

附件 1-1

中国计量大学新增硕士研究生指导教师申请表（校内）

申请学位点：材料科学与工程

一、基本情况

姓 名	孟宪赫	性 别	男	出生年月	1989. 01
最高学位及授予单位	理学博士学位，北京科技大学				
最高学历（包括毕业时间、学校、院（系））	博士研究生学历（2019 年 1 月，北京科技大学 物理系）				
职称，获得职称年月	讲师，2019 年 1 月				
主要研究方向	新型储能材料与机理				
主要经历（包括学历和工作经历，从大学开始）					
自何年月	至何年月	部 门			任 职
2019. 01	至今	中国计量大学			讲师
2013. 09	2019. 01	北京科技大学			博士
2012. 09	2013. 07	北京科技大学			研究生
2008. 09	2012. 07	潍坊学院			本科

二、近五年立项主持的代表性科研项目（限填 3 项）

项目名称及编号	项目来源 (项目类型)	起止时间	合同经费 (万元)	本人排名 /总人数	学院 审核人
无					

三、近五年发表的代表性学术论文（限填 5 篇）

序号	论文名称	刊物名称	发表时间	SCI、SSCI、EI 收录情况	本人排名 / 总人数	学院审核人
1	Porous Ni@C derived from bimetallic Metal - Organic Frameworks and its application for improving LiBH ₄ dehydrogenation	Journal of Alloys and Compounds	2018.02	SCI(二区)	1/4 第一作者	
2	Rodlike CeO ₂ /carbon nanocomposite derived from metal - organic frameworks for enhanced supercapacitor applications	Journal of Materials Science	2018.06	SCI(三区)	1/4 第一作者	
3	Nickel/porous carbon composite derived from bimetallic MOFs for electrical double-layer supercapacitor application	International Journal of Electrochemical Science	2018.08	SCI(四区)	1/5 第一作者	
4	Hierarchical porous architectures derived from low-cost biomass <i>Equisetum arvense</i> as a promising anode material for lithium-ion batteries	Journal of Molecular Structure	2020.12	SCI(三区)	5/6 通讯作者	
5	Synthesis and Surface Engineering of Composite Anodes by Coating	ACS Applied Energy Materials	2021.06	SCI(二区)	2/6 通讯作者	

	Thin-Layer Silicon on Carbon Cloth for Lithium Storage with High Stability and Performance					
--	---	--	--	--	--	--

四、近五年出版的学术专著（只填写专著，限填1项）

序号	专著名称	出版社名称，时间	本人排名/ 总人数	学院 审核人
1	无			

五、近五年获省部级及以上科研成果奖（限填1项）

序号	获奖名称	授予单位，获奖等级，时间	本人排名/ 总人数	学院 审核人
1	无			

六、近五年本人为第一发明人授权的有效期内发明专利（限填2项）

序号	专利名称 (国别及专利号)	授权 时间	技术转让到账经 费(万元)	本人排名/ 总人数	学院 审核人
1	无				
2					
专利技术转让到校总经费：			(万元)		

七、近五年参与制定并颁布实施的规程/规范/标准（限填2项）

序号	成果名称（编号）	发布单位	发布时间及类别	本人排名/ 总人数	学院 审核人
1	无				
2					

<p>本人以上填写内容真实性、准确性无误，工作中未有学术不端行为，自觉践行“四个统一”，做学生成长成才的指导者和引路人。</p>	
申请人签名：	年 月 日
申请人所在基层党组织对申请者工作表现和师德师风的意见：	
党支部书记签名：	年 月 日
申请人所在学院意见：	
分管院长签名：	（学院盖章） 年 月 日
研究生院审核意见：	
	年 月 日

佐 证 材 料

一、近五年立项主持的代表性科研项目，包括：合同首页、参加人员页、经费页、签名盖章页。

二、近五年发表的代表性学术论文，包括：检索证明（需包含作者信息、期刊信息、发表时间、论文发表当年的中科院分区）、封面、目录、正文首页、刊号。

三、近五年出版的学术专著，包括：封面、目录、相关内容。

四、近五年获省部级及以上科研成果奖：获奖证书。

五、近五年授权发明专利：专利证书，专利有效证明。

六、近五年主持制定并颁布实施的规程/规范/标准：相关材料全文



中国计量大学图书馆 CJLULIB

文献检索报告
Retrieval Report

单号: RT-2021-0739

附件一: 经检索《Science Citation Index Expanded》, 下述论文被 SCI-E 收录。(检索时间2021年12月1日)

