DEVELOPMENT OF HIGH PERFORMANCE SUPERCAPACITOR USING MANGANESE OXIDE, CONDUCTING POLYMERS AND CARBON-BASED FIBER COMPOSITES

MUHAMMAD AMIRUL AIZAT BIN MOHD ABDAH

FS 2019 58

DEVELOPMENT OF HIGH PERFORMANCE SUPERCAPACITOR USING MANGANESE OXIDE, CONDUCTING POLYMERS AND CARBON-BASED FIBER COMPOSITES

By

MUHAMMAD AMIRUL AIZAT BIN MOHD ABDAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

July 2019

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

DEVELOPMENT OF HIGH PERFORMANCE SUPERCAPACITOR USING MANGANESE OXIDE, CONDUCTING POLYMERS AND CARBON-BASED FIBER COMPOSITES

By

MUHAMMAD AMIRUL AIZAT BIN MOHD ABDAH

July 2019

Chair : Associate Professor Yusran Sulaiman, PhD
Faculty : Sains

An efficient energy storage device, supercapacitors have received great attention in achieving high specific capacitance due to its unique characteristics such as rapid charging/discharging rate, high specific power and good long-term cyclability. The fabrication of hybrid supercapacitors has been exploited to enhance the electrocapacitive performance of the electrode. In the present work, manganese oxide (MnO_2), conducting polymers and carbon based fiber composites were rationally designed and fabricated as symmetrical (polyvinyl alcohol (PVA)-graphene oxide (GO)-MnO_2/poly (3,4-ethylenedioxythiophene) (PEDOT) (PVA-GO-MnO_2/PEDOT), carbon nanofibers (CNFs)-MnO_2/polypyrrole (PPy) (CNFs-MnO_2/PPy) and functionalised carbon nanofibers (*f*-CNFs)/PPy/MnO_2) and asymmetrical (*f*-CNFs/PEDOT/MnO_2//activated carbon (AC) and porous functionalised carbon nanofibers (P-*f*-CNFs)/PEDOT/MnO_2//PCNFs) (ASC) supercapacitors. The morphology and chemical properties of all prepared electrodes were examined by means of field emission scanning electron microscopy (FESEM), Fourier transform infrared (FTIR), Raman spectroscopy and X-ray diffraction (XRD). The MnO_2 valence state (Mn^{4+}) was confirmed by the presence of two distinctive peaks of MnO_2 by X-ray photoelectron microscopy (XPS). Porous functionalised carbon nanofibers (P-*f*-CNFs) was initially optimised using different polyacrylonitrile /polytetrafluoroethylene (PAN/PTFE) blend ratio (1:2, 2:1, 2:3 and 3:2) in order to obtain mesoporous structure. Using PAN/PTFE (2:3), the capacitance of P-*f*-CNFs displayed the highest (176.6 F/g) with a specific surface area of 281 m^2/g. The electrochemical performances of MnO_2 based fiber composites were studied using two-electrode configuration in 1 M KCl electrolyte. Interestingly, the assembled ASC P-*f*-CNFs/PEDOT/MnO_2//PCNFs showed an excellent specific capacitance of 719.8 F/g compared to *f*-CNFs/PPy/MnO_2 (409.88 F/g), *f*-CNFs/PEDOT/MnO_2//AC (354 F/g), CNFs-

MnO_2/PPy (315.80 F/g) and PVA-GO-MnO_2/PEDOT (144.66 F/g) at 25 mV/s. A good synergistic effect contributed by each material in P-*f*-CNFs/PEDOT/MnO_2//PCNFs possessed remarkable specific energy of 60.5 Wh/kg and specific power of 555.3 W/kg at 0.6 A/g, indicating excellent electrochemical capacity. In addition, the enhancement of surface wettability and good mechanical strength of P-*f*-CNFs/PEDOT/MnO_2//PCNFs ASC demonstrated better cycle life with 104.6% initial capacitance over 5000 cycles compared to other electrodes. Three assembled ASC devices could successful light up 25 red light emitting diodes (LEDs), implying the capability of this material to be used in the practical supercapacitor application. Therefore, P-*f*-CNFs/PEDOT/MnO_2//PCNFs could be considered as a prospective candidate for high performance supercapacitor due to its remarkable supercapacitive performance.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN SUPERKAPASITOR BERPRESTASI TINGGI MENGGUNAKAN MANGAN OKSIDA, POLIMER KONDUKSI DAN KARBON BERASASKAN FIBER KOMPOSIT

Oleh

MUHAMMAD AMIRUL AIZAT BIN MOHD ABDAH

Julai 2019

Pengerusi : Prof Madya Yusran Sulaiman, PhD
Fakulti : Sains

Satu alat penyimpanan tenaga baru yang cekap, superkapasitor telah mendapat perhatian yang tinggi dalam mencapai kapasitan spesifik yang tinggi disebabkan oleh ciri-cirinya yang unik seperti kadar caj/discaj yang pantas, kuasa spesifik yang tinggi dan jangka hayat kitaran yang baik. Pembuatan superkapasitor hibrid telah dieksploitasi untuk meningkatkan prestasi elektrokapasitif elektrod. Dalam penyelidikan ini, komposit fiber berasaskan mangan oksida (MnO_2), polimer konduksi dan karbon direka bentuk secara rasional dan dihasilkan sebagai simetri (poli(vinil alkohol)-grafen oksida-MnO_2-poli(3,4-etilenadioksitiofena) (PVA-GO-MnO_2/PEDOT), nanofiber karbon- mangan oksida/polipirol (CNFs-MnO_2/PPy) dan nanofiber karbon berfungsi/polipirol/mangan oksida (*f*-CNFs/PPy/MnO_2) dan asimetri nanofiber karbon berfungsi/poli(3,4-etilenadioksitiofena)/mangan oksida//karbon aktifan (*f*-CNFs/PEDOT/MnO_2//AC) dan nanofiber karbon berfungsi yang berliang/poli(3,4-etilenadioksitiofena)/mangan oksida//nanofiber karbon yang berliang (P-*f*-CNFs/PEDOT/MnO_2//PCNFs) superkapasitor asimetri (ASC). Morfologi dan ciri-ciri kimia bagi semua elektrod yang disediakan telah diperiksa dengan menggunakan FESEM, spektroskopi Fourier inframerah (FTIR), spektroskopi Raman dan belauan sinar-X (XRD). Keadaan valens MnO_2 (Mn^{4+}) telah disahkan dengan kehadiran dua puncak tersendiri bagi MnO_2 oleh spektroskopi fotoelektron sinar-X (XPS). Pada awalnya, nanofiber karbon berfungsi yang berporos tinggi (P-*f*-CNFs) dioptimumkan dengan menggunakan campuran poliakrilonitril/politetrafluoroetilena (PTFE) (PAN/PTFE) yang berbeza (1:2, 2:1,2:3 and 3:2) untuk mendapatkan struktur liang meso. Dengan menggunakan PAN/PTFE (2:3), P-*f*-CNFs menunjukkan kapasitan yang paling tinggi (176.6 F/g) dengan luas permukaan spesifik sebanyak 281 m^2/g. Prestasi elektrokimia bagi komposit fiber berasaskan MnO_2 dikaji menggunakan konfigurasi dua elektrod dalam elektrolit 1 M KCl. Menariknya, ASC P-*f*-

CNFs/PEDOT/MnO_2//PCNFs menunjukkan kapasitan spesifik tertinggi 719.8 F/g berbanding *f*-CNFs/PPy/MnO_2 (409.88 F/g), *f*-CNFs/PEDOT/MnO_2//AC (354 F/g), CNFs-MnO_2/PPy (315.80 F/g) dan PVA-GO-MnO_2/PEDOT (144.66 F/g) pada kadar imbas 25 mV/s. Kesan sinegistik yang baik yang disumbangkan oleh setiap bahan dalam P-*f*-CNFs/PEDOT/MnO_2//PCNFs mempunyai tenaga spesifik yang luar biasa 60.5 Wh/kg dan kuasa spesifik 555.3 W/kg pada 0.6 A/g, menunjukkan kapasiti electrokimia yang tinggi. Sebagai tambahan, peningkatan kelembapan permukaan dan kekuatan mekanikal yang baik oleh P-*f*-CNFs/PEDOT/MnO_2//PCNFs ASC menunjukkan jangka hayat kitaran yang lebih panjang dengan mengekalkan kapasitan spesifik 104.6% selepas kitaran yang ke 5000 berbanding dengan elektrod yang lain. Tiga peranti ASC terhimpun berjaya menyalakan 25 lampu merah diod pancaran cahaya (LED), menunjukkan kemampuaan bahan ini untuk digunakan dalam aplikasi superkapasitor yang praktikal. Oleh itu, P-*f*-CNFs/PEDOT/MnO_2//PCNFs boleh dianggap sebagai calon prospektif untuk superkapasitor yang berprestasi tinggi kerana prestasi superkapasitifnya yang luar biasa.

ACKNOWLEDGEMENTS

First of all, I am deeply grateful to Allah S.W.T for giving me good health, abilities and courage in completing the lab works and thesis. I would like to express my gratitude to my parents, Mohd Abdah A Aziz and Zaiton Mohd Zin who always support, motivate and pray for my great success. They are always by my side when I needed them and served as my inspiration in pursuing this research. I would like to thank my supervisor, Assoc. Prof. Dr. Yusran Sulaiman for his sincere guidance and providing necessary information regarding this research. It was a great honor to complete this Ph.D. work under his supervision. Special thanks to my co-supervisors, Dr. Norizah Abdul Rahman and Assoc. Prof. Dr. Abdul Halim Abdullah for their endless support and understanding throughout my research period. To all my labmates; Nabilah, Shalini, Haffis, Dharshini, Hadi, Radha and Nusiba, I acknowledge them for their cooperation which helped me to accomplish this research.

I certify that a Thesis Examination Committee has met on 29 July 2019 to conduct the final examination of Muhammad Amirul Aizat Bin Mohd Abdah on his thesis entitled "Development of high performance supercapacitors using manganese oxide, conducting polymer and carbon-based fiber composites" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the (insert the name of relevant degree).

Members of the Thesis Examination Committee were as follows:

Zulkarnain bin Zainal, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Tan Kar Ban, PhD
Associate Professor
Faculty of Science
(Internal Examiner)

Suraya binti Mohd Rashid, PhD
Associate Professor
Faculty of Science
(Internal Examiner)

Jang Myoun Ko, PhD
Professor
Department of Chemical & Biological Engineering
Hanbat National University
South Korea
(External Examiner)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Yusran Sulaiman, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Norizah Abdul Rahman, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Member)

Abdul Halim Abdullah, PhD
Associate Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: ________________________ Date: __________________

Name and Matric No.: _______________________________________

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: ____________________________
Name of Chairman of Supervisory Committee: ____________________________

Signature: ____________________________
Name of Member of Supervisory Committee: ____________________________

Signature: ____________________________
Name of Member of Supervisory Committee: ____________________________

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Symbol	Meaning	Unit
C_{sp}	Specific capacitance	F/g
E	Specific energy	Wh/kg
P	Specific power	W/kg
R_{ct}	Charge transfer resistance	Ω
ESR	Equivalent series resistance	Ω
m	Mass of active materials	g
v	Scan rate	mV/s
I	Applied current	A
V	Potential	V
$\Delta V/\Delta E$	Potential window/operating voltage	V
Δt	Discharging time	s
Z´	Real impedance	Ω
Z"	Imaginary impedance	Ω
Cdl	Electrical double layer capacitance	-
CPE	Constant phase element	-
W	Warburg diffusion resistance	-
χ^2	Chi square	-

LIST OF ABBREVIATIONS

AC	Activated carbon
ACNFs	Activated carbon nanofibers
APD	Average pore distribution
ASCs	Asymmetric supercapacitors
BA	Boric acid
BET	Brunauer-Emmett-Teller
CB	Carbon black
CFC	Carbon fiber cloth
CFP	Carbon fiber paper
CFS	Carbon fibers sheet
CNF_{Mn}	Electrosprayed MnO_2 particles
CNF_{ox}	Oxidised carbon nanofibers
CNFs	Carbon nanofibers
CNT	Carbon nanotube
Co_3O_4	Cobalt oxide
CPs	Conducting polymers
CV	Cyclic voltammetry
CVD	Chemical vapour deposition
DMF	N,N-dimethylformamide
ECs	Electrochemical capacitors
EDLCs	Electrical double layer capacitors
EDOT	3,4-ethylenedioxythiophene

EIS	Electrochemical impedance spectroscopy
ES	Electrospinning
f-CNFs	Functionalised carbon nanofibers
Fe_3O_4	Iron oxide
FeOOH	Porous iron oxide-hydroxide
FESEM	Field emission scanning electron spectroscopy
FSCs	Flexible supercapacitors
FTIR	Field transform infrared spectroscopy
G	Graphene
GCD	Galvanostatic charge-discharge
GNFs	Graphitic nanofibers
GO	Graphene oxide
GQD	Graphene quantum dot
H_3BTC	Trimesic acid
HCs	Hybrid supercapacitors
HRTEM	High-resolution transmission electron microscopy
ITO	Indium tin oxide
$KMnO_4$	Potassium permanganate
LED	Light-emitting diode
LIBs	Lithium-ion batteries
$Mn(NO_3)_2$	Manganese nitrate
$MnCO_3$	Manganese carbonate
MnO_2	Manganese oxide
MOF	Metal-organic framework

MWs	Metal wires
NFs	Nanofibers
NiO	Nickel oxide
NPs	Nanoparticles
PAN	Polyacrylonitrile
PANi	Polyaniline
PBI	Poly(benzimidazole
PCNFs	Porous carbon nanofibers
PCs	Pseudocapacitors
PEDOT	Poly(3,4-ethylenedioxythiophene)
PEDOT:PSS	Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate)
PEO	Polyethylene oxide
PET	Polyethylene terephthalate
PLA	Polylactic acid
PMMA	Polymethacrylate
PPy	Polypyrrole
PTFE	Polytetrafluoroethylene
PVA	Polyvinyl alcohol
PVAc	Poly(vinyl acetate)
PVC	Polyvinylchloride
PVDF	Poly(vinylidene fluoride)
PVP	Poly(vinyl pyrrolidone)
RGO	Reduced graphene oxide
RuO_2	Ruthenium oxide

S_{BET}	BET specific surface area
SSA	Specific surface area
SWCNTs	Single walled carbon nanotubes
TEM	Transmission electron microscopy
TMOs	Transition metal oxides
V_2O_5	Vanadium oxide
VACNFs	Vertically aligned carbon nanofibers
VGCNFs	Vapour grown carbon nanofibers
VMCNFs	Amorphous V_2O_5 doped with multichannel CNFs
V_t	Total pore volume
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
ZnO	Zinc oxide

CHAPTER 1

INTRODUCTION

1.1 Background of research

In the past decades, the energy crisis has become a worldwide concern issue due to the rapid growth of human population, along with the accelerated global economy. The surveys on total world energy consumption provided by Energy Information Administration (EIA) show that fossil fuels (petroleum, coal, natural gas, etc.) play a major contribution in fulfilling the demand for sustainable energy. However, the dependence on energy based on fossil fuels could lead to excessive depletion and aggravating environmental pollution. Due to this environmental concern, the need for renewable energies such as solar, wind, hydro, geothermal, biogas and wave can be served as alternative sustainable energy resources owing to their abundance in nature and cost-effective. It has been reported that wind and solar energy could supply about 2.3% and 0.98% of the energy consumption, respectively, leading to the development of clean and environmental-friendly energy sources (Energy, 2016). Although tremendous efforts have been made to fully utilised these recyclable resources, climate change and environmental destruction have affected the requirements for the future energy system. These challenges have evolved the researcher's interest in developing advanced energy storage/conversion technologies with multifunctional applications. In the meantime, fuel cells, batteries, conventional capacitors and supercapacitors have taken center stage as the efficient energy storage devices to replace the existing energy storage sources (Sinprachim *et al.*, 2016). For fuel cells and batteries, despite their fascinating specific energy properties, but yet they may suffer from a drawback of poor specific power. To address this discrepancy, supercapacitors, also called as ultracapacitors have received great attention and emerged as promising energy storage candidates which fill the gap between batteries and traditional capacitors (Shown *et al.*, 2015). Supercapacitors are believed to meet the requirement for a future practical application which holds long cycle lifespan, high specific power and fast charging-discharging rate and relatively low cost. Additionally, supercapacitors have been employed in a wide range of applications include hybrid transportation, portable electronics, memory backup power as well in large industrial scale production (Yang *et al.*, 2016). In general, the enhancement of the overall performance of supercapacitors is dependent on the reasonable design of electro-active materials, therefore, supercapacitors should have a large specific surface area, excellent intrinsic conductivity, good mechanical stability and high specific energy and specific power. To date, the exploration of hybrid supercapacitors has been intensively studied as the demand for advanced electronic devices increase, which brings a new strategy in developing flexible and stretchable electronic devices in future applications.

