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RESEARCH PAPER

The influence of electrocoagulation on the reduction of COD, BOD, and TSS of Batik industry wastewater

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Abstract. Despite the positive effect of the growth of Batik industry in Yogyakarta in the economic sector, the wastewater from the dying process becomes a pollutant to the environment. Initial measurement of COD, BOD and TSS of wastewater resulted from the dying process using Naphtolat and Diazo Salts showed that they exceeded the threshold. Hence, this study implemented electrocoagulation for processing Batik wastewater. The results indicated that the range of the electrodes and the voltage affect the reduction in COD, BOD, and TSS in liquid sewage electrocoagulation process in dye wastewater in batik industry "Rara Djonggrang". The optimum electrode on TSS and BOD reduction is the range of 2 cm with 85.71% of TSS decrease and 7.02% of BOD reduction, while the optimum COD reduction is in the range of 4 cm with the decrease of 92.18%. The voltage of 15 could decrease 85.71% of TSS and 92.18% of COD. The most optimum of BOD value has the voltage of 10 and the range of 6 cm. Electrocoagulation process using aluminium electrode is the most appropriate for treating Diazol Salt sewage.

Keywords: electrocoagulation; aluminium; the distance between the electrodes; electrical voltage; batik wastewater.

1. Introduction

The batik industry in Yogyakarta is experiencing a rapid growth. From 2008 to 2010 national batik production increased from 3.2 trillion to 3.94 trillion rupiahs. Batik sales in Yogyakarta also experienced an increase of 30 per cent (Dekranasda Yogyakarta, 2013). However, the high level of batik production also causes an increase in the amount of waste particularly from the colouring process. One of the synthetic dyes that are harmful to the environment is the Naphtol. Therefore, the batik waste needs to be managed to prohibit it from exceeding the threshold mentioned in the Governor's Decree of the Head of the Special Region of Yogyakarta No: 281/KPTS/1998.

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The liquid waste treatment method which is currently being developed is the electrocoagulation. It is an electrochemical water treatment using metal plates, such as aluminium or iron, as electrodes which release active coagulants in the form of metal ions into the anode solution, whereas at the cathode an electrolysis reaction which occurs is the release of hydrogen gas (Holt et al., 1999).

The study conducted by Susetyo et al. (2008) showed that stress has an effect on the reduction of Sr-90 concentrations found in liquid waste. Yulianto et al. (2009) suggested that the distance between electrodes had an effect on the decrease in COD of batik waste using electrocoagulation. Hari and Harsanti (2010) suggested that electrocoagulation using aluminium plates could reduce levels of COD, BOD, and TSS in textile wastewater. Fadli et al. (2011) suggested that aluminium is better to use than iron and zinc in the electrocoagulation process of batik waste. For these reasons, this study conducted testing of COD, BOD, and TSS from the waste treated with batik using electrocoagulation with an aluminium plate as an electrode.

2. Review of the literature

2.1 Batik

Batik is the creation of images on fabric by using a "dye cover technique" with wax as a covering layer and colouring material on the fabric (Warsito, 2008). The batik is to draw a pattern on the cloth which is then covered in wax and dipped into certain dyes.

The colouring process on batik cloth has three stages, namely dyeing cloth on Naphtolat, dying on Diazo Salt to bring out the colour, and washing. Naphtolate is a process of mixing Naphtol with soda ash so that it can be compounded with Diazo Salt to produce colour on Naphtol (Susanto, 1973). Liquid waste from the colouring industry in the batik industry which has the highest levels of COD, BOD and TSS are derived from Naphtolat and Diazo Salt.

2.2 COD, BOD, dan TSS

COD is the amount of oxygen used to degrade the organic matter in the water through chemical processes (Djajadiningrat, 1993). BOD is the amount of oxygen used by microbes in waters in response to the entry of biodegradable organic matter. TSS is a total solid residue held by a filter with a particle size of a maximum of 2 μm or greater than the size of a colloidal particle.

