

The Effectiveness of Electrocoagulation Process in Rubber Wastewater Treatment using Combination Electrodes

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The Effectiveness of Electrocoagulation Process in Rubber Wastewater Treatment using Combination Electrodes

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Abstract. Industrial wastewater is one of the types of waste that can pollute the water environment. Almost the entire industry has one wastewater effluent owned rubber industry. Many of the rubber industry is less concerned about the quality of water and dispose of waste directly into the environment. Whereas in the rubber industry wastewater content, there are many pollutants that can harm the environment, especially the marine environment, such contaminants as metals, organic substances, and inorganic substances. For that, we need a method that can be used in treating wastewater of this rubber industry that is by electrocoagulation method. Electrocoagulation is a method of coagulation by using electric current through electrochemical events. Rubber wastewater treatment by electrocoagulation method is done by varying the voltage and process time, that is with variations of 12V, 15V, and 18V and with variation of process time 30 minutes, 60 minutes, 90 minutes, 120 minutes and 150 minutes to find out pH values, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD₅), and Ammonia levels. From the research results obtained, optimum conditions are at a voltage of 18 volts with a processing time of 150 minutes. The effectiveness electrocoagulation of rubber wastewater was for TSS 85.39%, COD 56.14%, BOD₅ 57.18%, and NH₃ 73.5%, respectively. These results have fulfilled the environmental standards of rubber wastewater.

1. Introduction

Wastewater treatment technology is vital to preserving the environment. Whatever type of domestic and industrial wastewater treatment technology is built, it must be operated and maintained by the local community. So the processing technology chosen must be following the technological capabilities of the people concerned. Various wastewater treatment techniques for removing pollutants have been tried and developed so far [1-3].

Development of new industries at this time can increase prosperity for the community, but bring negative impacts on the environment. These effects need to be considered several effects, such as waste produced. One industry that produces liquid waste is the rubber industry. Liquid waste produced by the rubber industry contains relatively high organic compounds. The existence of these organic materials causes the value of BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) in the liquid waste of the rubber industry to be high [4-8].

One of the chemical wastewater treatment without coagulant is electrocoagulation. The electrocoagulation method is a cheap and effective method for treating industrial waste. Electrocoagulation is an electrochemical method for waste treatment where an anode occurs in the release of active coagulant in the form of metal ions (usually aluminum or iron) into a solution, whereas in the cathode an electrolysis reaction occurs in the form of hydrogen gas release [9-12]. The electrocoagulation technique has several advantages, namely simple equipment, easy operation, short reaction time. Also, during the electrocoagulation process, the salt content does not increase



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significantly as it occurs in chemical processing, so the pH tends to be constant. The basic principle of electrocoagulation is the reduction and oxidation (redox) reaction. In an electrocoagulation cell, the oxidation event occurs at the electrode (+), which is the anode, while the reduction occurs at the electrode (-), which is the cathode. What is involved in electrocoagulation reactions other than electrodes is treated water, which functions as an electrolyte solution. Electrocoagulation is capable of removing various types of pollutants in water, namely suspended particles, heavy metals, colors in dyes, and various other harmful substances [13-17].

2. Materials and Method

The materials used in this study were rubber liquid waste, concentrated H_2SO_4 , KIO_3 , $FeSO_4 \cdot 6H_2O$, ferroin indicator, starch indicator, HCl , $AgSO_4$, potassium dichromate, and $Na_2S_2O_3$. The equipment used in this research is a set of electrocoagulation, which is equipped with aluminum and stainless steel electrodes, electrode cells, regulators, digital multimeters, and anode and cathode connecting cables. During the processing of this rubber liquid waste, the processing time is varied. The electrodes used were 11 cm long, 11 cm wide, the distance between the electrodes was 1 cm, and the thickness of the aluminum electrode was 0.25 cm, and the thickness of the stainless steel electrodes was 0.33 cm.