1.2 Problem statement

As it is well known, supercapacitors have outperformed other energy storage devices at this current stage of technology due to their superior capacitive features such as fast charge/discharge rate, long cyclic life and high specific power. The ongoing technological advances such as consumer electronics, hybrid vehicles, wireless sensor networks and energy harvesting have attracted extensive concern from the researchers to design and develop high-performance electrode materials for supercapacitors. Therefore, the selection of electrode materials plays an important role in determining the electrochemical performance of the supercapacitor.

The fabrication of one-dimensional (1D) nanofibers (NFs) has drawn considerable attention and shown great potential as an active nanomaterial for supercapacitor. A continuous electrospun NFs derived from biodegradable polymer such as polyvinyl alcohol (PVA) is widely used as a template to enlarge the surface area for charge accumulation. However, PVA nanofibers are electronically non-conductive and suffer from low mechanical strength, which severely limits their applications in supercapacitors. In order to address the drawback, the contribution of electrochemical double layer capacitors (EDLCs) such as graphene oxide (GO), carbon fibers (denoted as CNFs) and activated carbon (AC) are the best solution to improve the long-term stability performance of the fiber composite as they exhibit good electrical conductivity, an excellent mechanical strength with large accessible specific surface area but yet suffering from poor specific capacitance. Therefore, hybrid configuration of carbon materials (CNFs) with pseudocapacitive materials such as transition metal oxides (TMOs) and conducting polymers (CPs) could significantly enhance their supercapactive properties.

Among various TMOs, manganese oxide (MnO_2) is one of the promising candidates which possesses high theoretical specific capacitance, environmentally friendly and low-cost. Unfortunately, the inferior conductivity and densely packed structure of MnO_2 can restrict its actual specific capacitance at the same time giving poor rate capability. To overcome these constraints, conducting polymers such as poly(3,4 ethylenedioxythiophene) (PEDOT) and polypyrrole (PPy) have been introduced due to their high electrical conductivity and good chemical stability. However, such materials usually suffer from poor long-term stability due to volumetric change and subsequent mechanical degradation during the charging-discharging process. Thus, development of new supercapacitor electrodes consisting of MnO_2, CPs and carbon based fiber composites are much needed as they are believed to deliver significant improvement towards their capacitive performances such as specific capacitance, specific energy and cycling stability for supercapacitor applications.

1.3 Objectives

The aim of this research is to prepare and investigate the supercapacitive performances of MnO_2-based fiber composites for supercapacitors. The objectives of this research are:

1. To prepare MnO_2, CP and carbon based fiber composites as symmetrical and asymmetrical electrodes for supercapacitors.
2. To study the effect of surface wettability of MnO_2 based fiber composite towards its specific energy performance via electrochemical functionalisation.
3. To study the effect of porogen at different concentration on the supercapacitive performance of the P-*f*-CNFs/PEDOT/MnO_2 fiber composite.
4. To evaluate the supercapacitive performance of MnO_2, CP and carbon based fiber composites.

1.4 Scope of study

This study focuses on developing high performance supercapacitor using MnO_2, CP and carbon based fiber composites. The first supercapacitor electrode of PVA-GO-MnO_2/PEDOT was fabricated using electrospinning and electrochemical technique. Then, the fibers which derived from PAN-MnO_x precursor was carbonised into CNFs-MnO_2 to enhance the conductivity of the fibers, followed by *in-situ* polymerisation of PPy (CNFs-MnO_2/PPy). The improvement of specific energy has been achieved by modifying the surface wettability of CNFs via electrochemical functionalisation. In addition, the deposition of PPy and MnO_2 using chemical and electrochemical methods were performed on the functionalised carbon fibers (*f*-CNFs) to form *f*-CNFs/PPy/MnO_2. These three fabricated electrodes were assembled in symmetrical form and their electrochemical properties were studied using cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) measurements. In order to achieve wide potential windows, the asymmetrical supercapacitors were introduced consisting of *f*-CNFs/PEDOT/MnO_2 (positive electrode) and AC (negative electrode). By using the same assembly, the porogen (PTFE) was included in CNFs to form porous CNFs (PCNFs). The ratios between PAN:PTFE were varied to obtain the maximum specific surface area. Thereafter, P-*f*-CNFs were electrochemically incorporated with PEDOT and MnO_2 to form hybrid P-*f*-CNFs/PEDOT/MnO_2. The ASC device of P-*f*-CNFs/PEDOT/MnO_2//PCNFs was fabricated and its electrochemical performance was further evaluated using the same characterisations.

1.5 Organisation of chapters

This thesis consists of 8 chapters and organised as follows. Chapter 1 is the introduction of the thesis which comprises of research background, problem statement and research objectives. Recent progress on TMO-based fibers, TMO-based fibers, CP-based fibers and TMO/CP-based fibers in term of their materials design and synthesis, cell configuration and electrochemical properties are reviewed in Chapter 2. Chapter 3 discusses the electrochemical performances of the as-prepared PVA-GO-MnO_2/PEDOT. Chapter 4 elaborates the advantages of fabricated CNFs-MnO_2/PPy as symmetrical fiber composite in comparison with pure CNFs, CNFs/MnO_2 and CNFs/PPy. The enhancement of specific energy derived from the *f*-CNFs/PPy/MnO_2 electrodes using a similar approach in Chapter 4 and the benefits for the formation of *f*-CNFs via electrochemical functionalisation are explained in Chapter 5. Chapter 6 discusses the electrochemical behaviors of ASC based on *f*-CNFs/PEDOT/MnO_2 (positive) and AC (negative) using both three- and two-electrode configurations. Chapter 7 elaborates the effect of different PAN:PTFE ratios towards porosity and specific surface area of the as-prepared P-*f*-CNFs. The supercapacitive performances of assembled P-*f*-CNFs/PEDOT/MnO_2//PCNFs ASC were also studied in the same chapter. Finally, Chapter 8 states the conclusion drawn from the works, significant findings and provide the directions for future work.

REFERENCES

Abdur, R., Kim, K., Kim, J.-H. and Lee, J. (2015) Electrochemical behavior of manganese oxides on flexible substrates for thin film supercapacitors. *Electrochimica Acta.* 153**.** 184-189.

Afif, A., Rahman, S. M. H., Tasfiah Azad, A., Zaini, J., Islan, M. A. and Azad, A. K. (2019) Advanced materials and technologies for hybrid supercapacitors for energy storage – A review. *Journal of Energy Storage.* 25**.** 100852.

Agnihotri, N., Sen, P., De, A. and Mukherjee, M. (2017) Hierarchically designed PEDOT encapsulated graphene-MnO_2 nanocomposite as supercapacitors. *Materials Research Bulletin.* 88**.** 218-225.

Ahmed Aboueloyoun, T. (2015) Direct synthesis of mesostructured carbon nanofibers decorated with silver-nanoparticles as a multifunctional membrane for water treatment. *Advances in Natural Sciences: Nanoscience and Nanotechnology.* 6**.** 045003.

Aloqayli, S., Ranaweera, C. K., Wang, Z., Siam, K., Kahol, P. K., Tripathi, P., Srivastava, O. N., Gupta, B. K., Mishra, S. R., Perez, F., Shen, X. and Gupta, R. K. (2017) Nanostructured cobalt oxide and cobalt sulfide for flexible, high performance and durable supercapacitors. *Energy Storage Materials.* 8**.** 68-76.

Ameen, S., Akhtar, M. S., Seo, H. K., Kim, Y. S. and Shin, H. S. (2012) Influence of Sn doping on ZnO nanostructures from nanoparticles to spindle shape and their photoelectrochemical properties for dye sensitized solar cells. *Chemical Engineering Journal.* 187**.** 351-356.

Aradilla, D., Sadki, S. and Bidan, G. (2019) Beyond conventional supercapacitors: Hierarchically conducting polymer-coated 3D nanostructures for integrated on-chip micro-supercapacitors employing ionic liquid electrolytes. *Synthetic Metals.* 247**.** 131-143.

Asen, P. and Shahrokhian, S. (2017) A High Performance Supercapacitor Based on Graphene/Polypyrrole/Cu2O–Cu(OH)2 Ternary Nanocomposite Coated on Nickel Foam. *The Journal of Physical Chemistry C.* 121**.** 6508-6519.

Asen, P., Shahrokhian, S. and Zad, A. I. (2018) Ternary nanostructures of Cr_2O_3/graphene oxide/conducting polymers for supercapacitor application. *Journal of Electroanalytical Chemistry.* 823**.** 505-516.

Atchudan, R., Edison, T. N. J. I., Perumal, S., Thirukumaran, P., Vinodh, R. and Lee, Y. R. (2019) Green synthesis of nitrogen-doped carbon nanograss for supercapacitors. *Journal of the Taiwan Institute of Chemical Engineers.* 102**.** 475-486.

Ates, M., Bayrak, Y., Ozkan, H., Yoruk, O., Yildirim, M. and Kuzgun, O. (2019a) Synthesis of rGO/TiO_2/PEDOT nanocomposites, supercapacitor device performances and equivalent electrical circuit models. *Journal of Polymer Research.* 26.

Ates, M., Garip, A., Yörük, O., Bayrak, Y., Kuzgun, O. and Yildirim, M. (2019b) rGO/CuO/PEDOT nanocomposite formation, its characterisation and electrochemical performances for supercapacitors. *Plastics, Rubber and Composites.* 48**.** 168-184.

Azman, N. H. N., Lim, H. N. and Sulaiman, Y. (2016) Effect of electropolymerization potential on the preparation of PEDOT/graphene oxide hybrid material for supercapacitor application. *Electrochimica Acta.* 188**.** 785-792.

Azwar, E., Wan Mahari, W. A., Chuah, J. H., Vo, D.-V. N., Ma, N. L., Lam, W. H. and Lam, S. S. (2018) Transformation of biomass into carbon nanofiber for supercapacitor application – A review. *International Journal of Hydrogen Energy.* 43**.** 20811-20821.

Bai, X., Liu, Q., Liu, J., Zhang, H., Li, Z., Jing, X., Liu, P., Wang, J. and Li, R. (2017) Hierarchical Co_3O_4@$Ni(OH)_2$ core-shell nanosheet arrays for isolated all-solid state supercapacitor electrodes with superior electrochemical performance. *Chemical Engineering Journal.* 315**.** 35-45.

Bai, X., Tong, X., Gao, Y., Zhu, W., Fu, C., Ma, J., Tan, T., Wang, C., Luo, Y. and Sun, H. (2018) Hierarchical multidimensional MnO_2 via hydrothermal synthesis for high performance supercapacitors. *Electrochimica Acta.* 281**.** 525-533.

Balan, B. K., Chaudhari, H. D., Kharul, U. K. and Kurungot, S. (2013) Carbon nanofiber–RuO_2–poly(benzimidazole) ternary hybrids for improved supercapacitor performance. *RSC Advances.* 3**.** 2428-2436.

Banerjee, J., Dutta, K., Kader, M. A. and Nayak, S. K. (2019) An overview on the recent developments in polyaniline-based supercapacitors. *Polymers for Advanced Technologies.* 30**.** 1902-1921.

Bao, X., Qin, Z., Zhou, T. and Deng, J. (2018) In-situ generation of gold nanoparticles on MnO_2 nanosheets for the enhanced oxidative degradation of basic dye (Methylene Blue). *Journal of Environmental Sciences.* 65**.** 236-245.

Barakzehi, M., Montazer, M., Sharif, F., Norby, T. and Chatzitakis, A. (2019) A textile-based wearable supercapacitor using reduced graphene oxide/polypyrrole composite. *Electrochimica Acta.* 305**.** 187-196.

Bhagwan, J., Sahoo, A., Yadav, K. L. and Sharma, Y. (2017) Nanofibers of spinel-$CdMn_2O_4$: A new and high performance material for supercapacitor and Li-ion batteries. *Journal of Alloys and Compounds.* 703**.** 86-95.

Bhagwan, J., Sivasankaran, V., Yadav, K. L. and Sharma, Y. (2016) Porous, one-dimensional and high aspect ratio nanofibric network of cobalt manganese oxide as a high performance material for aqueous and solid-state supercapacitor (2 V). *Journal of Power Sources.* 327**.** 29-37.

Bhoyate, S., Kahol, P. K., Sapkota, B., Mishra, S. R., Perez, F. and Gupta, R. K. (2018) Polystyrene activated linear tube carbon nanofiber for durable and high-performance supercapacitors. *Surface and Coatings Technology.* 345**.** 113-122.

Bhujun, B., Tan, M. T. T. and Shanmugam, A. S. (2017) Study of mixed ternary transition metal ferrites as potential electrodes for supercapacitor applications. *Results in Physics.* 7**.** 345-353.

Budhiraju, V. S., Kumar, R., Sharma, A. and Sivakumar, S. (2017) Structurally stable hollow mesoporous graphitized carbon nanofibers embedded with $NiMoO_4$ nanoparticles for high performance asymmetric supercapacitors. *Electrochimica Acta.* 238**.** 337-348.

Cai, J., Niu, H., Wang, H., Shao, H., Fang, J., He, J., Xiong, H., Ma, C. and Lin, T. (2016) High-performance supercapacitor electrode from cellulose-derived, inter-bonded carbon nanofibers. *Journal of Power Sources.* 324**.** 302-308.

Canal-Rodríguez, M., Menéndez, J. A., Montes-Morán, M. A., Martín-Gullón, I., Parra, J. B. and Arenillas, A. (2019) The role of conductive additives on the performance of hybrid carbon xerogels as electrodes in aqueous supercapacitors. *Electrochimica Acta.* 295**.** 693-702.

Cao, X., Zeng, H.-Y., Xu, S., Yuan, J., Han, J. and Xiao, G.-F. (2019) Facile fabrication of the polyaniline/layered double hydroxide nanosheet composite for supercapacitors. *Applied Clay Science.* 168**.** 175-183.

Cao, Y., Wang, K., Wang, X., Gu, Z., Fan, Q., Gibbons, W., Hoefelmeyer, J. D., Kharel, P. R. and Shrestha, M. (2016) Hierarchical porous activated carbon for supercapacitor derived from corn stalk core by potassium hydroxide activation. *Electrochimica Acta.* 212**.** 839-847.

Casper, C. L., Stephens, J. S., Tassi, N. G., Chase, D. B. and Rabolt, J. F. (2004) Controlling surface morphology of electrospun polystyrene fibers: Effect of humidity and molecular weight in the electrospinning process. *Macromolecules.* 37**.** 573-578.

Chang, W.-M., Wang, C.-C. and Chen, C.-Y. (2016) Plasma-induced polyaniline grafted on carbon nanotube-embedded carbon nanofibers for high-performance supercapacitors. *Electrochimica Acta.* 212**.** 130-140.

Chang, Y., Han, G., Xiao, Y., Chang, Y., Song, H., Li, M., Li, Y. and Zhang, Y. (2017) Internal tandem flexible and compressible electrochemical capacitor based on polypyrrole/carbon fibers. *Electrochimica Acta.* 257**.** 335-344.

Chen, H., Dong, X., Shi, J., Zhao, J., Hua, Z., Gao, J., Ruan, M. and Yan, D. (2007) Templated synthesis of hierarchically porous manganese oxide with a crystalline nanorod framework and its high electrochemical performance. *Journal of Materials Chemistry.* 17**.** 855-860.

Chen, L., Li, D., Chen, L., Si, P., Feng, J., Zhang, L., Li, Y., Lou, J. and Ci, L. (2018) Core-shell structured carbon nanofibers yarn@polypyrrole@graphene for high performance all-solid-state fiber supercapacitors. *Carbon.* 138**.** 264-270.

Chen, L. F., Lu, Y., Yu, L. and Lou, X. W. (2017a) Designed formation of hollow particle-based nitrogen-doped carbon nanofibers for high-performance supercapacitors. *Energy and Environmental Science.* 10**.** 1777-1783.

Chen, L. Y., Hou, Y., Kang, J. L., Hirata, A., Fujita, T. and Chen, M. W. (2013) Toward the theoretical capacitance of RuO_2 reinforced by highly conductive nanoporous gold. *Advanced Energy Materials.* 3**.** 851-856.

Chen, S., Ma, W., Cheng, Y., Weng, Z., Sun, B., Wang, L., Chen, W., Li, F., Zhu, M. and Cheng, H.-M. (2015a) Scalable non-liquid-crystal spinning of locally aligned graphene fibers for high-performance wearable supercapacitors. *Nano Energy.* 15**.** 642-653.

Chen, X., Zhu, X., Xiao, Y. and Yang, X. (2015b) PEDOT/g-C_3N_4 binary electrode material for supercapacitors. *Journal of Electroanalytical Chemistry.* 743**.** 99-104.

Chen, Y., Hu, W., Gan, H., Wang, J.-W. and Shi, X.-C. (2017b) Enhancing high-rate capability of MnO_2 film electrodeposited on carbon fibers via hydrothermal treatment. *Electrochimica Acta.* 246**.** 890-896.

