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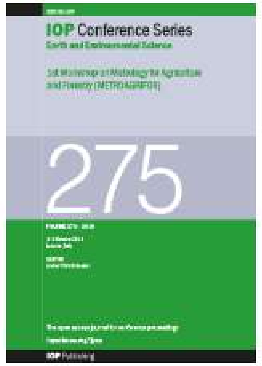

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Preface

Papers

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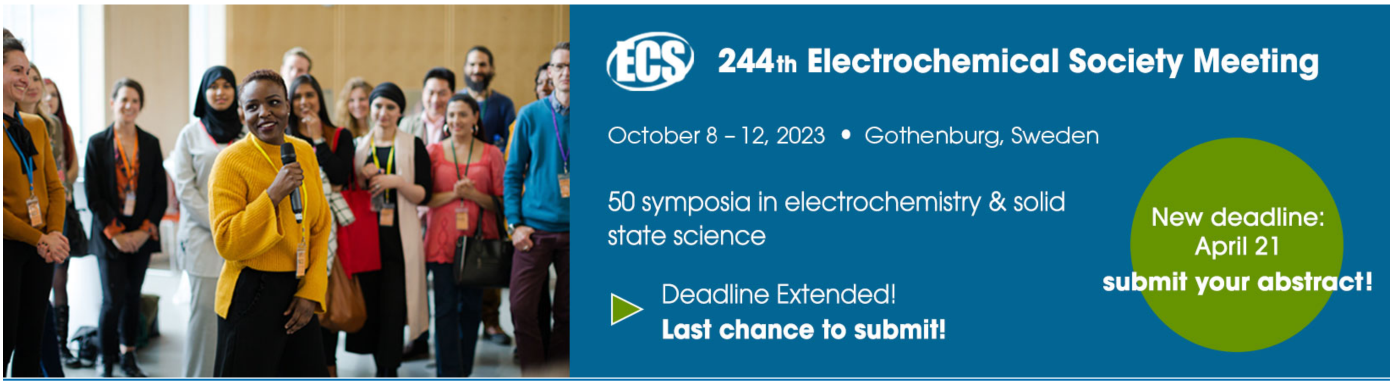

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Effect of electrode configuration and voltage variations on electrocoagulation process in phosphate removal of laundry wastewater

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Abstract. Indonesia is one of the countries that still have to deal with waste problems. In reducing waste, the government has made a series of efforts to reduce waste, especially wastewater. There are many kinds of wastewater. One of them is laundry wastewater. This research aims to estimate the dangerous substance in laundry wastewater and how to treat it. The method using some variables like Al-Al, Al-Fe, Fe-Fe, and Fe-Al and the voltage is changing from 20 V, 30 V, 40 V, and 60 V. The research shows that the most optimum result of laundry wastewater treatment was using Al-Fe electrode plate 60 V. The result that the phosphate concentration decreased by 6.56 mg/l from 9.58 mg/l to 3.01 mg/l and obtained phosphate removal efficiency of 68.56%. The most optimum results for the removal of phosphate levels contained in the 60 V voltage.

1. Introduction

Water is one of the essential things for human activities. Almost all human activities require water, from household activities to industrial activities. Human activities must produce waste, including wastewater. The laundry industry uses water as the main ingredient, resulting in large amounts of wastewater [1]. Detergent is a cleaning product that is generally used in the laundry process, with the main ingredients being surfactants and phosphates in the builder. It causes laundry waste to have a relatively high content of surfactants and phosphates [2]. It harms the environment because surfactants can have a toxic effect on flora and fauna of water bodies (0.8–2.0 mg/l) and phosphates which can cause eutrophication in water bodies [3][4].

Electrocoagulation (EC) is a technology that does not use additional chemicals, which is effective as a coagulant and has low operating costs. The findings from this study include knowing the effect of Al and Fe on the efficiency of reducing pollutant levels, knowing the effect of strong currents, and getting the level of effectiveness of electrocoagulation and filtration treatment in the optimal removal phosphates.

2. Methodology

Several equipment and materials were used in this research, including power supply, reactor, pump, electrode, and magnetic stirrer. An iron metal plate and an aluminium metal plate were selected as electrodes. Laundry industrial wastewater is the primary source of waste used in this study.

Several variables were used, including independent, dependent, and control variables. The current strength was used as the independent variable and the phosphate concentration as the dependent variable. Laundry wastewater discharge and reactor size were used as control variables. Voltage variations used in this study include 20 V, 30 V, 40 V, and 60 V, with electrode configurations of Al-Al, Al-Fe, Fe-Fe, and Fe-Al.