第1条, 共5条:

出版物类型: J

文献类型: Article

标题: Synthesis and Surface Engineering of Composite Anodes by Coating Thin-Layer Silicon on Carbon Cloth for Lithium Storage with High Stability and Performance

作者: Liu, HB (Liu, Hongbin); Meng, XH (Meng, Xianhe); Chen, Y (Chen, Yun); Zhao, Y (Zhao, Yue); Guo, XL (Guo, Xiaolin); Ma, TL (Ma, Tingli)

作者地址: [Liu, Hongbin; Chen, Yun; Zhao, Yue; Ma, Tingli] Kyushu Inst Technol, Grad Sch Life Sci & Syst Engr, Kitakyushu, Fukuoka 8080196, Japan.; [Meng, Xianhe; Guo, Xiaolin] China Jiliang Univ, Coll Mat & Chem, Hangzhou 310018, Peoples R China.

通讯作者地址: Ma, TL (corresponding author), Kyushu Inst Technol, Grad Sch Life Sci & Syst Engr, Kitakyushu, Fukuoka 8080196, Japan.; Meng, XH (corresponding author), China Jiliang Univ, Coll Mat & Chem, Hangzhou 310018, Peoples R China.

来源出版物: ACS APPLIED ENERGY MATERIALS 卷: 4 期: 7 页: 6982-6990 DOI: 10.1021/acs.aem.1c01049 出版年: 2021 出版日期: JUL 26

入藏号: WOS:000678382900063

核心合集中的 "被引频次": 0

语种: English

电子邮件地址: mengxhe@cjlu.edu.cn; tinglima@life.kyutech.ac.jp

IDS 号: TQ61W

ISSN: 2574-0962

JCR 期刊分区: CHEMISTRY, PHYSICAL [Q2] 46/162 (2020); ENERGY & FUELS [Q2] 34/114 (2020); MATERIALS SCIENCE, MULTIDISCIPLINARY [Q2] 87/333 (2020);

中科院期刊分区: 小类(基础版) (2020) 能源与燃料 [3]; 小类(基础版) (2020) 物理化学 [3]; 小类(基础版) (2020) 材料科学: 综合 [3]; 小类(升级版) (2020) 能源与燃料 [4]; 小类(升级版) (2020) 物理化学 [4]; 小类(升级版) (2020) 材料科学: 综合 [4]; 大类(基础版) (2020) 工程技术 [2]; 大类(升级版) (2020) 材料科学 [3];

第2条, 共5条:

出版物类型: J

文献类型: Article

标题: Hierarchical porous architectures derived from low-cost biomass equisetum arvense as a promising anode material for lithium-ion batteries

作者: Chen, Y (Chen, Yun); Liu, HB (Liu, Hongbin); Jiang, B (Jiang, Bo); Zhao, Y (Zhao, Yue); Meng, XH (Meng, Xianhe); Ma, TL (Ma, Tingli)

作者地址: [Chen, Yun; Liu, Hongbin; Jiang, Bo; Zhao, Yue; Ma, Tingli] Kyushu Inst Technol, Grad Sch Life Sci & Syst Engr, 2-4 Hibikino, Kitakyushu, Fukuoka, Japan.; [Meng, Xianhe; Ma, Tingli] China Jiliang Univ, Coll Mat & Chem, Hangzhou 310018, Peoples R China.

通讯作者地址: Ma, TL (corresponding author), Kyushu Inst Technol, Grad Sch Life Sci & Syst Engr, 2-4 Hibikino, Kitakyushu, Fukuoka, Japan.; Meng, XH (corresponding author), China Jiliang Univ, Coll Mat & Chem, Hangzhou 310018, Peoples R China.

来源出版物: JOURNAL OF MOLECULAR STRUCTURE 卷: 1221 页: 8 DOI: 10.1016/j.molstruc.2020.128794 出版年: 2020 出版日期: DEC 5

入藏号: WOS:000598738800016

核心合集中的 "被引频次": 3

语种: English

电子邮件地址: mengxhe@cjlu.edu.cn; tinglima@life.kyutech.ac.jp

IDS 号: PF0EW

ISSN: 0022-2860

eISSN: 1872-8014

JCR 期刊分区: CHEMISTRY, PHYSICAL [Q3] 83/162 (2020);

中科院期刊分区: 小类(基础版) (2020) 物理化学 [4]; 小类(升级版) (2020) 物理化学 [3]; 大类(基础版) (2020) 化学 [4]; 大类(升级版) (2020) 化学 [3];

