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C - 12

APPLICATION OF ELECTRO-COAGULATION PROCESS ON THE LABORATORY WASTEWATER TREATMENT

Rudy Syah Putra*, Gilang Ahmad Trahadinata, Arif Latif, Muhammad Solehudin

Environmental Remediation Research Group, Department of Chemistry, Faculty of Mathematics and Natural Sciences, Islamic University of Indonesia, Jl. Kaliurang Km. 14, Yogyakarta 55584, Indonesia
**Corresponding author: rudy.syahputra@uii.ac.id (Rudy)*
Telp.; +62-81327709104

Abstract

The electro-coagulation process on the laboratory wastewater treatment had been evaluated. The purpose of electro-coagulation process in this study was to reduce organic content and heavy metal concentration in the wastewater. The effectiveness of electro-coagulation process on the waste water treatment was measured by COD, BOD, and heavy metal (Pb, Cu) concentration. The result showed that the electroco-agulation process could reduce the concentration of COD by 52.6 %, BOD by 48.5 %, Pb by 28.9 % and Cu by 39.8 % from initial concentration. Those concentrations were met the water quality standard of class IV according to PP No.82/2001 about water quality management and control of water pollution.

Keywords: Electro-coagulation, laboratory wastewater, BOD, COD, heavy metal (Pb, Cu)

INTRODUCTION

The increasing of human activity comes in line with the pace of technological development, which will have notable to the environment. Environmental quality decreasing constantly cornering society by issues of enviromental deviation. Based on PP no.32/2009 about the Protection and Management of the Environment, Article 1, Section 14 states, that the pollution is an inclusion of a living creature, matter, energy, and / or other components into the environment by human activities that go beyond the absolute quality of the environment that has been set voluntarily or not. (Anonymous, 2009). According to KLH, PP No.18/1999 about Management of Hazardous and Toxic Waste, laboratories in universities have important roles as supporting facilities for educational and research purposes to the student and the lecturer. Laboratory activities was including generate hazardous waste and toxic materials.

Laboratory waste water is produced by the washing water of laboratory equipments and the waste products of various dangerous reactions solution from the research and practical activities in the laboratory. The chemical solution of which contain toxic chemicals, organic compounds and heavy metals that are harmful to living things and the environment. All this time, the processing of laboratory's waste water treatement at the Faculty of Mathematics and

Sains UII only done through conventional process by using activated carbon parallel reactor. Based on the evaluation, this waste treatment method is relatively rudimentary so it requires new ways which is more effective and efficient with an environmentally friendly approach. One way that was developed as an alternative waste treatment is electrocoagulation. When compared with activated carbon, electrocoagulation has several advantages properties including: environmental-friendly, non-toxic, and less residue.

Electrocoagulation process uses aluminum electrode as the anode and stainless steel as cathode. When an electric current passes, the ions (Al^{3+}) electrochemically generated at the anode, and will create coagulant $Al(OH)_3$. Coagulation reactions shown in equation 1-3.

Anoda : $Al \rightarrow Al^{3+}_{(aq)} + 3e^-$ (1)
Katoda : $3H_2O + 3e^- \rightarrow 3/2H_2 + 3OH^-$ (2)
Hidrolisis : $Al^{3+}_{(aq)} + 3OH^- \rightarrow Al(OH)_3$ (3)

In general, there are three important processes occured during electrocoagulation:
a) the electrolytic reaction at the electrode surface
b) the establishment of a coagulant in an aqueous medium;
c) adsorption of dissolved or colloidal pollutants by coagulant (in this case Al $(OH)_3$) and flotation due to the small bubbles of hydrogen generated by the cathode, thus simplifying the separation of the particles in the waste water (Chen, 2004; Holt, et al., 2005). Various studies have shown electrocoagulation as an efficient technique for discharging the pollutants in surface water in the lowlands (Jiang et al, 2002), the disposal of urban waste water (Vik et al, 1984), restaurant's waste (Chen et al, 2000), chromium metal waste (Barrera -D'ıaz et al., 2003a), and industrial waste (Barrera-D'ıaz et al, 2003b, 2009). Results of those studies have consistently shown that electrocoagulation is one of the most promising techniques for wastewater treatment, getting disposal efficiencies between 70 and 95% in terms of COD and BOD, and less produce sediment than alternative procedures (Barrera-D'ıaz et al, 2003a).