Cheng, G., Yang, W., Dong, C., Kou, T., Bai, Q., Wang, H. and Zhang, Z. (2015) Ultrathin mesoporous NiO nanosheet-anchored 3D nickel foam as an advanced electrode for supercapacitors. *Journal of Materials Chemistry A.* 3**.** 17469-17478.

Chi, H. Z., Zhu, H. and Gao, L. (2015) Boron-doped MnO_2/carbon fiber composite electrode for supercapacitor. *Journal of Alloys and Compounds.* 645. 199-205.

Choi, H. and Yoon, H. (2015) Nanostructured Electrode Materials for Electrochemical Capacitor Applications. *Nanomaterials (Basel).* 5. 906-936.

Chong, M. B., Azman, H. N., Mohd Abdah, A. M. and Sulaiman, Y. (2019) Supercapacitive Performance of N-Doped Graphene/Mn_3O_4/Fe_3O_4 as an Electrode Material. *Applied Sciences.* 9. 1-12.

Choudhury, A., Kim, J.-H., Sinha Mahapatra, S., Yang, K.-S. and Yang, D.-J. (2017) Nitrogen-enriched porous carbon nanofiber mat as efficient flexible electrode material for supercapacitors. *ACS Sustainable Chemistry & Engineering.* 5. 2109-2118.

Choudhury, A., Kim, J.-H., Yang, K.-S. and Yang, D.-J. (2016) Facile synthesis of self-standing binder-free vanadium pentoxide-carbon nanofiber composites for high-performance supercapacitors. *Electrochimica Acta.* 213. 400-407.

Daraghmeh, A., Hussain, S., Servera, L., Xuriguera, E., Cornet, A. and Cirera, A. (2017) Impact of binder concentration and pressure on performance of symmetric CNFs based supercapacitors. *Electrochimica Acta.* 245. 531-538.

Devadas, A., Baranton, S., Napporn, T. W. and Coutanceau, C. (2011) Tailoring of RuO_2 nanoparticles by microwave assisted "Instant method" for energy storage applications. *Journal of Power Sources.* 196. 4044-4053.

Diao, Y., Chen, H., Lu, Y., Santino, L. M., Wang, H. and D'arcy, J. M. (2019) Converting rust to PEDOT nanofibers for supercapacitors. *ACS Applied Energy Materials.* 2. 3435-3444.

Dong, P., Yang, B., Liu, C., Xu, F., Xi, X., Hou, G. and Shao, R. (2017) Highly enhanced photocatalytic activity of WO_3 thin films loaded with Pt–Ag bimetallic alloy nanoparticles. *RSC Advances.* 7. 947-956.

Du, W., Bai, Y.-L., Xu, J., Zhao, H., Zhang, L., Li, X. and Zhang, J. (2018) Advanced metal-organic frameworks (MOFs) and their derived electrode materials for supercapacitors. *Journal of Power Sources.* 402. 281-295.

Dubal, D. P., Dhawale, D. S., Salunkhe, R. R. and Lokhande, C. D. (2010) Conversion of chemically prepared interlocked cubelike Mn_3O_4 to birnessite MnO_2 using electrochemical cycling. *Journal of The Electrochemical Society.* 157. A812-A817.

Dubal, D. P., Lee, S. H., Kim, J. G., Kim, W. B. and Lokhande, C. D. (2012) Porous polypyrrole clusters prepared by electropolymerization for a high performance supercapacitor. *Journal of Materials Chemistry.* 22**.** 3044-3052.

Dubey, R. and Guruviah, V. (2019) Review of carbon-based electrode materials for supercapacitor energy storage. *Ionics.* 25**.** 1419-1445.

El-Deen, A. G., Barakat, N. a. M., Khalil, K. A. and Kim, H. Y. (2014) Hollow carbon nanofibers as an effective electrode for brackish water desalination using the capacitive deionization process. *New Journal of Chemistry.* 38**.** 198-205.

Energy, U. S. D. O. (2016) Energy Information Administration, "Annual Energy Outlook 2016".

Ezeigwe, E. R., Tan, M. T. T., Khiew, P. S. and Siong, C. W. (2015) One-step green synthesis of graphene/ZnO nanocomposites for electrochemical capacitors. *Ceramics International.* 41**.** 715-724.

Fan, Z., Huang, X., Tan, C. and Zhang, H. (2015) Thin metal nanostructures: Synthesis, properties and applications. *Chemical Science.* 6**.** 95-111.

Faraji, S. and Ani, F. (2014) Microwave-assisted synthesis of metal oxide/hydroxide composite electrodes for high power supercapacitors – A review. *Journal of Power Sources.* 263**.** 338–360.

Fathona, I. W. and Yabuki, A. (2016) Multi-plate, thin-film electrodes of manganese oxide synthesized via the thermal decomposition of a manganese-amine complex for use as electrochemical supercapacitors. *Electrochimica Acta.* 222**.** 693-700.

Faverolle, F., Attias, A. J., Bloch, B., Audebert, P. and Andrieux, C. P. (1998) Highly conducting and strongly adhering polypyrrole coating layers deposited on glass substrates by a chemical process. *Chemistry of Materials.* 10**.** 740-752.

Feng, H., Hu, H., Dong, H., Xiao, Y., Cai, Y., Lei, B., Liu, Y. and Zheng, M. (2016) Hierarchical structured carbon derived from bagasse wastes: A simple and efficient synthesis route and its improved electrochemical properties for high-performance supercapacitors. *Journal of Power Sources.* 302**.** 164-173.

Gan, J. K., Lim, Y. S., Huang, N. M. and Lim, H. N. (2015a) Hybrid silver nanoparticle/nanocluster-decorated polypyrrole for high-performance supercapacitors. *RSC Advances.* 5**.** 75442-75450.

Gan, J. K., Lim, Y. S., Pandikumar, A., Huang, N. M. and Lim, H. N. (2015b) Graphene/polypyrrole-coated carbon nanofiber core–shell architecture electrode for electrochemical capacitors. *RSC Advances.* 5**.** 12692-12699.

Gao, L., Mao, X., Zhu, H., Xiao, W., Gan, F. and Wang, D. (2014) Electropolymerization of PEDOT on CNTs conductive network assembled at water/oil interface. *Electrochimica Acta.* 136**.** 97-104.

Gao, Y., Xia, Y., Wan, H., Xu, X. and Jiang, S. (2019) Enhanced cycle performance of hierarchical porous sphere $MnCo_2O_4$ for asymmetric supercapacitors. *Electrochimica Acta.* 301**.** 294-303.

Garcia-Torres, J. and Crean, C. (2018) Ternary composite solid-state flexible supercapacitor based on nanocarbons/manganese dioxide/PEDOT:PSS fibres. *Materials and Design.* 155**.** 194-202.

Ghaly, H. A., El-Deen, A. G., Souaya, E. R. and Allam, N. K. (2019) Asymmetric supercapacitors based on 3D graphene-wrapped V_2O_5 nanospheres and Fe_3O_4@3D graphene electrodes with high power and energy densities. *Electrochimica Acta.* 310**.** 58-69.

Gong, X., Li, S. and Lee, P. S. (2017) A fiber asymmetric supercapacitor based on FeOOH/PPy on carbon fibers as an anode electrode with high volumetric energy density for wearable applications. *Nanoscale.* 9**.** 10794-10801.

González, A., Goikolea, E., Barrena, J. A. and Mysyk, R. (2016) Review on supercapacitors: Technologies and materials. *Renewable and Sustainable Energy Reviews.* 58**.** 1189-1206.

Grote, F. and Lei, Y. (2014) A complete three-dimensionally nanostructured asymmetric supercapacitor with high operating voltage window based on PPy and MnO_2. *Nano Energy.* 10**.** 63-70.

Guan, B. Y., Kushima, A., Yu, L., Li, S., Li, J. and Lou, X. W. (2017) Coordination polymers derived general synthesis of multishelled mixed metal-oxide particles for hybrid supercapacitors. *Advanced Materials.* 29**.** 1605902.

Guo, F. M., Xu, R. Q., Cui, X., Zhang, L., Wang, K. L., Yao, Y. W. and Wei, J. Q. (2016) High performance of stretchable carbon nanotube–polypyrrole fiber supercapacitors under dynamic deformation and temperature variation. *Journal of Materials Chemistry A.* 4**.** 9311-9318.

Guo, X., Bai, N., Tian, Y. and Gai, L. (2018) Free-standing reduced graphene oxide/polypyrrole films with enhanced electrochemical performance for flexible supercapacitors. *Journal of Power Sources.* 408**.** 51-57.

Gupta, B., Mehta, M., Melvin, A., Kamalakannan, R., Dash, S., Kamruddin, M. and Tyagi, A. K. (2014) Poly (3,4-ethylenedioxythiophene) (PEDOT) and poly (3,4-ethylenedioxythiophene)-few walled carbon nanotube (PEDOT-FWCNT) nanocomposite based thin films for Schottky diode application. *Materials Chemistry and Physics.* 147**.** 867-877.

Haldar, P., Biswas, S., Sharma, V., Chowdhury, A. and Chandra, A. (2019) Mn_3O_4-polyaniline-graphene as distinctive composite for use in high-performance supercapacitors. *Applied Surface Science.* 491**.** 171-179.

Hamra, A. a. B., Lim, H. N., Hafiz, S. M., Kamaruzaman, S., Rashid, S. A., Yunus, R., Altarawneh, M., Jiang, Z. T. and Huang, N. M. (2018) Performance stability of solid-state polypyrrole-reduced graphene oxide-modified carbon bundle fiber for supercapacitor application. *Electrochimica Acta.* 285**.** 9-15.

Han, Y., Zhang, Z., Yang, M., Li, T., Wang, Y., Cao, A. and Chen, Z. (2018) Facile preparation of reduced graphene oxide/polypyrrole nanocomposites with urchin-like microstructure for wide-potential-window supercapacitors. *Electrochimica Acta.* 289**.** 238-247.

Hao, X., Wang, J., Ding, B., Wang, Y., Chang, Z., Dou, H. and Zhang, X. (2017) Bacterial-cellulose-derived interconnected meso-microporous carbon nanofiber networks as binder-free electrodes for high-performance supercapacitors. *Journal of Power Sources.* 352**.** 34-41.

He, S. and Chen, W. (2015) 3D graphene nanomaterials for binder-free supercapacitors: scientific design for enhanced performance. *Nanoscale.* 7**.** 6957-6990.

Hsu, Y.-H., Lai, C.-C., Ho, C.-L. and Lo, C.-T. (2014) Preparation of interconnected carbon nanofibers as electrodes for supercapacitors. *Electrochimica Acta.* 127**.** 369-376.

Hu, C.-C., Chang, K.-H., Lin, M.-C. and Wu, Y.-T. (2006) Design and tailoring of the nanotubular arrayed architecture of hydrous RuO_2 for next generation supercapacitors. *Nano Letters.* 6**.** 2690-2695.

Huang, C. W., Hsieh, C. T., Kuo, P. L. and Teng, H. (2012) Electric double layer capacitors based on a composite electrode of activated mesophase pitch and carbon nanotubes. *Journal of Materials Chemistry.* 22**.** 7314-7322.

Huang, G., Li, C., Bai, J., Sun, X. and Liang, H. (2016a) Controllable-multichannel carbon nanofibers-based amorphous vanadium as binder-free and conductive-free electrode materials for supercapacitor. *International Journal of Hydrogen Energy.* 41**.** 22144-22154.

Huang, M., Mi, R., Liu, H., Li, F., Zhao, X. L., Zhang, W., He, S. X. and Zhang, Y. X. (2014) Layered manganese oxides-decorated and nickel foam-supported carbon nanotubes as advanced binder-free supercapacitor electrodes. *Journal of Power Sources.* 269**.** 760-767.

Huang, S., Han, Y., Lyu, S., Lin, W., Chen, P. and Fang, S. (2017) A facile one-step approach for the fabrication of polypyrrole nanowire/carbon fiber hybrid electrodes for flexible high performance solid-state supercapacitors. *Nanotechnology.* 28.

Huang, Y., Li, H., Wang, Z., Zhu, M., Pei, Z., Xue, Q., Huang, Y. and Zhi, C. (2016b) Nanostructured polypyrrole as a flexible electrode material of supercapacitor. *Nano Energy.* 22**.** 422-438.

Huang, Y., Zhong, M., Huang, Y., Zhu, M., Pei, Z., Wang, Z., Xue, Q., Xie, X. and Zhi, C. (2015) A self-healable and highly stretchable supercapacitor based on a dual crosslinked polyelectrolyte. *Nature Communications.* 6**.** 10310.

Huang, Z.-M., Zhang, Y. Z., Kotaki, M. and Ramakrishna, S. (2003) A review on polymer nanofibers by electrospinning and their applications in nanocomposites. *Composites Science and Technology.* 63**.** 2223-2253.

Huang, Z., Li, L., Wang, Y., Zhang, C. and Liu, T. (2018) Polyaniline/graphene nanocomposites towards high-performance supercapacitors: A review. *Composites Communications.* 8**.** 83-91.

Iqbal, N., Wang, X., Babar, A. A., Zainab, G., Yu, J. and Ding, B. (2017) Flexible Fe_3O_4@carbon nanofibers hierarchically assembled with MnO_2 particles for high-performance supercapacitor electrodes. *Sci Rep.* 7**.** 15153.

Iqbal, N., Wang, X., Ge, J., Yu, J., Kim, H.-Y., Al-Deyab, S. S., El-Newehy, M. and Ding, B. (2016) Cobalt oxide nanoparticles embedded in flexible carbon nanofibers: attractive material for supercapacitor electrodes and CO_2 adsorption. *RSC Advances.* 6**.** 52171-52179.

Jang, J., Bae, J., Choi, M. and Yoon, S.-H. (2005) Fabrication and characterization of polyaniline coated carbon nanofiber for supercapacitor. *Carbon.* 43**.** 2730-2736.

Jeong, J. H. and Kim, B.-H. (2018) Electrospun porous carbon nanofibers with controllable pore sizes by boron trioxide for electrochemical capacitor electrodes. *Journal of the Taiwan Institute of Chemical Engineers.* 84**.** 179-187.

Jhao, J.-J., Lin, C.-H., Yeh, T.-K., Wu, H.-C., Tsai, M.-C. and Hsieh, C.-K. (2017) The coaxial nanostructure of ruthenium oxide thin films coated onto the vertically grown graphitic nanofibers for electrochemical supercapacitor. *Surface and Coatings Technology.* 320**.** 263-269.

Ji, J., Li, R., Li, H., Shu, Y., Li, Y., Qiu, S., He, C. and Yang, Y. (2018) Phytic acid assisted fabrication of graphene/polyaniline composite hydrogels for high-capacitance supercapacitors. *Composites Part B: Engineering.* 155**.** 132-137.

Jiang, C., Chen, G. and Wang, X. (2012) High-conversion synthesis of poly(3,4-ethylenedioxythiophene) by chemical oxidative polymerization. *Synthetic Metals.* 162**.** 1968-1971.

Jin, K., Zhang, W., Wang, Y., Guo, X., Chen, Z., Li, L., Zhang, Y., Wang, Z., Chen, J., Sun, L. and Zhang, T. (2018) In–situ hybridization of polyaniline nanofibers on functionalized reduced graphene oxide films for high-performance supercapacitor. *Electrochimica Acta.* 285**.** 221-229.

Ju, J., Kang, W., Deng, N., Li, L., Zhao, Y., Ma, X., Fan, L. and Cheng, B. (2017a) Preparation and characterization of PVA-based carbon nanofibers with honeycomb-like porous structure via electro-blown spinning method. *Microporous and Mesoporous Materials.* 239**.** 416-425.

Ju, J., Kang, W., Deng, N., Li, L., Zhao, Y., Ma, X., Fan, L. and Cheng, B. (2017b) Preparation and characterization of PVA-based carbon nanofibers with honeycomb-like porous structure via electro-blown spinning method. *Microporous and Mesoporous Materials.* 239**.** 416-425.

Ju, J., Zhao, H., Kang, W., Tian, N., Deng, N. and Cheng, B. (2017c) Designing MnO_2 & carbon composite porous nanofiber structure for supercapacitor applications. *Electrochimica Acta.* 258**.** 116-123.

Kaipannan, S. and Sathish, M. (2019) Fabrication of 9.6 V High-performance asymmetric supercapacitors stack based on nickel hexacyanoferrate-derived $Ni(OH)_2$ nanosheets and bio-derived activated carbon. *Scientific Reports.* 9**.** 1-14.

Karade, S. S. and Sankapal, B. R. (2016) Room temperature PEDOT:PSS encapsulated MWCNTs thin film for electrochemical supercapacitor. *Journal of Electroanalytical Chemistry.* 771**.** 80-86.