第3条, 共5条:

出版物类型: J

文献类型: Article

标题: Rodlike CeO₂/carbon nanocomposite derived from metal-organic frameworks for enhanced supercapacitor applications

作者: Meng, XH (Meng, XianHe); Wan, CB (Wan, ChuBin); Jiang, XP (Jiang, XiaoPing); Ju, X (Ju, Xin)

作者地址: [Meng, XianHe; Wan, ChuBin; Ju, Xin] Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.; [Jiang, XiaoPing] Qilu Univ Technol, Shandong Prov Key Lab High Strength Lightweight M, Adv Mat Inst, Shandong Acad Sci, Jinan 250014, Shandong, Peoples R China.

通讯作者地址: Ju, X (corresponding author), Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.

来源出版物: JOURNAL OF MATERIALS SCIENCE 卷: 53 期: 19 页: 13966-13975 DOI: 10.1007/s10853-018-2536-5 出版年: 2018 出版日期: OCT

入藏号: WOS:000440047900058

核心合集中的 "被引频次": 12

语种: English

电子邮件地址: jux@ustb.edu.cn

IDS 号: GO5GV

ISSN: 0022-2461

eISSN: 1573-4803

JCR 期刊分区: MATERIALS SCIENCE, MULTIDISCIPLINARY [Q2] 82/293 (2018);

中科院期刊分区: 小类(基础版) (2018) 材料科学: 综合 [3]; 大类(基础版) (2018) 工程技术 [3];

第4条, 共5条:

出版物类型: J

文献类型: Article

标题: Porous Ni@C derived from bimetallic Metal-Organic Frameworks and its application for improving LiBH₄ dehydrogenation

作者: Meng, XH (Meng, XianHe); Wan, CB (Wan, ChuBin); Wang, YT (Wang, YuTing); Ju, X (Ju, Xin)

作者地址: [Meng, XianHe; Wan, ChuBin; Ju, Xin] Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.; [Wang, YuTing] Tsinghua Univ, Sch Mat Sci & Engn, State Key Lab New Ceram & Fine Proc, Beijing, Peoples R China.

通讯作者地址: Ju, X (corresponding author), Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.

来源出版物: JOURNAL OF ALLOYS AND COMPOUNDS 卷: 735 页: 1637-1647 DOI: 10.1016/j.jallcom.2017.11.191 出版年: 2018 出版日期: FEB 25

入藏号: WOS:000418518600200

核心合集中的 "被引频次": 13

语种: English

电子邮件地址: jux@ustb.edu.cn

IDS 号: FQ7BU

ISSN: 0925-8388

eISSN: 1873-4669

JCR 期刊分区: MATERIALS SCIENCE, MULTIDISCIPLINARY [Q1] 65/293 (2018); METALLURGY & METALLURGICAL ENGINEERING [Q1] 6/76 (2018); CHEMISTRY, PHYSICAL [Q2] 47/148 (2018);

中科院期刊分区: 小类(基础版) (2018) 物理化学 [3]; 小类(基础版) (2018) 材料科学: 综合 [3]; 小类(基础版) (2018) 冶金工程 [1]; 大类(基础版) (2018) 工程技术 [2] Top 期刊;

第 5 条, 共 5 条:

出版物类型: J

文献类型: Article

标题: Nickel/Porous Carbon Composite Derived from Bimetallic MOFs for Electrical Double-Layer Supercapacitor Application

作者: Meng, XH (Meng, XianHe); Wan, CB (Wan, ChuBin); Yu, SY (Yu, Suye); Jiang, XP (Jiang, XiaoPing); Ju, X (Ju, Xin)

作者地址: [Meng, XianHe; Wan, ChuBin; Yu, Suye; Ju, Xin] Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.; [Jiang, XiaoPing] Shandong Acad Sci, Adv Mat Inst, Shandong Key Lab High Strength Lightweight Metall, Jinan 250014, Shandong, Peoples R China.

通讯作者地址: Ju, X (corresponding author), Univ Sci & Technol Beijing, Dept Phys, Beijing, Peoples R China.

