POTENTIAL OF BIOMASS AS COAGULANT AID IN WASTEWATER TREATMENT

By

NOR RALINA BINTI KAMALUDDIN

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Dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor Engineering (Hons)
(Chemical Engineering)

MAY 2012

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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Approved by,

DR. USAMA MOHAMED NOUR ELDEMERDASH
..........Senior Lecturer in Chemical Engineering
Universiti Teknologi PETRONAS
(   )

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh, Perak

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ABSTRACT

The use of coagulant aid prepared from biomass has been studied as an alternative substitute for bentonite and kaolin clay for the removal of dyes from wastewater. The coagulation process for the removal of the azoic dye, Eriochrome Black T (EBT) from wastewater was investigated using low-cost, natural and eco-friendly coagulant aid, biomass as an ideal alternative to the conventional coagulant aids. Coagulant aid prepared from biomass is applied to remove the Eriochrome Black T (EBT) from the wastewater in the textile industry. This study investigates the potential use of biomass which is palm oil fiber for the removal of Eriochrome Black T (EBT) from simulated wastewater. The coagulation studies are carried out to study the effects of initial pH and coagulant aid (biomass) dosage while applying ferric (III) sulfate as the coagulant. Due to that, the coagulation parameters are obtained based on the series of jar-test experiment. Afterwards, the supernatant liquid will be evaluated in terms of final pH, color removal, chemical oxygen demand (COD) removal and amount of sludge produced.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Eventually, wastewater is the major environmental issue of textile industries besides other minor issues like solid waste, resource wastage and occupational, health and safety. Textile and dyeing mills use many kinds of artificial composite dyes and tend to discharge large amounts of highly colored wastewater. In addition, textile wastewater pollutants are generally consists of caustic soda, detergents, starch, wax, urea, ammonia, pigments and dyes that will increase its BOD, COD, solids contents and toxicity. Therefore, these wastes must be treated prior to discharge in order to comply with the environmental protection laws for the receiving waters.

Several treatment processes have been introduced in order to treat the textile effluents. Biological treatment processes are generally efficient for Biochemical Oxygen Demand (BOD) and suspended solids removal, but they are largely ineffective for removing color from the wastewater because dyes have slow biodegradation rate. Recently, the treatment technologies have recommended the physicochemical treatment adsorption, oxidation), chemical precipitation and etc. to meet the color removal requirements for the wastewater treatments. However, coagulation-flocculation is the most common chemical treatment method for decolorization or removing dyestuff in textile industries. Conventionally, employing coagulation and flocculation, as a unit process in wastewater treatment entails the application of metal salts such as alum and ferric salts. Meanwhile, the coagulant aids in the coagulation process are bentonite and kaolin clay has been successfully used.

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However, in the recent years, the materials of biological origin, including agriculture wastes, have been used to remove dyestuff and heavy metals. Coagulation onto raw agricultural waste is a low-cost treatment technique for the removal of contaminants from wastewater. In order to decrease the cost of treatment, attempts have been made to find inexpensive alternative coagulant aids. A number of non-conventional and low cost plant materials or residues such as sugarcane bagasse, palm oil residue, rice husk, barley husk and many more have been suggested by several researches to remove the dyestuff or heavy metals.

For this study, the potentiality of biomass as coagulant aid will be investigated to observe the efficiency in the dye removal from the wastewater. We choose Eriochrome Black T (EBT) as a model of azo dyes which represent more than a half of the global dye production. This dye has been identified as the most problematic in the effluents because it is resistant to fading from exposure to light, water and chemicals due to their complex chemical structure. Meanwhile, conventional coagulant that is ferric (III) sulfate is maintained in this study. Variation of parameter such as coagulant (biomass) dosage as a result in final pH and percentage of dye removal will be the core elements in this study. The experiment will be conducted for the purpose of studying the effects of the biomass dosage to the final pH, the percentage of COD and color removal using the specific analysis equipments.

1.2 Problem Statement

The wastewater from textile industry often composed of color containing substances and refractory organic compound. So there is a need of further and efficient removal of COD and color from the textile effluent. For that reason, this study will be focusing on finding a new treatment by implementing biomass as the coagulant aid so that the efficiency of the treatment can be increased.

The coagulation process is not always perfect and may result in small flocs when coagulation takes place. Principally, the main problems when dealing with dyes effluent is that, the dyestuffs must be removed completely since they can still be visible even at a very low concentration values (Najafi, H.; Mohaved H.R., 2009) A mechanism is needed to improve the coagulation and flocculation process to obtain a good quality effluent and the rapid sedimentation of the flocs formed. For this purpose, several products, denominated coagulant aids, can be used to act on the elements which affect coagulation or in order to increase floc density and hence, to improve sedimentation

In addition, in the early days, there are sample resources and negligible development, little attention has been given to the environmental issues. However, rapid economic development through the urbanization industrialization and the other land-use activities later on arises to water, air and land pollution, which remains as serious environmental problems in Malaysia. In order to obey the Environmental Quality Act 1974 which functions to preserve and protect Malaysia's abundant natural resources, therefore the wastewater treatments are needed such as coagulation process.

1.3 Objectives

There are several objectives that have been set up in this study:

A. To enhance the coagulation and flocculation in textile wastewater treatment by introducing a new biomass-based coagulant aid.

B. To observe the effect on addition of palm oil fruit fiber as the coagulant aid for coagulation and flocculation process.

The first objective emphasizes by introducing a new biomass-based coagulant aid to enhance the coagulation and flocculation in wastewater treatment. This biomass-based coagulant aid is investigated to observe whether it has the potentiality to act as coagulant aid.

Meanwhile, second objective will be implemented by experimental process. It is aimed to observe the effect on the addition of palm oil fruit fiber as the coagulant aid for coagulation and flocculation. The observation includes the estimation of the following optimum parameters which are dosage quantity of coagulant aid (biomass) and percentage of dye removal.

1.4 Scope of study

For this project, the scope of research is mainly focusing on the efficiency of the coagulation-flocculation process in eliminating dye stuff which is the major pollutant in the textile industry. Besides that, this project is concentrating on the ability of biomass to act as a new coagulant aid in wastewater treatment.

- Preparations of the synthetic effluent which consists of Eriochrome Black T dye.
- Preparation and characterizations of palm oil fruit fiber.
- Observing the effect of coagulant aids on the efficiency of the coagulation process such coagulant aid dosage (biomass), contact time and percentage of dye removal.

1.5 Relevancy of project

In terms of the relevancy of this project, it poses a great deal of significance to the wastewater treatment. There are a lot of studies have been done for biomass application in the wastewater treatment specifically adsorption, but none of them have done on coagulation process. For this project, the author is applying her theoretical and practical knowledge to implement of biomass in coagulation process instead of adsorption by means of dye removal enhancement. Hence, the outcome of this project is deemed crucial towards providing efficient technique of wastewater treatment.

1.6 Feasibility of project

All the objectives stated earlier are achievable and feasible in terms of this project duration and time frame. Since all the chemicals were already here in UTP, the experiment can be start as soon as the work flow is finished. Previously during the second year of study, the author has already been exposed to wastewater treatment subject. Since the author already acquired the basic understanding of wastewater treatment mechanism, the author is convinced to complete and it can be concluded that this research project is feasible and the stated objectives can be achieved within the scope of this Final Year Project.

CHAPTER 2

LITERATURE REVIEW

2.1 Coagulation and flocculation

Coagulation is defined as destabilization by particle charge neutralization and initial aggregation of colloids. Meanwhile, flocculation is agglomeration of coagulated colloidal and finely divided suspended material either by physical mixing or by chemical coagulant aids. Coagulation process neutralizes the charge present on the particles surfaces with the addition as coagulants whereas flocculation makes them to come close to each other to produce flocs by slow agitation. Settling follows coagulation and flocculation to remove resultant flocs from the wastewater, (Cooper, 1993; Jorgenson, 1974).

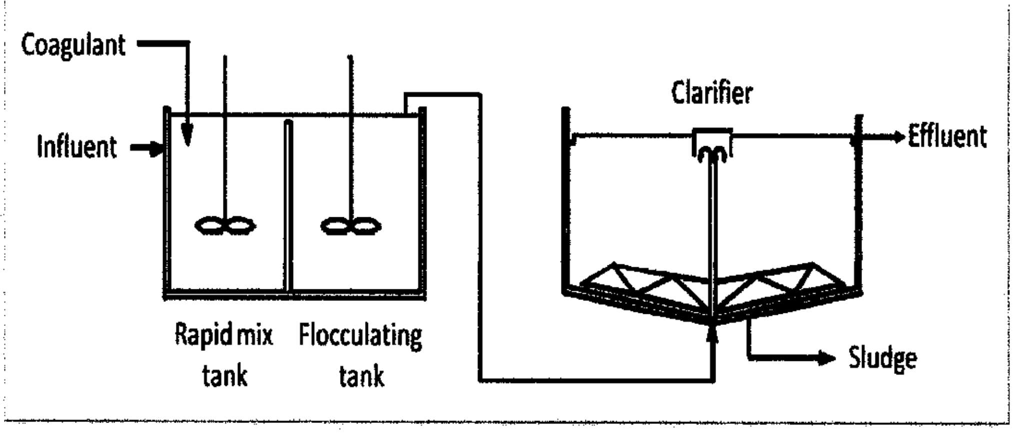

Figure 2.1: Clarification system incorporating coagulation and flocculation (Cooper, 1993; Jorgenson, 1974).

