sub>2</sub> [7]; Zhang et al. synthesized SnS<sub>2</sub> particles fixed on a small number of layered reduced graphene oxides (SnS<sub>2</sub>/rGO). The dispersing and conducting effects of rGO greatly increased the capacity of the SnS<sub>2</sub>/rGO [9]. Besides the performance of the electrode material itself, energy density is also very vital for whole battery systems. To construct SIBs with high energy density, another effective way is to fabricate a self-supporting electrode without using heavy metal substrate, binder and carbon additive [17,18]. Wang et al. synthesized free-standing flexible nitrogen-doped carbon nanofibers (N-CNFs), which had good rate performance and cycle stability [19]. Balogun et al. synthesized carbon quantum dot-coated VO<sub>2</sub> nanowires (CQDs) grown on carbon fibers which showed good sodium storage performance [20]. Thus, it is desirable to design self-supporting SnS<sub>2</sub> electrode with high electrochemical performance for high performance SIBs.

In this work, we first design SnS<sub>2</sub> nanoparticles impregnated in the carbon nanofibers (SnS<sub>2</sub>/CNFs) through electrospinning and post sulfuration to take advantages of high capacity of SnS<sub>2</sub> nanoparticles and the self-standing electrode. The carbon nanofibers network provides a conductive host and inhibits the aggregation and the volume expansion of SnS<sub>2</sub>, thereby maintaining the structural stability of the electrode. The as-prepared free-standing SnS<sub>2</sub>/CNFs with good flexibility can be directly used as anode for SIBs and shows excellent electrochemical performance.

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# Construction of effective symmetrical air-cooled system for battery thermal management

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## HIGHLIGHTS

- Performance of the air-cooled BTMS is improved by structural design.
- Influence of the battery cell number on the performance of BTMS is studied.
- The symmetrical BTMS with uneven cell spacing is constructed.
- $\Delta T_{\max}$  and  $W_p$  of the designed BTMS are respectively reduced by 43% and 33%.
- The designed BTMS performs better than the optimized ones in previous studies.

## ARTICLE INFO

### Keywords:

Air-cooled battery thermal management  
Symmetrical system  
Uneven cell-spacing distribution  
Cooling performance improvement

## ABSTRACT

In an air-cooled battery thermal-management system, inducing a large temperature difference in a battery pack is very easy because of the low specific heat of air. In this study, we develop a simple method of constructing a symmetrical air-cooled system with uneven cell-spacing distribution to improve the cooling performance. First, the influence of the battery cell number on the performance of an air-cooled system is numerically studied. The results show that the system with fewer battery cells can achieve a more uniform temperature distribution, and the energy consumption of each cell is lower. Then, different symmetrical systems are constructed based on asymmetrical systems with various inlet and outlet positions. The comparisons indicate that the symmetrical systems perform much better than the asymmetrical ones. Finally, uneven cell-spacing distribution is applied to the symmetrical systems, and the corresponding distribution expressions are derived. Compared with the asymmetrical system, we achieve at least 43% reduction in the maximum cell-temperature difference and at least 33% reduction in the energy consumption. Furthermore, the designed systems perform better than the optimized ones in the previous studies.

## 1. Introduction

In recent years, electric vehicles (EVs) have rapidly been developed owing to their potential to mitigate the energy crisis and environmental problems. Lithium-ion battery pack is the power source of EVs, and its corresponding performance determines the EV performance. The lithium-ion battery pack releases a large amount of heat during operation, and this heat should be quickly dissipated to guarantee that the temperature and temperature difference of the battery pack are within an appropriate range. Therefore, battery thermal-management system (BTMS) is introduced.