After the electrocoagulation cell is filled with rubber liquid waste, the anode and cathode connecting cables are connected, then the voltage flow is turned on by using voltage variations of 12 volts, 15 volts, 18 volts and the operating time of each process is 30 minutes, 60 minutes, 90 minutes, 120 minutes, and 150 minutes. The results of the electrocoagulation process were precipitated for 2 hours, then filtered from the results of the precipitate. The characteristics of the electrocoagulation process were determined by measuring the pH, BOD, COD, TSS, and ammonia levels in the filtered cell. The rubber waste treatment equipment using the electrocoagulation method is shown in Figure 1.

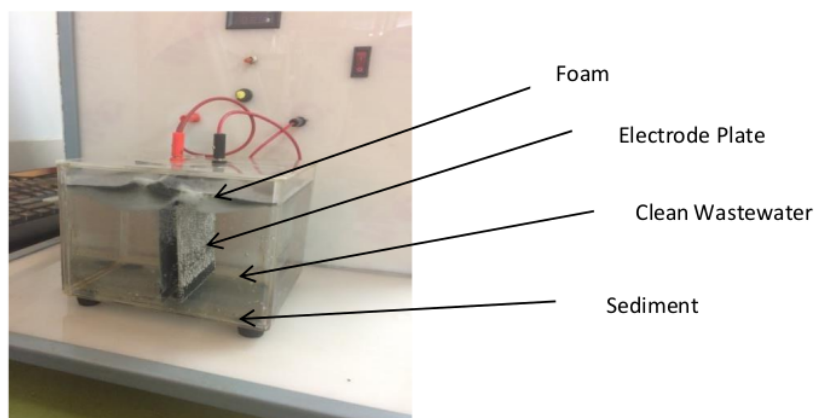


Figure 1. Rubber waste treatment by electrocoagulation method

3. Result and Discussion

3.1 Initial Characterization of Rubber Liquid Waste

Initial analysis was carried out on rubber industry liquid waste taken from a rubber processing plant in Kalidoni, Palembang City, South Sumatra. The initial characterization of rubber wastewater was carried out by electrocoagulation methods to analyze pH values, TSS levels, BOD5, COD, and Ammonia. The results of the analysis can be seen in Table 1.

Table 1. Initial Characterization of Rubber Liquid Waste

No	Parameter	Units	Results	Standards*
1	pH	-	6,79	6 – 9
2	TSS	mg/L	48,2	100
3	BOD ₅	mg/L	39,7	100
4	COD	mg/L	114	250
5	NH ₃	mg/L	2,00	15

*Source: Pergub Sumsel No.08 Tahun 2012[25]

3.2 Effect of Voltage and Processing Time on pH

The pH value is an expression and concentration of hydrogen ions (H⁺) in water. pH is very important as a parameter of water quality because it controls the type and rate of reaction of several substances in water.

The pH value of rubber wastewater before being processed by the electrocoagulation method has met the environmental quality standard requirements. In Figure 2, it can be seen that the pH value after processing is obtained the pH value, which reaches 7.04, which is very close to neutral pH, where the environmental quality standard pH value for rubber liquid waste is between 6-9. The ongoing process of electrolysis reaction results in changes in the composition of the electrolyte, especially the increase in pH due to the release of OH⁻ and H₂ gas.

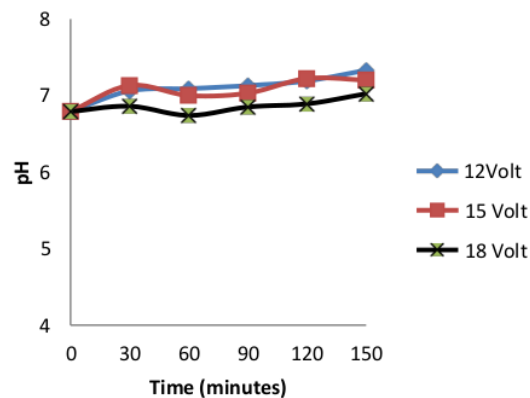


Figure 2. Effect of voltage and processing time on increase in pH

The optimum conditions for increasing the pH are at a voltage of 18 volts with a processing time of 150 minutes. This result was chosen because at a voltage of 18 volts with a processing time of 150 minutes produces a pH of 7.04, which is close to the neutral pH of water.