2.2 Coagulants for the coagulation process

Conventionally, electrolytes and polyelectrolyte are used to coagulate colloids. Electrolytes are materials which when placed in solution will cause the solution to be conductive to electricity because of charges that they posses. Meanwhile, polyelectrolyte are polymers possessing more than one electrolyte site in the molecule, and polymers are molecules joined together to form larger molecules. Electrolytes and polyelectrolyte are able to coagulate and precipitate colloids because of the charges. Polyelectrolyte has huge molecules with a high molecular weight which has a high ionization power. Besides that, it produces a large amount of ions in water and shows the properties of both polymers and electrolyte.

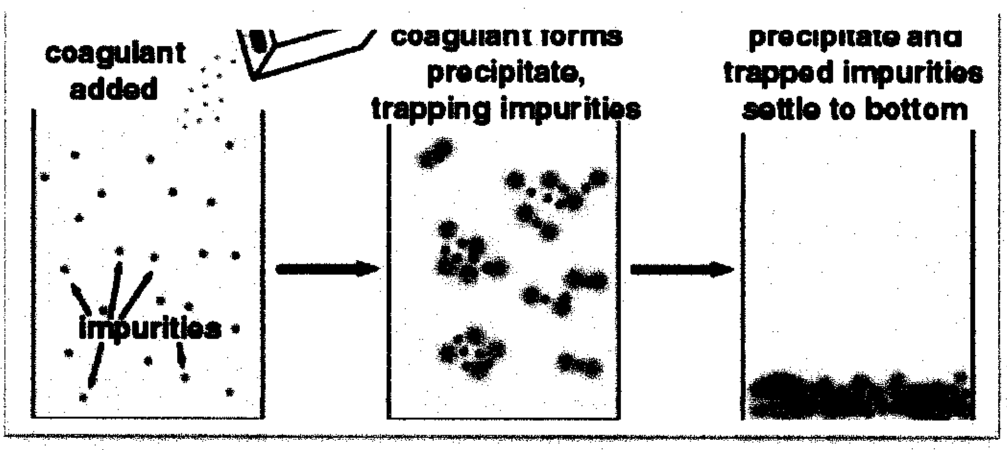

Figure 2.2: Coagulation and flocculation mechanism

(http://chemistry.tutorvista.com/physical-chemistry/flocculation.html)

2.3 Coagulant Aids

2.3.1 Conventional coagulant aids

Difficulties with settling often occur because of flocs that are slow-settling and are easily fragmented by the hydraulic shear in the settling basin. For these reasons, coagulant aids are normally used. Conventionally, activated silica and bentonite clay have been used as coagulant aids.

Bentonite clay is used as the weighting agent in water that is high in color but low in turbidity and mineral content. This type of water usually would not form floc large enough to settle down. Thus, the bentonite clay plays its role in dye removal employing coagulation and flocculation, joining the small floc quickly as mentioned by Chen, Y., *et al* (2004). Meanwhile, throughout the experimental works performed by M.H. Zoonozi, he is able to increase the dye removal from 18% to 33% by employing bentonite as coagulant aid.

2.3.2 Different background application of coagulant aids

Biomass comes from botanical (plant species) or biological (animal waste or carcass) sources or from a combination of these. Common sources of biomass:

- Agricultural: food grain, bagasse (crushed sugarcane), corn stalks, straw, seed hulls, nutshells and manure from cattle, poultry.
- Forest: trees, wood waste, wood or bark, sawdust, timber slash
- Municipal: sewage sludge, food waste, waste paper, yard clippings
- Energy: poplars, willows, switch grass, alfalfa, prairie bluestem, corn and soybean, canola and other plant oils
- Biological: animal waste, aquatic species, biological waste

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According to A. Oladoja, *et al* (2009), the research has been made by using the snail shell to act as coagulant aid in the alum precipitation of a basic dye malachite green form aqua system. Snail shell is being proposed as a low-cost material to remediate basic dye, malachite green (MG) and bearing water in the present studies. The use of snail shell as coagulant aid in the alum precipitation of basic dye malachite green is being optimized by methods of continuous variation based on the coagulant/coagulant aid dosage, pH and flocculation time.

This study observed that the snail shell exhibited some potential in the color removal but this potential was enhanced when the snail shell was combined with alum. In terms of settling characteristics of sludge, the snail shell is able to reduce the sludge production <50mg/g after 120 min. In addition, a good sludge should have sludge volume index (SVI) less than 80mg/g. (40)

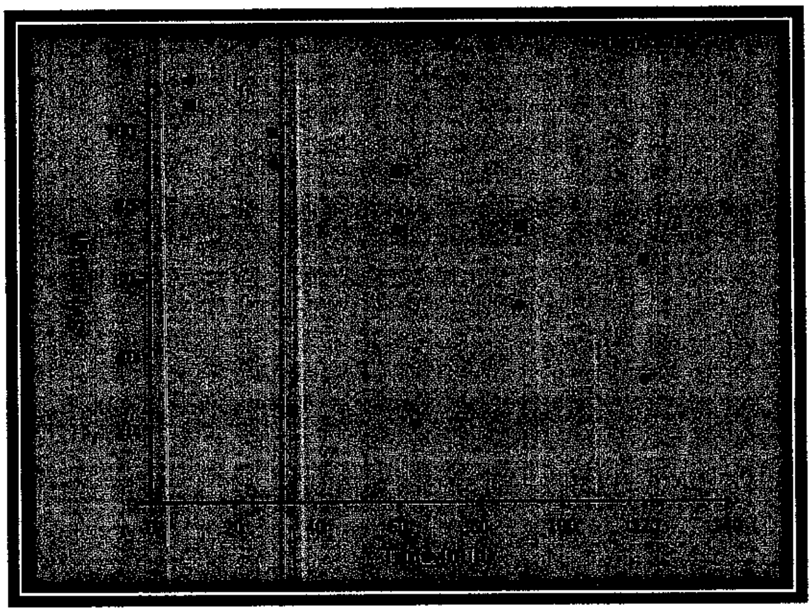

Figure 2.3: Determination of sludge settling characteristics (Oladoja. N.A, 2009)

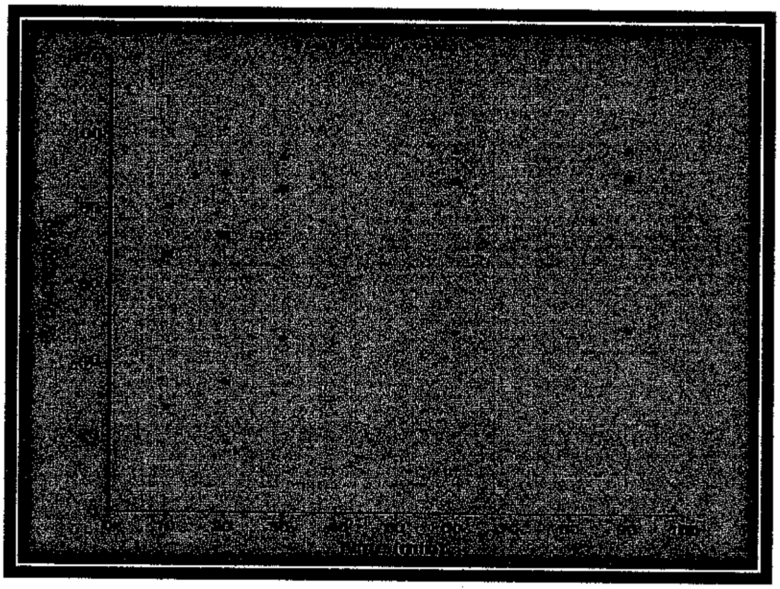

Figure 2.4: Effect of time on the flocculation of the precipitated MG molecule at optimum alum/SS dose (Oladoja. N.A, 2009)

Meanwhile, in other study of Ozacar,M, *et al* (2001), they have applied the tannins from Turkish Acorns (Valonia) as coagulant aid in the water and wastewater treatment and in the treatment of sludge. Tannins are high molecular weight polycyclic aromatic compounds which are widely distributed through the plant kingdom. And it is found in the leaves, fruits, barks, roots and wood of trees.

From the observation made, tannins able to act as coagulant aid as it decrease the water turbidity from10 and 20 to <0.02 and 0.9 FTU, respectively.

