

ADSORPTION OF METHYLENE BLUE USING
ACTIVATED CARBON FROM MIXED OF PALM
OIL PRESS FIBRES AND EMPTY FRUIT BUNCH

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FROM MIXED OF PALM OIL PRESS FIBRES AND EMPTY FRUIT

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AMIR RAHIMIE BIN RIDZUAN

A thesis submitted in fulfilment
of the requirements for the award of the Degree of
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JANUARY 2012

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Chemical Engineering.

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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*Special Dedication to my supervisor, my family members,
my friends, my fellow colleague and all faculty members
for all your care, support and believe in me.*

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ABSTRACT

Nowadays, palm oil industry wastes such as palm oil empty fruit bunch and palm oil press fibre have been sold as source of energy renewable in Malaysia. In the combustion process of palm oil empty fruit bunch and palm oil press fibre will produce carbon. This carbon can be activated to use in waste water treatment and chemical absorber. Methylene blue was use as adsorbate with different concentration. The activated carbons have been produce using chemical activation using potassium hydroxide. It has been carbonize at 250°C for 24 hour with nitrogen flow and the activation process also as carbonize process with temperature 300°C. The equilibrium study using UV-Visible Spectrophotometer is to make calibration curve and to determine the final concentration of the methylene blue solution. From the experiment, the adsorption graph show the 50% additional percentage weight of empty fruit bunch into palm oil press fibres give the high adsorption percentage and from the lagmuir isotherm it also give the high value R² and it maximum adsorption capacity is 111.111 mg/g. The characterization of the activated carbon produce have been determine using Fourier Transform Infrared Spectroscopy (FTIR), it presence of -OH (hydroxyl), C-H (alkanes and alkyls), C=O (Ketone or Asidcarbositik), and C-O-C (esters, eter or phenol). From this research, that can conclude the activated carbon is successfully produce and the characterization of the activated carbon also determine using FTIR. The optima condition is at 50% additional percentage weight of empty fruit bunch into palm oil press fibre.

ABSTRAK

Pada masa kini, di Malaysia, sisa buangan industry sawit seperti tandan kosong dan sabut sawit dijual sebagai bahan bakar untuk menjana tenaga. Dalam proses pembakaran tandan kosong dan sabut sawit ini akan menghasilkan karbon. Karbon ini boleh di aktifkan untuk digunakan dalam proses rawatan air dan penjerapan bahan kimia. Methylena biru digunakan sebagai adsorbate dengan kepekatan awal yang berbeza. Proses pengaktifan yang digunakan adalah menggunakan bahan kimia. Ianya dikarbonkan pada suhu 250°C selama 24 jam dengan disalurkan gas nitrogen dan proses menaktifkan adalah seperti proses dikarbonkan dengan suhu 300°C. Pelajaran keseimbangan dibuat menggunakan UV-Visible Spectrophotometer untuk membuat graf penentukuran dan untuk mencari kepekatan akhir larutan methylena biru. Daripada experiment, graf penjerapan menunjukkan 50% tambahan peratus berat sabut sawit kedalam sabut sawit memberi keputusan tertinggi bagi peratus penjerapan dan daripada sesuhu langmuir memberi baca tertinggi untuk R2 dan penjeratan kapasiti maksimum iaitu 111.111 mg/g. Pencirian karbon diaktifkan yang dihasilkan telah ditentukan menggunakan Fourier Transform Infrared Spectroscopy (FTIR), kehadiran -OH (hidroksil), CH (alkana dan alkyls) dan COC (ester, eter atau fenol). Dari penyelidikan ini, boleh disimpulkan karbon diaktifkan berjaya dihasilkan dan pencirian juga dapat diketahui menggunakan FTIR. Keadaan optima adalah pada berat peratus 50% tambahan tandan kosong kedalam sabut sawit.

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LIST OF SYMBOL

Co	Initial Concentration of Methylene Blue (mg/L)
Ce	Final Concentration of Methylene Blue (mg/L)
qe	Amount adsorbed at equilibrium in (mg/g)
Qo	Maximum Adsorption Capacity (mg/g)
qm	maximum monolayer adsorption capacity (mg.g)
kL	Adsorption equilibrium constant in (L/mg)

CHAPTER 1

INTRODUCTION

1.1 Research Background

Activated carbon (AC) is the carbonaceous material which an important thing in adsorption process. Its specialty to remove organic and inorganic chemical in waste, odor, taste and colour from any kind of chemical basically in waste water and water treatment based on their amazing properties. Activated carbon has high degree of surface reactivity which can influence its interaction with polar or nonpolar adsorbates. Besides, it also has higher surface area and micro porous structure. Activated carbon are widely use in wastewater treatment to remove harmful chemicals and heavy metal, industrial waste water or industrial flue gas. Their application in industry includes removing organic and inorganic pollutants from drinking water, industrial wastewater treatment, decolorizing of syrups and purification of air and pharmaceutical products.

The demand of the activated carbon is increasing year by year, because, it wide usage in industry. Commercial activated carbon is quite expensive. As such industry now seeks for the cheapest activated carbon derive from agriculture waste or residuals. The residuals can be rice husk, palm oil mill sludge, sawdust or other carbonaceous material. The raw material were processed and optimized to obtain excellent adsorptive properties. Activated carbon can be produced either by chemical or physical activation. Chemical activation only involves single step in heating process to activate the carbon. This process needs chemical activating agent like as $ZnCl_2$, KOH , H_3PO_4 or H_2SO_4 to enhance carbon

yield and produce micro pores on the surface of the carbon. Physical activation involves two steps of heating process and does not involve any chemicals.

Dyes (for example a methylene blue) have long and usually been used in dyeing, paper and pulp, textiles, plastics, leather, cosmetics and food industries. Colour stuff discharged from these industries will give certain hazards and environmental problems. These coloured compounds are not only aesthetically displeasing but also inhibiting sunlight penetration into the stream and affecting aquatic ecosystem. Dyes usually have complex aromatic molecular structures which make them more stable and also difficult to biodegrade.(Yamin *et al*,2007) Many dyes are toxic to some microorganisms and may cause direct destruction or inhibition of their catalytic capabilities

Hence, activated carbon is a suitable absorber material in removal dye in waste water from industry with its ability in absorption and it has high surface area. Activated carbon from palm press fibre and empty fruit bunch of palm oil residue can be obtained from industry that using this residue as combustion material for renewable energy.

1.2 Problem Statement

Industrial processing of palm oil from fresh palm oil fruit will produce biomass waste. Among of them is empty fruit brunch (EFB), palm pressed fibres (PPF), palm kernel cake and many more. At this time, this biomass waste only using as fuel in palm oil processing industry. A lot of biomass waste not being utilizes and converted to high valued product such as renewable energy. This combustion process will produce a lot of carbon solid and it only remains in the furnace than consider as waste.

1.3 Objective of Study

At the end of this study, it is necessary:

1. To produce and characterized the activated carbon from the palm press fibre with different additional empty fruit bunch using chemical activation process.
2. To study the optimal condition (additional composition empty fruit bunch into palm press fibre) of absorption process.
3. To study the effect of concentration of the methylene blue (MB) solution to the adsorption capacity.
4. To utilized the use of carbon produce from carbonization of palm oil residue that can be reuse or recycle to be another valuable product.

1.4 Research Scope

The scope of this study consists of:

1. Preparation of activated carbon using KOH as chemical activation
2. The initial concentration of methylene blue from 50, 100, 200, 300 and 400 mg/L
3. For methylene blue analysis, by using UV-Visible Spectrophotometer, the wavelength use is 665nm.
4. The effect of different percentage additional EFB into absorption process.
5. Activated carbon produce characterization using Fourier Transform Infrared Spectroscopy (FTIR)

1.5 Rationale and Significance of Study

Oil palm shredded pressed fibres and palm oil empty fruit bunch has been using in oil palm industry source of energy as fuel and it will cause air pollution. After the burning process the fiber will change into carbon and it will be as waste. That carbon can be use again as activated carbon for another process such as waste water treatment and chemical absorption.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition of Activated Carbon

Activated carbon (AC) is the carbonaceous material which an important thing in adsorption process. Its specialty to remove organic and inorganic chemical in waste, odor, taste and colour from any kind of chemical basically in waste water and water treatment based on their amazing properties. Activated carbon has high degree of surface reactivity which can influence its interaction with polar or nonpolar adsorbates. Besides, it also has higher surface area and micro porous structure. Activated carbon are widely use in wastewater treatment to remove harmful chemicals and heavy metal, industrial waste water or industrial flue gas. Their application in industry includes removing organic and inorganic pollutants from drinking water, industrial wastewater treatment, decolorizing of syrups and purification of air and pharmaceutical products. Activated carbon properties depend on:

- i. The polarity of the surface.
- ii. Pore size distribution.
- iii. The carbon surface area.
- iv. Chemical and porous structure of carbon
- v. Physical and chemical characteristic of adsorbate. (Bansal, 2005)
- vi. Heating method. (Foo *et al*, 2011)

2.2 Application of activated Carbon

Activated carbon is widely used in industrial waste water and many more. The examples of its usage are:

- i. Decolorizing of syrups, dye, sugars and molasses
- ii. Removal of Nitrogen from air.
- iii. Removal of SO_x and NO_x
- iv. Recovery of solvent vapors.
- v. Purification of helium
- vi. Water purification in removing in wastewater industry
- vii. Purification many chemical, pharmaceutical product and food industry
- viii. Air purification in inhabited space to remove odor.

2.3 Activated Carbon from Agriculture Waste Based

Activated carbon can be produce from organic material such as risk husk, coconut fiber and etc, also can find another new use for this activated carbon and the different method in journal.. “Liquid and solid waste, are a huge and always increasing problem for the industries and the environment. One of the most popular ways of dealing with solid waste is its use as a raw material for the production of activated carbons that can be subsequently employed for the removal of pollutants from liquid waste. As adsorbents, activated carbons bear extremely large surface area, with varying porous structure consisting of a network of interconnected macropores, mesopores and micropores. Their surface area also presents great diversity in terms of surface charge and surface groups, depending on the original raw material and the way of activation. For a raw material to be used for activated carbon production, it should have high carbon content. Agricultural waste is commonly exploited this way (Michailof *et al*, 2008).” Nowadays, this agriculture waste will be selling as material for combustion of furnace or boiler in industrial.

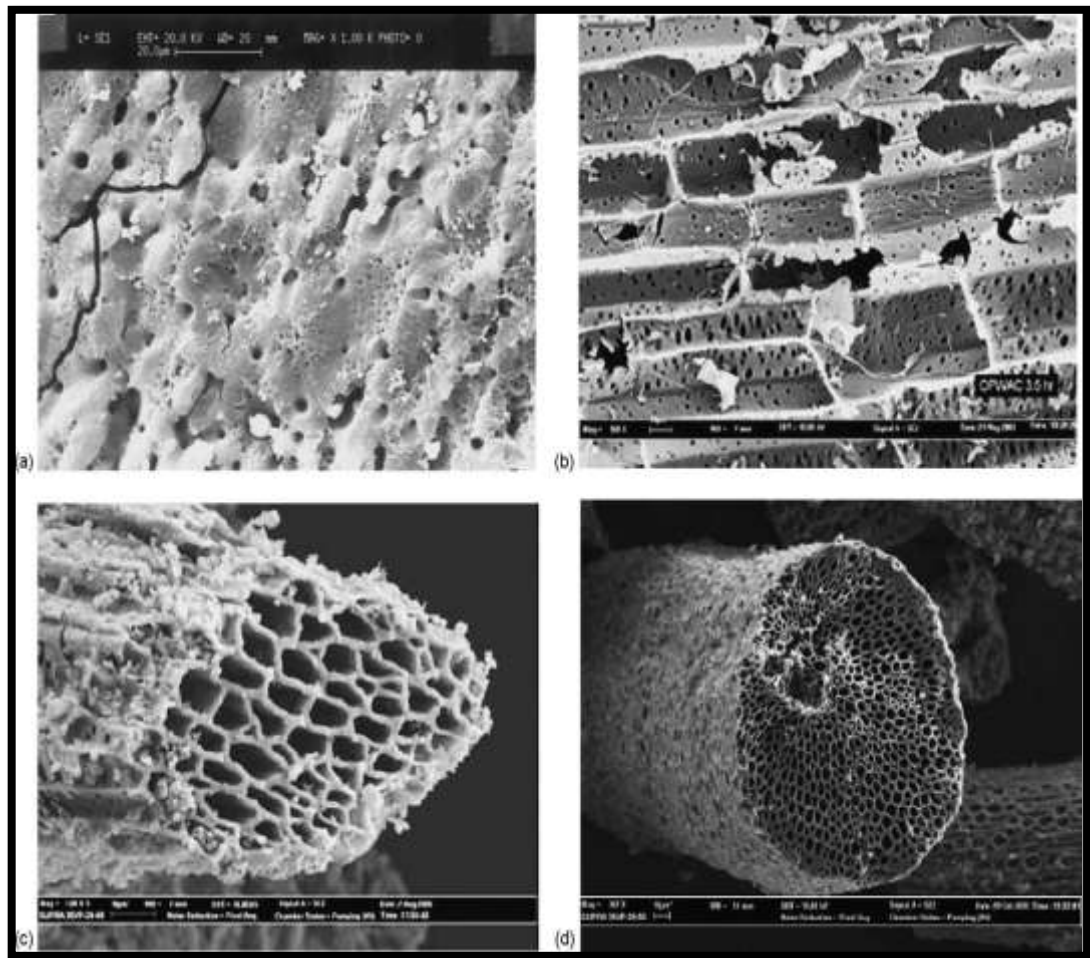


Figure 2.1: Scanning electron micrographs (SEM) of the activated carbons prepared from raw palm stone (a), oil palm wood (b), oil palm shell (c) and oil palm fiber (d)