2.3 Electrocoagulation

Electrocoagulation is an electrochemical water treatment method using a metal plate, such as aluminium or iron, as an electrode and at the anode, the active coagulant is released in the form of metal ions in solution, whereas at the cathode, an electrolysis reacts by releasing hydrogen gas (Holt et al., 1999). Some factors affecting the electrocoagulation are electric current density, operating time, electrical voltage, the distance between electrodes and pH. Electric currents that cause chemical changes flow through a medium such as metal or electrolytes, caused by a potential difference. The potential difference is related to electric current and resistance. The distance between electrodes also affects the electrolyte resistance. The farther the distance, the greater the resistance, so the smaller the current flows.

2.4 The theoretical framework

The elimination mechanism that generally occurs in electrocoagulation is the formation of coagulants caused by the electrolysis oxidation process at the electrode; destabilization of contaminants, suspended particles, and breakdown of emulsions; and aggregation from the destabilization that forms the flock. Electrode voltage and distance are two factors that influence the electrocoagulation process. In the electrocoagulation process, there is a relationship between potential difference (voltage), current, and resistance. The relationship of those three components is known as Ohm's Law which states that the current (I) is directly proportional to the potential difference (electric voltage) and inversely proportional to the resistance (R), which is formulated by the below equation:

$$I = V/R \qquad (1)$$

3. Research methodology

The main material used in this study was the liquid waste from the batik industry, namely Naphtolat and Diazo Salt. This study used a series of electrocoagulation devices that use aluminium plates as electrodes.

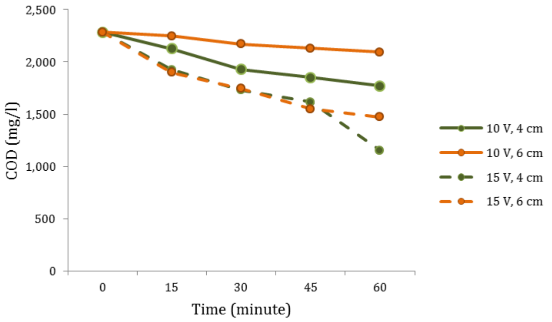
Pre and post analyses were applied in this study before and after the implementation of electrocoagulation for wastewater treatment. Three types batik of wastewater selected as the samples in this study were the batik wastewater containing Naphtolat, batik wastewater containing diazo salt and batik wastewater containing the mix of naphtholate and diazo salt. Pre analyses were conducted for measuring the COD, BOD and TSS of those three types of batik wastewater. Post analyses after electrocoagulation wastewater treatment were measured to identify the effect of distant and voltage of electrocoagulation to COD, BOD and TSS reduction.

The process of wastewater treatment using electrocoagulation is as follows. The first stage was to prepare a series of electrocoagulation devices and batik industry liquid waste samples which included Naphtolat, Diazo Salt, and mixtures of both wastes. Later, 1.5 L of the waste sample was put into a 2 L beaker glass. In the glass, there were electrodes that had been connected to a series of electrocoagulation devices with a certain distance.

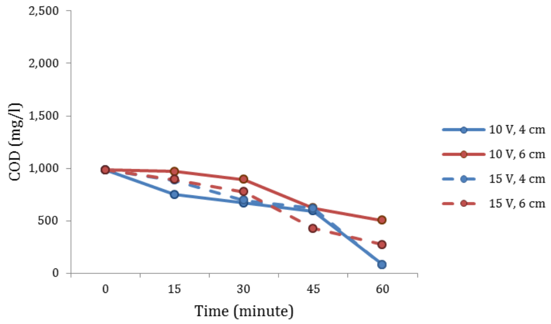
The electrode used was an aluminium plate with a thickness of 0.1 cm, a length of 10 cm and a width of 8 cm. The duration of the electrocoagulation process was 60 minutes, while the pH corresponds to the initial conditions of the waste (no pH regulation). The waste treatment process was carried out by varying the distances between the electrodes and the voltage. Diazo Naphtolat and Salt Waste used variations in electrode distance of 4 cm and 6 cm with a voltage of 10 V and 15 V. As for mixed waste, we used variations in electrode distance of 2 cm, 4 cm, and 6 cm with a voltage of 5 V, 10 V, and 15 V. To determine the electrode distance and optimum voltage, the sample was taken every 15 minutes during the process, then COD and TSS were analyzed, while BOD was analyzed at the end of the electrocoagulation process.