Table 2.1: The effect of Tannin as coagulant aids on turbidity removal

Initial turbidity (FTU)	pH	[illegible]	Residual turbidity (FTU)					
			[illegible]					
		[illegible]	[illegible]	0.05	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	<0.02	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

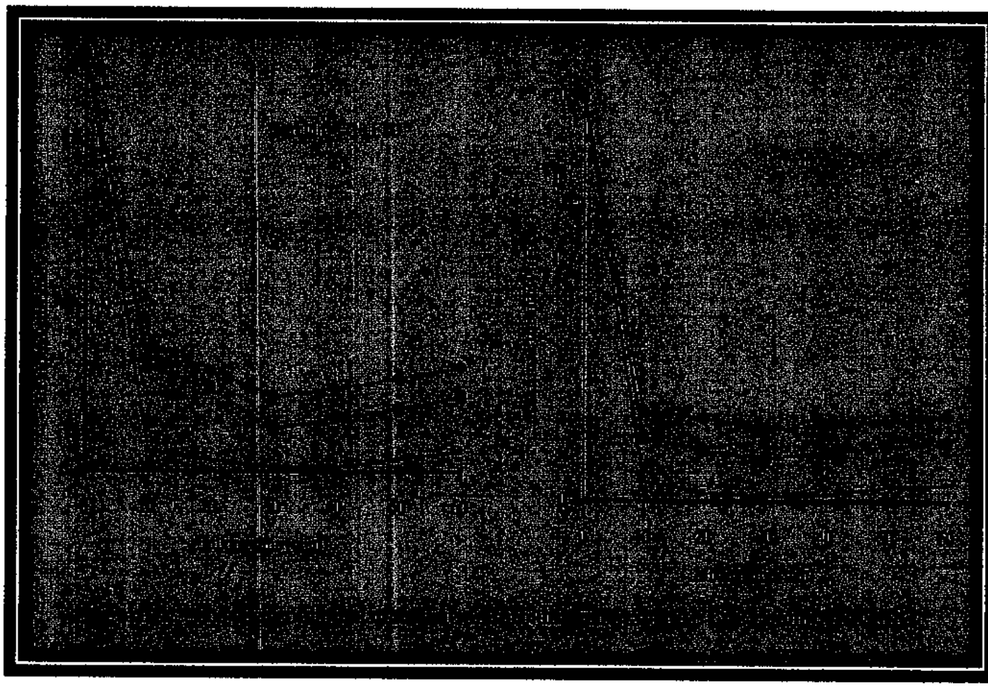

Figure 2.5: The effect of flocculation time on turbidity removal (Ozacar,M, 2001)

Meanwhile, based on Raghuwanshi P.K., *et al* (2002), study has been made on the utilization of agro based materials as coagulant aid such as Surjana seed (Moringa oleifera), Nirmali seed (Strychnos potatorum) and maize (Zeeymas) where alum acts as the coagulant.

Besides that, the results are observed by the volume of settled sludge (after 30 min of settling) produced was: alum + Surjana seed: 1.75 mL/L; alum + Nirmali seed: 1.6 mL/L; and alum alone: 2.8 mL/L, which indicated less sludge production in the case of agro based materials as a coagulant aid compared to alum alone. The observation was in agreement with the reported literature, that when synthetic polyelectrolytes are used as coagulant aid or alum sludge conditioning agents, they produced quite less sludge by (Kawamura 2000; Hudson 1981).

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CHAPTER 3

METHODOLOGY

RESEARCH METHODOLOGY

3.1 Preparation of synthetic wastewater and chemicals

Prior to conducting the experiment, a wastewater solution should be done first. According to Nigam P. *et al* (2000), a standard textile effluent is lower than 500ppm in concentration. Thus, throughout the experimental works, a 400ppm synthetic wastewater has been used. In order to prepare the synthetic wastewater, 1000mL of distilled water was added to 400 mg of Systerm StainPur Eriochrome Black T to dilute the solids. Apart from that, 0.1M of sodium hydroxide and calcium hydroxide were also prepared in order to control the pH of wastewater.

3.2 Preparation and characterization of biomass

The palm oil fruit bunch residue is collected from factory of FELCRA Nasaruddin, Bota, Perak. For the early treatment, the collected palm oil fruit fibers were washed with distilled water to remove external dirt. The oil palm fibre was deoiled by soaking in hot deionized water with detergent for 24 h. It was then rinsed in hot deionized water to remove all debris and air dried. The air dried oil palm fruit fibre was grounded and screened through a set of sieves (250 μm, 125 μm, 63 μm and 45 μm).

The characterization of both biomass were investigated by BET test to obtain the pore size distribution, FTIR analysis to determine the chemical functional group, FESEM analysis to determine the morphology of biomass and EDX to determine the ionic element.

3.3 Experimental Procedures –

A standard jar test apparatus was implemented during the experimental works by varying few parameters, which namely as dosage of inorganic coagulants, ferric (III) sulfate of 250ppm and pH 7 and all of them were carried out of the ambient temperature (~25°C). The FC6S-VELP (Scientifica) jar test principally was equipped with six paddle stirrer, together with six beaker apparatus. Besides that, Julabo SW22 shaking water bath was also been implemented through the experimental works to determine the various operating temperature (30-80°C). Each beaker used for both jar test and water bath shaker apparatus was contained with 100mL of synthetic wastewater prepared earlier.

Prior of pouring the wastewater into the beakers, the samples were mixed homogeneously to ensure a better dispersion of the dyestuffs. Then, the wastewater sample ought to be measured for the percentage of dye removal by measuring the color and chemical oxygen demand (COD) of the wastewater. The process which is performed in batch mode was agitated at various mixing times and speed which was rapid mixing at 200 rpm for 5 minutes after the preferred addition of inorganic coagulants, ferric (III) sulfate, subsequently followed by the slow mixing at 45 rpm for 30 minutes.

While conducting the experiments on the effect of the coagulant aids towards the process, the palm oil fruit fiber is added into the system during the slow mixing phase. Firstly, the palm oil fiber is stirred manually in different beaker before poured into the wastewater. Note that every beaker in the jar test is added with different particle size of palm oil fiber to determine the effect of different particle size on COD removal, color removal, final pH and amount of sludge formed.

Then, after the agitation was stopped, the suspension was allowed to settle down for another one hour.

3.4 Chemicals

a. Eriochrome Black T (EBT)
b. Ferric (III) Sulfate
c. Sodium Hydroxide, NaOH
d. Calcium hydroxide, $Ca(OH)_2$
e. Hexane

3.5 Equipments/Tools

Characterizations of biomass	• Fourier Transform Infra-red spectrometer (FTIR) • Field Scanning electron microscope (FESEM) • BET analyzer • X-ray diffraction (XRD)
Experimental	• Jar Test Apparatus
Analytical Analysis	• Total Suspended Solid (TSS) apparatus • UV-Visible Spectrophotometer • COD Spectrophotometer • pH meter

Table 2.2: List of Equipments

3.6 Analytical Analysis

Prior of measuring the final chemical oxygen demand (COD) and color, the supernatants in each beaker were filtered by means of Advantech Glass fiber filter (47 mm) and accomplished by the total suspended solids (TSS) apparatus. The main reason of applying the TSS apparatus and drying method were to measure the dry produced sludge during the experimental works. Literally, the volume of produced sludge is part of the major considerations when discussing about the coagulation and flocculation works since higher amount of the sludge may contributes to various difficulties to its disposal, handling and treatment at the later stage by Vesilind, P.A., *et al* (2003).

During the experimental works, the color analysis was performed by applying the UV-Visible spectrophotometer in which the wastewater was filled into the sample cell and put into the instrument cell compartment for the measurement analysis. Meanwhile, COD measurement was performed by means HACH Digital Reactor Block (DRB) 200 and HACH DR5000 Spectrophotometer through calorimetric for high range COD (0-1500 mg/L) determination at the wavelength of 620 nm.

In addition, the presence in reduction valued for both of COD and color is obtained according to the formula stated below:

$$\text{Percentage reduction } (\%) = \frac{C - C_0}{C_0} \times 100\%$$

Where: C = Final values for COD and color

C_0= Initial values for COD and color

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Overview

Color can be considered as an important pollutant that can be observed in polluted water. Industries such as textile, rubber, paper, plastic, cosmetics etc are using dyes widely in their manufacturing process. In addition, textile industries ranks first in uses of dyes for coloration of fiber among all the industries mentioned above. The extensive use of dyes, in both dye manufacturing and consuming industries create significant problems due to the discharge of colored wastewater.

Therefore, the removal of dyes from effluent using coagulation process provides an attractive alternative treatment, especially if the coagulant aid is inexpensive and readily available. As for Systerm StainPur Eriochrome Black T, the experiment has been done in different dosage of coagulant, ferric (III) sulfate that is varied between 250 until 1500ppm, but under the same operating temperature and pH which is ambient temperature and pH 7 respectively. The observation of reaction has been detected base on the final pH, percentage of color and COD removal and the amount of sludge formed.

Despite of various coagulant dosages, pH, operating temperature and the coagulation aid dosage, the color of synthetic wastewater is expected to be reduced after the coagulation treatment, which is originally from dark purple to the lighter color.

