TERNARY MAGNETIC BIOCHAR COMPOSITE FROM *CITRULLUS LANATUS* RIND FOR SUPERCAPACITOR'S ELECTRODE

NURIZAN BINTI OMAR

UNIVERSITI TEKNOLOGI MALAYSIA

TERNARY MAGNETIC BIOCHAR COMPOSITE FROM *CITRULLUS LANATUS* RIND FOR SUPERCAPACITOR'S ELECTRODE

NURIZAN BINTI OMAR

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Malaysia-Japan International Institute of Technology
Universiti Teknologi Malaysia

JULY 2022

DEDICATION

This thesis is dedicated to my Mama and Abah, who always believed in my potential and taught me that everything happens for a reason; thus, keep faith in Allah, He is the best planner. It is also dedicated to my husband and kids, who always stand by my side in every thick and thin. And not to forget to my late mother-in- law, who patiently waiting for me to complete my Doctorate Degree, but Allah loves her more.

ACKNOWLEDGEMENT

"Allah makes everything beautiful in its time, and I am blessed He has shown me mercies".

Praise be to Allah SWT for all His guidance and strength given to me to pursue and complete the study. My deepest gratitude goes to my principal supervisor, Prof. Dr. Ezzat Chan Bin Abdullah for his continuous support and guidance throughout my years at MJIIT. Along with the ups and downs of my journey for Ph.D., I have also been shaped by countless great minds, particularly my co-supervisors in the persons of Prof. Dr. Mohammad Khalid from Sunway University, Assoc. Prof. Dr. Mubarak Mujawar of the Universiti Teknologi Brunei, Dr. Siti Rahmah Binti Aid of MJIIT and also Senior Research Fellow, Dr. Numan Arshid of Sunway University. Million of thanks for their untold commitment, understanding, continuous guidance and support throughout this journey.

My heartfelt appreciation goes to my parents, Hj. Omar Hasan and Hjh. Noor' Ain Abd Hamid who were always there to support me. There are no words to describe how thankful I am to have such amazing, loving and wonderful parents who always pray for me day and night to see their daughter's life become a success story. Not to forget, my husband, Mohd Fairus Tugiran and the kids, Medina, Raissa, Zydan, Niyaz and Eijaz, who witnessed all my struggles towards the completion of my study and always stand beside me regardless of any situation.

My siblings, Nurihan, Nurida, Syahir and Shafi, your continuous moral and financial support are really appreciated. Only Allah knows how thankful am I to have such a supportive and loving sibling as all of you! Also, to my in-laws, thank you for the understanding and support throughout my Ph.D. years. Not everyone is privileged enough to have someone rooting them on even when they have lost all hope. I am extremely lucky to have all of you in my life!

Not to forget my labmates in Air-Resources iKohza and CheCa iKohza of MJIIT and Graphene and Advanced 2D Materials Research Group of Sunway University for their advice and assistance in my journey towards the completion of my study. Sincere appreciation is given to technical staff, administrators, fellow researchers, academicians and non-academicians in MJIIT for their immeasurable support.

In-depth sincere appreciation also to the Ministry of Higher Education (MOHE) Malaysia and Kulliyyah of Engineering, International Islamic University Malaysia, for their financial support throughout the study.

To Farah Jawahir, Dr. Noraini, Dr. Syazwani, Dr. Hanisah, and Dr. Maziati Akmal, what did I do to deserve such a great friend like all of you? Thank you for your help and continuous moral support throughout this trying times. I am truly blessed to have all you in my life!

ABSTRACT

Metal oxides and conducting polymers are renowned as some of the promising materials for electrochemical energy storage (EES) devices, which include batteries, supercapacitors, and hybrid EES devices. This is due to their unique redox properties, significant theoretical capacitance, and environmentally benign nature. However, unsupported metal oxides and conducting polymer nanostructures suffer from particle aggregation, which decreases their electrochemical surface area. In recent years, the preparation of EES from renewable biomass has been developed taking into consideration the economic and environmental feasibility. Biochar is one of the major products of the thermochemical conversion of biomass. Applications of biochar for agricultural and environmental areas have been studied and reviewed extensively but biochar for energy storage materials has not been widely explored and examined. Therefore, the aim of this study is to convert the watermelon rind (WR) into magnetic biochar through a single-route self-purging pyrolysis method. Binary metal oxides (BMOs), such as nickel ferrite ($NiFe_2O_4$) and cobalt ferrite ($CoFe_2O_4$), were impregnated in dried watermelon rind to incorporate metal ions into the magnetic biochar. Response surface methodology (RSM) was employed to determine the magnetic watermelon rind biochar (MWRB) synthesis conditions (pyrolysis temperature, pyrolysis time, and WR: BMO ratio). The optimised magnetic biochar was combined with polyaniline (PANI) to produce a ternary magnetic biochar composite with PANI (TC-MWRB/PANI) via in-situ polymerisation to further enhance its electrochemical performance. RSM was also implemented to determine the TC-MWRB/PANI synthesis conditions (PANI concentration, sonication time, and sonication amplitude). Characterisations were done through field emission scanning electron microscopy (FESEM), energy dispersive Xray spectroscopy (EDX), X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, Brunauer-Emmett-Teller (BET) surface area, and vibrating sample magnetometer (VSM). Electrochemical evaluations were performed through cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS). The XRD and FTIR results confirmed the successful formation of MWRB and TC-MWRB/PANI. The FESEM images revealed the porous structure of MWRB and fibrous-look PANI embedded on the surface of TC-MWRB/PANI, while the EDX results showed their associated elemental composition. The electrochemical investigations revealed excellent electrochemical performance of the MWRB and TC-MWRB/PANI for energy storage applications. Based on the electrode specific capacity, the regressed model and experimental results for the fabricated $MWRB_{NiFe2O4}$ and $MWRB_{CoFe2O4}$ were determined to be 191 C g^{-1} and 187 C g^{-1} and 200.05 C g^{-1} and 200.96 C g^{-1}, at 5 mV s^{-1}, respectively. In addition, the electrode specific capacity based on the regressed model and experimental results for the fabricated TC-$MWRB_{CoFe2O4}$/PANI were determined to be 488.22 C g^{-1} and 491.29 C g^{-1}. A two-electrode configuration with TC-$MWRB_{CoFe2O4}$/PANI as a positrode and watermelon rind biochar (WRB) as a negatrode was fabricated to form a hybrid device (supercapattery) that operated in a stable potential window of 1.5 V. The energy density and power density of the device measured at a current density of 4 A g^{-1} were estimated to be 22.45 Wh kg^{-1} and 833.19 W kg^{-1}, respectively. The fabricated supercapattery showed excellent cyclability with 97.46% specific capacity retention after 5,000 cycles.

ABSTRAK

Oksida logam dan polimer pengalir terkenal sebagai beberapa bahan berpotensi tinggi bagi peranti storan tenaga elektrokimia (EES), termasuk bateri, superkapasitor dan peranti EES hibrid, disebabkan oleh sifat redoks yang unik, kapasiti teori yang ketara, serta tidak berbahaya kepada alam sekitar. Walau bagaimanapun, oksida logam yang tidak disokong dan struktur nano polimer konduktif mengalami pengagregatan zarah, yang mengurangkan luas permukaan elektrokimia bahan. Dalam beberapa tahun kebelakangan ini, penyediaan EES daripada biojisim boleh diperbaharui telah dibangunkan dengan mengambil kira kebolehlaksanaan ekonomi dan alam sekitar. Biochar merupakan salah satu produk utama penukaran termokimia biojisim. Penggunaan biochar dalam bidang pertanian dan alam sekitar telah dikaji dan disemak secara meluas. Walau bagaimanapun, biochar bagi bahan storan tenaga masih belum diterokai dan disemak secara meluas. Dalam kajian ini, kulit tembikai (WR) telah ditukar kepada biochar magnetik melalui kaedah pirolisis pembersihan-sendiri laluan-tunggal. Oksida logam binari (BMO), seperti ferit nikel ($NiFe_2O_4$) dan ferit kobalt ($CoFe_2O_4$), telah diimpregnat dalam kulit tembikai kering untuk memasukkan ion logam ke dalam biochar magnetik. Metodologi permukaan tindak balas (RSM) telah digunakan untuk menentukan keadaan sintesis biochar kulit tembikai magnetik (MWRB) (suhu pirolisis, masa pirolisis dan nisbah WR:BMO). Biochar bermagnet yang dioptimumkan telah digabungkan dengan polyaniline (PANI) bagi menghasilkan komposit biochar bermagnet terner dengan PANI (TC-MWRB/PANI) melalui pempolimeran *in-situ* untuk meningkatkan lagi prestasi elektrokimianya. RSM juga digunakan untuk menentukan keadaan sintesis TC-MWRB/PANI (kepekatan PANI, masa sonikasi, dan amplitud sonikasi). Pencirian dilakukan melalui mikroskop elektron pengimbasan pelepasan medan (FESEM), spektroskopi sinar-X penyebaran tenaga (EDX), pembelauan sinar-X (XRD), spektroskopi inframerah transformasi Fourier (FTIR), luas permukaan Brunauer-Emmett-Teller (BET), dan magnetometer sampel bergetar (VSM). Selain itu, penilaian elektrokimia dilakukan melalui voltametri kitaran (CV), nyahcas cas-galvanostatik (GCD), dan spektroskopi impedans elektrokimia (EIS). Keputusan XRD dan FTIR mengesahkan pembentukan MWRB dan TC-MWRB/PANI. Imej FESEM mendedahkan struktur berliang MWRB dan rupa PANI bergentian yang tertanam pada permukaan TC-MWRB/PANI, manakala keputusan EDX menunjukkan komposisi unsur yang berkaitan. Penyiasatan elektrokimia mendapati prestasi elektrokimia yang sangat baik dalam MWRB dan TC-MWRB/PANI bagi aplikasi storan tenaga. Berdasarkan kapasiti khusus elektrod, model regresi dan keputusan eksperimen untuk fabrikasi $MWRB_{NiFe2O4}$ dan $MWRB_{CoFe2O4}$, masing-masing telah ditentukan pada 5 mV s^{-1} sebagai 191 C g^{-1} dan 187 C g^{-1}, dan 200.05 C g^{-1} dan 200.96 C g^{-1}. Di samping itu, kapasiti khusus elektrod berdasarkan model regresi dan keputusan eksperimen untuk TC-$MWRB_{CoFe2O4}$/PANI yang direka dan didapati sebagai 488.22 C g^{-1} and 491.29 C g^{-1}. Konfigurasi dua elektrod dengan TC-$MWRB_{CoFe2O4}$/PANI sebagai elektrod positif dan biochar kulit tembikai (WRB) sebagai elektrod negatif telah direka untuk membentuk peranti hibrid (*supercapattery*) yang beroperasi dalam tetingkap berpotensi stabil 1.5 V. Ketumpatan tenaga dan ketumpatan kuasa peranti yang diukur pada ketumpatan arus 4 A g^{-1} masing-masing dianggarkan 22.45 Wh kg^{-1} dan 833.19 W kg^{-1}. *Supercapattery* yang difabrikasi menunjukkan kebolehkitaran yang sangat baik dengan pengekalan kapasiti spesifik 97.46% selepas 5,000 kitaran.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	-	Activated carbon
BAWDC	-	Boron-doped activated wood-derived carbon
BET	-	Brunauer Emmett Teller
BMO	-	Binary metal oxide
CAD No.	-	Chemical Abstracts Service Number
CCD	-	Central Composite Design
CNT	-	Carbon nanotube
$CoFe_2O_4$	-	Cobalt ferrite
CV	-	Cyclic voltammogram
CVD	-	Chemical vapor deposition
DIB	-	Dual-ion battery
EDLC	-	Electrochemical double-layer capacitor
EDS	-	Energy dispersive spectroscopy
EES	-	Electrochemical Energy Storage
EIS	-	Electrochemical impedance spectroscopy
ESR	-	Equivalent series resistance
ESS	-	Energy storage system
EV	-	All-electric vehicle
FESEM	-	Field emission scanning electron microscopy
FTIR	-	Fourier transform infrared spectroscopy
GCD	-	Galvanostatic charge-discharge
GHBC	-	Grape husk biochar
GO	-	Graphene oxide
GSBC	-	Grape stalk biochar
GWR	-	Ground watermelon rind
HEV	-	Hybrid electric vehicle
HMB	-	Hierarchically porous magnetic biochars
JCPDS	-	Joint committee on powder diffraction
MB	-	Magnetic biochar
MOP	-	Magnetic orange peel

MWCNT	-	Multi-wall carbon nanotube
MWRB	-	Magnetic watermelon rind biochar
$MWRB_{CoFe2O4}$	-	Magnetic watermelon rind biochar with Cobalt ferrite
$MWRB_{NiFe2O4}$	-	Magnetic watermelon rind biochar with Nickel ferrite
NKWC	-	Wood-derived nitrogen-doped porous carbon
$NiFe_2O_4$	-	Nickel ferrite
NF	-	Nickel foam
NSBC	-	Nut shield biochar
NMP	-	N-methyl-2-pyrrolidone
PANI	-	Polyaniline
PEDOT	-	Poly(3,4-ethylenedioxythiophene)
Ppy	-	Polypyrrole
PSBC	-	Plum stone biochar
PVDF	-	Polyvinylidene fluoride
rGO	-	Reduced graphene oxide
SWCNT	-	Single-wall carbon nanotube
TMO	-	Transition metal oxide
UC	-	Ultra capacitor
VSM	-	Vibrating sample magnetometer
WR	-	Watermelon rind
WRB	-	Watermelon rind Biochar
WSBC	-	Wheat straw biochar
TC-$MWRB_{CoFe2O4}$/PANI	-	Ternary composite of magnetic watermelon rind biochar with cobalt ferrite/polyaniline
XRD	-	X-ray dispersive

LIST OF SYMBOLS

A	-	Surface area
B	-	Applied magnetic field
C_s	-	Specific capacitance of electrode
C	-	Coulomb
C	-	Material-specific curie constant
d	-	Thickness of double layer
dV	-	Potential window
f	-	Response function
F	-	Farad
Hz	-	Hertz
I	-	Current
k	-	Number of variables
m	-	Mass loading
M	-	Resulting magnetisation
M_S	-	Saturation magnetisation
M_r	-	Retentivity
pH	-	Potential of hydrogen
Oe	-	Coercive field
Q_s	-	Specific capacity of the electrode
Q_d	-	Specific capacity of the device
R_{ct}	-	Charge transfer resistance
$R2$	-	Correlation coefficient
v	-	Scan rate
T	-	Absolute temperature
Tc	-	Curie's temperature
V_i	-	Initial potential
V_f	-	Final potential
Z_{re}	-	Real part of impedance
Z_{im}	-	Imaginary part of impedance
Δt	-	Discharge time

ΔV	-	Voltage window
α	-	Absorption coefficient
λ	-	X-ray wavelength of radiation
Θ	-	Diffraction angle
ε	-	Experimental error or residuals
ε_0	-	Electrical permittivity of free space
ε_r	-	Dielectric constant
Ω	-	Ohm for impedance
χ	-	Magnetic susceptibility

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

The emergence of electronics has rapidly increased the demand for energy storage devices. On the other hand, the aggravation of environmental pollution and the depletion of fossil fuels have stimulated the development of green, renewable, and favorable energy storage devices (Agudosi et al., 2020; Dong et al., 2020; Xie et al., 2018). Supercapacitors, batteries, fuel cells, and conventional capacitors are standard smart energy technologies. Extensive research and exploration are being executed worldwide on each of these devices. Supercapacitors have drawn intensive attention due to their rapid charge-discharge rate, high power density, long cycle life, and eco-friendliness (Kalyani & Anitha, 2013). One of the impediments to employing supercapacitors on a large scale is the expense encountered. Thus, replacing commercial activated carbon with biochars can be considered an option due to the environmental considerations (Thomas et al., 2020).

Biochar is the solid carbon-rich material produced through the thermochemical conversion of biomass(Xiu et al., 2017; Zhang et al., 2014a; Zhang et al., 2014b). Biomass can be referred to as organic materials originating from living matters such as animals and plants or organic and inorganic tissues, such as excrement of animals, sludge, and waste wood (Cha et al., 2016; Tripathi et al., 2016). Over the years, biochar has gained substantial interest in developing materials for the applications ranging from carbon capture and storage, hydrogen storage, environmental remediation, and energy storage devices due to its unique properties such as high absorption capacity, variability in microporosity, high specific surface area, and high ion exchange capability (Balahmar et al., 2015; Blankenship et al.; Li et al., 2018a; Wang & Wang, 2019; Xiu et al., 2017).

The various methodological approaches developed and established throughout the years for biochar production include pyrolysis, carbonisation, and gasification. Essentially the production routes significantly affected the properties of the produced biochar. For instance, biochar yield greatly depends on pyrolysis type. For example, slow pyrolysis performed at a longer residence time and a moderate temperature (350–550 °C) in the absence of O_2 results in a higher yield of biochar (30%) than the fast pyrolysis (12%) or gasification (10%) (Inyang & Dickenson, 2015). Besides, the production temperature and the types of biomass precursors also play a vital role in determining the properties of biochar (Sun et al., 2014). The biochar needs some modifications to increase its specific surface area (SSA) and pore fraction or form functional groups before use to expand its applications. Pre/Post-synthetic changes are conducted based on as-synthesised biochar, like physical or chemical activation, surface functionalisation, or nanomaterials/biochar composites. In recent years, researchers have shown an increased interest in ternary composites by incorporating conducting polymers such as polyaniline, polypyrrole, polyacetylene, etc., as measures to enhance the electrochemical capacitance (Thomas et al., 2020; Yang & Ionescu, 2017).

This study converted the watermelon rinds into magnetic biochar through the self-purging pyrolysis method. Binary metal oxide, nickel ferrite ($NiFe_2O_4$) and cobalt ferrite ($CoFe_2O_4$) were impregnated on dried watermelon rind to incorporate metal ions into the magnetic biochar. The operating parameters (pyrolysis temperature, pyrolysis time and watermelon rind to binary metal oxide ratio) were optimised to produce magnetic biochar with high specific capacity for supercapacitor's electrode. The optimised magnetic watermelon rind biochar (MWRB) was then combined with polyaniline via in-situ polymerisation to produce a ternary composite of magnetic watermelon rind biochar and polyaniline (TC-MWRB/PANI) to enhance its electrochemical performance. This enables faradaic redox reaction, and charging occurs throughout the electrode materials. The electrode fabrication method is employed as adopted by Kouchachvili and Entchev (2017) and Thines et al. (2016), which is further elaborated in Methodology. In addition to these, Response Surface Methodology (RSM) will be carried out using a Design Expert to optimise the parameters in producing MWRB and TC-MWRB/PANI composites for supercapacitor's electrode application.

1.2 Problem Statement

Detrimental environmental consequences of fossil fuels usage and their depletion issue have motivated serious concerns leading to enormous research focusing on determining adequate alternatives for efficient energy storage systems from various abundantly available renewable and sustainable materials for energy sources (Kim et al., 2021). Among impending measures to meet increasing global energy demand, energy conversion applications, including hydrogen fuel cells, photovoltaic cells, wind power and energy storage applications, including metal-ion batteries and supercapacitors, are considered the most viable options (Iqbal et al., 2020b). The rapid pace in the emergent trend of portable electronic devices and hybrid vehicles is another cause to explore efficient energy storage systems.

As a class of promising energy storage systems, supercapacitors have received much attention owing to their expansive applications for storing intermittent electrical energy (Chen et al., 2015a). Thus, the electrode material as the key contributor to the energy storage of supercapacitors is attracting considerable research interest from the materials science and energy storage field (Chen et al., 2013; Liu et al., 2015b; Zhu et al., 2014).

Generally, activated carbon is commonly used as electrode material for supercapacitors. However, the drawbacks of using activated carbons as electrode materials are slow mass transport of electrolyte ions because of space confinement imposed by small pore sizes, low conductivity because of the presence of enormous surface functional groups and defects due to activated process, and collapse of porous structures during high temperature treatments is low capacitance stability at high current densities which limits their commercial applications.

In the use of biochar in energy storage applications, surface area, pore structure, and conductivity behavior of the porous carbon material are the most important properties that affect electrochemical performance. As the surface area increases, the capacitance increases due the higher amount of charge accumulated on the electrode surface. However, high surface area alone is not sufficient for high capacitance. It is also crucial that the pores are to be ‘open’ as well as their sizes. Not all pores on the surface are electrochemically accessible . Apart from carbon materials, conducting polymers such as polyaniline (PANI) has proved to be a promising supercapacitor electrode due to their high charge density and ease of fabrication. However, PANI experiences significant volumetric swelling and shrinking during the charge-discharge process due to ion doping and de-doping, leading to structural breakdown and flaking off PANI. Thus, compositing biomass carbon with metal oxides and conducting polymer lead to enhanced supercapacitor properties, as evident from previous research since the effective carbon support is expected to provide good electrical conduction with metal oxides, large surface area to disperse them, and suitable pore channels for their deposition and for electrolyte ion transportation (Thomas et al., 2020; Yang & Ionescu, 2017).

It was hypothesised that the preparation of MWRB via pyrolysis in vacuumed conditioned electric muffle furnace gives a great advantage as facile single route synthesis of magnetic biochar rather than conventional pyrolysis in the presence of inert gas. To date, biochar derived from biomass waste such as coconut shell, rice husk, coffee shell, durian rind, and the banana peel has been studied to evaluate its potential as a supercapacitor’s electrode. However, such information is limited for watermelon rind biomass. The introduction of binary metal oxides of $NiFe_2O_4$ and $CoFe_2O_4$ into the biochar framework was expected to improve the biochar’s porosity and promote active sites, which are expected to enhance the electrochemical properties of biochars. Lastly, the introduction of PANI was also anticipated to enhance electrochemical properties due to the synergetic combination of the excellent mechanical strength of carbon materials and the high pseudocapacitance of PANI.

1.3 Research Objectives

The research aims to develop the magnetic watermelon rind biochar with binary metal oxide (nickel ferrite, $NiFe_2O_4$ and cobalt ferrite, $CoFe_2O_4$) and a ternary composite of magnetic watermelon rind-polyaniline (TC-MWRB/PANI) for the fabrication of electrode materials for supercapacitors. It is known that the properties of magnetic biochars and magnetic biochar composites are found to be dependent on processing parameters, materials combination and proportion. Thus, a comprehensive selection of materials, synthesising parameters and materials ratio should be made. To achieve this key objective, several explicit aims need to be addressed:

i. To optimise MWRB synthesis parameters such as pyrolysis temperature, pyrolysis time and binary metal oxide to biomass ratio for specific capacity measurement using Response Surface Methodology (RSM) by Design Expert® Version 13.
ii. To synthesise TC-MWRB/PANI composites through in-situ polymerisation and optimise the parameters such as PANI ratio, sonication time and sonication amplitude for supercapacitor's electrode using RSM by Design Expert® Version 13.
iii. To study morphology, chemical, elemental, magnetic and electrochemical properties of the MWRB and TC-MWRB/PANI composites.
iv. To fabricate and investigate the performance of the synthesised TC-MWRB/PANI composites for energy storage application through CV, GCD, lifecycle and EIS measurements

1.4 Scopes of Research

Magnetic biochars were prepared from waste watermelon rind (WR) with the impregnation of binary metal oxide via self-purging pyrolysis by attaining limited oxygen conditions in an electric muffle furnace without using any carrier gas. There are two types of binary metal oxide used in the preparation of MWRB, which are $NiFe_2O_4$ and $CoFe_2O_4$. The RSM was implemented using Design-Expert© software Version 13 (Stat-Ease, Inc.) to optimise MWRB production. The pyrolysis independent variables and their ranges were pyrolysis temperature (600 °C-900 °C) and pyrolysis time (10-60minutes), and watermelon rind to binary metal oxide ratio ,WR:BMO (25-75 weight %). In contrast, the dependent variable was the specific capacity (Qs) response. The MWRB produced at optimum condition were then undergo extensive material characterisations involving field emission scanning electron microscopy-energy dispersive x-ray spectroscopy (FESEM-EDX), X-ray diffractometry (XRD), Fourier transforms infrared (FTIR), Brunauer–Emmett–Teller (BET) surface area and Vibrating sample magnetometer (VSM).

