

Froth Flotation Technique for Micro Algae Harvesting in Neutral Condition

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ABSTRACT

Columnar Froth Flotation is an old technique to harvest algae. Many years ago some methods were used with more than 3 chemical reagents to harvest algae. But this experiment used a simple technique with 2 chemical reagents. Both are collector reagents and frothers. The experiment in the laboratory can decrease by 76% the turbidity of watery algae. This research presents the result of the alternative harvesting method called, "Don't move water", but the algae can be harvested. However; the effect on waste water from this experiment needs further studied

Key words: Froth flotation, Micro algae, Algae harvesting

INTRODUCTION

Nowadays, petroleum is decreasing and more expensive. So many countries around the world are trying to find methods and using varied technology methods how to producing biomass energy in natural resources. The research has chosen the alternative energy which is very important to both the environment and human health when it is compared with using fossil fuel. That means the new energy resource can be produced continuously and eternally. Bio-diesel is an alternatively renewable energy which uses a very interesting method. They consume a large amount of carbon dioxide for running photosynthesis process to produce nutrients (Khattar et al., 2009). Algae will be extracted when they are controlled by using parameters to get the best oil. While algae are growing, they are enhancing the environment. Moreover, oil from algae growth is produced at a much faster rate tree growth which they spend a long time to be cut before using as charcoal.

There are many methods to harvest algae such as gravity filtration, vacuum filtration, gravity sedimentation, flocculate sedimentation, oil soluble chemical, high voltage electrostatic precipitator, hydrocyclone separator. However; the froth flotation is the alternatively method to be presented by the researcher.

MATERIALS AND METHODS

Froth flotation

Froth flotation is a separation process which has been used for a long time. There is mineral Talc in natural resources which has a hydrophobic property (Fuerstenau, 1957). When it is dropped into water, in a few minutes it float on the surface. On the other hand, silica impurities sink to the bottom showing a hydrophilic (Tschapek et al., 1987) property. This experiment showed the method how to apply a hydrophobic property of the algae surface for harvesting.

Chemical reagents

In this experiment is essential to use two types of chemical reagents; the first cationic collector is an organic compound as a positive charge in liquid. The common element is shared by all cationic collectors: a nitrogen group presenting with unpaired electrons. This covalent connection to nitrogen is usually a hydrogen atom and hydrocarbon group. A change in the number of hydro-

carbon radicals connected to the nitrogen determines flotation characteristics of amines in general, depending on the number of hydrocarbon radicals attached to the nitrogen bond. Another classification of amines includes alkyl amines, aryl amines and alkyl-aryl amines according to whether the nitrogen atom is attached to a carbon atom of a chain, or to a carbon atom of a cyclic structure or to both (Bulatovic, 2007). Primary aliphatic amine, n-dodecylamine ($C_{12}H_{25}NH_2$) (Figure 1a) and n-butylamine ($C_4H_9NH_2$), are cationic collectors which are used to cover surface of microalgae for bringing them with an air bubble.

Next pine oil for frothers which are heteropolar surface-active compounds with alcohol polar group (OH) and a hydrocarbon group for another side is non-polar group which can adsorb air bubbles in pulp. The pine oil is arranged at the gas and water interface by polar groups which are oriented into the water phase, and the non-polar aromatic hydrocarbon in the air phase, also lower the surface force of water and gas. Decreasing surface tension is a result of a surface of an air bubble in this experiment difficult to break. Pine oil is an aromatic hydrocarbon in one-side and the other side contains alcohol groups. General name is Phenol (C_6H_5OH) (Figure 1b) use for increasing stability around surface of air bubbles (Bulatovic, 2007).

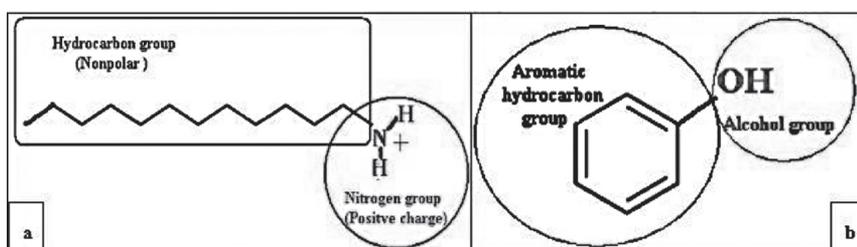


Figure 1. (a) n-dodecylamine chemical structure; left side is hydrocarbon group and right side connect with nitrogen group has a positive charge, (b) Phenol chemical structure; left side is aromatic hydrocarbon group and the right side connects with an alcohol group.