Sources: Foo *et al*, (2009)

2.4 Preparation of Activated Carbon

For preparation of activated carbon, the material needs to be carbonizing at the high temperature without oxygen or with hydrogen flow to produce the carbon. The activation process can be doing before or after carbonizing process, it depends to the method that used. To activate the carbon there have to activation process, physical activation process and chemical activation process.

2.4.1 Physical Activation Process

For the physical process, the activate process will be made before the carbonizing process. The material will be boiling in distilled water at 150°C for 2 hour, than will be dehydrate in oven to remove moisture. Than the material will be carbonize to produce activated carbon. (Alam *et al*, 2007)

2.4.2 Chemical Activation Process

For the chemical process, the char produce can be activated by using chemical such as KOH, ZnCl₂, H₃PO₄ or H₂SO₄ to enhance carbon yield and produce micro pores on the surface of the carbon. The carbon can be active before or after carbonize. By using KOH as agent to make the activation. The char produce will be soak in KOH solution with an impregnation (char: KOH) ratio (wt.%). (Foo *et al*, 2011). Than the soaked char will be dehydrate in oven to remove moisture and will be carbonize again with high temperature.

2.5 Palm Oil Biomass as Source Renewable Energy

The demand of energy sources and depleting supply of natural sources such as crude oil and natural gas will led to higher government expenditures subsidies to keep retail fuel price. So, another alternative to replace the energy sources such as fuel, the new thing have been discover that it use the agriculture waste as renewable energy source. Biomass power plant has been build to generate electricity energy, combustion agent for boiler and furnace for industrial and many more. (Mohammed *et al*, 2011). Recycling of palm oil waste as resources for activated carbons production are ready mention at the above. Oil palm waste as the energy sources for power generation to generate heat and electricity by combustion. The used of palm oil waste as activated carbon has been discovered and it real give excellent absorption. (Foo *et al*, 2009)

2.5.1 Palm Oil Press Fibres (PPF)

In Malaysia, biomass mass waste such as wood waste, agricultural crop, mill residues and many more give approximately 15 million tones collected/year.(FRIM 2010). A palm-pressed fibre has been category as mill residues in oil palm process. Oil palm press fibre (OPPF) or mesocarp fibre, is the fibre obtained after expressing oil from the fruit mesocarp. On average, for every tonne of fresh fruit bunches (FFB) processed, 120 kg mesocarp fibre was produced. In 1993, an estimated 4.74 million tonnes of FFB was produced. (Astimar *et al.*, 2002) In this time, palm pressed fibres usually using as fuel in oil palm process plant. From the Figure 2.2 palm pressed fibres come from plam fruit, after extraction process palm fruit will be dry and it called palm pressed fibres.

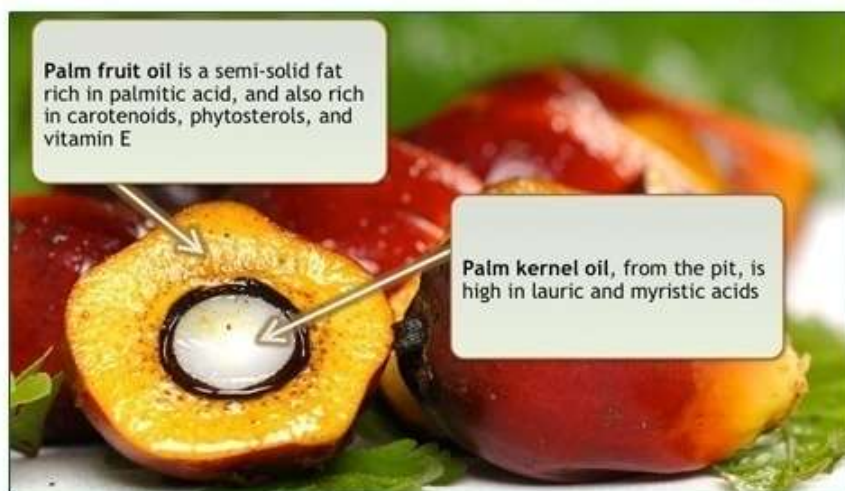


Figure 2.2: Cross Section of Palm Oil Fruit

2.5.2 Composition of Palm Oil Pressed Fibres (PPF)

Mostly characteristic of these residues is lignifications of the cellulose fibres, hemicelluloses, lignin and ash contain. Chemicals test has been made by using chemical treatment such as NaOH, KOH and many more to remove the unused contain. Table 2.1 shows the chemical composition of untreated palm-press fibres. It contain 39.9% of cellulose, 28.9% of hemicelluloses, 20.3 % of lignin and 3.6% ash contain. Table 2.2 show

the effect of chemical pretreatment on the composition of palm-press fibre. (Tong and Hamzah., 1989)

Table 2.1: Chemical Composition of Untreated Palm-Press Fibres

% Of Dry Matter				
	Cellulose	Hemicellulose	Lignin	Ash
Untreated	39.9	28.9	20.3	3.6

Source: Tong (1989)

Table 2.2: Effect of Chemical Pretreatment on the Composition of Palm-Press Fibres

% Of Dry Matter				
	Cellulose	Hemicellulose	Lignin	Ash
NaOH	40.7	29.1	8.0	9.2
KOH	44.5	27.7	14.6	3.3
Ca(OH) ₂	36.9	30.1	12.4	4.4
Na ₂ CO ₃	38.1	27.5	10.2	4.9
NH ₃	36.5	31.9	11.9	3.4
CO(NH ₂) ₂	36.4	35.5	15.9	9.8

Source: Tong (1989)

2.5.3 Palm Oil Empty Fruit Bunch (EFB)

Oil palms fruit will be harvested usually after 3 years from planting, but maximum yield can be achieved in the 12–14th year, and then continuously declines until the end of the 5th year. The Malaysian palm oil industry has grown tremendously over the last 25 years to become a very important agriculture-based industry, where the country is today the

world's leading producer and exporter of palm oil. The palm oil production has increased from 2.5 million tonnes in 1980 to 17.8 million tonnes in 2009 and presently Malaysia's production for 47% of the palm oil world production. "Palm oil forms about 10% of the whole palm oil tree, while the other 90% remains biomass. For example, fresh fruit bunch contains only 21% palm oil, while the rest 14–15% fiber, 6–7% palm kernel, 6–7% shell and 23% empty fruit bunch (EFB) are left as biomass" (Mohammed *et al*, 2011).



Figure 2.3: Palm Oil Empty Fruit Bunch

Source: Mohammed *et al*, (2011)

2.5.4 Composition of Empty Fruit Bunch (EFB)

Table 2.3 show the chemical composition of palm oil empty fruit bunch, it contains 38.3% of cellulose, 35.3% of hemicelluloses, 22.1% of lignin and 1.6% ash. Basically, the component has been built from the C-O that can help in production of carbon.

Table 2.3: Chemical Composition of Palm Oil Empty Fruit Bunch

Component	Chemical Composition (wt)%
Cellulose	38.3
Hemicellulose	35.3
Lignin	22.1
Ash	1.6

Source: Mohammed *et al*, (2011)

2.6 Introduction of Methylene Blue

Also called as dye, methylene blue (MB), its classification Number is 52,015, with chemical formula $C_{16}H_{18}N_3ClS$. Its molecule weight is 319.85 g/mol, the maximum wavelength is 668 nm (measured value). Methylene blue is usually used in absorption studies to measure the absorption of activated carbon. It is also harmful and should be handled safely. Make sure do not touch this chemical with bare hands.

2.6.1 Characteristic of Methylene Blue

The characteristics of methylene blue are summarized in Table 2.4 below.

Table 2.4: Characteristic of Methylene Blue

IUPAC name	
Other names	Dye
Molecular formula	$C_{16}H_{18}N_3ClS$
Molar mass (g/mol)	319.85
Appearance	Dark green powder Blue solution when dissolved in water
Density (g/cm ³)	1.757 (22°C)

Melting point (°C)	190
Solubility in water	50 g/L (20°C)
Acidity (pKa)	3.8

2.7 Langmuir Isotherm

Langmuir isotherm is a semi-empirical isotherm derived from a proposed kinetic mechanism. Langmuir isotherm is a model for monolayer localized physical adsorption on homogeneous surface; may be extended with heterogeneity effects, lateral interactions and multilayer effects. It is based on four assumptions:

- i. The surface of the adsorbent is uniform, that is, all the adsorption sites are equivalent.
- ii. Adsorbed molecules do not interact.
- iii. All adsorption occurs through the same mechanism.
- iv. At the maximum adsorption, only a monolayer is formed: molecules of adsorbate do not deposit on other, already adsorbed, molecules of adsorbate, only on the free surface of the adsorbent. (Ignatowicz, 2011)

The Langmuir equation may be written as:

$$qe = qm \frac{kL}{1+kL} \quad (2.1)$$

Where,

qe (mg/g) = amount of methylene blue adsorbed on the adsorbent surface at equilibrium,

c (mg/L) = methylene blue concentration in aqueous solutions at equilibrium,

qm (mg/g) = maximum monolayer adsorption capacity,

kL = constant related to the free energy of adsorption.

Equation 2.1 can be linearized to form equation 2.2 at the below.

$$\frac{C_e}{q_e} = \frac{1}{Q_0} C_e + \frac{1}{Q_0 k_L} \quad (2.2)$$

Where:

C_e = Equilibrium concentration of methylene blue in mg/L

q_e = Amount adsorbed at equilibrium in mg/g

Q_0 = Maximum adsorption capacity

k_L = Adsorption equilibrium constant in L/mg

The equation is then compared with the straight line graph of C_e/q_e versus C_e to get the value of maximum adsorption capacity Q_0 and adsorption equilibrium constant k_L

Reference. *Hameed et al (2011)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Preparation of Raw Material

The palm pressed fibres (PPF) and palm oil empty fruit bunch (EFB) will be using as raw material in this study. It can be obtained from a palm oil in Malaysia (Tong and Hamzah, 1989). Raw material uses in this study were obtained from Kilang Sawit LCSB Lepar, Kuantan, Malaysia. The sample was been cleaning to remove ash contain, empty fruit bunch was shredded from it stem.

Sample was dry in oven for 24 hour with temperature 105°C. The dry sample of palm press fibre been prepare with different additional percentage of empty fruit bunch 20%, 40%, 50%, 60% and 80% (PPF:EFB) (wt%).

3.3 Adsorbate

Methylene blue (MB) also called as dye with chemical formula $C_{16}H_{18}N_3ClS$, molecule weight 319.85 gram per mol and with max wave length is 668 nm (measured value), obtain from FKKSA laboratory. It was using as the adsorbate in this study.