The purpose of this study is to evaluate the effectiveness of the electrocoagulation process to reduce the organic content and heavy metals in wastewater laboratory. The effectiveness of electrocoagulation process on the waste water treatment was measured by COD, BOD, and heavy metal (Pb, Cu) concentration. So it will passes the water quality standard of class IV according to PP No.82/2001 about water quality management and control of water pollution, on the parameters COD, BOD, Pb, Cu and pH.

RESEARCH METHOD

HNO_3, H_2SO_4, Pb standard solution, Cu standard solution, aquades, an electrocoagulation reactor, DC voltage, Alumunium plate, and Stainless Steel plate. Also UV-visible spectrophotometer and pH meter. Before making the wastewater treatment using electrocoagulation method, the characterization of the laboratory wastewater was done to obtain the initial profile. The characteristic data includes COD, BOD, heavy metals (Pb, Cu), and pH. Analysis of COD (Chemical Oxygen Demand) was analyzed according to SNI 06-6989.2-2009 while BOD (Biochemical Oxygen Demand) was analyzed according to SNI06-6989.72-2009. Metals (Pb, Cu) concentration was measured by using AAS and pH measurement using a pH meter.

Electrocoagulation reactor is designed to accommodate waste as much as 10 L with size dimensions of length 35 cm, width 20 cm, height 20 cm that made from glass. This reactor is equipped with an aluminum plat as anoda (length 30 cm, width 20 cm, and a thickness of 0.7 mm), and stainless steel as cathode (30 cm length, width 20 cm, and thickness 0,7mm). Electrocoagulation system is using electrical DC voltage power by 20 volts.

In this research, electrocoagulation process is done by the batch system for the first hour and then done with the flow system for 9 hours. In the flow system, laboratory waste water is flowed from the waste tank which then passes through electrocoagulation reactor. The water flow rate in this process is 200mL/min within 1 hour retention time. Water sampling is done every hour for 9 hours electrocoagulation process.

RESULT AND DISCUSSION

Before performing laboratory waste treatment using electrocoagulation method, the laboratory waste water is characterized to be used as the initial condition profile data. Table 1 shows the profile of the laboratory waste water that compared with COD, BOD, Pb, Cu and pH standard of class IV and class III according to PP No.82/ 2001.

Table 1. UII laboratory waste water and water standard of class IV and class III according to PP No.82/ 2001.

Characterization	Laboratory waste water	Water class III	Water class IV	unit
COD	98.93	50	100	mg/L
BOD	12.39	6	12	mg/L
Pb	0,43	0.03	1	mg/L
Cu	0.10	0.02	0.2	mg/L
pH	7,2	6-9	5-9	

The laboratory waste water profile is seen passes the water category class IV, except BOD concentration that is more than 12 mg/L. However, when compared with water class III standard, the laboratory waste water profile is still out of the laboratory wastewater quality standards.

In this study, the electrocoagulation process using aluminum electrode as the anode and stainless steel as a cathode. When an electric current passed, the Al^{3+} ion is produced electrochemically near the anode and will create an active coagulant $Al(OH)_3$. The organic and metal ions substances can be coagulated by electrocoagulation method.

To determine the optimization of electrocoagulation process, batch process is carried out for 1 hour and then the flow process will be done. Water sampling at flow process is done every hour for 9 hours of the experiment. The results obtained from the analysis of COD and BOD in water samples are show in Table 2.

Table 2 shows the concentrations of COD and BOD at 1 hour batch process and 8 hours flow Electrocoagulation. Electrocoagulation's result in the batch system of first hour showed that electrocoagulation process was optimized with COD concentration reduced by 33.1%, and the concentration of BOD was reduced by 32.4% from the initial concentration of the waste water. It is also characterized by the flock formation and the transparency of the waste solution after 1 hour electrocoagulation process. At 1 hour batch electrocoagulation process, both the concentration of COD and BOD are already far below the water quality standard class IV.

Table 2. The COD and BOD concentration profile for the electrocoagulation process

No	Sample	COD (mg/L)	BOD (mg/L)
1	Initial	98.93	12.39
2	Sampling 1	63.17	8.38
3	Sampling 2	56.92	6.38
4	Sampling 3	61.57	6.38
5	Sampling 4	46.35	6.38
6	Sampling 5	42.98	6.38
7	Sampling 6	35.13	8.38
8	Sampling 7	38.61	4.38
9	Sampling 8	38.03	8.38
10	Sampling 9	35.99	6.38

Note:

1. Initial : The initial concentration before the process of electrocoagulation.
2. Sampling 1 : The sample's measurement was taken 1 hour after the electrocoagulation process.
3. Sampling 2-9 : The sample's flow measurement for each hour during electrocoagulation process.