Flotation equipment

In this experimental is used a Denver of laboratory machine. Algae is floated in a batch flotation cell, acrylic flotation cell. They are generally 1000 cubic centimeter (cm^3) size of floatation cell which is simulated from the pilot scale and industrial scale models a mechanically motor is driven by an AC motor, 1 phase, 1/4 horsepower (hp), voltage is 230V@ 1425 revolution per minute (rpm) speed of rotation can be adjusted by variable pulleys set to control an impeller at 900 rpm while mixed pulp mineral and 1200 rpm when recovered micro algae.

Air will flow to the bottom of the flotation cell goes through a vertical air inlet pipe above the impeller structure. Rotating of impeller under water is builds vacuum space at the bottom of cell, causing air flowing downwards, and the air stream is sheared into fine air bubbles, raised and picked up micro algae contacted with air bubbles to the surface.

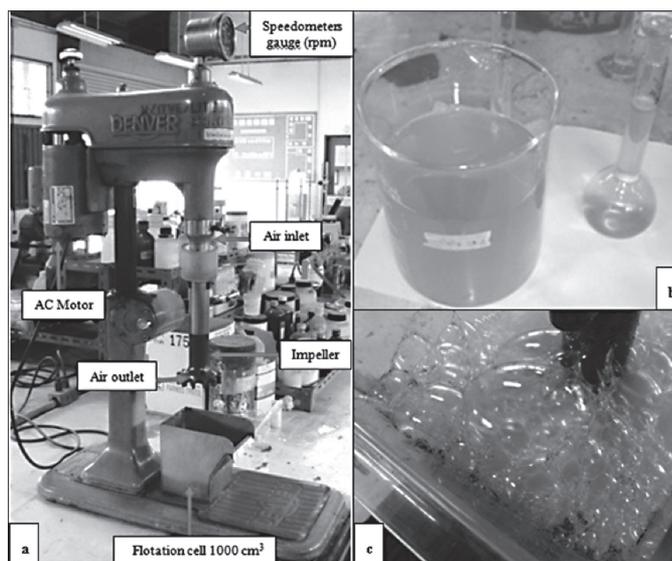


Figure 2. (a) Mechanically flotation machine laboratory scale, (b) *Chlorella algae* sample before diluting froth flotation, (c) Air bubbles bring up algae to the surface.

Froth flotation Process

This experiment uses "*Chlorella algae*" samples (Figure 2b). In fact an alga is green color in water. If algae are more in sample composition, they will make a greener color. At first dilute algae water 200 cm^3 with fresh water 400 cm^3 . It will be mixed to density pulp. Generally the surface electric charge of chlorella algae is a negative surface charge, obtained when pH is more than 4.1 (Wyatt et al., 2011). Easy to react with cationic amine collector. Next fill the amine collector in pulp density after that waiting 5 minutes for amine reagent to cover an algae while agitating by flotation machine after that add pine oil 2 milligrams (mg) for decreasing surface tension in water. At last the releasing air to make bubbles to bring up an algae to the surface (Figure 2c).

Environmental considerations

This experiment uses 2 chemical reagents, n-dodecylamine and phenol which considering on the environment when compares with the material safety data sheet (MSDS), because of removing water from algae for recycling of water may leak through the environment. A n-dodecylamine is toxicity data (The Safety Officer in Physical Chemistry at Oxford University, 2005a) showing that LD_{50} (median lethal dose) for rats at 1020 mg kg^{-1} of their bodies' weight. A butylamine is toxicity data (The Safety Officer in Physical Chemistry at Oxford University, 2005b) showing that LD_{50} for rats at $360 \text{ milligrams kg}^{-1}$ of there bodies' weight. And phenol is toxicity data (The Safety Officer in Physical Chemistry at Oxford University, 2005c) showing that LDLO (Lowest published lethal dose) for humans at 140 mg kg^{-1} of their bodies' weight which is conscious.

Experiment

This Experimental using control parameters which is neutral condition (around pH 7), flotation cell 1 liter size which is made from plastic acrylic. The speed of the agitator impeller is 1200 rpm. Quantity of n-dodecylamine and butylamine which collector are designed as variable parameter for flotation process. All steps of the experiment are as the following flowchart (Figure 3).