Air [1–5], liquid [6–8], and phase-change-material cooling [9–11]

are main battery thermal-management technologies. Among them, air cooling is widely used owing to its advantages in terms of simple structure and light weight. However, a large temperature difference can easily occur in a battery pack because of the low specific heat of air. Therefore, much effort has been made to improve the cooling performance of air-cooled BTMS. Fan et al. [12] experimentally studied the air-cooling performance of aligned, staggered, and cross battery packs. They found that the system with aligned arrangement achieved the best temperature uniformity and lowest energy consumption. Pesaran et al. [13] designed air-cooled BTMSs with parallel and serial flows. The comparison showed that the system with a parallel flow achieved a smaller cell-temperature difference. Based on a parallel air-cooled

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# Novel pH-Responsive Smart Fabric: From Switchable Wettability to Controllable On-Demand Oil/Water Separation

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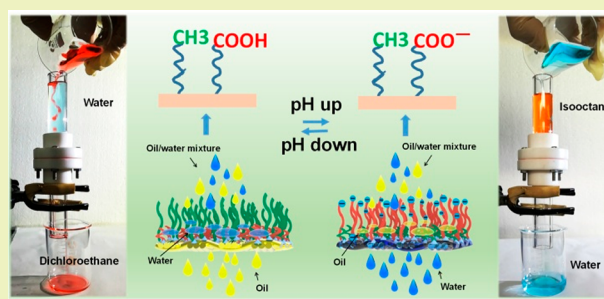
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## S Supporting Information

**ABSTRACT:** Stimulus-responsive materials have great potential in advanced controllable oil/water separation applications. Here, a novel, cost-effective, and green approach is developed to produce a pH-responsive smart fabric with switchable wettability. The approach first involves grafting polydopamine (PDA) and cystamine dihydrochloride (cystamine) on a fabric surface to obtain thiol-functionalized fabric (Fabric-SH). Hydrophobic stearyl methacrylate (SMA) and pH-responsive undecylenic acid are then decorated on the Fabric-SH surface through efficient and green photoinduced thiol–ene click coupling chemistry. The obtained fabric exhibits rapidly switchable wettability between superhydrophobicity and superhydrophilicity depending on the contacting liquid pH value and can be applied in controllable separation of various mixtures of water and oil with high efficiency up to 99%. More importantly, the as-prepared fabric is able to realize the separation of oil/water/oil ternary mixtures and can self-clean and repel oil fouling during the separation process. Its superhydrophobicity is robust, showing no significant change after a 500 cycle peeling test. This novel and cost-effective smart cotton fabric exhibits significant potential in satisfying different separation purposes under complicated conditions.

**KEYWORDS:** pH-responsive, Switchable wettability, Controllable oil/water separation, Efficient thiol–ene click coupling chemistry, Smart material



## INTRODUCTION

Rapidly increasing scientific and technological attention has been attracted in the field of oil/water separation over the past several decades because of serious oil pollution.<sup>1–5</sup> Oil/water separation materials with special wettability have been particularly studied in recent years and demonstrated to be convenient and effective.<sup>6–10</sup> Generally, these materials can be classified into three types: “oil-removing” type<sup>11,12</sup> with superhydrophobic and superoleophilic surface, “water-removing” type<sup>13</sup> because of their superhydrophilicity and underwater superoleophobicity, and smart controllable separation materials which can switch their surface wettability in response to external stimuli such as temperature,<sup>14,15</sup> pH,<sup>16,17</sup> light,<sup>18</sup> electric or magnetic field,<sup>19</sup> or chemical stimuli.<sup>20</sup> Among them, oil-removing materials are particularly convenient and desired for continuous oil/water separation systems. However, this type of material is inefficient for light oil/water mixtures (i.e.,  $\rho_{\text{oil}} < \rho_{\text{water}}$ ) as water would accumulate and form an additional barrier layer on the surface to prevent oil from contacting and passing through the separation materials.<sup>21</sup> Similarly, the water-removing type of material is not effective for heavy oil/water mixtures (i.e.,  $\rho_{\text{oil}} > \rho_{\text{water}}$ ). In addition, the water-removing

type of membrane can be easily polluted by oil in air, which leads to the loss of its underwater superoleophobicity. Smart separation materials with controllable wettability are able to overcome these drawbacks by wisely switching their surface from a superhydrophobic–superoleophilic surface to a superhydrophilic–underwater superoleophobic surface in a controllable manner. In addition to their flexibility to precisely separate both light oil and heavy oil feedstock, these smart oil/water separation materials also have advantages on accelerating separation rate, simplifying the separation setup, and reducing separation energy consumption; all of these greatly benefit oil-contaminated water treatment for different demands.

