ONE-STEP SYNTHESIS AND ADSORPTIVE CHARACTERISTICS OF COMPOSITE MAGNETIC ACTIVATED CARBON FOR RHODAMINE B REMOVAL

LEE LIN ZHI

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

School of Chemical and Energy Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

DECEMBER 2019

DEDICATION

This thesis is dedicated to my beloved parents and husband, for their love, endless support and encouragement.

ACKNOWLEDGEMENT

First and foremost, I would like to express my very deep gratitude to Dr. Muhammad Abbas Ahmad Zaini, my supervisor. The supervision, advice and encourage that he gave truly help the progression and smoothness of this project to meet the objectives. His willingness to give his time so generously are much indeed appreciated. This thesis would not have been possible without his guidance and support.

In addition, my sincere thanks are extended to my parents and husband as well as all my family members. Their concerns and support had motivated me to complete this project within the time.

I wish to express my appreciation to colleagues and other relevant parties who have, directly and indirectly, contributed towards the completion of this project.

Last but not least, deepest thankful is expressed to Universiti Teknologi Malaysia for the support of UTM Zamalah scholarship.

ABSTRACT

Most of adsorption research has been carried out with dyes since their existence affects not only the quality of water but also changes the aquatic ecosystems as well as reduces the light penetration. Fine activated carbons are effective in dye adsorption, but they are extremely difficult to be separated from the solution when the carbons become exhausted. Magnetic activated carbon (MAC) has an advantage for the separation of spent activated carbon due to its excellent magnetic properties. However, complicated and multiple steps in the preparation process, and smaller adsorption capacity as compared to conventional activated carbon are the significant drawbacks of magnetic activated carbon. A simple synthesis method which simultaneously involves the activation and magnetization in a single step was introduced. This work was aimed at evaluating the adsorptive properties of composite magnetic activated carbons prepared from palm kernel shell. The activated carbons were prepared at various impregnation ratios of $ZnCl_2$ and $FeCl_3$, activation temperatures ranging between 300 and 800^oC and times of 1 to 3 h. ZMAC-2.5 prepared at 600^oC and 2 h with impregnation ratios of $ZnCl_2$:$FeCl_3$:PKS = 1.5:1.0:1.0, which has BET surface area of 1775 m^2/g and mesoporosity of 93.8 % endowed a higher rhodamine B (RB) adsorption of 371 mg/g. For the purpose of comparison, MACs prepared by conventional magnetization methods and non-magnetic activated carbon (ZAC-1.5) were also employed in adsorption studies. MACs were characterized based on proximate analysis, elemental analysis, textural characteristics, chemical properties and magnetic properties. The batch adsorption was evaluated for equilibrium isotherm, kinetics and thermodynamics properties of RB by MACs. Langmuir isotherm model gave the best conformity of equilibrium data indicating a monolayer adsorption of RB onto activated carbons. The kinetics data were fitted better with pseudo-second-order model. The intraparticle diffusion and Boyd models revealed that both film and pore diffusion may be involved in the adsorption process, but none is the sole rate-limiting step. The positive values of enthalpy change and entropy change indicate that the adsorption process is endothermic and spontaneous at high temperature. The activation energy of 24.1 - 28.9 kJ/mol suggested that the adsorption of RB onto ZMAC-2.5 is a physisorption process. In fixed bed adsorption, the effect of initial RB concentration, flow rate and bed height were evaluated. The increase in initial concentration or flow rate, or the decrease in bed height could result in increasing adsorption capacity but decreasing breakthrough time. The column data fitted well with Thomas, Yoon-Nelson and Bohart-Adams models with high coefficient of determination (R^2) and low sum of squared errors (SSE). These models describe that the adsorption process is controlled by the interaction between RB molecules and ZMAC-2.5 surface. In hot water regeneration studies, ZMAC-2.5 showed a higher recovery than ZAC-1.5 for three consecutive regeneration cycles due to its magnetic properties. The optimum conditions were found to be 68.3 ^oC and 1 h to achieve the regeneration efficiency of 36.8 % and recovery of 93.7 %. Magnetic activated carbon showed a great potential to ease the separation of exhausted activated carbon using permanent magnet in wastewater treatment.

ABSTRAK

Kebanyakan kajian penjerapan telah dijalankan dengan pencelup kerana kewujudannya bukan hanya memberi kesan kepada kualiti air, ia juga mengubah ekosistem akuatik serta mengurangkan penembusan cahaya. Karbon teraktif halus berkesan dalam penjerapan pencelup, tetapi sukar dipisahkan daripada larutan apabila karbon menjadi tepu. Karbon teraktif magnet (MAC) mempunyai kelebihan untuk dipisahkan daripada air kerana sifat magnetnya yang sangat baik. Walau bagaimanapun, proses penyediaan yang rumit dan kapasiti penjerapannya yang lebih kecil berbanding karbon teraktif konvensional adalah kelemahan ketara bagi karbon teraktif magnet. Kaedah sintesis mudah yang melibatkan proses pengaktifan dan pemagnetan dalam satu langkah secara serentak telah diperkenalkan. Tujuan kajian ini adalah untuk menilai sifat-sifat penjerapan karbon teraktif magnet komposit yang disediakan daripada kulit isirung sawit. Penyediaan karbon teraktif dengan komposit $ZnCl_2$ dan $FeCl_3$ dilakukan pada pelbagai nisbah penepuan, suhu pengaktifan antara 300 hingga 800°C dan masa pengaktifan antara 1 hingga 3 jam. ZMAC-2.5 yang disediakan pada 600°C selama 2 jam dengan nisbah penepuan $ZnCl_2$:$FeCl_3$:PKS=1.5:1.0:1.0 mempunyai luas permukaan 1775 m^2/g dan mesoporositi 93.8%, juga memberikan kapasiti penjerapan rhodamine B (RB) sebanyak 371 mg/g. Untuk tujuan perbandingan, MACs dengan kaedah pemagnetan lazim dan karbon teraktif bukan magnet (ZAC-1.5) juga disediakan dalam kajian penjerapan. MACs dicirikan berdasarkan analisis anggaran, analisis unsur, ciri-ciri tekstur, sifat-sifat kimia dan sifat-sifat magnet. Penjerapan berkelompok digunakan untuk mengkaji keseimbangan isoterma penjerapan, kinetik dan sifat termodinamik RB pada MACs. Model isoterma Langmuir memberikan pematuhan terbaik data keseimbangan, menunjukkan bahawa kehadiran penjerapan RB bersifat satu lapisan pada karbon teraktif. Data kinetik memberikan penyesuaian terbaik dengan model pseudo-tertib-kedua. Model resapan intrazarah dan model Boyd menunjukkan bahawa kedua-dua resapan filem dan liang mungkin berlaku dalam proses penjerapan, tetapi ia bukan langkah penghad kadar tunggal. Nilai-nilai positif perubahan entalpi dan perubahan entropi menunjukkan bahawa proses penjerapan adalah endotermik dan spontan pada suhu tinggi. Tenaga pengaktifan antara 24.1 hingga 28.9 kJ/mol mencadangkan bahawa penjerapan RB pada ZMAC-2.5 adalah proses penjerapan fizikal. Dalam penjerapan melalui turus lapisan tetap, kesan kepekatan RB awal, kadar alir dan ketinggian lapisan telah dikaji. Peningkatan kepekatan awal atau peningkatan kadar alir, atau penurunan ketinggian lapisan boleh mengakibatkan peningkatan kapasiti penjerapan tetapi menurunkan masa pintasan. Data turus proses penjerapan disesuaikan dengan model Thomas, Yoon-Nelson dan Bohart-Adam dengan pekali penentuan yang tinggi (R^2) dan jumlah ralat sisa kuadrat yang rendah (SSE). Kesesuaian model-model ini menerangkan bahawa proses penjerapan dikawal oleh tindak balas permukaan antara molekul RB dan permukaan ZMAC-2.5. Dalam penjanaan semula karbon teraktif dengan air panas, ZMAC-2.5 menunjukkan perolehan lebih tinggi berbanding dengan ZAC-1.5 bagi tiga kitaran penjanaan semula kerana sifat magnetnya. Keadaan operasi optimum adalah 68.3°C dan 1 jam untuk mencapai kecekapan penjanaan semula sebanyak 36.8% dan perolehan sebanyak 93.7%. Karbon teraktif magnet menunjukkan potensi besar bagi memudahkan pemisahan karbon teraktif tepu dalam rawatan air sisa.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA	-	Activating agent
AC	-	Activated carbon
ANOVA	-	Analysis of variance
BET	-	Brunauer–Emmett–Teller
BTC	-	Breakthrough curve
CAC	-	Commercial activated carbon
CHNOS	-	Carbon, hydrogen, nitrogen, oxygen and sulphur
C.I.	-	Colour Index
DBT	-	Dibenzothiophene
df	-	Degree of freedom
DMF	-	N.N-dimethylformamide
DR	-	Dubinin-Radushkevich
EDTA	-	Ethylenediaminetetraacetic acid
emu	-	Electromagnetic unit
FESEM	-	Field emission scanning electron microscope
FTIR	-	Fourier transform infrared spectroscopy
GAC	-	Granular activated carbon
IR	-	Impregnation ratio
IUPAC	-	International Union of Pure and Applied Chemistry
MAC	-	Magnetic activated carbon
MB	-	Methylene blue
MTZ	-	Mass transfer zone
MW	-	Molecular weight
PAC	-	Powdered activated carbon
pH_{PZC}	-	pH of the point of zero charge
PKS	-	Palm kernel shell

PKS-AC	-	Palm kernel shell based activated carbon
RB	-	Rhodamine B
RE	-	Regeneration efficiency
RP	-	Redlich-Peterson
RSM	-	Response surface methodology
SEM	-	Scanning electron microscope
SSE	-	Sum of squares of the residuals / sum of squared errors
SSR	-	Sum of squares due to regression
SST	-	Total sum of squares
TEM	-	Transmission electron microscope
TGA	-	Thermogravimetric analysis
VSM	-	Vibrating sample magnetometer
XRD	-	X-Ray Diffraction

LIST OF SYMBOLS

A	-	Frequency factor in Arrgenius equation
B	-	Magnetic flux density
b	-	Langmuir adsorption constant
c	-	Intercept to the y-axis
CO	-	Carbon monoxide
CO_2	-	Carbon dioxide
C_{Ae}	-	Amount adsorbed on solid at equilibrium
C_d	-	Desorption concentration in solution
C_e	-	Equilibrium concentration of adsorbate solution
C_o	-	Initial concentration of adsorbate solution
C_r	-	Re-adsorption equilibrium concentration of adsorbate solution
C_t	-	Effluent concentration at time t
D_i	-	Effective diffusion coefficient
d_i	-	Internal diameter of column
D_p	-	Average pore diameter
d_p	-	Particle diameter
E	-	Mean free energy
E_a	-	Activation energy
$FeCl_3$	-	Ferric chloride
Fe^{2+}	-	Ferrous ion
Fe^{3+}	-	Ferric ion
Fe_3O_4	-	Magnetite
H	-	magnetizing force
h	-	Initial adsorption rate
HCl	-	Hydrochloride acid
H_C	-	Coercivity