3.3 Chemical and Apparatus

During the experiment, there is another chemical that used other than metylene blue and apparatus to complete the research. The chemical and apparatus that use is a following:

List of chemical use:

- i. Potassium Hydroxide (KOH)
- ii. Hydrogen Chloride (HCl)
- iii. Distilled water

List of glassware and apparatus:

- i. Volumetric flask 1000ml
- ii. Beaker 50ml and 100ml
- iii. Measuring cylinder 10ml
- iv. Glass rod
- v. Conical Flask 250ml
- vi. Whatman filter paper
- vii. pH meter
- viii. UV-Visible Spectrophotometer
- ix. Furnace, oven and centrifugal
- x. Blander
- xi. Pipe 10ml
- xii. Centrifugal tube
- xiii. Fourier Transform Infrared Spectroscopy (FTIR)

3.4 Preparation of Activated Carbon and Activation

The sample was weight to find early weight and carbonized using gas furnace with ramping increasing to 200°C for 2 hour, constant 200°C for 30 minutes, increasing to 250°C for 1 hour, constant 250°C for 30 minutes and cooling to 100°C for 3 hour. This carbonized conducting with purified nitrogen gas 99.99% all the time.

The char produce have been take out from the gas furnace and cooling down to room temperature. The char produce have been weight to find weight lost for calculation char yield. The char produced was soaked in potassium hydroxide (KOH) solution with an impregnation (char:KOH) ratio of 1:0.5 (wt%). The mixture was then dehydrated in an

oven overnight at 105°C to remove moisture and was then activated under the same condition as carbonization, but to a 300°C. The activated product was then cooled to room temperature again then washed with distilled water and 0.1 M hydrochloric acid until the pH of the washing solution reached 6-7. The washed continue until the washing solution gives very less black colour.

3.5 Equilibrium Adsorption Studies

About 0.2 g of adsorbed was added into the 250 ml conical flask with known concentration of methylene blue. Then the solution was shaken for 24 hours by using the orbital shaker at 150 rpm. The 5 ml of solution then separate from their precipitate by using centrifugal. 1ml of separated solution was dilute into 10ml volumetric flask, the dilute solution placed into cuvette and measured with UV-Visible spectrophotometer at wavelength of 665nm.

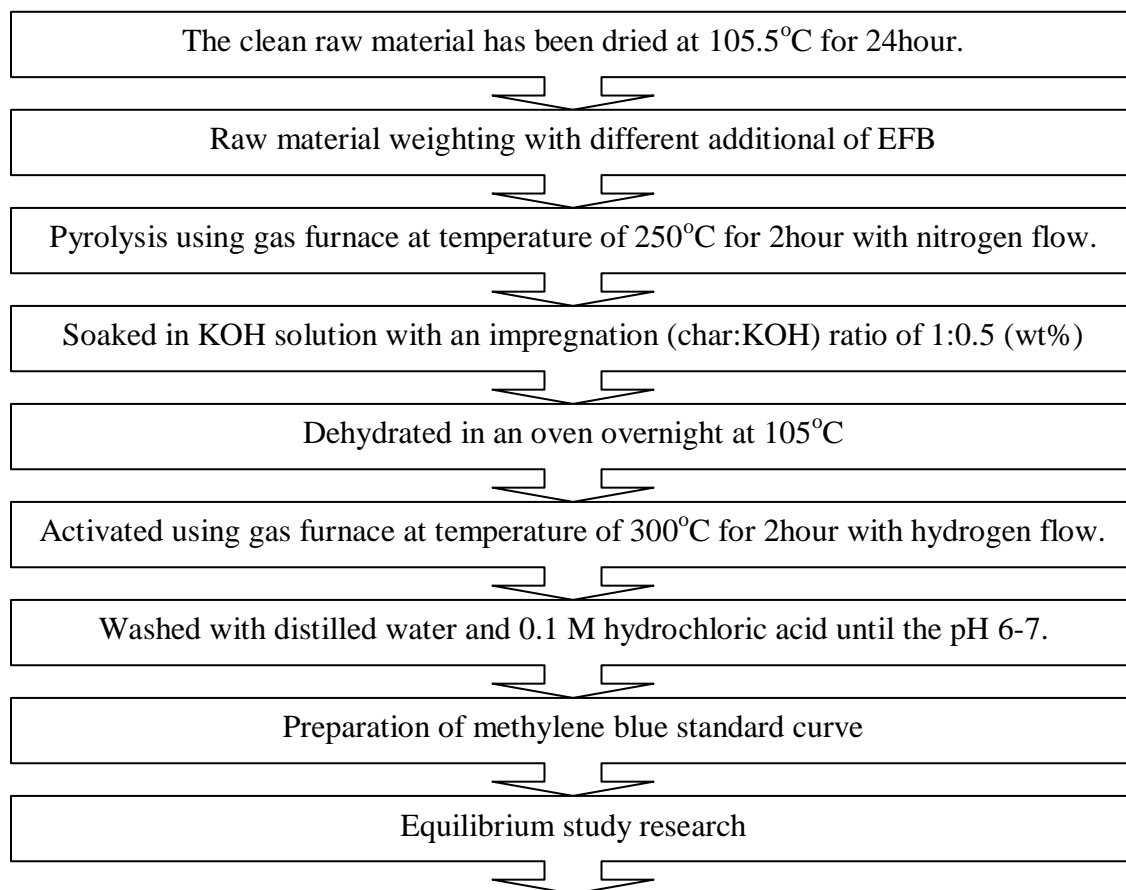
3.5.1 Preparation of Calibration Curve

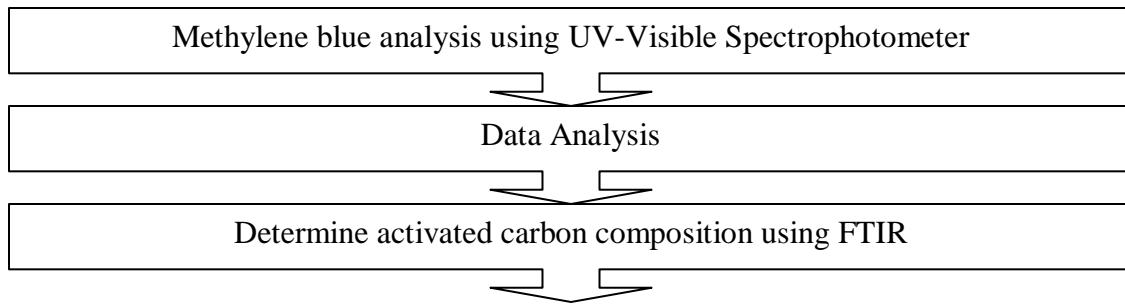
Standard or calibration curve is a method used to determine the unknown concentration of methylene blue solution by comparing the unknown concentration with a standard sample of known concentration. The method can convert the value of absorption (ABS) from UV-Visible Spectrophotometer reading into the value of concentration. Hence final concentration of methylene blue solution can be known. Standard curve was prepared by dilution of methylene blue solution into 1, 5, 10, 15 and 20 mg/L. Then measure the ABS by using UV-Visible Spectrophotometer. Then the graphs of absorption (ABS) are plotted against initial methylene blue concentration.



Figure 3.1: UV-Visible Spectrophotometer

3.6 Summary of Research Procedure





3.7 Research Design Calculations

3.7.1 Percentage Methylene Blue Removal Equation

For the percentage removal of methylene blue, the equation used as follow:

$$\%ABS = \frac{Co - Ce}{Co} \times 100 \quad (3.1)$$

Where:

Co = Initial concentration of methylene blue in mg/L

Ce = Equilibrium concentration of methylene blue in mg/L

3.7.2 Equilibrium Adsorption Equation

To calculate equilibrium adsorption data the equation used as follow:

$$qe = \frac{(Co - Ce)V}{W} \quad (3.2)$$

Where:

Co = Initial concentration of methylene blue in mg/L

Ce = Equilibrium concentration of methylene blue in mg/L

V = Volume of the solution in L

W = Mass of the adsorbent use in g

Reference. *Hameed et al (2011)

3.7.3 Langmuir Isotherm Equation

To calculate Langmuir Isotherm data the equation used as follow:

$$\frac{C_e}{q_e} = \frac{1}{Q_o} C_e + \frac{1}{Q_o k_L} \quad (3.3)$$

Where:

C_e = Equilibrium concentration of methylene blue in mg/L

q_e = Amount adsorbed at equilibrium in mg/g

Q_o = Maximum adsorption capacity

k_L = Adsorption equilibrium constant in L/mg

The equation is then compared with the straight line graph of C_e/q_e versus C_e to get the value of maximum adsorption capacity Q_o and adsorption equilibrium constant k_L .

Reference. *Hameed et al (2011)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Calibration Curve of Methylene Blue

Table 4.1 shows the calibration data on phenol at different initial concentration ranging from 0 until 50 mg/L. The ABS values are increased as the concentration increased.

Table 4.1: Calibration Data of Phenol at Initial Concentration 1 until 20 ppm

Concentration (ppm)	ABS
1	0.204
5	0.836
10	1.676
15	2.229
20	2.796

Figure 4.1 show the straight line graph of different concentration of methylene blue from 1 to 20 ppm versus ABS

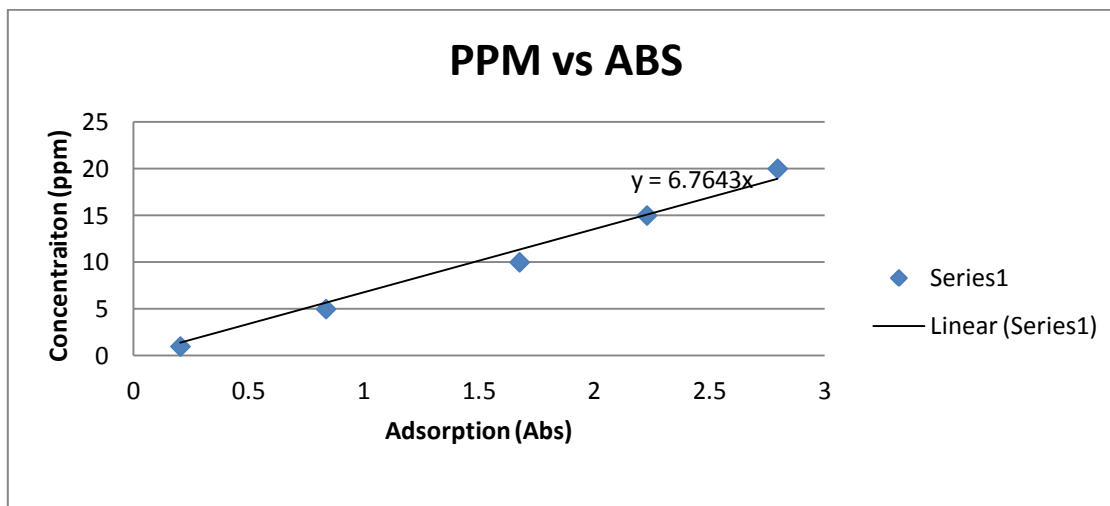


Figure 4.1: Concentration of Methylene Blue versus ABS

4.2 Adsorption Percentage Study

Table 4.2 below shows the absorption data from UV-Visible Spectrophotometer the adsorption of methylene blue with different initial concentration and different additional percent composition of empty fruit bunch into palm press fibre. The final concentration of the methylene blue were determine using calibration graph to determine final concentration of the solution.

Table 4.2: Adsorption of Methylen Blue with Different Initial Concentration and Additional Of Empty Fruit Bunch

Additional EFB (%)	%ABS				
	50ppm	100ppm	200ppm	300ppm	400ppm
20	95.008168	31.88652	16.93808	10.0388	18.1556
40	76.298944	14.0972	21.57142	4.447227	22.48456
50	96.577416	91.572056	57.25152	46.02328	24.61522
60	96.306856	96.827684	50.2846	15.26963	10.74902
80	84.591608	98.552504	92.08612	28.07613	39.09018



Figure 4.2: Final Concentration of Methylene Blue with Initial Concentration 50ppm

The Table 4.2 shows, at initial concentration methylene blue 50ppm. The adsorption is more than 90% for additional 20%, 50% and 60% of EFB into PPF. At 40% additional of EFB it show the lower percentage adsorption of methylene blue and for the 80% additional EFB, there is very close to percentage adsorption of another additional EFB. From the experiment observation, at the 80% additional EFB show that it also give more adsorption, but the black colour from the activated carbon effected the reading of UV-Visible Spectrophotometer. This observation show in Figure 4.2



Figure 4.3: Final Concentration of Methylene Blue with Initial Concentration 100ppm

Figure 4.3 show the final concentration of methylene blue with initial concentration 100ppm. There is not a lot different to observe and the same observation result for 200ppm, 300ppm and 400ppm. The final concentration of methylene blue at this all concentration needs to be dilute to find the ABS using UV-Visible Spectrophotometer.