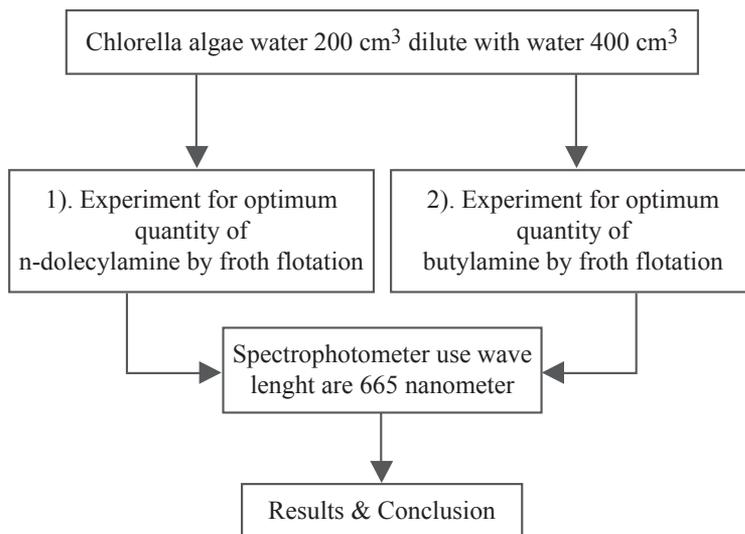


Figure 3. Flowchart of experimentation.

RESULTS

At first the experiment for optimum quantity of n-dodecylamine by froth flotation is varied from 0.002 to 0.028 gram, Preparations n-dodecylamine weigh 0.50 gram diluting in fresh water 500 ml, mix n-dodecylamine solvent. In each 1 ml of solvent, there are chemical reagents 0.001 gram (or 1 milligram). Results from water after floated are: (Figure 4a) algae (Figure 4b) from flotation cell. Those bring it to spectrophotometer and analyze 3 times from each sample (Figure 4c) by using the spectrum. It is 665 nm from the record data (Table 1) and plot graph (Figure 5).

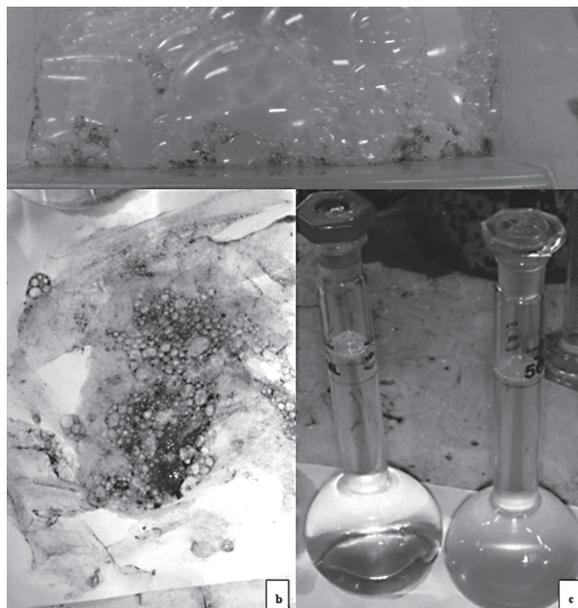


Figure 4. (a) Algae is floated by air bubbles, (b) Algae sample is floated, (c) Water after froth flotation finished compare with algae water before diluting.

Table 1. Effect of quantities n-dodecylamine to %turbidity.

n-Dodecylamine; Spectrophotometer; 665 nm					
Type of Sample	Absorbance	Absorbance	Absorbance	Absorbance average	% Turbidity
Algae water (AW)	0.066	0.067	0.067	0.0667	–
Fresh water (FW)	0.001	0	0.001	0.0007	–
AW : FW 200 ml : 400 ml	0.044	0.046	0.046	0.0453	100%
Dodecylamine 2 mg	0.040	0.038	0.040	0.0393	87%
Dodecylamine 4 mg	0.041	0.041	0.040	0.0407	90%
Dodecylamine 6 mg	0.033	0.032	0.032	0.0323	71%
Dodecylamine 8 mg	0.022	0.024	0.024	0.0233	51%
Dodecylamine 10 mg	0.019	0.022	0.023	0.0213	47%
Dodecylamine 12 mg	0.011	0.010	0.012	0.0110	24%
Dodecylamine 16 mg	0.020	0.023	0.023	0.0220	49%
Dodecylamine 20 mg	0.019	0.024	0.025	0.0227	50%
Dodecylamine 24 mg	0.032	0.028	0.029	0.0297	65%
Dodecylamine 28 mg	0.023	0.025	0.026	0.0247	54%