Ke, F., Tang, J., Guang, S. and Xu, H. (2016) Controlling the morphology and property of carbon fiber/polyaniline composites for supercapacitor electrode materials by surface functionalization. *RSC Advances.* 6**.** 14712-14719.

Khalifa, N., Souissi, A., Attar, I., Daoudi, M., Yakoubi, B. and Chtourou, R. (2013) Uncommon photoluminescence behavior of Fe^{3+} doped polyvinyl alcohol films. *Optics & Laser Technology.* 54**.** 335-338.

Khoh, W.-H. and Hong, J.-D. (2014) Solid-state asymmetric supercapacitor based on manganese dioxide/reduced-graphene oxide and polypyrrole/reduced-graphene oxide in a gel electrolyte. *Colloids and Surfaces A: Physicochemical and Engineering Aspects.* 456**.** 26-34.

Kim, B.-H., Kim, C. H. and Lee, D. G. (2016) Mesopore-enriched activated carbon nanofiber web containing RuO_2 as electrode material for high-performance supercapacitors. *Journal of Electroanalytical Chemistry.* 760**.** 64-70.

Kim, B.-H., Kim, C. H., Yang, K. S., Rahy, A. and Yang, D. J. (2012) Electrospun vanadium pentoxide/carbon nanofiber composites for supercapacitor electrodes. *Electrochimica Acta.* 83**.** 335-340.

Kim, B.-H., Yang, K. S., Woo, H.-G. and Oshida, K. (2011) Supercapacitor performance of porous carbon nanofiber composites prepared by electrospinning polymethylhydrosiloxane (PMHS)/polyacrylonitrile (PAN) blend solutions. *Synthetic Metals.* 161**.** 1211-1216.

Kim, C., Joo, Y. H., Kim, J. H., Lee, W. J. and Yang, K. S. (2006) Performances of electrochemical hybrid supercapacitor of RuO_2/ activated carbon nanofibers from electrospinning. *WSEAS Transactions on Systems.* 5**.** 1971-1975.

Kim, C., Ngoc, B. T. N., Yang, K. S., Kojima, M., Kim, Y. A., Kim, Y. J., Endo, M. and Yang, S. C. (2007) Self-sustained thin webs consisting of porous carbon nanofibers for supercapacitors via the electrospinning of polyacrylonitrile solutions containing zinc chloride. *Advanced Materials.* 19**.** 2341-2346.

Kim, C. and Yang, K. S. (2003) Electrochemical properties of carbon nanofiber web as an electrode for supercapacitor prepared by electrospinning. *Applied Physics Letters.* 83**.** 1216-1218.

Kim, M., Yoo, Y. and Kim, J. (2014) Synthesis of microsphere silicon carbide/nanoneedle manganese oxide composites and their electrochemical properties as supercapacitors. *Journal of Power Sources.* 265**.** 214-222.

Kim, S. H., Kim, Y. I., Park, J. H. and Ko, J. M. (2009) Cobalt-manganese oxide/carbon-nanofiber composite electrodes for supercapacitors. *International Journal of Electrochemical Science.* 4**.** 1489-1496.

Klankowski, S. A., Pandey, G. P., Malek, G., Thomas, C. R., Bernasek, S. L., Wu, J. and Li, J. (2015) Higher-power supercapacitor electrodes based on mesoporous manganese oxide coating on vertically aligned carbon nanofibers. *Nanoscale.* 7**.** 8485-8494.

Kolathodi, M. S., Palei, M. and Natarajan, T. S. (2015) Electrospun NiO nanofibers as cathode materials for high performance asymmetric supercapacitors. *Journal of Materials Chemistry A.* 3**.** 7513-7522.

Kong, S., Cheng, K., Ouyang, T., Ye, K., Wang, G. and Cao, D. (2017) Freestanding MnO_2 nanoflakes on carbon nanotube covered nickel foam as a 3D binder-free supercapacitor electrode with high performance. *Journal of Electroanalytical Chemistry.* 786**.** 35-42.

Kuang, M., Wen, Z. Q., Guo, X. L., Zhang, S. M. and Zhang, Y. X. (2014) Engineering firecracker-like beta-manganese dioxides@spinel nickel cobaltates nanostructures for high-performance supercapacitors. *Journal of Power Sources.* 270**.** 426-433.

Kulandaivalu, S. and Sulaiman, Y. (2019) Recent advances in layer-by-layer assembled conducting polymer based composites for supercapacitors. *Energies.* 12.

Kumar, S., Rath, T., Mahaling, R. N. and Das, C. K. (2007) Processing and characterization of carbon nanofiber/syndiotactic polystyrene composites in the absence and presence of liquid crystalline polymer. *Composites Part A: Applied Science and Manufacturing.* 38**.** 1304-1317.

Kumar, S., Verma, S., Shawat, E., Nessim, G. D. and Jain, S. L. (2015) Amino-functionalized carbon nanofibres as an efficient metal free catalyst for the synthesis of quinazoline-2,4(1H,3H)-diones from CO_2 and 2-aminobenzonitriles. *RSC Advances.* 5**.** 24670-24674.

Kundu, M. and Liu, L. (2015) Binder-free electrodes consisting of porous NiO nanofibers directly electrospun on nickel foam for high-rate supercapacitors. *Materials Letters.* 144**.** 114-118.

Ladrón-De-Guevara, A., Boscá, A., Pedrós, J., Climent-Pascual, E., De Andrés, A., Calle, F. and Martínez, J. (2019) Reduced graphene oxide/polyaniline electrochemical supercapacitors fabricated by laser. *Applied Surface Science.* 467-468**.** 691-697.

Lai, C.-C. and Lo, C.-T. (2015) Preparation of Nanostructural Carbon Nanofibers and Their Electrochemical Performance for Supercapacitors. *Electrochimica Acta.* 183**.** 85-93.

Le, T., Yang, Y., Yu, L., Huang, Z.-H. and Kang, F. (2016) In-situ growth of MnO2 crystals under nanopore-constraint in carbon nanofibers and their electrochemical performance. *Scientific Reports.* 6**.** 37368.

Lee, D., Jung, J. Y., Jung, M. J. and Lee, Y. S. (2015) Hierarchical porous carbon fibers prepared using a SiO2 template for high-performance EDLCs. *Chemical Engineering Journal.* 263**.** 62-70.

Lee, D. G. and Kim, B.-H. (2016) MnO_2 decorated on electrospun carbon nanofiber/graphene composites as supercapacitor electrode materials. *Synthetic Metals.* 219**.** 115-123.

Lee, D. G., Kim, Y. A. and Kim, B. H. (2016) Capacitive properties of hierarchically structured carbon nanofiber/graphene/MnO2 hybrid electrode with nitrogen and oxygen heteroatoms. *Carbon.* 107**.** 783-791.

Lee, E., Kim, M., Ju, J., Jang, S., Baeck, S. H. and Shim, S. E. (2017) The electrochemical enhancement due to the aligned structural effect of carbon nanofibers in a supercapacitor electrode. *Synthetic Metals.* 226**.** 195-206.

Lee, K. S., Park, C. W. and Kim, J.-D. (2018a) Synthesis of ZnO/activated carbon with high surface area for supercapacitor electrodes. *Colloids and Surfaces A: Physicochemical and Engineering Aspects.* 555**.** 482-490.

Lee, S. H., Sohn, J. S., Kulkarni, S. B., Patil, U. M., Jun, S. C. and Kim, J. H. (2014) Modified physico–chemical properties and supercapacitive performance via DMSO inducement to PEDOT:PSS active layer. *Organic Electronics.* 15**.** 3423-3430.

Lee, T. H., Pham, D. T., Sahoo, R., Seok, J., Luu, T. H. T. and Lee, Y. H. (2018b) High energy density and enhanced stability of asymmetric supercapacitors with mesoporous MnO_2@CNT and nanodot MoO_3@CNT free-standing films. *Energy Storage Materials.* 12**.** 223-231.

Li, K., Liu, X., Chen, S., Pan, W. and Zhang, J. (2019a) A flexible solid-state supercapacitor based on graphene/polyaniline paper electrodes. *Journal of Energy Chemistry.* 32**.** 166-173.

Li, M., Zhou, M., Wen, Z. Q. and Zhang, Y. X. (2017a) Flower-like NiFe layered double hydroxides coated MnO_2 for high-performance flexible supercapacitors. *Journal of Energy Storage.* 11**.** 242-248.

Li, Q., Guo, J., Xu, D., Guo, J., Ou, X., Hu, Y., Qi, H. and Yan, F. (2018a) Electrospun N-doped porous carbon nanofibers incorporated with NiO nanoparticles as free-standing film electrodes for high-performance supercapacitors and CO_2 capture. *Small.* 14.

Li, Q., Zheng, S., Xu, Y., Xue, H. and Pang, H. (2018b) Ruthenium based materials as electrode materials for supercapacitors. *Chemical Engineering Journal.* 333**.** 505-518.

Li, S., Chang, Y., Han, G., Song, H., Chang, Y. and Xiao, Y. (2019b) Asymmetric supercapacitor based on reduced graphene oxide/MnO_2 and polypyrrole deposited on carbon foam derived from melamine sponge. *Journal of Physics and Chemistry of Solids.* 130**.** 100-110.

Li, X., Chen, Y., Huang, H., Mai, Y.-W. and Zhou, L. (2016a) Electrospun carbon-based nanostructured electrodes for advanced energy storage – A review. *Energy Storage Materials.* 5**.** 58-92.

Li, X., Chen, Y., Huang, H., Mai, Y. W. and Zhou, L. (2016b) Electrospun carbon-based nanostructured electrodes for advanced energy storage - A review. *Energy Storage Materials.* 5**.** 58-92.

Li, X., Zhao, Y., Bai, Y., Zhao, X., Wang, R., Huang, Y., Liang, Q. and Huang, Z. (2017b) A Non-Woven Network of Porous Nitrogen-doping Carbon Nanofibers as a Binder-free Electrode for Supercapacitors. *Electrochimica Acta.* 230**.** 445-453.

Li, X., Zhou, M., Xu, H., Wang, G. and Wang, Z. (2014) Synthesis and electrochemical performances of a novel two-dimensional nanocomposite: Polyaniline-coated laponite nanosheets. *Journal of Materials Science.* 49**.** 6830-6837.

Li, Y., Cao, D., Wang, Y., Yang, S., Zhang, D., Ye, K., Cheng, K., Yin, J., Wang, G. and Xu, Y. (2015a) Hydrothermal deposition of manganese dioxide nanosheets on electrodeposited graphene covered nickel foam as a high-performance electrode for supercapacitors. *Journal of Power Sources.* 279**.** 138-145.

Li, Y., Han, X., Yi, T., He, Y. and Li, X. (2018c) Review and prospect of $NiCo_2O_4$-based composite materials for supercapacitor electrodes. *Journal of Energy Chemistry.*

Li, Y., Ou-Yang, W., Xu, X., Wang, M., Hou, S., Lu, T., Yao, Y. and Pan, L. (2018d) Micro-/mesoporous carbon nanofibers embedded with ordered carbon for flexible supercapacitors. *Electrochimica Acta.* 271**.** 591-598.

Li, Y., Wang, X., Yang, Q., Javed, M. S., Liu, Q., Xu, W., Hu, C. and Wei, D. (2017c) Ultra-fine CuO nanoparticles embedded in three-dimensional graphene network nano-structure for high-performance flexible supercapacitors. *Electrochimica Acta.* 234**.** 63-70.

Li, Y., Yu, N., Yan, P., Li, Y., Zhou, X., Chen, S., Wang, G., Wei, T. and Fan, Z. (2015b) Fabrication of manganese dioxide nanoplates anchoring on biomass-derived cross-linked carbon nanosheets for high-performance asymmetric supercapacitors. *Journal of Power Sources.* 300**.** 309-317.

Lian, Y.-M., Utetiwabo, W., Zhou, Y., Huang, Z.-H., Zhou, L., Muhammad, F., Chen, R.-J. and Yang, W. (2019) From upcycled waste polyethylene plastic to graphene/mesoporous carbon for high-voltage supercapacitors. *Journal of Colloid and Interface Science.*

Liang, Y., Wang, H., Sanchez Casalongue, H., Chen, Z. and Dai, H. (2010) TiO2 nanocrystals grown on graphene as advanced photocatalytic hybrid materials. *Nano Research.* 3**.** 701-705.

Lim, Y. S., Tan, Y. P., Lim, H. N., Huang, N. M., Tan, W. T., Yarmo, M. A. and Yin, C.-Y. (2014) Potentiostatically deposited polypyrrole/graphene decorated nano-manganese oxide ternary film for supercapacitors. *Ceramics International.* 40**.** 3855-3864.

Lin, J., Yan, Y., Wang, H., Zheng, X., Jiang, Z., Wang, Y., Qi, J., Cao, J., Fei, W. and Feng, J. (2019) Hierarchical Fe_2O_3 and NiO nanotube arrays as advanced anode and cathode electrodes for high-performance asymmetric supercapacitors. *Journal of Alloys and Compounds.* 794**.** 255-260.

Lin, S.-C., Lu, Y.-T., Chien, Y.-A., Wang, J.-A., You, T.-H., Wang, Y.-S., Lin, C.-W., Ma, C.-C. M. and Hu, C.-C. (2017) Asymmetric supercapacitors based on functional electrospun carbon nanofiber/manganese oxide electrodes with high power density and energy density. *Journal of Power Sources.* 362**.** 258-269.

Lin, S. C., Lu, Y. T., Chien, Y. A., Wang, J. A., Chen, P. Y., Ma, C. C. M. and Hu, C. C. (2018a) Asymmetric supercapacitors based on electrospun carbon nanofiber/sodium-pre-intercalated manganese oxide electrodes with high power and energy densities. *Journal of Power Sources.* 393**.** 1-10.

Lin, S. C., Lu, Y. T., Wang, J. A., Ma, C. C. M. and Hu, C. C. (2018b) A flexible supercapacitor consisting of activated carbon nanofiber and carbon nanofiber/potassium-pre-intercalated manganese oxide. *Journal of Power Sources.* 400**.** 415-425.

Lin, Z., Li, Z., Moon, K.-S., Fang, Y., Yao, Y., Li, L. and Wong, C.-P. (2013) Robust vertically aligned carbon nanotube–carbon fiber paper hybrid as versatile electrodes for supercapacitors and capacitive deionization. *Carbon.* 63**.** 547-553.

Lindfors, T., Boeva, Z. and Latonen, R.-M. (2014) Electrochemical synthesis of poly(3,4-ethylenedioxythiophene) in aqueous dispersion of high porosity reduced graphene oxide. *RSC Advances.* 4**.** 25279.

Liu, C.-K., Feng, Y., He, H.-J., Zhang, J., Sun, R.-J. and Chen, M.-Y. (2015) Effect of carbonization temperature on properties of aligned electrospun polyacrylonitrile carbon nanofibers. *Materials & Design.* 85**.** 483-486.

Liu, F., Su, H., Jin, L., Zhang, H., Chu, X. and Yang, W. (2017a) Facile synthesis of ultrafine cobalt oxide nanoparticles for high-performance supercapacitors. *Journal of Colloid and Interface Science.* 505**.** 796-804.

Liu, J., Jiang, J., Cheng, C., Li, H., Zhang, J., Gong, H. and Fan, H. J. (2011) Co_3O_4 nanowire@MnO_2 ultrathin nanosheet core/shell arrays: a new class of high-performance pseudocapacitive materials. *Advanced Materials.* 23**.** 2076-2081.

Liu, M., Gan, L., Xiong, W., Xu, Z., Zhu, D. and Chen, L. (2014a) Development of MnO_2/porous carbon microspheres with a partially graphitic structure for high performance supercapacitor electrodes. *Journal of Materials Chemistry A.* 2**.** 2555-2562.

Liu, Q., Yan, Q., Wu, S., Wang, J. and Liu, H. (2016) Ultrathin porous NiO nanoflake arrays on nickel foam as binder-free electrodes for supercapacitors. *Electrochemistry.* 84**.** 219-223.

Liu, Q., Zhu, J., Zhang, L. and Qiu, Y. (2018a) Recent advances in energy materials by electrospinning. *Renewable and Sustainable Energy Reviews.* 81**.** 1825-1858.

Liu, W., Feng, K., Zhang, Y., Yu, T., Han, L., Lui, G., Li, M., Chiu, G., Fung, P. and Yu, A. (2017b) Hair-based flexible knittable supercapacitor with wide operating voltage and ultra-high rate capability. *Nano Energy.* 34**.** 491-499.

Liu, Y., Liu, M., Zheng, P., Ge, D. and Yang, L. (2019) Controllable hydrogel-thermal synthesis of Mn_2O_3/CNT aerogels: Shape evolution, growth mechanism and electrochemical properties. *Materials & Design.* 182**.** 108022.