The optimised MWRB samples were then were added with PANI to produce TC-MWRB/PANI composites via in-situ polymerisation. Likewise, the RSM by Design Expert© software Version 13 software (Stat-Ease, Inc.) was employed to optimise TC-MWRB/PANI synthesis. The factors such as the PANI concentration, sonication amplitude, and sonication time were optimised within 3-7 mmol, 30-80 %, and 15-30 minutes, respectively. The electrochemical performance of the composites in terms of their specific capacity was designated as the response. The characterisations of optimised TC-MWRB/PANI composites were done through FESEM-EDX, XRD, FTIR, BET surface area, and VSM studies.

The electrochemical evaluations of both optimised MWRB and TC-MWRB/PANI composite were investigated through cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS). A solution of potassium hydroxide (KOH), 1M, was used as an electrolyte. At the same time, the as-synthesised MWRB and TC-MWRB/PANI composites, saturated calomel electrode (SCE), and platinum wire were employed as working reference, and counter electrodes, respectively.

1.5 Significance of Research

This recent research developed MWRB from waste watermelon rinds and TC-MWRB/PANI composites for supercapacitor's electrode material. Transition metal oxides of $NiFe_2O_4$ and $CoFe_2O_4$ were used to produce MWRB since the pseudocapacitive oxides of transition metal are widely explored due to their high theoretical capacitance, low cost, and reversible faradaic redox reactions compared to carbonaceous materials. Thus, incorporating these transition metal oxides was expected to enhance the specific capacitance of synthesised MWRB.

It is well known that, among various electrode materials, PANI has been proved to be a favorable supercapacitor's electrode material due to its low cost, high charge density, good electrical conductivity in doped states, and facile fabrication for large scale devices (Yu et al., 2015). However, PANI experiences significant volumetric swelling and shrinking during the charge-discharge process due to electrochemical instability. Consequently, the combination of MWRB with PANI becomes favorable in increasing the electrochemical performance of the electrode materials. Thus, the incorporation of earth-abundant carbon materials such as biomass with PANI is one of the effective ways to improve the electrochemical stability of PANI and enhance energy output.

Besides, the demand for watermelon in Malaysia is not decreasing due to its delicious taste and broad availability, especially during hot weather. As more fruits are being consumed daily, the availability of the rinds is increasing as well. Managing these rinds is quite tedious, and humans generally opt for the dumping and burning choice to overcome this problem. This option has already led to several environmental issues (Khedari et al., 2003). Dumping food waste in the landfill will gradually rot and release methane, a strong greenhouse gas. Hence this approach is expected to contribute to minimising the issues mentioned above.

1.6 Thesis Outline

This thesis comprises five chapters.

Chapter 1 provides a brief background about the energy storage devices and the problems encountered due to the shortage of fossil fuels. Then comes the introduction of biochar as an alternative. The types of biochar, its processing methods, and applications in the various field are delineated. The biochar's modification to enhance its properties is also deliberated in this chapter.

Chapter 2 presents the details of the literature, and the feasibility study of this research is given and elaborated. It also explains the general concepts related to Response Surface Methodology (RSM), electrochemical analysis and the characterisations involved in biochar specifically for energy storage applications.

Chapter 3 highlights the overall research methodology and procedures. The experimental procedures for the synthesis and production of MWRB and TC-MWRB/PANI composites are reported. The experimental methods, materials, and design factors for optimisation and their ranges are stated with justifications. The material characterisations (FTIR, XRD, BET, VSM, and FESEM-EDX) and the electrochemical evaluation (CV, GCDs, and EIS) techniques for analysing optimised samples for both the as-synthesised MWRB and TC-MWRB/PANI composites are articulated. A flowchart illustrating the summary of this chapter is presented in this chapter.

Chapter 4 provides in-depth discussions and thorough analysis and the results of statistical RSM analysis of MWRB and TC-MWRB/PANI and elemental, morphological, structural, and electrochemical analysis of the optimised MWRB and TC-MWRB/PANI composites.

Lastly, Chapter 5 summarily presents the findings based on the set of objectives and recommendations for future research based on present findings.

REFERENCES

Abdel Maksoud, M., Fahim, R. A., Shalan, A. E., Abd Elkodous, M., Olojede, S., Osman, A. I., et al. (2021). Advanced materials and technologies for supercapacitors used in energy conversion and storage: a review. *Environmental Chemistry Letters, 19*(1), 375-439.

Acharya, S., Sahoo, S., Sonal, S., Lee, J. H., Mishra, B. K., & Nayak, G. C. (2020). Adsorbed Cr(VI) based activated carbon/polyaniline nanocomposite: A superior electrode material for asymmetric supercapacitor device. *Composites Part B: Engineering, 193*, 107913. doi:https://doi.org/10.1016/j.compositesb.2020.107913

Achaw, O.-W. (2012). A study of the porosity of activated carbons using the scanning electron microscope. In *Scanning electron microscopy*: IntechOpen.

Adhikari, A. D., Oraon, R., Tiwari, S. K., Jena, N. K., Lee, J. H., Kim, N. H., et al. (2017). Polyaniline-Stabilized Intertwined Network-like Ferrocene/Graphene Nanoarchitecture for Supercapacitor Application. *Chemistry–An Asian Journal, 12*(8), 900-909.

Agudosi, E. S., Abdullah, E. C., Numan, A., Khalid, M., Mubarak, N. M., Benages-Vilau, R., et al. (2021). Optimisation of NiO electrodeposition on 3D graphene electrode for electrochemical energy storage using response surface methodology. *Journal of Electroanalytical Chemistry, 882*, 114992. doi:https://doi.org/10.1016/j.jelechem.2021.114992

Agudosi, E. S., Abdullah, E. C., Numan, A., Mubarak, N. M., Khalid, M., & Omar, N. (2020). A Review of the Graphene Synthesis Routes and its Applications in Electrochemical Energy Storage. *Critical Reviews in Solid State and Materials Sciences, 45*(5), 339-377. doi:10.1080/10408436.2019.1632793

Ahmad, J., Patuzzi, F., Rashid, U., Shahabz, M., Ngamcharussrivichai, C., & Baratieri, M. (2021). Exploring untapped effect of process conditions on biochar characteristics and applications. *Environmental Technology & Innovation, 21*, 101310. doi:https://doi.org/10.1016/j.eti.2020.101310

Ahmad, M. A., Ahmad, N., & Bello, O. S. (2015). Modified durian seed as adsorbent for the removal of methyl red dye from aqueous solutions. *Applied Water Science, 5*(4), 407-423.

Ahmed, M. B., Zhou, J. L., Ngo, H. H., Guo, W., & Chen, M. (2016). Progress in the preparation and application of modified biochar for improved contaminant removal from water and wastewater. *Bioresource Technology, 214*, 836-851.

Akasaka, H., Takahata, T., Toda, I., Ono, H., Ohshio, S., Himeno, S., et al. (2011). Hydrogen storage ability of porous carbon material fabricated from coffee bean wastes. *International Journal of Hydrogen Energy, 36*(1), 580-585.

Akgül, G., Maden, T. B., Diaz, E., & Jiménez, E. M. (2018). Modification of tea biochar with Mg, Fe, Mn and Al salts for efficient sorption of PO43− and Cd2+ from aqueous solutions. *Journal of Water Reuse and Desalination, 9*(1), 57-66. doi:10.2166/wrd.2018.018

Akhil, D., Lakshmi, D., Kartik, A., Vo, D.-V. N., Arun, J., & Gopinath, K. P. (2021). Production, characterization, activation and environmental applications of engineered biochar: a review. *Environmental Chemistry Letters, 19*(3), 2261-2297.

Alcaraz-Espinoza, J. J., & de Oliveira, H. P. (2018). Flexible supercapacitors based on a ternary composite of polyaniline/polypyrrole/graphite on gold coated sandpaper. *Electrochimica Acta, 274*, 200-207.

Ali, I., Peng, C., Lin, D., Saroj, D. P., Naz, I., Khan, Z. M., et al. (2019). Encapsulated green magnetic nanoparticles for the removal of toxic Pb^{2+} and Cd^{2+} from water: development, characterization and application. *Journal of environmental management, 234*, 273-289.

Amenaghawon, A. N., Anyalewechi, C. L., Okieimen, C. O., & Kusuma, H. S. (2021). Biomass pyrolysis technologies for value-added products: a state-of-the-art review. *Environment, Development and Sustainability, 23*(10), 14324-14378.

Andrade, T. S., Vakros, J., Mantzavinos, D., & Lianos, P. (2020). Biochar obtained by carbonization of spent coffee grounds and its application in the construction of an energy storage device. *Chemical Engineering Journal Advances, 4*, 100061.

Aneke, M., & Wang, M. (2016). Energy storage technologies and real life applications–A state of the art review. *Applied Energy, 179*, 350-377.

Arie, A. A., Kristianto, H., Susanti, R. F., & Lee, J. K. (2021). Rambutan peel derived porous carbons for lithium sulfur battery. *SN Applied Sciences, 3*(5), 1-10.

Ariharan, A., & Viswanathan, B. (2018). Porous activated carbon material derived from sustainable bio-resource of peanut shell for H_2 and CO_2 storage applications.

Asare, K. (2020). *Porous and Hollow Carbon Nanofibers from Electrospinning and Their Use as Electrode for Energy Storage Application.* North Carolina Agricultural and Technical State University.

Asghar, A., Abdul Raman, A. A., & Daud, W. M. A. W. (2014). A Comparison of Central Composite Design and Taguchi Method for Optimizing Fenton Process. *The Scientific World Journal, 2014*, 869120. doi:10.1155/2014/869120

Ashiq, M., Ehsan, M., Iqbal, M., & Gul, I. (2011). ChemInform Abstract: Synthesis, Structural and Electrical Characterization of Sb3+ Substituted Spinel Nickel Ferrite (NiSbxFe2-xO4) Nanoparticles by Reverse Micelle Technique. *Journal of Alloys and Compounds, 509*, 5119-5126. doi:10.1016/j.jallcom.2011.01.193

Askari, M. B., & Salarizadeh, P. (2020). Binary nickel ferrite oxide (NiFe2O4) nanoparticles coated on reduced graphene oxide as stable and high-performance asymmetric supercapacitor electrode material. *International Journal of Hydrogen Energy, 45*(51), 27482-27491.

Augustyn, V., Simon, P., & Dunn, B. (2014). Pseudocapacitive oxide materials for high-rate electrochemical energy storage. *Energy & Environmental Science, 7*(5), 1597-1614. doi:10.1039/C3EE44164D

Avci, B., Girotra, K., & Netessine, S. (2015). Electric vehicles with a battery switching station: Adoption and environmental impact. *Management Science, 61*(4), 772-794.

Ayinla, R. T., Dennis, J. O., Zaid, H. M., Sanusi, Y. K., Usman, F., & Adebayo, L. L. (2019). A review of technical advances of recent palm bio-waste conversion to activated carbon for energy storage. *Journal of Cleaner Production, 229*, 1427-1442. doi:https://doi.org/10.1016/j.jclepro.2019.04.116

Baghali, M., Jayathilaka, W., & Ramakrishna, S. (2021). The role of electrospun nanomaterials in the future of energy and environment. *Materials, 14*(3), 558.

Bai, M.-H., Liu, T.-Y., Luan, F., Li, Y., & Liu, X.-X. (2014). Electrodeposition of vanadium oxide–polyaniline composite nanowire electrodes for high energy density supercapacitors. *Journal of Materials Chemistry A, 2*(28), 10882-10888.

Baig, M. M., & Gul, I. H. (2021). Conversion of wheat husk to high surface area activated carbon for energy storage in high-performance supercapacitors. *Biomass and Bioenergy, 144*, 105909.

Baker, M. J., Trevisan, J., Bassan, P., Bhargava, R., Butler, H. J., Dorling, K. M., et al. (2014). Using Fourier transform IR spectroscopy to analyze biological materials. *Nat. Protocols, 9*(8), 1771-1791. doi:10.1038/nprot.2014.110

Balahmar, N., Mitchell, A. C., & Mokaya, R. (2015). Generalized Mechanochemical Synthesis of Biomass-Derived Sustainable Carbons for High Performance CO_2 Storage. *Advanced Energy Materials, 5*(22), 1500867. doi:https://doi.org/10.1002/aenm.201500867

Balasubramaniam, S., Mohanty, A., Balasingam, S. K., Kim, S. J., & Ramadoss, A. (2020). Comprehensive Insight into the Mechanism, Material Selection and Performance Evaluation of Supercapatteries. *Nano-Micro Letters, 12*(1), 85. doi:10.1007/s40820-020-0413-7

Balasubramanian, K., & Burghard, M. (2008). Electrochemically functionalized carbon nanotubes for device applications. *Journal of Materials Chemistry, 18*(26), 3071-3083.

Balint, R., Cassidy, N. J., & Cartmell, S. H. (2014). Conductive polymers: Towards a smart biomaterial for tissue engineering. *Acta biomaterialia, 10*(6), 2341-2353.

Balogun, M.-S., Qiu, W., Wang, W., Fang, P., Lu, X., & Tong, Y. (2015). Recent advances in metal nitrides as high-performance electrode materials for energy storage devices. *Journal of Materials Chemistry A, 3*(4), 1364-1387.

Banerjee, S., & Kar, K. K. (2020). Conducting polymers as electrode materials for supercapacitors. In *Handbook of Nanocomposite Supercapacitor Materials II* (pp. 333-352): Springer.

Basri, N. H., Deraman, M., Kanwal, S., Talib, I. A., Manjunatha, J. G., Aziz, A. A., et al. (2013). Supercapacitors using binderless composite monolith electrodes from carbon nanotubes and pre-carbonized biomass residues. *Biomass and Bioenergy, 59*, 370-379. doi:https://doi.org/10.1016/j.biombioe.2013.08.035

Bayindir, K. Ç., Gözüküçük, M. A., & Teke, A. (2011). A comprehensive overview of hybrid electric vehicle: Powertrain configurations, powertrain control techniques and electronic control units. *Energy Conversion and Management, 52*(2), 1305-1313.

Beguin, F., & Frackowiak, E. (2009). *Carbons for electrochemical energy storage and conversion systems*: CRC Press.

Berckmans, G., Messagie, M., Smekens, J., Omar, N., Vanhaverbeke, L., & Van Mierlo, J. (2017). Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030. *Energies, 10*(9), 1314. Retrieved from https://www.mdpi.com/1996-1073/10/9/1314

Bhadra, S., Khastgir, D., Singha, N. K., & Lee, J. H. (2009). Progress in preparation, processing and applications of polyaniline. *Progress in polymer science, 34*(8), 783-810.

Bharti, Kumar, A., Ahmed, G., Gupta, M., Bocchetta, P., Adalati, R., et al. (2021). Theories and models of supercapacitors with recent advancements: impact and interpretations. *Nano Express, 2*(2), 022004. doi:10.1088/2632-959x/abf8c2

Bhuvanendran, N., Ravichandran, S., Kandasamy, S., Zhang, W., Xu, Q., Khotseng, L., et al. (2021). Spindle-shaped CeO2/biochar carbon with oxygen-vacancy as an effective and highly durable electrocatalyst for oxygen reduction reaction. *International Journal of Hydrogen Energy, 46*(2), 2128-2142. doi:https://doi.org/10.1016/j.ijhydene.2020.10.115

Blanco-Esqueda, I. G., Ortega-Zarzosa, G., Martínez, J. R., & Guerrero, A. L. (2015). Preparation and Characterization of Nickel Ferrite-SiO_2/Ag Core/Shell Nanocomposites. *Advances in Materials Science and Engineering, 2015*, 678739. doi:10.1155/2015/678739

Blankenship, T., Balahmar, N., & Mokaya, R. Oxygen-rich microporous carbons with exceptional hydrogen storage capacity, Nat. Commun. 8 (2017).

Bordoloi, N., Narzari, R., Sut, D., Saikia, R., Chutia, R. S., & Kataki, R. (2016). Characterization of bio-oil and its sub-fractions from pyrolysis of Scenedesmus dimorphus. *Renewable Energy, 98*, 245-253.

Borenstein, A., Hanna, O., Attias, R., Luski, S., Brousse, T., & Aurbach, D. (2017). Carbon-based composite materials for supercapacitor electrodes: a review. *Journal of Materials Chemistry A, 5*(25), 12653-12672.

Borghei, M., Laocharoen, N., Kibena, E., Johansson, L.-S., Campbell, J., Kauppinen, E., et al. (2016). Porous N,P-doped Carbon from Coconut Shells with High Electrocatalytic Activity for Oxygen Reduction: Alternative to Pt-C for Alkaline Fuel Cells. *Applied Catalysis B: Environmental, 204*. doi:10.1016/j.apcatb.2016.11.029

Brousse, T., Bélanger, D., & Long, J. W. (2015). To be or not to be pseudocapacitive? *Journal of the Electrochemical Society, 162*(5), A5185.

Brownson, D. A., & Banks, C. E. (2014). The handbook of graphene electrochemistry.

Bruce, P. G., Freunberger, S. A., Hardwick, L. J., & Tarascon, J.-M. (2012). Li–O_2 and Li–S batteries with high energy storage. *Nature Materials, 11*(1), 19-29. doi:10.1038/nmat3191

Bryan, A. M., Santino, L. M., Lu, Y., Acharya, S., & D'Arcy, J. M. (2016). Conducting polymers for pseudocapacitive energy storage. *Chemistry of Materials, 28*(17), 5989-5998.

Budai, A., Calucci, L., Rasse, D. P., Strand, L. T., Pengerud, A., Wiedemeier, D., et al. (2017). Effects of pyrolysis conditions on Miscanthus and corncob chars: Characterization by IR, solid state NMR and BPCA analysis. *Journal of Analytical and Applied Pyrolysis, 128*, 335-345.

Budai, A., Wang, L., Gronli, M., Strand, L. T., Antal, M. J., Abiven, S., et al. (2014). Surface Properties and Chemical Composition of Corncob and Miscanthus Biochars: Effects of Production Temperature and Method. *Journal of Agricultural and Food Chemistry, 62*(17), 3791-3799. doi:10.1021/jf501139f

Burke, A. (2007a). R&D considerations for the performance and application of electrochemical capacitors. *Electrochimica Acta, 53*(3), 1083-1091. doi:https://doi.org/10.1016/j.electacta.2007.01.011

Burke, A., & Zhao, H. (2015). Applications of supercapacitors in electric and hybrid vehicles. *Institute of Transportation Studies, University of California, Davis*.

Burke, A. F. (2007b). Batteries and ultracapacitors for electric, hybrid, and fuel cell vehicles. *Proceedings of the IEEE, 95*(4), 806-820.

Cabana, J., Monconduit, L., Larcher, D., & Palacin, M. R. (2010). Beyond intercalation-based Li-ion batteries: the state of the art and challenges of electrode materials reacting through conversion reactions. *Advanced Materials, 22*(35), E170-E192.

Cai, W., Liu, J., Liu, P., Liu, Z., Xu, H., Chen, B., et al. (2019). A direct carbon solid oxide fuel cell fueled with char from wheat straw. *International Journal of Energy Research, 43*(7), 2468-2477.

Cai, X., Li, J., Liu, Y., Hu, X., Tan, X., Liu, S., et al. (2020). Design and preparation of chitosan-crosslinked bismuth ferrite/biochar coupled magnetic material for methylene blue removal. *International Journal of Environmental Research and Public Health, 17*(1), 6.

Cai, Z., Jiang, C., Xiao, X., Zhang, Y., & Liang, L. (2018). *Lignin-based biochar/graphene oxide composites as supercapacitor electrode materials.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Cao, X., Sun, S., & Sun, R. (2017). Application of biochar-based catalysts in biomass upgrading: a review. *RSC Advances, 7*(77), 48793-48805.

Carlin, R. T., Hugh, C., Fuller, J., & Trulove, P. C. (1994). Dual intercalating molten electrolyte batteries. *Journal of the Electrochemical Society, 141*(7), L73.

Çeçen, F. (2000). Activated carbon. *Kirk-Othmer Encyclopedia of Chemical Technology*, 1-34.

Cha, J. S., Park, S. H., Jung, S.-C., Ryu, C., Jeon, J.-K., Shin, M.-C., et al. (2016). Production and utilization of biochar: A review. *Journal of Industrial and Engineering Chemistry, 40*, 1-15.

Chacón, F. J., Cayuela, M. L., Roig, A., & Sánchez-Monedero, M. A. (2017). Understanding, measuring and tuning the electrochemical properties of biochar for environmental applications. *Reviews in Environmental Science and Bio/Technology, 16*(4), 695-715.

Chakraborty, I., Sathe, S., Dubey, B., & Ghangrekar, M. (2020). Waste-derived biochar: applications and future perspective in microbial fuel cells. *Bioresource Technology, 312*, 123587.

Chandran, M., Shamna, I., Anusha, A., & Bhagiyalakshmi, M. (2019). Synthesis of mesoporous carbon-polymeric hybrid material for energy storage application. *SN Applied Sciences, 1*(6), 1-10.

Charlier, J.-C., Blase, X., & Roche, S. (2007). Electronic and transport properties of nanotubes. *Reviews of modern physics, 79*(2), 677.

Chatterjee, D. P., & Nandi, A. K. (2021). A review on the recent advances in hybrid supercapacitors. *Journal of Materials Chemistry A, 9*(29), 15880-15918.

Chatterjee, R., Sajjadi, B., Chen, W.-Y., Mattern, D. L., Hammer, N., Raman, V., et al. (2020). Effect of Pyrolysis Temperature on PhysicoChemical Properties and Acoustic-Based Amination of Biochar for Efficient CO2 Adsorption. *Frontiers in Energy Research, 8*(85). doi:10.3389/fenrg.2020.00085

Chauhan, A., & Chauhan, P. (2014). Powder XRD Technique and its Applications in Science and Technology. *Journal of Analytical & Bioanalytical Techniques, 5*(5), 1.

Chawla, N., Bharti, N., & Singh, S. (2019). Recent Advances in Non-Flammable Electrolytes for Safer Lithium-Ion Batteries. *Batteries, 5*(1), 19. Retrieved from https://www.mdpi.com/2313-0105/5/1/19

Chen, B., & Chen, Z. (2009). Sorption of naphthalene and 1-naphthol by biochars of orange peels with different pyrolytic temperatures. *Chemosphere, 76*(1), 127-133. doi:https://doi.org/10.1016/j.chemosphere.2009.02.004

Chen, B., Chen, Z., & Lv, S. (2011). A novel magnetic biochar efficiently sorbs organic pollutants and phosphate. *Bioresource Technology, 102*(2), 716-723. doi:https://doi.org/10.1016/j.biortech.2010.08.067

Chen, G. Z. (2017). Supercapacitor and supercapattery as emerging electrochemical energy stores. *International Materials Reviews, 62*(4), 173-202. doi:10.1080/09506608.2016.1240914

Chen, H., Hu, L., Yan, Y., Che, R., Chen, M., & Wu, L. (2013). One-Step Fabrication of Ultrathin Porous Nickel Hydroxide-Manganese Dioxide Hybrid Nanosheets for Supercapacitor Electrodes with Excellent Capacitive Performance. *Advanced Energy Materials, 3*(12), 1636-1646. doi:https://doi.org/10.1002/aenm.201300580

Chen, H., Liu, D., Shen, Z., Bao, B., Zhao, S., & Wu, L. (2015a). Functional Biomass Carbons with Hierarchical Porous Structure for Supercapacitor Electrode Materials. *Electrochimica Acta, 180*, 241-251. doi:https://doi.org/10.1016/j.electacta.2015.08.133

Chen, H., Wang, G., Chen, L., Dai, B., & Yu, F. (2018). Three-dimensional honeycomb-like porous carbon with both interconnected hierarchical porosity and nitrogen self-doping from cotton seed husk for supercapacitor electrode. *Nanomaterials, 8*(6), 412.