H_2SO_4	-	Sulfuric acid
K, n	-	Freundlich constants
KOH	-	Potassium hydroxide
K_{ad}	-	Dubinin-Radushkevich isotherm constant
K_{BA}	-	Bohard-Adams rate constant
K_d	-	Distribution coefficient
k_d	-	Rate constant for intraparticle diffusion
K_{NY}	-	Yoon and Nelson rate constant
$K_{R,}$ α_R	-	Redlich-Peterson isotherm constants
K_{TH}	-	Thomas rate constant
k_1	-	Rate constant of pseudo-first-order
k_2	-	Rate constant of pseudo-second-order
K_2CO_3	-	Potassium carbonate
L	-	Column length
m	-	mass
m_T	-	Total mass
M_R	-	Remanence magnetization
M_S	-	Saturation magnetization
$NaHCO_3$	-	Sodium bicarbonate
NaOH	-	Sodium hydroxide
Na_2CO_3	-	Sodium carbonate
N_o	-	Saturation concentration in bed
N_2	-	Nitrogen
Oe	-	Oersted
pH	-	Potential hydrogen
Q	-	Volumetric flow rate
q_d	-	Desorption amount
q_e	-	Equilibrium adsorption capacity
q_m	-	Maximum adsorption capacity

q_o	-	Maximum adsorption capacity in column adsorption
q_r	-	Equilibrium re-adsorption capacity
q_s	-	Dubinin-Radushkevich isotherm saturation capacity
q_T	-	Total bed capacity
q_t	-	Adsorption amount at time t
R	-	Gas constant (8.314 J/mol.K)
r	-	Radius of particle
R^2	-	Correlation coefficient
R_A^2	-	Adjusted correlation coefficient
R_A	-	Adsorbate removal percentage in column adsorption
R_L	-	Separation factor
S	-	Bed cross section area
S_{BET}	-	BET surface area
T	-	Temperature
t	-	time
t_b	-	Breakthrough time
t_E	-	Exhausted time
t_T	-	Total flow time
U_o	-	Superficial velocity
V	-	Volume
V_T	-	Total effluent volume
Z	-	Bed height
$ZnCl_2$	-	Zinc chloride
γ-Fe_2O_3	-	Maghemite
$\triangle G^o$	-	Gibbs energy
$\triangle H^o$	-	Enthalpy
$\triangle S^o$	-	Entropy
ε	-	Polanyi potential
λ_{max}	-	Maximum wavelength

τ	-	Time required for 50% adsorbate breakthrough
$\%_{micro}$	-	Microporosity

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Research Background

Activated carbon is widely used as an adsorbent for adsorption due to its large porous surface area, controlled pore structure and inert properties (See *et al.*, 2015; Lee and Zaini, 2015). Activated carbon can be prepared from a variety of raw materials, especially agricultural by-products such as coconut shells, corn cobs, apricot stone, and so on (Wan *et al.*, 2014; Rocha *et al.*,2015; Albroomi *et al.*, 2017). These products are regarded as waste and can cause a serious disposal problem in some countries. Therefore, converting them into activated carbon is a feasible solution to the environmental problem.

Malaysia is one of the largest exporters of palm oil in the international market, which is expected about 20 million tonnes production of crude palm oil in the year 2017 (Intan, 2017). Besides the production of crude palm oil, a large amount of solid waste such as palm kernel shell is also an output from the palm oil industry. The amount of palm kernel shell generated is approximately 5.61 million annually (Rugayah *et al.*, 2014). The disposal of palm kernel shell contributes to a major economic and environmental issue. So, many research works have been carried out to study the conversion of this waste to activated carbon (Yacob *et al.*, 2009; Abechi *et al.*, 2013b; Ogunsile *et al.*, 2014; Lee and Zaini, 2015; Vincent *et al.*, 2016; Hidayu and Muda, 2016). Palm kernel shell is a promising candidate as the precursor of palm kernel shell because it can be activated into high porosity carbon in short time due to its high lignin content, low cellulose content and less fibrous structure (Lee and Zaini, 2015). In this study, palm kernel shell was used as the precursor of activated carbon.

Fine activated carbons are effective in adsorption of pollutants from water, but they are extremely difficult to be separated from the solution when the carbons become exhausted. The traditional method for separating activated carbon is by filtration, so the filter blockage and the loss of carbon could be the significant regeneration issue, consequently, limiting its application in many fields (Jia *et al.*, 2011). Magnetic separation is considered as a rapid and effective technique for the removal of spent adsorbents from solution. Recently, great attention has been paid on the application of magnetic activated carbon in adsorption of organic pollutants, dyes and heavy metals such as trinitrophenol, methylene blue, arsenic(V) (Mohan *et al.*, 2011; Zhang *et al.*, 2015; Chomehoey *et al.*, 2013). However, the complication of multiple steps process for the preparations of magnetic activated carbon and deterioration in its specific surface area due to the pores blockage by the attachment of magnetic particles are the significant drawbacks that have to be resolved in order to apply magnetic activated carbon in wastewater treatment (Zaini *et al.*, 2017).

Most of the adsorption research has been carried out with organic compounds, including phenolic compounds and dyes, as well as heavy metals. Biodegradation potential of organic compounds is emerging treatment process. However, products of biodegradation are hazardous in some cases, while some organic materials are extremely recalcitrant to biodegradation. Adsorption is a potential technique for the removal of these organic substances from wastewater. Among all organic substances, dye, phenolic compounds and pesticides are highly received attention. Dyes wastewater is very difficult to approach with common methods due to unfavorable in terms of economy and technical since the dyes are recalcitrant molecules, resistant to aerobic digestion and stable to oxidizing agents (Gadd, 2009). Dye is a visible pollutant. Its existence affects not only the quality of surface water but also changes the aquatic ecosystems as well as reduces light penetration. Rhodamine B (RB) is a water-soluble cationic dye which is a common water tracer fluorescent to determine the rate and direction of flow and transport. RB is widely used in research because it has a strong absorption band in the visible region of 554 nm and high stability against pH change (Muhammad, 2014). RB irritates eyes and skin, respiratory as well as gastrointestinal tract (Rochart *et al.*, 1978). In this study, RB used as the specific adsorbate.

Batch adsorption study is usually applied to determine the effectiveness of the activated carbon and its adsorption mechanism by providing the maximum adsorption capacity, isotherm constants as well as kinetic properties. Although batch adsorption study provides useful data and parameters on the application of specific adsorbents for the removal of a specific pollutant, it is not sufficient while designing a treatment system for continuous operation. Therefore, a continuous adsorption study is necessary to be performed using columns and provide information for the industrial-scale (Afroze *et al.*, 2016; Albroomi *et al.*, 2017).

1.2 Problem Statement

Magnetic activated carbons have a great potential to be used in wastewater treatment due to their magnetic properties, which make more effective for the recovery of spent activated carbon from treated water. In recent years, magnetic activated carbons have been widely studied to remove organic and inorganic pollutants from wastewater. However, the preparations of magnetic activated carbon were often complicated which involved multiple steps process. Usually raw materials have to be converted into activated carbon by activation process, then followed by magnetization process including chemical coprecipitation and high-temperature impregnation. The attachment of magnetic particles could lead the blockage of the pores of activated carbon, thereby magnetic activated carbons have the drawbacks of smaller adsorption capacity compared to activated carbons as reported in previous studies.

A simple synthesis method was suggested which involves the activation and the magnetization process in a single step simultaneously opens up the possibility where the iron serves both as an activating agent and as a magnetic element in the preparation of magnetic activated carbon. However, low dye adsorption performance (22.31 mg/g) was reported since ferric chloride ($FeCl_3$) is not a strong activating agent (Cazetta *et al.*, 2016). According to Zhang *et al.* (2015), composite of magnetite (Fe_3O_4) and potassium carbonate (K_2CO_3) was used as activating agent in preparation of magnetic activated carbon, but lack of information was reported to show the improvement in adsorption performance of magnetic activated carbon. Zinc chloride

($ZnCl_2$) is a strong activating agent and widely used in the preparation of activated carbons for research, while $FeCl_3$ have similar characteristics to $ZnCl_2$ in aqueous solution, which opens up the possibility of using composite of $ZnCl_2$ and $FeCl_3$ as activating agent in the preparation of activated carbon (Rufford *et al.*, 2010). Lee and Zaini (2017) reported that the specific surface area of composite $ZnCl_2$-$FeCl_3$ activated carbon (411 m^2/g) is higher than that of $ZnCl_2$ activated carbon (395 m^2/g) because $FeCl_3$ is also acted as mild activator in preparation of activated carbon.

In this study, composite magnetic activated carbon was prepared from palm kernel shell by one-step synthesis, making the procedure for the preparation of magnetic activated carbon simpler compared to the conventional multiple-step process. Composite of $ZnCl_2$ and $FeCl_3$ was used as the activating agent to minimize the drawbacks of poorer adsorption performance since $ZnCl_2$ can be served as strong activator whereas $FeCl_3$ can be served as magnetic element as well as mild activator. The magnetic activated carbons prepared by conventional magnetization methods and non-magnetic activated carbon (origin of magnetic activated carbon) were also employed for the comparison purpose. The adsorptive characteristics of composite magnetic activated carbon could show the improvement in pore development and adsorption performance without deterioration of magnetic properties in order to evaluate the potential of magnetic activated carbon in dye wastewater treatment.

1.3 Objectives

Four objectives of this research are stated below:

i. To synthesize, optimize and characterize magnetic activated carbons from palm kernel shell by the composite of zinc and ferric chloride salts activation.

ii. To establish the adsorptive properties of rhodamine B removal by activated carbons at different initial concentrations, pH, time intervals and temperatures.

iii. To investigate the effect of bed height, flow rate and initial concentration on column adsorption studies.

iv. To evaluate the regeneration of spent activated carbon using hot water.

1.4 Scope of Study

i. To synthesizes, optimize and characterize magnetic activated carbons from palm kernel shell by the composite of zinc and ferric chloride salts activation.

Palm kernel shell was used as the precursor in the synthesis of magnetic activated carbon. Impregnation was carried out using composites of metals chloride salts as activating agents, which were $ZnCl_2$ and $FeCl_3$ at various impregnation ratios from 1.0 to 2.5. The heating temperature and heating period were varied from 300 to 800 ^oC and 1 to 3 h, respectively. Response surface methodology (RSM) was used to optimize the operating condition for the preparation of activated carbons. Conventional methods for preparation of magnetic activated carbon including chemical coprecipitation and high-temperature impregnation were carried out with optimum impregnation ratio of activating agent.