4. Results and discussion

The electrocoagulation methods with various distances between electrodes and electrical voltage had could accelerate the decrease COD, BOD and TSS in the waste Naphtolat, Diazo Salt and the mixture of the two wastes. The results of the COD, TSS and BOD tests on the naphtholate, diazo salt and mixtures are shown in Figures 1, 2 and 3.



(a)



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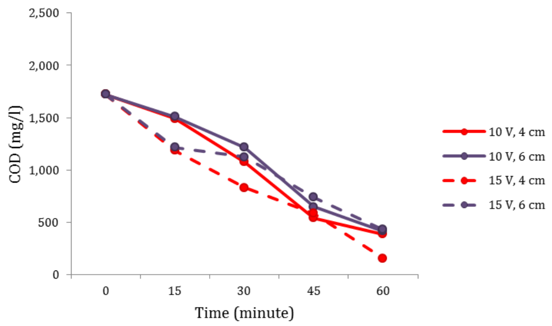

(c)

Figure 1. The effect of electrode distance on COD reduction in batik waste using (a) naphtholate, (b) diazo salt and (c) mixed of naphtholate and diazo salt.

Figures 1 and 2 show that the closer the electrode distance, the faster the decrease in COD and TSS of batik waste using naphtholate, diazo salt and a mixture of both. The electrode distance also affected the BOD reduction value as shown in Figure 3. Based on Figures 1 and 2, the electrical stress used by the electrocoagulation process could also decrease the COD and TSS contained in batik waste using naphtholate, diazo salt and the mixture of both. The higher the voltage, the higher the amount of COD and TSS that can be lowered. In addition to reducing COD and TSS, Figure 3 shows that the electric voltage also affected the decrease in BOD.