Chen, L.-F., Ma, S.-X., Lu, S., Feng, Y., Zhang, J., Xin, S., et al. (2017a). Biotemplated synthesis of three-dimensional porous MnO/CN nanocomposites from renewable rapeseed pollen: an anode material for lithium-ion batteries. *Nano Research, 10*(1), 1-11.

Chen, M., Wumaie, T., Li, W., Song, H., & Song, R. (2015b). Electrochemical performance of cotton stalk based activated carbon electrodes modified by MnO2 for supercapacitor. *Materials Technology, 30*(sup1), A2-A7.

Chen, M., Yu, D., Zheng, X., & Dong, X. (2019a). Biomass based N-doped hierarchical porous carbon nanosheets for all-solid-state supercapacitors. *Journal of Energy Storage, 21*, 105-112. doi:https://doi.org/10.1016/j.est.2018.11.017

Chen, S., Feng, Y., Wang, J., Zhang, E., Yu, X., & Lu, B. (2021a). Free-standing N-doped hollow carbon fibers as high-performance anode for potassium ion batteries. *Science China Materials, 64*(3), 547-556.

Chen, X., Du, G., Zhang, M., Kalam, A., Su, Q., Ding, S., et al. (2019b). Nitrogen-doped hierarchical porous carbon derived from low-cost biomass pomegranate residues for high performance lithium-sulfur batteries. *Journal of Electroanalytical Chemistry, 848*, 113316.

Chen, X., Li, F., Su, S., Chen, H., Zhang, J., & Cai, D. (2021b). Efficient honeycomb–shaped biochar anodes for lithium-ion batteries from Eichhornia crassipes biomass. *Environmental Chemistry Letters, 19*(4), 3505-3510. doi:10.1007/s10311-021-01221-y

Chen, Z.-H., Du, X.-L., He, J.-B., Li, F., Wang, Y., Li, Y.-L., et al. (2017b). Porous coconut shell carbon offering high retention and deep lithiation of sulfur for lithium–sulfur batteries. *ACS Applied Materials & Interfaces, 9*(39), 33855-33862.

Cheng, B.-H., Tian, K., Zeng, R. J., & Jiang, H. (2017a). Preparation of high performance supercapacitor materials by fast pyrolysis of corn gluten meal waste. *Sustainable Energy & Fuels, 1*(4), 891-898. doi:10.1039/C7SE00029D

Cheng, B.-H., Zeng, R. J., & Jiang, H. (2017b). Recent developments of post-modification of biochar for electrochemical energy storage. *Bioresource Technology, 246*, 224-233.

Cherpozat, L., Loranger, E., & Daneault, C. (2017). Ultrasonic pretreatment effects on the bio-oil yield of a laboratory-scale slow wood pyrolysis. *Journal of Analytical and Applied Pyrolysis, 126*, 31-38.

Cho, D.-W., Kwon, G., Yoon, K., Tsang, Y. F., Ok, Y. S., Kwon, E. E., et al. (2017). Simultaneous production of syngas and magnetic biochar via pyrolysis of paper mill sludge using CO_2 as reaction medium. *Energy Conversion and Management, 145*, 1-9.

Chodankar, N. R., Dubal, D. P., Lokhande, A. C., Patil, A. M., Kim, J. H., & Lokhande, C. D. (2016). An innovative concept of use of redox-active electrolyte in asymmetric capacitor based on MWCNTs/MnO_2 and Fe_2O_3 thin films. *Scientific reports, 6*(1), 1-14.

Chodankar, N. R., Pham, H. D., Nanjundan, A. K., Fernando, J. F., Jayaramulu, K., Golberg, D., et al. (2020). True meaning of pseudocapacitors and their performance metrics: asymmetric versus hybrid supercapacitors. *Small, 16*(37), 2002806.

Chua, C. K., Ambrosi, A., & Pumera, M. (2011). Graphene based nanomaterials as electrochemical detectors in Lab-on-a-chip devices. *Electrochemistry communications, 13*(5), 517-519.

Coey, J. M. (2010). *Magnetism and magnetic materials*: Cambridge university press.

Coey, J. M. D. (2001). Magnetic materials. *Journal of Alloys and Compounds, 326*(1), 2-6. doi:https://doi.org/10.1016/S0925-8388(01)01239-7

Commission, E. (2021). *Malaysia Energy Statistics Handbook 2020*.

Conder, J., Fic, K., & Matei Ghimbeu, C. (2019). Supercapacitors (electrochemical capacitors). In J. Mejdi & L. Lionel (Eds.), *Char and Carbon Materials Derived from Biomass. Production, Characterization and Applications* (pp. 383-427): Elsevier.

Conway, B. E. (1999). Similarities and Differences between Supercapacitors and Batteries for Storing Electrical Energy. In *Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications* (pp. 11-31). Boston, MA: Springer US.

Cooper, A., & Kellaway, M. (2008). *Advanced lead-acid–the new battery system for hybrid electric vehicles.* Paper presented at the Proceeding of EET-2008 European Ele-Drive Conference, Geneva.

Cui, H.-t., Zhou, O., & Stoner, B. R. (2000). Deposition of aligned bamboo-like carbon nanotubes via microwave plasma enhanced chemical vapor deposition. *Journal of Applied Physics, 88*(10), 6072-6074.

Cui, M., & Meng, X. (2020). Overview of transition metal-based composite materials for supercapacitor electrodes. *Nanoscale Advances, 2*(12), 5516-5528. doi:10.1039/D0NA00573H

Cuisinier, M., Cabelguen, P. E., Adams, B. D., Garsuch, A., Balasubramanian, M., & Nazar, L. F. (2014). Unique behaviour of nonsolvents for polysulphides in lithium–sulphur batteries. *Energy & Environmental Science, 7*(8), 2697-2705. doi:10.1039/C4EE00372A

Dai, L., Lu, Q., Zhou, H., Shen, F., Liu, Z., Zhu, W., et al. (2021). Tuning oxygenated functional groups on biochar for water pollution control: A critical review. *Journal of Hazardous Materials, 420*, 126547.

Dai, X.-H., Fan, H.-X., Zhang, J.-J., & Yuan, S.-J. (2019). Sewage sludge-derived porous hollow carbon nanospheres as high-performance anode material for lithium ion batteries. *Electrochimica Acta, 319*, 277-285.

Das, A., Raj, B., Mohapatra, M., Andersen, S. M., & Basu, S. (2021). Performance and future directions of transition metal sulfide-based electrode materials towards supercapacitor/supercapattery. *Wiley Interdisciplinary Reviews: Energy and Environment*, e414.

de Azevedo, A. C., Vaz, M. G., Gomes, R. F., Pereira, A. G., Fajardo, A. R., & Rodrigues, F. H. (2017). Starch/rice husk ash based superabsorbent composite: high methylene blue removal efficiency. *Iranian Polymer Journal, 26*(2), 93-105.

De, S., Acharya, S., Sahoo, S., & Nayak, G. C. (2020). Present status of biomass-derived carbon-based composites for supercapacitor application. In *Nanostructured, Functional, and Flexible Materials for Energy Conversion and Storage Systems* (pp. 373-415): Elsevier.

De Souza, L. L. P., Lora, E. E. S., Palacio, J. C. E., Rocha, M. H., Renó, M. L. G., & Venturini, O. J. (2018). Comparative environmental life cycle assessment of conventional vehicles with different fuel options, plug-in hybrid and electric vehicles for a sustainable transportation system in Brazil. *Journal of Cleaner Production, 203*, 444-468.

Dehkhoda, A. M., Gyenge, E., & Ellis, N. (2016). A novel method to tailor the porous structure of KOH-activated biochar and its application in capacitive deionization and energy storage. *Biomass and Bioenergy, 87*, 107-121. doi:https://doi.org/10.1016/j.biombioe.2016.02.023

Deng, L., Yuan, Y., Zhang, Y., Wang, Y., Chen, Y., Yuan, H., et al. (2017a). Alfalfa leaf-derived porous heteroatom-doped carbon materials as efficient cathodic catalysts in microbial fuel cells. *ACS Sustainable Chemistry & Engineering, 5*(11), 9766-9773.

Deng, W., Ci, S., Li, H., & Wen, Z. (2017b). One-step ultrasonic spray route for rapid preparation of hollow Fe3O4/C microspheres anode for lithium-ion batteries. *Chemical Engineering Journal, 330*, 995-1001.

Deng, W., Ji, X., Chen, Q., & Banks, C. E. (2011). Electrochemical capacitors utilising transition metal oxides: an update of recent developments. *RSC Advances, 1*(7), 1171-1178.

Dhyani, V., & Bhaskar, T. (2018). A comprehensive review on the pyrolysis of lignocellulosic biomass. *Renewable Energy, 129*, 695-716.

Ding, Y., Li, Y., Wang, L., Han, X., Zhu, L., & Wang, S. (2021). A novel approach for preparing nitrogen-doped porous nanocomposites for supercapacitors. *Fuel, 304*, 121449.

Ding, Y., Wang, T., Dong, D., & Zhang, Y. (2020). Using biochar and coal as the electrode material for supercapacitor applications. *Frontiers in Energy Research*, 159.

Divya, K., & Østergaard, J. (2009). Battery energy storage technology for power systems—An overview. *Electric power systems research, 79*(4), 511-520.

Dong, C.-D., Chen, C.-W., Kao, C.-M., Chien, C.-C., & Hung, C.-M. (2018a). Wood-biochar-supported magnetite nanoparticles for remediation of PAH-contaminated estuary sediment. *Catalysts, 8*(2), 73.

Dong, C., Gao, W., Jin, B., & Jiang, Q. (2018b). Advances in Cathode Materials for High-Performance Lithium-Sulfur Batteries. *iScience, 6*, 151-198. doi:https://doi.org/10.1016/j.isci.2018.07.021

Dong, J., Li, S., & Ding, Y. (2020). Anchoring nickel-cobalt sulfide nanoparticles on carbon aerogel derived from waste watermelon rind for high-performance asymmetric supercapacitors. *Journal of Alloys and Compounds, 845*, 155701.

Dong, X., Shen, W., Gu, J., Xiong, L., Zhu, Y., Li, H., et al. (2006). MnO2-embedded-in-mesoporous-carbon-wall structure for use as electrochemical capacitors. *J Phys Chem B, 110*(12), 6015-6019. doi:10.1021/jp056754n

Dong, X., Yu, Y., Jing, X., Jiang, H., Hu, T., Meng, C., et al. (2021). Sandwich-like honeycomb Co_2SiO_4/rGO/honeycomb Co_2SiO_4 structures with enhanced electrochemical properties for high-performance hybrid supercapacitor. *Journal of Power Sources, 492*, 229643. doi:https://doi.org/10.1016/j.jpowsour.2021.229643

Du, W., Wang, X., Sun, X., Zhan, J., Zhang, H., & Zhao, X. (2018). Nitrogen-doped hierarchical porous carbon using biomass-derived activated carbon/carbonized polyaniline composites for supercapacitor electrodes. *Journal of Electroanalytical Chemistry, 827*, 213-220.

Duraisamy, N., Arshid, N., Kandiah, K., Iqbal, J., Arunachalam, P., Dhanaraj, G., et al. (2019). Development of asymmetric device using Co3(PO4)2 as a positive electrode for energy storage application. *Journal of Materials Science: Materials in Electronics, 30*(8), 7435-7446. doi:10.1007/s10854-019-01057-x

Ehsani, A., & Parsimehr, H. (2020). Electrochemical energy storage electrodes from fruit biochar. *Advances in Colloid and Interface Science*, 102263.

Ehsani, M., Gao, Y., & Miller, J. M. (2007). Hybrid electric vehicles: Architecture and motor drives. *Proceedings of the IEEE, 95*(4), 719-728.

Elaiyappillai, E., Anandaraj, S., S, R., E, J., & Merlin, J. (2017). Polyaniline based Charcoal/Ni nanocomposite material for High Performance Supercapacitor. *Sustainable Energy & Fuels, 2*. doi:10.1039/C7SE00490G

Elanthamilan, E., Sathiyan, A., Rajkumar, S., Sheryl, E. J., & Merlin, J. P. (2018). Polyaniline based charcoal/Ni nanocomposite material for high performance supercapacitors. *Sustainable Energy & Fuels, 2*(4), 811-819.

Elemike, E. E., Osafile, O. E., & Omugbe, E. (2021). New perspectives 2Ds to 3Ds MXenes and graphene functionalized systems as high performance energy storage materials. *Journal of Energy Storage, 42*, 102993.

Elkholy, A. E., Heakal, F. E.-T., & Allam, N. K. (2017). Nanostructured spinel manganese cobalt ferrite for high-performance supercapacitors. *RSC Advances, 7*(82), 51888-51895.

Elmouwahidi, A., Zapata-Benabithe, Z., Carrasco-Marín, F., & Moreno-Castilla, C. (2012). Activated carbons from KOH-activation of argan (Argania spinosa) seed shells as supercapacitor electrodes. *Bioresource Technology, 111*, 185-190. doi:https://doi.org/10.1016/j.biortech.2012.02.010

Ensminger, D., & Bond, L. J. (2011). *Ultrasonics: fundamentals, technologies, and applications*: CRC press.

Etacheri, V., Marom, R., Elazari, R., Salitra, G., & Aurbach, D. (2011). Challenges in the development of advanced Li-ion batteries: a review. *Energy & Environmental Science, 4*(9), 3243-3262.

Fan, L., Li, Z., Kang, W., & Cheng, B. (2020). Biomass-derived tube-like nitrogen and oxygen dual-doped porous carbon in the sulfur cathode for lithium sulfur battery. *Renewable Energy, 155*, 309-316.

Fang, G., Liu, C., Gao, J., Dionysiou, D. D., & Zhou, D. (2015). Manipulation of Persistent Free Radicals in Biochar To Activate Persulfate for Contaminant Degradation. *Environmental Science & Technology, 49*(9), 5645-5653. doi:10.1021/es5061512

Farias-Mancilla, R., Elizalde-Galindo, J. T., Vigueras-Santiago, E., Hernández-Escobar, C. A., Vega-Rios, A., & Zaragoza-Contreras, E. A. (2016). Synthesis and characterization of polyaniline/magnetite nanocomposite. *International Journal of Theoretical and Applied Nanotechnology, 4*, 1-8.

Fei, H., Peng, Z., Li, L., Yang, Y., Lu, W., Samuel, E. L., et al. (2014). Preparation of carbon-coated iron oxide nanoparticles dispersed on graphene sheets and applications as advanced anode materials for lithium-ion batteries. *Nano Research, 7*(4), 502-510.

Feng, Q., Li, H., Tan, Z., Huang, Z., Jiang, L., Zhou, H., et al. (2018). Design and preparation of three-dimensional MnO/N-doped carbon nanocomposites based on waste biomass for high storage and ultra-fast transfer of lithium ions. *Journal of Materials Chemistry A, 6*(40), 19479-19487. doi:10.1039/C8TA07096B

Fernando, J. F. S., Siriwardena, D. P., Firestein, K. L., Zhang, C., von Treifeldt, J. E., Lewis, C.-E. M., et al. (2020). Enriched pseudocapacitive lithium storage in electrochemically activated carbonaceous vanadium(iv, v) oxide hydrate. *Journal of Materials Chemistry A, 8*(26), 13183-13196. doi:10.1039/D0TA04191B

Fic, K., Platek, A., Piwek, J., & Frackowiak, E. (2018). Sustainable materials for electrochemical capacitors. *Materials today, 21*(4), 437-454.

Fila, W. A., Itam, E. H., Johnson, J. T., Odey, M. O., Effiong, E. E., Dasofunjo, K., et al. (2013). Comparative Proximate Compositions of Watermelon Citrullus Lanatus,

Squash Cucurbita Pepo'l and Rambutan Nephelium Lappaceum. *International Journal of Science and Technology, Volume 2*(No. 1), 8.

Fleischmann, S., Mitchell, J. B., Wang, R., Zhan, C., Jiang, D.-e., Presser, V., et al. (2020). Pseudocapacitance: From Fundamental Understanding to High Power Energy Storage Materials. *Chemical Reviews, 120*(14), 6738-6782. doi:10.1021/acs.chemrev.0c00170

Frackowiak, E., & Béguin, F. (2001). Carbon materials for the electrochemical storage of energy in capacitors. *Carbon, 39*(6), 937-950. doi:https://doi.org/10.1016/S0008-6223(00)00183-4

Frank, R. (2005). Jacob Fraden: Handbook of modern sensors: physics, designs, and applications. *Analytical and Bioanalytical Chemistry, 382*(1), 8-9. doi:10.1007/s00216-004-3037-8

Fu, H., Ma, S., Xu, S., Duan, R., Cheng, G., & Zhao, P. (2021). Hierarchically porous magnetic biochar as an efficient amendment for cadmium in water and soil: Performance and mechanism. *Chemosphere, 281*, 130990.

Gan, L., Shang, S., Yuen, C. W. M., Jiang, S.-x., & Hu, E. (2015). Hydrothermal synthesis of magnetic CoFe2O4/graphene nanocomposites with improved photocatalytic activity. *Applied surface science, 351*, 140-147.

Gan, L., Zhong, Q., Geng, A., Wang, L., Song, C., Han, S., et al. (2019). Cellulose derived carbon nanofiber: A promising biochar support to enhance the catalytic performance of CoFe2O4 in activating peroxymonosulfate for recycled dimethyl phthalate degradation. *Science of the Total Environment, 694*, 133705. doi:https://doi.org/10.1016/j.scitotenv.2019.133705

Gao, M., Wang, W.-K., Zheng, Y.-M., Zhao, Q.-B., & Yu, H.-Q. (2020). Hierarchically porous biochar for supercapacitor and electrochemical H_2O_2 production. *Chemical Engineering Journal, 402*, 126171.

Gao, Y., Zhang, Y., Li, A., & Zhang, L. (2018). Facile synthesis of high-surface area mesoporous biochar for energy storage via in-situ template strategy. *Materials Letters, 230*, 183-186.

Garba, A., Tahir, A., & Yusuf, A. (2021). Adsorption of Methylene Blue Using Activated Carbon Made from Watermelon Rinds. *Journal of Sustainable Materials Processing and Management, 1*, 38-43. doi:10.30880/jsmpm.2021.01.01.005

Garg, R., Elmas, S., Nann, T., & Andersson, M. R. (2017). Deposition methods of graphene as electrode material for organic solar cells. *Advanced Energy Materials, 7*(10), 1601393.

Genovese, M., Jiang, J., Lian, K., & Holm, N. (2015). High capacitive performance of exfoliated biochar nanosheets from biomass waste corn cob. *Journal of Materials Chemistry A, 3*(6), 2903-2913.

Genovese, M., & Lian, K. (2017). Polyoxometalate modified pine cone biochar carbon for supercapacitor electrodes. *Journal of Materials Chemistry A, 5*(8), 3939-3947. doi:10.1039/C6TA10382K

Gergova, K., Eser, S., & Schobert, H. (1993). Preparation and characterization of activated carbons from anthracite. *Energy & Fuels, 7*(5), 661-668.

Gidwani, M., Bhagwani, A., & Rohra, N. (2014). Supercapacitors: the near future of batteries. *International Journal of Engineering Inventions, 4*(5), 22-27.

Gkikas, G., Barkoula, N.-M., & Paipetis, A. (2012). Effect of dispersion conditions on the thermo-mechanical and toughness properties of multi walled carbon nanotubes-reinforced epoxy. *Composites Part B: Engineering, 43*(6), 2697-2705.

Glaize, C., & Genies, S. (2013). *Lithium batteries and other electrochemical storage systems*: John Wiley & Sons.

Gong, Y., Li, D., Luo, C., Fu, Q., & Pan, C. (2017). Highly porous graphitic biomass carbon as advanced electrode materials for supercapacitors. *Green chemistry, 19*(17), 4132-4140.

González, A., Goikolea, E., Barrena, J. A., & Mysyk, R. (2016). Review on supercapacitors: Technologies and materials. *Renewable and sustainable energy reviews, 58*, 1189-1206. doi:https://doi.org/10.1016/j.rser.2015.12.249

Gouws, S. M., Carrier, M., Bunt, J. R., & Neomagus, H. W. (2021). Co-pyrolysis of coal and raw/torrefied biomass: A review on chemistry, kinetics and implementation. *Renewable and sustainable energy reviews, 135*, 110189.

Goyal, H., Seal, D., & Saxena, R. (2008). Bio-fuels from thermochemical conversion of renewable resources: a review. *Renewable and Sustainable Energy Reviews, 12*(2), 504-517.

Gu, X., Wang, Y., Lai, C., Qiu, J., Li, S., Hou, Y., et al. (2015). Microporous bamboo biochar for lithium-sulfur batteries. *Nano Research, 8*(1), 129-139.

Guan, L., Yu, L., & Chen, G. Z. (2016). Capacitive and non-capacitive faradaic charge storage. *Electrochimica Acta, 206*, 464-478.

Gubin, S., Spichkin, Y. I., Yurkov, G. Y., & Tishin, A. (2002). Nanomaterial for high-density magnetic data storage. *Russian Journal of Inorganic Chemistry C/C of Zhurnal Neorganicheskoi Khimii, 47*(Sup/1), S32-S67.

Gupta, B. S., & Ako, J. E. (2005). Application of guar gum as a flocculant aid in food processing and potable water treatment. *European Food Research and Technology, 221*(6), 746-751. doi:10.1007/s00217-005-0056-4

Gupta, R. K., Dubey, M., Kharel, P., Gu, Z., & Fan, Q. H. (2015). Biochar activated by oxygen plasma for supercapacitors. *Journal of Power Sources, 274*, 1300-1305. doi:https://doi.org/10.1016/j.jpowsour.2014.10.169

Gusain, M., Ahmed, I., & Zhan, Y. (2021). Conducting polymeric nanocomposite for supercapattery. In *Advances in Supercapacitor and Supercapattery* (pp. 63-91): Elsevier.

Hagemann, N., Spokas, K., Schmidt, H.-P., Kägi, R., Böhler, M. A., & Bucheli, T. D. (2018). Activated carbon, biochar and charcoal: linkages and synergies across pyrogenic carbon's ABCs. *Water, 10*(2), 182.

Hairuddin, M. N., Mubarak, N. M., Khalid, M., Abdullah, E. C., Walvekar, R., & Karri, R. R. (2019). Magnetic palm kernel biochar potential route for phenol removal from wastewater. *Environmental Science and Pollution Research, 26*(34), 35183-35197. doi:10.1007/s11356-019-06524-w

Han, X.-R., Guo, X.-T., Xu, M.-J., Pang, H., & Ma, Y.-W. (2020). Clean utilization of palm kernel shell: sustainable and naturally heteroatom-doped porous activated carbon for lithium–sulfur batteries. *Rare Metals, 39*(9), 1099-1106.

Hao, L., Li, X., & Zhi, L. (2013). Carbonaceous Electrode Materials for Supercapacitors. *Advanced Materials, 25*(28), 3899-3904. doi:https://doi.org/10.1002/adma.201301204

Hao, L., Zhao, Y., Jiao, Q., & Chen, P. (2014). Synthesis of zinc–nickel ferrite nanorods and their magnetic properties. *RSC Advances, 4*(30), 15650-15654. doi:10.1039/C3RA47780K

Harris, P. J., & Harris, P. J. F. (2009). *Carbon nanotube science: synthesis, properties and applications*: Cambridge university press.