4.2 Characterization of palm oil fruit fiber

The palm oil fruit fiber was analyzed by Field Emission Scanning Electron Micrographs (FESEM). FESEM is widely used to study the morphological features and surface characteristics of the coagulant aid materials. In the present study, FESEM of palm oil fruit fiber reveals surface texture and porosity. The Energy-dispersive- X-ray (EDX) analysis of palm oil fruit fiber was carried out revealed the existence of calcium carbonate, $CaCO_3$ and silicon oxide, SiO_2 with weight percent of 57.68% and 39.68% respectively. Meanwhile, FTIR spectra revealed the following components such as O-C-C stretch (1031.52 cm^{-1}) and C-C-O(1606.32 cm^{-1}) as main functional groups on the surface of the fiber. Figures for all analysis are attached in Appendix A.

4.3 Determination of the optimal coagulant dosage

The experiments were performed by varying the coagulant, ferric (III) sulfate dose between 250 until 1500ppm, with the optimum pH and temperature in order to determine the optimum dose for coagulation process. It can be observed that pH reduces from 9 to acidic pH value, range from 4.95 to 5.25. Figure 4.1 show the plots for the parameter final pH versus concentration of coagulant.

The coagulant dosage is primarily one of the critical parameter in determining the effectiveness of the coagulation and flocculation process experimental works. Determining the optimal dosage point for the coagulation are important in order to achieve a better performance on the dye removal, to minimize the dosing cost as well as to reduce the number of sludge created during the process.

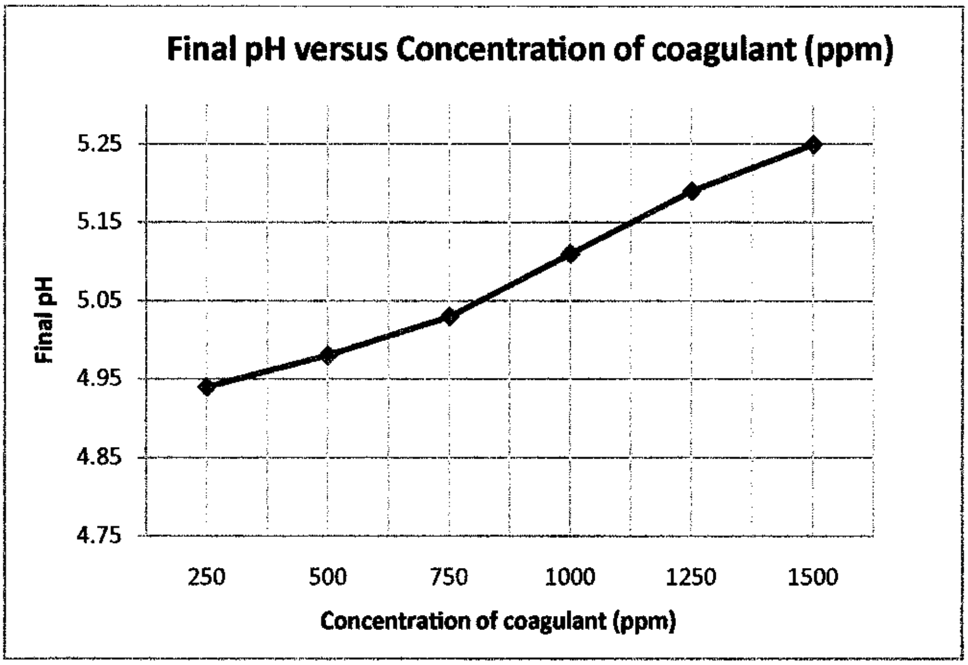

Figure 4.1 Final pH versus different concentration of coagulant

The results on color and COD at different coagulant dosage were presented in Figure 4.2 and Figure 4.3 respectively. The experiment was done in room temperature, with the pH adjusted to 9 by using lime solution. From Figure 4.2, the curve of color reduction gives almost straight line, which indicates that the removal efficiency increasing with the increasing coagulant dosage at first (250-1000ppm), but start to decline afterward. At 1000ppm of coagulant dosage, the percentage of color removal achieved is 85.98%.

Meanwhile, Figure 4.3 shows the percentage of COD removal shows a slightly reduction after the concentration of coagulant reaches 1000ppm. The result shows that at 1250 -1500ppm of coagulant dosage, the percentage of COD removal does not even achieved up to 70%. According to M. Ariffin *et al.*, the reduced performance of COD removal after the optimum point was caused by the excess coagulant which has been absorbed onto the colloidal surfaces. At 1000ppm of coagulant dosage, the percentage of COD removal achieved is 61.83%.