The data collected are primary data and secondary data. Initial data was obtained from testing the effect of electric voltage and electrode configuration on phosphate removal. Secondary data were obtained from literature and also from the internet.

3. Results and discussion

3.1. Characteristic of laundry wastewater

The distinctive character of laundry wastewater, it has a brownish white colour and contains high suspended particles. Then carried out a preliminary test on laundry wastewater for parameters pH, COD, BOD, TSS, phosphate and surfactant. The following are the results of the initial characteristics of laundry waste:

Table 1. Characteristics test results and comparison with applicable quality standards.

Parameters	Unit	Test Results	Quality Standard*	Description
pH	-	8.70	6-9	Meet
TSS	mg/L	260	60	Not Meet
Phosphate	mg/L	9,58	2	Not Meet
Surfactant	mg/L	21.30	3	Not Meet
COD	Mg/L	708.67	180	Not Meet

**) Based on Central Java Regional Regulation No. 5 of 2012 concerning Wastewater Quality Standards in the Soap and Detergent Industry*

In this case, laundry wastewater has a phosphate content of 9.58 mg/L, which does not meet the quality standard for laundry wastewater treatment which is 2 mg/L. The research method uses electrocoagulation with iron (Fe) and aluminium (Al) electrodes and direct electric current strength. Iron and aluminium will be oxidized to produce coagulants that can bind to colloids and form flocs.

3.2. Effect of voltage variation and electrode configuration on phosphate value

The effect of voltage variations and electrode configuration and on Phosphate removal was made by varying the configuration of Al-Al, Al-Fe, Fe-Fe, Fe-Al electrodes with voltage variations of 20 V, 30 V, 40 V, and 60 V. The results of laundry wastewater treatment with electrocoagulation can be seen in the following table:

Table 2. Phosphate removal result with Al-Al electrodes.

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
20	25	9.58	3.89	59.39
	30	9.58	4.39	54.10
	35	9.58	3.90	59.28
	40	9.58	3.87	59.62
20	45	9.58	3.58	62.60
	50	9.58	4.36	54.43

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
30	25	9.58	4.14	56.75
	30	9.58	3.91	59.17
	35	9.58	4.34	54.65
	40	9.58	4.49	53.10
	45	9.58	3.59	62.49
	50	9.58	4.97	48.13
40	25	9.58	3.96	58.62
	30	9.58	4.22	55.97
	35	9.58	4.64	51.56
	40	9.58	4.52	52.77
	45	9.58	4.61	51.89
	50	9.58	5.35	44.16
60	25	9.58	4.61	51.89
	30	9.58	4.23	55.86
	35	9.58	3.84	59.95
	40	9.58	4.52	52.77
	45	9.58	3.84	59.95
	50	9.58	3.75	60.83

Table 3. Phosphate removal result with Al-Fe electrodes.

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
20	25	9.58	4.35	54.54
	30	9.58	4.04	57.85
	35	9.58	3.88	59.51
	40	9.58	3.99	58.29
	45	9.58	4.16	56.52
	50	9.58	4.39	54.10
30	25	9.58	4.80	49.90
	30	9.58	4.22	55.97
	35	9.58	3.69	61.49
	40	9.58	4.68	51.11
	45	9.58	4.52	52.77
	50	9.58	5.16	46.15
40	25	9.58	4.46	53.43
	30	9.58	3.67	61.71
	35	9.58	4.04	57.85
	40	9.58	4.02	58.07
	45	9.58	3.38	64.69
	50	9.58	3.49	63.59
60	25	9.58	3.01	68.56
	30	9.58	4.13	56.86
	35	9.58	3.66	61.82
	40	9.58	4.27	55.42
	45	9.58	5.19	45.82
	50	9.58	5.99	37.43

Table 4. Phosphate removal result with Fe-Fe electrodes.

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
20	25	9.58	3.96	58.62
	30	9.58	3.58	62.60
	35	9.58	3.87	59.62
	40	9.58	3.84	59.95
	45	9.58	4.24	55.75
	50	9.58	3.56	62.82
30	25	9.58	3.94	58.84
	30	9.58	3.88	59.51
	35	9.58	3.81	60.17
	40	9.58	3.41	64.36
	45	9.58	3.68	61.60
	50	9.58	3.93	58.95
40	25	9.58	3.02	68.45
	30	9.58	3.72	61.16
	35	9.58	3.81	60.17
	40	9.58	3.85	59.84
	45	9.58	3.84	59.95
	50	9.58	3.44	64.03
60	25	9.58	3.94	58.84
	30	9.58	3.74	60.94
	35	9.58	3.67	61.71
	40	9.58	3.87	59.62
	45	9.58	3.42	64.25
	50	9.58	3.55	62.93

Table 5. Phosphate removal result with Fe-Al electrodes.