Hatch, G. P., & Stelter, R. E. (2001). Magnetic design considerations for devices and particles used for biological high-gradient magnetic separation (HGMS) systems. *Journal of Magnetism and Magnetic Materials, 225*(1), 262-276. doi:https://doi.org/10.1016/S0304-8853(00)01250-6

He, G., Ke, W., Chen, X., Kong, Y., Zheng, H., Yin, Y., et al. (2017). Preparation and properties of quaternary ammonium chitosan-g-poly(acrylic acid-co-acrylamide) superabsorbent hydrogels. *Reactive and Functional Polymers, 111*, 14-21. doi:https://doi.org/10.1016/j.reactfunctpolym.2016.12.001

Heimböckel, R., Hoffmann, F., & Fröba, M. (2019). Insights into the influence of the pore size and surface area of activated carbons on the energy storage of electric double layer capacitors with a new potentially universally applicable capacitor model. *Physical Chemistry Chemical Physics, 21*(6), 3122-3133. doi:10.1039/C8CP06443A

Heng, I., Lai, C. W., Juan, J. C., Numan, A., Iqbal, J., & Teo, E. Y. L. (2019). Low-temperature synthesis of TIO2 nanocrystals for high performance electrochemical supercapacitors. *Ceramics International, 45*(4), 4990-5000. doi:https://doi.org/10.1016/j.ceramint.2018.11.199

Hillier, N., Yong, S., & Beeby, S. (2020). The good, the bad and the porous: A review of carbonaceous materials for flexible supercapacitor applications. *Energy Reports, 6*, 148-156. doi:https://doi.org/10.1016/j.egyr.2020.03.019

Ho, M. Y., Khiew, P. S., Isa, D., Tan, T. K., Chiu, W. S., & Chia, C. H. (2014). A Review of Metal Oxide Composite Electrode Materials for Electrochemical Capacitors. *Nano, 09*(06), 1430002. doi:10.1142/s1793292014300023

Holmberg, S., Perebikovsky, A., Kulinsky, L., & Madou, M. (2014). 3-D micro and nano technologies for improvements in electrochemical power devices. *Micromachines, 5*(2), 171-203.

Hong, K.-l., Qie, L., Zeng, R., Yi, Z.-q., Zhang, W., Wang, D., et al. (2014). Biomass derived hard carbon used as a high performance anode material for sodium ion batteries. *Journal of Materials Chemistry A, 2*(32), 12733-12738.

Horn, M., MacLeod, J., Liu, M., Webb, J., & Motta, N. (2019). Supercapacitors: A new source of power for electric cars? *Economic Analysis and Policy, 61*, 93-103. doi:https://doi.org/10.1016/j.eap.2018.08.003

Hossain, M. A., Ganesan, P., Jewaratnam, J., & Chinna, K. (2017). Optimization of process parameters for microwave pyrolysis of oil palm fiber (OPF) for hydrogen and biochar production. *Energy Conversion and Management, 133*, 349-362.

Hosseini, S. H., Rahimi, R., & Kerdari, H. (2011). Preparation of a nanocomposite of magnetic, conducting nanoporous polyaniline and hollow manganese ferrite. *Polymer journal, 43*(9), 745-750.

Huang, B. (2020). Carbon nanotubes and their polymeric composites: the applications in tissue engineering. *Biomanufacturing Reviews, 5*(1), 3. doi:10.1007/s40898-020-00009-x

Huang, M., Yang, J., Xi, B., Mi, K., Feng, Z., Liu, J., et al. (2019). Enhancing kinetics of Li-S batteries by graphene-like N, S-codoped biochar fabricated in NaCl non-aqueous ionic liquid. *Science China Materials, 62*(4), 455-464.

Huang, S., Ding, Y., Li, Y., Han, X., Xing, B., & Wang, S. (2021). Nitrogen and sulfur co-doped hierarchical porous biochar derived from the pyrolysis of mantis shrimp shell for supercapacitor electrodes. *Energy & Fuels, 35*(2), 1557-1566.

Huang, Y., Candelaria, S. L., Li, Y., Li, Z., Tian, J., Zhang, L., et al. (2014). Sulfurized activated carbon for high energy density supercapacitors. *Journal of Power Sources, 252*, 90-97. doi:https://doi.org/10.1016/j.jpowsour.2013.12.004

Huggins, R. A. (2010). *Energy storage* (Vol. 406): Springer.

Huggins, T., Wang, H., Kearns, J., Jenkins, P., & Ren, Z. J. (2014). Biochar as a sustainable electrode material for electricity production in microbial fuel cells. *Bioresource Technology, 157*, 114-119.

Husain, Z., Shakeelur Raheman, A. R., Ansari, K. B., Pandit, A. B., Khan, M. S., Qyyum, M. A., et al. (2022). Nano-sized mesoporous biochar derived from biomass pyrolysis as electrochemical energy storage supercapacitor. *Materials Science for Energy Technologies, 5*, 99-109. doi:https://doi.org/10.1016/j.mset.2021.12.003

Hyland, C., & Sarmah, A. K. (2014). Advances and innovations in biochar production and utilization for improving environmental quality. In *Bioenergy Research: Advances and Applications* (pp. 435-446): Elsevier.

Intani, K., Latif, S., Kabir, A. K. M. R., & Müller, J. (2016). Effect of self-purging pyrolysis on yield of biochar from maize cobs, husks and leaves. *Bioresource Technology, 218*, 541-551. doi:https://doi.org/10.1016/j.biortech.2016.06.114

Inyang, M., & Dickenson, E. (2015). The potential role of biochar in the removal of organic and microbial contaminants from potable and reuse water: A review. *Chemosphere, 134*, 232-240. doi:https://doi.org/10.1016/j.chemosphere.2015.03.072

Iqbal, J., Numan, A., Jafer, R., Bashir, S., Jilani, A., Mohammad, S., et al. (2020a). Ternary nanocomposite of cobalt oxide nanograins and silver nanoparticles grown on reduced graphene oxide conducting platform for high-performance supercapattery electrode material. *Journal of Alloys and Compounds, 821*, 153452.

Iqbal, J., Numan, A., Omaish Ansari, M., Jafer, R., Jagadish, P. R., Bashir, S., et al. (2020b). Cobalt Oxide Nanograins and Silver Nanoparticles Decorated Fibrous Polyaniline Nanocomposite as Battery-Type Electrode for High Performance Supercapattery. *Polymers, 12*(12), 2816. doi:10.3390/polym12122816

Iqbal, M. Z., Faisal, M. M., Ali, S. R., Afzal, A. M., Karim, M. R. A., Kamran, M. A., et al. (2020c). Strontium phosphide-polyaniline composites for high performance supercapattery devices. *Ceramics International, 46*(8), 10203-10214.

Iqbal, M. Z., Faisal, M. M., Ali, S. R., Farid, S., & Afzal, A. M. (2020d). Co-MOF/polyaniline-based electrode material for high performance supercapattery devices. *Electrochimica Acta, 346*, 136039.

Iro, Z. S., Subramani, C., & Dash, S. (2016). A brief review on electrode materials for supercapacitor. *Int. J. Electrochem. Sci, 11*(12), 10628-10643.

Ishihara, T., Koga, M., Matsumoto, H., & Yoshio, M. (2007). Electrochemical intercalation of hexafluorophosphate anion into various carbons for cathode of dual-carbon rechargeable battery. *Electrochemical and solid-state letters, 10*(3), A74.

Jagadish, P. R., Khalid, M., Amin, N., Li, L. P., & Chan, A. (2017). Process optimisation for n-type Bi2Te3 films electrodeposited on flexible recycled carbon fibre using response surface methodology. *Journal of materials science, 52*(19), 11467-11481.

Jain, R., & Mishra, S. (2021). Conducting Polymer Carbon-Based Binary Hybrid for Supercapacitors. *Handbook of Supercapacitor Materials: Synthesis, Characterization, and Applications*, 205-224.

Jalal, N. I., Ibrahim, R. I., & Oudah, M. K. (2021). A review on Supercapacitors: types and components. *Journal of Physics: Conference Series, 1973*(1), 012015. doi:10.1088/1742-6596/1973/1/012015

Jawad, A. H., Ngoh, Y. S., & Radzun, K. A. (2018). Utilization of watermelon (Citrullus lanatus) rinds as a natural low-cost biosorbent for adsorption of methylene blue: kinetic, equilibrium and thermodynamic studies. *Journal of Taibah University for Science, 12*(4), 371-381. doi:10.1080/16583655.2018.1476206

Jeevagan, K., & Jagannathan, K. (2021). Synthesis and dielectric analyses of NiS reinforced Polyaniline nanocomposites. *Journal of Materials Science: Materials in Electronics, 32*(23), 27409-27421. doi:10.1007/s10854-021-07116-6

Ji, X., & Nazar, L. F. (2010). Advances in Li–S batteries. *Journal of Materials Chemistry, 20*(44), 9821-9826. doi:10.1039/B925751A

Jian, X., Liu, S., Gao, Y., Tian, W., Jiang, Z., Xiao, X., et al. (2016). Carbon-based electrode materials for supercapacitor: progress, challenges and prospective solutions. *J. Electr. Eng, 4*(2), 75-87.

Jiang, B., Cao, L., Yuan, Q., Ma, Z., Huang, Z., Lin, Z., et al. (2022). Biomass Straw-Derived Porous Carbon Synthesized for Supercapacitor by Ball Milling. *Materials, 15*(3), 924.

Jiang, J., Zhang, L., Wang, X., Holm, N., Rajagopalan, K., Chen, F., et al. (2013). Highly ordered macroporous woody biochar with ultra-high carbon content as supercapacitor electrodes. *Electrochimica Acta, 113*, 481-489. doi:https://doi.org/10.1016/j.electacta.2013.09.121

Jiang, Y., Ji, J., Huang, L., He, C., Zhang, J., Wang, X., et al. (2020). One-pot mechanochemical exfoliation of graphite and in situ polymerization of aniline for the production of graphene/polyaniline composites for high-performance supercapacitors. *RSC Advances, 10*(73), 44688-44698. doi:10.1039/D0RA08450F

Jiang, Y., & Liu, J. (2019). Definitions of pseudocapacitive materials: a brief review. *Energy & Environmental Materials, 2*(1), 30-37.

Jin, H., Wang, X., Gu, Z., & Polin, J. (2013). Carbon materials from high ash biochar for supercapacitor and improvement of capacitance with HNO3 surface oxidation. *Journal of Power Sources, 236*, 285-292. doi:https://doi.org/10.1016/j.jpowsour.2013.02.088

Jin, H., Wang, X., Shen, Y., & Gu, Z. (2014). A high-performance carbon derived from corn stover via microwave and slow pyrolysis for supercapacitors. *Journal of Analytical and Applied Pyrolysis, 110*, 18-23. doi:https://doi.org/10.1016/j.jaap.2014.07.010

Ju, F., Zhang, Q., Deng, W., & Li, J. (2014). *Review of structures and control of battery-supercapacitor hybrid energy storage system for electric vehicles.* Paper presented at the 2014 IEEE international conference on automation science and engineering (CASE).

Jun, Y.-w., Huh, Y.-M., Choi, J.-s., Lee, J.-H., Song, H.-T., KimKim, et al. (2005). Nanoscale Size Effect of Magnetic Nanocrystals and Their Utilization for Cancer Diagnosis via Magnetic Resonance Imaging. *Journal of the American Chemical Society, 127*(16), 5732-5733. doi:10.1021/ja0422155

Jun, Y. W., Huh, Y. M. & Choi, J. S. . (2005). Nanoscale size efect of magnetic nanocrystals and their utilization for cancer diagnosis via magnetic resonance imaging. *J. Am. Chem. Soc. , 127*, 5732–5733

Kalghatgi, G. (2018). Is it really the end of internal combustion engines and petroleum in transport? *Applied Energy, 225*, 965-974.

Kalyani, P., & Anitha, A. (2013). Biomass carbon & its prospects in electrochemical energy systems. *International Journal of Hydrogen Energy, 38*(10), 4034-4045. doi:https://doi.org/10.1016/j.ijhydene.2013.01.048

Kamali-Heidari, E., Kamyabi-Gol, A., Heydarzadeh Sohi, M., & Ataie, A. (2018). Electrode materials for lithium ion batteries: a review. *Journal of Ultrafine Grained and Nanostructured Materials, 51*(1), 1-12.

Kan, T., Strezov, V., & Evans, T. J. (2016). Lignocellulosic biomass pyrolysis: A review of product properties and effects of pyrolysis parameters. *Renewable and sustainable energy reviews, 57*, 1126-1140.

Karim, M. R., Lee, C. J., & Lee, M. S. (2007). Synthesis and characterization of conducting polyaniline-activated carbon nanocomposites. *Journal of applied polymer science, 103*(3), 1973-1977.

Karri, R. R., Tanzifi, M., Tavakkoli Yaraki, M., & Sahu, J. N. (2018). Optimization and modeling of methyl orange adsorption onto polyaniline nano-adsorbent through response surface methodology and differential evolution embedded neural network. *Journal of environmental management, 223*, 517-529. doi:https://doi.org/10.1016/j.jenvman.2018.06.027

Kesavan, T., Partheeban, T., Vivekanantha, M., Kundu, M., Maduraiveeran, G., & Sasidharan, M. (2019). Hierarchical nanoporous activated carbon as potential electrode materials for high performance electrochemical supercapacitor. *Microporous and Mesoporous Materials, 274*, 236-244. doi:https://doi.org/10.1016/j.micromeso.2018.08.006

Khairy, M. (2014). Synthesis, characterization, magnetic and electrical properties of polyaniline/NiFe2O4 nanocomposite. *Synthetic Metals, 189*, 34-41.

Khammar, H., Abdelwahab, A., Abdel-Samad, H. S., & Hassan, H. H. (2021). Synergistic performance of simply fabricated polyaniline/carbon xerogel composite as supercapacitor electrode. *Journal of Electroanalytical Chemistry, 880*, 114848.

Khan, A., Arumugam Senthil, R., Pan, J., Sun, Y., & Liu, X. (2020). Hierarchically porous biomass carbon derived from natural withered rose flowers as high-performance material for advanced supercapacitors. *Batteries & Supercaps, 3*(8), 731-737.

Khan, J. H., Marpaung, F., Young, C., Lin, J., Islam, M. T., Alsheri, S. M., et al. (2019). Jute-derived microporous/mesoporous carbon with ultra-high surface area using a chemical activation process. *Microporous and Mesoporous Materials, 274*, 251-256. doi:https://doi.org/10.1016/j.micromeso.2018.07.050

Khan, Z. U., Kausar, A., Ullah, H., Badshah, A., & Khan, W. U. (2016). A review of graphene oxide, graphene buckypaper, and polymer/graphene composites: Properties and fabrication techniques. *Journal of plastic film & sheeting, 32*(4), 336-379.

Khanmohammadi, Z., Afyuni, M., & Mosaddeghi, M. R. (2015). Effect of pyrolysis temperature on chemical and physical properties of sewage sludge biochar. *Waste Management & Research, 33*(3), 275-283.

Khedari, J., Charoenvai, S., & Hirunlabh, J. (2003). New insulating particleboards from durian peel and coconut coir. *Building and Environment, 38*(3), 435-441. doi:http://dx.doi.org/10.1016/S0360-1323(02)00030-6

Khorshidi, M., Asadpour, S., Sarmast, N., & Dinari, M. (2021). A review of the synthesis methods, properties, and applications of layered double hydroxides/carbon nanocomposites. *Journal of Molecular Liquids*, 118399.

Khudzari, J. M., Gariépy, Y., Kurian, J., Tartakovsky, B., & Raghavan, G. V. (2019). Effects of biochar anodes in rice plant microbial fuel cells on the production of bioelectricity, biomass, and methane. *Biochemical Engineering Journal, 141*, 190-199.

Kim, H.-J., Lee, H.-D., Rao, S. S., Reddy, A. E., Kim, S.-K., & Thulasi-Varma, C. V. (2016). Well-dispersed NiS nanoparticles grown on a functionalized CoS nanosphere surface as a high performance counter electrode for quantum dot-sensitized solar cells. *RSC Advances, 6*(35), 29003-29019.

Kim, M., Lim, H., Xu, X., Hossain, M. S. A., Na, J., Awaludin, N. N., et al. (2021). Sorghum biomass-derived porous carbon electrodes for capacitive deionization and energy storage. *Microporous and Mesoporous Materials, 312*, 110757. doi:https://doi.org/10.1016/j.micromeso.2020.110757

Kim, T., Song, W., Son, D.-Y., Ono, L. K., & Qi, Y. (2019). Lithium-ion batteries: outlook on present, future, and hybridized technologies. *Journal of Materials Chemistry A, 7*(7), 2942-2964.

Kim, Y. A., Kojima, M., Muramatsu, H., Umemoto, S., Watanabe, T., Yoshida, K., et al. (2006). In situ Raman study on single-and double-walled carbon nanotubes as a function of lithium insertion. *Small, 2*(5), 667-676.

Kirubasankar, B., Palanisamy, P., Arunachalam, S., Murugadoss, V., & Angaiah, S. (2019). 2D MoSe2-Ni (OH) 2 nanohybrid as an efficient electrode material with high rate capability for asymmetric supercapacitor applications. *Chemical Engineering Journal, 355*, 881-890.

Klüpfel, L., Keiluweit, M., Kleber, M., & Sander, M. (2014). Redox properties of plant biomass-derived black carbon (biochar). *Environmental Science & Technology, 48*(10), 5601-5611.

Kolhatkar, A., Jamison, A., Litvinov, D., Willson, R., & Lee, T. (2013). Tuning the Magnetic Properties of Nanoparticles. *International journal of molecular sciences, 14*, 15977-16009. doi:10.3390/ijms140815977

Kong, L. B., Que, W., Liu, L., Boey, F. Y. C., Xu, Z. J., Zhou, K., et al. (2017). Carbon Based Supercapacitors. In *Nanomaterials for Supercapacitors* (pp. 28-161): CRC Press.

Konsolakis, M., Kaklidis, N., Marnellos, G. E., Zaharaki, D., & Komnitsas, K. (2015). Assessment of biochar as feedstock in a direct carbon solid oxide fuel cell. *RSC Advances, 5*(90), 73399-73409.

Kooti, M., Sedeh, A. N., Gheisari, K., & Figuerola, A. (2021). Synthesis, characterization, and performance of nanocomposites containing reduced graphene oxide, polyaniline, and cobalt ferrite. *Physica B: Condensed Matter, 612*, 412974.

Kotutha, I., Duangchuen, T., Swatsitang, E., Meewasana, W., Khajonrit, J., & Maensiri, S. (2019). Electrochemical properties of rGO/$CoFe_2O_4$ nanocomposites for energy storage application. *Ionics, 25*(11), 5401-5409.

Kötz, R., & Carlen, M. (2000). Principles and applications of electrochemical capacitors. *Electrochimica Acta, 45*(15), 2483-2498. doi:https://doi.org/10.1016/S0013-4686(00)00354-6

Kouchachvili, L., Maffei, N., & Entchev, E. (2015). Infested ash trees as a carbon source for supercapacitor electrodes. *Journal of Porous Materials, 22*(4), 979-988. doi:10.1007/s10934-015-9972-2

Kouchachvili, L., Yaïci, W., & Entchev, E. (2018). Hybrid battery/supercapacitor energy storage system for the electric vehicles. *Journal of Power Sources, 374*, 237-248.

Kouhnavard, M., Ludin, N. A., Ghaffari, B. V., Sopian, K., & Ikeda, S. (2015). Carbonaceous materials and their advances as a counter electrode in dye-sensitized solar cells: challenges and prospects. *ChemSusChem, 8*(9), 1510-1533.

Kousksou, T., Bruel, P., Jamil, A., El Rhafiki, T., & Zeraouli, Y. (2014). Energy storage: Applications and challenges. *Solar Energy Materials and Solar Cells, 120*, 59-80.

Kumar, A., Bhattacharya, T., Mozammil Hasnain, S. M., Kumar Nayak, A., & Hasnain, M. S. (2020). Applications of biomass-derived materials for energy production, conversion, and storage. *Materials Science for Energy Technologies, 3*, 905-920. doi:https://doi.org/10.1016/j.mset.2020.10.012

Kumar, M., Dutta, S., You, S., Luo, G., Zhang, S., Show, P. L., et al. (2021). A critical review on biochar for enhancing biogas production from anaerobic digestion of food waste and sludge. *Journal of Cleaner Production, 305*, 127143.

Kundu, A., Gupta, B. S., Hashim, M. A., Sahu, J. N., Mujawar, M., & Redzwan, G. (2015). Optimisation of the process variables in production of activated carbon by microwave heating. *RSC Advances, 5*(45), 35899-35908. doi:10.1039/C4RA16900J

Laird, D. A., Brown, R. C., Amonette, J. E., & Lehmann, J. (2009). Review of the pyrolysis platform for coproducing bio-oil and biochar. *Biofuels, Bioproducts and Biorefining, 3*(5), 547-562.

Lam, S. S., Liew, R. K., Lim, X. Y., Ani, F. N., & Jusoh, A. (2016). Fruit waste as feedstock for recovery by pyrolysis technique. *International Biodeterioration & Biodegradation, 113*, 325-333. doi:https://doi.org/10.1016/j.ibiod.2016.02.021

Le, T.-H., Kim, Y., & Yoon, H. (2017). Electrical and electrochemical properties of conducting polymers. *Polymers, 9*(4), 150.

Lee, C. C., Omar, F. S., Numan, A., Duraisamy, N., Ramesh, K., & Ramesh, S. (2017). An enhanced performance of hybrid supercapacitor based on polyaniline-manganese phosphate binary composite. *Journal of Solid State Electrochemistry, 21*(11), 3205-3213.

Lee, H. W., Kim, Y.-M., Kim, S., Ryu, C., Park, S. H., & Park, Y.-K. (2018). Review of the use of activated biochar for energy and environmental applications. *Carbon letters, 26*, 1-10.

Lee, K., & Choo, W.-S. (2020). Extraction Optimization and Physicochemical Properties of Pectin from Watermelon (Citrullus lanatus) Rind: Comparison of Hydrochloric and Citric acid Extraction. *Journal of Nutraceuticals and Food Science, 5*. doi:10.36648/nutraceuticals.5.1.1

Lee, S.-Y., Choi, Y., Kim, J.-K., Lee, S.-J., Bae, J. S., & Jeong, E. D. (2021). Biomass-garlic-peel-derived porous carbon framework as a sulfur host for lithium-sulfur batteries. *Journal of Industrial and Engineering Chemistry, 94*, 272-281.

Lei, W., Wang, X., Zhang, Y., Luo, Z., Xia, P., Zou, Y., et al. (2021a). Facile synthesis of Fe3C nano-particles/porous biochar cathode materials for lithium sulfur battery. *Journal of Alloys and Compounds, 853*, 157024.

Lei, W., Yang, B., Sun, Y., Xiao, L., Tang, D., Chen, K., et al. (2021b). Self-sacrificial template synthesis of heteroatom doped porous biochar for enhanced electrochemical energy storage. *Journal of Power Sources, 488*, 229455.

Leng, L., & Huang, H. (2018). An overview of the effect of pyrolysis process parameters on biochar stability. *Bioresource Technology, 270*, 627-642.

Leng, L., Xiong, Q., Yang, L., Li, H., Zhou, Y., Zhang, W., et al. (2021). An overview on engineering the surface area and porosity of biochar. *Science of the Total Environment, 763*, 144204.

Li, B., Dai, F., Xiao, Q., Yang, L., Shen, J., Zhang, C., et al. (2016a). Nitrogen-doped activated carbon for a high energy hybrid supercapacitor. *Energy & Environmental Science, 9*(1), 102-106. doi:10.1039/C5EE03149D

Li, H., Mahyoub, S. A. A., Liao, W., Xia, S., Zhao, H., Guo, M., et al. (2017). Effect of pyrolysis temperature on characteristics and aromatic contaminants adsorption behavior of magnetic biochar derived from pyrolysis oil distillation residue. *Bioresource Technology, 223*, 20-26.

Li, H., Xiong, J., Xiao, T., Long, J., Wang, Q., Li, K., et al. (2019a). Biochar derived from watermelon rinds as regenerable adsorbent for efficient removal of thallium(I) from wastewater. *Process Safety and Environmental Protection*. doi:https://doi.org/10.1016/j.psep.2019.04.031

Li, J., Dai, J., Liu, G., Zhang, H., Gao, Z., Fu, J., et al. (2016b). Biochar from microwave pyrolysis of biomass: A review. *Biomass and Bioenergy, 94*, 228-244.