Figure 4.4 below is a graph of percentage adsorption verses initial concentration of methylene blue.

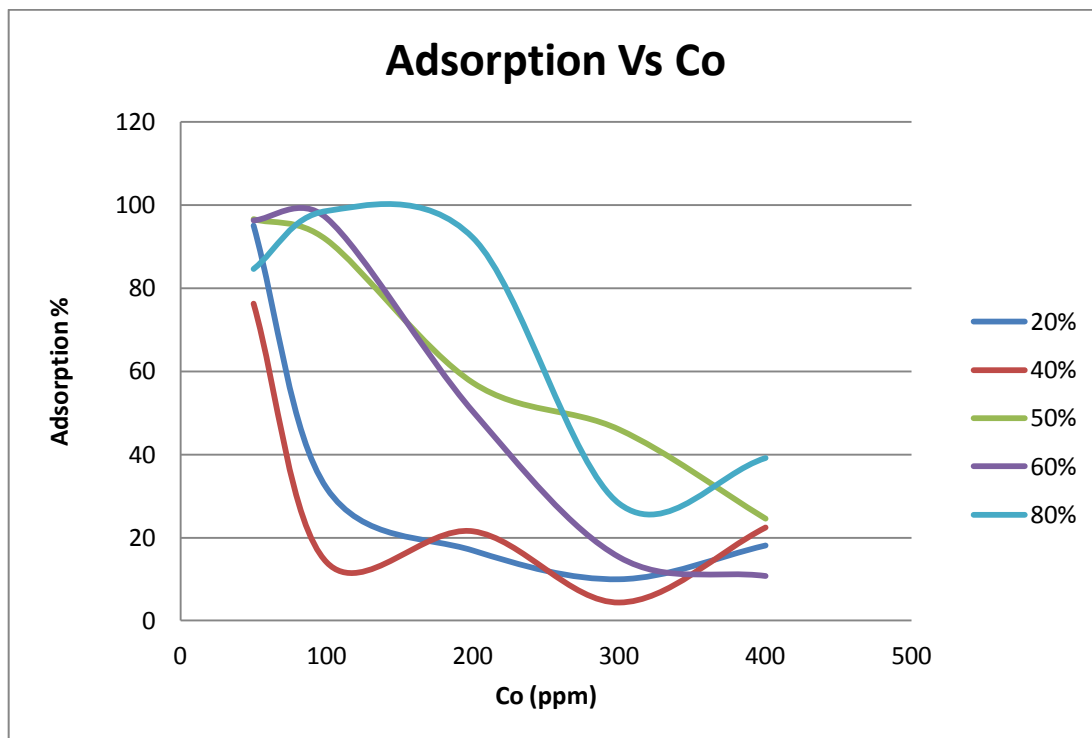


Figure 4.4: Graph Adsorption of Methylene Blue Versus Initial Concentration.

From the Figure 4.4, at 80% additional of EFB into PPF give more adsorption when initial concentration methylene blue 100 ppm and 200 ppm. As what been discuss at the above, at the concentration 50 ppm for 80% additional EFB, there have disturbance of activated carbon black colour that effect UV-Visible Spectrophotometer reading. This mean, 80% additional of EFB into PPF give excellent adsorption percentage that other additional of EFB.

4.3 Equilibrium Adsorption Study

Figure 4.5 below show the equilibrium adsorption versus initial concentration of methylene blue for 5 different additional composition of EFB into PPF in percentages.

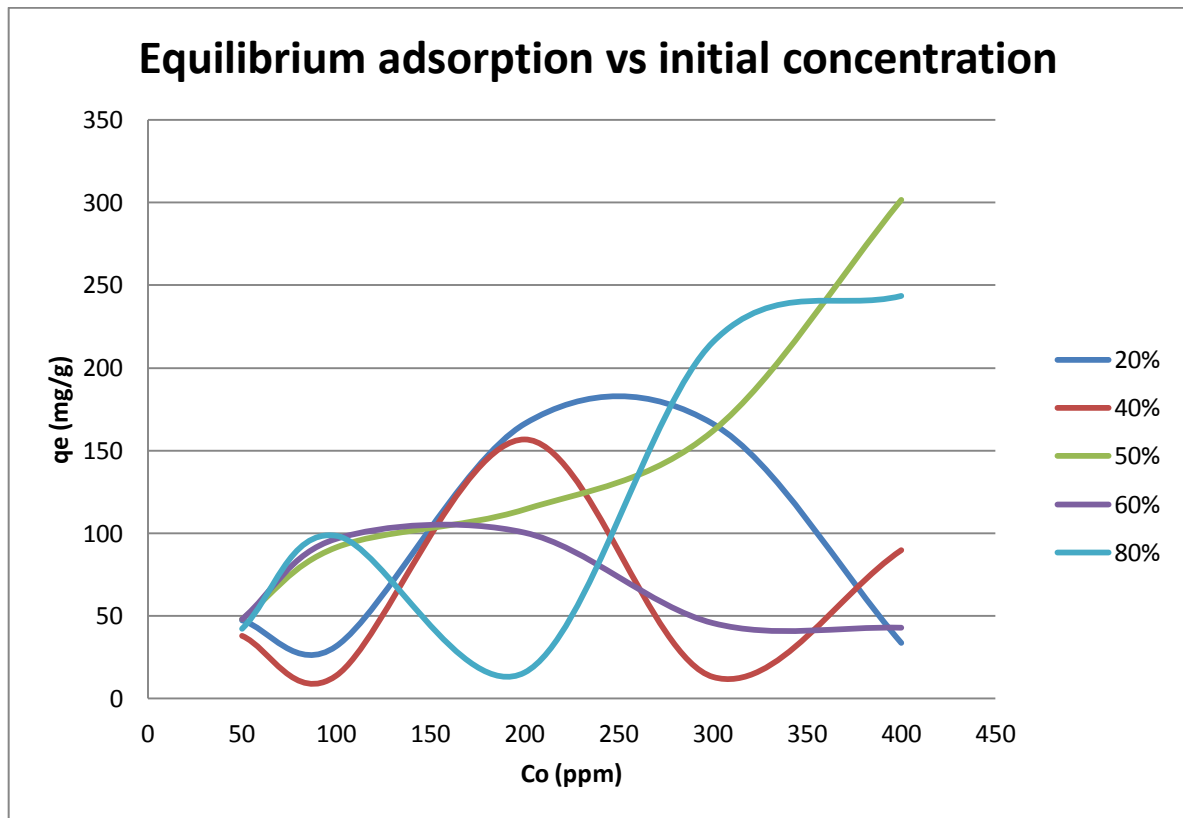


Figure 4.5: Graph of Equilibrium Adsorption versus Initial Concentration of Methylene Blue.

From the Figure 4.4 there is graph of equilibrium adsorption versus initial concentration of methylene blue. The trend for any additional percentage of EFB in to PPF show there is no reaching the equilibrium state. The trends of the graph are not steady. But, for the the 50% additional of EFB, it show the increasing of the adsorption equilibrium. That mean, the 50% additional of EFB can absorb more and event the concentration of the methylene blue high, it also can give excellent performance.

Basically, when the concentration is increase, the percentage adsorption will be decrease. According to equation 3.2, when the value of adsorption increase, equilibrium adsorption also will increase. (Tan *et al*, 2008). From the result what show in Figure 4.4 for percentage adsorption and figure 4.5 for the equilibrium concentration, there only have 1

trend that show the right condition for the adsorption, it is 50% percentage weight additional empty fruit bunch into palm oil press fibre. For another trend, the reason of the random trend for the adsorption percentage and equilibrium adsorption is, there have having desorption. Desorption is a process that the activated carbon will absorb the matylene blue into it porous then when the capacity of that porous if high and it can't absorb another matylene blue, it will release back the matylene blue in the porous into the solution again. (Blockhaus *et al*, 1996).

4.4 Langmuir Isotherm

Five set samples of methylene blue solution at different concentration have been prepared. The sample of activated carbon was prepared with different percentage additional of empty fruit bunch in to palm press fibres. Initial and final ABS readings are taken from UV-Visible Spectrophotometer and converted into concentration values. The equilibrium concentrations are tabulated in Table 4.3 below.

The langmuir isotherm indicates how the adsorption molecules distribute between the solid phase and the liquid phase when the adsorption process reaches an equilibrium state. The analysis of the isotherm data by fitting them to different isotherm models is an important step to find the suitable model that can be used for design purposes. Adsorption isotherm is basically important to describe how solutes interact with adsorbents, and is critical in optimizing the use of adsorbents. The langmuir isotherm is used in this research to determine the applicability of the isotherm models to the adsorption study done was compared by take the correlation coefficients, R^2 values.

The equation 3.3 at the below is the langmuir isotherm equation and the related with the equation 4.2 are basic straight line equation.

$$\frac{C_e}{q_e} = \frac{1}{Q_0} C_e + \frac{1}{Q_0 k_L} \quad (3.3)$$

$$y = mx + c \quad (4.2)$$

The graph C_e/q_e versus C_e has been plot. From the equation 3.3 and 4.2, it can be related to equation 4.3 and 4.4 that use to determine the maximum adsorption capacity (Q_0) and adsorption equilibrium constant in L/mg (kL).

$$m = \frac{1}{Q_0} \quad (4.3)$$

$$C = \frac{1}{Q_0 k_L} \quad (4.4)$$

Table 4.3 Equilibrium Concentration and Equilibrium Concentration over Equilibrium Adsorption at Different Percentage Additional Of EFB into PPF

Co	Percentage Additional EFB into PPF											
	20%		40%		50%		60%		80%			
	Ce _{vol}	Ce/qe _{vol}	Ce _{vol}	Ce/qe _{vol}	Ce _{vol}	Ce/qe _{vol}	Ce _{vol}	Ce/qe _{vol}	Ce _{vol}	Ce/qe _{vol}		
50	2.495916	0.052541	11.85053	0.310634	1.711292	0.035439	1.846572	0.038348	7.704196	0.18215		
100	68.11348	2.136121	85.9028	6.093607	8.427944	0.092036	3.172316	0.032762	1.447496	0.014688		
200	166.12384	4.903857	156.8572	3.635763	85.49696	0.746679	99.4308	0.98868	15.82776	0.08594		
300	269.8836	8.96135	286.6583	21.48592	161.9302	1.172813	254.19112	5.548949	215.7716	2.561744		
400	327.3776	4.507942	310.0618	3.447496	301.5391	3.062527	357.00392	8.303174	243.6393	1.558187		

Figure 4.6.4.7.4.8, 4.9 and 4.10 show the graph of C_e/q_e versus C_e .