3.3 Effect of Voltage and Processing Time on TSS

TSS is a solid that is suspended in water in the form of organic and inorganic materials. TSS values that are too high can cause turbidity in water. The turbidity of the water is not expected in waters because if it is too turbid, it can reduce or inhibit the sun's rays entering the water so that it can interfere with the development of aquatic biota. If wastewater contains high TSS, it can be concluded that the waste is of poor quality. In the initial analysis, TSS levels did not exceed environmental quality standards. This is due to good waste sampling and also the condition of waste that is still good when analyzed [18-21].

Figure 3 shows that the TSS values obtained are not stable. This is caused by electrodes decaying during the processing process and unstable voltage resulting in an increase and decrease in the results obtained.

At the anode, an oxidation reaction occurs to the anion (negative ion), an anode made of metals such as stainless steel will undergo an oxidation reaction to form Fe_3^+ . Hydrogen gas from the cathode helps floc $Fe(OH)_3$ in solution raised to the surface. The mechanism of precipitation of $Fe(OH)_3$ floc in the electrocoagulation bath follows the coagulation-flocculation principle because of the growth of the floc mass so that the specific gravity of the floc becomes large and eventually settles. This is very related to the magnitude of the electric current and voltage are given during the electrocoagulation process [22-24].

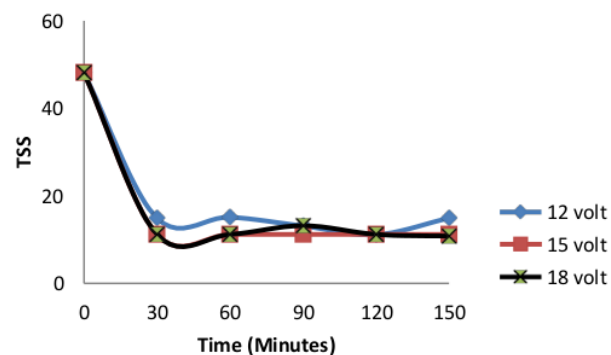


Figure 3. Effect of voltage and processing time on TSS

The optimum conditions for the decrease in TSS values are at the 18 volt voltage and 150 minutes processing time, where the value drops from 48.2 mg/L to 10.8 mg/L. Requirements for the environmental quality standard permitted TSS levels of 100 mg/L.

3.4. Effect of Voltage and Processing Time on BOD_5

BOD_5 is the amount of oxygen needed by bacteria during the breakdown of organic compounds under aerobic conditions for five days. BOD measurements were carried out for five days because, for five days, the number of organic compounds described had reached 70%. High levels of BOD_5 indicate that there are many organic compounds in the waste, so that much oxygen is needed by microorganisms to break down these organic compounds. The principle of checking BOD parameters is based on the oxidation reaction of organic substances with oxygen in the water, and the process takes place due to the presence of aerobic bacteria. In Figure 4, the results are decreased with BOD_5 levels. In the initial analysis of the BOD_5 content, the BOD_5 content obtained meets the environmental quality standard requirements of rubber liquid waste [25].

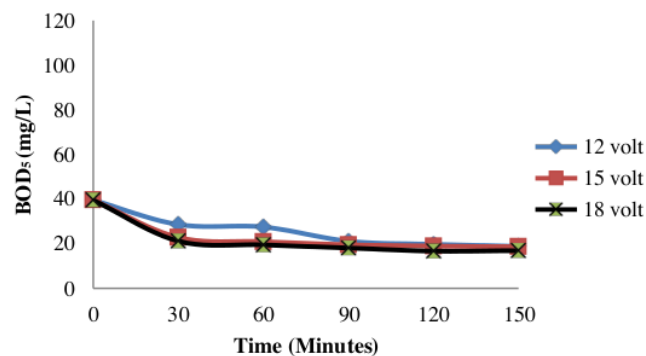


Figure 4. Effect of voltage and processing time on BOD₅

The optimum conditions obtained from the BOD₅ value are 18 volt voltage and 150 minutes processing time, where the value is from 39.7 mg/L to 17 mg/L.