Activated carbons were characterized based on proximate analysis, elemental analysis, specific surface area, morphology, surface functional group, Boehm titration, magnetic properties and X-Ray diffraction analysis.

ii. To establish the adsorptive properties of pollutant removal by activated carbons at different initial concentrations, pH, time intervals and temperatures.

Rhodamine B was used as the adsorbate model. Four isotherm models which are Langmuir, Freundlich, Redlich-Peterson and Dubinin-Radushkevich were used to fit the adsorption data at initial concentrations from 5 to 800 mg/L. The rate of adsorption for three initial concentrations at time intervals from 0.17 to 72 h was evaluated using the pseudo-first-order equation, pseudo-second order equation, intraparticle diffusion model and Boyd model. The thermodynamics properties, name by Gibbs energy, $\triangle G^o$, enthalpy, $\triangle H^o$ and entropy, $\triangle S^o$ were investigated through the effect of temperature on dye adsorption from 30 to 60 ºC for the best-performed activated carbon.

iii. To investigate the effect of bed height, flow rate and initial concentration on column adsorption studies.

The effect of initial concentration of rhodamine B from 5 t o15 mg/L, flow rate from 16 to 28 mL/min and bed height from 2 to 6 cm were investigated on column adsorption of rhodamine B by the best-performed activated carbon and analysed based on three models, which are Thomas, Yoon-Nelson and Bohart-Adams models.

iv. To evaluate the regeneration of spent activated carbon using hot water.

The regeneration study was performed using hot water at various temperatures and time for three consecutive adsorption-desorption cycles to determine the regeneration efficiency and recovery of the best-performed activated carbon. Response surface methodology (RSM) was used to optimize the operating condition for regeneration.

1.5 Significance of Study

This study is carried out to give a further understanding of the contribution of agricultural waste activated carbon to wastewater treatment. The issues related to palm kernel shell management can be reduced if it is converted into activated carbon. The simplicity of magnetic separation technique makes the suitability of activated carbon for wider applications. This study also proposes an environmentally friendly approach for regeneration method of spent activated carbon.

1.6 Thesis Outline

This thesis composed of five chapters that embody the research works in sequential order. Firstly, Chapter 1 introduces the research background, problem statement, objectives, scopes of study, significance of study as well as thesis outline. Then, Chapter 2 consists of an overview of previous research on activated carbon, magnetic activated carbon, dyes and environment, adsorption, regeneration of activated carbon as well as response surface methodology. Next, Chapter 3 includes all the materials used and covers the procedures and methods involves in this study, which are synthesis, optimization and characterizations of magnetic activated carbons, adsorption studies in batch and column mode as well as approach of regeneration studies. After that, Chapter 4 presents the results and the analyzed experimental data with discussion. Finally, Chapter 5 concludes the findings according to the objectives in this study and provides recommendations for future work.

REFERENCES

Abbas, A., Murtza, S., Munie, M., Zahir, T., Abbas, N. and Mushtaq, A. (2011). Removal of Congo Red from Aqueous Solutions with *Raphanus sativus* Peel Sand Activated Carbon: A Comparative Study. *American- Eurasian Journal of Agricultural and Environmental Science*. 15(5), 802-809.

Abbas, A., Murtaza, S. Shahid, K. Munir, M. Ayub, R. and Akber, S. (2012). Comparative Study of Adsorption Removal of Congo Red and Brilliant Green Dyes from Water Using Peanut Shell. *Middle-East Journal of Scientific Research.* 11(6), 828-832.

Abechi, S. E., Gimba, C. E., Uzairu, A., Kagbu, J. A. and Ocholi, O. J (2013a). Equilibrium Adsorption Studies of Methylene Blue onto Palm Kernel Shell-Based Activated Carbon. *International Refereed Journal of Engineering and Science*. 2(5), 38-45.

Abechi, S. E., Gimba, C. E., Uzairu, A. and Dallatu, Y. A. (2013b). Preparation and Characterization of Activated Carbon from Palm Kernel Shell by Chemical Activation. *Research Journal of Chemical Sciences*. 3(7), 54-61.

Abou-Gamra, Z. M. and Medien, H. A. A. (2013). Kinetic, Thermodynamic and Equilibrium Studies of Rhodamine B Adsorption by Low Cost Biosorbent Sugar Cane Bagasse. *European Chemical Bulletin.* 2(7), 417-422.

Abrahart, E. N. (1977). *Dyes and Their Intermediates*. New York: Chemical Publishing.

Adamczyk, D. and Bezak-Mazur, E. (2012). Regeneration of WD-Extra Activated Carbon Spent on Acid Dyes Adsorption Process by Fenton's Reagent. *Advanced Research in Scientific Areas 2012*. 1(1), 1408-1411.

Afroze, S., Sen, T. K. and Ang, H. M. (2016). Adsorption Performance of Continuous Fixed Bed Column for the Removal of Methylene Blue (MB) Dye Using Eucalyptus Sheathiana Bark Biomass. *Research on Chemical Intermediat*es. 42(3), 2343-2364.

Ahmad, M. A., Puad, N. A. A. and Bello, O. S. (2014). Kinetic, Equilibrium and Thermodynamic Studies of Synthetic Dye Removal Using Pomegranate Peel Activated Carbon Prepared by Microwave-Induced KOH Activation. *Water Resources and Industry*. 6, 18-35.

Ahmad, A., Al-Swaidan, H. M. and Alghamdi, A. H. (2015). Production of Activated Carbon from Raw Date Palm Fronds by $ZnCl_2$ Activation. *Journal of the Chemical Society of Pakistan.* 37(6), 1081-1087.

Akbarzadeh, A., Samiei, M. and Davaran, S. (2012). Magnetic Nanoparyicles: Preparation Physical Properties and Applications in Biomedicine. *Nanoscale Research Letter*. 7(1), 144-156.

Albroomi, H. I., Elsayed, M. A., Baraka, A. and Abdelmaged, M. A. (2017). Batch and Fixed Bed Adsorption of Tartrazine Azo-Dye onto Activated Carbon Prepared from Apricot Stones. Applied Water Science. 7(4), 2063-2074.

Alfaro-Cuevas-Villanueva, R., Hidalgo-Vazquez, A. R., Penagos, C. J. C. and Cortes-Martinez, R. (2014). Thermodynamic, Kinetic, and Equilibrium Parameters for the Removal of Lead and Cadmium from Aqueous Solutions with Calcium Alginate Beads. *The Scientific World Journal*. 2014, 1-9.

Ali, R. M., Hamd, H. A., Hussein, M. M. and Malash, G. F. (2016). Potential of Using Green Adsorbent of Heavy Metal Removal Fromaqueous Solutions: Adsorption Kinetics, Isotherm, Thermodynamic, Mechanism and Economic Analysis. *Ecological Engineering*. 91, 317-332.

Aliabadi, M., Khazaei, I., Hajiabadi, M. and Fazel, S. (2012). Removal of Rhodamine B from Aqueous Solution by Almond Shell Biosorbent. *Journal of Biodiversity and Environmental Sciences.* 2(9), 39-44.

Allen, S. J., Mckay, G. and Porter, J. F. (2004). Adsorption Isotherm Models for Basic Dye Adsorption by Peat in Single and Binary Component System. *Journal of Colloid and Interface Science.* 280, 322-333.

Alslaibi, T. M., Abustan, I., Ahamd, M. A. and Foul, A. A. (2014). Kinetics and Equilibrium Adsorption of Iron (II), Lead (II), and Copper (II) onto Activated Carbon Prepared from Olive Stone Waste. *Desalination and Water Treatment*. 52, 7887-7897.

Alvarez, P. M., Beltran, F. J., Gomez-Serrano, V., Jaramillo, J., Rodriguez, E. M. (2004). Comparison between Thermal and Ozone Regenerations of Spent Activated Carbon Exhausted with Phenol. *Water Research.* 38, 2155-2165.

Amin, A. J. and Murni, M. A. (2011). Torrefaction Of Malaysia Palm Kernel Shell in Value-Added Solid Fuels. *International Journal of Chemical Science and Engineering*. 5(12), 401-404.

Amosa, M. K., Jami, M. S. and Alkhath, M. F. R. (2016). Electrostatic Biosorption of COD, Mn and H_2S on EFB-Based Activated Carbon Produced through Steam Pyrolysis: An Analysis Based on Surface Chemistry, Equilibria and Kinetics. *Waste Biomass Valor*. 7, 109-124.

Angin, D., Altintig, E. and Kose, T. E. (2013). Influence of Process Parameters on the Surface and Chemical Properties of Activated Carbon Obtained from Biochar by Chemical Activation. *Bioresource Technology*. 148, 542-549.

Ania, C. O., Parra, J. B., Menendez, J. A. and Pis, J. J. (2007). Microwave-Assisted Regeneration of Activated Carbons Load with Pharmaceuticals. *Water Research*. 41(15), 3299-3306.

Arivoli, S., Ramuthai, S., Nandhakumar, V., Thiruchelvi, M. and Vikayakumaran, V. (2009). Rhodamine B Adsorption - Kinetic, Mechanistic and Thermodynamic Studies. *E-Journal of Chemistry*. 6(S1), S363-S373.

Asante-Duah, D. K. (1995). *Management of Contaminated Site Problems*. U.S.A.: CRC Press LLC.

ASTM D2867-17 (2017). *Standard Test Methods for Moisture in Activated Carbon*. West Conshohocken: ASTM International.

ASTM D2866-11 (2018), *Standard Test Method for Total Ash Content of Activated Carbon*. West Conshohocken: ASTM International.

Auta, M. (2012). Fixed-Bed Adsorption Studies of Rhodamine B Dye Using Oil Palm Empty Fruits Bunch Activation Carbon. *Journal of Engineering Research and Studies*. 3(3), 3-6.

Azizi, H. A., Yusoff, M. S., Adlan, M. N., Adnan, N. H., Alias, S. (2004). Physico-Chemical Removal of Iron from Semi-Aerobic Landfill Leachate by Limestone Filter. *Waste Management.* 24, 353-358.

Badgujar, N. P. (2014). *Introduction of Dyes*. Unpublished note, Shroff S. R. Rotary Institute of Chemical Tech.

Bagreey, A., Rahman, H. and Bandosz, T. J. (2000). Study of H_2S Adsorption and Water Regeneration of Spent Coconut-Based Activated Carbon. *Environmental Science & Technology*. 34(21), 4587-4592.

Bansal, R. C., Donnet, J. B. and Stoeckli, F. (1988). *Active Carbon*. N. Y.: Marcel Dekker, Inc.

Basu, P. (2010). *Biomass gasification and pyrolysis*. Massachusetts: Academic Press.

Bhatnagar, A. and Jain, A. K. (2005). A Comparative Adsorption Study with Different Industrial Wastes as Adsorbents for the Removal of Cationic Dyes from Water. *Journal of Colloid and Interface Science*. 281, 49-55.

Biswas, S. and Mishra, U. (2015). Continuous Fixed-Bed Column Study and Adsorption Modeling: Removal of Lead Ion from Aqueous Solution by Charcoal Originated from Chemical Carbonization of Rubber Wood Sawdust. *Journal of Chemistry*. 2015, 1-9.