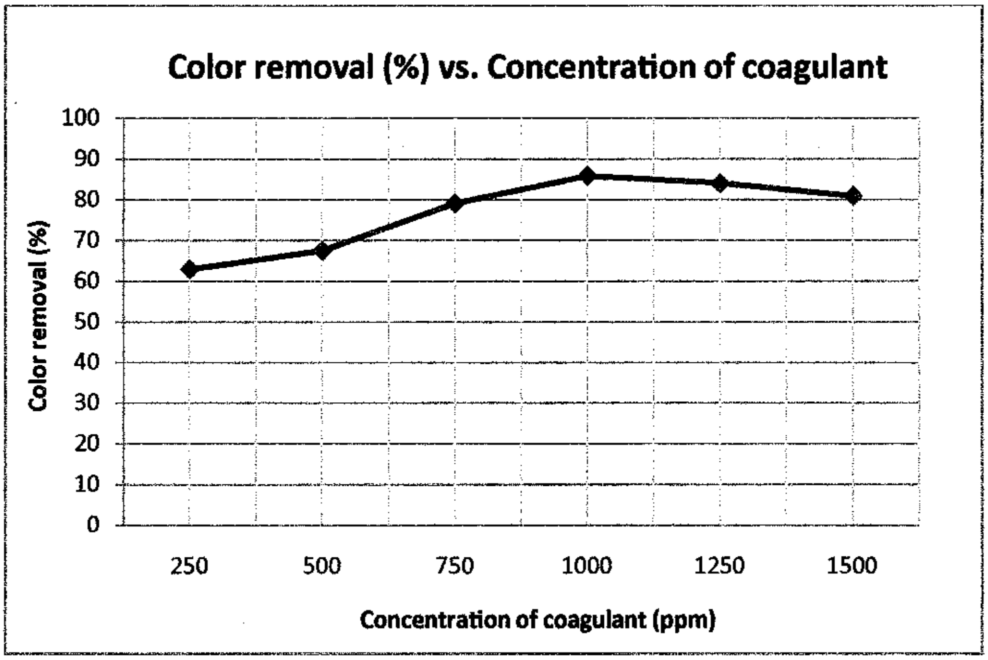

Figure 4.2 Color removals (%) versus different concentration of coagulant

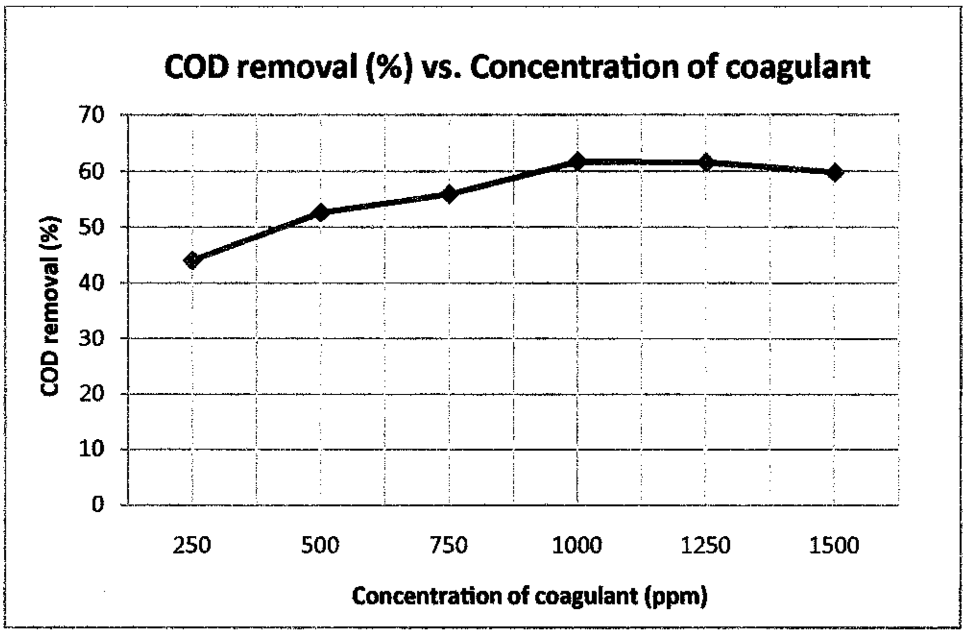

Figure 4.3 COD removal (%) versus different concentration of coagulant

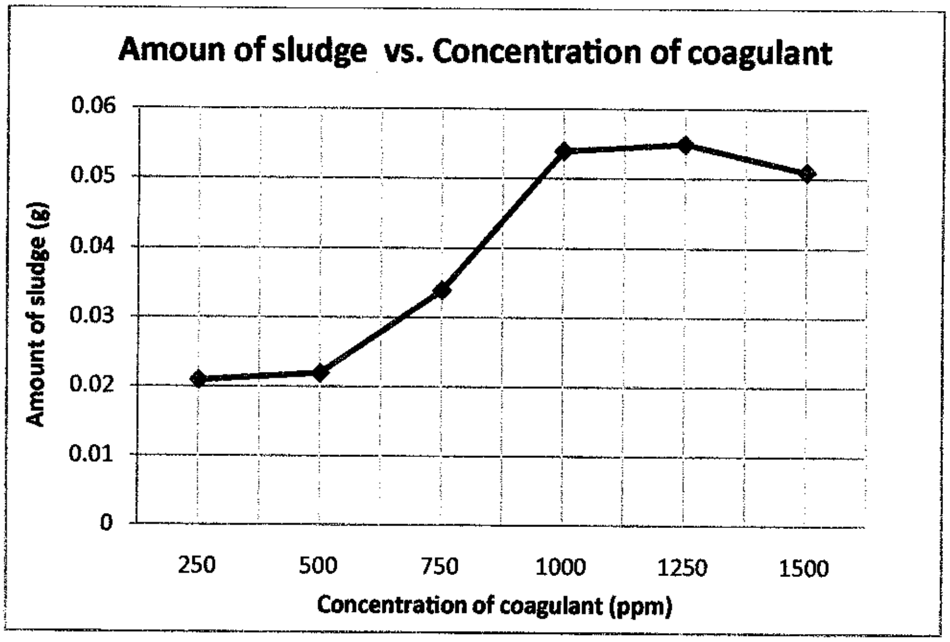

Figure 4.4 Amount of sludge formed versus different concentration of coagulant

Figure 4.4 presents the amount of sludge accumulated in the process unit in terms of gram. The value was recorded after the sludge was collected by filtering the treated water. The sludge was then dried and weighted to get the final amount of solid precipitates. The amount produces from this treatment is ranges from 0.02 to 0.06 gram. Based on data showed above, the amount of sludge produced is increasing by the increment of coagulant dosage. This phenomenon may have been influenced during the filtration process as there is maybe small amount of precipitates that pass through the filter and calculated together as the results.

4.4 Determination of the optimal pH

In the coagulation-flocculation process, it is very important to control pH since the coagulation occurs within the specific range for each coagulant. With the previously established coagulant doses found for each, the experiments were performed by varying the pH ranging from 5 to 11. Meanwhile, the concentration of the coagulant is fixed to the optimum dosage that is 1000ppm at 30°C. Figure 4.5 show the plots for the parameter final pH versus initial pH.

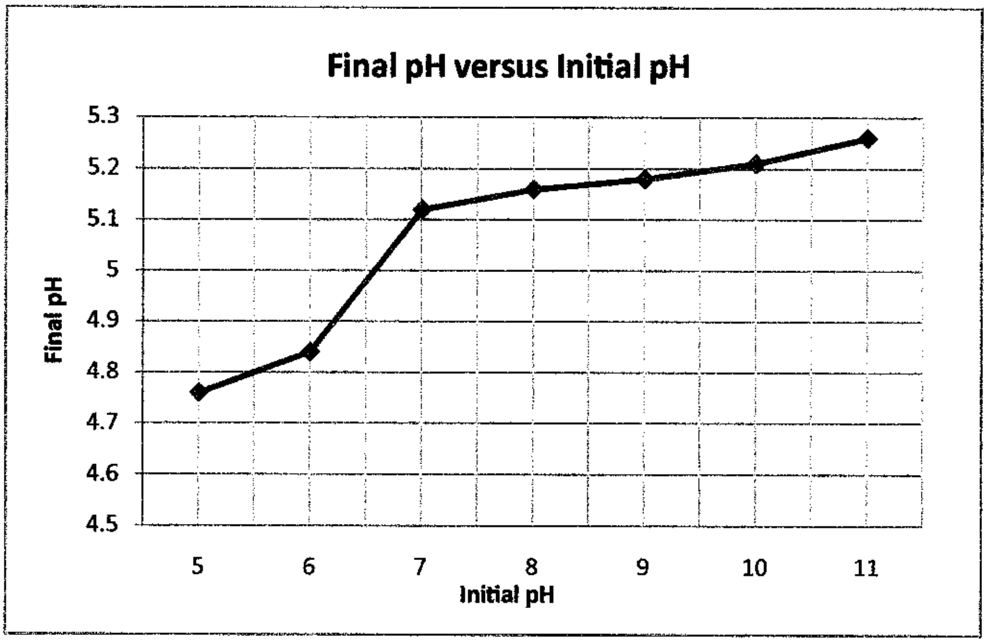

Figure 4.5 Final pH versus different initial pH

Based on Figure 4.5, it can be observed that that the increasing initial pH will give an increasing final pH after the treatment process which ranges between 4.70 and 5.30. This range of pH is said to still violating the Standard A and B in the Malaysia Environmental Quality (Sewage and Industrial Effluent).

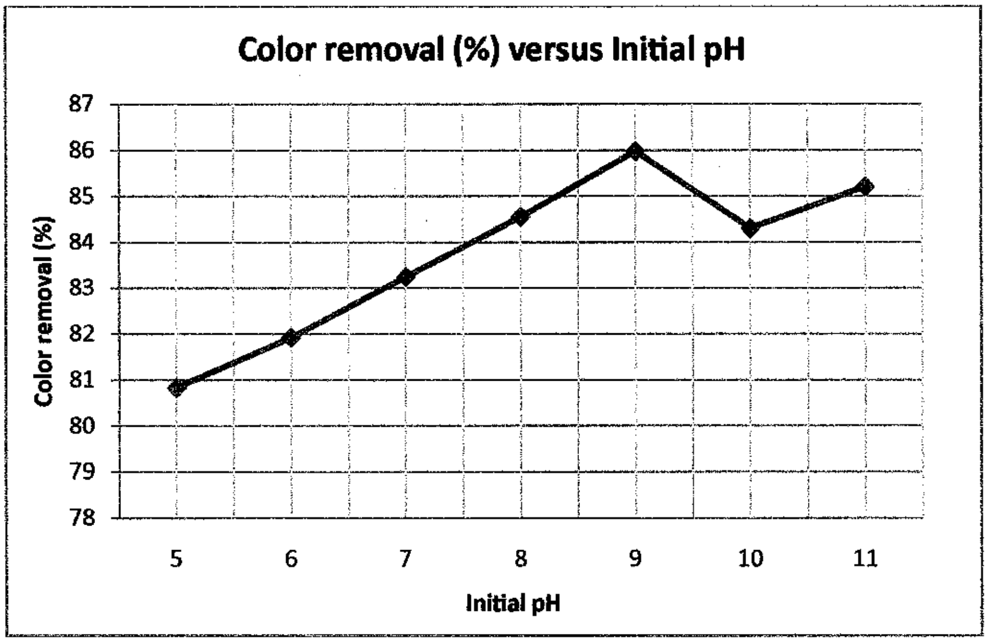

Figure 4.6 Color removals (%) versus different initial pH

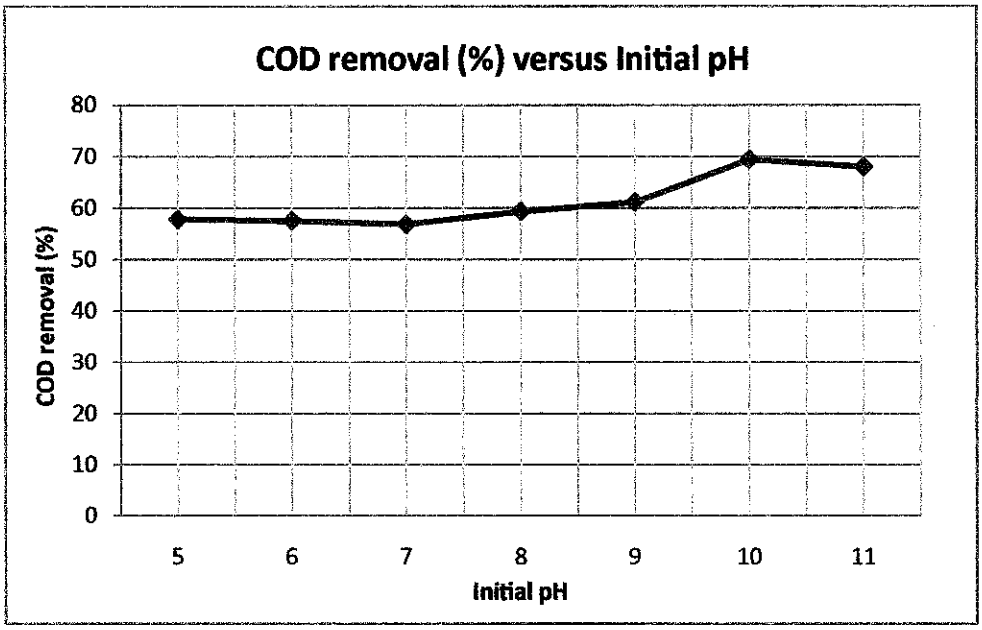

Figure 4.7 COD removal (%) versus different initial pH

Figure 4.6 illustrates that the percentage of color removal with different initial pH. The highest color removal happens when the initial pH of the wastewater in basic pH range that is 9. The color removal increased from pH 5 to pH 9, and then reduced in pH 10. From the result, it can be concluded that the removal percentage is higher in basic pH range which is pH 7 to 11. Since the pH of the solution was controlled by the addition of lime into the synthetic wastewater, it can be assumed that the higher the pH is, and then higher percentage of color removal is achieved. In addition, lime which also acts as a coagulant aid is able to help in increasing the percentage of color removal.