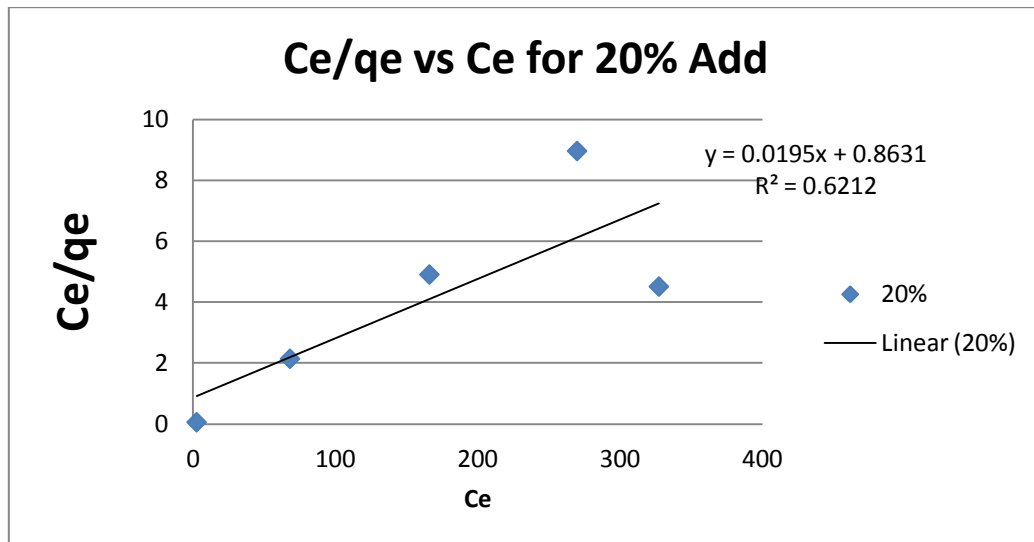


Figure 4.6: Graph of C_e versus C_e/Q_e For 20% Additional Percentage of EFB

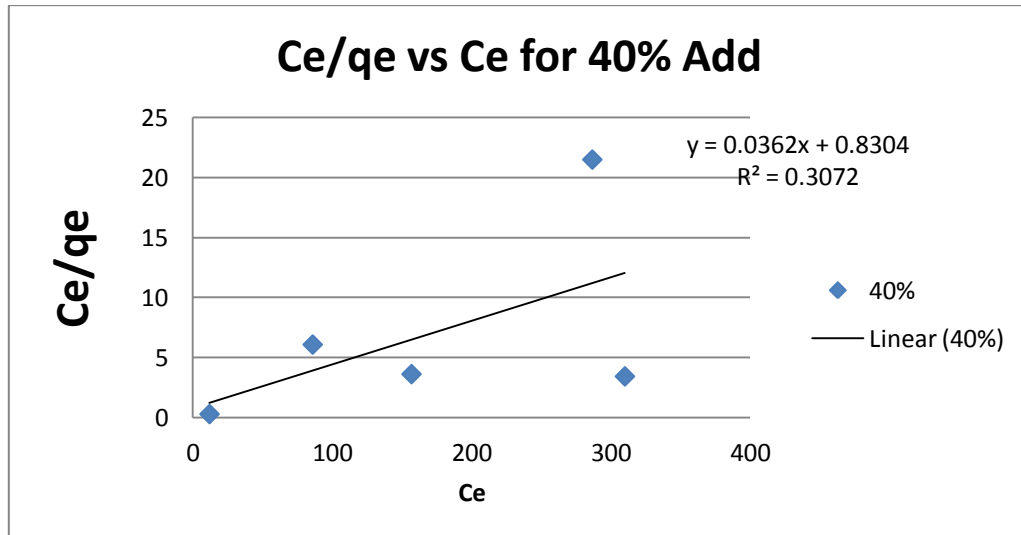


Figure 4.7: Graph of C_e versus C_e/Q_e For 40% Additional Percentage of EFB

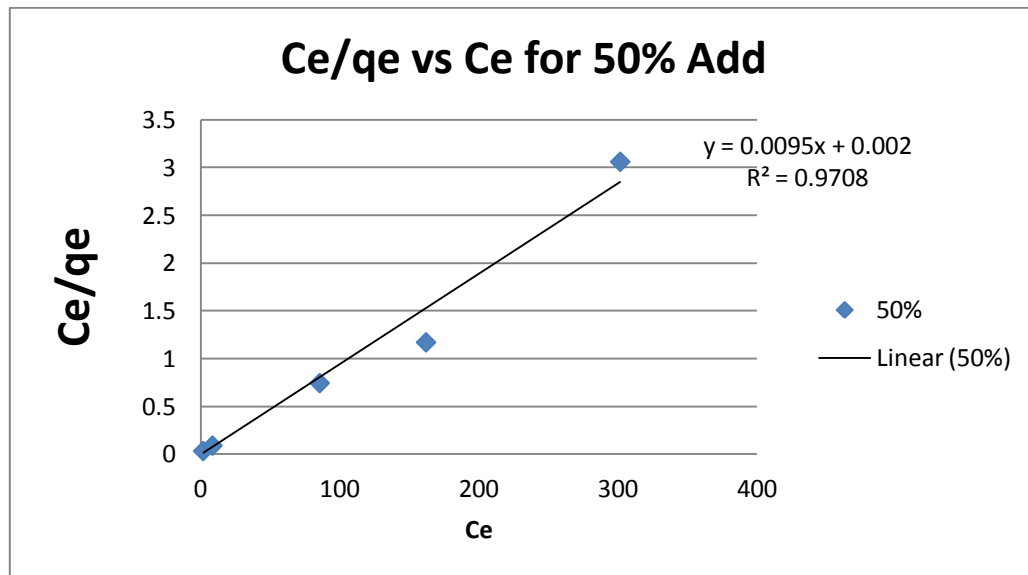


Figure 4.8: Graph of Ce versus Ce/Qe For 50% Additional Percentage of EFB

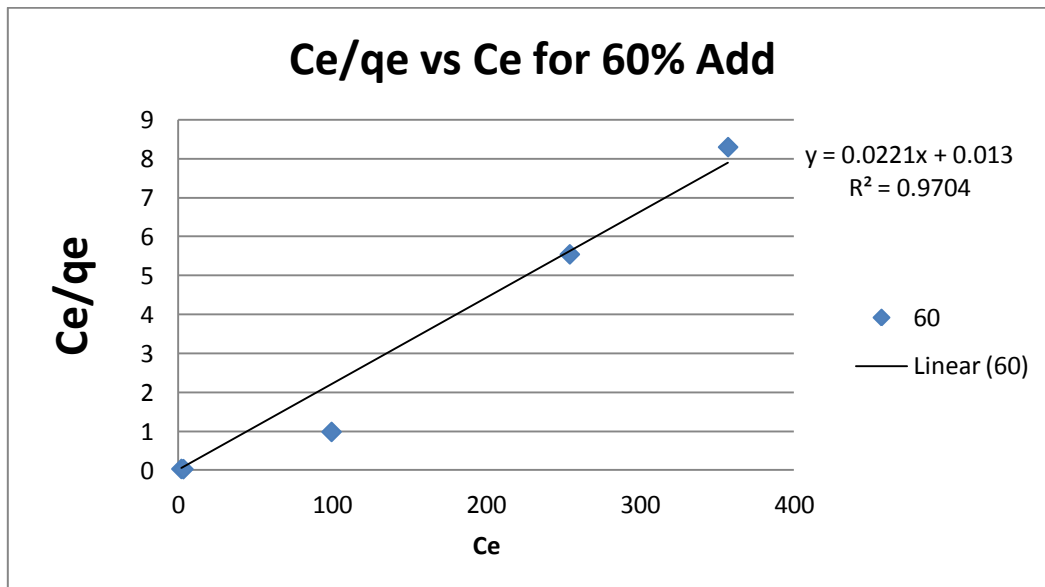


Figure 4.9: Graph of Ce versus Ce/Qe For 60% Additional Percentage of EFB

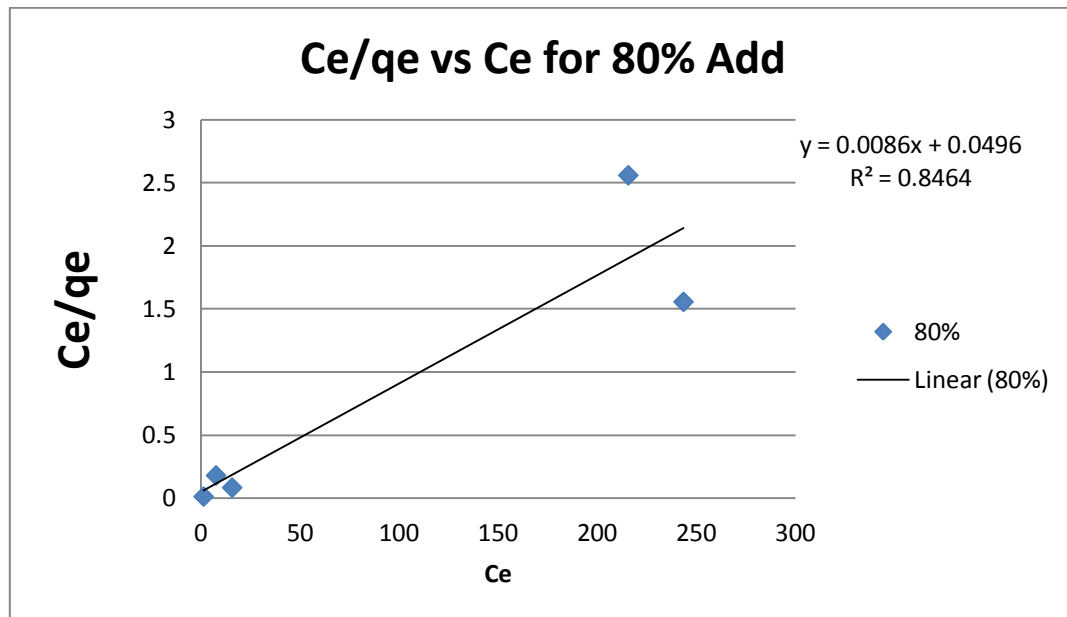


Figure 4.10: Graph of Ce versus Ce/Qe For 80% Additional Percentage of EFB

When Ce/q_e was plotted against Ce , a straight line with slope of $1/Q_0$ was obtained, as shown in Figure. From the Figure 4.5 and 4.6, the value of R^2 is 0.97 and it is the highest value than other R^2 for another figure. This mean at the additional of EFB into PPF is 50% and 60% were best fitted to the Langmuir isotherm model. The Langmuir constants Q_0 and k_L were calculated from equation 4.4 and 4.5 and their values are shown in Table 4.4.

From the result, there only 50% and 60% additional percentage weight of empty fruit bunch into palm oil press fibre conditions that can be use the langmuir isotherm and it is satisfy the the value need for the R^2 . For another condition, it's can't use there lagmuir isotherm because for another additional percentage weight, maybe the data from there experiment have many error that happen when running the experiment or the natural desorption of the activated carbon. To achieve the langmuir isotherm, it is based on four assumption. The surface of the adsorbent is uniform, that is, all adsorption sites are equivalent, molecules adsorbed do not interact, adsorption occurs through the same mechanism and with maximum adsorption avoid the desorption. (Ignatowicz, 20111)

4.5 Summary of Langmuir Isotherm

Table 4.4 below show the data for the Q_0 and k_L for each langmuir isotherm graph at the above. What those have been discussing before, the highest R^2 is for 50% and 60% of additional composition of EFB into PPF. Data in the Table 4.4 show, at the 50% additional composition of EFB into PPF, the Q_0 is 111.111 and k_L is 4.5. For the 60% additional of composition of EFB into PPF, the Q_0 is 45.4545 and k_L is 1.69231.

Table 4.4: Langmuir Isotherm Constants and Regression Correlation Coefficients

%	Langmuir Isotherm Model				
	m	Q_0	k_L	c	R^2
20	0.019	52.6316	0.02202	0.863	0.621
40	0.036	27.7778	0.04337	0.83	0.307
50	0.009	111.111	4.5	0.002	0.97
60	0.022	45.4545	1.69231	0.013	0.97
80	0.008	125	0.16327	0.049	0.846

4.6 Characterization of Activated Carbon

To determine the characterization of activated carbon that has been produce, the FTIR were used. From the results that have in langmuir isotherm, there are 2 highest value of R^2 . Figure 4.10 show the wavelength from the FTIR reading for the activated carbon produce with 50% additional composition of EFB into PPF. The obtained spectrum of activated carbon exhibited intensive peaks at 3655.52, 3564.97, 2933.94, 1711.87, 1092.02,

992.78 and 537.24 cm^{-1} , which are identical to the presence of $-\text{OH}$ (hydroxyl), C-H (alkanes and alkyls), C=O (Ketone or Asidcarbosilik), C-O-C (esters, eter or phenol) and Bromida or Iodida.