Byrne, C. E. and Nagle, D. C. (1997). Carbonization of Wood for Advanced Materials Applications. *Carbon.* 35(2), 259-266.

Budayari, S. (1989). *The Merck Index Encyclopedia of Chemicals, Drugs and Biologicals*. Rahway, N. J.: Merck and Co., Inc.

Butt, H. J., Graf, K. and Kappl, M. (2003). *Physics and Chemistry of Interfaces*. Weinheim: Wiley-VCH.

Cameron Carbon Inc. (2006). *Activated Carbon Manufacture, Structure and Properties* [Brochure]. USA: Cameron Carbon Inc.

Cantu, Y., Remes, A., Reyna, A., Martiez, D., Villarreal, J., Ramos, H., Trevino, S., Tamez, C., Martinex, A., Eubanks, T and Parsons, J. G. (2014). Thermodynamics, Kinetics, and Activation Energy Studies of The Sorption of Chromium(III) and Chromium(VI) to A Mn_3O_4 Nanomaterial. *Chemical Engineering* Journal. 254, 374-383.

Carmen, Z. and Daniela, S. (2012). *Textile Organic Dyes – Characteristics, Polluting Effects and Separation/Elimination Procedures from Industrial Effluents: A Critical Overview.* In Puzyn, T. (Ed.) *Organic Pollutants Ten Years After the Stockholm Convention – Environment and Analytical Updat*e (pp. 55-86). Europe: In Tech.

Cazetta, A. L., Pezoti, O., Bedin, K. C., Silva, T. L., Junior, A. P., Asefa, T. and Almeida, V. C. (2016). Magnetic Activated Carbon Derived from Biomass Waste by Concurrent Synthesis: Efficient Adsorbent for Toxic Dyes. *American Chemical Society Sustainable Chemistry Engineering.* 4, 1058-1068.

Ceyhan, A. A., Sahin, Ö., Baytar, O. and Saka, C. (2013a). Surface and Porous Characterization of Activated Carbon Prepared from Pyrolysis of Biomass by Two-Stage Procedure at Low Activation Temperature and Its the Adsorption of Iodine. *Journal of Analytical and Applied Pyrolysis.* 104, 378-383.

Ceyhan, A. A., Sahin, Ö., Saka, C. and Yalcin, A. (2013b). A Novel Thermal Process for Activated Carbon Production from the Vetch Biomass with Air at Low Temperature by Two-Stage Procedure. *Journal of Analytical and Applied Pyrolysis*. 104, 170-175.

Chiang, H. L. and Chiang, P. (2000). *Physicochemical Characteristics of Ozonation Activated Carbon*. In Do, D. D. (Ed.) *Adsorption Science and Technology*. (pp. 135-139). Singapore: World Scientific Publishing.

Chomehoey, N., Bhongsuwan, G. and Bhongsuwan, T. (2013). Arsenic Removal from Synthesis Wastewater by Activated Carbon-Magnetic Nanoparticles Composite. *ASEAN++ 2013 Moving Forward: The 11th International Conference on Mining, Materials and Petroleum Engineering, The 7th International Conference on Earth Resource Technology*. 11-13, November. Chiang Mai, 10-14.

Cong, Y. Q. and Wu, Z. C. (2007). Self-Regeneration of Activated Carbon Modified with Palladium Catalyst for Electrochemical Dechlorination. *Chinese Chemical Letters*. 18(8), 1013-1016.

Cornell, J. A. (1990). *Volume 8: How to Apply Response Surface Methodology*. Wisconsin: American Society for Quality.

Ćurković, L., Čan-Mioč, A. R., Majić, M. and Župan J. (2011). Application of Different Isotherm Models on Lead Ions Sorption onto Electric Furnace Slag. *The Holistic Approach to Environment 1*. 1, 13-18.

Dada, A. O., Olalekan, A. P., Olatunya, A. M. and Dada, O. (2012). Langmuir, Freundlich, Temkin and Dubinin-Radushkevich Isotherms Studies of Equilibrium Sorption of Zn^{2+}onto Phosphoric Acid Modified Rice Husk. *Journal of Applied Chemistry*. 3(1), 38-45.

Dahri, M. K., Kooh, M. R. R. and Lim, L. B. L. (2016). Remediation of Rhodamine B Dye from Aqueous Solution Using Casuarina equisetifolia Cone Powder as a Low-Cost Adsorbent. *Advances in Physical Chemistry*. 2016, 1-7.

Derbyshier, F., Jagtoyen, M. and Thwaites, M. (1995). *Porosity in carbons*. In Patrick, J. W. (Ed.) *Porosity in Carbons: Characterization and Applications*. (pp. 227). London: Edward Arnold.

Devi, A. S., Kalavathy, M. H. and Miranda, L. R. (2015). Optimization of the Process Parameters for the Preparation of Activated Carbon from Low Cost Phoenix Dactylifera Using Response Surface Methodology. *Austin Chemical Engineering*. 2(2), 1021-1029.

Dhodapkar, R., Rao, N. N., Pande, S. P., Nandy, T. and Devotta, S. (2007). Adsorption of Cationic Dyes on Jalshakti, Super Adsorbent Polymer and Photocatalytic Regeneration of the Adsorbent. *Reactive & Functional Polymers*. 67, 540-548.

Ding, L., Zou, B., Gao, W., Liu, Q., Wang, Z., Guo, Y., Wang, X. and Liu, Y. (2014). Adsorption of Rhodamine-B from Aqueous Solution Using Treated Rice Husk-Based Activated Carbon. *Colloids and Surface A: Physicochemical and Engineering Aspects*. 446, 1-7.

Dire, D. J. and Wilkinson, J. A. (1987). Acute Exposure to Rhodamine B. *Journal of Toxicology. Clinical Toxicology.* 25(7), 603-607.

Do, M. H., Phan, N. H, Nguyen, T. D., Pham, T. T. S., Nguyen, V. K., Vu, T. T. T. and Nguyen, T. K. P. (2011). Activated Carbon/Fe_3O_4 Nanoparticle Composite: Fabrication, Methyl Orange Removal and Regeneration by Hydrogen Peroxide. *Chemosphere*. 85, 1269-1276.

Dris, S. (2016). *Magnetic Hysteresis* [Lecturer note]. University of California, U. S.

Dubinin, M. M. and Radushkevich, L. V. (1947). Equation of the Characteristic Curve of Activated Charcoal. *Proceedings of the Academy of Sciences of the USSR: Physical Chemistry Section*. 55(1), 331-337.

Edwards, I. A. S., Marsh, H. and Menendez, R. (1989). *Introduction to carbon science*. Oxford: Butterworth-Heinemann.

Elementary (2016). *CHNS Analysis of Coal Samples with the Vario MICRO Cube* [Product Guide]. Hanau, Germery.

El-Naas, M. H. and Alhaijia, M. A. (2011). *Modeling of Adsorption Processes*. In Brennan, C. R. (Ed.) *Mathematical Modelling*. (pp.1-22). New York: Nova Publishers, Inc.

El-Wakil, A. M., Abou El-Maaty, W. M. and Awad, F. S. (2013). Adsorption of Methylene Blue and Rhodamine B from Aqueous Solutions Using Dry or Carbonized Water Hyacinth Plant. *Journal of Applied Sciences Research.* 9(6), 3607-3619.

Emdadi, L. (2013). *Characterizing Porous Materials and Powders N_2 Adsorption Isotherms.* College Park: University of Maryland.

Farah Adilla (2017, May 22) The growing palm oil sector. *New Straits Times*, Retrieved June 12, 2017, from https://www.nst.com.my/news/nation/2017/05/241469/growing-palm-oil-sector

Faulconer, E. K., Reitzenstein, N. H. and Mazyck, D. W. (2012). Optimization of Magnetic Powdered Activated Carbon for Aqueous Hg(II) Removal and Magnetic Recovery. *Journal of Hazardous Materials*. 199-200, 9-14.

Foo, K. Y. and Hameed, B. H. (2010). Insights into the Modeling of Adsorption Isotherm System. *Chemical Engineering Journal*. 156, 2-10.

Fu, K., Yue, Q., Gao, B., Sun, Y. and Zhu, L. (2013). Preparation, Characterization and Application of Lignin-Based Activated Carbon from Black Liquor Lignin by Steam Activation. *Chemical Engineering Journal.* 228, 1074-1082.

Gadd, G. M. (2009). Biosorption: Critical Review of Scientific Rationale, Environmental Importance and Significance for Pollution Treatment. *Journal of Chemical Technology and Biotechnology.* 84(1), 13-28.

Gaines, D. R. E. (1980). Dilution as A Source of Error: Implications for Preparation and Calibration of Laboratory Standards and For Quality Control of Radioimmunoassays. *American Association for Clinical Chemistry*. 26(12), 1726-1729.

Gecgel, U., Uner, O., Gokara, G. and Bayrak, Y. (2016). Adsorption of Cationic Dyes on Activated Carbon Obtained from Waste Elaeagnus Stone. *Adsorption Science and Technology*. 34(9-10), 512-525.

Ghorbani, F. and Kamari, S. (2017). Application of Response Surface Methodology for Optimization of Methyl Orange Adsorption by Fe-Grafting Sugar Beet Bagasse. *Adsorption Science & Technology*. 35(3-4), 317-338.

Goel, J., Kadirvelu, K., Rajagopal, C. and Garg, V. K. (2005). Removal of Lead(II) by Adsorption Using Treated Granular Activated Carbon: Batch and Column Studies. *Journal of Hazardous Materials*. B125, 211-220.

Guo, J. and Lua, A. C. (2002). Characterization of Adsorbent Prepared from Oil-Palm Shell by CO_2 Activation for Removal of gaseous Pollutants. *Material Letters.* 55, 334-339.

Guo, J., Luo, Y., Chi, R. A., Chen, Y. L., Bao, X. T. and Xiang, S. X. (2007). Adsorption of Hydrogen Sulphide (H_2S) by Activated Carbons Derived from Oil-Palm Shell. *Carbon*. 45, 330-336.

Guo, Z., Liu, X. and Huang, H. (2015). Kinetics and Thermodynamics of Reserpine Adsorption onto Strong Acidic Cationic Exchange Fiber. *PLoS ONE*. 10(9), e0138619.

Halim, H. N. A. and Mee, K. L. K. (2011). Adsorption of Basic Red 46 by Granular Activated Carbon in a Fixed-Bed Column. *2011 International Conference on Environment and Industrial Innovation*. 12, 263-267.

Hameed, B. H. and El-Khaiary, M. L. (2008). Equilibrium, Kinetics and Mechanism of Malachite Green Adsorption on Activated Carbon Prepared from Bamboo by K_2CO_3 Activation and Subsequent Gasification with CO_2. *Journal of Hazardous Materials.* 157(2-3), 344-351.