The pH-responsive smart separation materials represent one of the most exciting and emerging areas of scientific interest on account of their rapid response, easy operation, and wide applicability. Lee et al.<sup>22</sup> synthesized a copolymer [DPAEMA-co-TSPM] via conventional free radical polymerization and then coated this copolymer onto an electrospun fabric to obtain a pH-

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## PAPER

# Opposite superwetting magnetic stainless-steel mesh for multiple types of oil/water separation

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**Keywords:** superhydrophobicity, superhydrophilicity, magnetic, mechanical and chemical stability, oil/water separation

Supplementary material for this article is available [online](#)

## Abstract

Oil spill accidents and discharge of oily wastewater from human daily life occur frequently. More and more attention has been paid to wettable interface materials for oil/water separation. However, to date, there has been little reports about on-demand and continuous oil/water separation. Therefore, we proposed a simple and environmentally friendly method to construct rough surface structure by spraying magnetic Fe<sub>3</sub>O<sub>4</sub> nanoparticles, and modified the surface by attaching dopamine and grafting n-dodecyl mercaptan on dopamine to prepare SSM with opposite wetting properties. The obtained meshes exhibit excellent resistance to mechanical and chemical damages, and can be long-term storage. More importantly, the as-prepared superhydrophilic mesh and superhydrophobic mesh can be used to continuously separate oil-water mixtures with high efficiency. At the same time, they could be controlled by magnetic force, and have the application prospect in sewage treatment, oil-water separation and deep-sea oil leakage treatment.

## 1. Introduction

In 2018, the Carbon 9 products (C9) leakage occurred in Quanzhou, China, which caused serious pollution to the nearby sea areas. Moreover, the volatilization of C9 after leakage seriously polluted the air and endangered local people's life and health. Once the oil leakage accident occurs, the rapid and continuous handling method is urgently needed to reduce the loss of oil and avoid the secondary air pollution that caused by the oil volatilization [1–4]. Traditional oil/water separation techniques including burning, oil skimmers, centrifuges, coalescers, and flotation, have common shortcomings such as low separation efficiency, poor oil/water selectively, high energy cost and difficulty to achieve continuous oil-water separation [5–7]. Special wetting oil-water separation material is an effective oil-water separation technology with high separation efficiency, low energy consumption and no secondary pollution to water and oil, which has received extensive attention and research in recent years [8–10].

'Oil-removing' type materials [11, 12], 'water-removing' type materials [13–19] and smart controllable separation materials are three main types of special wettability oil-water separation materials [20, 21]. The 'oil-removing' materials owning superhydrophobicity and superoleophilicity are particularly handy and can be designed into continuous oil/water separation device. However, the 'oil-removing' materials have a poor separation ability for light oil/water mixtures ( $\rho_{\text{oil}} < \rho_{\text{water}}$ ) since water will accumulate on the membrane after sinking and the sinking liquid forms a barrier layer that oil is unable to contact and pass through the membrane [22]. Similarly, the 'water-removing' type materials owning superhydrophilicity and underwater superoleophobicity are not effectively for a heavy oil/water mixture ( $\rho_{\text{oil}} > \rho_{\text{water}}$ ). The smart controllable separation materials are able to overcome these drawbacks of 'oil-removing' and 'water-removing' type materials through switching the surface wettability controllably such as switching a superhydrophobic-superoleophilic surface into a superhydrophilic-underwater superoleophobic surface. However, smart

## Materials Research Express



## PAPER

## Robust superhydrophobic mesh with excellent chemical resistance for separation of complicated boiling water/oil mixtures