Figure 4.11 show the wavelength from the FTIR reading for the activated carbon produce with 60% additional composition of EFB into PPF. The obtained spectrum of activated carbon exhibited intensive peaks at 3649.20, 2868.99, 1705.61 and 1109.83 cm^{-1} , which are identical to the presence of $-\text{OH}$ (hydroxyl), C-H (alkanes and alkyls), C=O (Ketone or Asidcarbosilik), and C-O-C (esters, eter or phenol). But from the spectrum missing part also have spectrum wavelength that consider as Bromida or Iodida.

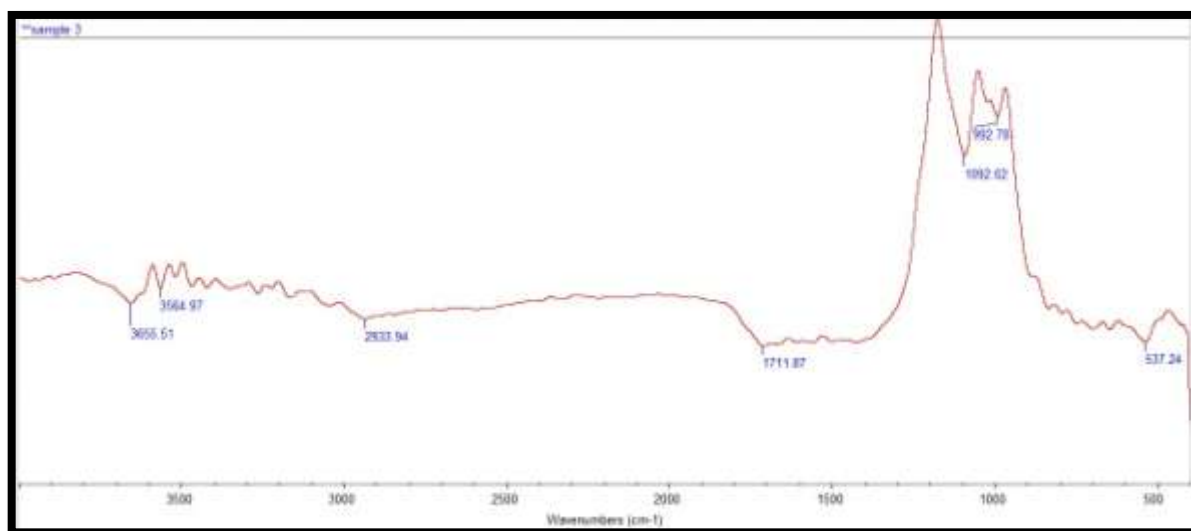


Figure 4.10: FTIR of Activated Carbon For 50% Additional Composition of EFB into PPF

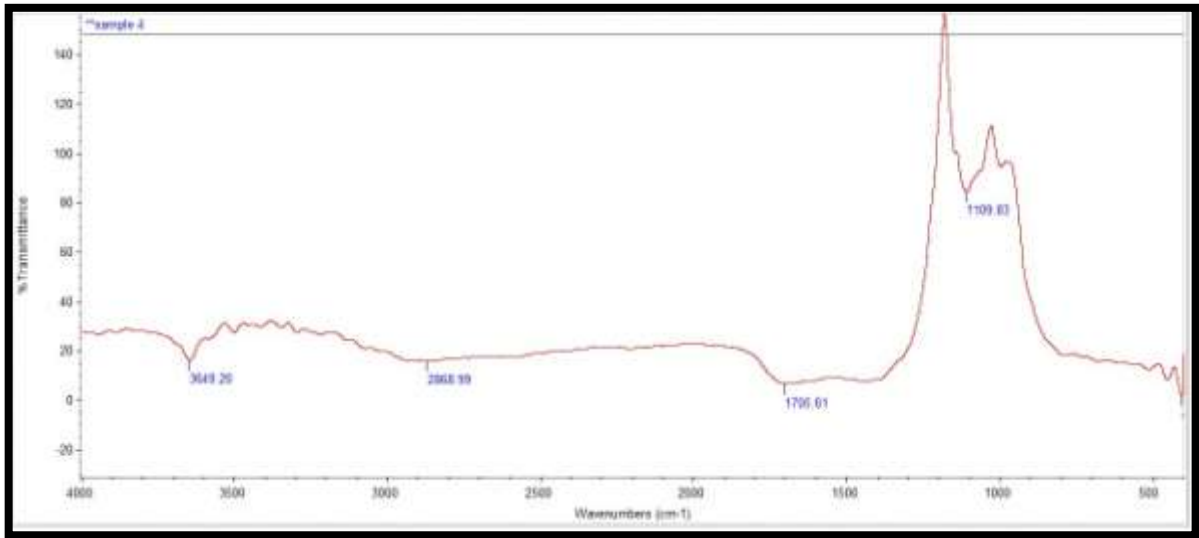


Figure 4.11: FTIR of Activated Carbon For 60% Additional Composition of EFB into PPF

CHAPTER 5

CONCLUSION

5.1 Conclusion

For this research, the activated carbon is successfully produced with different additional percentage weight composition of empty fruit bunch into palm oil pressed fibre. From the research that has been done. The result show, the adsorption will increase with increasing additional percentage weight of empty fruit bunch. This mean, the empty fruit bunch gives more adsorption then palm oil press fibres. There still have error when running the experiment like the black colour of activated carbon that be disturb the reading of UV-Visible Spectrophotometer. Also, from 5 sample that made. The sample for 40% additional percentage weight of empty fruit bunch into palm oil press fibre not is successfully activated. That will cause the adsorption for this sample is lower than another sample.

To determine the best adsorption for this activated carbon produce, the langmuir isotherm has been use to determine the R^2 . From the result, the hight R^2 are 50% and 60% additional percentage weight of empty fruit bunch into palm oil press fibre with the value is 0.97. The summary of langmuir isotherm for maximum adsorption capacity (Q_0) and adsorption equilibrium constant (k_L) have been show in Table 4.4. The characterized of the activated carbon produce have been analysis using Fourier Transform Infrared Spectroscopy (FTIR). The both additional percentage weight that have higher value of R^2 have been study. From the spectrum of FTIR reading, both of additional percentage weight which are identical to the presence of $-OH$ (hydroxyl), $C-H$ (alkanes and alkyls), $C=O$

(Ketone or Asidcarbosilik), and C-O-C (esters, eter or phenol). But from the spectrum missing part also have spectrum wavelength that consider as Bromida or Iodida.

From the research that has been done, that can be conclude the carbon produce from carbonization of palm oil residue can be reuse or recycle to activated carbon for another used such as in dry removal and many more.

5.2 Recommendation

The experiment still do not have the exactly result. There are still having errors when running the experiment. The recommendation in running the experiment if try to avoid the human error, use new and good condition apparatus and equipment. To get the best value or accurate result, experiment should be running at least 5 times and the best result is taken from the 5 set experiment. Also, the value of the data should be taken more than 5 and the mean for that value need be calculated. The measurement should be accurate and avoid any ash contain from the outside.

This research is to reuse or recycle of the activated carbons that produce in combustion of palm oil residue. But, after the treatment the used activated carbon will be contain the chemical that it adsorb. So, it will be category as the schedule waste. To avoid this problem, the used activated carbon can be study more that it can be recycle again or not. For the chemical use as adsorbate. There should be use the waste water from the industry, there can be see either the activated carbon produce can be use to treatment in industry or not.

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APPENDIX A

RESEARCH CALCULATION

Research calculation for dilution of HCl and Methylene Blue Solution

HCl Calculation

Stock bottle of 37% HCL.

Determination of molarity of 37% HCL V/V

37 ml of solute/100 ml of solution.

HCL - 37% v/v. Specific gravity: 1.19 g/ml

37ml/100 ml or 370 ml/1000 ml x 1.19 g/ml = 440.3 g/L

HCL Molecular weight = 36.5

Molarity:

440.3 grams /36.5 grams = 12.06 M or ~12M

Compounding 1 liter of 0.1N Solution

$M_1V_1 = M_2V_2$

$(0.1)(1000) = (12)(x)$

$$x = (0.1) (1000) / 12$$

$$x = 8.3 \text{ ml}$$

Therefore add 8.3 ml of 37% HCL to 1 liter of D5W or NS to create a 0.1N HCL solution.

Methylene Blue Calculation

Preparation 1, 5, 10, 15 and 20 mg/l solution of methylene blue for calibration curve study.

100mg MB powder add into 1L of distilled water to produce 100mg/L MB solution

$$M_1V_1 = M_2V_2 \quad M=(\text{mg/L}) \quad V=(\text{L})$$

$$100(V_1) = 1(0.1) \quad V_2 = 0.5 \text{ ml}$$

$$100(V_1) = 5(0.1) \quad V_2 = 2.5 \text{ ml}$$

$$100(V_1) = 10(0.1) \quad V_2 = 5 \text{ ml}$$

$$100(V_1) = 15(0.1) \quad V_2 = 7.50 \text{ ml}$$

$$100(V_1) = 20(0.1) \quad V_2 = 10 \text{ ml}$$

For preparation 50, 100, 200, 300 and 400 mg/L methylene blue solution.

0.05gram MB powder has been weight and add into 1L of distilled water.

0.1 gram MB powder has been weight and add into 1L of distilled water.

0.2 gram MB powder has been weight and add into 1L of distilled water.

0.3 gram MB powder has been weight and add into 1L of distilled water.

0.4 gram MB powder has been weight and add into 1L of distilled water.

APPENDIX B

MSDS SHEET, MATERIAL SAFETY DATA SHEET

Hydrochloric Acid MSDS Sheet, Material safety Data Sheet

HYDROCHLORIC ACID, 33 - 40%

MSDS Number: H3880 --- *Effective Date: 11/17/99*

1. Product Identification

Synonyms: Muriatic acid; hydrogen chloride, aqueous

CAS No.: 7647-01-0

Molecular Weight: 36.46

Chemical Formula: HCl

Product Codes:

J.T. Baker: 5367, 5537, 5575, 5800, 5814, 5839, 6900, 7831, 9529, 9530, 9534, 9535, 9536, 9537, 9538, 9539, 9540, 9544, 9548

Mallinckrodt: 2062, 2612, 2624, 2626, 5587, H611, H613, H987, H992, H999, V078, V628

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
-----	-----	-----	-----
Hydrogen Chloride 40% Yes	7647-01-0	33 -	
Water 67% No	7732-18-5	60 -	

3. Hazards Identification

Emergency Overview

POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS

**TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED.
INHALATION MAY CAUSE LUNG DAMAGE.**

J.T. Baker SAF-T-DATA^(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)

Flammability Rating: 0 - None

Reactivity Rating: 2 - Moderate

Contact Rating: 3 - Severe (Corrosive)

Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD;
PROPER GLOVES

Storage Color Code: White (Corrosive)

Potential Health Effects

Inhalation:

Corrosive! Inhalation of vapors can cause coughing, choking, inflammation of the nose, throat, and upper respiratory tract, and in severe cases, pulmonary edema, circulatory failure, and death.

Ingestion:

Corrosive! Swallowing hydrochloric acid can cause immediate pain and burns of the mouth, throat, esophagus and gastrointestinal tract. May cause nausea, vomiting, and diarrhea. Swallowing may be fatal.

Skin Contact:

Corrosive! Can cause redness, pain, and severe skin burns. Concentrated solutions cause deep ulcers and discolor skin.

Eye Contact:

Corrosive! Vapors are irritating and may cause damage to the eyes. Contact may cause severe burns and permanent eye damage.

Chronic Exposure:

Long-term exposure to concentrated vapors may cause erosion of teeth. Long term exposures seldom occur due to the corrosive properties of the acid.

Aggravation of Pre-existing Conditions:

Persons with pre-existing skin disorders or eye disease may be more susceptible to the effects of this substance.

4. First Aid Measures

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion:

DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention immediately.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

5. Fire Fighting Measures

Fire:

Extreme heat or contact with metals can release flammable hydrogen gas.

Explosion:

Not considered to be an explosion hazard.

Fire Extinguishing Media:

If involved in a fire, use water spray. Neutralize with soda ash or slaked lime.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Structural firefighter's protective clothing is ineffective for fires involving hydrochloric acid. Stay away from ends of tanks. Cool tanks with water spray until well after fire is out.

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB(R) or TEAM(R) 'Low Na+' acid neutralizers are recommended for spills of this product.