Liu, Y., Lu, Q., Huang, Z., Sun, S., Yu, B., Evariste, U., Jiang, G. and Yao, J. (2018b) Electrodeposition of Ni-Co-S nanosheet arrays on N-doped porous carbon nanofibers for flexible asymmetric supercapacitors. *Journal of Alloys and Compounds.* 762**.** 301-311.

Liu, Y., Yan, D., Li, Y., Wu, Z., Zhuo, R., Li, S., Feng, J., Wang, J., Yan, P. and Geng, Z. (2014b) Manganese dioxide nanosheet arrays grown on graphene oxide as an advanced electrode material for supercapacitors. *Electrochimica Acta.* 117**.** 528-533.

Liu, Z., Fu, D., Liu, F., Han, G., Liu, C., Chang, Y., Xiao, Y., Li, M. and Li, S. (2014c) Mesoporous carbon nanofibers with large cage-like pores activated by tin dioxide and their use in supercapacitor and catalyst support. *Carbon.* 70**.** 295-307.

Lota, K., Khomenko, V. and Frackowiak, E. (2004) Capacitance properties of poly(3,4-ethylenedioxythiophene)/carbon nanotubes composites. *Journal of Physics and Chemistry of Solids.* 65**.** 295-301.

Low, W. H., Khiew, P. S., Lim, S. S., Siong, C. W. and Ezeigwe, E. R. (2019) Recent development of mixed transition metal oxide and graphene/mixed transition metal oxide based hybrid nanostructures for advanced supercapacitors. *Journal of Alloys and Compounds.* 775**.** 1324-1356.

Lu, X., Shen, C., Zhang, Z., Barrios, E. and Zhai, L. (2018) Core–shell composite fibers for high-performance flexible supercapacitor electrodes. *ACS Applied Materials & Interfaces.* 10**.** 4041-4049.

Luan, Y., Nie, G., Zhao, X., Qiao, N., Liu, X., Wang, H., Zhang, X., Chen, Y. and Long, Y.-Z. (2019) The integration of SnO_2 dots and porous carbon nanofibers for flexible supercapacitors. *Electrochimica Acta.* 308**.** 121-130.

Luo, H., Lu, H. and Qiu, J. (2018) Carbon fibers surface-grown with helical carbon nanotubes and polyaniline for high-performance electrode materials and flexible supercapacitors. *Journal of Electroanalytical Chemistry.* 828**.** 24-32.

Luo, J., Zhong, W., Zou, Y., Xiong, C. and Yang, W. (2016) Preparation of morphology-controllable polyaniline and polyaniline/graphene hydrogels for high performance binder-free supercapacitor electrodes. *Journal of Power Sources.* 319**.** 73-81.

Lv, J., Zhang, Y., Lv, Z., Huang, X., Wang, Z., Zhu, X. and Wei, B. (2016) Strontium doped lanthanum manganite/manganese dioxide composite electrode for supercapacitor with enhanced rate capability. *Electrochimica Acta.* 222**.** 1585-1591.

Ma, C., Li, Z., Li, J., Fan, Q., Wu, L., Shi, J. and Song, Y. (2018a) Lignin-based hierarchical porous carbon nanofiber films with superior performance in supercapacitors. *Applied Surface Science.* 456**.** 568-576.

Ma, C., Ruan, S., Wang, J., Long, D., Qiao, W. and Ling, L. (2018b) Free-standing carbon nanofiber fabrics for high performance flexible supercapacitor. *Journal of Colloid and Interface Science.* 531**.** 513-522.

Ma, C., Sheng, J., Ma, C., Wang, R., Liu, J., Xie, Z. and Shi, J. (2016a) High-performanced supercapacitor based mesoporous carbon nanofibers with oriented mesopores parallel to axial direction. *Chemical Engineering Journal.* 304**.** 587-593.

Ma, C., Wang, R., Xie, Z., Zhang, H., Li, Z. and Shi, J. (2017) Preparation and molten salt-assisted KOH activation of porous carbon nanofibers for use as supercapacitor electrodes. *Journal of Porous Materials.* 24**.** 1437-1445.

Ma, L., Su, L., Zhang, J., Zhao, D., Qin, C., Jin, Z. and Zhao, K. (2016b) A controllable morphology GO/PANI/metal hydroxide composite for supercapacitor. *Journal of Electroanalytical Chemistry.* 777**.** 75-84.

Ma, S.-B., Lee, Y.-H., Ahn, K.-Y., Kim, C.-M., Oh, K.-H. and Kim, K.-B. (2006) Spontaneously Deposited Manganese Oxide on Acetylene Black in an Aqueous Potassium Permanganate Solution. *Journal of The Electrochemical Society.* 153**.** C27-C32.

Ma, S.-B., Nam, K.-W., Yoon, W.-S., Yang, X.-Q., Ahn, K.-Y., Oh, K.-H. and Kim, K.-B. (2008) Electrochemical properties of manganese oxide coated onto carbon nanotubes for energy-storage applications. *Journal of Power Sources.* 178**.** 483-489.

Ma, S., Wang, Y., Liu, Z., Huang, M., Yang, H. and Xu, Z.-L. (2019) Preparation of carbon nanofiber with multilevel gradient porous structure for supercapacitor and CO_2 adsorption. *Chemical Engineering Science.* 205**.** 181-189.

Ma, X., Kolla, P., Zhao, Y., Smirnova, A. L. and Fong, H. (2016c) Electrospun lignin-derived carbon nanofiber mats surface-decorated with MnO2 nanowhiskers as binder-free supercapacitor electrodes with high performance. *Journal of Power Sources.* 325**.** 541-548.

Ma, X., Kolla, P., Zhao, Y., Smirnova, A. L. and Fong, H. (2016d) Electrospun lignin-derived carbon nanofiber mats surface-decorated with MnO2 nanowhiskers as binder-free supercapacitor electrodes with high performance. *Journal of Power Sources.* 325**.** 541-548.

Mallakpour, S. and Motirasoul, F. (2017) Preparation of PVA/α-MnO_2-KH550 nanocomposite films and study of their morphology, thermal, mechanical and Pb(II) adsorption properties. *Progress in Organic Coatings.* 103**.** 135-142.

Manigandan, R., Giribabu, K., Munusamy, S., Praveen Kumar, S., Muthamizh, S., Dhanasekaran, T., Padmanaban, A., Suresh, R., Stephen, A. and Narayanan, V. (2015) Manganese sesquioxide to trimanganese tetroxide hierarchical hollow nanostructures: effect of gadolinium on structural, thermal, optical and magnetic properties. *CrystEngComm.* 17**.** 2886-2895.

Mao, N., Chen, W., Meng, J., Li, Y., Zhang, K., Qin, X., Zhang, H., Zhang, C., Qiu, Y. and Wang, S. (2018) Enhanced electrochemical properties of hierarchically sheath-core aligned carbon nanofibers coated carbon fiber yarn electrode-based supercapacitor via polyaniline nanowire array modification. *Journal of Power Sources.* 399**.** 406-413.

Mi, H., Zhang, X., An, S., Ye, X. and Yang, S. (2007) Microwave-assisted synthesis and electrochemical capacitance of polyaniline/multi-wall carbon nanotubes composite. *Electrochemistry Communications.* 9**.** 2859-2862.

Miao, F., Shao, C., Li, X., Lu, N., Wang, K., Zhang, X. and Liu, Y. (2016) Polyaniline-coated electrospun carbon nanofibers with high mass loading and enhanced capacitive performance as freestanding electrodes for flexible solid-state supercapacitors. *Energy.* 95**.** 233-241.

Miniach, E., Śliwak, A., Moyseowicz, A., Fernández-Garcia, L., González, Z., Granda, M., Menendez, R. and Gryglewicz, G. (2017) MnO_2/thermally reduced graphene oxide composites for high-voltage asymmetric supercapacitors. *Electrochimica Acta.* 240**.** 53-62.

Mohd Abdah, M. a. A., Abdul Rahman, N. and Sulaiman, Y. (2018a) Enhancement of electrochemical performance based on symmetrical poly-(3,4-ethylenedioxythiophene) coated polyvinyl alcohol/graphene oxide/manganese oxide microfiber for supercapacitor. *Electrochimica Acta.* 259**.** 466-473.

Mohd Abdah, M. a. A., Abdul Rahman, N. and Sulaiman, Y. (2018b) Enhancement of electrochemical performance based on symmetrical poly-(3,4-ethylenedioxythiophene) coated polyvinyl alcohol/graphene oxide/manganese oxide microfiber for supercapacitor. *Electrochimica Acta.* 259**.** 466-473.

Mohd Abdah, M. a. A., Abdul Rahman, N. and Sulaiman, Y. (2019a) Ternary functionalised carbon nanofiber/polypyrrole/manganese oxide as high specific energy electrode for supercapacitor

Ceramics International. 45**.** 8433-8439.

Mohd Abdah, M. a. A., Abdul Rahman, N. and Sulaiman, Y. (2019b) Ternary functionalised carbon nanofibers/polypyrrole/manganese oxide as high specific energy electrode for supercapacitor. *Ceramics International.* 45**.** 8433-8439.

Mohd Abdah, M. a. A., Mohammed Modawe Aldris Edris, N., Kulandaivalu, S., Abdul Rahman, N. and Sulaiman, Y. (2018c) Supercapacitor with superior electrochemical properties derived from symmetrical manganese oxide-carbon fiber coated with polypyrrole. *International Journal of Hydrogen Energy.* 43**.** 17328-17337.

Mohd Abdah, M. a. A., Mohd Razali, N. S., Lim, P. T., Kulandaivalu, S. and Sulaiman, Y. (2018d) One-step potentiostatic electrodeposition of polypyrrole/graphene oxide/multi-walled carbon nanotubes ternary nanocomposite for supercapacitor. *Materials Chemistry and Physics.* 219**.** 120-128.

Mohd Abdah, M. a. A., Zubair, N. A., Azman, N. H. N. and Sulaiman, Y. (2017) Fabrication of PEDOT coated PVA-GO nanofiber for supercapacitor. *Materials Chemistry and Physics.* 192**.** 161-169.

Molina, B. G., Dominguez, E., Armelin, E. and Aleman, C. (2018) Assembly of Conducting Polymer and Biohydrogel for the Release and Real-Time Monitoring of Vitamin K3. *Gels.* 4**.** 7-14.

Mothkuri, S., Chakrabarti, S., Gupta, H., Padya, B., Rao, T. N. and Jain, P. K. (2019) Synthesis of MnO_2 nano-flakes for high performance supercapacitor application. *Materials Today: Proceedings.*

Moyseowicz, A., Śliwak, A., Miniach, E. and Gryglewicz, G. (2017) Polypyrrole/iron oxide/reduced graphene oxide ternary composite as a binderless electrode material with high cyclic stability for supercapacitors. *Composites Part B: Engineering.* 109**.** 23-29.

Mu, H., Bai, J., Li, C. and Sun, W. (2019) Strong physisorption and superb thermal stability of carbon nanofibers carried CuxO-V_2O_5 enabling the flexible and long-cycling supercapacitor. *Journal of Alloys and Compounds.* 775**.** 872-882.

Mukhiya, T., Dahal, B., Ojha, G. P., Kang, D., Kim, T., Chae, S.-H., Muthurasu, A. and Kim, H. Y. (2019) Engineering nanohaired 3D cobalt hydroxide wheels in electrospun carbon nanofibers for high-performance supercapacitors. *Chemical Engineering Journal.* 361**.** 1225-1234.

Mustafa, M. N., Shafie, S., Zainal, Z. and Sulaiman, Y. (2017) Poly(3,4-ethylenedioxythiophene) doped with various carbon-based materials as counter electrodes for dye sensitized solar cells. *Materials & Design.* 136**.** 249-257.

Muzaffar, A., Ahamed, M. B., Deshmukh, K. and Thirumalai, J. (2019) A review on recent advances in hybrid supercapacitors: Design, fabrication and applications. *Renewable and Sustainable Energy Reviews.* 101**.** 123-145.

Mylarappa, M., Lakshmi, V. V., Mahesh, K. R. V., Nagaswarupa, H. P. and Raghavendra, N. (2016) A facile hydrothermal recovery of nano sealed MnO_2 particle from waste batteries: An advanced material for electrochemical and environmental applications. *IOP Conference Series: Materials Science and Engineering.* 149**.** 1-9.

Nantao, H., Zhi, Y., Yanyan, W., Liling, Z., Ying, W., Xiaolu, H., Hao, W., Liangmin, W. and Yafei, Z. (2014) Ultrafast and sensitive room temperature NH 3 gas sensors based on chemically reduced graphene oxide. *Nanotechnology.* 25**.** 025502.

Nataraj, S. K., Yang, K. S. and Aminabhavi, T. M. (2012) Polyacrylonitrile-based nanofibers - A state-of-the-art review. *Progress in Polymer Science (Oxford).* 37**.** 487-513.

Navale, S. T., Mane, A. T., Chougule, M. A., Sakhare, R. D., Nalage, S. R. and Patil, V. B. (2014) Highly selective and sensitive room temperature NO_2 gas sensor based on polypyrrole thin films. *Synthetic Metals.* 189**.** 94-99.

Navarro-Pardo, F., Martinez-Barrera, G., Martinez-Hernandez, A. L., Castano, V. M., Rivera-Armenta, J. L., Medellin-Rodriguez, F. and Velasco-Santos, C. (2013) Effects on the Thermo-Mechanical and Crystallinity Properties of Nylon 6,6 Electrospun Fibres Reinforced with One Dimensional (1D) and Two Dimensional (2D) Carbon. *Materials (Basel).* 6**.** 3494-3513.

Ndiaye, N. M., Ngom, B. D., Sylla, N. F., Masikhwa, T. M., Madito, M. J., Momodu, D., Ntsoane, T. and Manyala, N. (2018) Three dimensional vanadium pentoxide/graphene foam composite as positive electrode for high performance asymmetric electrochemical supercapacitor. *Journal of Colloid and Interface Science.* 532**.** 395-406.

Ng, C. H., Lim, H. N., Lim, Y. S., Chee, W. K. and Huang, N. M. (2015) Fabrication of flexible polypyrrole/graphene oxide/manganese oxide supercapacitor. *International Journal of Energy Research.* 39**.** 344-355.

Nguyen, T., Boudard, M., João Carmezim, M. and Fátima Montemor, M. (2017) $NixCo_1$-$x(OH)_2$ nanosheets on carbon nanofoam paper as high areal capacity electrodes for hybrid supercapacitors. *Energy.* 126**.** 208-216.

Nie, G., Lu, X., Chi, M., Gao, M. and Wang, C. (2018) General synthesis of hierarchical $C/MO_x@MnO_2$ (M=Mn, Cu, Co) composite nanofibers for high-performance supercapacitor electrodes. *Journal of Colloid and Interface Science.* 509**.** 235-244.

Ning, P., Duan, X., Ju, X., Lin, X., Tong, X., Pan, X., Wang, T. and Li, Q. (2016) Facile synthesis of carbon nanofibers/MnO_2 nanosheets as high-performance electrodes for asymmetric supercapacitors. *Electrochimica Acta.* 210**.** 754-761.

Nirmalesh Naveen, A. and Selladurai, S. (2015) Fabrication and performance evaluation of symmetrical supercapacitor based on manganese oxide nanorods–PANI composite. *Materials Science in Semiconductor Processing.* 40**.** 468-478.

Noh, J., Yoon, C.-M., Kim, Y. K. and Jang, J. (2017) High performance asymmetric supercapacitor twisted from carbon fiber/MnO_2 and carbon fiber/MoO_3. *Carbon.* 116**.** 470-478.

Ogata, A., Komaba, S., Baddour-Hadjean, R., Pereira-Ramos, J. P. and Kumagai, N. (2008) Doping effects on structure and electrode performance of K-birnessite-type manganese dioxides for rechargeable lithium battery. *Electrochimica Acta.* 53**.** 3084-3093.

Othman, F. E. C., Yusof, N., Jaafar, J., Ismail, A., Abdullah, N. and Hasbullah, H. (2016) Adsorption of cadmium (II) ions by polyacrylonitrile-based activated carbon nanofibers/magnesium oxide as its adsorbents. *Malaysian Journal of Analytical Sciences.* 20**.** 1467 - 1473.

Padmini, M., Elumalai, P. and Thomas, P. (2018) Symmetric supercapacitor performances of $CaCu_3Ti_4O_{12}$ decorated polyaniline nanocomposite. *Electrochimica Acta.* 292**.** 558-567.

Pandey, G. P. and Rastogi, A. C. (2012) Solid-state supercapacitors based on pulse polymerized poly(3,4- ethylenedioxythiophene) electrodes and ionic liquid gel polymer electrolyte. *Journal of the Electrochemical Society.* 159**.** A1664-A1671.

Patil, D. S., Pawar, S. A., Kim, J. H., Patil, P. S. and Shin, J. C. (2016) Facile preparation and enhanced capacitance of the Ag-PEDOT:PSS/polyaniline nanofiber network for supercapacitors. *Electrochimica Acta.* 213**.** 680-690.