3.5 Effect of Voltage and Processing Time on COD

COD (Chemical oxygen demand) is the total amount of oxygen needed to oxidize all organic matter contained in waters. COD is the amount of oxidant that reacts with the sample under certain conditions. The amount of oxidant used is proportional to oxygen demand. Organic and inorganic compounds in the sample are oxidized subjects, but organic compounds are more dominant. COD is often used as a measure of the number of pollutants in water. In the initial analysis, the COD level did not exceed the environmental quality standard. This is due to good waste sampling.

In Figure 5, after processing by the electrocoagulation method, the treated waste has decreased. The decrease in concentration is due to the oxidation and reduction processes in the electrocoagulation process. Gas electrodes are formed, such as oxygen and hydrogen, which will influence the reduction of COD. This decrease is also due to the floc formed by organic compound ions, which bind to positive coagulant ions [26].

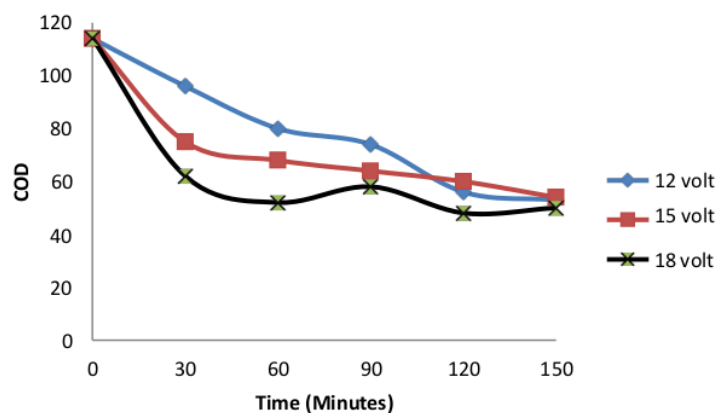


Figure 5. Effect of voltage and processing time on COD

The optimum conditions obtained from the variation of voltage and processing time in reducing COD levels are with a voltage of 18 volts with a processing time of 150 minutes that is 50 mg/L. This indicates that the higher the voltage and processing time, the COD concentration will decrease.

3.6 Effect of Voltage and Processing Time on NH_3

NH_3 levels are important to analyze because high NH_3 levels can damage the environment and endanger the health of living things in them. In the initial analysis results, NH_3 levels from rubber liquid waste before being processed by the electrocoagulation method have met the environmental quality standard requirements. High ammonia levels will cause the death of living things found in these waters. High ammonia levels in river water indicate pollution. Consequently the taste of river water is less pleasant and smelly [26].

From Figure 6, the ammonia level obtained is decreased. The greater the voltage applied, the ammonia levels obtained decreases. Ammonia levels obtained meet the environmental quality standard requirements.

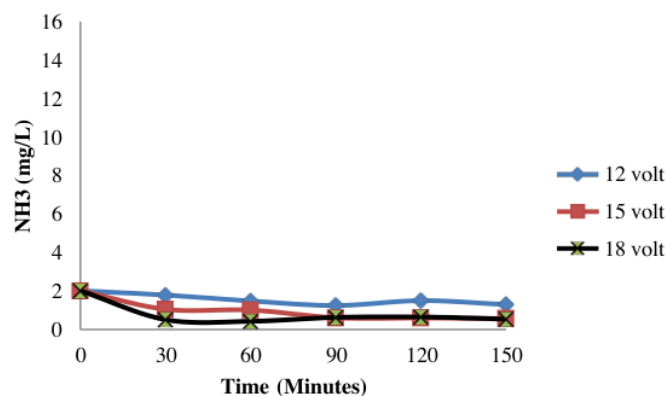


Figure 6. Effect of voltage and processing time on NH_3

The optimum conditions obtained from the variation of voltage and processing time in reducing NH_3 levels are at 18 volts with a processing time of 150 minutes, 0.53 mg/L.