7. Handling and Storage

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage. Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, the acid should always be added slowly to water and in small amounts. Never use hot water and never add water to the acid. Water added to acid can cause uncontrolled boiling and splashing. When opening metal containers, use non-sparking tools because of the possibility of hydrogen gas being present. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:

-OSHA Permissible Exposure Limit (PEL):

5 ppm Ceiling

-ACGIH Threshold Limit Value (TLV):

5 ppm Ceiling

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded, a full facepiece respirator with an acid gas cartridge may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. **WARNING:** Air purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure to prevent skin contact.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:

Colorless, fuming liquid.

Odor:

Pungent odor of hydrogen chloride.

Solubility:

Infinite in water with slight evolution of heat.

Density:

1.18

pH:

For HCL solutions: 0.1 (1.0 N), 1.1 (0.1 N), 2.02 (0.01 N)

% Volatiles by volume @ 21C (70F):

100

Boiling Point:

53C (127F) Azeotrope (20.2%) boils at 109C (228F)

Melting Point:

-74C (-101F)

Vapor Density (Air=1):

No information found.

Vapor Pressure (mm Hg):

190 @ 25C (77F)

Evaporation Rate (BuAc=1):

No information found.

10. Stability and Reactivity

Stability:

Stable under ordinary conditions of use and storage. Containers may burst when heated.

Hazardous Decomposition Products:

When heated to decomposition, emits toxic hydrogen chloride fumes and will react with water or steam to produce heat and toxic and corrosive fumes. Thermal oxidative decomposition produces toxic chlorine fumes and explosive hydrogen gas.

Hazardous Polymerization:

Will not occur.

Incompatibilities:

A strong mineral acid, concentrated hydrochloric acid is incompatible with many substances and highly reactive with strong bases, metals, metal oxides, hydroxides, amines, carbonates and other alkaline materials. Incompatible with materials such as cyanides, sulfides, sulfites, and formaldehyde.

Conditions to Avoid:

Heat, direct sunlight.

11. Toxicological Information

Inhalation rat LC50: 3124 ppm/1H; oral rabbit LD50: 900 mg/kg (Hydrochloric acid concentrated); investigated as a tumorigen, mutagen, reproductive effector.

-----\Cancer Lists\-----

Ingredient	---NTP Carcinogen---		IARC Category
	Known	Anticipated	
Hydrogen Chloride (7647-01-0)	No	No	3
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:

When released into the soil, this material is not expected to biodegrade. When released into the soil, this material may leach into groundwater.

Environmental Toxicity:

This material is expected to be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: HYDROCHLORIC ACID

Hazard Class: 8

UN/NA: UN1789

Packing Group: II

Information reported for product/size: 475LB

International (Water, I.M.O.)

Proper Shipping Name: HYDROCHLORIC ACID

Hazard Class: 8

UN/NA: UN1789

Packing Group: II

Information reported for product/size: 475LB

15. Regulatory Information

-----\Chemical Inventory Status - Part 1\-----

Ingredient	TSCA	EC	Japan	Australia
Hydrogen Chloride (7647-01-0)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

-----\Chemical Inventory Status - Part 2\-----

Ingredient	--Canada--	Korea	DSL	NDSL	Phil.
Hydrogen Chloride (7647-01-0)		Yes	Yes	No	Yes
Water (7732-18-5)		Yes	Yes	No	Yes

-----\Federal, State & International Regulations - Part 1\-----

Ingredient	-SARA 302-		-----SARA 313-----	
	RQ	TPQ	List	Chemical Catg.
Hydrogen Chloride (7647-01-0)		5000	500*	Yes No
Water (7732-18-5)	No	No	No	No

-----\Federal, State & International Regulations - Part 2\-----

Ingredient	-RCRA-		-TSCA-	
	CERCLA	261.33	8(d)	
Hydrogen Chloride (7647-01-0)		5000	No	No
Water (7732-18-5)	No	No	No	

Chemical Weapons Convention: No TSCA 12(b): No CDTA: Yes
 SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
 Reactivity: No (Mixture / Liquid)

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **0**

Label Hazard Warning:

POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR INHALED. INHALATION MAY CAUSE LUNG DAMAGE.

Label Precautions:

Do not get in eyes, on skin, or on clothing.

Do not breathe vapor or mist.

Use only with adequate ventilation.

Wash thoroughly after handling.

Store in a tightly closed container.

Remove and wash contaminated clothing promptly.

Label First Aid:

In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.

Product Use:

Laboratory Reagent.

Revision Information:

No changes.

Disclaimer:

Methylene Blue MSDS Sheet, Material safety Data Sheet

1. Product Identification

Synonyms: Basic Blue 9, trihydrate; Methylene blue trihydrate; 3,7-Bis(dimethylamino)phenazathionium chloride trihydrate
CAS No.: 61-73-4 (Anhydrous); 7220-79-3 (Trihydrate)
Molecular Weight: 373.91
Chemical Formula: C₁₆H₁₈N₃S · 3H₂O

2. Composition/Information on Ingredients

Ingredient: Methylene Blue
CAS No.: 61-73-4
Percent: 100%

3. Hazards Identification

Emergency Overview

Methylene Blue is relatively non-hazardous in routine industrial situations.

Potential Health Effects

Inhalation: No adverse health effects expected from inhalation. May cause a short period of rapid or difficult breathing.

Ingestion: A burning sensation of the mouth may be noted following ingestion of methylene blue. May cause nausea, vomiting, diarrhea, and gastritis. Large doses may cause abdominal and chest pain, headache, profuse sweating, mental confusion, painful micturition, and methemoglobinemia.

Skin Contact: Not expected to be a health hazard from skin exposure. Methylene blue may color the skin a bluish color. May cause photosensitization.

Eye Contact: No adverse effects expected. May cause mechanical irritation.

Chronic Exposure: No information found.

Aggravation of Pre-existing Conditions: No information found.

4. First Aid Measures

Inhalation: Remove to fresh air. Give oxygen if breathing is difficult; give artificial respiration if breathing has stopped. Keep person warm and quiet; get medical attention.

Ingestion: Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

Skin Contact: Immediately flush skin with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention.

5. Fire Fighting Measures

Fire: Methylene blue is considered to be a fire hazard.

Explosion: Not considered to be an explosion hazard.

Fire Extinguishing Media: Use any means suitable for extinguishing surrounding fire.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece.

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment. Pick up spills and place in a suitable container for reclamation or disposal, using a method that does not generate dust.

7. Handling and Storage

Keep Methylene Blue in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Avoid dust formation and control ignition sources. Isolate from incompatible substances. Containers of Methylene Blue may be hazardous when empty.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits: None established.

Ventilation System: In general, dilution ventilation is a satisfactory health hazard control for this substance. However, if conditions of use create discomfort to the worker, a local exhaust system should be considered.

Personal Respirators (NIOSH Approved): Not expected to require personal respirator usage. For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn. If oil particles (e.g. lubricants, cutting fluids, glycerin, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator.

Skin Protection: Wear protective gloves and clean body-covering clothing.

Eye Protection: Use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance: Methylene Blue is dark green crystals with bronze luster or crystalline powder.

Odor: Odorless.

Solubility: Soluble in water.

Specific Gravity: No information found.

pH: No information found.

% Volatiles by volume @ 21C (70F): 0

Boiling Point: Decomposes.

Melting Point: 100 - 110C (212 - 230F)

Vapor Density (Air=1): 13

Vapor Pressure (mm Hg): Not applicable.

Evaporation Rate (BuAc=1): No information found.

10. Stability and Reactivity

Stability: Methylene Blue is stable under ordinary conditions of use and storage.

Hazardous Decomposition Products: May produce oxides of nitrogen, sulfur and carbon when heated to decomposition.

Hazardous Polymerization: Will not occur.

Incompatibilities: Strong oxidizing agents, alkali, dichromates, alkali iodides, reducing agents.

Conditions to Avoid: Heat, flame, ignition sources, dusting and incompatibles.

11. Toxicological Information

Methylene Blue: 1180 mg/kg LD50 oral rat. Investigated as a mutagen, reproductive effector.

-----\Cancer Lists\-----

----- NTP Carcinogen---

Ingredient	-----Known	-- Anticipated	IARC Category
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Methylene Blue(61-73-4)	---- No	----- No	----- None
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12. Ecological Information

Environmental Fate: When released into the soil, this material is not expected to evaporate significantly. When released into water, this material is not expected to evaporate significantly. This material has an estimated bioconcentration factor (BCF) of less than 100. This material is not expected to significantly bioaccumulate. When released into the air, this material is expected to be readily degraded by reaction with photochemically produced hydroxyl radicals. When released into the air, this material may be removed from the atmosphere to a moderate extent by wet deposition. When released into the air, this material may be removed from the atmosphere to a moderate extent by dry deposition.

Environmental Toxicity: No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may

change the waste management options. Dispose of container and unused Methylene Blue in accordance with legal requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

-----\Chemical Inventory Status - Part 1\-----				
Ingredient	TSCA	EC	Japan	Australia
Methylene Blue (61-73-4)	Yes	Yes	Yes	Yes

-----\Chemical Inventory Status - Part 2\-----					Canada--
Ingredient		Korea	DSL	NDSL	Phil.
Methylene Blue (61-73-4)		Yes	Yes	No	Yes

-----\Federal, State & International Regulations - Part 1\-----				
-SARA 302- -----SARA 313-----				
Ingredient	RQ	TPQ	List	Chemical Catg.
Methylene Blue (61-73-4)	No	No	No	No

-----\Federal, State & International Regulations - Part 2\-----			
-RCRA- -TSCA			
Ingredient	CERCLA	261.33	8(d)
Methylene Blue (61-73-4)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
 SARA 311/312: Acute: Yes Chronic: No Fire: No Pressure: No Reactivity: No (Pure / Solid)
Australian Hazchem Code: None allocated.
Poison Schedule: None allocated.

EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:

Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

16. Other Information

Potassium Hydroxide MSDS Sheet, Material safety Data Sheet**MSDS NUMBER:** M31867**SUBSTANCE:** CAUSTIC POTASH ANHYDROUS (ALL GRADES)**TRADE NAMES:**Caustic Potash Standard Crystal; Caustic Potash Standard Flake; Caustic Potash-Crystal;
Caustic Potash-Flake;

Caustic Potash-Briquettes; Caustic Potash-Flake 90%; Caustic Potash Briquettes 90%

SYNONYMS:

Potassium hydroxide, KOH Dry

PRODUCT USE: glass manufacture, cleaner, process chemical, petroleum industry, food processing**REVISION DATE:** Jun 20 2006**2. HAZARDS IDENTIFICATION****NFPA RATINGS (SCALE 0-4):** HEALTH=3 FIRE=0 REACTIVITY=1**HMIS RATINGS (SCALE 0-4):** HEALTH=3 FLAMMABILITY=0 REACTIVITY=1**Occidental Chemical Corporation****5005 LBJ Freeway****P.O. Box 809050****Dallas, Texas 75380-9050****24 HOUR EMERGENCY TELEPHONE: 1-800-733-3665 or 1-972-404-3228 (U.S.);
32.3.575.55.55 (Europe);****1800-033-111 (Australia)****TO REQUEST AN MSDS: MSDS@oxy.com or 1-972-404-3245****CUSTOMER SERVICE: 1-800-752-5151 or 1-972-404-3700**

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POTENTIAL HEALTH EFFECTS:**INHALATION:****SHORT TERM EXPOSURE:** irritation (possibly severe), burns, pulmonary edema**LONG TERM EXPOSURE:** to our knowledge, no effects are known**SKIN CONTACT:****SHORT TERM EXPOSURE:** irritation (possibly severe), burns**LONG TERM EXPOSURE:** dermatitis**EYE CONTACT:****SHORT TERM EXPOSURE:** irritation (possibly severe), burns, eye damage, blindness**LONG TERM EXPOSURE:** visual disturbances**INGESTION:****SHORT TERM EXPOSURE:** irritation (possibly severe), burns, nausea, vomiting**LONG TERM EXPOSURE:** to our knowledge, no effects are known**CARCINOGEN STATUS:****OSHA:** No**NTP:** No**IARC:** No

3. COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: POTASSIUM HYDROXIDE

CAS NUMBER: 1310-58-3

PERCENTAGE: 84.5-90.5

COMPONENT: WATER

CAS NUMBER: 7732-18-5

PERCENTAGE: 9.5-15.5

4. FIRST AID MEASURES

INHALATION: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. If breathing is difficult, oxygen should be administered by qualified personnel. If respiration or pulse

has stopped, have a trained person administer Basic Life Support (Cardio-Pulmonary Resuscitation/Automatic

External Defibrillator) and CALL FOR EMERGENCY SERVICES IMMEDIATELY.