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
20	25	9.58	3.56	62.82
	30	9.58	3.77	60.61
	35	9.58	3.70	61.38
	40	9.58	3.93	58.95
	45	9.58	3.65	61.93
	50	9.58	3.86	59.73
30	25	9.58	4.14	56.75
	30	9.58	3.61	62.27
	35	9.58	3.88	59.51
	40	9.58	3.80	60.28
	45	9.58	4.05	57.74
	50	9.58	4.22	55.97
40	25	9.58	3.71	61.27
	30	9.58	3.70	61.38
	35	958	3.79	60.39
	40	9.58	3.58	62.60
	45	9.58	3.48	63.70
	50	9.58	3.62	62.15

Voltage (volt)	Time (minute)	Initial Concentration (mg/l)	Final Concentration (mg/l)	Removal Efficiency (%)
60	25	9.58	3.68	61.60
	30	9.58	3.96	58.62
	35	9.58	3.77	60.61
	40	9.58	3.91	59.17
	45	9.58	3.62	62.15
	50	9.58	3.97	58.51

Based on the results of measuring the phosphate concentration of each treatment with variations in the configuration of the Al-Al, Al-Fe, Fe-Fe, Fe-Al electrodes and variations in voltages of 20 volts, 30 volts, 40 volts, and 60 volts, the optimum results were obtained to reduce the phosphate concentration. Namely, the treatment uses an Al-Fe electrode configuration with a voltage of 60 volts. The following is a graph showing the results of measuring phosphate concentration in the treatment with optimum results.

At the contact time of 25 minutes, the efficiency value increased to 68.56%, with the phosphate concentration value reaching 3.01 mg/l. Although the efficiency is quite good, the phosphate concentration has not met the quality standard of Central Java Regional Regulation No. 5 of 2012. According to the regulation, the maximum allowed phosphate concentration is 2 mg/l. In this study, the optimum time with the treatment of several variations is 25 minutes, which means the optimum time is when the highest efficiency increase occurs from all treatments carried out.

Phosphate removal depends on the amount of coagulant formed in the waste. Al $(OH)_3$ or $Fe(OH)_2$ formed acts as a coagulant resulting from the oxidation process, anode, and reduction from the cathode. In principle, electrocoagulation is the same as chemical coagulation, which begins with the process of destabilizing the particles in the wastewater so that they break up and form precipitated flocs. The destabilization process in laundry wastewater uses an electric field that arises from the electrodes to move the particles [5].

The configuration of the electrodes in the electrocoagulation process affects decreasing the concentration of phosphate in laundry wastewater. Based on several treatments given with four electrode configurations (Al-Al, Al-Fe, Fe-Fe, Fe-Al), phosphate concentration decreased in the Al-Fe electrode configuration. It could be due to the Al metal being on the left of Fe, which means that Al metal is more easily oxidized than Fe metal. Fe metal is not more easily reduced than Al metal so that the reduction reaction at the cathode does not produce more OH^- ions and H_2 gas. The coagulant formation process can be formed faster than other electrode configurations. Al^{3+} or Fe^{2+} ions are formed at the anode, which reacts with OH^- ions formed at the cathode to form $Al(OH)_3$ coagulant, which can cause floc formation to reduce the phosphate concentration. In water, Al^{3+} from anode will react with OH^- from the cathode to form $Al(OH)_3$ or $Fe(OH)_2$, a coagulant to bind phosphate in laundry wastewater.

The coagulant $Al(OH)_3$ or $Fe(OH)_2$ formed is influenced by the voltage applied to the two electrodes. The only operating parameter that can be directly controlled is the voltage because the voltage will change over time. The amount of coagulant dose, gas bubble formation rate, agitation strength, and mass transfer at the electrode will be influenced and determined by the voltage [6]. If the more significant the applied voltage, then the greater the current density value. It can be interpreted that the higher the current density value, the phosphate removal in laundry wastewater will increase, but if the current density is too large, the electrodes will be more saturated so that the treatment process is not efficient [7].

4. Conclusion

Al-Fe electrode plates electrified with a voltage of 60 V will produce the most optimal laundry waste treatment because it will reduce the phosphate concentration by 3.01 mg/l, and the efficiency level obtained in phosphate removal is 68.56%. The only operating parameter that can be directly controlled is the voltage, as it will continue to change over time. Suppose the more significant the voltage applied, then the greater the value of the current density. It can be interpreted that the higher the current density

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value, the phosphate removal in laundry wastewater will increase, but if the current density is too large, the electrodes will be more saturated so that the treatment process is not efficient [7].

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