Meanwhile, Figure 4.7 illustrates that the highest COD removal happens when the initial pH of the wastewater 10. The COD removal increased slightly from pH 5 to pH 10, and then reduced in pH 11. From the result, it can be concluded that the removal percentage is higher in basic pH range which is pH 7 to 11 similarly for color removal.

4.5 Determination of the optimal operating temperature

Based on the Figure 4.8 and 4.9 below, the color and COD removal are decreasing by increasing the temperature from 30°C to 80°C. This condition can be explained by basic theory of kinetic energy, where higher temperature will cause the higher amount in the particle's kinetic energy. Due to the higher kinetic energy, the particles will move faster and resulting in the re-dissolving of the flocs into the water. Therefore, the percentage of COD and color removal show a poor performance in this experiment.

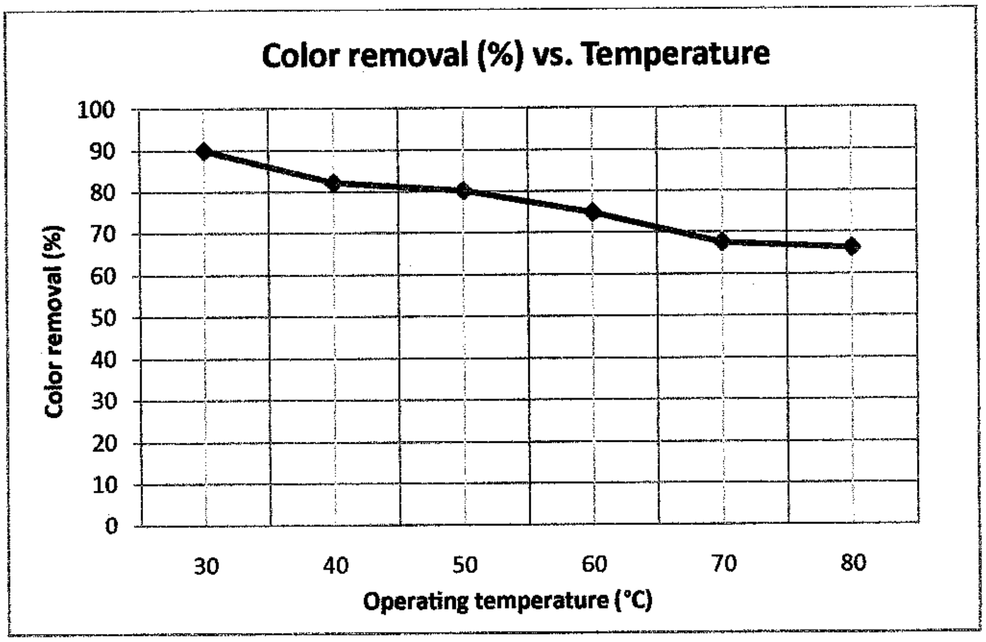

Figure 4.8 Color removals (%) versus different initial temperature

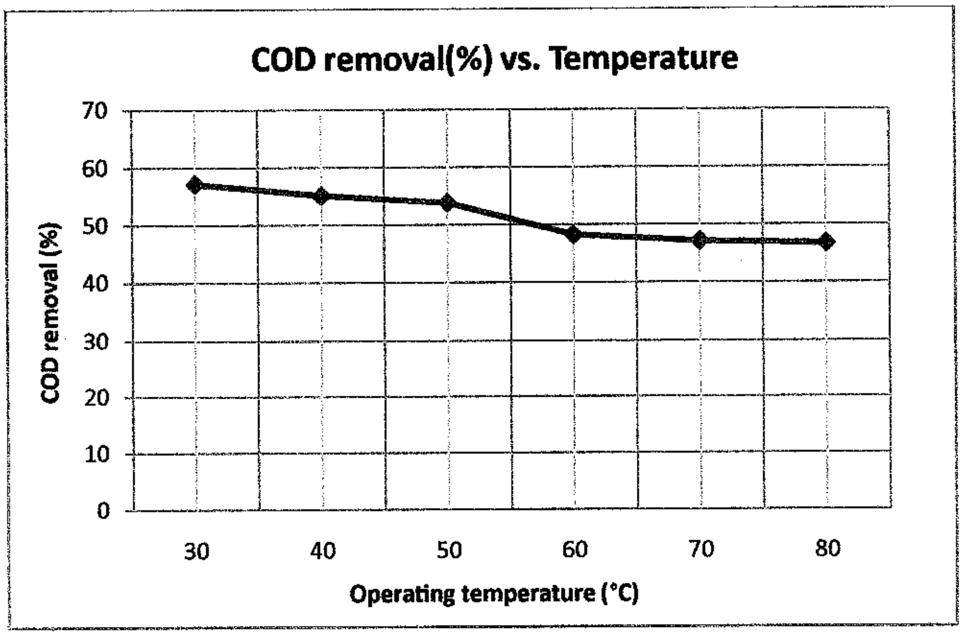

Figure 4.9 COD removals (%) versus different initial temperature

4.6 Determination of the optimum particle size of biomass

4.7 Determination of the optimum amount of biomass

The experiment was performed with different particle size of palm oil fruit fiber which is 45μm, 63μm, 125μm and 250μm. The amount of palm oil fiber was varied from 0.40 to 2.00 g. In order to determine the optimal particle size of palm oil fiber, the color removal and COD removal efficiency were taken into account. Table 4.1 shows the effects of different particle size and amount added of palm oil fiber to the final pH, percentage of COD and color removal and amount of sludge formed

This experiment is fixed to the optimum conditions which are the concentration of coagulant is 1000ppm, pH 9 and temperature of 30°C.

Results on Table 1 are presented in form of graph analysis based on Figure 5.0, Figure 5.1 and Figure 5.2.

Table 4.1 Results for the addition of palm oil fruit fiber as coagulant aid

Particle size (µm)	**45µm**					**63µm**				
	0.40	**0.80**	**1.20**	**1.60**	**2.00**	**0.40**	**0.80**	**1.20**	**1.60**	**2.00**
Final Ph	5.70	5.82	6.17	6.11	6.24	5.73	5.88	6.20	6.25	6.31
Color removal (%)	49.12	49.33	49.92	50.38	51.04	49.34	49.19	50.11	50.59	51.39
COD removal (%)	39.41	41.46	42.85	42.90	43.08	42.55	42.98	43.41	44.09	45.96
Amount of sludge (g)	0.0524	0.0543	0.0635	0.0641	0.0648	0.0626	0.0634	0.0649	0.0654	0.0671

Particle size (µm)	**125µm**					**250µm**				
	0.40	**0.80**	**1.20**	**1.60**	**2.00**	**0.40**	**0.80**	**1.20**	**1.60**	**2.00**
Final Ph	5.78	5.97	6.11	6.19	6.21	5.67	5.73	5.91	6.24	6.32
Color removal (%)	48.72	49.66	52.16	54.79	58.38	50.58	51.22	50.95	53.04	55.69
COD removal (%)	43.76	44.65	44.21	45.24	47.46	49.88	50.21	51.89	52.04	52.34
Amount of sludge (g)	0.0531	0.0538	0.0546	0.0642	0.0669	0.0628	0.0658	0.0669	0.0676	0.0686