Xinjuan Zeng<sup>1</sup>, Kangquan Yang<sup>1</sup>, Kai Yang<sup>1</sup>, Shouping Xu<sup>1</sup>, Mengyi Xu<sup>2,3</sup>, Pihui Pi<sup>1,3</sup> and Xiufang Wen<sup>1,3</sup> <sup>1</sup> School of Chemistry and Chemical Engineering, South China University of Technology, Guangzhou, People's Republic of China 510640<sup>2</sup> School of Chemical Engineering and Technology, Guangdong Industry Polytechnic, Guangzhou, People's Republic of China 510300<sup>3</sup> Authors to whom any correspondence should be addressed.E-mail: 2010103089@gdip.edu.cn (M Y Xu), [phpi@scut.edu.cn](mailto:phpi@scut.edu.cn) and [xfwen@scut.edu.cn](mailto:xfwen@scut.edu.cn)**Keywords:** superhydrophobicity, mechanical stability, chemical resistance, boiling water repellent ability, high separation capabilitySupplementary material for this article is available [online](#)**Abstract**

Nowadays, inferior mechanical stability and poor resistance to chemical corrosion and hot water severely restricted the broad applications of superhydrophobic materials. In this work, a robust superhydrophobic mesh was prepared by using the cured thermoset phenolic resin (TPR) to anchor the hydrophobic SiO<sub>2</sub> nanoparticles on stainless-steel mesh surface (SiO<sub>2</sub>@TPR-SSM). The obtained superhydrophobic SiO<sub>2</sub>@TPR-SSM exhibits excellent resistance to various mechanical, chemical and high temperature damages. Violent hand kneading or 70 cycles of abrasion by sandpaper could not make the superhydrophobicity of SiO<sub>2</sub>@TPR-SSM lose. And it would not cause effect on its wettability with immersion in various organic solvents, or strong acid and high-concentration salt solution for 192 h. Even in boiling water or in the environment of 0 °C to 240 °C, the SiO<sub>2</sub>@TPR-SSM still could retain its superhydrophobicity. Moreover, the obtained superhydrophobic SiO<sub>2</sub>@TPR-SSM shows high separation capability in separating various water/oil mixtures and the separation cycles are larger than 200. And it also demonstrates high separation capability for boiling strong acid, base and high-concentration salt water/oil mixtures, which makes the SiO<sub>2</sub>@TPR-SSM into a promising material in industrial separation practice under harsh conditions.

**1. Introduction**

With the development of industry, lots of complicated water/oil mixtures are extremely urgent to be separated but is a huge challenge, such as oily water with corrosive medium and high-viscosity water-containing crude oil which cannot flow unless be heated to high temperature [1–3]. In recent years, the special wettability materials designed by combination of surface chemical composition and surface roughness have been widely studied to solve oil pollution issue on the basis of the interfacial phenomenon of oil and water, and proved to be convenient and effective [4–9].

Numerous special wettability separation materials are prepared by constructing inorganic nanostructures on the porous substrate surface [10–12], such as growing copper hydroxide nanowire [13, 14], ZnO nanorod [15, 16], TiO<sub>2</sub> nanowires [17], Cu<sub>2</sub>S nanoflake [18] or assembling inorganic particle SiO<sub>2</sub> [19], TiO<sub>2</sub> [20, 21] and attapulgite [22]. But the inorganic nanostructures on surface are instability and prone to be detached from the substrate, especially in high fluid pressure of practical application. The fluorine-free organic coatings or organic-inorganic hybrid coatings on porous substrate surface are also popularly used to prepare special wettability surface due to its simple production process and low cost [23–31]. These organic coating surfaces often have great mechanical stability because of the high adhesion between these coatings and substrate. However, these common organic coatings are easy to disintegrate in the organic solvent condition and harsh corrosion environment because of its poor resistance to organic solvents, chemical corrosions and hot water. Moreover, the organic solvents like methylbenzene, tetrahydrofuran and acetone, and corrosive mediums like acid, alkali and salt massively exist in the oily water and the water/oil mixtures coming from factory often contain a lot of

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Sincerely,

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