Hameed, B. H. (2009). Evaluation of Papaya Seeds as A Novel Non-Conventional Lost-Cost Adsorbent for Removal of Methylene Blue. *Journal of Hazardous Materials*. 162(2), 939-944.

Han, X., Wishart, E. and Zheng, Y. (2014). A Comparison of Three Methods to Regenerate Activated Carbon Saturated by Diesel Fuels. *The Canadian Journal of Chemical Engineering*. 92, 884-891.

Han, Z., Sani, B., Akkanen, J., Abel, S., Nybom, I., Karapanagioti, H. K. and Werner, D. (2015). A Critical Evaluation of Magnetic Activated Carbon's Potential for The Remediation of Sediment Impacted by Polycyclic Aromatic Hydrocarbons. *Journal of Hazardous Materials*. 286, 41-47.

Han, C. Y. and Yin, L. L. (2019). Effect of Activating Agents for Producing Activated Carbon Using A Facile One-Step Synthesis with Waste Coffee Grounds for Symmetric Supercapacitors. *Journal of the Taiwan Institute of Chemical Engineers*. 101, 177-185.

Hamad, B. K., Noor, A. M., Afida, A. R. and Mohd Asri, M. N. (2010). High Removal of 4-chloroguaiacol by High Surface Area of Oil Palm Shell-Activated Carbon Activated with NaOH from aqueous solution. *Desalination.* 257, 1-7.

Hema, M. and Arivoli, S. (2007). Comparative Study on the Adsorption Kinetics and Thermodynamics of Dyes onto Acid Activated Low Cost Carbon. *International Journal of Physics Sciences.* 2(1), 10-17.

Hidayu, A. R. and Muda, N. (2016). Preparation and Characterization of Impregnated Activated Carbon from Palm Kernel Shell and Coconut Shell for CO_2 Capture. *Procedia Engineering*. 148, 106-113.

Hitachi High-Technologies Corporation (2011). *Ultra-High Resolution Scanning Electron Microscope SU8000 Series* [Brochure]. Tokyo, Japan.

Hu, Z. H. and Srinivasan, M. P. (1999). Preparation of High Surface Area Activated Carbons from Coconut Shell. *Microporous and Mesoporous Materials.* 27(1), 11-18.

Hu, Z. and Vansant, E. F. (1995). A New Composite Adsorbent Produced by Chemical Activation of Elutrilithe with Zinc Chloride. *Journal of Colloid and Interface Science.* 176(2), 422-431.

Hunger, K. (2003). *Industrial Dyes: Chemistry, Properties, Applications*. Germany: Wiley-VCH Verlag Gmbh & Co. KHaA.

Hussaro, K. (2014). Preparation of Activation Carbon from Palm Oil Shell by Chemical Activation with Na2CO3 and ZnCl2 as Impregnated Agents for H2S Adsorption. *American Journal of Environmental Sciences*. 10(4), 336-346.

Imalerio, T. I., Amah, A. N., Onoja, D. A. and Oberafo, A. A. (2014). Nano Pores Surface Area Evaluation in Palm Kernel Shells and Masonia Wood Derived Activated Carbons. *Journal of Natural Sciences Research*. 4(1), 54-58.

Intan Farhana Zainul (2017, March 8). Thorny issues: palm oil industry needs to improve production efficiencies. *The Star*. Retrieved July 29, 2017, from https://www.thestar.com.my/business/business-news/2017/03/08/thorny-issues/

Inyinbor, A. A., Adekola, F. A. and Olatunji, G. A. (2015). Adsorption of Rhodamine B Dye from Aqueous Solution on *Irvingia gabonensis* Biomass: Kinetics nad Thermodynamics Studies. *South African Journal of Chemistry*. 68, 115-125.

Ioannidou, O. and Zabaniotou, A. (2007). Agricultural Residues as Precursors for Activated Carbon Production – A Review. *Renewable Sustainable Energy Reviews.* 11(9), 470-475.

Jedynak, K., Widel, D. and Redzia, N. (2019). Removal of Rhodamine B (A Basic Dye) and Acid Yellow 17 (An Acidic Dye) from Aqueous Solutions by Ordered Mesoporous Carbon and Commercial Activated Carbon. *Colloids and Interfaces*. 3(30), 1-16.

Jeirani, Z., Jan, B. M., Ali, B. S., Noor, I. M., See, C. H. and Saphanuchart, W. (2013). Prediction of Water and Oil Percolation Thresholds of A Microemulsion By Modeling of Dynamic Viscosity Using Response Surface Methodology. *Journal of Industrial and Engineering Chemistry*. 19, 554-560.

Jeyaraj, B., Subbareddy, Y., Jayakumar, C., Nagaraja, K. S. and Valli, S. (2014). Equilibrium, Kinetic and Thermodynamic Study of Adsorption of Rhodamine B from Aqueous Solution by Activated Carbon from Peltophorum Pterocarpum Leaf. *Wastewater and Biosolids Treatment and Reuse*. 8-14 June. Otranto, Italy.

Jha, R. (2016). *Diamagnetic, Paramagnetic & Ferromagnetic Substance*. Unpublished Articles. Quantum Study.

Ji, H., Wang, X., Gu, Z. and Polin, J. (2013). Carbon Materials from High Ash Biochar for Supercapacitor and Improvement of Capacitance with HNO_3 Surface Oxidation. *Journal of Power Sources*. 236, 285-292.

Jia, B., Su, L., Han, G., Wang, G., Zhang, J. and Wang, L. (2011). Adsorption Properties of Nickel-Based Magnetic Activated Carbon Prepared by Pd-Free Electroless Plating. *Bioresources*. 6(1), 70-80.

Jiles, D. (2016). *Introduction to Magnetism and Magnetic Materials, Third Edition*. Boca Raton: CPC press Taylor & Francis Group.

Jin, X. J., Yu, Z. M. and Wu, Y. (2012). Preparation of Activated Carbon from Lignin Obtained by Straw Pulping by KOH and K_2CO_3 Chemical Activation. *Cellulose Chemistry and Technology*. 46(1-2), 79-85.

Kadir, S. A. S. A., Matali, S., Mohamad, N. F. and Rani, N. H. A. (2014). Preparation of Activated Carbon from Oil Palm Empty Fruit Bunch (EFB) by Steam Activation Using Response Surface Methodology. *International Journal of Materials Science and Applications*. 3(5), 159-163.

Kakavandi, B., Jafari, A. J., Kalantary, R. R., Nasseri, S., Ameri, A. and Esrafily, A. (2013). Synthesis and Properties of Fe_3O_4-Activated Carbon Magnetic Nanoparticles for Removal of Aniline from Aqueous Solution: Equilibrium, Kinetic and Thermodynamic Studies. Iranian *Journal of Environmental Health Science & Engineering*. 10(1), 19-27.

Karthiketan, S., Sivakumar, B. and Sivakumar, N. (2010). Film and Pore Diffusion Modeling for Adsorption of Reactive Red 2 from Aqueous Solution on to Activated Carbon Prepared from Bio-Diesel Industrial Waste. *E-Journal of Chemistry*. 7(S1), S175-S184.

Karthikeyan, S. and Sivakumar, P. (2012). The Effect of Activating Agents on the Activated Carbon Prepared from Feronia limonia (L.) Swingle (Wood Apple) Shell. *J. Environ. Nanotechnology*. 1(1), 5-12.

Karunarathre, H. D. S. S. and Amarasinghe, B. M. W. P. K. (2013). Fixed Bed Adsorption Column Studies for the Removal of Aqueous Phenol from Activated Carbon Prepared from Sugarcane Bagasse. *Energy Procedia*. 34, 83-90.

Khan, T. A., Sharma, S. and Ali, I. (2011). Adsorption of Rhodamine B Dye from Aqeuous Solution onto Acid Activated Mango (Magnifereindica) Leaf Powder: Equilibrium, Kinetic and Thermodynamic Studies. *Journal of Toxicology and Environmental Health Sciences.* 3(10), 286-297.

Khan, T. A., Nazir, M. and Khan, E. A. (2013). Adsorptive Removal of Rhodamine B from Textile Wastewater Using Water Chesnut (Trapanatas L.) Peel: Adsorption Dynamics and Kinetic Studies. *Toxicological & Environmental Chemistry*. 95(6), 919-931.

Kim, B. T., Lee, H. K., Moon, H. and Lee, K. J. (1995). Adsorption of Radionuclides from Aqueous Solutions by Inorganic Adsorbents. *Separation and Purification Technology*. 30, 3165-3182.

Kobiraj, R., Gupta, N., Kushwaha, A. K. and Chattopadhyaya, M. C. (2012). Determination of Equilibrium, Kinetic and Thermodynamic Parameters for The Adsorption of Brilliant Green Dye from Aqueous Solutions onto Eggshell Powder. *Indian Journal of Chemical Technology*. 19, 26-31.

Kosmulski, M. (2009). *Surface charging and points of zero charge (vol. 145)*. Florida: CRC Press.

Kuo, C. Y., Wu, C. H. and Wu, J. Y. (2008). Adsorption of Direct Dyes from Aqueous Solutions by Carbon Nanotubes: Determination of Equilibrium, Kinetics and Thermodynamics Parameters. *Journal of Colloid and Interface Science*. 327, 308-315.

Kwaghger, A. and Adejoh, E. (2012). Optimization of Conditions for the Preparation of Activated Carbon from Mango Nuts Using $ZnCl_2$. *International Journal of Engineering Research and Development*. 1(8), 1-7.

Kyzas, G. Z. (2012). Commercial Coffee Wastes as Materials for Adsorption of Heavy Metals from Aqueous Solutions. *Materials*, 5(10). 1826-1840.

Lacerda, R. S., Makishi, L. A., Chambib, H. N. M., Monica, A., Bittante, Q. B., Gomide, C. A., Costa, P. A., Sobral, P. J. A. (2014). Castor Bean (Ricinus communis) Cake Protein Extraction by Alkaline Solubilization: Definition of Process Parameters. *Chemical Engineering Transactions*. 37, 775–780.

Lai, B. and Sarma, P. M. (2011). *Wealth from Waste: Trends and Technologies*. (3rd ed.). India: TERI Press The Energy and Resources Institute.

Lartey, R. B., Acquah, F. and Nketia, K. S. (1999). Developing National Capability for Manufacture of Activated Carbon from Agricultural Wastes. *The Ghana Engineer.*

Lee, L. Z. and Zaini, M. A. A. (2015). Potassium Carbonate-Treated Palm Kernel Shell Adsorbent for Congo Red Removal from Water. *Jurnal Teknologi*. 75(1), 233-239.

Lee, L. Z. (2016). *Adsorption of Rhodamine B by Metals Chloride-Activated Castor Bean Residue Carbon*. Degree of Master. Universiti Teknologi Malaysia, Johor.

Lee, L. Z. and Zaini, M. A. A. (2016). Metal Chloride Salts in The Preparation of Activated Carbon and Their Hazardous Outlook. *Desalination and Water Treatment*. 57, 16078-16085.

