Enhancement of electroflotation using *Musa acuminate* peel as biocoagulant on the wastewater treatment of chemical laboratory

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**Abstract.** In this study, the combined biocoagulation electroflotation process using *Musa acuminate* peel coagulant was evaluated using chemical laboratory wastewater as water sample. The effectiveness of the combined biocoagulation electroflotation process was seen based on the proportion of turbidity removal (%) and the proportion of TDS removal (%). The results showed that the proportion of turbidity reduction in chemical laboratory waste was 98.23% and the proportion of TDS disposal was 28.85% using an optimum coagulant dose of 0.5g/500 mL of chemical laboratory wastewater.

**1. Introduction**

Laboratory activities that use chemicals will inevitably produce both solid and liquid waste such as laboratory wastewater. There are two types of waste, solid waste and liquid waste. Liquid waste is more dangerous than solid waste [1]. Liquid waste must be treated before being discharged into the environment. Coagulation is the often method used in wastewater treatment by adding the coagulants such as aluminium salts to stabilize the colloidal material [2]. However, the chemical coagulants can cause Alzheimer’s disease [3], and pre-senile dementia [4]. To avoid this, natural coagulants are used to replace the chemical one, whichs extracted from microorganisms, animals, and plants [5].

Banana is a plant that is given by Southeast Asia and spread widely to Africa, South America, and Central America and spread throughout the world. Bananas can be consumed in the form of fresh fruit and the form of processed and consists of various types. Banana peels are a lot of waste from bananas and contain 1/3 part of bananas. Bananas contains 10-21% of pectin [6-7].

Electroflotation focuses on the formation of bubbles based on the redox reaction of water. The size of the bubbles directly affects the effectiveness of the process. Electrodes material is the most important part of electroflotation [7]. Graphite and lead oxide are the electrodes commonly used in electroflotation [8]. Ketkar et al (1991) described graphite and PbO₂ electrodes have high potential to produce large O₂ bubbles [9]. Therefore, this study will combine the electroflotation process with biocoagulants so that it will improve the performance of the electroflotation process in treating chemical laboratory wastewater.
2. Experimental methods

2.1. Electroflotation reactor design
In the electroflotation process, the reactor design is made of glass with a design of 10cm (length) x 10cm (width) x 15cm (height). This electroflotation reactor can be used up to 1 L. Graphite electrodes are as anodes and cathodes. Figure 1 shows the dimensions of the electroflotation reactor used in this study.

![Figure 1. The dimension of electroflotation reactor used in this study.](image)

2.2. Preparation of biocoagulant
*Musa acuminate* peels were cleaned with distilled water and then dried at room temperature for 2 hours. Furthermore, all peels were dried in oven at 100 °C for 8 hours. Dried peel was then mashed and sieved using 150 mesh to obtain a uniform size.

2.3. Voltage optimization
The optimization of the electroflotation process was carried out using 0,001 M MgSO₄ as electrolyte solution in several of DC voltage of 10, 14, 18, 22, 26 and 30 V for 30 minutes. The optimum results were concluded by direct measuring the distribution and size of bubbles at each voltage. Bubble image was captured by using 8 times of magnifying glass and digital camera in the distance between the camera and reactor was 17 cm. This measurement was then calibrated by Image J software.

2.4. Dosage optimization
As much as 500 mL of wastewater was put into the beaker and then added coagulant *Musa acuminate* peels coagulant as much as 0,25; 0,5; 1; 3; and 5 g then stirred for 1 hour. The determination of the optimal dose of coagulant is done by looking at the lowest turbidity number at each dose.

2.5. Electroflotation processes without biocoagulant
The optimum voltage was applied in the electroflotation of wastewater for 60 minutes at 500 mL solution. This process was carried out without adding a coagulant to compare with the electroflotation with biocoagulant.
2.6. Electroflotation processes with biocoagulant

As much as 500 mL of liquid waste is put into the reactor then coagulant is added according to the optimum dose with the optimum dc current for 30 minutes.

3. Result and discussion

3.1. Characterization of biocoagulant

Functional groups contained in the coagulant are identified to determine the presence of functional groups that may interact with dissolved particles in solution[10]. Pectin is a macromolecule containing carboxyl and methoxyl groups which can function as coagulants and flocculants agent [11]. Figure 2 shows FTIR peaks of functional groups in *Musa acuminate* peel coagulant. Peak observations were made in the range 1730–1760 cm\(^{-1}\) and 1600–1630 cm\(^{-1}\) to see the presence of a carbonyl group (C=O) and a carboxyl group (COO\(^{-}\))[12]. In Figure 2 there are absorptions peak at 1603 cm\(^{-1}\) which indicates the presence of a carboxylate group (COO\(^{-}\)) and a peak of 1736 cm\(^{-1}\)which indicates the presence of a carbonyl group (C=O). It can be concluded that *Musa acuminate* peel coagulant contain biopolymers which can be used as coagulants.

