Effect of electrode numbers in electrocoagulation of Batik Cual wastewater: analysis on water quality and energy used

R F Gusa¹, D N Sari², F Afriani², W Sunanda¹ and Y Tiandho*¹
¹Department of Electrical Engineering, Faculty of Engineering, Universitas Bangka Belitung 33172, Indonesia
²Department of Physics Faculty of Engineering, Universitas Bangka Belitung, Bangka 33172, Indonesia
*E-mail: yuant@ubb.ac.id

Abstract. Batik cual is one of the leading textile products in the Bangka Belitung Islands. In their production processes resulted dye pollutan in wastewater. Most batik cual industries use synthetic dyes such as remazol brilliant blue royal which can damage the environment if discharge without further treatment. Electrocoagulation is a method that can be used as a first step in processing batik cual wastewater. In this paper, we analyze the relationship between the number of aluminium electrodes used in the electrocoagulation process and the quality of the water produced and the energy used. Wastewater quality parameters observed included pH level, number of dissolved particles, conductivity level and turbidity. Through this comparison, it can be obtained information related to the key parameters of electrocoagulation to increase its efficiency. The optimum result obtained when using six electrodes in the electrocoagulation process.

1. Introduction
Bangka Belitung Islands is one of the provinces in Indonesia which has a textile culture product in the form of woven fabric which is named "cual". As an effort to promote cual fabric, in recent years the Bangka Belitung Islands government has often held festivals related to tourism development. This has invited many local and foreign tourists and made cual as a souvenir [1]. However, like a woven fabric that is not easy to produce, the price of cual woven fabric is relatively high. Therefore, to reduce production costs, industry craftsman in this province innovated to produce cual as a batik: "batik cual" [2].

Along with the increase in batik cual enthusiasts, the wastewater by batik production also increased. The batik production process can produce wastewater about 100 litres to 125 litres per kilogram of batik [3]. Remazol synthetic dyes are the choice of the craftsmen because the colour produced is more stable, more practical and easier to obtain and also cheaper than other dyes. However, remazol contains carcinogenic chemical compounds and it can cause skin irritation, eye irritation, even cancer [4]. Besides, remazol is also non-biodegradable thus if the craftsmen discharge the wastewater, it can harm microorganisms that live in water and damage the environment [5].

According to Tahreen et al. [6], technology for processing textile wastewater can be carried out using biological processes, physical-chemical processes, advanced oxidation processes and membrane filtration.
and absorption [6]. Biological treatment has a weakness in the quality of microbes that must be kept alive and active by regulating the temperature and pH of wastewater, and can only reduce biodegradable compounds while non-biodegradable compounds will remain sediment or sludge that will hold on the environment. On the other hand, chemical processing is considered effective because it can treat wastewater on a large scale but the addition of chemicals will increase the processing costs and it produce sludge in relatively large amounts, with an increased risk of secondary contamination. The advanced oxidation process requires strong oxidants in wastewater treatment and of course, it requires a large amount of funding. Membrane filtration and adsorption cannot treat wastewater efficiently unless it is integrated with a comprehensive pre-treatment process [7],[8]. Therefore, some researchers on wastewater treatment have proposed a new textile waste treatment method based on electrochemical mechanisms. Among all electrochemical processes, the electrocoagulation method stands out as the most sustainable alternative for treating wastewater because of its simple operation, small sludge, and it can treat large amounts of waste without complicated maintenance [9],[10].

In this paper, we propose a method of treating batik cual wastewater by electrocoagulation. The main purpose of this research to find out the effect of the number of electrode and the result refers to the water quality standards set by the Indonesian government. To analyze the quality aspects of treated wastewater, we also analyze the electrical energy consumed during the electrocoagulation process. This aspect is important because, at the application, it related to the operational costs. Also, we optimize the method through the number of electrodes.

2. Methods
The batik cual wastewater used in this research is produced by one of the batik cual craftsmen in Pangkal Pinang. While the tools used in treating batik cual wastewater by electrocoagulation method are electrodes from aluminium, power supply, glass containers, watt-energy meters, pH-meters, Total Dissolve Solid (TDS)-meters and turbidity meter.

The electrocoagulation process is conducted by immersing the electrode plate in 700 ml of wastewater. The number of electrodes used varies from 2, 4 to 6 electrodes. The voltage between the electrodes was kept 20 volts. Water quality parameters observed in this study are pH, the number of dissolved particles, and the turbidity. In addition, the electrical energy consumed during the electrocoagulation process is measured by the watt-energy meter.

3. Results and Discussion
After processing the batik cual wastewater using the electrocoagulation method, the results are as shown in Figure 1. Based on Figure 1, it is clear that a significant difference in the colour of the batik cual wastewater between before and after the electrocoagulation process. This shows that the electrocoagulation method is quite effective to treat batik cual waste.

![Figure 1. Batik cual wastewater: (a) before and (b) after the electrocoagulation process.](image-url)
The color of batik cual wastewater resulted from remazol brilliant blue royal dye. Each sample (wastewater) was treated with electrocoagulation for 120 minutes. The best result obtained when using 6 plates of electrode can be seen in Figure 1(b).