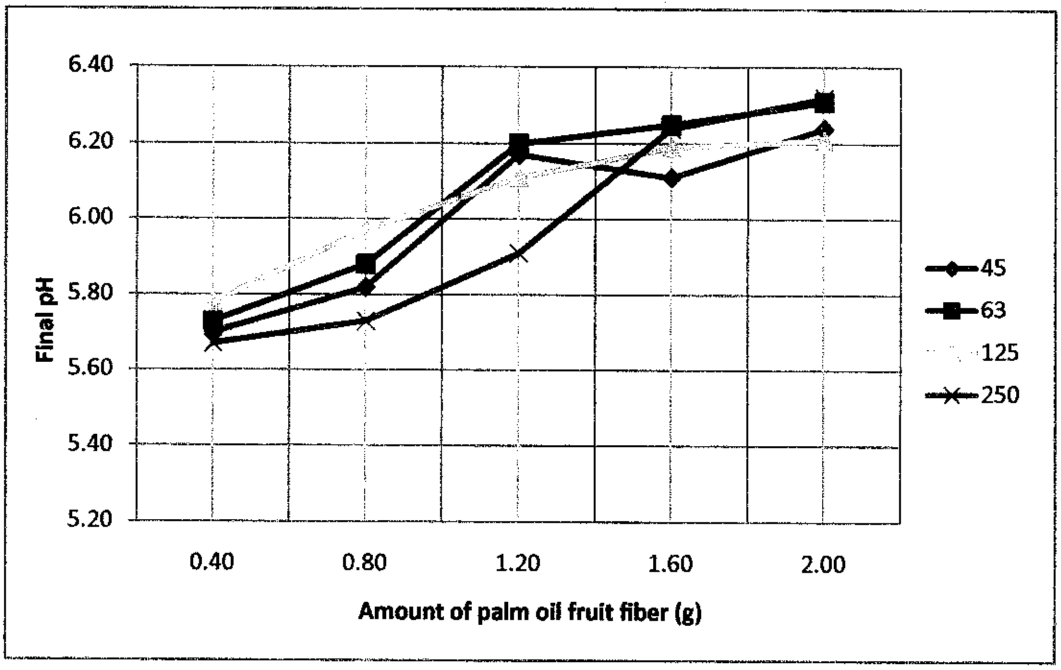

Figure 5.0 Final pH versus amount of palm oil fruit fiber for different particle size

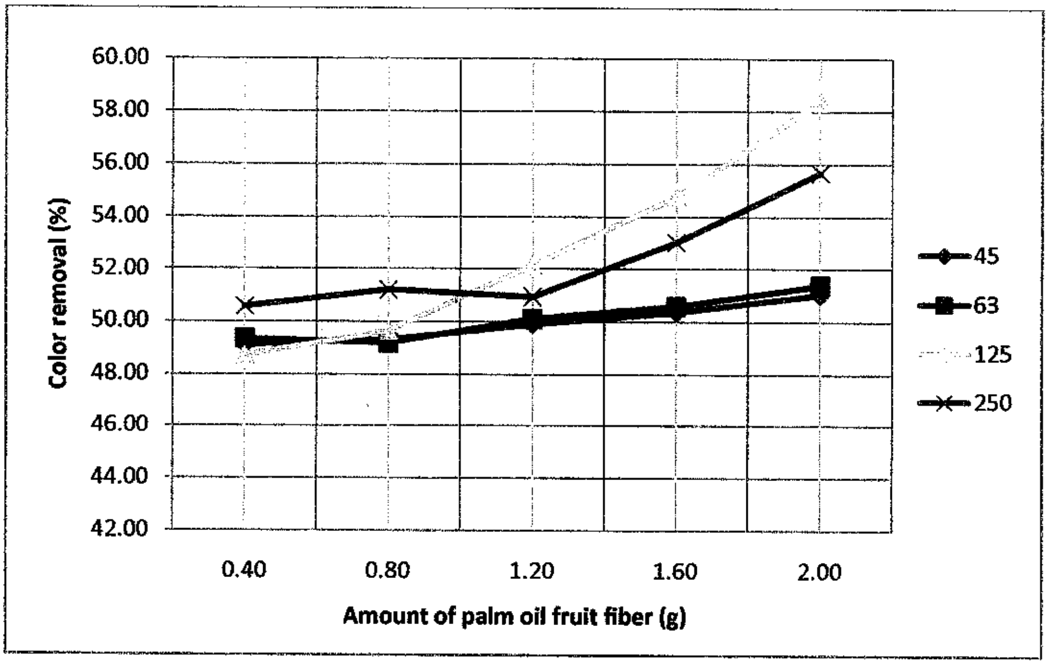

Figure 5.1 Color removal versus amount of palm oil fruit fiber for different particle size

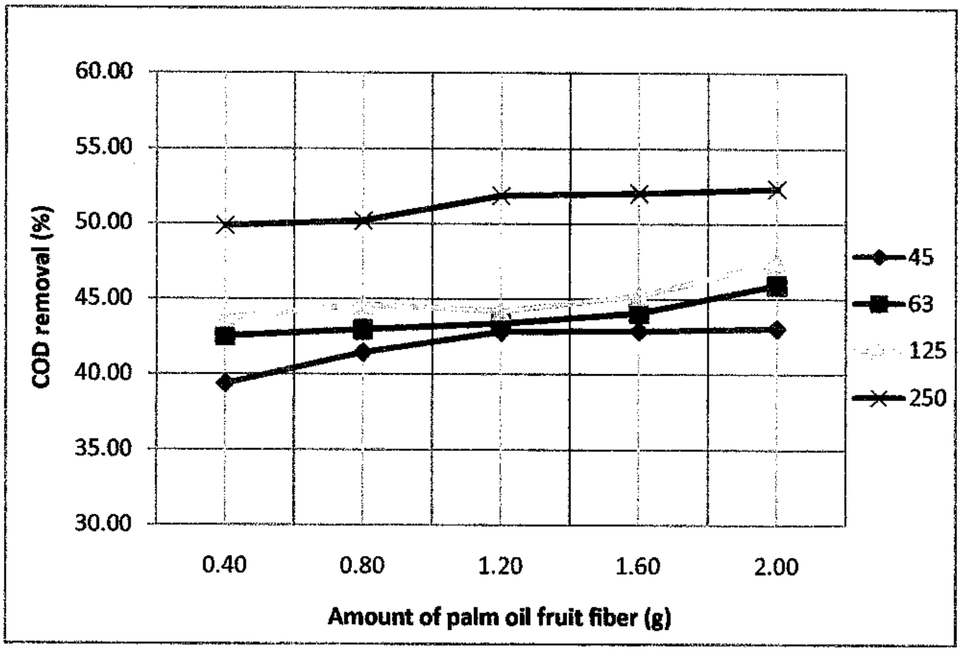

Figure 5.2 COD removal versus amount of palm oil fruit fiber for different particle size

Based on Figure 5.0, the graph presents the effect on various amount of palm oil fruit fiber to the final Ph. As the amount of coagulant aid is increasing, the final pH is also increasing between the ranges of 5.70 to 6.30 that indicate the reaction happened in basic condition. The highest final pH is achieved by 45 and 250μm of particle size and there is only slightly increment for every particle size.

Based on Figure 5.1, the highest percentage of color removal that have been achieved is 58.00 % when the addition of 2.00g of 125μm. Meanwhile, the lowest color removal is achieved through the addition of 0.40g of 125μm. From the graph analysis, the addition of palm oil fruit fiber as the coagulant aid in only able to remove up to 58.00% of color compared to the application of bentonite and kaolin. From the previous research, the use of bentonite as coagulant aid is able to remove up approximately 95.14% with the optimum conditions being fixed. Besides that, there is no significant color reduction observed after the addition of palm oil fruit fiber.

Based on Figure 5.1, the highest percentage of COD removal that have been achieved is 53.04 % when the addition of 2.00g of 250μm. Meanwhile, the lowest COD removal is achieved through the addition of 0.40g of 45μm 39.41%. in addition, as the amount of palm oil fruit fiber added to the solution is increased, certain amount of COD is removed but only in a slightly increment. No significant increment is being observed throughout this analysis, therefore it is expected that more COD is able to be removed if the amount of palm oil fruit fiber is added to the solution.

Another important element in COD and color measurement is the solubility rate of palm oil fruit fiber. It is observed that the use of biomass or specifically in a solid form is quite difficult as they tend to float in the wastewater surface. Therefore, the measurement of COD and color tend o be affected due to this condition. Application of biomass also may leads to the existence of certain impurities which also may affect the result of the experiment. Due to that reason, details properties of palm oil fruit fiber should be investigated in terms of the moisture and oil content to make sure better performance can be achieved. This is also related to the biomass preparation that needs to be follow so that there will be no impurities or dirt being left in that particular biomass. The existence of impurities or dirt will effect directly to the measurement results as they tend to react with the solution and give poor performance in terms of color and COD.

POTENTIAL OF BIOMASS AS COAGULANT AID IN WASTEWATER TREATMENT

CONCLUSION

Although there are many other treatments available, coagulation was chosen to be studied because it is widely used, and was claimed to be economically feasible. In addition, the idea of introducing a new coagulant aid based on biomass may help in reducing the operational cost of certain factories.