Li, L., Dong, S., Chen, X., Han, P., Xu, H., Yao, J., et al. (2012). A renewable bamboo carbon/polyaniline composite for a high-performance supercapacitor electrode material. *Journal of Solid State Electrochemistry, 16*(3), 877-882.

Li, L., Sun, F., Gao, J., Wang, L., Pi, X., & Zhao, G. (2018a). Broadening the pore size of coal-based activated carbon via a washing-free chem-physical activation method for high-capacity dye adsorption. *RSC Advances, 8*(26), 14488-14499. doi:10.1039/C8RA02127A

Li, Q., Bai, X., Meng, Q., Chen, T., Zhu, W., Yao, W., et al. (2018b). Porous biochar generated from natural Amorphophallus konjac for high performance supercapacitors. *Applied surface science, 448*, 16-22.

Li, Q., Guo, J., Zhao, J., Wang, C., & Yan, F. (2019b). Porous nitrogen-doped carbon nanofibers assembled with nickel nanoparticles for lithium–sulfur batteries. *Nanoscale, 11*(2), 647-655.

Li, Q., Li, H., Xia, Q., Hu, Z., Zhu, Y., Yan, S., et al. (2021a). Extra storage capacity in transition metal oxide lithium-ion batteries revealed by in situ magnetometry. *Nature Materials, 20*(1), 76-83.

Li, Q., Zhou, J., Liu, R., & Han, L. (2019c). An amino-functionalized metal–organic framework nanosheet array as a battery-type electrode for an advanced supercapattery. *Dalton Transactions, 48*(46), 17163-17168. doi:10.1039/C9DT03821C

Li, R., Miao, C., Zhang, M., & Xiao, W. (2020a). Novel hierarchical structural SnS2 composite supported by biochar carbonized from chewed sugarcane as enhanced anodes for lithium ion batteries. *Ionics, 26*(3), 1239-1247.

Li, S., Harris, S., Anandhi, A., & Chen, G. (2019d). Predicting biochar properties and functions based on feedstock and pyrolysis temperature: A review and data syntheses. *Journal of Cleaner Production, 215*, 890-902.

Li, W., Liu, J., & Zhao, D. (2016c). Mesoporous materials for energy conversion and storage devices. *Nature Reviews Materials, 1*(6), 1-17.

Li, X., Cao, Y., Qi, W., Saraf, L. V., Xiao, J., Nie, Z., et al. (2011). Optimization of mesoporous carbon structures for lithium–sulfur battery applications. *Journal of Materials Chemistry, 21*(41), 16603-16610. doi:10.1039/C1JM12979A

Li, X., & Wei, B. (2013). Supercapacitors based on nanostructured carbon. *Nano Energy, 2*(2), 159-173. doi:https://doi.org/10.1016/j.nanoen.2012.09.008

Li, Y., Li, Z., Xing, B., Li, H., Ma, Z., Zhang, W., et al. (2021b). Green conversion of bamboo chips into high-performance phenol adsorbent and supercapacitor electrodes by simultaneous activation and nitrogen doping. *Journal of Analytical and Applied Pyrolysis, 155*, 105072. doi:https://doi.org/10.1016/j.jaap.2021.105072

Li, Y., Liu, L., Shi, R., Yang, S., Zhao, C., Shi, Y., et al. (2019e). Natural Okra Shells Derived Nitrogen-Doped Porous Carbon to Regulate Polysulfides for High-Performance Lithium–Sulfur Batteries. *Energy Technology, 7*(12), 1900165.

Li, Y., Shao, J., Wang, X., Deng, Y., Yang, H., & Chen, H. (2014). Characterization of Modified Biochars Derived from Bamboo Pyrolysis and Their Utilization for Target Component (Furfural) Adsorption. *Energy & Fuels, 28*(8), 5119-5127. doi:10.1021/ef500725c

Li, Y., Wu, J., & Chopra, N. (2015). Nano-carbon-based hybrids and heterostructures: progress in growth and application for lithium-ion batteries. *Journal of materials science, 50*(24), 7843-7865.

Li, Y., Xing, B., Ding, Y., Han, X., & Wang, S. (2020b). A critical review of the production and advanced utilization of biochar via selective pyrolysis of lignocellulosic biomass. *Bioresource Technology, 312*, 123614.

Li, Y., Zhang, X., Deng, J., Yang, X., Wang, J., & Wang, Y. (2020c). Hierarchical porous biochar derived from cotinus coggygria flower by using a novel composite activator for supercapacitors. *Chemical Physics Letters, 747*, 137325.

Li, Y., Zhu, L., Shi, J., Dou, Y., Li, S., You, R., et al. (2021c). Super-hydrophilic microporous biochar from biowaste for supercapacitor application. *Applied surface science, 561*, 150076.

Liang, C., Gascó, G., Fu, S., Méndez, A., & Paz-Ferreiro, J. (2016). Biochar from pruning residues as a soil amendment: effects of pyrolysis temperature and particle size. *Soil and Tillage Research, 164*, 3-10.

Liao, Z., Su, H.-Y., Cheng, J., Sun, G.-T., Zhu, L., & Zhu, M.-Q. (2021). CoFe2O4-mesoporous carbons derived from Eucommia ulmoides wood for supercapacitors: Comparison of two activation method and composite carbons material synthesis method. *Industrial Crops and Products, 171*, 113861. doi:https://doi.org/10.1016/j.indcrop.2021.113861

Lin, T., Chen, I.-W., Liu, F., Yang, C., Bi, H., Xu, F., et al. (2015). Nitrogen-doped mesoporous carbon of extraordinary capacitance for electrochemical energy storage. *Science, 350*(6267), 1508-1513. doi:10.1126/science.aab3798

Lin, X.-Q., Yang, N., Lü, Q.-F., & Liu, R. (2019). Self-Nitrogen-Doped Porous Biocarbon from Watermelon Rind: A High-Performance Supercapacitor Electrode and Its Improved Electrochemical Performance Using Redox Additive Electrolyte. *Energy Technology, 7*(3), 1800628. doi:https://doi.org/10.1002/ente.201800628

Linares, N., Silvestre-Albero, A. M., Serrano, E., Silvestre-Albero, J., & García-Martínez, J. (2014). Mesoporous materials for clean energy technologies. *Chemical Society Reviews, 43*(22), 7681-7717.

Liu, Wu-Jun, Jiang, H., & Yu, H.-Q. (2015a). Development of Biochar-Based Functional Materials: Toward a Sustainable Platform Carbon Material. *Chemical Reviews, 115*(22), 12251-12285. doi:10.1021/acs.chemrev.5b00195

Liu, C., Chen, W., Li, M., Hong, S., Li, W., Pan, M., et al. (2019a). Rapid microwave activation of waste palm into hierarchical porous carbons for supercapacitors using biochars from different carbonization temperatures as catalysts. *RSC Advances, 9*(34), 19441-19449.

Liu, D., Yu, S., Shen, Y., Chen, H., Shen, Z., Zhao, S., et al. (2015b). Polyaniline Coated Boron Doped Biomass Derived Porous Carbon Composites for Supercapacitor Electrode Materials. *Industrial & Engineering Chemistry Research, 54*(50), 12570-12579. doi:10.1021/acs.iecr.5b02507

Liu, D., Zhang, W., Lin, H., Li, Y., Lu, H., & Wang, Y. (2016a). A green technology for the preparation of high capacitance rice husk-based activated carbon. *Journal of Cleaner Production, 112*, 1190-1198. doi:https://doi.org/10.1016/j.jclepro.2015.07.005

Liu, J., Deng, Y., Li, X., & Wang, L. (2016b). Promising Nitrogen-Rich Porous Carbons Derived from One-Step Calcium Chloride Activation of Biomass-Based Waste for High Performance Supercapacitors. *ACS Sustainable Chemistry & Engineering, 4*(1), 177-187. doi:10.1021/acssuschemeng.5b00926

Liu, M., He, S., Fan, W., Miao, Y.-E., & Liu, T. (2014a). Filter paper-derived carbon fiber/polyaniline composite paper for high energy storage applications. *Composites science and technology, 101*, 152-158.

Liu, P., Yan, J., Guang, Z., Huang, Y., Li, X., & Huang, W. (2019b). Recent advancements of polyaniline-based nanocomposites for supercapacitors. *Journal of Power Sources, 424*, 108-130.

Liu, R., Liu, G., Yousaf, B., Niu, Z., & Abbas, Q. (2022). Novel investigation of pyrolysis mechanisms and kinetics for functional groups in biomass matrix. *Renewable and sustainable energy reviews, 153*, 111761.

Liu, W.-J., Jiang, H., & Yu, H.-Q. (2015c). Development of Biochar-Based Functional Materials: Toward a Sustainable Platform Carbon Material. *Chemical Reviews, 115*(22), 12251-12285. doi:10.1021/acs.chemrev.5b00195

Liu, W.-J., Jiang, H., & Yu, H.-Q. (2019c). Emerging applications of biochar-based materials for energy storage and conversion. *Energy & Environmental Science, 12*(6), 1751-1779.

Liu, W.-J., Tian, K., He, Y.-R., Jiang, H., & Yu, H.-Q. (2014b). High-Yield Harvest of Nanofibers/Mesoporous Carbon Composite by Pyrolysis of Waste Biomass and Its Application for High Durability Electrochemical Energy Storage. *Environmental Science & Technology, 48*(23), 13951-13959. doi:10.1021/es504184c

Liu, W.-J., Tian, K., Jiang, H., & Yu, H.-Q. (2013). Facile synthesis of highly efficient and recyclable magnetic solid acid from biomass waste. *Scientific reports, 3*, 2419. doi:10.1038/srep02419

Liu, W.-J., Tian, K., Jiang, H., & Yu, H.-Q. (2014c). Harvest of Cu NP anchored magnetic carbon materials from Fe/Cu preloaded biomass: their pyrolysis, characterization, and catalytic activity on aqueous reduction of 4-nitrophenol. *Green Chemistry, 16*(9), 4198-4205. doi:10.1039/C4GC00599F

Liu, W.-x., Na, L., Song, H.-h., & Chen, X.-h. (2011). Properties of polyaniline/ordered mesoporous carbon composites as electrodes for supercapacitors. *New carbon materials, 26*(3), 217-223.

Liu, W., & Zhao, G. (2012). Effect of temperature and time on microstructure and surface functional groups of activated carbon fibers prepared from liquefied wood. *BioResources, 7*(4), 5552-5567.

Liu, Y., Chen, J., Cui, B., Yin, P., & Zhang, C. (2018). Design and preparation of biomass-derived carbon materials for supercapacitors: A review. *C, 4*(4), 53.

Liu, Y., He, Z., & Uchimiya, M. (2015d). Comparison of biochar formation from various agricultural by-products using FTIR spectroscopy. *Modern Applied Science, 9*(4), 246.

Liu, Y., Jiang, S. P., & Shao, Z. (2020). Intercalation pseudocapacitance in electrochemical energy storage: recent advances in fundamental understanding and materials development. *Materials Today Advances, 7*, 100072. doi:https://doi.org/10.1016/j.mtadv.2020.100072

Lokhande, V. C., Lokhande, A. C., Lokhande, C. D., Kim, J. H., & Ji, T. (2016). Supercapacitive composite metal oxide electrodes formed with carbon, metal oxides and conducting polymers. *Journal of Alloys and Compounds, 682*, 381-403.

Lotfabad, E. M., Ding, J., Cui, K., Kohandehghan, A., Kalisvaart, W. P., Hazelton, M., et al. (2014). High-density sodium and lithium ion battery anodes from banana peels. *Acs Nano, 8*(7), 7115-7129.

Lu, A. H., Salabas, E. e. L., & Schüth, F. (2007a). Magnetic nanoparticles: synthesis, protection, functionalization, and application. *Angewandte Chemie International Edition, 46*(8), 1222-1244.

Lu, A. H., Schmidt, W., Matoussevitch, N., Bönnemann, H., Spliethoff, B., Tesche, B., et al. (2004). Nanoengineering of a magnetically separable hydrogenation catalyst. *Angewandte Chemie, 116*(33), 4403-4406.

Lu, B., Jin, X., Han, Q., & Qu, L. (2021). Planar Graphene-Based Microsupercapacitors. *Small, 17*(48), 2006827.

Lu, S., Corzine, K. A., & Ferdowsi, M. (2007b). A New Battery/Ultracapacitor Energy Storage System Design and Its Motor Drive Integration for Hybrid Electric Vehicles. *IEEE Transactions on Vehicular Technology, 56*(4), 1516-1523. doi:10.1109/TVT.2007.896971

Lu, X., & Chen, Z. (2005). Curved pi-conjugation, aromaticity, and the related chemistry of small fullerenes (< C60) and single-walled carbon nanotubes. *Chemical Reviews, 105*(10), 3643-3696.

Lukatskaya, M. R., Dunn, B., & Gogotsi, Y. (2016). Multidimensional materials and device architectures for future hybrid energy storage. *Nature communications, 7*, 12647. doi:10.1038/ncomms12647

Luna-Lama, F., Rodríguez-Padrón, D., Puente-Santiago, A. R., Muñoz-Batista, M. J., Caballero, A., Balu, A. M., et al. (2019). Non-porous carbonaceous materials derived from coffee waste grounds as highly sustainable anodes for lithium-ion batteries. *Journal of Cleaner Production, 207*, 411-417. doi:https://doi.org/10.1016/j.jclepro.2018.10.024

Ma, H., Li, J.-B., Liu, W.-W., Miao, M., Cheng, B.-J., & Zhu, S.-W. (2015). Novel synthesis of a versatile magnetic adsorbent derived from corncob for dye removal. *Bioresource Technology, 190*, 13-20. doi:https://doi.org/10.1016/j.biortech.2015.04.048

Ma, L.-L., Hu, X., Liu, W.-J., Li, H.-C., Lam, P. K., Zeng, R. J., et al. (2021a). Constructing N, P-dually doped biochar materials from biomass wastes for high-performance bifunctional oxygen electrocatalysts. *Chemosphere, 278*, 130508.

Ma, Y., Hou, C., Zhang, H., Zhang, Q., Liu, H., Wu, S., et al. (2019). Three-dimensional core-shell Fe_3O_4/Polyaniline coaxial heterogeneous nanonets: Preparation and high performance supercapacitor electrodes. *Electrochimica Acta, 315*, 114-123. doi:https://doi.org/10.1016/j.electacta.2019.05.073

Ma, Z.-W., Liu, H.-Q., & Lü, Q.-F. (2021b). Porous biochar derived from tea saponin for supercapacitor electrode: Effect of preparation technique. *Journal of Energy Storage, 40*, 102773.

Ma, Z., Yang, Y., Ma, Q., Zhou, H., Luo, X., Liu, X., et al. (2017). Evolution of the chemical composition, functional group, pore structure and crystallographic structure of bio-char from palm kernel shell pyrolysis under different temperatures. *Journal of Analytical and Applied Pyrolysis, 127*, 350-359. doi:https://doi.org/10.1016/j.jaap.2017.07.015

Magnacca, G., Guerretta, F., Vizintin, A., Benzi, P., Valsania, M. C., & Nisticò, R. (2018). Preparation, characterization and environmental/electrochemical energy storage testing of low-cost biochar from natural chitin obtained via pyrolysis at mild conditions. *Applied surface science, 427*, 883-893.

Magu, T., Agobi, A., Hitler, L., & Dass, P. (2019). A review on conducting polymers-based composites for energy storage application. *Journal of Chemical Reviews, 1*(1), 19-34.

Mahlia, T. M. I., Saktisahdan, T. J., Jannifar, A., Hasan, M. H., & Matseelar, H. S. C. (2014). A review of available methods and development on energy storage; technology update. *Renewable and sustainable energy reviews, 33*, 532-545. doi:https://doi.org/10.1016/j.rser.2014.01.068

Mai, D., Wen, R., Cao, W., Yuan, B., Liu, Y., Liu, Q., et al. (2017). Effect of heavy metal (Zn) on redox property of hydrochar produced from lignin, cellulose, and d-Xylose. *ACS Sustainable Chemistry & Engineering, 5*(4), 3499-3508.

Majumdar, D., Mandal, M., & Bhattacharya, S. K. (2020). Journey from supercapacitors to supercapatteries: recent advancements in electrochemical energy storage systems. *Emergent Materials, 3*(3), 347-367. doi:10.1007/s42247-020-00090-5

Manyà, J. J. (2012). Pyrolysis for Biochar Purposes: A Review to Establish Current Knowledge Gaps and Research Needs. *Environmental Science & Technology, 46*(15), 7939-7954. doi:10.1021/es301029g

Marichi, R. B., Sahu, V., Sharma, R. K., & Singh, G. (2017). Efficient, Sustainable, and Clean Energy Storage in Supercapacitors Using Biomass-Derived Carbon Materials. In L. M. T. Martínez, O. V. Kharissova, & B. I. Kharisov (Eds.), *Handbook of Ecomaterials* (pp. 1-26). Cham: Springer International Publishing.

Marsh, H., & Reinoso, F. R. (2006). *Activated carbon*: Elsevier.

Maruthapandi, M., Saravanan, A., Manoj, S., Luong, J. H., & Gedanken, A. (2021). Facile ultrasonic preparation of a polypyrrole membrane as an absorbent for efficient oil-water separation and as an antimicrobial agent. *Ultrasonics sonochemistry, 78*, 105746.

Masala, O., & Seshadri, R. (2004). Synthesis routes for large volumes of nanoparticles. *Annu. Rev. Mater. Res., 34*, 41-81.

Matei, E., Predescu, A., Vasile, E., & Predescu, A. (2011). Properties of magnetic iron oxides used as materials for wastewater treatment. *Journal of Physics: Conference Series, 304*, 012022. doi:10.1088/1742-6596/304/1/012022

Mayyas, M., & Sahajwalla, V. (2019). Carbon nano-sponge with enhanced electrochemical properties: A new understanding of carbon activation. *Chemical Engineering Journal, 358*, 980-991. doi:https://doi.org/10.1016/j.cej.2018.10.094

McCreery, R. L. (2021). Carbon electrodes: structural effects on electron transfer kinetics. In *Electroanalytical chemistry* (pp. 221-374): CRC Press.

McCullough, F., Levine, C., & Snelgrove, R. (1989). *Secondary battery*.

McKone, J. R., DiSalvo, F. J., & Abruña, H. D. (2017). Solar energy conversion, storage, and release using an integrated solar-driven redox flow battery. *Journal of Materials Chemistry A, 5*(11), 5362-5372. doi:10.1039/C7TA00555E

McLarnon, F. R., & Cairns, E. J. (1989). Energy storage. *Annual review of energy, 14*(1), 241-271.

Michálková, Z., Komárek, M., Šillerová, H., Della Puppa, L., Joussein, E., Bordas, F., et al. (2014). Evaluating the potential of three Fe- and Mn-(nano)oxides for the stabilization of Cd, Cu and Pb in contaminated soils. *Journal of environmental management, 146*, 226-234. doi:https://doi.org/10.1016/j.jenvman.2014.08.004

Miller, J. R. (2010). Introduction to electrochemical capacitor technology. *IEEE Electrical Insulation Magazine, 26*(4), 40-47. doi:10.1109/MEI.2010.5511188

Minakshi, M., Mitchell, D. R., Jones, R. T., Pramanik, N. C., Jean-Fulcrand, A., & Garnweitner, G. (2020). A hybrid electrochemical energy storage device using sustainable electrode materials. *ChemistrySelect, 5*(4), 1597-1606.

Mitra, M., Kulsi, C., Chatterjee, K., Kargupta, K., Ganguly, S., Banerjee, D., et al. (2015). Reduced graphene oxide-polyaniline composites—synthesis, characterization and optimization for thermoelectric applications. *RSC Advances, 5*(39), 31039-31048.

Mo, R.-J., Zhao, Y., Wu, M., Xiao, H.-M., Kuga, S., Huang, Y., et al. (2016). Activated carbon from nitrogen rich watermelon rind for high-performance supercapacitors. *RSC Advances, 6*(64), 59333-59342. doi:10.1039/C6RA10719B

Mohammed, L., Gomaa, H. G., Ragab, D., & Zhu, J. (2017). Magnetic nanoparticles for environmental and biomedical applications: A review. *Particuology, 30*, 1-14. doi:https://doi.org/10.1016/j.partic.2016.06.001

Mordina, B., Kumar, R., Neeraj, N. S., Srivastava, A. K., Setua, D. K., & Sharma, A. (2020). Binder free high performance hybrid supercapacitor device based on nickel ferrite nanoparticles. *Journal of Energy Storage, 31*, 101677.

Morin, M., Pécate, S., Hémati, M., & Kara, Y. (2016). Pyrolysis of biomass in a batch fluidized bed reactor: Effect of the pyrolysis conditions and the nature of the biomass on the physicochemical properties and the reactivity of char. *Journal of Analytical and Applied Pyrolysis, 122*, 511-523. doi:https://doi.org/10.1016/j.jaap.2016.10.002

Moseley, P. T., & Crocker, J. (2020). *Sensor materials*: CRC Press.

Motovilova, E., & Huang, S. (2017). 3 Magnetic Materials for Nuclear Magnetic Resonance and Magnetic Resonance Imaging. *Advances in Magnetic Materials: Processing, Properties, and Performance*, 131-188.

Mubarak, N., Kundu, A., Sahu, J., Abdullah, E., & Jayakumar, N. (2014). Synthesis of palm oil empty fruit bunch magnetic pyrolytic char impregnating with $FeCl_3$ by microwave heating technique. *Biomass and Bioenergy, 61*, 265-275.

Muhammad, R. M., & Masdek, N. R. N. M. (2016). Overview of Melon Industry in Malaysia. In *FFTC Agricultural Policy Platform (FFTC-AP)* (Vol. 2016).

Mukherjee, A., Zimmerman, A. R., & Harris, W. (2011). Surface chemistry variations among a series of laboratory-produced biochars. *Geoderma, 163*(3), 247-255. doi:https://doi.org/10.1016/j.geoderma.2011.04.021

Murtaza, G., Ahmed, Z., & Usman, M. (2022). Feedstock type, pyrolysis temperature and acid modification effects on physiochemical attributes of biochar and soil quality. *Arabian Journal of Geosciences, 15*(3), 1-30.

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

Nabais, J. V., Laginhas, C., Carrott, M. R., Carrott, P., Amorós, J. C., & Gisbert, A. N. (2013). Surface and porous characterisation of activated carbons made from a novel biomass precursor, the esparto grass. *Applied surface science, 265*, 919-924.

Nagaraju, G., Cha, S. M., & Yu, J. S. (2017). Ultrathin nickel hydroxide nanosheet arrays grafted biomass-derived honeycomb-like porous carbon with improved electrochemical performance as a supercapacitive material. *Scientific reports, 7*(1), 1-11.

Najib, S., & Erdem, E. (2019). Current progress achieved in novel materials for supercapacitor electrodes: mini review. *Nanoscale Advances, 1*(8), 2817-2827.

Nanda, S., & Berruti, F. (2021). A technical review of bioenergy and resource recovery from municipal solid waste. *Journal of Hazardous Materials, 403*, 123970.

Nangir, M., Massoudi, A., & Tayebifard, S. A. (2020). Investigation of the lithium-ion depletion in the silicon-silicon carbide anode/electrolyte interface in lithium-ion battery via electrochemical impedance spectroscopy. *Journal of Electroanalytical Chemistry, 873*, 114385.

Nave, C. L. (2008). *Magnetic Properties of Solids. HyperPhysics*.

Ni, J., & Li, Y. (2016). Carbon nanomaterials in different dimensions for electrochemical energy storage. *Advanced Energy Materials, 6*(17), 1600278.