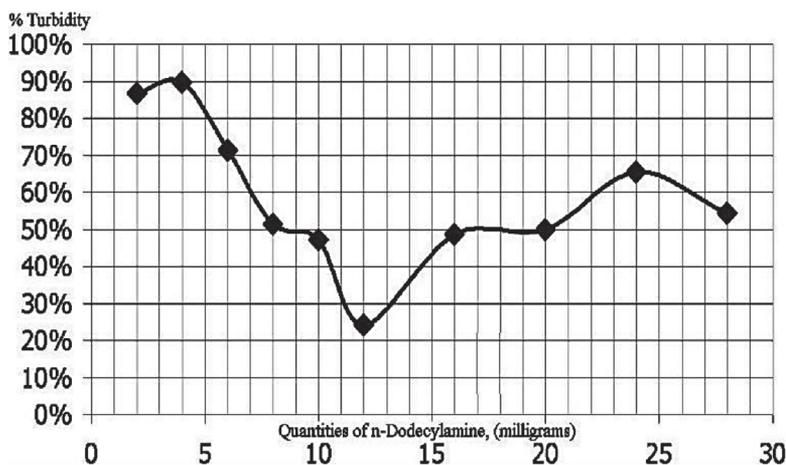


Figure 5. Effect of quantities n- dodecylamine to %turbidity by graph.

Next step of the experiment for optimum quantity of n-butylamine by froth flotation varies from 0.010 to 0.040 gram, Preparations n-butylamine weigh 1 grams diluting in fresh water 1000 ml. When it is mixed in n- butylamine solvent. There are chemical reagents 0.001 gram (or 1 milligram) in each 1 ml of solvent. Results from water after floated algae from flotation cell bring it to spectrophotometer and analyze 3 times from each sample by spectrum. It is 665 nm and the record data (Table 2) of chemical reagents : 0.001 gram (or 1 milligram).

Table 2. Effect of quantities n- butylamine to %turbidity.

n-butylamine; Spectrophotometer ; 665 nm					
Type of Sample	Absorbance	Absorbance	Absorbance	Absorbance average	% Turbidity
Algae water (AW)	0.0660	0.0670	0.0670	0.0667	–
Fresh water (FW)	0.0010	0.0000	0.0010	0.0007	–
AW : FW 200 ml : 400 ml	0.0440	0.0460	0.0460	0.0453	100%
Butylamine 10 mg	0.0420	0.0410	0.0420	0.0417	92%
Butylamine 15 mg	0.0410	0.0400	0.0410	0.0407	90%
Butylamine 20 mg	0.0400	0.0390	0.0400	0.0397	88%
Butylamine 35 mg	0.0380	0.0380	0.0370	0.0377	83%
Butylamine 40 mg	0.0410	0.0410	0.0400	0.0407	90%

DISCUSSION AND CONCLUSION

In these samples from trial to optimum quantity of n-dodecylamine by froth flotation are 12 mg and 24% Turbidity. Using collector chemical reagents less than suitable scale causing algae still suspends in a water sample and more than suitable scale a collector reagent chemical make a water sample more turbidity by itself cause n-dodecylamine solvent as like as pulp cream, white and viscous, starch slurry, extravagant of n-dodecylamine, leaks to environment is concerned while green micro algae have been already recovered by froth flotation. But the researcher tries to test n-butylamine in froth flotation process because hydrocarbon group of n-butylamine is shorter than n-dodecylamine cause easily to digest by natural, from observations by researcher 5 samples in every sample. It is found that “No different” from the sample before trials. Although spectrophotometer can be detected the sample. Another result is a microalga which does not appear on air bubbles.

The efforts to harvest micro algae from the huge pond in a practice by pumping and filtering through the filter system. Although a micro algae is trapped in the filtration method or others which is a high efficiency. But ever the energy which moves the huge water separates the algae from water the same as catching fish in the Gulf of Thailand by pumping and filtering on the ground after taking water from the Gulf to the Andaman Sea. Do the fish still get more profit than using energy to move that water? This research is the only alternative of harvesting: “Don’t move water” method. The recommendations from researcher may make the circle algae pond when it is ready to harvest, they can be turn blades by agitators around the circle pond. That can be added collector reagent less than the optimum point which is ensures that the collector has been used for coating the surface of algae. Then they remain to leave a little bit of algae for breeding in the circle pond again.

The other method, when finish harvesting all algae and degeneration water needs to be used for the other kinds of plant for repairing and filling the nutrient by plants as natural ways. At last the researcher still studies the effect on water degeneration to other objectives. The same as growing the other kinds after harvesting the main crop in order to increase more nutrients in the soil before growing the main crop again.

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