Lee, L. Z. and Zaini, M. A. A. (2017). Adsorption Properties of Cationic Rhodamine B Dye onto Metals Chloride-Activated Castor Bean Residue Carbons. *Water Science & Technology*. 75(4), 864-880.

Li, H., Huang, G., An, C., Hu, J. and Yang, S. (2013). Removal of Tannin from Aqueous Solution by Adsorption onto Treated Coal Fly Ash: Kinetic, Equilibrium, and Thermodynamic Studies. *Industrial & Engineering Chemistry Research.* 52, 15923–15931.

Lim, W. C., Srinicasakannan, C. and Balasubramanian, N. (2010). Activation of Palm Shells by Phosphoric Acid Impregnation for High Yielding Activated Carbon. *Journal of Analytical and Applied Pyrolysis*. 88(2), 181-186.

Lima, S. B., Borges, S. M. S., Rangel, M. C. and Marchetti, S. G. (2013). Effect of Iron Content on the Catalytic Properties of Activated Carbon-Supported Magnetite Derived from Biomass. *Journal of The Brazilian Chemical Society*. 24(2), 3444-354.

Ling, C. P., Tan, I. A. W. and Lim, L. L. P. (2016). Fixed-Bed Column Study for Adsorption of Cadmium on Oil Palm Shell-Derived Activated Carbon. *Journal of Applied Science and Process Engineering*. 3(2), 60-71.

Liu, K, Xu, L. and Zhang F. (2014). A New Preparation Process of Coal-Based Magnetically Activated Carbon. Chinese *Journal of Geochemistry*. 33, 173-177.

Livani, M. J., Ghorbani, M. and Mehdipour, H. (2018). Preparation of An Activated Carbon from Hazelnut Shells and Its Hybrids with Magnetic $Nife_2o_4$ Nanoparticles. *New Carbon Materials*. 33(6), 578-586.

Lopez-Cervantes, J., Sanchez-Machado, D. I., Sanchez-Duarte, R. G. and Correa-Murrieta, M. A. (2018). Study of A Fixed-Bed Column in the Adsorption of An Azo Dye from An Aqueous Medium Using a Chitosan-Glutaraldehyde Biosorbent. *Adsorption Science & Technology*. 36(1-2), 215-232.

Loven, A. W. (1973). Perspectives on Carbon Regeneration. *Chemical Engineering Progress.* 60(11), 56.

Lu, P. J., Lin, H. C., Yu, W. T. and Chern, J. M. (2011). Chemical Regeneration of Activated Carbon Used for Dye Adsorption. *Journal of the Taiwan Institute of Chemical Engineers*. 42, 305-311.

Lua, A. C., Yang, T. and Guo, J. (2004). Effects of Pyrolysis Conditions on the Properties of Activated Carbons Prepared from Pistachio-Nut Shells. *Journal of Analytical and Applied Pyrolysis* 72, 279-287.

Ma, Y., Gao, N., Chu, W. and li, C. (2013). Removal of Phenol by Powdered Activated Carbon Adsorption. *Frontiers of Environmental Science & Engineering*. 7(2), 158-165.

Margaritis, A. (2007). *Adsorption Processes*. Unpublished note, Fall.

Martin, C., Moure, A., Martin, G., Carrillo, E., Dominguez, H. and Parajo, C. (2010). Fractional Characterisation of Jatropha, Neem, Moringa, Trisperma, Castor and Candlenut Seeds as Potential Feedstocks for Biodiesel Production in Cuba. *Biomass and Bioenegry*. 34(4), 533-538.

Maulina, S. and Iriansyah, M. (2018). Characteristics of Activated Carbon Resulted from Pyrolysis of The Oil Palm Fronds Powder. *IOP Conference Series: Materials Science and Engineering*. 309, 012072.

Michael David Surfanarski (1999). *The Regeneration of Granular Activated Carbon Using Hydrothermal Technology*. Master Thesis, The University of Texas, Austin.

Mohammadi, M., Hassani, A. J., Mohamed, A. R. and Najafpour, G. D. (2010). Removal of Rhodamine B from Aqueous Solution Using Palm Shell-Based Activated Carbon: Adsorption and Kinetic Studies. *Journal of Chemical & Engineering Data.* 55, 5777-5785.

Mohan, D., Sarswat, A., Singh, V. K., Alexandre-Franco, M. and Pitman Jr., C. U. (2011). Development of Magnetic Activated Carbon from Almond Shells for Trinitrophenol Removal from Water. *Chemical Engineering Journal*. 172, 1111-1125.

Morali, U., Demirai, H. and Sensoz, S. (2018). Optimization of Activated Carbon Production from Sunflower Seed Extracted Meal: Taguchi Design of Experiment Approach and Analysis of Variance. *Journal of Cleaner Production*. 189, 602-611.

Moreno-Virgen, M. R., Tovar-Gomez, R., Mendoza-Castillo, D. I. and Bonilla-Petriciolet, R. (2012). *Applications of Activated Carbon Obtained from Lignocellulosic Materials for the Wastewater Treatment.* In Montoya, V. H. (Ed.) *Lignocellulosic Precursors Used in the Synthesis of Activated Carbon – Characterization Techniques and Applications in the Wastewater Treatment* (pp. 57-75). Europe: InTech.

Mourabet, M., El Rhilassi, A., El Boujaady, H., Bennani-Ziatni, M. and Taitai, A. (2017). Use of Response Surface Methodology for Optimization of Fluoride Adsorption in An Aqueous Solution by Brushite. *Arabian Journal of Chemistry*. 10(S2), S3292-S3302.

Mourao, P. A. M., Carrott, P. J. M., Ribeiro Carrott, M. M. L. and Marques, L. (2008). Different Ways to Regenerate an Activated Carbon: Comparison between an Activated Carbon from Cork and a Commercial Carbon. *Materials Science Forum*. 587-588, 844-848.

Muhammad Azhar Shahzad (2014). *Catalytic Decolourization of Aqueous Solutions of Methyl Orange and Rhodamine B Dyes.* Master Thesis, Government College University, Faisalabad.

Nada Ahmed (2013, September 3). Adsorption. *Weebly*. Retrieved July 27, 2017, from http://myxc.weebly.com/adsorption/-adsorption

Nazri, I., Ahmad, Z. A., Ahmad, M. A., Ahamd, N. and Sulaiman, S. K. (2011). Optimization of Process Variables for Malachite Green Dye Removal Using Rubber Seed Coat Based Activated Carbon. *International Journal of Engineering & Technology.* 11, 305-311.

Nidheesh, P. V., Gandhimathi, R., Ramesh, S. T. and Singh, T. S. A. (2012). Adsorption and Desorption Characteristics of Crystal Violet in Bottom Ash Column. *Journal of Urban and Environmental Engineering*. 6(1), 18-29.

NIST/SEMATECH (2012). e-Handbook of Statistical Methods. Retrieved November 5, 2019, from http://www.itl.nist.gov/div898/handbook/

Nunes, C. A. and Guerreiro, M. C. (2011). Estimation of Surface Area and Pore Volume of Activated Carbons by Methylene Blue and Iodine Numbers. *Química Nova.* 34(3), 472-476.

Nurul Ain binti Jabit (2007). *The Production and Characterization of Activated Carbon Using Local Agricultural Waste through Chemical Activation Process*. Master Thesis, Universiti Sains Malaysia, Pulau Pinang.

Nwabanne, J. T. and Igbokwe, P. K. (2012). Adsorption Performance of Packed Bed Column for the Removal of Lead (ii) using Oil Palm Fibre. *International Journal of Applied Science and Technology*. 2(5), 106-115.

Obaid, M. K., Abdullah, L. C., Mahdi, D. S., Idan, I. J. and Md. Jamil, S. N. (2017). Fixed bed Adsorption Study for Removing of Reactive Orange 16 and Acid Red 114 Dyes from Aqueous Solution Using Kenaf. *International Journal of Research in Advanced Engineering and Technology*. 3(1), 32-40.

Ogunsile, B. O., Odesola, I. F., Oluwole, O. and Labulo, A. H. (2014). Production and Characterization of Activated Carbon from Chemically Treated Agricultural Wastes. *Journal of Applied Science Research*. 10(2), 29-35.

Oh, W. C. and Ko, W. B. (2006). Physical Properties of K-Activated Carbon and Its Removal Efficiencies for Chemical Factors. *Journal of Industrial and Engineering Chemistry*. 12(3), 373-379.

Oh, W. D., Lua, S. K., Dong, Z. and Lim, T. T. (2015). Performance of Magnetic Activated Carbon Composite as Peroxymonosulfate Activator and Regenerable Adsorbent via Sulfate Radical-Medical Oxidation Processes. *Journal of Hazardous Materials*. 284, 1-9.

Oliveira, L. C. A., Pereira, E., Guimaraes, I. R., Vallone, A., Pereira, M., Mesquita, J. P. and Sapaq, K. (2009). Preparation of Activated Carbons from Coffee Husks Utilizing $FeCl_3$ and $ZnCl_2$ as Activating Agents. *Journal of Hazardous Materials*. 165, 87-94.

Onochie, U. P., Obanor, A. I., Aliu, S. A. and Ighodaro, O. O. (2017). Proximate and Ultimate Analysis of Fuel Pellets from Oil Palm Residues. *Nigerian Journal of Technology*. 26(3), 987-990.

Osman, N. B., Shamsuddin, N. and Uemura, Y. (2016). Activated Carbon of Oil Palm Empty Fruit Bunch (EFB); Core and Shaggy. *Procedia Engineering*. 148, 758-764.

Othman, N. A., Kim, T., Imamura, A., Miyawaki, J., Mochida, I. and Yoon, S. H. (2013). Investigation on H_2S Removal Factors of Activated Carbons Derived from Waste Palm Trunk. *Journal of Novel Carbon Resource Sciences*. 7, 7-11.

Ozdemir, I., Sahin, M., Orhan, R. and Erdem, M. (2014). Preparation and Characterization of Activated Carbon from Grape Stalk by Zinc Chloride Activation. *Fuel Process. Technol.* 125, 200–206.

Pal, A., Kil, H. S., Mitra, S., Thu, K., Saha, B. B., Yoon, S. H., Mivawaki, J., Miyazaki, T. and Koyama, S. (2017). Ethanol Adsorption Uptake and Kinetics onto Waste Palm Trunk and Mangrove Based Activated Carbons. *Applied Thermal Engineering*. 22, 389-397.

Patel, H. (2019). Fixed-Bed Column Adsorption Study: A Comprehensive Review. *Applied Water Science*. 9(45), 1-17.

Panneerselvam, P., Morad, N., Tan, K. A. and Mathiyarasi, R. (2012). Removal of Rhodamine B Dye Using Activated Carbon Prepared from Palm Kernel Shell and Coated with Iron Oxide Nanoparticles. *Separation Science and Technology*. 47(5), 742-752.