Nirosha, B., Selvakumar, R., Jeyanthi, J., & Vairam, S. (2020). Elaeocarpus tectorius derived phosphorus-doped carbon as an electrode material for an asymmetric supercapacitor. *New Journal of Chemistry, 44*(1), 181-193. doi:10.1039/C9NJ04813H

Niu, J., Shao, R., Liang, J., Dou, M., Li, Z., Huang, Y., et al. (2017). Biomass-derived mesopore-dominant porous carbons with large specific surface area and high defect density as high performance electrode materials for Li-ion batteries and supercapacitors. *Nano Energy, 36*, 322-330. doi:https://doi.org/10.1016/j.nanoen.2017.04.042

Nizamuddin, S., Mubarak, N., Tiripathi, M., Jayakumar, N., Sahu, J., & Ganesan, P. (2016). Chemical, dielectric and structural characterization of optimized hydrochar produced from hydrothermal carbonization of palm shell. *Fuel, 163*, 88-97.

Noel, M., & Suryanarayanan, V. (2002). Role of carbon host lattices in Li-ion intercalation/de-intercalation processes. *Journal of Power Sources, 111*(2), 193-209.

Noraini, M., Abdullah, E., Othman, R., & Mubarak, N. (2016). Single-route synthesis of magnetic biochar from sugarcane bagasse by microwave-assisted pyrolysis. *Materials Letters, 184*, 315-319.

Norouzi, O., Di Maria, F., & Dutta, A. (2020). Biochar-based composites as electrode active materials in hybrid supercapacitors with particular focus on surface topography and morphology. *Journal of Energy Storage, 29*, 101291.

Norouzi, O., Pourhosseini, S., Naderi, H. R., Di Maria, F., & Dutta, A. (2021). Integrated hybrid architecture of metal and biochar for high performance asymmetric supercapacitors. *Scientific reports, 11*(1), 1-13.

Norouzi, O., Safari, F., Jafarian, S., Tavasoli, A., & Karimi, A. (2017). Hydrothermal gasification performance of Enteromorpha intestinalis as an algal biomass for hydrogen-rich gas production using Ru promoted Fe–Ni/γ-Al_2O_3 nanocatalysts. *Energy Conversion and Management, 141*, 63-71. doi:https://doi.org/10.1016/j.enconman.2016.04.083

Numan, A. (2018). *Development of metal oxide nanostructures incorporated with carbon matrix for electrochemical applications/Numan Arshid.* University of Malaya,

Numan, A., Ramesh kumar, P., Khalid, M., Ramesh, S., Ramesh, K., Shamsudin, E. M., et al. (2020). Facile sonochemical synthesis of 2D porous Co_3O_4 nanoflake for supercapattery. *Journal of Alloys and Compounds, 819*, 153019. doi:https://doi.org/10.1016/j.jallcom.2019.153019

Numan, A., Zhan, Y., Khalid, M., & Hatamvand, M. (2021). Introduction to supercapattery. In *Advances in Supercapacitor and Supercapattery* (pp. 45-61): Elsevier.

Nystrom, G., Mihranyan, A., Razaq, A., Lindstrom, T., Nyholm, L., & Strømme, M. (2010). A nanocellulose polypyrrole composite based on microfibrillated cellulose from wood. *The Journal of Physical Chemistry B, 114*(12), 4178-4182.

Okonkwo, C. A., Lv, T., Hong, W., Li, G., Huang, J., Deng, J., et al. (2020). The synthesis of micromesoporous carbon derived from nitrogen-rich spirulina extract impregnated castor shell based on biomass self-doping for highly efficient supercapacitor electrodes. *Journal of Alloys and Compounds, 825*, 154009. doi:https://doi.org/10.1016/j.jallcom.2020.154009

Oladipo, A. A., & Ifebajo, A. O. (2018). Highly efficient magnetic chicken bone biochar for removal of tetracycline and fluorescent dye from wastewater: two-stage adsorber analysis. *Journal of environmental management, 209*, 9-16.

Olofsson, Y., & Romare, M. (2013). *Life cycle assessment of lithium-ion batteries for plug-in hybrid buses.*

Othman, Y., & Subhadrabandhu, S. (1995). The production of economic fruits in south-east Asia. *International Tropical Fruits Network. (n.d.). Watermelon*, 215.

Oumabady, S., Kamaludeen, S. P., Ramasamy, M., Kalaiselvi, P., & Parameswari, E. (2020). Preparation and characterization of optimized hydrochar from paper board mill sludge. *Scientific reports, 10*(1), 1-12.

Ozel, F. a. K., H. . (2015). Growth and characterizations of magnetic nanoparticles under hydrothermal conditions: Reaction time and temperature. *J. Magn. Magn. Mater. , 373*, 213–216.

Ozturk, M., Saba, N., Altay, V., Iqbal, R., Hakeem, K. R., Jawaid, M., et al. (2017). Biomass and bioenergy: An overview of the development potential in Turkey and Malaysia. *Renewable and sustainable energy reviews, 79*, 1285-1302.

Pallarés, J., González-Cencerrado, A., & Arauzo, I. (2018). Production and characterization of activated carbon from barley straw by physical activation with carbon dioxide and steam. *Biomass and Bioenergy, 115*, 64-73. doi:https://doi.org/10.1016/j.biombioe.2018.04.015

Pan, P., Hu, Y., Wu, K., Cheng, Z., Shen, Z., Jiang, L., et al. (2020). Growth of $ZnCo_2O_4$ nanocubes on flexible biochar substrate derived from natural silk waste fabric for lithium-ion battery anode. *Journal of Alloys and Compounds, 814*, 152306. doi:https://doi.org/10.1016/j.jallcom.2019.152306

Pandey, D., Daverey, A., & Arunachalam, K. (2020). Biochar: Production, properties and emerging role as a support for enzyme immobilization. *Journal of Cleaner Production, 255*, 120267.

Pang, H., Shi, Y., Du, J., Ma, Y., Li, G., Chen, J., et al. (2012). Porous nickel oxide microflowers synthesized by calcination of coordination microflowers and their applications as glutathione electrochemical sensor and supercapacitors. *Electrochimica Acta, 85*, 256-262. doi:https://doi.org/10.1016/j.electacta.2012.08.057

Panwar, N., & Pawar, A. (2020). Influence of activation conditions on the physicochemical properties of activated biochar: a review. *Biomass Conversion and Biorefinery*, 1-23.

Park, M.-S., Needham, S. A., Wang, G.-X., Kang, Y.-M., Park, J.-S., Dou, S.-X., et al. (2007). Nanostructured SnSb/carbon nanotube composites synthesized by reductive precipitation for lithium-ion batteries. *Chemistry of Materials, 19*(10), 2406-2410.

Patra, B. R., Mukherjee, A., Nanda, S., & Dalai, A. K. (2021). Biochar production, activation and adsorptive applications: a review. *Environmental Chemistry Letters*, 1-23.

Pawar, R. C., & Lee, C. S. (2015). Chapter 2 - Nanomaterial-Based Photocatalysis. In R. C. Pawar & C. S. Lee (Eds.), *Heterogeneous Nanocomposite-Photocatalysis for Water Purification* (pp. 25-41). Boston: William Andrew Publishing.

Pender, J. P., Jha, G., Youn, D. H., Ziegler, J. M., Andoni, I., Choi, E. J., et al. (2020). Electrode degradation in lithium-ion batteries. *Acs Nano, 14*(2), 1243-1295.

Peng, L., Liang, Y., Huang, J., Xing, L., Hu, H., Xiao, Y., et al. (2019). Mixed-biomass wastes derived hierarchically porous carbons for high-performance electrochemical energy storage. *ACS Sustainable Chemistry & Engineering, 7*(12), 10393-10402.

Peng, P., Lang, Y.-H., & Wang, X.-M. (2016). Adsorption behavior and mechanism of pentachlorophenol on reed biochars: pH effect, pyrolysis temperature, hydrochloric acid treatment and isotherms. *Ecological Engineering, 90*, 225-233. doi:https://doi.org/10.1016/j.ecoleng.2016.01.039

Perrotta, D., Ribeiro, B., Rossetti, R. J., & Afonso, J. L. (2012). On the potential of regenerative braking of electric buses as a function of their itinerary. *Procedia-Social and Behavioral Sciences, 54*, 1156-1167.

Peter, A., Chabot, B., & Loranger, E. (2019). *Enhancing surface properties of softwood biochar by ultrasound assisted slow pyrolysis.* Paper presented at the 2019 IEEE International Ultrasonics Symposium (IUS).

Pipitone, E., & Vitale, G. (2020). A regenerative braking system for internal combustion engine vehicles using supercapacitors as energy storage elements-Part 1: System analysis and modelling. *Journal of Power Sources, 448*, 227368.

Pistone, A., & Espro, C. (2020). Current trends on turning biomass wastes into carbon materials for electrochemical sensing and rechargeable battery applications. *Current Opinion in Green and Sustainable Chemistry, 26*, 100374.

Placke, T., Kloepsch, R., Dühnen, S., & Winter, M. (2017). Lithium ion, lithium metal, and alternative rechargeable battery technologies: the odyssey for high energy density. *Journal of Solid State Electrochemistry, 21*(7), 1939-1964.

Pontiroli, D., Scaravonati, S., Magnani, G., Fornasini, L., Bersani, D., Bertoni, G., et al. (2019). Super-activated biochar from poultry litter for high-performance supercapacitors. *Microporous and Mesoporous Materials, 285*, 161-169.

Pourhosseini, S. E. M., Norouzi, O., Salimi, P., & Naderi, H. R. (2018). Synthesis of a Novel Interconnected 3D Pore Network Algal Biochar Constituting Iron Nanoparticles Derived from a Harmful Marine Biomass as High-Performance Asymmetric Supercapacitor Electrodes. *ACS Sustainable Chemistry & Engineering, 6*(4), 4746-4758. doi:10.1021/acssuschemeng.7b03871

Pradhan, S., Hedberg, J., Blomberg, E., Wold, S., & Wallinder, I. O. (2016). Effect of sonication on particle dispersion, administered dose and metal release of non-functionalized, non-inert metal nanoparticles. *Journal of nanoparticle research, 18*(9), 1-14.

Prasanna, G., Ashok, R., Prasad, V., & Jayanna, H. (2015). Synthesis and characterization of magnetic and conductive nickel ferrite–polyaniline nanocomposites. *Journal of Composite Materials, 49*(21), 2649-2657.

Qambrani, N. A., Rahman, M. M., Won, S., Shim, S., & Ra, C. (2017). Biochar properties and eco-friendly applications for climate change mitigation, waste management, and wastewater treatment: A review. *Renewable and sustainable energy reviews, 79*, 255-273. doi:https://doi.org/10.1016/j.rser.2017.05.057

Qian, K., Kumar, A., Zhang, H., Bellmer, D., & Huhnke, R. (2015). Recent advances in utilization of biochar. *Renewable and sustainable energy reviews, 42*, 1055-1064.

Qiao, Y., Zhang, C., Kong, F., Zhao, Q., Kong, A., & Shan, Y. (2021). Activated biochar derived from peanut shells as the electrode materials with excellent performance in Zinc-air battery and supercapacitance. *Waste Management, 125*, 257-267.

Qin, C., Wang, H., Yuan, X., Xiong, T., Zhang, J., & Zhang, J. (2020). Understanding structure-performance correlation of biochar materials in environmental remediation and electrochemical devices. *Chemical Engineering Journal, 382*, 122977.

Qiu, B., Deng, Y., Du, M., Xing, M., & Zhang, J. (2016a). Ultradispersed cobalt ferrite nanoparticles assembled in graphene aerogel for continuous photo-Fenton reaction and enhanced lithium storage performance. *Scientific reports, 6*(1), 1-10.

Qiu, S., Wang, Z., He, Z., & Yi, S. (2016b). The effect of ultrasound pretreatment on poplar wood dimensional stability. *BioResources, 11*(3), 7811-7821.

Qiu, Z., Wang, Y., Bi, X., Zhou, T., Zhou, J., Zhao, J., et al. (2018). Biochar-based carbons with hierarchical micro-meso-macro porosity for high rate and long cycle life supercapacitors. *Journal of Power Sources, 376*, 82-90.

Quah, R. V., Tan, Y. H., Mubarak, N., Khalid, M., Abdullah, E., & Nolasco-Hipolito, C. (2019). An overview of biodiesel production using recyclable biomass and non-biomass derived magnetic catalysts. *Journal of Environmental Chemical Engineering, 7*(4), 103219.

Rafiq, M. K., Bachmann, R. T., Rafiq, M. T., Shang, Z., Joseph, S., & Long, R. (2016). Influence of Pyrolysis Temperature on Physico-Chemical Properties of Corn Stover (Zea mays L.) Biochar and Feasibility for Carbon Capture and Energy Balance. *PloS one, 11*(6), e0156894-e0156894. doi:10.1371/journal.pone.0156894

Rahman, M. Z., Edvinsson, T., & Kwong, P. (2020). Biochar for electrochemical applications. *Current Opinion in Green and Sustainable Chemistry, 23*, 25-30.

Ramanavicius, S., & Ramanavicius, A. (2020). Conducting polymers in the design of biosensors and biofuel cells. *Polymers, 13*(1), 49.

Rath, P. C., Patra, J., Huang, H.-T., Bresser, D., Wu, T.-Y., & Chang, J.-K. (2019). Carbonaceous Anodes Derived from Sugarcane Bagasse for Sodium-Ion Batteries. *ChemSusChem, 12*(10), 2302-2309. doi:https://doi.org/10.1002/cssc.201900319

Ray, A., Banerjee, A., & Dubey, A. (2020). Characterization of biochars from various agricultural by-products using FTIR spectroscopy, SEM focused with image processing. *International Journal of Agriculture, Environment and Biotechnology, 13*(4), 423-430.

Raymundo-Piñero, E., Kierzek, K., Machnikowski, J., & Béguin, F. (2006). Relationship between the nanoporous texture of activated carbons and their capacitance properties in different electrolytes. *Carbon, 44*(12), 2498-2507. doi:https://doi.org/10.1016/j.carbon.2006.05.022

Reddy, N. A., Lakshmipathy, R., & Sarada, N. C. (2014). Application of Citrullus lanatus rind as biosorbent for removal of trivalent chromium from aqueous solution. *Alexandria Engineering Journal, 53*(4), 969-975. doi:https://doi.org/10.1016/j.aej.2014.07.006

Reddy, R. C. K., Lin, J., Chen, Y., Zeng, C., Lin, X., Cai, Y., et al. (2020). Progress of nanostructured metal oxides derived from metal–organic frameworks as anode materials for lithium–ion batteries. *Coordination Chemistry Reviews, 420*, 213434.

Reguyal, F., Sarmah, A. K., & Gao, W. (2017). Synthesis of magnetic biochar from pine sawdust via oxidative hydrolysis of FeCl2 for the removal sulfamethoxazole from aqueous solution. *Journal of Hazardous Materials, 321*, 868-878.

Reitz, F., Milford, J., & Christy, R. (2003). *Foundations of Electromagnetic Teory*.

Ren, K., Liu, Z., Wei, T., & Fan, Z. (2021). Recent Developments of Transition Metal Compounds-Carbon Hybrid Electrodes for High Energy/Power Supercapacitors. *Nano-Micro Letters, 13*(1), 129. doi:10.1007/s40820-021-00642-2

Ren, Y., Xu, Q., Zhang, J., Yang, H., Wang, B., Yang, D., et al. (2014). Functionalization of Biomass Carbonaceous Aerogels: Selective Preparation of MnO_2@CA Composites for Supercapacitors. *ACS Applied Materials & Interfaces, 6*(12), 9689-9697. doi:10.1021/am502035g

Rhim, Y.-R., Zhang, D., Fairbrother, D. H., Wepasnick, K. A., Livi, K. J., Bodnar, R. J., et al. (2010). Changes in electrical and microstructural properties of microcrystalline cellulose as function of carbonization temperature. *Carbon, 48*(4), 1012-1024.

Romelle, F. D., P, A. R., & Manohar, R. S. (2016). Chemical Composition of Some Selected Fruit Peels. *European Journal of Food Science and Technology, Vol.4*(No.4), 9.

Ronsse, F., Van Hecke, S., Dickinson, D., & Prins, W. (2013). Production and characterization of slow pyrolysis biochar: influence of feedstock type and pyrolysis conditions. *Gcb Bioenergy, 5*(2), 104-115.

Ruthiraan, M., Abdullah, E. C., Mubarak, N. M., & Noraini, M. N. (2017). A promising route of magnetic based materials for removal of cadmium and methylene blue from waste water. *Journal of Environmental Chemical Engineering, 5*(2), 1447-1455. doi:https://doi.org/10.1016/j.jece.2017.02.038

Saeed, A. A. H., Harun, N. Y., Sufian, S., Bilad, M. R., Nufida, B. A., Ismail, N. M., et al. (2021a). Modeling and optimization of biochar based adsorbent derived from Kenaf using response surface methodology on adsorption of Cd^{2+}. *Water, 13*(7), 999.

Saeed, A. A. H., Harun, N. Y., Sufian, S., Bilad, M. R., Zakaria, Z. Y., Jagaba, A. H., et al. (2021b). Pristine and Magnetic Kenaf Fiber Biochar for Cd2+ Adsorption from Aqueous Solution. *International Journal of Environmental Research and Public Health, 18*(15), 7949. Retrieved from https://www.mdpi.com/1660-4601/18/15/7949

Sagadevan, S., Johan, M. R., Marlinda, A. R., Akbarzadeh, O., Pandian, K., Shahid, M. M., et al. (2021). Chapter one - Background of energy storage. In N. Arshid, M. Khalid, & A. N. Grace (Eds.), *Advances in Supercapacitor and Supercapattery* (pp. 1-26): Elsevier.

Said, K. A. M., & Amin, M. A. M. (2015). Overview on the response surface methodology (RSM) in extraction processes. *Journal of Applied Science & Process Engineering, 2*(1).

Saini, M., & Shukla, R. (2020). Silver nanoparticles-decorated $NiFe_2O_4$/polyaniline ternary nanocomposite for electromagnetic interference shielding. *Journal of Materials Science: Materials in Electronics, 31*(7), 5152-5164.

Sajib, S. K., & Adhikari, S. (2020). Effect of Pyrolysis Method on Physical Properties of Activated Biochar and its Application as Cathode Material for Lithium-Sulfur Battery. *Transactions of the ASABE, 63*(2), 485-493.

Sajjadi, B., Chen, W.-Y., & Egiebor, N. O. (2019a). A comprehensive review on physical activation of biochar for energy and environmental applications. *Reviews in Chemical Engineering, 35*(6), 735-776.

Sajjadi, B., Zubatiuk, T., Leszczynska, D., Leszczynski, J., & Chen, W. Y. (2019b). Chemical activation of biochar for energy and environmental applications: a comprehensive review. *Reviews in Chemical Engineering, 35*(7), 777-815.

Salimi, P., Norouzi, O., Pourhoseini, S., Bartocci, P., Tavasoli, A., Di Maria, F., et al. (2019a). Magnetic biochar obtained through catalytic pyrolysis of macroalgae: A promising anode material for Li-ion batteries. *Renewable Energy, 140*, 704-714.

Salimi, P., Norouzi, O., & Pourhosseini, S. (2019b). Two-step synthesis of nanohusk Fe_3O_4 embedded in 3D network pyrolytic marine biochar for a new generation of anode materials for Lithium-Ion batteries. *Journal of Alloys and Compounds, 786*, 930-937.

Salinas-Torres, D., Ruiz-Rosas, R., Morallón, E., & Cazorla-Amorós, D. (2019). Strategies to Enhance the Performance of Electrochemical Capacitors Based on Carbon Materials. *Frontiers in Materials, 6*(115). doi:10.3389/fmats.2019.00115

Salvatierra, R. V., Oliveira, M. M., & Zarbin, A. J. (2010). One-pot synthesis and processing of transparent, conducting, and freestanding carbon nanotubes/polyaniline composite films. *Chemistry of Materials, 22*(18), 5222-5234.

Samantara, A. K., & Ratha, S. (2017). Materials development for Active/Passive components of a supercapacitor: background, present status and future perspective.

Samantara, A. K., & Ratha, S. (2021). *Metal-Ion Hybrid Capacitors for Energy Storage: A Balancing Strategy Toward Energy-Power Density*: Springer Nature.

Sambandam, B., Paul David, S., Sakthivel, T., Sivaramalingam, A., Soosaimanickam, A., & Kim, J. (2021). Metal Oxides for Rechargeable Batteries Energy Applications. In *Metal and Metal Oxides for Energy and Electronics* (pp. 1-58): Springer.

Santhosh, C., Daneshvar, E., Tripathi, K. M., Baltrėnas, P., Kim, T., Baltrėnaitė, E., et al. (2020). Synthesis and characterization of magnetic biochar adsorbents for the removal of Cr(VI) and Acid orange 7 dye from aqueous solution. *Environmental Science and Pollution Research, 27*(26), 32874-32887. doi:10.1007/s11356-020-09275-1

Sapurina, I., Kompan, M., & Shishov, M. (2015). Polymer–carbonaceous composites as electrode materials with high electrochemical capacitance. *Russian Journal of Electrochemistry, 51*, 528-537. doi:10.1134/S1023193515060166

Sarkar, S., Roy, S., Hou, Y., Sun, S., Zhang, J., & Zhao, Y. (2021). Recent Progress in Amorphous Carbon-Based Materials for Anodes of Sodium-Ion Batteries: Synthesis Strategies, Mechanisms, and Performance. *ChemSusChem, 14*(18), 3693-3723.

Sarswat, A., & Mohan, D. (2016). Sustainable development of coconut shell activated carbon (CSAC) & a magnetic coconut shell activated carbon (MCSAC) for phenol (2-nitrophenol) removal. *RSC Advances, 6*(88), 85390-85410. doi:10.1039/C6RA19756F

Schranger, H., Barzegar, F., & Abbas, Q. (2020). Hybrid electrochemical capacitors in aqueous electrolytes: challenges and prospects. *Current Opinion in Electrochemistry, 21*, 167-174.

Scott, K. (2016). Electrochemical principles and characterization of bioelectrochemical systems. In *Microbial Electrochemical and Fuel Cells* (pp. 29-66): Elsevier.

Seel, J., & Dahn, J. (2000). Electrochemical intercalation of PF 6 into graphite. *Journal of the Electrochemical Society, 147*(3), 892.

Selvakumari, J. C., Nishanthi, S., Dhanalakshmi, J., Ahila, M., & Padiyan, D. P. (2018). Bio-active synthesis of tin oxide nanoparticles using eggshell membrane for energy storage application. *Applied surface science, 441*, 530-537.

Sengodu, P., & Deshmukh, A. D. (2015). Conducting polymers and their inorganic composites for advanced Li-ion batteries: a review. *RSC Advances, 5*(52), 42109-42130.

Senthilkumar, B., Sankar, K. V., Sanjeeviraja, C., & Selvan, R. K. (2013). Synthesis and physico-chemical property evaluation of PANI–$NiFe_2O_4$ nanocomposite as electrodes for supercapacitors. *Journal of Alloys and Compounds, 553*, 350-357.

Serp, P., & Machado, B. (2015). *Nanostructured carbon materials for catalysis*: Royal Society of Chemistry.

Sevilla, M., & Mokaya, R. (2014). Energy storage applications of activated carbons: supercapacitors and hydrogen storage. *Energy & Environmental Science, 7*(4), 1250-1280.

Shafizadeh, F. (1982). Introduction to pyrolysis of biomass. *Journal of Analytical and Applied pyrolysis, 3*(4), 283-305.

Shah, A. u. H. A., Khan, M. O., Bilal, S., Rahman, G., & Hoang, H. V. (2018). Electrochemical co-deposition and characterization of polyaniline and manganese oxide nanofibrous composites for energy storage properties. *Advances in Polymer Technology, 37*(6), 2230-2237.

Shahdan, D., Ahmad, S., Chen, R. S., Omar, A., Zailan, F. D., & Hassan, N. A. A. (2020). Mechanical performance, heat transfer and conduction of ultrasonication treated polyaniline bio-based blends. *International Communications in Heat and Mass Transfer, 117*, 104742.