Patil, J. V., Mali, S. S., Kamble, A. S., Hong, C. K., Kim, J. H. and Patil, P. S. (2017) Electrospinning: A versatile technique for making of 1D growth of nanostructured nanofibers and its applications: An experimental approach. *Applied Surface Science.* 423**.** 641-674.

Pech, O. and Maensiri, S. (2019) Electrochemical performances of electrospun carbon nanofibers, interconnected carbon nanofibers, and carbon-manganese oxide composite nanofibers. *Journal of Alloys and Compounds.* 781**.** 541-552.

Peng, S., Li, L., Kong Yoong Lee, J., Tian, L., Srinivasan, M., Adams, S. and Ramakrishna, S. (2016) Electrospun carbon nanofibers and their hybrid composites as advanced materials for energy conversion and storage. *Nano Energy.* 22**.** 361-395.

Peng, Y.-J., Wu, T.-H., Hsu, C.-T., Li, S.-M., Chen, M.-G. and Hu, C.-C. (2014) Electrochemical characteristics of the reduced graphene oxide/carbon nanotube/polypyrrole composites for aqueous asymmetric supercapacitors. *Journal of Power Sources.* 272**.** 970-978.

Perera, S. D., Rudolph, M., Mariano, R. G., Nijem, N., Ferraris, J. P., Chabal, Y. J. and Balkus, K. J. (2013) Manganese oxide nanorod–graphene/vanadium oxide nanowire–graphene binder-free paper electrodes for metal oxide hybrid supercapacitors. *Nano Energy.* 2**.** 966-975.

Poonam, Sharma, K., Arora, A. and Tripathi, S. K. (2019) Review of supercapacitors: Materials and devices. *Journal of Energy Storage.* 21**.** 801-825.

Potphode, D. D., Mishra, S. P., Sivaraman, P. and Patri, M. (2017) Asymmetric supercapacitor devices based on dendritic conducting polymer and activated carbon. *Electrochimica Acta.* 230**.** 29-38.

Prasankumar, T., Irthaza Aazem, V. S., Raghavan, P., Prem Ananth, K., Biradar, S., Ilangovan, R. and Jose, S. (2017) Microwave assisted synthesis of 3D network of Mn/Zn bimetallic oxide-high performance electrodes for supercapacitors. *Journal of Alloys and Compounds.* 695**.** 2835-2843.

Priyadharsini, N. and Kalai Selvan, R. (2017) Nano-sheet-like $KNiPO_4$ as a positive electrode material for aqueous hybrid supercapacitors. *Electrochimica Acta.* 246**.** 963-970.

Qi, B., Di, L., Xu, W. and Zhang, X. (2014) Dry plasma reduction to prepare a high performance Pd/C catalyst at atmospheric pressure for CO oxidation. *Journal of Materials Chemistry A.* 2**.** 11885-11890.

Qie, L., Chen, W., Xu, H., Xiong, X., Jiang, Y., Zou, F., Hu, X., Xin, Y., Zhang, Z. and Huang, Y. (2013) Synthesis of functionalized 3D hierarchical porous carbon for high-performance supercapacitors. *Energy and Environmental Science.* 6**.** 2497-2504.

Qiu, H.-J., Liu, L., Mu, Y.-P., Zhang, H.-J. and Wang, Y. (2015) Designed synthesis of cobalt-oxide-based nanomaterials for superior electrochemical energy storage devices. *Nano Research.* 8**.** 321-339.

Qu, J., Shi, L., He, C., Gao, F., Li, B., Zhou, Q., Hu, H., Shao, G., Wang, X. and Qiu, J. (2014) Highly efficient synthesis of graphene/MnO_2 hybrids and their application for ultrafast oxidative decomposition of methylene blue. *Carbon.* 66**.** 485-492.

Radhamani, A. V., Krishna Surendra, M. and Ramachandra Rao, M. S. (2018) Tailoring the supercapacitance of Mn_2O_3 nanofibers by nanocompositing with spinel-$ZnMn_2O_4$. *Materials & Design.* 139**.** 162-171.

Radhamani, A. V., Shareef, K. M. and Rao, M. S. R. (2016) ZnO@MnO_2 core-shell nanofiber cathodes for high performance asymmetric supercapacitors. *ACS Applied Materials and Interfaces.* 8**.** 30531-30542.

Rahaman, M. S. A., Ismail, A. F. and Mustafa, A. (2007) A review of heat treatment on polyacrylonitrile fiber. *Polymer Degradation and Stability.* 92**.** 1421-1432.

Rahmat Ullah, N., Thiringer, T. and Karlsson, D. (2008) Temporary Primary Frequency Control Support by Variable Speed Wind Turbines—Potential and Applications. *IEEE Transactions on Power Systems.* 23**.** 601-612.

Raj, C. J., Kim, B. C., Cho, W. J., Lee, W. G., Jung, S. D., Kim, Y. H., Park, S. Y. and Yu, K. H. (2015) Highly flexible and planar supercapacitors using graphite flakes/polypyrrole in polymer lapping film. *ACS Applied Materials and Interfaces.* 7**.** 13405-13414.

Rajesh, M., Justin Raj, C., Kim, B. C., Manikandan, R., Kim, K. H., Park, S. Y. and Yu, K. H. (2017a) Evaporative successive ionic layer adsorption and reaction polymerization of PEDOT: a simple and cost effective technique for binder free supercapacitor electrodes. *Electrochimica Acta.* 240**.** 231-238.

Rajesh, M., Raj, C. J., Kim, B. C., Manikandan, R., Kim, S.-J., Park, S. Y., Lee, K. and Yu, K. H. (2016) Expeditious and eco-friendly hydrothermal polymerization of PEDOT nanoparticles for binder-free high performance supercapacitor electrodes. *RSC Advances.* 6**.** 110433-110443.

Rajesh, M., Raj, C. J., Manikandan, R., Kim, B. C., Park, S. Y. and Yu, K. H. (2017b) A high performance PEDOT/PEDOT symmetric supercapacitor by facile in-situ hydrothermal polymerization of PEDOT nanostructures on flexible carbon fibre cloth electrodes. *Materials Today Energy.* 6**.** 96-104.

Rajkumar, M., Hsu, C.-T., Wu, T.-H., Chen, M.-G. and Hu, C.-C. (2015) Advanced materials for aqueous supercapacitors in the asymmetric design. *Progress in Natural Science: Materials International.* 25**.** 527-544.

Ramli, N. I. T., Abdul Rashid, S., Sulaiman, Y., Mamat, M. S., Mohd Zobir, S. A. and Krishnan, S. (2016) Physicochemical and electrochemical properties of carbon nanotube/graphite nanofiber hybrid nanocomposites for supercapacitor. *Journal of Power Sources.* 328**.** 195-202.

Ravit, R., Abdullah, J., Ahmad, I. and Sulaiman, Y. (2019) Electrochemical performance of poly(3, 4-ethylenedioxythipohene)/nanocrystalline cellulose (PEDOT/NCC) film for supercapacitor. *Carbohydrate Polymers.* 203**.** 128-138.

Ren, B., Fan, M., Liu, Q., Wang, J., Song, D. and Bai, X. (2013) Hollow NiO nanofibers modified by citric acid and the performances as supercapacitor electrode. *Electrochimica Acta.* 92**.** 197-204.

Ryu, K. S., Kim, K. M., Park, N.-G., Park, Y. J. and Chang, S. H. (2002a) Symmetric redox supercapacitor with conducting polyaniline electrodes. *Journal of Power Sources.* 103**.** 305-309.

Ryu, K. S., Kim, K. M., Park, N. G., Park, Y. J. and Chang, S. H. (2002b) Symmetric redox supercapacitor with conducting polyaniline electrodes. *Journal of Power Sources.* 103**.** 305-309.

Ryu, K. S., Kim, K. M., Park, Y. J., Park, N. G., Kang, M. G. and Chang, S. H. (2002c) Redox supercapacitor using polyaniline doped with Li salt as electrode. *Solid State Ionics.* 152-153**.** 861-866.

Sankar, S., Ahmed, A. T. A., Inamdar, A. I., Im, H., Im, Y. B., Lee, Y., Kim, D. Y. and Lee, S. (2019) Biomass-derived ultrathin mesoporous graphitic carbon nanoflakes as stable electrode material for high-performance supercapacitors. *Materials & Design.* 169**.** 107688.

Sari, B., Talu, M. and Yildirim, F. (2002) Electrochemical polymerization of aniline at low supporting-electrolyte concentrations and characterization of obtained films. *Russian Journal of Electrochemistry.* 38**.** 707-713.

Sarmah, D. and Kumar, A. (2019) Ion beam modified molybdenum disulfide-reduced graphene oxide/ polypyrrole nanotubes ternary nanocomposite for hybrid supercapacitor electrode. *Electrochimica Acta.* 312**.** 392-410.

Sekhar, B. C., Babu, G. and Kalaiselvi, N. (2015) Nanoflake driven Mn_2O_3 microcubes modified with cooked rice derived carbon for improved electrochemical behavior. *RSC Advances.* 5**.** 4568-4577.

Sharaf El-Deen Sahar, E. A., Moussa Saber, I., Mekawy Zakaria, A., Shehata Mohamed, K. K., Sadeek Sadeek, A. and Someda Hanan, H. (2017) Evaluation of CNTs/MnO_2 composite for adsorption of 60Co(II), 65Zn(II) and Cd(II) ions from aqueous solutions. *Radiochimica Acta.* 105**.** 43.

Shi, X., Zeng, Z., Guo, E., Long, X., Zhou, H. and Wang, X. (2017) A growth mechanism investigation on the anodic deposition of nanoporous gold supported manganese oxide nanostructures for high performance flexible supercapacitors. *Journal of Alloys and Compounds.* 690**.** 791-798.

Shi, X., Zheng, S., Wu, Z.-S. and Bao, X. (2018) Recent advances of graphene-based materials for high-performance and new-concept supercapacitors. *Journal of Energy Chemistry.* 27**.** 25-42.

Shivakumara, S. and Munichandraiah, N. (2017) Asymmetric supercapacitor based on nanostructured porous manganese oxide and reduced graphene oxide in aqueous neutral electrolyte. *Solid State Communications.* 260**.** 34-39.

Shown, I., Ganguly, A., Chen, L.-C. and Chen, K.-H. (2015) Conducting polymer-based flexible supercapacitor. *Energy Science & Engineering.* 3**.** 2-26.

Shrestha, S. and Mustain, W. E. (2010) Properties of Nitrogen-Functionalized Ordered Mesoporous Carbon Prepared Using Polypyrrole Precursor. *Journal of The Electrochemical Society.* 157**.** B1665-B1672.

Sidhu, N. K. and Rastogi, A. C. (2016) Bifacial carbon nanofoam-fibrous PEDOT composite supercapacitor in the 3-electrode configuration for electrical energy storage. *Synthetic Metals.* 219**.** 1-10.

Simon, P. and Gogotsi, Y. (2008) Materials for electrochemical capacitors. *Nat Mater.* 7**.** 845-854.

Sinprachim, T., Phumying, S. and Maensiri, S. (2016) Electrochemical energy storage performance of electrospun AgOx-MnOx/CNF composites. *Journal of Alloys and Compounds.* 677**.** 1-11.

Śliwak, A. and Gryglewicz, G. (2014) High-voltage asymmetric supercapacitors based on carbon and manganese oxide/oxidized carbon nanofiber composite electrodes. *Energy Technology.* 2**.** 819-824.

Snook, G. A., Kao, P. and Best, A. S. (2011) Conducting-polymer-based supercapacitor devices and electrodes. *Journal of Power Sources.* 196**.** 1-12.

Song, J., Yuan, Q., Liu, X., Wang, D., Fu, F. and Yang, W. (2015) Combination of Nitrogen Plasma Modification and Waterborne Polyurethane Treatment of Carbon Fiber Paper Used for Electric Heating of Wood Floors. *BioResources.* 10**.** 5820-5829.

Song, N., Wu, Y., Wang, W., Xiao, D., Tan, H. and Zhao, Y. (2019) Layer-by-layer in situ growth flexible polyaniline/graphene paper wrapped by MnO_2 nanoflowers for all-solid-state supercapacitor. *Materials Research Bulletin.* 111**.** 267-276.

Song, Z., Zhu, D., Xue, D., Yan, J., Chai, X., Xiong, W., Wang, Z., Lv, Y., Cao, T., Liu, M. and Gan, L. (2018) Nitrogen-Enriched Hollow Porous Carbon Nanospheres with Tailored Morphology and Microstructure for All-Solid-State Symmetric Supercapacitors. *ACS Applied Energy Materials.* 1**.** 4293-4303.

Sridhar, R., Lakshminarayanan, R., Madhaiyan, K., Barathi, V. A., Limh, K. H. C. and Ramakrishna, S. (2015) Electrosprayed nanoparticles and electrospun nanofibers based on natural materials: Applications in tissue regeneration, drug delivery and pharmaceuticals. *Chemical Society Reviews.* 44**.** 790-814.

Stoller, M. D. and Ruoff, R. S. (2010) Best practice methods for determining an electrode material's performance for ultracapacitors. *Energy & Environmental Science.* 3**.** 1294-1301.

Su, F. and Miao, M. (2014) Flexible, high performance two-ply yarn supercapacitors based on irradiated carbon nanotube yarn and PEDOT/PSS. *Electrochimica Acta.* 127**.** 433-438.

Sulaiman, Y., Azmi, M. K. S., Mohd Abdah, M. a. A. and Azman, N. H. N. (2017) One step electrodeposition of poly-(3,4-ethylenedioxythiophene)/graphene oxide/cobalt oxide ternary nanocomposite for high performance supercapacitor. *Electrochimica Acta.* 253**.** 581-588.

Sun, J., Huang, Y., Sze Sea, Y. N., Xue, Q., Wang, Z., Zhu, M., Li, H., Tao, X., Zhi, C. and Hu, H. (2017) Recent progress of fiber-shaped asymmetric supercapacitors. *Materials Today Energy.* 5**.** 1-14.

Sun, W., Zheng, R. and Chen, X. (2010) Symmetric redox supercapacitor based on micro-fabrication with three-dimensional polypyrrole electrodes. *Journal of Power Sources.* 195**.** 7120-7125.

Supaphol, P. and Chuangchote, S. (2008) On the electrospinning of poly(vinyl alcohol) nanofiber mats: A revisit. *Journal of Applied Polymer Science.* 108**.** 969-978.

Syed Zainol Abidin, S. N. J., Azman, N. H. N., Kulandaivalu, S. and Sulaiman, Y. (2017) Poly(3,4-ethylenedioxythiophene) Doped with Carbon Materials for High-Performance Supercapacitor: A Comparison Study. *Journal of Nanomaterials.* 2017**.** 13.

Syed Zainol Abidin, S. N. J., Mamat, M. S., Rasyid, S. A., Zainal, Z. and Sulaiman, Y. (2018a) Electropolymerization of poly(3,4-ethylenedioxythiophene) onto polyvinyl alcohol-graphene quantum dot-cobalt oxide nanofiber composite for high-performance supercapacitor. *Electrochimica Acta.* 261**.** 548-556.

Syed Zainol Abidin, S. N. J., Mamat, S., Abdul Rasyid, S., Zainal, Z. and Sulaiman, Y. (2018b) Fabrication of poly(vinyl alcohol)-graphene quantum dots coated with poly(3,4-ethylenedioxythiophene) for supercapacitor. *Journal of Polymer Science Part A: Polymer Chemistry.* 56**.** 50-58.

Tan, S., Kraus, T. J. and Li-Oakey, K. D. (2019) Understanding the supercapacitor properties of electrospun carbon nanofibers from powder river basin coal. *Fuel.* 245**.** 148-159.

Tang, C., Tang, Z. and Gong, H. (2012) Hierarchically Porous Ni-Co Oxide for High Reversibility Asymmetric Full-Cell Supercapacitors. *Journal of The Electrochemical Society.* 159**.** A651-A656.

Tang, P., Han, L. and Zhang, L. (2014) Facile synthesis of graphite/PEDOT/MnO_2 Composites on commercial supercapacitor separator membranes as flexible and high-performance supercapacitor electrodes. *ACS Applied Materials & Interfaces.* 6**.** 10506-10515.

Thangappan, R., Kalaiselvam, S., Elayaperumal, A. and Jayavel, R. (2014) Synthesis of graphene oxide/vanadium pentoxide composite nanofibers by electrospinning for supercapacitor applications. *Solid State Ionics.* 268, Part B**.** 321-325.

Tian, Y., Yang, C., Song, X., Liu, J., Zhao, L., Zhang, P. and Gao, L. (2019) Engineering the volumetric effect of Polypyrrole for auto-deformable supercapacitor. *Chemical Engineering Journal.* 374**.** 59-67.