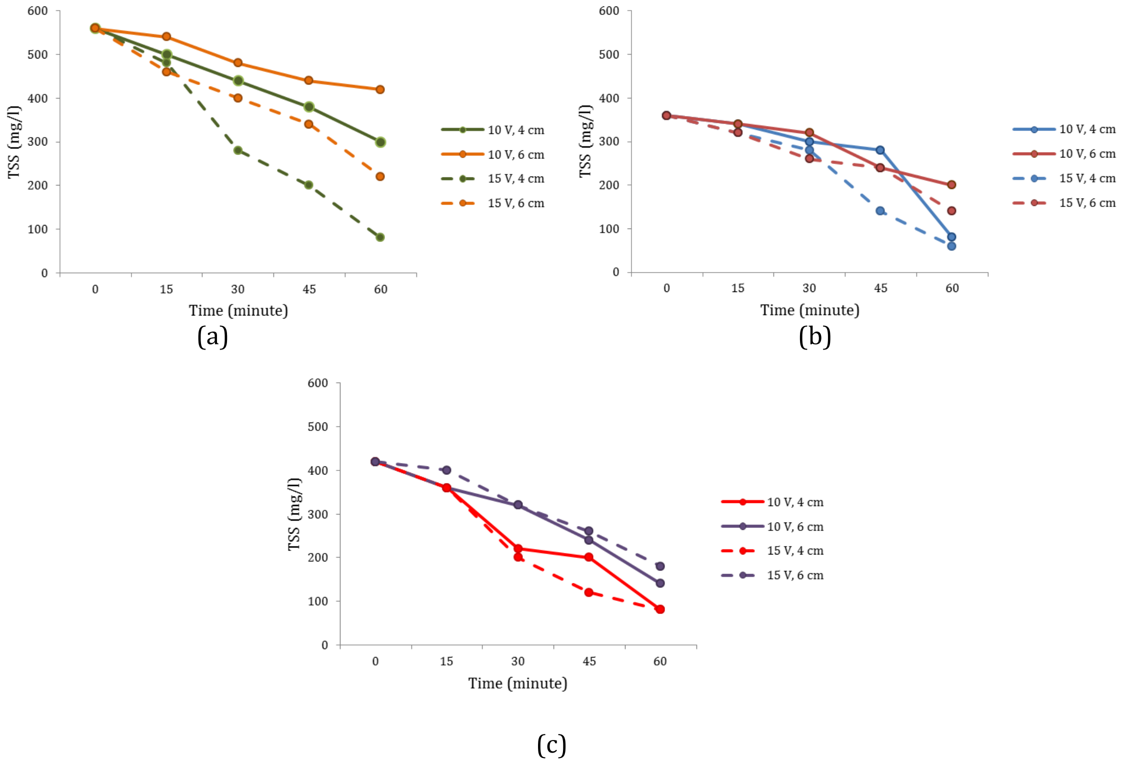

Figure 2. The effect of electrocoagulation on TSS reduction: (a) Naphtolate, (b) Diazo Salt and (c) mixture of Naphtolat and Salt Diazo

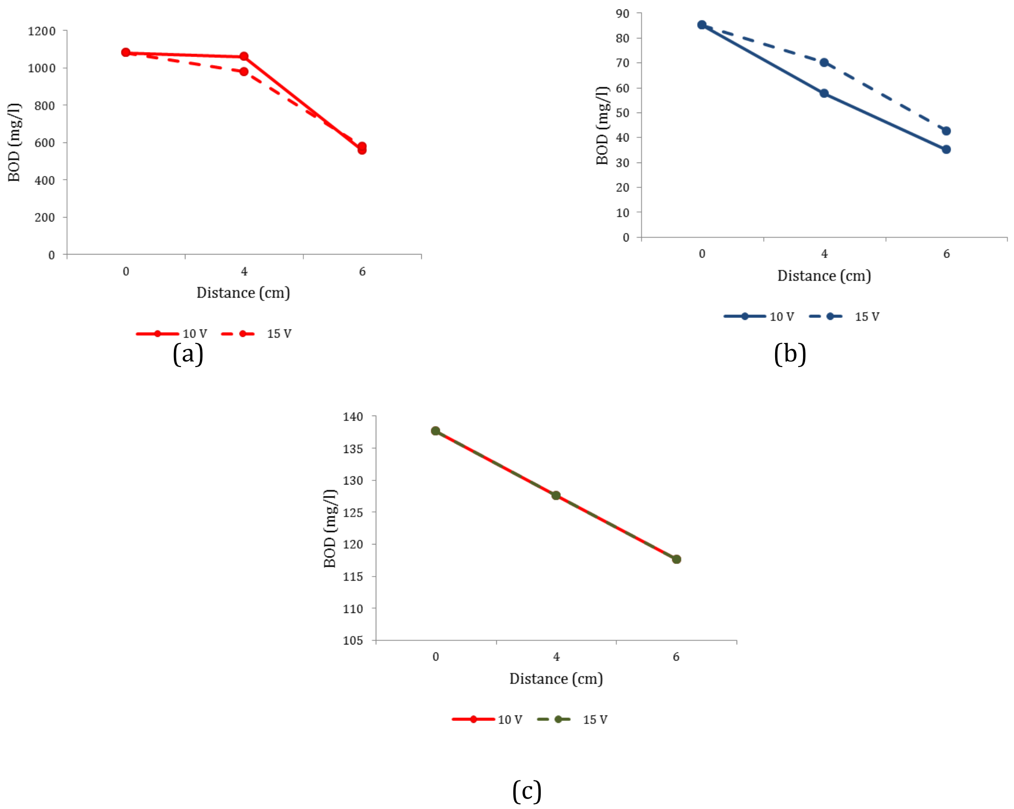

Figure 3. The effect of electrocoagulation on decreasing BOD: (a) Naphtolate, (b) Diazo Salt and (c) mixture of Naphtolat and Salt Diazo

The influences of distance and electrical voltage that affect the decrease in COD, BOD, and TSS in the electrocoagulation process were related to the presence of colloids in solution. Vepsäläinen (2012) suggested that aluminium is an electrode material that is more suitable to be applied in electrocoagulation because it produces Al (III) species. In addition, the electrocoagulation process in solution shows that colloids are said to be stable in solution when sedimentation runs so slowly that the movement of colloids stabilizes. This was very important in the management of raw water or wastewater if the particles could not be removed by the sedimentation within a specified time period.