Therefore, several conclusions have been summarized throughout this experimental works:

a. The optimum conditions by applying ferric (III) sulfate as coagulant are 1000ppm of coagulant at temperature of f 30°C with pH 9.
b. Potential of biomass has been investigated as an alternative for the conventional coagulant aids in wastewater treatment. As the results, the following conclusion have been achieved:
    - The final pH is slightly increased
    - The amount of sludge formed is between 0.050 and 0.070g
    - The color and COD removal results are giving lower percentage of removal compared to the conventional coagulant aid.

c. Palm oil fruit fiber is able to remove COD and color in lower percentage than the conventional coagulant aid. Therefore, the application of palm oil fiber as the coagulant aid is not competitive compared to bentonite and kaolin clay as only small percentage of color and COD are being removed.

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RECOMMENDATION

Through the research works, there are several recommendations which are proposed and can be applied for future undertakings. The recommendations are as follows:

- Further and detailed research on the preparation of biomass should be investigated to make sure there will be no more impurities and dirt that can lead to a poor performance of coagulation.
- It is difficult for palm oil fruit fiber in terms of the solubility as it is in the solid form and tends to float on the water surface. Therefore, the physical properties of palm oil fruit fiber should be investigated so that, this solubility problem can be overcome.
- Biomass may perform better with a pretreatment at the beginning of experiment instead of using raw biomass. This can be suggested with the addition of certain chemicals to react with the biomass in the early stage.

POTENTIAL OF BIOMASS AS COAGULANT AID IN WASTEWATER TREATMENT

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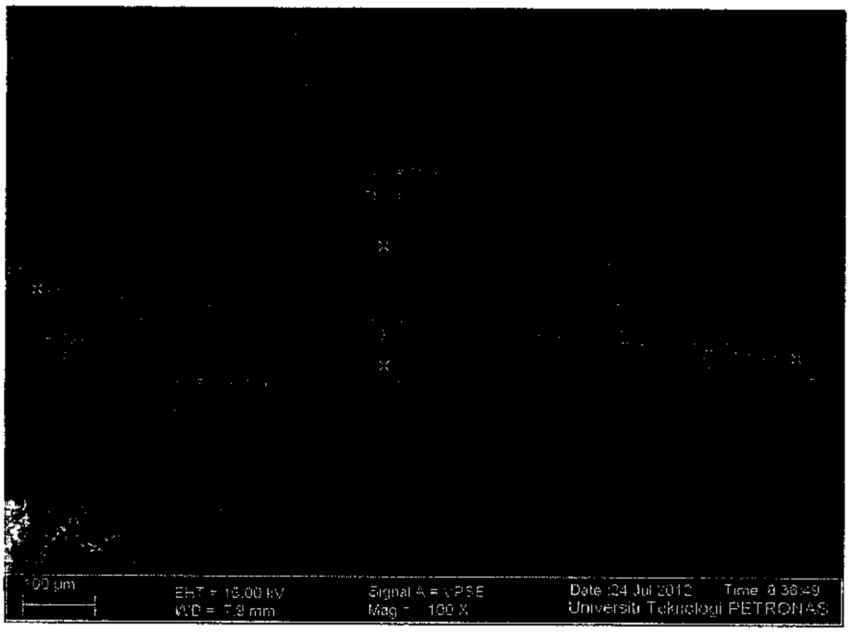
17. Coagulation and Flocculation Mechanism

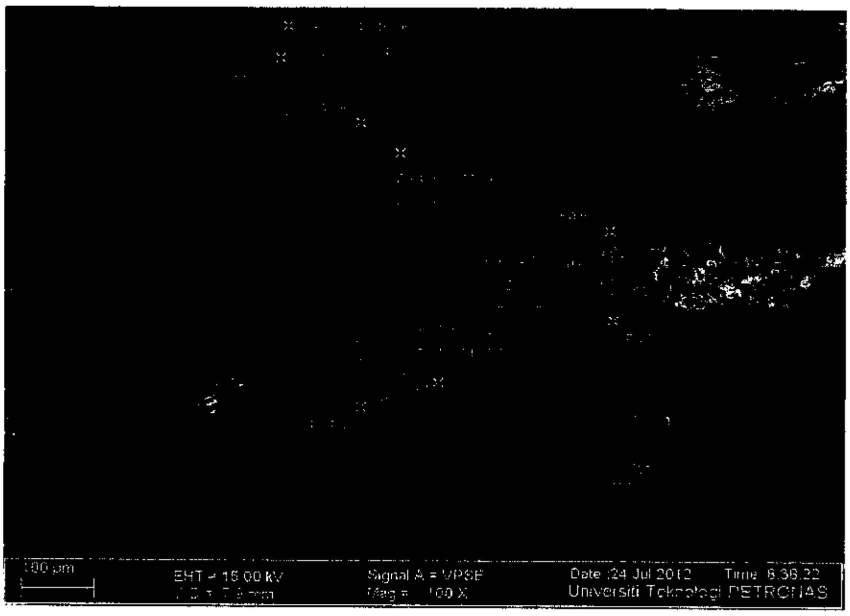
(http://chemistry.tutorvista.com/physical-chemistry/flocculation.html)

POTENTIAL OF BIOMASS AS COAGULANT AID IN WASTEWATER TREATMENT

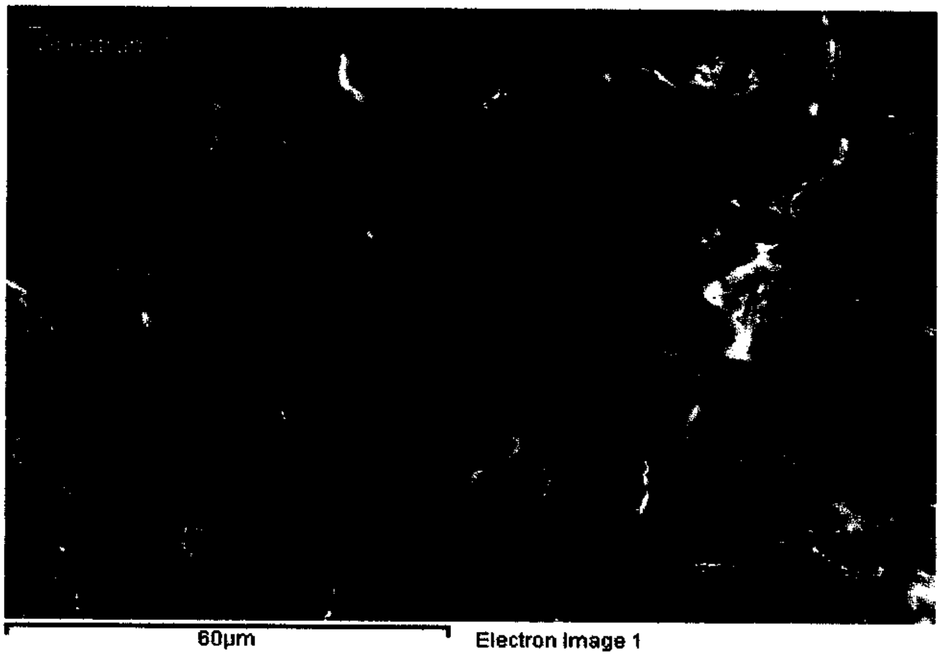
APPENDIX A

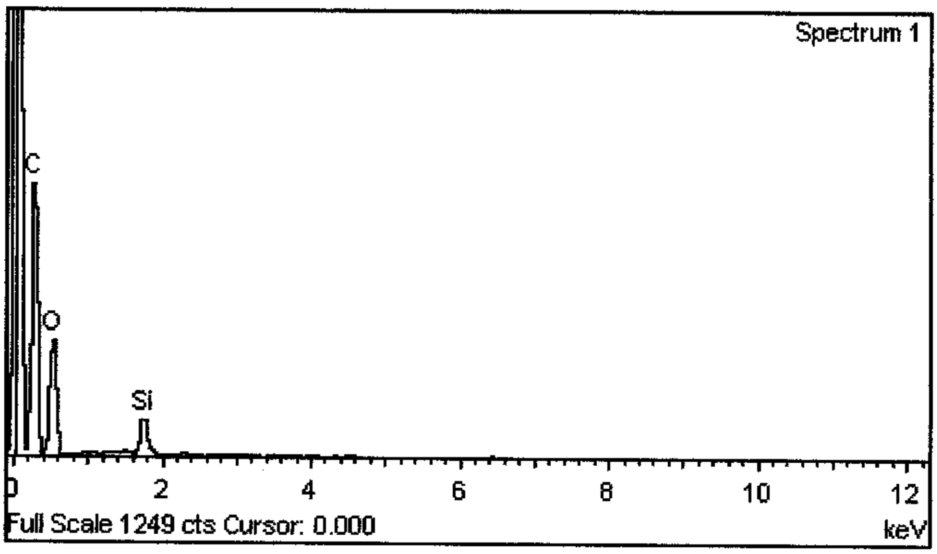
1. **Field Emission Scanning Electron Micrographs (FESEM)**





2. The Energy-dispersive- X-ray (EDX)





Element	Weight%	Atomic%
C K	57.68	65.10
O K	39.68	33.62
Si K	2.64	1.28
Totals	100.00	

3. Fourier Transform Infrared (FTIR)