Tong, L., Liu, J., Boyer, S. M., Sonnenberg, L. A., Fox, M. T., Ji, D., Feng, J., Bernier, W. E. and Jones Jr, W. E. (2017) Vapor-phase polymerized poly(3,4-ethylenedioxythiophene) (PEDOT)/TiO_2 composite fibers as electrode materials for supercapacitors. *Electrochimica Acta.* 224**.** 133-141.

Tong, L., Skorenko, K. H., Faucett, A. C., Boyer, S. M., Liu, J., Mativetsky, J. M., Bernier, W. E. and Jones, W. E. (2015) Vapor-phase polymerization of poly(3,4-ethylenedioxythiophene) (PEDOT) on commercial carbon coated aluminum foil as enhanced electrodes for supercapacitors. *Journal of Power Sources.* 297**.** 195-201.

Toupin, M., Brousse, T. and Bélanger, D. (2004) Charge storage mechanism of MnO_2 electrode used in aqueous electrochemical capacitor. *Chemistry of Materials.* 16**.** 3184-3190.

Tran, C. and Kalra, V. (2013) Fabrication of porous carbon nanofibers with adjustable pore sizes as electrodes for supercapacitors. *Journal of Power Sources.* 235**.** 289-296.

Ustamehmetoğlu, B. (2014) Synthesis and characterization of thiophene and thiazole containing polymers. *Electrochimica Acta.* 122**.** 130-140.

Vaibhav, V., Gajanan, V. H., Anjaneyulu, P., Ramesh, K. P. and Reghu, M. (2013) Probing disorder and transport properties in polypyrrole thin-film devices by impedance and Raman spectroscopy. *Journal of Physics D: Applied Physics.* 46**.** 365306.

Wang, B., Qiu, J., Feng, H. and Sakai, E. (2015a) Preparation of graphene oxide/polypyrrole/multi-walled carbon nanotube composite and its application in supercapacitors. *Electrochimica Acta.* 151**.** 230-239.

Wang, C.-H., Hsu, H.-C. and Hu, J.-H. (2014a) High-energy asymmetric supercapacitor based on petal-shaped MnO2 nanosheet and carbon nanotube-embedded polyacrylonitrile-based carbon nanofiber working at 2 V in aqueous neutral electrolyte. *Journal of Power Sources.* 249**.** 1-8.

Wang, C., Li, Y., Ding, G., Xie, X. and Jiang, M. (2013a) Preparation and characterization of graphene oxide/poly(vinyl alcohol) composite nanofibers via electrospinning. *Journal of Applied Polymer Science.* 127**.** 3026-3032.

Wang, G., Zhang, L. and Zhang, J. (2012a) A review of electrode materials for electrochemical supercapacitors. *Chemical Society Reviews.* 41**.** 797-828.

Wang, H., Casalongue, H. S., Liang, Y. and Dai, H. (2010) $Ni(OH)_2$ Nanoplates Grown on Graphene as Advanced Electrochemical Pseudocapacitor Materials. *Journal of the American Chemical Society.* 132**.** 7472-7477.

Wang, H., Gao, M., Zhu, Y.-A., Zhou, H., Liu, H., Gao, L. and Wu, M. (2018a) A flexible 3-D structured carbon molecular sieve@PEDOT composite electrode for supercapacitor. *Journal of Electroanalytical Chemistry.* 826**.** 191-197.

Wang, H., Yi, H., Chen, X. and Wang, X. (2013b) Facile synthesis of a nano-structured nickel oxide electrode with outstanding pseudocapacitive properties. *Electrochimica Acta.* 105**.** 353-361.

Wang, J.-G., Kang, F. and Wei, B. (2015b) Engineering of MnO_2-based nanocomposites for high-performance supercapacitors. *Progress in Materials Science.* 74**.** 51-124.

Wang, J.-G., Yang, Y., Huang, Z.-H. and Kang, F. (2012b) Rational synthesis of MnO_2/conducting polypyrrole@carbon nanofiber triaxial nano-cables for high-performance supercapacitors. *Journal of Materials Chemistry.* 22**.** 16943-16949.

Wang, J.-G., Yang, Y., Huang, Z.-H. and Kang, F. (2012c) Synthesis and electrochemical performance of MnO2/CNTs–embedded carbon nanofibers nanocomposites for supercapacitors. *Electrochimica Acta.* 75**.** 213-219.

Wang, J.-G., Yang, Y., Huang, Z.-H. and Kang, F. (2013c) A high-performance asymmetric supercapacitor based on carbon and carbon–MnO_2 nanofiber electrodes. *Carbon.* 61**.** 190-199.

Wang, J.-G., Yang, Y., Huang, Z.-H. and Kang, F. (2014b) MnO2/polypyrrole nanotubular composites: reactive template synthesis, characterization and application as superior electrode materials for high-performance supercapacitors. *Electrochimica Acta.* 130**.** 642-649.

Wang, J. G., Yang, Y., Huang, Z. H. and Kang, F. (2011) Coaxial carbon nanofibers/MnO_2 nanocomposites as freestanding electrodes for high-performance electrochemical capacitors. *Electrochimica Acta.* 56**.** 9240-9247.

Wang, L., Huang, M., Chen, S., Kang, L., He, X., Lei, Z., Shi, F., Xu, H. and Liu, Z.-H. (2017a) δ-MnO_2 nanofiber/single-walled carbon nanotube hybrid film for all-solid-state flexible supercapacitors with high performance. *Journal of Materials Chemistry A.* 5**.** 19107-19115.

Wang, L., Ji, H., Wang, S., Kong, L., Jiang, X. and Yang, G. (2013d) Preparation of Fe_3O_4 with high specific surface area and improved capacitance as a supercapacitor. *Nanoscale.* 5**.** 3793-3799.

Wang, P., Zhou, H., Meng, C., Wang, Z., Akhtar, K. and Yuan, A. (2019a) Cyanometallic framework-derived hierarchical Co_3O_4-NiO/graphene foam as high-performance binder-free electrodes for supercapacitors. *Chemical Engineering Journal.* 369**.** 57-63.

Wang, R., Jin, D., Zhang, Y., Wang, S., Lang, J., Yan, X. and Zhang, L. (2017b) Engineering metal organic framework derived 3D nanostructures for high performance hybrid supercapacitors. *Journal of Materials Chemistry A.* 5**.** 292-302.

Wang, T., Chen, H. C., Yu, F., Zhao, X. S. and Wang, H. (2019b) Boosting the cycling stability of transition metal compounds-based supercapacitors. *Energy Storage Materials.* 16**.** 545-573.

Wang, T., Song, D., Zhao, H., Chen, J., Zhao, C., Chen, L., Chen, W., Zhou, J. and Xie, E. (2015c) Facilitated transport channels in carbon nanotube/carbon nanofiber hierarchical composites decorated with manganese dioxide for flexible supercapacitors. *Journal of Power Sources.* 274**.** 709-717.

Wang, W., Yuan, Y., Yang, J., Meng, L., Tang, H., Zeng, Y., Ye, Z. and Lu, J. (2018b) Hierarchical core–shell Co_3O_4/graphene hybrid fibers: potential electrodes for supercapacitors. *Journal of Materials Science.* 53**.** 6116-6123.

Wang, Y., Huang, S., Lu, Y., Cui, S., Chen, W. and Mi, L. (2017c) High-rate-capability asymmetric supercapacitor device based on lily-like Co_3O_4 nanostructures assembled using nanowires. *RSC Advances.* 7**.** 3752-3759.

Wang, Y. G., Li, H. Q. and Xia, Y. Y. (2006) Ordered whiskerlike polyaniline grown on the surface of mesoporous carbon and Its electrochemical capacitance performance. *Advanced Materials.* 18**.** 2619-2623.

Wei, K., Kim, K.-O., Song, K.-H., Kang, C.-Y., Lee, J. S., Gopiraman, M. and Kim, I.-S. (2017) Nitrogen- and oxygen-containing porous ultrafine carbon nanofiber: A highly flexible electrode material for supercapacitor. *Journal of Materials Science & Technology.* 33**.** 424-431.

Wei, W., Cui, X., Chen, W. and Ivey, D. G. (2011) Manganese oxide-based materials as electrochemical supercapacitor electrodes. *Chemical Society Reviews.* 40**.** 1697-1721.

Wen, Y., Qin, T., Wang, Z., Jiang, X., Peng, S., Zhang, J., Hou, J., Huang, F., He, D. and Cao, G. (2017) Self-supported binder-free carbon fibers/MnO_2 electrodes derived from disposable bamboo chopsticks for high-performance supercapacitors. *Journal of Alloys and Compounds.* 699**.** 126-135.

Wong, S. I., Sunarso, J., Wong, B. T., Lin, H., Yu, A. and Jia, B. (2018) Towards enhanced energy density of graphene-based supercapacitors: Current status, approaches, and future directions. *Journal of Power Sources.* 396**.** 182-206.

Wu, K., Zhao, J., Zhang, X., Zhou, H. and Wu, M. (2019a) Hierarchical mesoporous MoO_2 sphere as highly effective supercapacitor electrode. *Journal of the Taiwan Institute of Chemical Engineers.* 102**.** 212-217.

Wu, Q., Chen, M., Wang, S., Zhang, X., Huan, L. and Diao, G. (2016) Preparation of sandwich-like ternary hierarchical nanosheets manganese dioxide/polyaniline/reduced graphene oxide as electrode material for supercapacitor. *Chemical Engineering Journal.* 304**.** 29-38.

Wu, Q., Xu, Y., Yao, Z., Liu, A. and Shi, G. (2010a) Supercapacitors based on flexible graphene/polyaniline nanofiber composite films. *ACS Nano.* 4**.** 1963-1970.

Wu, W., Niu, D., Zhu, J., Gao, Y., Wei, D., Zhao, C., Wang, C., Wang, F., Wang, L. and Yang, L. (2019b) Hierarchical architecture of Ti_3C_2@PDA/$NiCo_2S_4$ composite electrode as high-performance supercapacitors. *Ceramics International.* 45**.** 16261-16269.

Wu, W., Yang, L., Chen, S., Shao, Y., Jing, L., Zhao, G. and Wei, H. (2015) Core–shell nanospherical polypyrrole/graphene oxide composites for high performance supercapacitors. *RSC Advances.* 5**.** 91645-91653.

Wu, Y. and Ran, F. (2017) Vanadium nitride quantum dot/nitrogen-doped microporous carbon nanofibers electrode for high-performance supercapacitors. *Journal of Power Sources.* 344**.** 1-10.

Wu, Z.-S., Wang, D.-W., Ren, W., Zhao, J., Zhou, G., Li, F. and Cheng, H.-M. (2010b) Anchoring hydrous RuO_2 on graphene sheets for high-performance electrochemical capacitors. *Advanced Functional Materials.* 20**.** 3595-3602.

Xia, H., Hong, C., Shi, X., Li, B., Yuan, G., Yao, Q. and Xie, J. (2015) Hierarchical heterostructures of Ag nanoparticles decorated MnO_2 nanowires as promising electrodes for supercapacitors. *Journal of Materials Chemistry A.* 3**.** 1216-1221.

Xia, H., Zhu, D., Luo, Z., Yu, Y., Shi, X., Yuan, G. and Xie, J. (2013) Hierarchically Structured Co3O4@Pt@MnO2 Nanowire Arrays for High-Performance Supercapacitors. *Scientific Reports.* 3**.** 2978.

Xia, L., Huang, H., Fan, Z., Hu, D., Zhang, D., Khan, A. S., Usman, M. and Pan, L. (2019) Hierarchical macro-/meso-/microporous oxygen-doped carbon derived from sodium alginate: A cost-effective biomass material for binder-free supercapacitors. *Materials & Design.* 182**.** 108048.

Xianwen, M., Hatton, T. A. and Gregory, C. R. (2013) A review of electrospun carbon fibers as electrode materials for energy storage. *Current Organic Chemistry.* 17**.** 1390-1401.

Xie, B., Yu, M., Lu, L., Feng, H., Yang, Y., Chen, Y., Cui, H., Xiao, R. and Liu, J. (2019) Pseudocapacitive Co_9S_8/graphene electrode for high-rate hybrid supercapacitors. *Carbon.* 141**.** 134-142.

Xie, Q., Bao, R., Xie, C., Zheng, A., Wu, S., Zhang, Y., Zhang, R. and Zhao, P. (2016) Core-shell N-doped active carbon fiber@graphene composites for aqueous symmetric supercapacitors with high-energy and high-power density. *Journal of Power Sources.* 317**.** 133-142.

Xie, S., Liu, S., Cheng, F. and Lu, X. (2018) Recent advances toward achieving high-performance carbon-fiber materials for supercapacitors. *ChemElectroChem.* 5**.** 571-582.

Xu, C., Sun, J. and Gao, L. (2011) Synthesis of novel hierarchical graphene/polypyrrole nanosheet composites and their superior electrochemical performance. *Journal of Materials Chemistry.* 21**.** 11253-11258.

Xu, J., Xiao, T., Tan, X., Xiang, P., Jiang, L., Wu, D., Li, J. and Wang, S. (2017a) A new asymmetric aqueous supercapacitor: Co_3O_4//Co_3O_4@polypyrrole. *Journal of Alloys and Compounds.* 706**.** 351-357.

Xu, J., Zhang, L., Xu, G., Sun, Z., Zhang, C., Ma, X., Qi, C., Zhang, L. and Jia, D. (2018a) Facile synthesis of NiS anchored carbon nanofibers for high-performance supercapacitors. *Applied Surface Science.* 434**.** 112-119.

Xu, J., Zheng, F., Xi, C., Yu, Y., Chen, L., Yang, W., Hu, P., Zhen, Q. and Bashir, S. (2018b) Facile preparation of hierarchical vanadium pentoxide (V_2O_5)/titanium dioxide (TiO_2) heterojunction composite nano-arrays for high performance supercapacitor. *Journal of Power Sources.* 404**.** 47-55.

Xu, K., Li, S., Yang, J. and Hu, J. (2018c) Hierarchical hollow MnO_2 nanofibers with enhanced supercapacitor performance. *Journal of Colloid and Interface Science.* 513**.** 448-454.

Xu, K., Li, S., Yang, J., Xu, H. and Hu, J. (2016) Hierarchical MnO_2 nanosheets on electrospun $NiCo_2O_4$ nanotubes as electrode materials for high rate capability and excellent cycling stability supercapacitors. *Journal of Alloys and Compounds.* 678**.** 120-125.

Xu, K., Yang, X., Yang, J. and Hu, J. (2017b) Synthesis of hierarchical Co_3O_4@$NiCo_2O_4$ core-shell nanosheets as electrode materials for supercapacitor application. *Journal of Alloys and Compounds.* 700**.** 247-251.

Xu, L. (2019) Rationally designed hierarchical $NiCo_2O_4$–C@$Ni(OH)_2$ core-shell nanofibers for high performance supercapacitors. *Carbon.* v. 152**.** pp. 652-660-2019 v.152.

Xu, X., Gao, J., Tian, Q., Zhai, X. and Liu, Y. (2017c) Walnut shell derived porous carbon for a symmetric all-solid-state supercapacitor. *Applied Surface Science.* 411**.** 170-176.

Xu, Y., Wei, J., Tan, L., Yu, J. and Chen, Y. (2015) A facile approach to $NiCoO_2$ intimately standing on nitrogen doped graphene sheets by one-step hydrothermal synthesis for supercapacitors. *Journal of Materials Chemistry A.* 3**.** 7121-7131.

Xue, D., Zhu, D., Liu, M., Duan, H., Li, L., Chai, X., Wang, Z., Lv, Y., Xiong, W. and Gan, L. (2018) Schiff-Base/Resin Copolymer under Hypersaline Condition to High-Level N-Doped Porous Carbon Nanosheets for Supercapacitors. *ACS Applied Nano Materials.* 1**.** 4998-5007.

Xue, G., Zhong, J., Cheng, Y. and Wang, B. (2016) Facile fabrication of cross-linked carbon nanofiber via directly carbonizing electrospun polyacrylonitrile nanofiber as high performance scaffold for supercapacitors. *Electrochimica Acta.* 215**.** 29-35.

Yan, B., Matsushita, S. and Akagi, K. (2017) Aligned carbon and graphite fibers prepared from poly(3,4-ethylenedioxythiophene) single crystals synthesized by solid-state polymerization and their supercapacitor performance. *Journal of Materials Chemistry C.* 5**.** 3823-3829.

Yan, J., Choi, J.-H. and Jeong, Y. G. (2018) Freestanding supercapacitor electrode applications of carbon nanofibers based on polyacrylonitrile and polyhedral oligomeric silsesquioxane. *Materials & Design.* 139**.** 72-80.

Yan, J., Fan, Z., Wei, T., Qian, W., Zhang, M. and Wei, F. (2010) Fast and reversible surface redox reaction of graphene–MnO_2 composites as supercapacitor electrodes. *Carbon.* 48**.** 3825-3833.