![Figure 2. IR peaks of active groups in *Musa acuminate* peel coagulant.](image)

3.2. Voltage optimization

Table 1 shows the plot results of bubble sizes distribution was generated at different DC currents in the cathode and anode electrode. The linear regression value (R\(^2\)) was used to evaluate the optimal voltage in the electroflotation. Direct measurement of bubble size distribution using camera image was plotted with software measurement with ImageJ software to get R\(^2\) value. In the electroflotation process, the amount of current is directly proportional to the formation of gas bubbles. The greater the current used the faster the formation of gas bubbles to affect the electroporation performance due to shrinkage of the bubble nucleation time. When nucleation shrinkage occurs, the bubbles produced will have a smaller size and cause the collision process between bubbles and particles to be greater so that the efficiency of the electroflotation process will increase [13]. From the 6 voltage variations, the voltage of 26 V has a linear regression that is close to one at both the anode and cathode. This shows the closeness of the calculation results between manual calculations with ImageJ software in determining the size of the bubbles. So it can be concluded that the optimum voltage for the electroflotation process is 26 V.
| DC Voltage | Cathode | Anode |
|------------|---------|-------|
| 10 V       | ![Graph](image) | ![Graph](image) |
|            | $y = -11x + 80$  
$R^2 = 0.8176$ | $y = -1.0164x + 13.443$  
$R^2 = 0.9405$ |
| 14 V       | ![Graph](image) | ![Graph](image) |
|            | $y = 0.3571x + 4.2857$  
$R^2 = 0.1453$ | $y = 1.5x - 5$  
$R^2 = 0.75$ |
| 18 V       | ![Graph](image) | ![Graph](image) |
|            | $y = 0.8421x + 1.0526$  
$R^2 = 0.8421$ | $y = -0.0253x + 6.8354$  
$R^2 = 0.0506$ |

Table 1. Results of manual measurement vs ImageJ plots on determining bubble size.
22 V

\[ y = 0.7x + 2 \]
\[ R^2 = 0.6447 \]

26 V

\[ y = 0.8689x + 0.8738 \]
\[ R^2 = 0.9844 \]

30 V

\[ y = 0.6902x + 1.3988 \]
\[ R^2 = 0.9586 \]
3.3. Dosage optimization
Some important parameters in determining water quality are turbidity and TDS. Figure 3 shows the effect of biocoagulants on decreasing the wastewater turbidity. The optimum dose of coagulant is 0.5 g/500 mL with a turbidity of 1.26 NTU with percent removal 99.16%. This shows that the pectin in *Musa acuminate* peel coagulant that has a COO⁻ functional group will bind to positive particles in wastewater [11]. However, there is an increase in the value of turbidity if the coagulant dose exceeds 0.5 g due to the repulsion between particles with the same charge so that floc deflocculation occurs as a result, the turbidity of the wastewater increases [14]. On the other hand, *Musa acuminate* peel coagulant did not affect the decrease in TDS which can be seen in Figure 4 where the more coagulant doses were added, the TDS value did not decrease. It can be concluded that *Musa acuminate* peel coagulant can reduce turbidity due to the presence of the COO⁻ functional group but does not have an impact on decreasing TDS in waste. The optimal dose of coagulant is 0.5 g.

![Figure 3. Effect of biocoagulant dosage on turbidity.](image1)

![Figure 4. Effect of biocoagulant dosage on TDS.](image2)

3.4. Chemical laboratory wastewater treatment using electroflotation
In this study, an electrode in the form of graphite was used both as anode and cathode. The use of graphite electrodes is due to its high efficiency in the production of hydrogen. This is due to the presence of a layer in the graphite electrode and the porous nature of the material so that it can increase water diffusion which causes the production of hydrogen to increase [15]. Table 2 shows the comparison of the results between the electrofloation process and the electrofloation-biocoagulation. In the electrofloation process, the turbidity decreased by 97.02% and the TDS decreased by 32.08%. In the biocoagulation electrofloation process, the decrease in turbidity was greater, 98.23%, but the decrease in TDS was only 28.85%. It can be concluded that the combined electrofloation-biocoagulation process is better at reducing wastewater turbidity compared to electrofloation.

| Treatment                  | TDS (ppm) | Turbidity (NTU) |
|----------------------------|-----------|-----------------|
| Wastewater                 | 5580      | 150             |
| Electrofloation            | 3790      | 4.47            |
| Combine process            | 3970      | 2.65            |
| (electrofloation-biocoagulation) |          |                 |
4. Conclusion
Based on the research results, it can be seen that *Musa acuminate* peel biocoagulants can improve electrofloitation performance when compared to electrofloation without using biocoagulants. In electricity without using a coagulant, the percentage of turbidity reduction and TDS reduction percentage was 97.02% and 32.08%. Whereas in the combined process the decrease in the percentage of turbidity increased to 98.23% but the percentage decrease in TDS was only 28.85%. It can be concluded that the combined biocoagulation electrofloitation process using *Musa acuminate* peel coagulants is considered good because it can reduce turbidity beyond the usual electrofloitation process.

5. Acknowledgements
The authors would like to thank Ministry of Education and Culture and Ministry of Research and Technology of the Republic of Indonesia for their financial support through Excellence Higher Education Basic Research (PDUPT) 2019-2020 (Research contract: 227/SP2H/LT/DRPM/2019; LLDIKTI and UII contract: 1627.1/LL5/PG/2020).

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