来源出版物: INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE 卷: 13 期: 8 页: 8179-8188 DOI: 10.20964/2018.08.49 出版年: 2018

出版日期: AUG

入藏号: WOS:000441821400075

核心合集中的 "被引频次": 3

语种: English

电子邮件地址: jux@ustb.edu.cn

IDS 号: GQ6KR

ISSN: 1452-3981

JCR 期刊分区: ELECTROCHEMISTRY [Q4] 22/26 (2018);

中科院期刊分区: 小类(基础版) (2018) 电化学 [4]; 大类(基础版) (2018) 化学 [4];





Porous Ni@C derived from bimetallic Metal–Organic Frameworks and its application for improving LiBH₄ dehydrogenation

XianHe Meng^a, ChuBin Wan^a, YuTing Wang^b, Xin Ju^{a,*}

^a Department of Physics, University of Science and Technology Beijing, Beijing, China

^b State Key Laboratory of New Ceramics and Fine Processing, School of Materials Science and Engineering, Tsinghua University, Beijing, China

ARTICLE INFO

Article history:

Received 27 May 2017

Received in revised form

5 August 2017

Accepted 15 November 2017

Available online 16 November 2017

Keywords:

Lithium borohydride

Dehydrogenation

MOFs

Ni nanoparticles

Porous carbon

ABSTRACT

Hierarchically porous activated carbon (PAC) and Ni@C composite materials have been synthesized initially from MOF-5 and bimetallic Ni(II)-doped MOF-5s with the effective incorporation of Ni²⁺ ions into the frameworks. The products (PAC-1, Ni@C-1 and Ni@C-2) derived from MOFs contained rich micro/mesoporous structure and high specific surface areas (SSA): 2247, 919, and 484 m² g^{−1}, respectively. Interestingly, LiBH₄ doped with Ni@C-1 showed the lowest onset temperature around 180 °C and fastest dehydrogenation kinetics. Results reveal that favorable synergistic effects of nanoconfinement and catalysis in Ni@C materials may improve hydrogen desorption kinetics, which demonstrates a promising strategy for the hydrogen-storage application of LiBH₄.

© 2017 Elsevier B.V. All rights reserved.

1. Introduction

Hydrogen is the most promising energy fuel for future various applications, and hydrogen storage has attracted an enormous amount of research in recent years [1]. Complex metal hydrides are typical hydrogen storage materials with wide attention because of their high gravimetric H₂ capacity. Notably, Lithium borohydride (LiBH₄) possesses one of the highest theoretical gravimetric hydrogen storage capacities 18.5 wt.%, but requires temperatures around 460 °C to dehydrogenate and only rehydrogenate at 600 °C under 350 bar of H₂ [2,3]. A number of novel strategies, such as destabilization by catalyst doping, confinement in porous materials have therefore been adopted to reduce the desorption enthalpy, improve the dehydrogenation reaction kinetics readily achievable under normal conditions [4,5]. The addition of carbon such as graphite/graphene, carbon nanofibers, carbon nanotubes, activated carbon to LiBH₄ have been explored exhibiting prominent advantage, which may be ascribed to the synergistic effect of destabilization and confinement in porous carbon materials [6–11]. The catalytic effect of transition metals, metal chlorides, metal halides, and metal oxides on the hydrogen storage properties of LiBH₄ have

also recently been comprehensively investigated and have led to lower onset temperature, increased dehydrogenation capacity [5,12–15]. Among these catalysts, nanoscale Ni additives are typical catalysts for LiBH₄ by virtue of their high catalytic effect, low cost and benign environmental effect [16–19].

Recently, Metal–organic frameworks (MOFs) always as highly porous crystalline materials constructed by coordination bonds between metal ions/clusters and organic ligands to form three-dimensional (3D) structures have attracted intense interest during the past two decades [20,21]. MOFs have been developed very quickly, not only in terms of their broad range of structures, topologies and compositions, but also their potential applications: gas storage and separation [22–25], sensors [26,27], catalysis [28,29] and drug delivery [30], which are due to their special properties (e.g. a low-density porous structure, surface area, hybrid features and tunable porosity). MOF-5 is one of the most prominent representatives of these porous materials. It consists of four [Zn₄O]⁶⁺ clusters in octahedral subunits that are connected to each other by benzene-1,4-dicarboxylate (BDC) groups, to form a porous cubic framework [31]. This special structure of MOF-5 gives large surface area, exceptional pore volume and relatively high thermal stability, which displays considerable applications in many fields. Besides, there are a few works reported on increasing the functionality for MOF-5 with the effective incorporation of metal ions (such as Co²⁺, Ni²⁺, etc.) into the material framework by one-pot or

* Corresponding author.

E-mail address: jux@ustb.edu.cn (X. Ju).