Derjaguin (1941) and Verwey (1947) explained that the stability or destabilization of colloids in water is a balance between electrostatic resistance and attraction, London-van der Waals. Derjaguin-Landau-Verwey-Overbeek (DLVO)'s theory estimated the energy of attraction and repulsion. Vepsäläinen (2012) described that the London-van der Waals attraction is caused by two permanent poles (positive and negative) or induction with very short distances. The repulsion force is caused by overlapping that occurs in two layers of electricity, which leads to higher concentrations of opponents resulting in repulsion between particles. The repulsion force is the exponential function of the distance between particles with the range of the thickness arrangement of two electricity layers, while the tensile force decreases as the inverse strength of the distance between particles.

5. Conclusions

From this study, we could conclude that the closer the electrode distance is, the more quickly COD, BOD, and TSS decrease. The optimum electrode distance for decreasing BOD and TSS is 2 cm which can reduce BOD by 27.02% and TSS by 85.7%. While the optimum electrode distance from COD reduction is 4 cm with COD removal of 92.18%. From this study, we could also conclude that the greater the voltage, the faster the decrease in COD, BOD, and TSS. The optimum electrical voltage for decreasing COD and TSS is 15 V, while for BOD decrease, the optimum electricity voltage is 10 V

Diazol Salt is the most suitable waste to be processed using the electrocoagulation method with aluminium electrodes because it has the highest COD and BOD removal. While the highest TSS removal was found in the mixture of Naphtolat and Diazo Salt waste.

References

Al-Kdasi, A., Idris, A., Saed, K. and Guan, C.T., 2004, Treatment of textile wastewater by advanced oxidation processes, Int. J. 6(3): 222-230

Avsar, Y., Kurt, U., and Talha Gonullu, 2007, Comparison of classical chemical and electrochemical processes for treating rose processing wastewater, Journal of Hazardous Materials, 148: 340–345

Balasubramanian, N., and K. Madhavan, 2001, Arsenic removal from industrial effluent through electrocoagulation, Chem. Eng. Technol. 24:519–521.

Can˜izares, P., Jime´nez, C., Martı´nez, F., Sa´ez, C., and Manuel A. Rodrigo., 2007, Study of the Electrocoagulation Process Using Aluminum and Iron Electrodes, Chem. Res., 46: 6189-6195

Chaorenlarp, K. and Cyophan, W., 2009, Reuse of Dye Wastewater Through Colour Removal With Electrocoagulation Process, As. J. Energy Env., 10(04): 250-260

Chen, X., Chen, G., Yue, P.L., 2000, Separation of pollutants from restaurant wastewater by electrocoagulation, Sep. Purif. Technol, 19: 65–76.

Daneshvar, N., Khataee, A.R., Ghadim, A.R.A., and M.H. Rasoulifard., 2007, Decolorization of C.I. Acid Yellow 23 Solution by Electrocoagulation Process: Investigation of Operational Parameters and Evaluation of Specific Electrical Energy Consumption (SEEC), Journal of Hazardous Materials 148: 566–572

Departemen Perindustrian, 1987, Sejarah Industri Batik Indonesia, Balai Besar Penelitian dan Pengembangan Industri Kerajinan dan Batik, Yogyakarta.

Donini, J.C., Kan, J., Szynkarczuk, Hassan, T.A., and K.L. Kar, Operating cost of electro coagulation, Can. J. Chem. Eng, 72: 1007–1012.