Shao, Y., El-Kady, M. F., Sun, J., Li, Y., Zhang, Q., Zhu, M., et al. (2018). Design and Mechanisms of Asymmetric Supercapacitors. *Chemical Reviews, 118*(18), 9233-9280. doi:10.1021/acs.chemrev.8b00252

Sharma, H. B., Sarmah, A. K., & Dubey, B. (2020). Hydrothermal carbonization of renewable waste biomass for solid biofuel production: A discussion on process mechanism, the influence of process parameters, environmental performance and fuel properties of hydrochar. *Renewable and sustainable energy reviews, 123*, 109761. doi:https://doi.org/10.1016/j.rser.2020.109761

Sharma, K., Pareek, K., Rohan, R., & Kumar, P. (2019). Flexible supercapacitor based on three-dimensional cellulose/graphite/polyaniline composite. *International Journal of Energy Research, 43*(1), 604-611.

Shell, K. M., Rodene, D. D., Amar, V., Thakkar, A., Maddipudi, B., Kumar, S., et al. (2021). Supercapacitor performance of corn stover-derived biocarbon produced from the solid co-products of a hydrothermal liquefaction process. *Bioresource Technology Reports, 13*, 100625. doi:https://doi.org/10.1016/j.biteb.2021.100625

Shen, K., Ran, F., Zhang, X., Liu, C., Wang, N., Niu, X., et al. (2015). Supercapacitor electrodes based on nano-polyaniline deposited on hollow carbon spheres derived from cross-linked co-polymers. *Synthetic Metals, 209*, 369-376.

Shi, F., Mang, C., Liu, H., & Dong, Y. (2020). Flexible and high-energy-density Zn/MnO_2 batteries enabled by electrochemically exfoliated graphene nanosheets. *New Journal of Chemistry, 44*(3), 653-657.

Shi, Y., Peng, L., Ding, Y., Zhao, Y., & Yu, G. (2015). Nanostructured conductive polymers for advanced energy storage. *Chemical Society Reviews, 44*(19), 6684-6696.

Shojaeiarani, J., Bajwa, D., & Holt, G. (2020). Sonication amplitude and processing time influence the cellulose nanocrystals morphology and dispersion. *Nanocomposites, 6*(1), 41-46.

Shown, I., Ganguly, A., Chen, L. C., & Chen, K. H. (2015). Conducting polymer-based flexible supercapacitor. *Energy Science & Engineering, 3*(1), 2-26.

Shu, Y., Maruyama, J., Iwasaki, S., Li, C., Shen, Y., & Uyama, H. (2017). Hierarchical activated green carbons from abundant biomass waste for symmetric supercapacitors. *Bulletin of the Chemical Society of Japan, 90*(9), 1058-1066.

Shuit, S. H., Tan, K. T., Lee, K. T., & Kamaruddin, A. H. (2009). Oil palm biomass as a sustainable energy source: A Malaysian case study. *Energy, 34*(9), 1225-1235. doi:https://doi.org/10.1016/j.energy.2009.05.008

Siatecka, A., & Oleszczuk, P. (2022). Mechanism of aging of biochars obtained at different temperatures from sewage sludges with different composition and character. *Chemosphere, 287*, 132258.

Simon, P., & Gogotsi, Y. (2008). Materials for electrochemical capacitors. *Nature Materials, 7*(11), 845-854. doi:10.1038/nmat2297

Simon, P., Gogotsi, Y., & Dunn, B. (2014). Materials science. Where do batteries end and supercapacitors begin? *Science, 343*(6176), 1210-1211. doi:10.1126/science.1249625

Singh, A., Sharma, R., Pant, D., & Malaviya, P. (2021a). Engineered algal biochar for contaminant remediation and electrochemical applications. *Science of the Total Environment, 774*, 145676.

Singh, G., Kumar, Y., & Husain, S. (2021b). Improved electrochemical performance of symmetric polyaniline/activated carbon hybrid for high supercapacitance: Comparison with indirect capacitance. *Polymers for Advanced Technologies, 32*(11), 4490-4501.

Singh, R., Chadetrik, R., Kumar, R., Bishnoi, K., Bhatia, D., Kumar, A., et al. (2010). Biosorption optimization of lead(II), cadmium(II) and copper(II) using response surface methodology and applicability in isotherms and thermodynamics modeling. *Journal of Hazardous Materials, 174*(1), 623-634. doi:https://doi.org/10.1016/j.jhazmat.2009.09.097

Sinha, P., & Kar, K. K. (2020). Characteristics of supercapacitors. In *Handbook of Nanocomposite Supercapacitor Materials II* (pp. 71-87): Springer.

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

Soam, A., Kumar, R., Sahoo, P. K., Mahender, C., Kumar, B., Arya, N., et al. (2019). Synthesis of Nickel Ferrite Nanoparticles Supported on Graphene Nanosheets as Composite Electrodes for High Performance Supercapacitor. *ChemistrySelect, 4*(34), 9952-9958. doi:https://doi.org/10.1002/slct.201901117

Sodtipinta, J., Amornsakchai, T., & Pakawatpanurut, P. (2017). Nanoporous carbon derived from agro-waste pineapple leaves for supercapacitor electrode. *Advances in Natural Sciences: Nanoscience and Nanotechnology, 8*(3), 035017.

Souad, A., Jamal, P., & Olorunnisola, K. (2012). Effective jam preparations from watermelon waste.

Sozeri, H., Kurtan, U., Topkaya, R., Baykal, A., & Toprak, M. S. (2013). Polyaniline (PANI)–Co0. 5Mn0. $5Fe_2O_4$ nanocomposite: Synthesis, characterization and magnetic properties evaluation. *Ceramics International, 39*(5), 5137-5143.

Spain, E., & Venkatanarayanan, A. (2014). 13.02 Review of Physical Principles of Sensing and Types of Sensing Materials. *Comprehensive Materials Processing, Elsevier, Oxford*.

Stevenson, A. J., Gromadskyi, D. G., Hu, D., Chae, J., Guan, L., Yu, L., et al. (2015). Supercapatteries with hybrids of redox active polymers and nanostructured carbons. *Nanocarbons for advanced energy storage, 1*, 179-210.

Su, D. S. (2011). 20 years of carbon nanotubes. In: Wiley Online Library.

Suliman, W., Harsh, J. B., Abu-Lail, N. I., Fortuna, A.-M., Dallmeyer, I., & Garcia-Perez, M. (2016). Influence of feedstock source and pyrolysis temperature on biochar bulk and surface properties. *Biomass and Bioenergy, 84*, 37-48.

Sun, B., He, X., Leng, X., Jiang, Y., Zhao, Y., Suo, H., et al. (2016a). Flower-like polyaniline–NiO structures: a high specific capacity supercapacitor electrode material with remarkable cycling stability. *RSC Advances, 6*(50), 43959-43963.

Sun, J., He, F., Pan, Y., & Zhang, Z. (2017). Effects of pyrolysis temperature and residence time on physicochemical properties of different biochar types. *Acta Agriculturae Scandinavica, Section B—Soil & Plant Science, 67*(1), 12-22.

Sun, N., Liu, H., & Xu, B. (2015a). Facile synthesis of high performance hard carbon anode materials for sodium ion batteries. *Journal of Materials Chemistry A, 3*(41), 20560-20566.

Sun, W., Lipka, S. M., Swartz, C., Williams, D., & Yang, F. (2016b). Hemp-derived activated carbons for supercapacitors. *Carbon, 103*, 181-192.

Sun, X., Gan, M., Ma, L., Wang, H., Zhou, T., Wang, S., et al. (2015b). Fabrication of PANI-coated honeycomb-like MnO2 nanospheres with enhanced electrochemical performance for energy storage. *Electrochimica Acta, 180*, 977-982.

Sun, Y., Gao, B., Yao, Y., Fang, J., Zhang, M., Zhou, Y., et al. (2014). Effects of feedstock type, production method, and pyrolysis temperature on biochar and hydrochar properties. *Chemical Engineering Journal, 240*, 574-578. doi:https://doi.org/10.1016/j.cej.2013.10.081

Tag, A. T., Duman, G., Ucar, S., & Yanik, J. (2016). Effects of feedstock type and pyrolysis temperature on potential applications of biochar. *Journal of Analytical and Applied Pyrolysis, 120*, 200-206.

Taha, S. M., Amer, M. E., Elmarsafy, A. E., & Elkady, M. Y. (2014). Adsorption of 15 different pesticides on untreated and phosphoric acid treated biochar and charcoal from water. *Journal of Environmental Chemical Engineering, 2*(4), 2013-2025. doi:https://doi.org/10.1016/j.jece.2014.09.001

Tajik, S., Beitollahi, H., Nejad, F. G., Shoaie, I. S., Khalilzadeh, M. A., Asl, M. S., et al. (2020). Recent developments in conducting polymers: Applications for electrochemistry. *RSC Advances, 10*(62), 37834-37856.

Tan, X. W., Romainor, A. N. B., Chin, S. F., & Ng, S. M. (2014). Carbon dots production via pyrolysis of sago waste as potential probe for metal ions sensing. *Journal of Analytical and Applied Pyrolysis, 105*, 157-165. doi:https://doi.org/10.1016/j.jaap.2013.11.001

Tan, Y., Liu, Y., Zhang, Y., Xu, C., Kong, L., Kang, L., et al. (2018). Dulse-derived porous carbon–polyaniline nanocomposite electrode for high-performance supercapacitors. *Journal of applied polymer science, 135*(5), 45776.

Tao, K., Gong, Y., & Lin, J. (2019). Epitaxial grown self-supporting NiSe/Ni_3S_2/$Ni_{12}P_5$ vertical nanofiber arrays on Ni foam for high performance supercapacitor: matched exposed facets and re-distribution of electron density. *Nano Energy, 55*, 65-81.

Teimuri-Mofrad, R., Payami, E., & Ahadzadeh, I. (2019). Synthesis, characterization and electrochemical evaluation of a novel high performance GO-Fc/PANI nanocomposite for supercapacitor applications. *Electrochimica Acta, 321*, 134706.

Tessonnier, J. P., & Su, D. S. (2011). Recent progress on the growth mechanism of carbon nanotubes: a review. *ChemSusChem, 4*(7), 824-847.

Thangavel, R., Kannan, A. G., Ponraj, R., Thangavel, V., Kim, D.-W., & Lee, Y.-S. (2018). High-energy green supercapacitor driven by ionic liquid electrolytes as an ultra-high stable next-generation energy storage device. *Journal of Power Sources, 383*, 102-109. doi:https://doi.org/10.1016/j.jpowsour.2018.02.037

Thines, K., Abdullah, E., Ruthiraan, M., Mubarak, N., & Tripathi, M. (2016a). A new route of magnetic biochar based polyaniline composites for supercapacitor electrode materials. *Journal of Analytical and Applied Pyrolysis, 121*, 240-257.

Thines, K. R., Abdullah, E. C., & Mubarak, N. M. (2017a). Effect of process parameters for production of microporous magnetic biochar derived from agriculture waste biomass. *Microporous and Mesoporous Materials, 253*, 29-39. doi:https://doi.org/10.1016/j.micromeso.2017.06.031

Thines, K. R., Abdullah, E. C., Mubarak, N. M., & Ruthiraan, M. (2017b). In-situ polymerization of magnetic biochar – polypyrrole composite: A novel application in supercapacitor. *Biomass and Bioenergy, 98*, 95-111. doi:https://doi.org/10.1016/j.biombioe.2017.01.019

Thines, K. R., Abdullah, E. C., Ruthiraan, M., Mubarak, N. M., & Tripathi, M. (2016b). A new route of magnetic biochar based polyaniline composites for supercapacitor electrode materials. *Journal of Analytical and Applied Pyrolysis, 121*, 240-257. doi:https://doi.org/10.1016/j.jaap.2016.08.004

Thomas, D., Fernandez, N. B., Mullassery, M. D., & Surya, R. (2020). Iron oxide loaded biochar/polyaniline nanocomposite: Synthesis, characterization and electrochemical analysis. *Inorganic Chemistry Communications, 119*, 108097. doi:https://doi.org/10.1016/j.inoche.2020.108097

Thulaja, N. R. (2016). Watermelon. *Singapore Infopedia*.

Titirici, M.-M., White, R. J., Brun, N., Budarin, V. L., Su, D. S., del Monte, F., et al. (2015). Sustainable carbon materials. *Chemical Society Reviews, 44*(1), 250-290.

Tomczyk, A., Sokołowska, Z., & Boguta, P. (2020). Biochar physicochemical properties: pyrolysis temperature and feedstock kind effects. *Reviews in Environmental Science and Bio/Technology, 19*(1), 191-215. doi:10.1007/s11157-020-09523-3

Trakal, L., Veselská, V., Šafařík, I., Vítková, M., Číhalová, S., & Komárek, M. (2016). Lead and cadmium sorption mechanisms on magnetically modified biochars. *Bioresource Technology, 203*, 318-324. doi:https://doi.org/10.1016/j.biortech.2015.12.056

Tripathi, M., Bhatnagar, A., Mubarak, N. M., Sahu, J. N., & Ganesan, P. (2020). RSM optimization of microwave pyrolysis parameters to produce OPS char with high yield and large BET surface area. *Fuel, 277*, 118184. doi:https://doi.org/10.1016/j.fuel.2020.118184

Tripathi, M., Sahu, J. N., & Ganesan, P. (2016). Effect of process parameters on production of biochar from biomass waste through pyrolysis: A review. *Renewable and Sustainable Energy Reviews, 55*, 467-481. doi:https://doi.org/10.1016/j.rser.2015.10.122

Tsai, W.-Y., Lin, R., Murali, S., Li Zhang, L., McDonough, J. K., Ruoff, R. S., et al. (2013). Outstanding performance of activated graphene based supercapacitors in ionic liquid electrolyte from −50 to 80°C. *Nano Energy, 2*(3), 403-411. doi:https://doi.org/10.1016/j.nanoen.2012.11.006

Uchimiya, M., Wartelle, L. H., Klasson, K. T., Fortier, C. A., & Lima, I. M. (2011). Influence of Pyrolysis Temperature on Biochar Property and Function as a Heavy Metal Sorbent in Soil. *Journal of Agricultural and Food Chemistry, 59*(6), 2501-2510. doi:10.1021/jf104206c

Uetani, K., Ata, S., Tomonoh, S., Yamada, T., Yumura, M., & Hata, K. (2014). Elastomeric thermal interface materials with high through-plane thermal conductivity from carbon fiber fillers vertically aligned by electrostatic flocking. *Advanced Materials, 26*(33), 5857-5862.

Üner, O., Geçgel, Ü., & Bayrak, Y. (2016). Adsorption of Methylene Blue by an Efficient Activated Carbon Prepared from Citrullus lanatus Rind: Kinetic, Isotherm, Thermodynamic, and Mechanism Analysis. *Water, Air, & Soil Pollution, 227*(7), 247. doi:10.1007/s11270-016-2949-1

Uzzaman, T., Zawar, S., Ansar, M. T., Ramay, S. M., Mahmood, A., & Atiq, S. (2021). Electrochemical performance of NiFe2O4 nanostructures incorporating activated carbon as an efficient electrode material. *Ceramics International, 47*(8), 10733-10741.

Vermisoglou, E. C., Devlin, E., Giannakopoulou, T., Romanos, G., Boukos, N., Psycharis, V., et al. (2014). Reduced graphene oxide/iron carbide nanocomposites for magnetic and supercapacitor applications. *Journal of Alloys and Compounds, 590*, 102-109. doi:https://doi.org/10.1016/j.jallcom.2013.11.087

Vivekanandhan, S. (2018). Biochar supercapacitors: recent developments in the materials and methods. *Green and Sustainable Advanced Materials: Applications, 2*, 223-249.

Vlad, A., & Balducci, A. (2017). Porous materials get energized. *Nature Materials, 16*(2), 161-162. doi:10.1038/nmat4851

Wahid, M., Puthusseri, D., Phase, D., & Ogale, S. (2014). Enhanced capacitance retention in a supercapacitor made of carbon from sugarcane bagasse by hydrothermal pretreatment. *Energy & Fuels, 28*(6), 4233-4240.

Wan, C., Jiao, Y., & Li, J. (2016). Core–shell composite of wood-derived biochar supported MnO_2 nanosheets for supercapacitor applications. *RSC Advances, 6*(69), 64811-64817.

Wan, C., & Li, J. (2016). Wood-derived biochar supported polypyrrole nanoparticles as a free-standing supercapacitor electrode. *RSC Advances, 6*(89), 86006-86011.

Wan, M. (2008). *Conducting polymers with micro or nanometer structure*: Springer.

Wang, B., Gao, B., & Fang, J. (2017a). Recent advances in engineered biochar productions and applications. *Critical reviews in environmental science and technology, 47*(22), 2158-2207.

Wang, C., Wu, D., Wang, H., Gao, Z., Xu, F., & Jiang, K. (2018a). A green and scalable route to yield porous carbon sheets from biomass for supercapacitors with high capacity. *Journal of Materials Chemistry A, 6*(3), 1244-1254. doi:10.1039/C7TA07579K

Wang, F., Liu, Y., Zhao, Y., Wang, Y., Wang, Z., Zhang, W., et al. (2018b). Facile synthesis of two-dimensional porous $MgCo_2O_4$ nanosheets as anode for lithium-ion batteries. *Applied Sciences, 8*(1), 22.

Wang, H., Gao, B., Wang, S., Fang, J., Xue, Y., & Yang, K. (2015a). Removal of Pb(II), Cu(II), and Cd(II) from aqueous solutions by biochar derived from KMnO4 treated hickory wood. *Bioresource Technology, 197*, 356-362. doi:https://doi.org/10.1016/j.biortech.2015.08.132

Wang, H., Lin, J., & Shen, Z. X. (2016). Polyaniline (PANi) based electrode materials for energy storage and conversion. *Journal of science: Advanced materials and devices, 1*(3), 225-255.

Wang, H., Ma, G., Tong, Y., & Yang, Z. (2018c). Biomass carbon/polyaniline composite and WO_3 nanowire-based asymmetric supercapacitor with superior performance. *Ionics, 24*(10), 3123-3131.

Wang, H., Zhao, W., Chen, Y., & Li, Y. (2020a). Nickel aluminum layered double oxides modified magnetic biochar from waste corncob for efficient removal of acridine orange. *Bioresource Technology, 315*, 123834. doi:https://doi.org/10.1016/j.biortech.2020.123834

Wang, J.-R., Wan, F., Lü, Q.-F., Chen, F., & Lin, Q. (2018d). Self-nitrogen-doped porous biochar derived from kapok (Ceiba insignis) fibers: Effect of pyrolysis temperature and high electrochemical performance. *Journal of Materials Science & Technology, 34*(10), 1959-1968. doi:https://doi.org/10.1016/j.jmst.2018.01.005

Wang, J., & Wang, S. (2019). Preparation, modification and environmental application of biochar: A review. *Journal of Cleaner Production, 227*, 1002-1022. doi:https://doi.org/10.1016/j.jclepro.2019.04.282

Wang, K., Wu, H., Meng, Y., & Wei, Z. (2014a). Conducting polymer nanowire arrays for high performance supercapacitors. *Small, 10*(1), 14-31.

Wang, M., & Feng, Z. (2021). Interfacial processes in electrochemical energy systems. *Chemical Communications, 57*(81), 10453-10468. doi:10.1039/D1CC01703A

Wang, M., Wang, W., Wang, W., & Guo, X. (2014b). Synthesis of partially graphitic nanoflake-like carbon/Fe 3 O 4 magnetic composites from chitosan as high-performance electrode materials in supercapacitors. *RSC Advances, 4*(75), 39625-39633.

Wang, M., Zhang, J., Wang, Y., & Lu, Y. (2021). Material and structural design of microsupercapacitors. *Journal of Solid State Electrochemistry*, 1-22.

Wang, P., Zhang, Y., Jiang, H., Dong, X., & Meng, C. (2022). Ammonium vanadium oxide framework with stable NH^{4+} aqueous storage for flexible quasi-solid-state supercapacitor. *Chemical Engineering Journal, 427*, 131548. doi:https://doi.org/10.1016/j.cej.2021.131548

Wang, Q., Zhang, Y., Xiao, J., Jiang, H., Hu, T., & Meng, C. (2019). Copper oxide/cuprous oxide/hierarchical porous biomass-derived carbon hybrid composites for high-performance supercapacitor electrode. *Journal of Alloys and Compounds, 782*, 1103-1113. doi:https://doi.org/10.1016/j.jallcom.2018.12.235

Wang, S., Gao, B., Li, Y., Mosa, A., Zimmerman, A. R., Ma, L. Q., et al. (2015b). Manganese oxide-modified biochars: Preparation, characterization, and sorption of arsenate and lead. *Bioresource Technology, 181*, 13-17. doi:https://doi.org/10.1016/j.biortech.2015.01.044

Wang, S., Gao, B., Zimmerman, A. R., Li, Y., Ma, L., Harris, W. G., et al. (2015c). Removal of arsenic by magnetic biochar prepared from pinewood and natural hematite. *Bioresource Technology, 175*, 391-395.

Wang, X., Gu, L., Zhou, P., Zhu, N., Li, C., Tao, H., et al. (2017b). Pyrolytic temperature dependent conversion of sewage sludge to carbon catalyst and their performance in persulfate degradation of 2-Naphthol. *Chemical Engineering Journal, 324*, 203-215.

Wang, X., Zeng, X., & Cao, D. (2018e). Biomass-derived nitrogen-doped porous carbons (NPC) and NPC/polyaniline composites as high performance supercapacitor materials. *Engineered Science, 1*(50), 55-63.

Wang, Y., Zhang, Y., Pei, L., Ying, D., Xu, X., Zhao, L., et al. (2017c). Converting Ni-loaded biochars into supercapacitors: Implication on the reuse of exhausted carbonaceous sorbents. *Scientific reports, 7*(1), 1-8.

Wang, Z., Liu, Y., Li, K., Liu, D., Yang, T., Wang, J., et al. (2017d). The influence and mechanism of different acid treatment to activated carbon used as air-breathing cathode catalyst of microbial fuel cell. *Electrochimica Acta, 246*, 830-840. doi:https://doi.org/10.1016/j.electacta.2017.05.086

Wang, Z., Zhang, X., Li, Y., Liu, Z., & Hao, Z. (2013). Synthesis of graphene–$NiFe_2O_4$ nanocomposites and their electrochemical capacitive behavior. *Journal of Materials Chemistry A, 1*(21), 6393-6399. doi:10.1039/C3TA10433H

Wang, Z., Zhang, X., Liu, X., Zhang, Y., Zhao, W., Li, Y., et al. (2020b). High specific surface area bimodal porous carbon derived from biomass reed flowers for high performance lithium-sulfur batteries. *Journal of colloid and interface science, 569*, 22-33.

Wayu, M. (2021). Manganese Oxide Carbon-Based Nanocomposite in Energy Storage Applications. *Solids, 2*(2), 232-248. Retrieved from https://www.mdpi.com/2673-6497/2/2/15

Weber, K., & Quicker, P. (2018). Properties of biochar. *Fuel, 217*, 240-261.

Wesley, R. J., Durairaj, A., Ramanathan, S., Obadiah, A., Justinabraham, R., Lv, X., et al. (2021). Potato peels biochar composite with Copper phthalocyanine for energy storage application. *Diamond and Related Materials, 115*, 108360.

Wu, C., Yang, S., Cai, J., Zhang, Q., Zhu, Y., & Zhang, K. (2016). Activated microporous carbon derived from almond shells for high energy density asymmetric supercapacitors. *ACS Applied Materials & Interfaces, 8*(24), 15288-15296.

Wu, H., Lin, J., Mou, J., Zheng, Q., & Lin, D. (2017a). A sustainable hierarchical carbon derived from cultivated fibroid fungus for high performance lithium–sulfur batteries. *RSC Advances, 7*(75), 47407-47415. doi:10.1039/C7RA08501J

Wu, X., Fan, L., Wang, M., Cheng, J., Wu, H., Guan, B., et al. (2017b). Long-life lithium–sulfur battery derived from nori-based nitrogen and oxygen dual-doped 3D hierarchical biochar. *ACS Applied Materials & Interfaces, 9*(22), 18889-18896.