Rodlike CeO₂/carbon nanocomposite derived from metal–organic frameworks for enhanced supercapacitor applications

XianHe Meng¹, ChuBin Wan¹, XiaoPing Jiang², and Xin Ju^{1,*}

¹Department of Physics, University of Science and Technology Beijing, Beijing, People's Republic of China

²Shandong Provincial Key Laboratory for High Strength Lightweight Metallic Materials, Advanced Materials Institute, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250014, People's Republic of China

Received: 20 March 2018

Accepted: 31 May 2018

© Springer Science+Business Media, LLC, part of Springer Nature 2018

ABSTRACT

The rod-shaped CeO₂@C architectures have been synthesized by novel and facile methods initially from metal–organic frameworks (MOFs). The MOF-derived material showed a pseudocapacitance of 1102 F g^{−1} at 2 A g^{−1} and 418 F g^{−1} at a high current density of 20 A g^{−1} and had excellent cyclic stability of about 2.3% decrease after 5000 cycles. Results revealed that favorable effects of dispersed partially graphitic carbon in the CeO₂@C composite could improve electronic conductivity, which made this product be an alternative high-performance electrode for supercapacitors.

Introduction

With the increasing demands for energy and the growing concerns about air pollution and global warming, the choice of effective energy storage more environmentally friendly is very urgent. Among the major energy storage systems, supercapacitors are confirmed as an excellent promising clean electrochemical energy storage (EES) devices with a wide range of applications because of their high power delivery, long cycle life and fast charge–discharge dynamic characteristics. Supercapacitors have drawn more and more attention in recent years and been classified into two major types: electric double-layer capacitors (EDLCs) and pseudocapacitors, based on charge storage mechanisms and active materials

utilized [1, 2]. The EDLCs usually made of mesoscopic materials such as activated carbon, carbon nanotube and graphene come from pure electrostatic charges accumulated at the interface of electrode/electrolyte showing large power density and long cycle life, but low electrochemical capacitance [3, 4]. In contrast to EDLCs, pseudocapacitors such as some transition metal oxides/hydroxides exhibit larger specific capacitance owing to the fast and reversible faradic redox reactions of electroactive materials, but always have poor electrical conductivity [5–8]. Considering this, the hybrid electrodes with transition metal oxides/hydroxides and carbon have been studied, which show the combined advantages of pseudocapacitors and EDLCs to

Address correspondence to E-mail: jux@ustb.edu.cn

Nickel/Porous Carbon Composite Derived from Bimetallic MOFs for Electrical Double-Layer Supercapacitor Application

XianHe Meng¹, ChuBin Wan¹, SuYe Yu¹, XiaoPing Jiang², Xin Ju^{1,*}

¹ Department of Physics, University of Science and technology Beijing, Beijing, P. R. China

² Shandong Key Laboratory for High Strength Lightweight Metallic Materials, Advanced Materials Institute, Shandong Academy of Sciences, Jinan 250014, P. R. China

*E-mail: jux@ustb.edu.cn

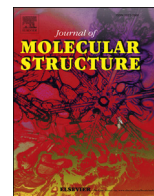
Received: 11 April 2018 / Accepted: 8 June 2018 / Published: 5 July 2018

A novel method to synthesize nickel/ porous activated carbon composite materials has been proposed initially from bimetallic Ni(II)-MOF-5s. Electrochemical results present that the nickel /activated carbon maintains nearly 83 % capacity with the current density increases from 0.2 to 50 A g⁻¹ and shows excellent cyclic stability of about 1.5 % decrease after 5000 cycles. This product also demonstrated a good rectangularity at a high scan voltage of 2 V s⁻¹ and very low charge transfer resistance of approximately 0.35 Ω, which can be a prospective electrode material for electrochemical double-layer supercapacitor applications.

Keywords: Bimetallic MOFs; Ni nanoparticles; Graphitic porous carbon; Supercapacitor

1. INTRODUCTION

Over the past few decades, electrochemical double-layer capacitors (EDLCs) have been successfully applied in high-power-density energy-storage devices; EDLCs can also be used for various energy conversion applications[1-3]. Carbon-based materials are important high-performance EDLCs electrode materials due to their excellent inherent features such as high electrical conductivity, physicochemical stability, high specific surface areas, acceptable cost and environmental friendliness [4-7]. The ideal EDLC electrode materials would exhibit satisfactory conductivity and interconnected channels to accelerate ion dispersion efficiently [6-8]. However, it is crucial to design novel carbon materials to improve high-rate electrochemical processes such as electronic transport and ion diffusion in porous electrodes. Recently, one possible route for enhancing the conductivity and electrochemical performances of these materials through doping with metallic Ni via various synthetic methods has been developed [9-12]. These studies suggest that the Ni/C hybrid composite materials could enhance