Eddy & Metcalf, 1991, Wastewater Engineering: Treatment and Reuse, Edisi III. Mc. Graw Hill Inc., New York

Hari, B. dan Harsanti, M., 2010, Pengolahan Limbah Cair Tekstil Menggunakan Proses Elektrokoagulasi dengan Sel Al-Al, ISSN 1693-4393

Peter Holt, Geoffrey Barton and Cynthia Mitchell, 1999, Electrocoagulation as a Wastewater Treatment, The Third Annual Australian Environmental Engineering Research Event. 23-26 November Castlemaine

Kobya, M., Bayramoglu, M., and Murat Eyvaz., 2007, Techno-economical evaluation of electrocoagulation for the textile wastewater using different electrode connections, Journal of Hazardous Materials, 148: 311–318

Lin, S.H. and C.F. Peng, 1994, Treatment of textile wastewater by electrochemical method, Water Res., 28: 277–282.

Lin, S.H. and M.L. Chen, 1997, Treatment of textile wastewater by electrochemical methods for reuse, Water Res, 31: 868–876.

Lin, S.H. and C.H. Lin, Treatment of textile wastewater by ozonation and chemical coagulation, Water Res, 27: 1743–1748.

Mahida, U.N., 1984, Pencemaran air dan Pemanfaatan Limbah Industri, Penerbit CV. Radjawali, Jakarta

Mameri, N., Lounici, H., Belhocine, D., Grib, H., Piron, D.L., and Y.Yahiat, 2001, Defluoridation of Shara water by small plant electro coagulation using bipolar aluminium electrodes, Sep. Purif. Technol, 24: 113–119.

Marmagne O. and Coste C., 1996, Color removal from textile plant effluents, American Dyestuff Reports, 85: 15-21

Matteson, M.J., Dobson, R.L., Glenn, R.W. Jr., Kuku, N.S. Jr., Waits III, W.H., and E.J. Clayfield, Electro coagulation and Separation of aqueous suspensions of ultra fine particles, Colloids Surf. A, 104: 101–109.

Mollah, M. Y. A., Paul M., Jewel A. G. G., Mehmet K., Jose P., and David L. C. 2004.

"Fundamentals, Present and Future Perspectives of Electrocoagulation". Journal of Hazardous Materials, B114: 199 – 210

Ogutveren, U.B., Gonen, N., Koparal, S., 1992, Removal of dyestuffs from wastewater: electrocoagulation using soluble anode, J. Environ. Sci. Health, 27: 1237–1247

Pagga U. and Brown D., 1986, The degradation of dyestuffs: part II behaviour of dyestuffs in aerobic biodegradation tests, Chemosphere, 15: 479-491.

Putero, S.H., Kusnanto dan Yusriyani, 2008, Pengaruh Tegangan listrik dan Waktu Pada Pengolahan Limbah Radioaktif yang Mengandung Sr-90 Menggunakan Metode Elektrokoagulasi, ISSN 0854-2910

Raghu, S. and Ahmed Basha, 2007, Chemical or Electrochemical Techniques, Followed by Ion Exchange, for Recycle of Textile Dye Wastewater, Journal of Hazardous Materials, 149: 324–330.

Susanto, S., 1973, Seni Kerajinan Batik Indonesia, Lembaga Penelitian dan Pendidikan Industri, Jakarta

Warlina, L., 2004, Pencemaran Air : Sumber, Dampak dan Penanggulangannya, Institut Pertanian Bogor, Bogor

Warsito, T., 2008, Batik sebagai Aset Diplomasi Kebudayaan Indonesia. Paguyuban Pecinta Batik Indonesia Sekar Jagad Yogyakarta, Yogyakarta

Wulandari, A., 2011, Batik Nusantara, Penerbit Andi, Yogyakarta.

Yılmaz, A. E., Boncukcuoğlu, R., and M. Muhtar Kocakerm, 2007, A Quantitative Comparison Between Electrocoagulation and Chemical Coagulation for Boron Removal from Boron-Containing Solution, Journal of Hazardous Materials, 149: 475–481

Yulianto, A., Hakim, L., Purwaningsih, I., dan Vidya Ayu Pravitasari, 2009, Pengolahan Limbah Cair Industri Batik Pada Skala Laboratorium Dengan Menggunakan Metode Elektrokoagulasi, 5(1): 6-11