PerkinElmer, Inc. (2010). *A Beginner's Guide to Thermogravimetric Analysis (TGA)* [Product Guide]. Waltham, USA.

Plakas, K. V. and Karabelas, A. J. (2016). A Study on Heterogeneous Fenton Regeneration of Powdered Activation Carbon Impregnated with Iron Oxide Nanoparticles. *Global NEST Journal*. 18(2), 259-268.

Prabakaran, R. and Arivoli, S. (2012). Equilibrium Isotherm, Kinetic and thermodynamic Studies of Rhodamine B Adsorption using Thespedia populnea Bark. *Journal of Chemical and Pharmaceutical Research*. 4(10), 4550-4557.

Prabudi, M., Nurtama, B. and Purnomo, E. H. (2018). Application of Response Surface Methodology (RSM) Using Historical Data on Optimzation Burger Production Process. *Jurnal Mutu Pangan*. 5(2), 109-115.

PubChem (2005). *Rhodamine B*. [Material Safety Data Sheet]. U. S.

Purkait, M. K., Maiti, A., DasGupta, S. and De, S. (2007). Removal of Congo Red Using Activated Carbon and Its Regeneration. *Journal of Hazardous Materials*. 145(1-2), 287-295.

Quinones, D. H., Rey, A., Alvarez, P. M., Beltran, F. J. and Plucinski, P. K. (2014). Enhanced Activity and Reusability of TiO_2 Loaded Magnetic Activated Carbon for Solar Photocatalytic Ozonation. *Applied Catalysis B: Environmental*. 144, 96-106.

Radovic, L. (2001). *Chemistry and Physics of Carbon: Volume 27.* New York: Marcel Dekker.

Railsback, L. B. (2006). *Some Fundamentals of Mineralogy and Geochemistry.* Georgia: University of Georgia.

Raja, K., Ramesh, P. S. and Geetha, D. (2014). Structural, FTIR and Photoluminescence Studies of Fe Doped ZnO Nanopowder By Co-Precipitation Method. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*. 131, 183-188.

Rajeshwar, S. M., Amar, Y. P., Bhadra, P. P. and Ram, P. R. (2012). Preparation and Characterization of Activated Carbon from Lapsi (Choerospondias axillaris) Seed Store by Chemical Activation with Phosphoric Acid. *Research Journal of Chemical Sciences.* 2(10), 80-86.

Redlich, O. and Peterson, D. L. (1959). A Useful Adsorption Isotherm. *Journal of Physical Chemistry*. 63, 1024-1026.

Rocha, P. D., Franca, A. S. and Oliveira, L. S. (2015). Batch and Column Studies of Phenol Adsorption by an Activated Carbon Based on Acid Treatment of Corn Cobs. IACSIT International Journal of Engineering and Technology. 7(6), 459-464.

Rochart, J., Demenge, P. and Rerat, J. C. (1978). Toxicological Study of a Fluorescent Tracer: Rhodamine B. *Toxicological European Research.* 1, 23-26.

Rodriguez-Reinoso, F. (2002). *Production and Application of Activated Carbons.* In Schuth, F., Sing, K. S. W. and Weitkamp, J. (Ed.) *Handbook of Porous Solids.* (pp. 1766-1827). Weinheim, Germany: Wiley-VCH Verlag GmbH.

Rufford, T. E., Hulicova-Jurcakova, D., Zhu, Z. and Lu, G. Q. (2010). A Comparative Study of Chemical Treatment by $FeCl_3$, $MgCl_2$ and $ZnCl_2$ on Microstructure, Surface Chemistry, and Double-Layer Capacitance of Carbons from Waste Biomass. *Journal of Materials Research.* 25(8), 1451-1459.

Rugayah, A. F., Astimar, A. A. and Norzita, N. (2014). Preparation and Characterisation of Activated Carbon from Palm Kernel Shell by Physical Activation with Steam. *Journal of Oil Palm Research*. 26(3), 251-264.

Ruiz, H. A., Zambrano, M. A., Giraldo, L., Sierra, R. and Moreno-Pirajan, J. C. (2014). Production and Characterization of Activated Carbon from Oil-Palm Shell for Carboxylic Acid Adsorption. Oriental Journal of Chemistry. 31(2), 1-10.

Ryu, Y. K., Kim, K. L. and Lee, C. H. (2000). Adsorption and Desorption of n- Hexane, Methyl Ethly Ketone, and Toluene on an Activated Carbon Fiber from Supercritical Carbon Dioxide. *Industrial & Engineering Chemistry Research.* 39(7), 2510-2518.

Salahudeen, N., Ajinomoh, C. S., Omaga, S. O. andAkpaka, C. S. (2014). Production of Activated Carbon from Cassava Peel. *Journal of Applied Hytotechnology in Environmental Sanitation.* 3(2), 75-80.

Salman, J. M. (2014). Optimization of Preparation Conditions for Activated Carbon from Palm Oil Fronds Using Response Surface Methodology on Removal of Pesticides from Aqueous Solution. *Arabian Journal of Chemistry*. 7(1), 101-108.

Sampranpiboon, P. and Charnkeitkong, P. (2010). Equilibrium Isotherm, Thermodynamic and Kinetic Studies of Lead Adsorption onto Pineapple and Paper Waste Sludges. *International Journal of Energy and Environment*. 4(3), 88-98.

Scholz M. and Martin R. J. (1998), Control of Bio-regenerated Granular Activated Carbon by Spreadsheet Modelling. *Journal of Chemical Technology and Biotechnology*. 71(3), 253-261.

See, M. T., Lee, L. Z., Zaini, M. A. A., Quah, Z. Y. and Aw, Y. P. Y. (2015). *Activated Carbon for Dyes Adsorption in Aqueous Solution*. In Daniels, J. A. (ed.). *Advances in Environmental Research 36*. (pp. 217-234). New York: Nova Science Publishers, Inc.

Shahbeig, H., Bagheri, N., Ghorbanian, S. A., Hallajisani, A. and Poorkarimi, S. (2013). A New Adsorption Isotherm Model of Aqueous Solutions on Granular Activated Carbon. *World Journal of Modeling and Simulation.* 9(4), 243-254.

Shahmohammadi-Kalalagh, S., Babazadeh, H., Nazemi, A. H. and Manshouri, M. (2011). Isotherm and Kinetic Studies on Adsorption of Pb, Zn and Cu by Kaolinite. *Caspian Journal of Environmental Sciences.* 9(2), 243-255.

Shahavi, M. H., Hosseini, M., Jahanshahi, M. and Darzi, G. N. (2015). Optimization of Encapsulated Clove Oil Particle Size with Biodegradable Shell Using Design Expert Methodology. *Pakistan Journal of Biotechnology*. 12(2), 149-160.

Sharman, P., Kour, H. and Sharma, M. (2011). A Review on Applicability of Naturally Available Adsorbents for the Removal of Hazardous Dyes from Aqueous Waste. *Environmental Monitoring and Assessment.* 183, 151-195.

Shrestha, D., Gyawali, G. and Rajbhandari, A. (2018). Preparation and Characterization of Activated Carbon from Waste Sawdust From Saw Mill. *Journal of Institute of Science and Technology*. 22(2), 103-108.

Shimadzu Corporation (2013). *Fourier Transform Infrared Spectrophotometer IRTracer-1000* [Product Guide]. Japan.

Sivakumar, P. and Palanisamy, P. N. (2009). Packed Bed Column Studies for the Removal of Acid Blue 92 and Basic Red 29 Using Non-Conventional Adsorbent. *Indian Journal of Chemical Technology*. 16, 301-307.

Smrutirekha, D. (2014). *Characterization of Activated Carbon of Coconut Shell, Rice Husk and Karanja oil* Cake. Bachelor Thesis, National Institute of Technology, Rourkela.

Spinu, L., Dodrill, B. C. and Radu, C. (2013). *Magnetometry Measurements*. In Slawnich, D. (ed.). *Magnetic Technology International*. (pp. 62-65). U. K.: UKIP Media & Events Ltd.

Srivastava, P. and Hasan, S. H. (2011). Biomass of Mucos Heimalis for the Biosortption of Cadmium from Aqueous Solutions: Equilibrium and Kinetic Studies. *Bioresources.* 6(4), 3656-3675.

Subha, R. and Namasivayam, C. (2008). Modeling of Adsorption Isotherms and Kinetics of 2,4,6-Trichlorophenol onto Microporous $ZnCl_2$ Activated Coir Pith Carbon. *Environmental Engineering and Management Journal.* 18(4), 275-280.

Subha, R. and Namasivayam, C. (2010). $ZnCl_2$-Modified Activated Carbon from Biomass Coir Pith for the Removal of 2-Chlorophenol by Adsorption Process. *Bioremediation Journal.* 14(1), 1-9.

Sugashini, S. and Meera-Sheriffa-Begum, K. M. (2013). Column Adsorption Studies for The Removal of Cr(VI) Ions by Ethylamine Modified Chitosan Carbonized Rice Husk Composite Beads with Modelling and Optimization. *Journal of Chemistry*. 2013(460971), 1-11.

Sulaymon, A. H. and Abood, W. M. (2008). Estimation of Efficiency of Regenerated Granular Activated Carbon by Different Methods. *Journal of Engineering*. 14(2), 2677-2683.

Sumathi, S., Bhatia, S., Lee, K. T. and Mohamed, A. R. (2010). Cerium Impregnated Palm Shell Activated Carbon (Ce/PSAC) Sorbent for Simultaneous removal of SO_2 and NO – Process Study. *Chemical Engineering Journal*. 162, 51-57.

Sun, K., Jiang, J. C. and Xu, J. M. (2009). Chemical Regeneration of Exhausted Granular Activated Carbon Used in Citric Acid Fermentation Solution Decolouration. *Iranian Journal of Chemistry and Chemical Engineering.* 28(4), 79-84.

Sun, Y. and Webley, P. A. (2010). Preparation of Activated Carbon from Corncob with Large Specific Surface Area by a Variety of Chemical Activators and Their Application in Gas Storage. *Chemical Engineering Journal.* 162, 883-892.

Sun, Y., Yue, Q., Mao, Y., Gao, B., Gao, Y. and Huang, L. (2014). Enhanced Adsorption of Chromium onto Activated Carbon by Microwave-Assisted H_3PO_4 Mixed with Fe/Al/Mn Activation. *Journal of Hazardous Materials.* 265, 191–200.

Sunanda, Tiwari, D. P., Sharma, D. N. and Kumar, R. T. S. (2013). Sapindus Based Activated Carbon by Chemical Activation. *Research Journal of Material Sciences.* 1(7), 9-15.

Suteu, S. and Malutan, T. (2013) Industrial Cellolignin Wastes as Adsorbent for Removal of Methylene Blue Dye from Aqueous Solutions. *Bioresources.* 8(1), 427-446.