Hierarchical porous architectures derived from low-cost biomass *Equisetum arvense* as a promising anode material for lithium-ion batteries

Yun Chen^a, Hongbin Liu^a, Bo Jiang^a, Yue Zhao^a, Xianhe Meng^{b,*,**}, Tingli Ma^{a,b,*}

^a Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu, Kitakyushu, Japan

^b College of Materials and Chemistry, China Jiliang University, Hangzhou, 310018, PR China

ARTICLE INFO

Article history:

Received 26 May 2020

Received in revised form

18 June 2020

Accepted 28 June 2020

Available online 2 July 2020

Keywords:

Equisetum arvense

SiO_x/C

Environmental-friendly

Lithium-ion batteries

Anode

ABSTRACT

Biomass-derived carbonaceous materials as anodes for Lithium-ion batteries have been paid much attention due to the low cost and Environmental-friendly. So far, *Equisetum Arvense* (EQ), wide grass as anode electrodes of Li-ion battery has not been reported. The *Equisetum Arvense* (>30 wt% silica) is one of the highest Si accumulators in the plant kingdom with a widely distributed and strong reproductive ability. In this work, we used ZnCl₂ as an activator during carbonization and obtained a hierarchically porous structure with a high specific surface area. When taken as an anode in Li-ion batteries, it exhibits remarkable capacities (773 mA h g⁻¹ at 0.1 A g⁻¹) following 100 cycles and desirable rate performance (472 mA h g⁻¹ at 1 A g⁻¹). The hierarchical structure and naturally dispersed carbon network in this SiO_x/C composite can provide stable solid electrolyte interphase, maintain its structural integrity and improve the electronic and ionic conductivity, thus ensuring an excellent electrochemical performance. The proposed SiO_x/C composite has a bright future for next-generation LIBs anodes with environmental-friendly and large-scale (low-cost) production.

© 2020 Published by Elsevier B.V.

1. Introduction

The ever-increasing demand for high-energy density and desirable cycling performance in lithium-ion batteries has stimulated advanced research of anode materials [1–5]. At present, graphite is commonly applied as anode due to such advantages as cheap affordability, mass production and long service life. In spite of this, the capacity of graphite is 372 mA h g⁻¹, which is incapable to satisfy the demands of LIBs. Silicon (Si) is most suitable as anode in lithium-ion batteries (LIBs) due to the excellent capacity in theory (~4200 mA h g⁻¹) [6]. However, the huge volume increase (~300%) during Li⁺ insertion/extraction hinders its commercial progress [7–9]. Intensive efforts have led to the discovery that SiO_x could be a potential substitute for Si due to its excellent cycling performance, low cost, and easy synthesis. Nevertheless, the low

intrinsic electronic and ionic conductivities of SiO_x still result in a poor electrochemical performance of the LIBs [10–13].

Extensive research studies have demonstrated that carbon is a promising substrate for the anode due to its high conductivity and capability to prevent the aggregation of SiO_x. A series of SiO_x/C composites have been prepared, such as homogeneous SiO_x/C microspheres [14], graphite-like blocky SiO_x/C [15], three-layer C@SiO₂@C composites [16], SiO_x@C composite nanorods [17], and Yolk@Shell SiO_x/C [18] which show enhanced LIB performances. However, the synthesis techniques, such as chemical vapor deposition of the expensive and highly pyrophoric silane, require the involvement of complex equipment. It remains challenging to find a simple method to synthesize SiO_x/C with an optimized structure [19,20].

Considering the environmental, economic and social issues, biomass-derived products are becoming an appealing resource [21]. In fact, there are already many plenty of biomass materials that have been studied for application in lithium-ion batteries. The research mainly focuses on two aspects, which are biomass-derived carbonaceous materials and biomass-derived Si-based materials. On the one hand, biomass-derived carbonaceous materials have been reported, for example, sugarcane [22], wheat straw [23],

* Corresponding author. Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu, Kitakyushu, Japan.

** Corresponding author.

E-mail addresses: mengxhe@cjlu.edu.cn (X. Meng), tinglima@life.kyutech.ac.jp (T. Ma).