Yan, X., Tai, Z., Chen, J. and Xue, Q. (2011) Fabrication of carbon nanofiber–polyaniline composite flexible paper for supercapacitor. *Nanoscale.* 3**.** 212-216.

Yang, C.-M. and Kim, B.-H. (2019) Incorporation of MnO_2 into boron-enriched electrospun carbon nanofiber for electrochemical supercapacitors. *Journal of Alloys and Compounds.* 780**.** 428-434.

Yang, C. M. and Kim, B. H. (2018) Highly conductive pitch-based carbon nanofiber/MnO_2 composites for high-capacitance supercapacitors. *Journal of Alloys and Compounds.* 749**.** 441-447.

Yang, D., Ni, W., Cheng, J., Wang, Z., Li, C., Zhang, Y. and Wang, B. (2017a) Omnidirectional porous fiber scrolls of polyaniline nanopillars array-N-doped carbon nanofibers for fiber-shaped supercapacitors. *Materials Today Energy.* 5**.** 196-204.

Yang, Q., Pang, S.-K. and Yung, K.-C. (2014) Study of PEDOT–PSS in carbon nanotube/conducting polymer composites as supercapacitor electrodes in aqueous solution. *Journal of Electroanalytical Chemistry.* 728**.** 140-147.

Yang, S.-Y., Chang, K.-H., Tien, H.-W., Lee, Y.-F., Li, S.-M., Wang, Y.-S., Wang, J.-Y., Ma, C.-C. M. and Hu, C.-C. (2011) Design and tailoring of a hierarchical graphene-carbon nanotube architecture for supercapacitors. *Journal of Materials Chemistry.* 21**.** 2374-2380.

Yang, Y., Lee, S., Brown, D. E., Zhao, H., Li, X., Jiang, D., Hao, S., Zhao, Y., Cong, D., Zhang, X. and Ren, Y. (2016) Fabrication of ultrafine manganese oxide-decorated carbon nanofibers for high-performance electrochemical capacitors. *Electrochimica Acta.* 211**.** 524-532.

Yang, Y., Yang, F., Hu, H., Lee, S., Wang, Y., Zhao, H., Zeng, D., Zhou, B. and Hao, S. (2017b) Dilute NiO/carbon nanofiber composites derived from metal organic framework fibers as electrode materials for supercapacitors. *Chemical Engineering Journal.* 307**.** 583-592.

Yang, Z., Ma, J., Bai, B., Qiu, A., Losic, D., Shi, D. and Chen, M. (2019) Free-standing PEDOT/polyaniline conductive polymer hydrogel for flexible solid-state supercapacitors. *Electrochimica Acta.* 322**.** 134769.

Yanilmaz, M., Dirican, M., Asiri, A. M. and Zhang, X. (2019) Flexible polyaniline-carbon nanofiber supercapacitor electrodes. *Journal of Energy Storage.* 24**.** 100766.

Yao, J., Ji, P., Sheng, N., Guan, F., Zhang, M., Wang, B., Chen, S. and Wang, H. (2018) Hierarchical core-sheath polypyrrole@carbon nanotube/bacterial cellulose macrofibers with high electrochemical performance for all-solid-state supercapacitors. *Electrochimica Acta.* 283**.** 1578-1588.

Yarin, A. L., Zussman, E., Wendorff, J. H. and Greiner, A. (2007) Material encapsulation and transport in core–shell micro/nanofibers, polymer and carbon nanotubes and micro/nanochannels. *Journal of Materials Chemistry.* 17**.** 2585-2599.

Yi, C.-Q., Zou, J.-P., Yang, H.-Z. and Leng, X. (2018) Recent advances in pseudocapacitor electrode materials: Transition metal oxides and nitrides. *Transactions of Nonferrous Metals Society of China.* 28**.** 1980-2001.

Yi, T.-F., Mei, J., Guan, B., Cui, P., Luo, S., Xie, Y. and Liu, Y. (2019) Construction of spherical NiO@MnO_2 with core-shell structure obtained by depositing MnO_2 nanoparticles on NiO nanosheets for high-performance supercapacitor. *Ceramics International.*

Yin, B. S., Wang, Z. B., Zhang, S. W., Liu, C., Ren, Q. Q. and Ke, K. (2016) In situ growth of free-standing all metal oxide asymmetric supercapacitor. *ACS Applied Materials and Interfaces.* 8**.** 26019-26029.

Yin, C., Zhou, H. and Li, J. (2019) Facile one-step hydrothermal synthesis of PEDOT:PSS/MnO_2 nanorod hybrids for high-rate supercapacitor electrode materials. *Ionics.* 25**.** 685-695.

Yu, B., Gele, A. and Wang, L. (2018) Iron oxide/lignin-based hollow carbon nanofibers nanocomposite as an application electrode materials for supercapacitors. *International Journal of Biological Macromolecules.* 118**.** 478-484.

Yu, D., Qian, Q., Wei, L., Jiang, W., Goh, K., Wei, J., Zhang, J. and Chen, Y. (2015) Emergence of fiber supercapacitors. *Chemical Society Reviews.* 44**.** 647-662.

Yu, M., Wang, Z., Han, Y., Tong, Y., Lu, X. and Yang, S. (2016a) Recent progress in the development of anodes for asymmetric supercapacitors. *Journal of Materials Chemistry A.* 4**.** 4634-4658.

Yu, N., Yin, H., Zhang, W., Liu, Y., Tang, Z. and Zhu, M.-Q. (2016b) High-performance fiber-shaped all-solid-state asymmetric supercapacitors based on ultrathin MnO_2 nanosheet/carbon fiber cathodes for wearable electronics. *Advanced Energy Materials.* 6**.** 1501458.

Yuksel, R., Alpugan, E. and Unalan, H. E. (2018) Coaxial silver nanowire/polypyrrole nanocomposite supercapacitors. *Organic Electronics.* 52**.** 272-280.

Zang, L., Zhu, J. and Xia, Y. (2014) Facile synthesis of porous NiO nanofibers for high-performance supercapacitors. *Journal of Materials Engineering and Performance.* 23**.** 679-683.

Zeng, Z., Zhou, H., Long, X., Guo, E. and Wang, X. (2015) Electrodeposition of hierarchical manganese oxide on metal nanoparticles decorated nanoporous gold with enhanced supercapacitor performance. *Journal of Alloys and Compounds.* 632**.** 376-385.

Zhai, Y., Dou, Y., Zhao, D., Fulvio, P. F., Mayes, R. T. and Dai, S. (2011) Carbon materials for chemical capacitive energy storage. *Advanced Materials.* 23**.** 4828-4850.

Zhang, B., Kang, F., Tarascon, J.-M. and Kim, J.-K. (2016a) Recent advances in electrospun carbon nanofibers and their application in electrochemical energy storage. *Progress in Materials Science.* 76**.** 319-380.

Zhang, B., Xu, Y., Zheng, Y., Dai, L., Zhang, M., Yang, J., Chen, Y., Chen, X. and Zhou, J. (2011a) A Facile Synthesis of Polypyrrole/Carbon Nanotube Composites with Ultrathin, Uniform and Thickness-Tunable Polypyrrole Shells. *Nanoscale Research Letters.* 6**.** 431.

Zhang, D., Dong, Q.-Q., Wang, X., Yan, W., Deng, W. and Shi, L.-Y. (2013) Preparation of a Three-Dimensional Ordered Macroporous Carbon Nanotube/Polypyrrole Composite for Supercapacitors and Diffusion Modeling. *The Journal of Physical Chemistry C.* 117**.** 20446-20455.

Zhang, D., Zhang, Y., Luo, Y. and Chu, P. K. (2015a) Highly porous honeycomb manganese oxide@carbon fibers core–shell nanocables for flexible supercapacitors. *Nano Energy.* 13**.** 47-57.

Zhang, J., Jiang, J., Li, H. and Zhao, X. S. (2011b) A high-performance asymmetric supercapacitor fabricated with graphene-based electrodes. *Energy & Environmental Science.* 4**.** 4009-4015.

Zhang, J., Qiu, K., Sun, B., Fang, J., Zhang, K., Ei-Hamshary, H., Al-Deyab, S. S. and Mo, X. (2014) The aligned core–sheath nanofibers with electrical conductivity for neural tissue engineering. *Journal of Materials Chemistry B.* 2**.** 7945-7954.

Zhang, K., Xu, J., Zhu, X., Lu, L., Duan, X., Hu, D., Dong, L., Sun, H., Gao, Y. and Wu, Y. (2015b) Poly(3,4-ethylenedioxythiophene) nanorods grown on graphene oxide sheets as electrochemical sensing platform for rutin. *Journal of Electroanalytical Chemistry.* 739**.** 66-72.

Zhang, K., Zhang, L. L., Zhao, X. S. and Wu, J. (2010) Graphene/Polyaniline Nanofiber Composites as Supercapacitor Electrodes. *Chemistry of Materials.* 22**.** 1392-1401.

Zhang, L., Jamal, R., Zhao, Q., Wang, M. and Abdiryim, T. (2015c) Preparation of PEDOT/GO, PEDOT/MnO_2, and PEDOT/GO/MnO_2 nanocomposites and their application in catalytic degradation of methylene blue. 10**.** 148.

Zhang, L., Jiang, Y., Wang, L., Zhang, C. and Liu, S. (2016b) Hierarchical porous carbon nanofibers as binder-free electrode for high-performance supercapacitor. *Electrochimica Acta.* 196**.** 189-196.

Zhang, L. L. and Zhao, X. S. (2009) Carbon-based materials as supercapacitor electrodes. *Chemical Society Reviews.* 38**.** 2520-2531.

Zhang, Q.-Z., Zhang, D., Miao, Z.-C., Zhang, X.-L. and Chou, S.-L. (2018a) Research progress in MnO_2–carbon based supercapacitor electrode materials. *Small.* 14**.** 1702883.

Zhang, S., Pang, Y., Wang, Y., Dong, B., Lu, S., Li, M. and Ding, S. (2018b) NiO nanosheets anchored on honeycomb porous carbon derived from wheat husk for symmetric supercapacitor with high performance. *Journal of Alloys and Compounds.* 735**.** 1722-1729.

Zhang, Y., Ju, P., Zhao, C. and Qian, X. (2016c) In-situ grown of MoS_2/RGO/MoS_2@Mo nanocomposite and Its supercapacitor performance. *Electrochimica Acta.* 219**.** 693-700.

Zhang, Z., Xu, Z., Yao, Z., Meng, Y., Xia, Q., Li, D. and Jiang, Z. (2019) Ultrahigh capacitance of TiO_2 nanotube arrays/C/MnO_2 electrode for supercapacitor. *Journal of Alloys and Compounds.* 805**.** 396-403.

Zhao, C., Tan, A., Pastorin, G. and Ho, H. K. (2013) Nanomaterial scaffolds for stem cell proliferation and differentiation in tissue engineering. *Biotechnology Advances.* 31**.** 654-668.

Zhao, Q., Jamal, R., Zhang, L., Wang, M. and Abdiryim, T. (2014) The structure and properties of PEDOT synthesized by template-free solution method. *Nanoscale Res Lett.* 9**.** 1-9.

Zhao, X., Du, Y., Li, Y. and Zhang, Q. (2015) Encapsulation of manganese oxides nanocrystals in electrospun carbon nanofibers as free-standing electrode for supercapacitors. *Ceramics International.* 41**.** 7402-7410.

Zhao, Y., Kang, W., Li, L., Yan, G., Wang, X., Zhuang, X. and Cheng, B. (2016) Solution blown silicon carbide porous nanofiber membrane as electrode materials for supercapacitors. *Electrochimica Acta.* 207**.** 257-265.

Zheng, J. H., Zhang, R. M., Yu, P. F. and Wang, X. G. (2019) Binary transition metal oxides (BTMO) (Co-Zn, Co-Cu) synthesis and high supercapacitor performance. *Journal of Alloys and Compounds.* 772**.** 359-365.

Zheng, S., Wu, Z.-S., Wang, S., Xiao, H., Zhou, F., Sun, C., Bao, X. and Cheng, H.-M. (2017) Graphene-based materials for high-voltage and high-energy asymmetric supercapacitors. *Energy Storage Materials.* 6**.** 70-97.

Zhou, D., Lin, H., Zhang, F., Niu, H., Cui, L., Wang, Q. and Qu, F. (2015) Freestanding MnO_2 nanoflakes/porous carbon nanofibers for high-performance flexible supercapacitor electrodes. *Electrochimica Acta.* 161**.** 427-435.

Zhou, H. and Zhai, H.-J. (2016) A highly flexible solid-state supercapacitor based on the carbon nanotube doped graphene oxide/polypyrrole composites with superior electrochemical performances. *Organic Electronics.* 37**.** 197-206.

Zhou, M., Pu, F., Wang, Z. and Guan, S. (2014) Nitrogen-doped porous carbons through KOH activation with superior performance in supercapacitors. *Carbon.* 68**.** 185-194.

Zhou, Q., Wei, T., Yue, J., Sheng, L. and Fan, Z. (2018a) Polyaniline nanofibers confined into graphene oxide architecture for high-performance supercapacitors. *Electrochimica Acta.* 291**.** 234-241.

Zhou, T., Jiang, Q., Wang, L., Qiu, Z., Liu, Y., Zhou, J. and Liu, B. (2018b) Facile preparation of nitrogen-enriched hierarchical porous carbon nanofibers by $Mg(OAc)_2$-assisted electrospinning for flexible supercapacitors. *Applied Surface Science.* 456**.** 827-834.

Zhou, Z. and Wu, X.-F. (2013) Graphene-beaded carbon nanofibers for use in supercapacitor electrodes: Synthesis and electrochemical characterization. *Journal of Power Sources.* 222**.** 410-416.

Zhou, Z. and Wu, X.-F. (2014) High-performance porous electrodes for pseudosupercapacitors based on graphene-beaded carbon nanofibers surface-coated with nanostructured conducting polymers. *Journal of Power Sources.* 262**.** 44-49.

Zhu, D., Cheng, K., Wang, Y., Sun, D., Gan, L., Chen, T., Jiang, J. and Liu, M. (2017a) Nitrogen-doped porous carbons with nanofiber-like structure derived from poly (aniline-co-p-phenylenediamine) for supercapacitors. *Electrochimica Acta.* 224**.** 17-24.

Zhu, D., Jiang, J., Sun, D., Qian, X., Wang, Y., Li, L., Wang, Z., Chai, X., Gan, L. and Liu, M. (2018) A general strategy to synthesize high-level N-doped porous carbons via Schiff-base chemistry for supercapacitors. *Journal of Materials Chemistry A.* 6**.** 12334-12343.

Zhu, D., Xu, C., Nakura, N. and Matsuo, M. (2002) Study of carbon films from PAN/VGCF composites by gelation/crystallization from solution. *Carbon.* 40**.** 363-373.

Zhu, G., Chen, J., Zhang, Z., Kang, Q., Feng, X., Li, Y., Huang, Z., Wang, L. and Ma, Y. (2016a) NiO nanowall-assisted growth of thick carbon nanofiber layers on metal wires for fiber supercapacitors. *Chemical Communications.* 52**.** 2721-2724.

Zhu, J., Feng, T., Du, X., Wang, J., Hu, J. and Wei, L. (2017b) High performance asymmetric supercapacitor based on polypyrrole/graphene composite and its derived nitrogen-doped carbon nano-sheets. *Journal of Power Sources.* 346**.** 120-127.

Zhu, Y., Bai, J., Wang, J. and Li, C. (2016b) Novel carbon nanofiber-supported Ni(0) nanoparticles catalyse the Heck reaction under ligand-free conditions. *RSC Advances.* 6**.** 29437-29440.

Zhu, Y., Shi, K. and Zhitomirsky, I. (2014) Polypyrrole coated carbon nanotubes for supercapacitor devices with enhanced electrochemical performance. *Journal of Power Sources.* 268**.** 233-239.

Zhuo, H., Hu, Y., Chen, Z. and Zhong, L. (2019) Cellulose carbon aerogel/PPy composites for high-performance supercapacitor. *Carbohydrate Polymers.* 215**.** 322-329.

Zilong, W., Zhu, Z., Qiu, J. and Yang, S. (2014) High performance flexible solid-state asymmetric supercapacitors from MnO_2/ZnO core-shell nanorods//specially reduced graphene oxide. *Journal of Materials Chemistry C.* 2**.** 1331-1336.

Zubair, N. A., Rahman, N. A., Lim, H. N. and Sulaiman, Y. (2017) Production of conductive PEDOT-Coated PVA-GO composite nanofibers. *Nanoscale Res Lett.* 12**.** 113.

Zubair, N. A., Rahman, N. A., Lim, H. N., Zawawi, R. M. and Sulaiman, Y. (2016) Electrochemical properties of PVA-GO/PEDOT nanofibers prepared using electrospinning and electropolymerization techniques. *RSC Advances.* 6**.** 17720-17727.