3.7 Currents Efficiency

In experiments that can be determined, current efficiency (η) calculated gravimetrically by weighing the electrode weight before treatment and after treatment. The difference from initial weight and the final weight is the weight of electrodes dissolved in the experiment (wd), for the theoretically dissolved weight is calculated using the Faraday formula using the current and time data used.

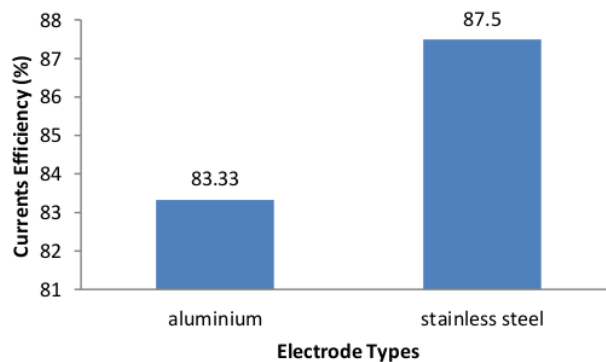


Figure 7. Currents efficiency of the electrocoagulation method for electrode types

From the calculation, it is known that the weight of the electrolyzed metal (w_d) is 0.2 grams and the weight of the electrolyzed metal theoretically (w_i) is 0.24 grams, the current efficiency for the aluminum electrode is 83.33%, and the stainless steel electrode is known (w_d) namely 0.42 grams and (w_i), i.e. 0.48 grams, the current efficiency is 87.5%. With a current efficiency value of less than 100%, this shows the current loss in the electrocoagulation system.

3.8 Dissolved Metals

In the electrocoagulation process, the use of metals as electrodes electrocuted will cause some of the metal contents to be released from liquid waste and even will be dissolved in liquid waste.

At the cathode surface, absorption occurs, while at the anode, there is a decrease in positive ions. Anode will release positive ions so that positive ions will continue to decrease when electrified, while the cathode will produce a new layer on the surface of the plate. This happens because of the absorption of interactions between the ions present in wastewater. The released ions will cause erosion on the electrode surface.

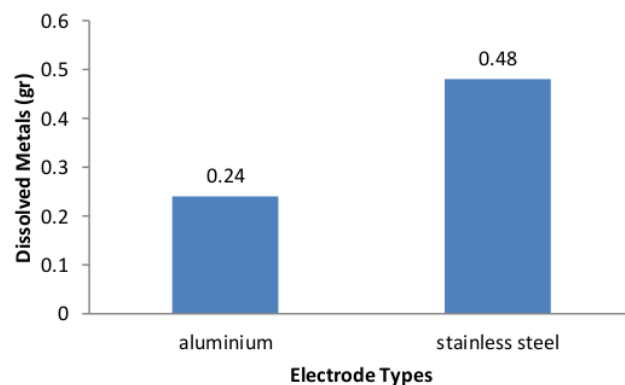


Figure 8. Dissolved metals to electrode types

From the results of this study, it was found that the weight of the dissolved metal using aluminum electrodes was 0.24 grams, and stainless steel electrodes were 0.48 grams (Figure 8).

4 Conclusions

The electrocoagulation process using aluminum-stainless steel electrodes effectively reduces the value of TSS, BOD₅, COD, and also NH₃ and can significantly increase the pH value in rubber liquid waste. After the electrocoagulation process the pH value increased to near neutral pH 7.04 and decreased TSS levels (10.8 mg/L), BOD (5.17 mg/L), COD (50 mg/L), and NH₃ (0.53 mg/L). The results obtained show that the electrocoagulation method is able to reduce levels of pollutants in rubber liquid waste and is below the environmental quality standard which means the liquid waste does not pollute the surrounding environment. The optimum condition for this electrocoagulation method is at 18 volts, with a processing time of 150 minutes. From the results of this study also found that metal dissolved using aluminum electrodes of 0.24 g and stainless steel electrodes of 0.48 grams. Furthermore, obtained current efficiency using aluminum electrodes that are 83.33% and stainless steel electrodes, which are 87.5%.

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