Synthesis and Surface Engineering of Composite Anodes by Coating Thin-Layer Silicon on Carbon Cloth for Lithium Storage with High Stability and Performance

Hongbin Liu, Xianhe Meng,* Yun Chen, Yue Zhao, Xiaolin Guo, and Tingli Ma*



Cite This: *ACS Appl. Energy Mater.* 2021, 4, 6982–6990



Read Online

ACCESS |



Metrics & More



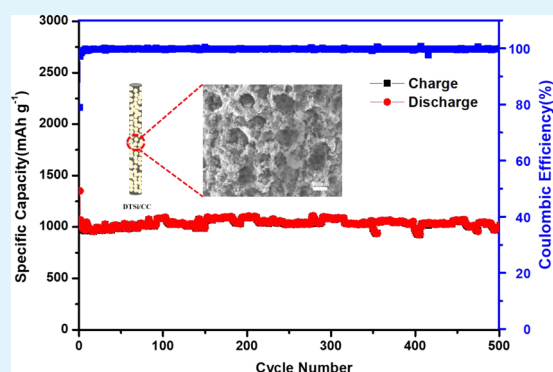
Article Recommendations



Supporting Information

ABSTRACT: Silicon-flexible carbon composites can achieve binder-free application and solve the problem of silicon expansion during cycles. The effective loading and dispersion of silicon onto carbon play an important role in improving the performance of anode materials. Herein, surface engineering of the hole-opening process was successfully achieved before the deposition of silicon. This resulted in fine holes on the carbon cloth, increasing the specific surface area to provide abundant confined spaces for dispersing nano-silicon. A composite structure was formed and structurally optimized by depositing an ultra-thin silicon layer in the holes of mesoporous carbon fiber cloth (DTSi/CC), improving the conductivity of the material, increasing the migration rate of lithium ions, and inhibiting the volume expansion of the anode material during the cycles. At 100 mA g^{-1} , the fabricated half-cells achieved a reversible capacity of 1457 mA h g^{-1} and retained 70.9% initial capacity after 100 cycles. Even when the current density was increased to 1.0 A g^{-1} , they boasted a capacity of 1037 mA h g^{-1} and had 76.8% capacity retention after 500 cycles. Free of binders and conductive additives, the DTSi/CC composite was directly used as the anode, exhibiting superior properties with high reversible specific capacity, excellent cyclic performance, and good rate capability. This study provides a straightforward, effective route to obtain high-performance silicon-based anode materials for lithium-ion batteries.

KEYWORDS: surface engineering, energy, thin silicon, LIB anode, ultra-stable



INTRODUCTION

Against the backdrop of climate change and dwindling fossil fuel resources, electronic devices are becoming more and more important. Lithium-ion batteries (LIBs), widely used in electronic equipment, electric vehicles, and energy storage, have increasingly higher requirements for energy density, electrochemical cycling, and safety performance.^{1–3} However, due to the specific capacity of conventional cathode and anode active materials, it is difficult for the current generation of commercial batteries to meet the demand for higher energy density. Therefore, as an important component of LIBs, the development and research of new high-capacity and -rate-capability lithium storage anode materials have an extremely high research value and widespread application prospects.^{4–6} With the abundance and low cost of raw materials and a higher theoretical specific capacity of 4200 mA h g^{-1} , the silicon materials have signified a great increase compared to conventional commercial anode materials such as graphite (372 mA h g^{-1}).⁷ Silicon materials are thus considered to be the most promising alternative to graphite for the next generation of LIB anodes.^{8,9}

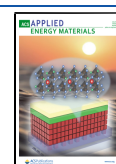
The biggest drawback of silicon-based negative electrodes is that they cannot effectively curb the volume expansion

resulting from the charge and discharge process.^{10–13} The volume expansion rate of the crystal lattice after charge and discharge is as high as 300%. With the resulting stress unable to be effectively released, the anode material cracks and pulverizes, thereby losing electrical contact with the current collector.^{14–17} Furthermore, the solid–electrolyte interphase (SEI) film on the surface of the anode material is destroyed, with the constantly regenerating electrolyte film consuming a large amount of electrolytes and causing more side reactions, which ultimately leads to a linear decline of the electrochemical performance.^{18–20} In addition, the intrinsic conductivity of silicon materials is very low, resulting in a slow electron conduction rate and a poor rate performance of the anode.^{21,22} Evidently, there is still a long way to go for the application of silicon anode materials.