EMERGENCY OVERVIEW:

COLOR: white

PHYSICAL FORM: solid

ODOR: odorless

SIGNAL WORD: DANGER

MAJOR HEALTH HAZARDS: CORROSIVE. CAUSES BURNS TO THE RESPIRATORY TRACT, SKIN, EYES AND GASTROINTESTINAL TRACT. CAUSES PERMANENT EYE DAMAGE.

PHYSICAL HAZARDS: Mixing with water, acid or incompatible materials may cause splattering and release of heat.

ECOLOGICAL HAZARDS: This material has exhibited moderate toxicity to aquatic organisms.

PRECAUTIONARY STATEMENTS: Do not get in eyes, on skin, or on clothing. Do not breathe dust.

Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation.

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SKIN CONTACT: Immediately flush contaminated areas with water. Remove contaminated clothing, jewelry, and shoes immediately. Wash contaminated areas with soap and water. Thoroughly clean and dry contaminated clothing and shoes before reuse. Discard contaminated leather goods. GET MEDICAL ATTENTION

IMMEDIATELY.

EYE CONTACT: Immediately flush eyes with a directed stream of water for at least 15 minutes, forcibly

holding eyelids apart to ensure complete irrigation of all eye and lid tissues. Washing eyes within several seconds is essential to achieve maximum effectiveness. GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION: Never give anything by mouth to an unconscious or convulsive person. If swallowed, do not induce vomiting. Give large amounts of water. If vomiting occurs spontaneously, keep airway clear. Give more water when vomiting stops. GET MEDICAL ATTENTION IMMEDIATELY.

NOTE TO PHYSICIAN: The absence of visible signs or symptoms of burns does NOT reliably exclude the presence of actual tissue damage. Probable mucosal damage may contraindicate the use of gastric lavage.

5. FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Negligible fire hazard.

EXTINGUISHING MEDIA: Do not use water. Use extinguishing agents appropriate for surrounding fire.

FIRE FIGHTING: Move container from fire area if it can be done without risk. Wear NIOSH approved positive-pressure self-contained breathing apparatus. Avoid contact with skin.

SENSITIVITY TO MECHANICAL IMPACT: Not sensitive

SENSITIVITY TO STATIC DISCHARGE: Not sensitive

FLASH POINT: Not flammable

6. ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL RELEASE:

Wear appropriate personal protective equipment recommended in Section 8 of the MSDS. Shovel dry material

into suitable container. Keep out of water supplies and sewers. This material is alkaline and may raise the pH of surface waters with low buffering capacity. Releases should be reported, if required, to appropriate agencies.

Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater

than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and is reportable under CERCLA

Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

7. HANDLING AND STORAGE

STORAGE: Store and handle in accordance with all current regulations and standards. Keep container tightly

closed and properly labeled. Do not store in aluminum container or use aluminum fittings or transfer lines, as flammable hydrogen gas may be generated. Keep separated from incompatible substances (see Section 10 of the MSDS).

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HANDLING: Avoid breathing dust. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Mixing with water, acid or incompatible materials may cause splattering and release of heat.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:

CAUSTIC POTASH ANHYDROUS (ALL GRADES):

POTASSIUM HYDROXIDE:

2 mg/m³ ACGIH ceiling

VENTILATION: Provide local exhaust ventilation where dust or mist may be generated. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear chemical resistant safety goggles if eye contact is possible. When wet mixing, wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear protective clothing to minimize skin contact. When potential for contact with wet material exists, wear Tychem® or a similar chemical protective suit. When potential for contact with dry material exists, wear disposable coveralls such as Tyvek®. Thoroughly clean and dry contaminated clothing before reuse. Discard contaminated leather goods.

GLOVES: Wear appropriate chemical resistant gloves.

PROTECTIVE MATERIAL TYPES: butyl rubber, natural rubber, nitrile, polyvinyl chloride (PVC), Tychem®, Tyvek®

RESPIRATOR: Where dust or vapor concentration exceeds or is likely to exceed applicable exposure limits, a NIOSH approved respirator is required.

If eye irritation occurs, a full face style mask should be used.

Air-purifying respirators should be equipped with a minimum N-95 dust/mist filter (1/2 facepiece) and N-100 dust/mist filter (full facepiece).

When an air-purifying respirator is not adequate or during spills and/or emergencies of unknown

concentrations, a NIOSH approved self-contained breathing apparatus or airline respirator with full-face piece is required.

A respiratory protection program that meets 29 CFR 1910.134 must be followed whenever workplace conditions warrant use of a respirator.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE: solid

COLOR: white

ODOR: odorless

MOLECULAR WEIGHT: 56.11

MOLECULAR FORMULA: KOH

BOILING POINT: Not applicable

MELTING POINT: 752 F (400 C)

VAPOR PRESSURE: 60 mmHg @ 1013 C

VAPOR DENSITY: Not applicable

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SPECIFIC GRAVITY (water=1): 2.044 @ 20 C

WATER SOLUBILITY: 100%

PH: Not applicable

VOLATILITY: 0%

ODOR THRESHOLD: Not available

EVAPORATION RATE: Not applicable

COEFFICIENT OF WATER/OIL DISTRIBUTION: Not available

10. STABILITY AND REACTIVITY

REACTIVITY: Stable at normal temperatures and pressure.

CONDITIONS TO AVOID: Mixing with water, acid or incompatible materials may cause splattering and

release of large amounts of heat. Will react with some metals forming flammable hydrogen gas. Carbon

monoxide gas may form upon contact with reducing sugars or food and beverage products in enclosed spaces.

INCOMPATIBILITIES: acids, halogenated compounds, prolonged contact with aluminum, brass, bronze,

copper, lead, tin, zinc or other alkali sensitive metals or alloys

HAZARDOUS DECOMPOSITION:

Thermal decomposition products: None known.

POLYMERIZATION: Will not polymerize.

11. TOXICOLOGICAL INFORMATION

CAUSTIC POTASH ANHYDROUS (ALL GRADES):

TOXICITY DATA: As a solid, this material interacts with moist tissue to cause damage. When in solution, this material will affect all tissues with which it comes in contact. The severity of the tissue damage is a function of concentration, the length of tissue contact time, and local tissue conditions. After exposure there may be a time delay before irritation and other effects occur. This material is a strong irritant and is corrosive to the skin, eyes, and mucous membranes. This material may cause severe burns and permanent damage to any tissue with which it comes into contact. Inhalation will cause severe irritation, possible burns with pulmonary edema, which may lead to pneumonitis. Skin contact with this material may cause severe irritation and corrosion of tissue. Eye contact can cause severe irritation, corrosion with possible corneal damage and blindness. In general, chronic effects are due to long-term irritation. This material may cause dermatitis on the skin, or recurrent corneal ulceration and visual disturbances. In rare cases reports have noted long-term inhalation causes bronchial inflammatory reaction or obstructive airway dysfunction.

LOCAL EFFECTS:

Corrosive: inhalation, skin, eye, ingestion

TARGET ORGANS: eyes, skin, respiratory system

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: respiratory system (including asthma and other breathing disorders)

12. ECOLOGICAL INFORMATION

ECOTOXICITY DATA:

FISH TOXICITY: This material has exhibited moderate toxicity to aquatic organisms. For potassium

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hydroxide: 80 mg/L 96 hours LC50 Mosquito fish; 165 mg/L 24 hours LC50 Guppy

FATE AND TRANSPORT:

BIODEGRADATION: This material is inorganic and not subject to biodegradation.

PERSISTENCE: This material is alkaline and may raise the pH of surface waters with low buffering capacity.

This material is believed to exist in the disassociated state in the environment.

BIOCONCENTRATION: This material is believed not to bioaccumulate.

OTHER ECOLOGICAL INFORMATION: This material has exhibited slight toxicity to terrestrial organisms.

13. DISPOSAL CONSIDERATIONS

Reuse or reprocess if possible. Dispose in accordance with all applicable regulations.

14. TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101:

PROPER SHIPPING NAME: Potassium hydroxide, solid

ID NUMBER: UN1813

HAZARD CLASS OR DIVISION: 8

PACKING GROUP: II

LABELING REQUIREMENTS: 8

DOT HAZARDOUS SUBSTANCE(S):

Potassium hydroxide 1000 lb(s) (454 kg(s))

CANADIAN TRANSPORTATION OF DANGEROUS GOODS:

SHIPPING NAME: Potassium hydroxide, solid

UN NUMBER: UN1813

CLASS: 8

PACKING GROUP/RISK GROUP: II

15. REGULATORY INFORMATION

U.S. REGULATIONS:

CERCLA SECTIONS 102a/103 HAZARDOUS SUBSTANCES (40 CFR 302.4):

POTASSIUM HYDROXIDE: 1000 LBS RQ

SARA TITLE III SECTION 302 EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355.30): Not

regulated.

SARA TITLE III SARA SECTIONS 311/312 HAZARDOUS CATEGORIES (40 CFR 370.21):

ACUTE: Yes

CHRONIC: No

FIRE: No

REACTIVE: Yes

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SUDDEN RELEASE: No

SARA TITLE III SECTION 313 (40 CFR 372.65): Not regulated.

OSHA PROCESS SAFETY (29CFR1910.119): Not regulated.

FDA: This material has Generally Recognized as Safe (GRAS) status under specific FDA regulations.

Additional information is available from the Code of Federal Regulations (CFR) which is accessible on the

FDA's website.

STATE REGULATIONS:

California Proposition 65: This product is not listed, but it may contain contaminants known to the State of

California to cause cancer or reproductive toxicity as listed under Proposition 65 State Drinking Water and

Toxic Enforcement Act. For additional information, contact Customer Service.

NEW JERSEY WORKER AND COMMUNITY RIGHT TO KNOW:**REPORTING REQUIREMENT:**

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

WATER 7732-18-5 9.5-15.5%

RIGHT TO KNOW HAZARDOUS SUBSTANCE LIST:

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

SPECIAL HEALTH HAZARD SUBSTANCE LIST:

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

PENNSYLVANIA RIGHT TO KNOW:**REPORTING REQUIREMENT:**

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

WATER 7732-18-5 9.5-15.5%

HAZARDOUS SUBSTANCE LIST:

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

ENVIRONMENTAL HAZARDOUS SUBSTANCE LIST:

POTASSIUM HYDROXIDE 1310-58-3 84.5-90.5%

SPECIAL HAZARDOUS SUBSTANCE LIST:

Not regulated.

CANADIAN REGULATIONS:

CONTROLLED PRODUCTS REGULATIONS (CPR): This product has been

classified in accordance with

the criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information

required by the CPR.

WHMIS CLASSIFICATION: E.**NATIONAL INVENTORY STATUS:**

U.S. INVENTORY (TSCA): All the components of this substance are listed on or are

exempt from the

inventory.

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TSCA 12(b) EXPORT NOTIFICATION: Not listed.

CANADA INVENTORY (DSL/NDL): All components of this product are listed on the

DSL.

16. OTHER INFORMATION**MSDS SUMMARY OF CHANGES**

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

2. HAZARDS IDENTIFICATION

3. COMPOSITION, INFORMATION ON INGREDIENTS

4. FIRST AID MEASURES

5. FIRE FIGHTING MEASURES

6. ACCIDENTAL RELEASE MEASURES

7. HANDLING AND STORAGE

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

10. STABILITY AND REACTIVITY

11. TOXICOLOGICAL INFORMATION

12. ECOLOGICAL INFORMATION

15. REGULATORY INFORMATION

APPENDIX C

LIST OF ABBREVIATIONS

EFB	Empaty Fruit Bunch
PPF	Palm Oil Press Fibres
MB	Methylene Blue
KOH	Potassium Hydroxide
HCl	Hydrochloric Acid