In the process of the flow, the concentration of COD and BOD in the water system decreased significantly if compared with the initial concentration. The COD concentration in each hour of flow electrocoagulation process decreased, from the sampling 2 until the sampling 4, then the COD concentration was stabilized at 35-50 mg/L from sampling 4 until sampling 9. Meanwhile, the concentration of BOD seemed stable at the sampling 2 until sampling 9. There was a decreasing in average concentration of COD by 53 %, and BOD by 45 %. This indicated that the electrocoagulation process was very effective for lowering the concentration of COD and BOD in water systems. This is due to when electric current passed, the Al^{3+} ions were electrochemically generated near the anode, and then would created active coagulant, which was $Al(OH)_3$. The suspended organic substances could be coagulated by coagulant $Al(OH)_3$.

Table 3 shows the condition of the concentration Pb and Cu in the first hour and 9 hour from the electrocoagulation process. The outcome of the first hour electrocoagulation suggests that the process of electrocoagulation increased optimally with a concentration of Pb being reduced by 12,8%, and a concentration of Cu being decrease to 36,6% from the initial concentration of wastes. In the flow proccess of the electrocoagulation process, there had been a decreasing in the concentration of Pb and Cu from the water of waste that quite significant compared with the initial waste concentrations.This is because the existence of the negative charge around cathode. With the negative charges around cathode, the ions Pb2+ and Cu2+ is moving toward to the cathode. So when it happens, there is a tendency that ions Pb2+ and Cu2+ would attached themselves to the whole surface of plat electroda.

In the process of electrohemistry, in the same time the electric current excecuted to the anoda, it will made the alumunium suffering oxidation reactions of Al3+ ions and shall bind ions (OH)- to form flocks Al(OH)3 that can fasten Pb2+ dan Cu2+ ions also caught most of the Pb metas who not keep in the cathode.

Table 3. Profile of Pb and Cu Concentration in the electrocoagulation process

No	Sample	Metals Concentration	
		Pb (mg/L)	Cu (mg/L)
1	Initial	0.43	0.10
2	Sampling 1	0.37	0.06
3	Sampling 2	0.34	0.07
4	Sampling 3	0.34	0.08
5	Sampling 4	0.36	0.06
6	Sampling 5	0.33	0.06
7	Sampling 6	0.30	0.04
8	Sampling 7	0.32	0.045
9	Sampling 8	0.28	0.06
10	Sampling 9	0.30	0.06

Note:

1. Initial : The initial concentration before the process of electrocoagulation.
2. Sampling 1 : The sample's measurement was taken 1 hour after the electrocoagulation process.
3. Sampling 2-9 : The sample's flow measurement for each hour during electrocoagulation process.

The results of both process allow the decreased concentration of Pb and Cu in laboratory wastes. In this experiments, the decline in average concentration of Pb as 23.4 % and the decline in average concentration of Cu as 39.5 % from the initial waste water concentrations.

pH measuring done in every hour in the process of electrocoagulation flow to find out how the influence of the elctrocoagulation process to changes in the level of acidity in the waste system. The result of which can be obtained from the analysis level of pH in the waste system electrocoagulation get shown on Table 4.

Table 4. pH profile in the electrocoagulation process

No	Sample	pH
1	Initial	7.2
2	Sampling 1	7.37
3	Sampling 2	7.12
4	Sampling 3	7.22
5	Sampling 4	7.26
6	Sampling 5	7.17
7	Sampling 6	7.17
8	Sampling 7	7.11
9	Sampling 8	7.11

Note:

1. Initial : The initial concentration before the process of electrocoagulation.

2. Sampling 1 : The sample's measurement was taken 1 hour after the electrocoagulation process.
3. Sampling 2-9 : The sample's flow measurement for each hour during electrocoagulation process.

Table 4 suggests that level of pH in every hour in the electrocoagulation process. It can be seen that the level of pH is stable in range of pH 7,01 to 7,37. This could be the indication that the process of electrocoagulation does not change the level of acidity significantly.

CONCLUSION AND SUGGESTION

Based on data of the reasearch that has been done by electrocoagulation method in the waste water treatment, we can conclude that laboratory waste water treatment by using a electrocoagulation process can shows the reduction of the number concentration of COD was reduced by 53 %, BOD was reduced by 45 %, and a heavy metal Pb was reduced by 23.4 % also Cu was reduced by 39.5 % from the initial waste concentrations. So, the concentrations of COD, BOD, Pb, and Cu have been met the water quality standard of class IV according to PP No.82/2001 about water quality management and control of water pollution.

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