Received: April 10, 2021

Accepted: June 17, 2021

Published: June 28, 2021



ARTICLE

MOFs and their derivatives as Sn-based anode materials for lithium/sodium ion batteries

Kaiyuan Liu ^a, Chao Li ^a, Lijing Yan ^a, Meiqiang Fan ^a, Yechao Wu ^a, Xianhe Meng ^{a*}, Tingli Ma ^{a,b*}Received 00th January 20xx,
Accepted 00th January 20xx

DOI: 10.1039/x0xx00000x

The rapid development of electric vehicles and consumer electronics places higher demands on the performance of secondary batteries. Tin-based materials are expected to be a commercial anode material candidate of next-generation rechargeable batteries due to their high gravimetric/volumetric capacity. However, tin anodes have large volume changes during charge-discharge cycles which leads to a rapid capacity decay. The emerging tin-based metal-organic frameworks (Sn-MOFs) recently attracted the attention of researchers. Their characteristics of tunable porosity, huge surface area and multiple active sites offer a wide range of possibilities for Li/Na ions storage and transport, and the coordination bonds stabilize the Sn atoms to the organic matrix buffering the pulverization and aggregation. Besides, MOFs-related Sn derivatives could also have novel diverse functional structures and achieve high-rate capacity and excellent cycle stability. In this review, we mainly summarize the structures features, energy storage mechanism, recent advances in rational design and preparation of Sn-MOFs and MOFs-derived Sn-based composites for LIBs and SIBs anodes, and the current challenges and future directions for further development are discussed.

1. Introduction

With the continuous development of the global economy, energy supply systems play a huge role in human production and life. Nowadays, the demand for energy is growing, as are the concerns about related issues such as global climate change and local environmental degradation. Therefore, it is the key research content to develop clean, safe and sustainable technologies in the field of energy applications. After nearly 30 years of development, lithium-ion batteries (LIBs) have been widely used in consumer electronics, electric vehicles and renewable energy storage.¹⁻⁴ It has the advantages of high energy density, long cycle life, low self-discharge rate, and no memory effect. At the same time, with the continuous diversification development of secondary batteries, Sodium-ion batteries (SIBs) serve as another promising rechargeable battery, which began in the 1980s and developed almost at the same time as LIBs.^{5, 6} More importantly, compared with the increasing shortage of lithium resources, sodium minerals are cheaper, more abundant, and available worldwide.^{7, 8} However, the relative atomic mass of sodium (22.99 g mol⁻¹) and the standard electrode potential (−2.71 V vs. SHE) are higher than those of lithium (6.94 g mol⁻¹, −3.04 V vs. SHE).⁸ As a result, the energy density of SIBs is generally lower than that of LIBs. In addition, the larger ionic radius of sodium leads to slow

electrochemical interface reaction kinetics and limits the types of applicable electrode materials. Overall, the two kinds of secondary batteries are mutually complementary, and the related electrode materials are constantly researched and updated to enhance performance.⁹⁻¹¹

At present, graphite and hard carbon are the most widely used commercial anode materials for LIBs and SIBs, respectively. However, their low theoretical specific capacities limit the energy density of full cells, which hardly meets the growing demand in many emerging fields. Therefore, it is of great significance to develop the next-generation anode materials with high reversible capacity and long-term cycling stability.¹¹⁻¹⁸ Metallic tin (Sn) and its oxides, sulfides and alloys have caught great attention since they can form alloys with lithium or sodium and have much higher specific capacities than graphite and hard carbon.¹⁹⁻²³ Besides, Sn-based anode materials have the advantages of environment-friendly, low cost and high security. However, the drastic volume change of Sn during alloying/dealloying (260% for LIBs and 420% for SIBs) causes a series of negative consequences, such as the pulverization of active materials and the continuous formation of SEI film, resulting in a rapid decline in reversible capacity.^{23, 24} To solve these issues, a large number of modification strategies have been developed, including reducing the particle size, introducing inert metals, and combining with carbon materials. In addition, well-designed structures such as hollow structure, layered structure and core-shell structure play a key role in alleviate the volume expansion.^{25, 26} However, some other novel strategies should also be proposed to further explore and expand the applicability of Sn-based materials.

Metal-organic frameworks (MOFs) are rapidly developing functional porous materials which consist of organic ligands and

^a College of Materials and Chemistry, China Jiliang University, Hangzhou, 310018, PR China.

^b Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology, 2-4 Hibikino, Wakamatsu-ku, Kitakyushu-shi, Fukuoka, 808-0196, Japan.

*Corresponding author. E-mail address: mengxhe@cjlu.edu.cn (Xianhe Meng); tinglima6@gmail.com (Tingli Ma).