Xia, G., Li, X., He, J., Wang, Y., Gu, Y., Liu, L., et al. (2021). A biomass-derived biochar-supported NiS/C anode material for lithium-ion batteries. *Ceramics International, 47*(15), 20948-20955.

Xia, P., Chen, F., Lei, W., Pan, Y., & Ma, Z. (2020). Long cycle performance folium cycas biochar/S composite material for lithium-sulfur batteries. *Ionics, 26*(1), 183-189.

Xia, Y., Mathis, T. S., Zhao, M.-Q., Anasori, B., Dang, A., Zhou, Z., et al. (2018). Thickness-independent capacitance of vertically aligned liquid-crystalline MXenes. *Nature, 557*(7705), 409-412.

Xiang, H., Deng, N., Zhao, H., Wang, X., Wei, L., Wang, M., et al. (2021). A review on electronically conducting polymers for lithium-sulfur battery and lithium-selenium battery: Progress and prospects. *Journal of Energy Chemistry, 58*, 523-556.

Xie, K., Zhang, M., Yang, Y., Zhao, L., & Qi, W. (2018). Synthesis and Supercapacitor Performance of Polyaniline/Nitrogen-Doped Ordered Mesoporous Carbon Composites. *Nanoscale Research Letters, 13*(1), 163. doi:10.1186/s11671-018-2577-3

Xiong, W., Liu, M., Gan, L., Lv, Y., Li, Y., Yang, L., et al. (2011). A novel synthesis of mesoporous carbon microspheres for supercapacitor electrodes. *Journal of Power Sources, 196*(23), 10461-10464. doi:https://doi.org/10.1016/j.jpowsour.2011.07.083

Xiu, S., Shahbazi, A., & Li, R. (2017). Characterization, modification and application of biochar for energy storage and catalysis: a review. *Trends in renewable energy, 3*(1), 86-101.

Xu, D., Zhao, Y., Sun, K., Gao, B., Wang, Z., Jin, J., et al. (2014). Cadmium adsorption on plant-and manure-derived biochar and biochar-amended sandy soils: impact of bulk and surface properties. *Chemosphere, 111*, 320-326.

Xu, G., Yuan, J., Tao, X., Ding, B., Dou, H., Yan, X., et al. (2015). Absorption mechanism of carbon-nanotube paper-titanium dioxide as a multifunctional barrier material for lithium-sulfur batteries. *Nano Research, 8*(9), 3066-3074.

Xu, T., Li, X., Liang, Z., Amar, V. S., Huang, R., Shende, R. V., et al. (2020). Carbon nanofibrous sponge made from hydrothermally generated biochar and electrospun polymer nanofibers. *Advanced Fiber Materials, 2*(2), 74-84.

Xu, X., Sielicki, K., Min, J., Li, J., Hao, C., Wen, X., et al. (2022). One-step converting biowaste wolfberry fruits into hierarchical porous carbon and its application for high-performance supercapacitors. *Renewable Energy, 185*, 187-195. doi:https://doi.org/10.1016/j.renene.2021.12.040

Xue, M., Lu, W., Chen, C., Tan, Y., Li, B., & Zhang, C. (2019). Optimized synthesis of banana peel derived porous carbon and its application in lithium sulfur batteries. *Materials Research Bulletin, 112*, 269-280.

Yaashikaa, P. R., Kumar, P. S., Varjani, S., & Saravanan, A. (2020). A critical review on the biochar production techniques, characterization, stability and applications for circular bioeconomy. *Biotechnology Reports, 28*, e00570. doi:https://doi.org/10.1016/j.btre.2020.e00570

Yahya, M. A., Al-Qodah, Z., & Ngah, C. W. Z. (2015). Agricultural bio-waste materials as potential sustainable precursors used for activated carbon production: A review. *Renewable and sustainable energy reviews, 46*, 218-235. doi:https://doi.org/10.1016/j.rser.2015.02.051

Yakout, S. M., Daifullah, A. E. H. M., & El-Reefy, S. A. (2015). Pore structure characterization of chemically modified biochar derived from rice straw. *Environ. Eng. Manag. J., 14*(2), 473-480.

Yan, J., Fang, Y.-Y., Wang, S.-W., Wu, S.-D., Wang, L.-X., Zhang, Y., et al. (2020). Nitrogen-doped oxygen-rich activated carbon derived from Longan shell for supercapacitors. *Int. J. Electrochem. Sci, 15*(1982.10), 20964.

Yan, L., Wang, H., Huang, D., & Luo, H. (2018). Electrodes with high conductivities for high performance lithium/sodium ion batteries. *Engineered Science, 1*(27), 4-20.

Yang, D., & Ionescu, M. (2017). Metal Oxide–Carbon Hybrid Materials for Application in Supercapacitors. In (pp. 193-218).

Yang, G., & Park, S.-J. (2018). MnO_2 and biomass-derived 3D porous carbon composites electrodes for high performance supercapacitor applications. *Journal of Alloys and Compounds, 741*, 360-367. doi:https://doi.org/10.1016/j.jallcom.2018.01.108

Yang, K., Gao, Q., Tan, Y., Tian, W., Qian, W., Zhu, L., et al. (2016). Biomass-Derived Porous Carbon with Micropores and Small Mesopores for High-Performance Lithium–Sulfur Batteries. *Chemistry–A European Journal, 22*(10), 3239-3244.

Yang, M., Kim, D. S., Hong, S. B., Sim, J.-W., Kim, J., Kim, S.-S., et al. (2017). MnO_2 nanowire/biomass-derived carbon from hemp stem for high-performance supercapacitors. *Langmuir, 33*(21), 5140-5147.

Yang, S., Wang, S., Liu, X., & Li, L. (2019). Biomass derived interconnected hierarchical micro-meso-macro-porous carbon with ultrahigh capacitance for supercapacitors. *Carbon, 147*, 540-549.

Yang, W., Chen, D., She, Y., Zeng, M., Lin, X., Ang, E. H., et al. (2020). Rational design of vanadium chalcogenides for sodium-ion batteries. *Journal of Power Sources, 478*, 228769.

Yang, X., Cheng, C., Wang, Y., Qiu, L., & Li, D. (2013). Liquid-mediated dense integration of graphene materials for compact capacitive energy storage. *Science, 341*(6145), 534-537.

Ye, Z.-G. (2008). *Handbook of advanced dielectric, piezoelectric and ferroelectric materials: Synthesis, properties and applications*: Elsevier.

Yeboah, M. L., Li, X., & Zhou, S. (2020). Facile fabrication of biochar from palm kernel shell waste and its novel application to magnesium-based materials for hydrogen storage. *Materials, 13*(3), 625.

Yesuraj, J., Elumalai, V., Bhagavathiachari, M., Samuel, A. S., Elaiyappillai, E., & Johnson, P. M. (2017). A facile sonochemical assisted synthesis of α-$MnMoO_4$/PANI nanocomposite electrode for supercapacitor applications. *Journal of Electroanalytical Chemistry, 797*, 78-88.

Yi, Y., Huang, Z., Lu, B., Xian, J., Tsang, E. P., Cheng, W., et al. (2020). Magnetic biochar for environmental remediation: A review. *Bioresource Technology, 298*, 122468.

Yin, Z., & Zheng, Q. (2012). Controlled synthesis and energy applications of one-dimensional conducting polymer nanostructures: an overview. *Advanced Energy Materials, 2*(2), 179-218.

Yinghuai, Z., Peng, A. T., Carpenter, K., Maguire, J. A., Hosmane, N. S., & Takagaki, M. (2005). Substituted carborane-appended water-soluble single-wall carbon nanotubes: new approach to boron neutron capture therapy drug delivery. *Journal of the American Chemical Society, 127*(27), 9875-9880.

Yoo, K., Jeon, B. G. & Chun, S. H. . (2016). Quantitative measurements of size-dependent magnetoelectric coupling in Fe_3O_4 nanoparticles. *Nano Lett., 16*, 7408–7413.

Yoshino, A. (2014). Development of the lithium-ion battery and recent technological trends. In *Lithium-ion batteries* (pp. 1-20): Elsevier.

You, Y., Shi, Z., Li, Y., Zhao, Z., He, B., & Cheng, X. (2021). Magnetic cobalt ferrite biochar composite as peroxymonosulfate activator for removal of lomefloxacin hydrochloride. *Separation and Purification Technology, 272*, 118889.

Yu, G., Hu, L., Liu, N., Wang, H., Vosgueritchian, M., Yang, Y., et al. (2011). Enhancing the supercapacitor performance of graphene/MnO_2 nanostructured electrodes by conductive wrapping. *Nano letters, 11*(10), 4438-4442.

Yu, L., & Chen, G. Z. (2020). Supercapatteries as high-performance electrochemical energy storage devices. *Electrochemical Energy Reviews, 3*(2), 271-285.

Yu, S., Liu, D., Zhao, S., Bao, B., Jin, C., Huang, W., et al. (2015). Synthesis of wood derived nitrogen-doped porous carbon–polyaniline composites for supercapacitor electrode materials. *RSC Advances, 5*(39), 30943-30949. doi:10.1039/C5RA01949D

Yuan, L., Lu, X. H., Xiao, X., Zhai, T., Dai, J., Zhang, F., et al. (2011). Flexible Solid-State Supercapacitors Based on Carbon Nanoparticles/MnO_2 Nanorods Hybrid Structure. *Acs Nano, 6*, 656-661.

Yuan, Y., Ding, Y., Wang, C., Xu, F., Lin, Z., Qin, Y., et al. (2016). Multifunctional stiff carbon foam derived from bread. *ACS Applied Materials & Interfaces, 8*(26), 16852-16861.

Zaman, C. Z., Pal, K., Yehye, W. A., Sagadevan, S., Shah, S. T., Adebisi, G. A., et al. (2017). *Pyrolysis: a sustainable way to generate energy from waste* (Vol. 1): IntechOpen Rijeka, Croatia.

Zhang, C., Lv, W., Tao, Y., & Yang, Q.-H. (2015a). Towards superior volumetric performance: design and preparation of novel carbon materials for energy storage. *Energy & Environmental Science, 8*(5), 1390-1403.

Zhang, H., Yu, F., Kang, W., & Shen, Q. (2015b). Encapsulating selenium into macro-/micro-porous biochar-based framework for high-performance lithium-selenium batteries. *Carbon, 95*, 354-363.

Zhang, J., Jiang, J., & Zhao, X. S. (2011a). Synthesis and Capacitive Properties of Manganese Oxide Nanosheets Dispersed on Functionalized Graphene Sheets. *The Journal of Physical Chemistry C, 115*(14), 6448-6454. doi:10.1021/jp200724h

Zhang, J., Liu, J., & Liu, R. (2015c). Effects of pyrolysis temperature and heating time on biochar obtained from the pyrolysis of straw and lignosulfonate. *Bioresource Technology, 176*, 288-291.

Zhang, J., Xiang, J., Dong, Z., Liu, Y., Wu, Y., Xu, C., et al. (2014a). Biomass derived activated carbon with 3D connected architecture for rechargeable lithium−sulfur batteries. *Electrochimica Acta, 116*, 146-151. doi:https://doi.org/10.1016/j.electacta.2013.11.035

Zhang, J., Zhong, Z., Shen, D., Zhao, J., Zhang, H., Yang, M., et al. (2011b). Preparation of bamboo-based activated carbon and its application in direct carbon fuel cells. *Energy & Fuels, 25*(5), 2187-2193.

Zhang, L., Jiang, J., Holm, N., & Chen, F. (2014b). Mini-chunk biochar supercapacitors. *Journal of Applied Electrochemistry, 44*(10), 1145-1151. doi:10.1007/s10800-014-0726-7

Zhang, L., Mohamed, H. H., Dillert, R., & Bahnemann, D. (2012). Kinetics and mechanisms of charge transfer processes in photocatalytic systems: A review. *Journal of Photochemistry and Photobiology C: Photochemistry Reviews, 13*(4), 263-276.

Zhang, M., Jin, X., Wang, L., Sun, M., Tang, Y., Chen, Y., et al. (2017a). Improving biomass-derived carbon by activation with nitrogen and cobalt for supercapacitors and oxygen reduction reaction. *Applied surface science, 411*, 251-260.

Zhang, Q., Huang, J. Q., Zhao, M. Q., Qian, W. Z., & Wei, F. (2011c). Carbon nanotube mass production: principles and processes. *ChemSusChem, 4*(7), 864-889.

Zhang, Q., Wang, J., Lyu, H., Zhao, Q., Jiang, L., & Liu, L. (2019a). Ball-milled biochar for galaxolide removal: Sorption performance and governing mechanisms. *Science of the Total Environment, 659*, 1537-1545. doi:https://doi.org/10.1016/j.scitotenv.2019.01.005

Zhang, S., & Zhao, D. (2017). *Advances in magnetic materials: processing, properties, and performance*: CRC press.

Zhang, S., Zheng, M., Lin, Z., Li, N., Liu, Y., Zhao, B., et al. (2014c). Activated carbon with ultrahigh specific surface area synthesized from natural plant material for lithium–sulfur batteries. *Journal of Materials Chemistry A, 2*(38), 15889-15896.

Zhang, W., Jin, X., Chai, H., Diao, G., & Piao, Y. (2018). 3D Hybrids of Interconnected Porous Carbon Nanosheets/Vertically Aligned Polyaniline Nanowires for High-Performance Supercapacitors. *Advanced Materials Interfaces, 5*(11), 1800106.

Zhang, W., Lin, N., Liu, D., Xu, J., Sha, J., Yin, J., et al. (2017b). Direct carbonization of rice husk to prepare porous carbon for supercapacitor applications. *Energy, 128*, 618-625.

Zhang, X., Wang, Y., Ju, N., Ai, Y., Liu, Y., Liang, J., et al. (2021a). Ultimate Resourcization of Waste: Crab Shell-Derived Biochar for Antimony Removal and Sequential Utilization as an Anode for a Li-Ion Battery. *ACS Sustainable Chemistry & Engineering, 9*(26), 8813-8823. doi:10.1021/acssuschemeng.1c01851

Zhang, X., Wang, Z., Dang, G., Zhang, D., Zhou, D., Fan, Y., et al. (2019b). Mesoporous biochar derived from silkworm excrement for high-performance supercapacitors. *Int. J. Electrochem. Sci, 14*, 8793-8804.

Zhang, Y., Ichihashi, T., Landree, E., Nihey, F., & Iijima, S. (1999). Heterostructures of single-walled carbon nanotubes and carbide nanorods. *Science, 285*(5434), 1719-1722.

Zhang, Y., Wang, C., Dong, X., Jiang, H., Hu, T., Meng, C., et al. (2021b). Alkali etching metal silicates derived from bamboo leaves with enhanced electrochemical properties for solid-state hybrid supercapacitors. *Chemical Engineering Journal, 417*, 127964. doi:https://doi.org/10.1016/j.cej.2020.127964

Zhang, Y., Zhang, J. M., Hua, Q., Zhao, Y., Yin, H., Yuan, J., et al. (2019c). Synergistically reinforced capacitive performance from a hierarchically structured composite of polyaniline and cellulose-derived highly porous carbons. *Materials Letters, 244*, 62-65.

Zhao, B., O'Connor, D., Zhang, J., Peng, T., Shen, Z., Tsang, D. C., et al. (2018). Effect of pyrolysis temperature, heating rate, and residence time on rapeseed stem derived biochar. *Journal of Cleaner Production, 174*, 977-987.

Zhao, D., Zhang, Y., & Essene, E. J. (2015a). Electron probe microanalysis and microscopy: Principles and applications in characterization of mineral inclusions in chromite from diamond deposit. *Ore Geology Reviews, 65*, 733-748.

Zhao, H., Wu, Q., Hu, S., Xu, H., & Rasmussen, C. N. (2015b). Review of energy storage system for wind power integration support. *Applied Energy, 137*, 545-553. doi:https://doi.org/10.1016/j.apenergy.2014.04.103

Zhao, M., Tan, L., Zhang, W., Ji, M., Liu, Y., & Yu, L. (2010). Decomposing the influencing factors of industrial carbon emissions in Shanghai using the LMDI method. *Energy, 35*(6), 2505-2510.

Zhao, S.-X., Ta, N., & Wang, X.-D. (2017a). Effect of temperature on the structural and physicochemical properties of biochar with apple tree branches as feedstock material. *Energies, 10*(9), 1293.

Zhao, Y.-Q., Lu, M., Tao, P.-Y., Zhang, Y.-J., Gong, X.-T., Yang, Z., et al. (2016). Hierarchically porous and heteroatom doped carbon derived from tobacco rods for supercapacitors. *Journal of Power Sources, 307*, 391-400.

Zhao, Y., Cui, Y., Shi, J., Liu, W., Shi, Z., Chen, S., et al. (2017b). Two-dimensional biomass-derived carbon nanosheets and MnO/carbon electrodes for high-performance Li-ion capacitors. *Journal of Materials Chemistry A, 5*(29), 15243-15252.

Zhao, Y., Zhang, R., Liu, H., Li, M., Chen, T., Chen, D., et al. (2019a). Green preparation of magnetic biochar for the effective accumulation of Pb (II): Performance and mechanism. *Chemical Engineering Journal, 375*, 122011.

Zhao, Y., Zhang, R., Liu, H., Li, M., Chen, T., Chen, D., et al. (2019b). Green preparation of magnetic biochar for the effective accumulation of Pb(II): Performance and mechanism. *Chemical Engineering Journal, 375*, 122011. doi:https://doi.org/10.1016/j.cej.2019.122011

Zhi, M., Xiang, C., Li, J., Li, M., & Wu, N. (2013). Nanostructured carbon–metal oxide composite electrodes for supercapacitors: a review. *Nanoscale, 5*(1), 72-88. doi:10.1039/C2NR32040A

Zhong, K., Li, M., Yang, Y., Zhang, H., Zhang, B., Tang, J., et al. (2019). Nitrogen-doped biochar derived from watermelon rind as oxygen reduction catalyst in air cathode microbial fuel cells. *Applied Energy, 242*, 516-525. doi:https://doi.org/10.1016/j.apenergy.2019.03.050

Zhou, G., Yang, Q., Guo, X., Chen, Y., Yang, Q., Xu, L., et al. (2018). Coupling molybdenum carbide nanoparticles with N-doped carbon nanosheets as a high-efficiency electrocatalyst for hydrogen evolution reaction. *International Journal of Hydrogen Energy, 43*(19), 9326-9333. doi:https://doi.org/10.1016/j.ijhydene.2018.04.002

Zhou, J., Sheng, Z., Han, H., Zou, M., & Li, C. (2012a). Facile synthesis of fluorescent carbon dots using watermelon peel as a carbon source. *Materials Letters, 66*(1), 222-224. doi:https://doi.org/10.1016/j.matlet.2011.08.081

Zhou, L., Huang, Y., Qiu, W., Sun, Z., Liu, Z., & Song, Z. (2017). Adsorption Properties of Nano-MnO2–Biochar Composites for Copper in Aqueous Solution. *Molecules, 22*(1), 173. Retrieved from https://www.mdpi.com/1420-3049/22/1/173

zhou, X., Li, L., Dong, S., Chen, X., Han, P., Xu, H., et al. (2012b). A renewable bamboo carbon/polyaniline composite for a high-performance supercapacitor electrode material. *Journal of Solid State Electrochemistry, 16*(3), 877-882. doi:10.1007/s10008-011-1435-3

Zhu, Y., Gao, S., & Hosmane, N. (2018). 2.2 Carbonaceous Materials. In I. Dincer (Ed.), *Comprehensive Energy Systems* (pp. 40-71). Oxford: Elsevier.

Zhu, Y., Gao, T., Fan, X., Han, F., & Wang, C. (2017). Electrochemical techniques for intercalation electrode materials in rechargeable batteries. *Accounts of chemical research, 50*(4), 1022-1031.

Zhu, Z., Hu, Y., Jiang, H., & Li, C. (2014). A three-dimensional ordered mesoporous carbon/carbon nanotubes nanocomposites for supercapacitors. *Journal of Power Sources, 246*, 402-408. doi:https://doi.org/10.1016/j.jpowsour.2013.07.086

Zornoza, R., Moreno-Barriga, F., Acosta, J., Muñoz, M., & Faz, A. (2016). Stability, nutrient availability and hydrophobicity of biochars derived from manure, crop residues, and municipal solid waste for their use as soil amendments. *Chemosphere, 144*, 122-130.

Zou, C., Zhang, L., Hu, X., Wang, Z., Wik, T., & Pecht, M. (2018a). A review of fractional-order techniques applied to lithium-ion batteries, lead-acid batteries, and supercapacitors. *Journal of Power Sources, 390*, 286-296.

Zou, R., Quan, H., Wang, W., Gao, W., Dong, Y., & Chen, D. (2018b). Porous carbon with interpenetrating framework from Osmanthus flower as electrode materials for high-performance supercapacitor. *Journal of Environmental Chemical Engineering, 6*(1), 258-265.

LIST OF PUBLICATIONS

Journal with Impact Factor

1	**Omar, N.,** Abdullah, E.C., Petrus, A.A. *et al.* Single-route synthesis of binary metal oxide loaded coconut shell and watermelon rind biochar: Characterizations and cyclic voltammetry analysis. *Biomass Conv. Bioref.* (2021). https://doi.org/10.1007/s13399-021-01367-3	**Q2, IF: 4.987**
2	**Omar, N**., Abdullah. E.C., Arshid, N., Mubarak, N.M., Khalid, M., Aid, S.R., and Agudosi, E.S. (2022). Facile synthesis of a binary composite from watermelon rind using response surface methodology for supercapacitor electrode material. *Journal of Energy Storage,45* https://doi.org/10.1016/j.est.2022.104147	**Q1, IF: 6.583**
3	**Omar, N**., Abdullah. E.C., Arshid, N., Mubarak, N.M., Khalid, M., Aid, S.R., and Agudosi, E.S. (2022). Recent Development of Biochar-based nanocomposites for Electrochemical Energy Storage Application. *Journal of Energy Storage* (Under review)	**-**
4	Agudosi, E. S., Abdullah, E. C., Numan, A., Mubarak, N. M., Khalid, M., & **Omar, N.** (2020a). A Review of the Graphene Synthesis Routes and its Applications in Electrochemical Energy Storage. *Critical Reviews in Solid State and Materials Sciences*, 45(5), 339-377. https://doi.org/10.1080/10408436.2019.1632793	**Q1, IF: 8.344**
5	Agudosi, E. S., Abdullah, E. C., Numan, A., Mubarak, N. M., Aid, S. R., Benages-Vilau, R., Gómez-Romero, P., Khalid, M., & **Omar, N.** (2020b). Fabrication of 3D binder-free graphene NiO electrode for highly stable supercapattery. *Scientific Reports,* 10(1), 11214. https://doi.org/10.1038/s41598-020-68067-2	**Q1, IF: 4.011**
6	Agudosi, E. S., Abdullah, E. C., Numan, A., Khalid, M., Mubarak, N. M., Aid, S. R., & **Omar, N.** (2021). Optimising the fabrication of 3D binder-free graphene electrode for electrochemical energy storage application. *Surface and Coatings Technology,* (413), 127080 https://doi.org/10.1016/j.surfcoat.2021.127080	**Q1, IF: 4.158**

7	Agudosi, E. S., Abdullah, E. C., Numan, A., Khalid, M., Mubarak, N. M., Benages-Vilau, R., Gómez-Romero, P., Aid, S. R & **Omar, N.** (2021) Optimisation of NiO electrodeposition on 3D graphene electrode for electrochemical energy storage using response surface methodology. *Journal of Electroanalytical Chemistry*, (482) https://doi.org/10.1016/j.jelechem.2021.114992	**Q1, IF: 4.46**