Tan, I. A. W. and Hameed, B. H. (2010). Adsorption Isotherms, Kinetics, Thermodynamics and Desorption of Activated Carbon Derived from Oil Palm Empty Fruit Bunch. *Journal of Applied Sciences*. 10, 2565-2571.

Thakur, A. and Kaur, H. (2017). Response Surface Optimization of Rhodamine B Dye Removal Using Paper Industry Waste as Adsorbent. *International Journal of Industrial Chemistry*. 8,175-186.

Thermo Fisher Scientific, Inc. (2009). *Thermo Scientific Surfer Gas Adsorption Porosimeter* [Product Specifications]. Milan, Italy.

Theydan, S. K. and Ahmed, M. J. (2012). Adsorption of Methylene blue onto Biomass-Based Activated Carbon by $FeCl_3$ Activation: Equilibrium, Kinetics, and Thermodynamic Studies. *Journal of Analytical and Applied Pyrolysis*. 97, 116-122.

Thuan, T. V., Quynh, B. T. P., Nguyen, T. D., Ho, V. T. T. and Bach, L. G. (2017). Response Surface Methodology Approach for Optimization of Cu^{2+}, Ni^{2+} and Pb^{2+} Adsorption Using KOH-Activated Carbon from Banana Peel. *Surfaces and Interfaces*. 6, 209-217.

Tian, D., Xu, Z., Zhang, D., Chen, W., Cai, J., Deng, H., Sun, Z. and Zhou, Y. (2019). Micro-Mesoporous Carbon from Cotton Waste Activated by $FeCl_3/ZnCl_2$: Preparation, Optimization, Characterization and Adsorption of Methylene Blue and Eriochrome Black T. *Journal of Solid State Chemistry*. 269, 580-587.

Tolga, D., Busetty, S. and Yunus, O. (2014). Investigation of the Potential of Activated and Magnetic Activated Carbon Produced from Turkish Lignite as Gold Adsorbents. *Asian Journal of Applied Sciences*. 7(6), 486-498.

Ulfah, M., Raharjo, S., Hastuti, P. and Darmadji, P. (2016). The Potential of Palm Kernel Shell Activated Carbon as an Adsorbent for β-Carotene Recovery from Crude Palm Oil. *AIP Conference Proceedings*. 1755(1), 1-5.

Uner, O., Gecgel, U. and Bayrak, Y. (2015). Preparation and Characterization of Mesoporous Activated Carbons from Waste Watermelon Rind by Using the Chemical Activation Method with Zinc Chloride. *Arabian Journal of Chemistry*. In press.

Varila, T., Bergna, D., Lahti, R., Romar, H., Hu, T. and Lassi, U. (2017). Activated Carbon Production from Peat Using $Zncl_2$ Characterization and Applications. *Bioresources*. 12(4), 8078-8092.

Vatta, L. L., Sanderson, R. D. and Koch, K. R. (2006). Magnetic Nanoparticles: Properties and Potential Applications. *Pure and Applied Chemistry*. 78(9), 1793-1801.

Vijayakumar, G., Yoo, C. K., Elango, K. G. P. and Dharmendirakumar, M. (2010). Adsorption Characteristics of Rhodamine B from Aqueous Solution onto Baryte. *Clean – Soil, Air, Water*. 38(2), 202-209.

Vincent, O., Solomon, N and Jude, D. (2016). Study of Kinetics of Chemically Activated Carbon Produced from Palm Kernel Shell. *British Journal of Applied Science & Technology*. 16(6), 1-9.

Viswanathan, B., Indra Neel, P. and Varadarajan, T. K. (2009). *Methods of Activation and Specific Applications of Carbon Materials.* Chennai, India: National Centre for Catalysis Research.

Wan, J., Deng, H., Shi, J., Zhou, L. and Su, Tong. (2014). Synthesized Magnetic Manganese Ferrite Nanoparticles on Activated Carbon for Sulfamethoxazole Removal. *Clean – Soil, Air, Water*. 42(9), 1199-1207.

Wang, L., Zhang, J., Zhao, R., Li, C., Li, Y. and Zhang, C. (2010). Adsorption of Basic Dyes on Activated Carbon Prepared from Polygonumorientale Linn: Equilibrium, Kinetic and Thermodynamic Studies. *Desalination*. 254 (1-3), 68-74.

Wang, X., Li, D., Li, W., Peng, J., Xia, H., Zhang, L., Guo, S. and Chen, G. (2013). Optimization of Mesoporous Activated Carbon from Coconut Shells by Chemical Activation with Phosporic Acid. *Bioresources.* 9(4), 6184-6195.

Webb, P. A. (2003). *Introduction to Chemical Adsorption Analytical Techniques and Their Application to Catalysis.* Unpublished Articles. Micromeritics Technical Publications

Wechsler, B. A., Lindsley, D. H. and Prewitt, C. T. (1984). Crystal Structure and Cation Distribution in Titanomagnetites ($Fe_{3-x}Ti_xO_4$). *American Mineralogist*. 69(6), 754-770.

Wei, Q., Chen, Z., Cheng, Y., Wang, X., Yang, X., Yang, X. and Wang, Z. (2019). ‘Preparation and Electrochemical Performance of Orange Peel Based-Activated Carbons Activated by Different Activators. *Colloids and Surfaces A: Physisochemical and Engineering Aspects*. 574, 221-227.

Werner, K., Pommer, L. and Brostrom, M. (2014). Thermal Decomposition of Hemicelluloses. *Journal of Analytical and Applied Pyrolysis*. 100(1), 130-137.

Wu, F. C., Tseng, R. L. and Juang, R. S. (2009). Initial Behavious of Intraparticle Diffusion Model Used in The Description of Adsorption Kinetics. *Chemical Engineering Journal*. 153, 1-8.

Xie, T. P., Xu, L. J., Liu, C. J., He, C. L., Xiao, Z. M. and Wang, J. C. (2012). Preparation of Magnetic Activated Carbon and Adsorption Properties for $KMnO_4$. *Science China Press*. 42(8), 1152-1160.

Xu, Z., Cai, J. and Pan, B. (2013). Review: Mathematically Modeling Fixed-Bed Adsorption in Aqueous System. *Applied Physics & Engineering*. 14(3), 155-176.

Yacob, A. R., Majid, Z. A., Dasril, R. S. D. and Inderen, V. (2008). Comparison of Various Sources of High Surface Area Carbon Prepared by Different Types of Activation. *The Malaysian Journal of Analytical Sciences.* 12(1), 264-271.

Yacob, A. R., Hanapi, S. T., and Inderan, V. (2009). Nano Tungsten Supported on Carbon from Palm Kernel Shell in Remediation of Chlorofluorocarbon (CFC-12). *2009 International Conference on Computer Engineering and Technology*. 22-24 January. Singapora: IEEE, 556-563.

Yahaya, N. K. E. M., Latiff, M. F. P. M., Abustan, I. and Ahmad, M. A. (2010). Effect of Preparation Conditions of Activated Carbon Prepared from Rice Husk by ZnCl2 Activation for Removal of Cu (II) from Aqueous Solution. *International Journal of Engineering & Technology*. 10(6), 28-32.

Yang, R. T. (2003). *Adsorbents: Fundamentals and Applications.* Hoboken, New Jersey: John Wiley & Sons, Inc.

Yang, T. and Lua, A. C. (2003). Characteristics of Activated Carbons Prepared from Pistachio-Nut Shells by Physical Activation. *Journal of Colloid and Interface Science.* 267, 408-417.

Yang, J. L., Fang, F. and Zhou, J. B. (2013). Effect of Microstructure and Surface Chemistry in Liquid-Phase Adsorptive Nicotine by Almond-Shell-Based Activated Carbon. *Environmental Science & Technology.* 58, 3715–3720.

Yao, M., Zhang, Q., Hand, D. W. and Perram, D. (2009). Adsorption and Regeneration on Activated Carbon Fiber Cloth for Volatile Organic Compounds at Indoor Concentration Levels. *Journal of the Air & Waste Management Association*. 59, 31-36.

Yashim, M. M., Razali, N., Saadon, N. and Rahman, N. A. (2016). Effect of Activation Temperature on Properties of Activated Carbon Prepared from Oil Palm Kernel Shell (OPKS). Journal of Engineering and Applied Science. 11(10), 6389-6392.

Yin, C. Y., Aroua, M. K. and Wan Daud, W. M. A. (2007). Review of Modificationsof Activated Carbon for Enchancing Contaminant Uptakes from Aqueous Solution. *Separation and Purification Technology.* 52(3), 403-415.

Yong, Q. Z. and Zaini, M. A. A. (2016). Adsorption of Rhodamine B by Palm Kernel Shell Adsorbents. *Journal of Engineering and Technology*. 7(2), 1-16.

Yorgun, S., Vural, N. and Demiral, H. (2009). Preparation of High-Surface Area Activated Carbons from Paulownia Wood by $ZnCl_2$ Activation. *Microporous and Mesoporous Materials.* 122, 189-194.

Zahoor, M. and Mahramanlioglu, M. (2011). Adsorption of Imidacloprid on Powdered Activated Carbon and Magnetic Activated Carbon. *Chemical and Biochemical Engineering Quarterly*. 25(1), 55-63.

Zaini, M. A. A., Yunus, M. A. C., Setapar, S. H. M., Amano, Y. and Machida, M. (2013). Effect of Heat Treatment on Copper Removal onto Manure-Compost-Activated Carbon. *Desalination and Water Treatment*. 51, 5608-5616.

Zaini, M. A. A., Lee, L. Z. and Tang, S. H. (2017). *Activated Carbon-Doped Magnetic Nanoparticles for Wastewater Treatment.* In Gautam, R. K. and Chattopadhyaya, M. C. (eds.). *Advanced Nanomaterials for Wastewater Remediation*. (pp. 277-290). Florida: CRC press, Taylor & Francis Group.

Zanella, O., Tessaro, I. C. and Feris, L. A. (2015). Nitrate Sorption on Activated Carbon Modified with $CaCl_2$: Equilibrium, Isotherms and Kinetics. *Chemical Industry & Chemical Engineering Quarterly*. 21(1) 23-33.

Zargar, B., Parham, H. and Rezazade, M. (2011). Fast Removal and Recovery of Methylene Blue by Activated Carbon Modified with Magnetic Iron Oxide Nanoparticles. *Journal of the Chinese Chemical Society*. 58, 694-699.

Zenz, C. (1988). *Occupational Medicine-Principles and Practical Applications.* (2nd ed.) St. Louis, M. O.: Mosby-Yearbook, Inc.

Zhang, S., Tao, L., Jiang, M., Gou, G. and Zhou, Z. (2015). Single-Step Synthesis of Magnetic Activated Carbon from Peanut Shell. *Materials Letters*. 157, 281-284.

Zhu, J., Wei, S., Chen, M., Gu, H., Rapole, S. B., Pallavkar, S., Ho, T. C., Hopper, J. and Guo, Z. (2013). Magnetic Nanocomposites for Environmental Remediation. *Advanced Powder Technology*. 24, 459-467.