Figure 2 shows the pattern of changes in pH of batik cual wastewater before and after the electrocoagulation process with variations in the number of electrodes. It appears that the electrocoagulation process can improve the pH of the wastewater. Before the electrocoagulation process, the pH of the batik cual wastewater was 10.3. After 120 minutes, on the 6 electrode plates, the pH of wastewater reduces to 9.2. While the pH of wastewater of 4 electrodes is 9.9 and the pH of wastewater of 2 electrodes is 10.2. This shows the more number of electrode plates and the longer the electrocoagulation time of using, it can increase the quality of wastewater in the acidity level. The entire batik cual wastewater treatment process indicates that the electrocoagulation method can satisfy the regulation of acidity of wastewater according to Ministry of Environment of the Republic of Indonesia which sets the pH of textile industry wastewater is 6.0 - 9.0 [11].

![Figure 2](image2.png)

**Figure 2.** Relationship between the number of electrodes and the pH of batik cual wastewater

In Figure 3 it can be seen that from the TDS measurement of batik cual wastewater, the longer the electrocoagulation process, the lower the TDS value. Before the wastewater treatment process, the TDS value of batik cual wastewater was 510 ppm. The treatment using 6 electrode plates with electrocoagulation time for 120 minutes reduce the TDS in wastewater up to 418 ppm. The TDS of wastewater after electrocoagulation with 4 electrodes is 235 ppm, while for 2 electrodes is 346 ppm. These results indicate that the electrocoagulation process is very effective in treating batik cual wastewater because it meets the standards set by the Ministry of Health of the Republic of Indonesia [11].

![Figure 3](image3.png)

**Figure 3.** Relationship between the number of electrode plates and the number of dissolved particles in batik cual wastewater.
In Figure 4, the relationship between the electrode numbers and the turbidity level of batik cual wastewater after electrocoagulation is shown. It can be seen that the more electrodes, it can increase the clarity of batik cual wastewater. In the treatment using 2 electrodes, the wastewater turbidity result is 37.9 NTU (Nephelometer Turbidity Unit). The turbidity of wastewater after processed using 4 electrodes is 24.6 NTU. Meanwhile, the turbidity of wastewater using 6 electrodes is 5.98 NTU. Based on the result, the electrocoagulation with 4 and 6 electrodes have satisfied the standards i.e under 25 NTU [12, 13].

![Figure 4. Relationship between the electrode numbers with the turbidity of wastewater.](image)

In Figure 5 the relationship between the electrode numbers and the energy consumed during the electrocoagulation process of batik cual wastewater is shown. It appears that the greater the number of electrode plates used, the higher the energy used in the electrocoagulation process of wastewater. The energy used in electrocoagulation with 2, 4 and 6 electrodes are 0.034 kWh, 0.064 kWh, and 0.096 kWh respectively. The average electricity tariff for medium to large scale industries (in 2019) is charged between Rp. 997/kWh up to Rp. 1,036/kWh. Thus, we can calculate that the operational cost of electrocoagulation process for 700 ml batik cual wastewater in term of electricity is around Rp. 0.099. Based on these calculations it appears that the batik cual wastewater treatment by the electrocoagulation method is relatively low cost.

![Figure 5. Relationship between the electrode numbers with the energy used in the electrocoagulation process.](image)
Based on Figure 5, the more the number of electrodes, the more electricity consumption increases. This is because every 2 electrodes use 20 volts, so it needs 40 volts when using 4 electrodes and 60 volts when using 6 electrodes.

4. Conclusion
According to the results, it can be concluded that the more electrodes used in the electrocoagulation process, the lower the TDS value, pH, and turbidity level of batik cual wastewater. However, the opposite result occurs in the energy consumed. Based on the parameters that have been obtained, it can be stated that the electrocoagulation process can significantly improve the quality of cual batik wastewater and relatively low cost. The best result was obtained when using 6 electrodes in the electrocoagulation process.

References
[1] Ayan S, Furqon C and Sultan M A 2018 The International Journal of Business Review (The Jobs Review)1 115
[2] Tomohardjo I S, Tresnawati Y and Yulista Y 2018 Proceedings of The International Conference on Social Sciences (ICSS) 1 279
[3] Apriyani 2018 Media Ilmiah Teknik Lingkungan3 21
[4] Chaturvedi S 2019 Research & Reviews: Journal of Microbiology and Biotechnology 89
[5] Deogaonkar S C, Wakode P and Rawat K 2019 Radiation Physics and Chemistry 165 1
[6] Tahreen A, Jami M S and Ali F 2020 Journal of Water Process Engineering 37 101440
[7] Tiandho Y 2019 IOP Conference Series: Materials Science and Engineering 496 012079
[8] Tiandho Y, Aldila H, Mustari, Megiyo and Afriani F 2018 IOP Conference Series: Journal of Physics: Conf. Series1013 012181
[9] Nawarkar C J and Salkar V D 2018 Fuel 237 222
[10] Sharma D, Chaudhari P K, Dubey S and Prajapati A K 2020 Journal of Environmental Engineering 146 03120009
[11] Nurbaya S 2019 Regulation of the Minister of Environment and Forestry of the Republic Of Indonesia
[12] Sandi, Nurdandi D and Tiandho Y 2019 Proceedings of National Colloquium Research and Community Service 3 12
[13] Nurdandi D, Sandi, S, Afriani F and Tiandho Y 2019 Proceedings of National Colloquium Research and Community Service 3 5

Acknowledgment
This research was funded by the Institute for Research and Community Services - Universitas Bangka Belitung (LPPM-UBB) through the Penelitian Unggulan scheme in 2020 (No. 192/UN50.11/PP/2020).