APLICATION OF ELECTROCOAGULATION METHOD TO REDUCE HYPOCHLORITE IONS LEVELS IN THE WATER POOL WITH ALUMINUM-GRAPHITE ELECTRODE

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Abstract

This study aims to determine the optimum potential and optimum time of elektrocoagulation process, with aluminum and graphite electrodes to reduce hypochlorite ions form the water pool and determine the concentration of hypochlorite ions before and after electrocoagulation process. The subject of this research was optimum electric potential and optimum time of electrocoagulation efficiency against hypochlorite reduction. The Object of this research was hypochlorite ions in pool water Hercules Maguwoharjo Yogyakarta. The Optimization of the electrical voltage was done on variation 4, 6, 8, 10, and 12 volts and optimization of the time electrocoagulation process was done on variations 2, 4, 6, and 8 hours. Parameters used are concentration of hypochlorite ions in the water. The Effectiveness of electrocoagulation was seen from the graph of changes in the concentration of hypochlorite ions after electrocoagulation process. The determination of hypochlorite content was using uv-vis spectrophotometry with wavelength 556 nm. The results showed that the highest electric potential is 12 volt and the longest time of electrocoagulation process is 8 hours. The Use of electrocoagulation method for pool water treatment effectively decreases the consentration of hypochlorite ions.

Keywords : elektrocoagulation, hypochlorite, aluminum, graphite.

PRELIMINARY

Swimming has many benefits, but many people do not aware that swimming can also transmit diseases caused by an unclean pool. Various diseases that can be transmitted through swimming pools, ie symptoms of fever, cough, cold, and pharyngeal infection of conjunctivitis caused by adenovirus. Thus the swimming pool can be one of the media in the transmission of disease through a swimming pool water intermediary, so that the swimming pool sanitation needs to be considered (Cita & Adriyani, 2013). The cleaness water in the swiimming pool is one of the requirements the existence of a swimming pool. According to Permenkes RI No: 416/Menkes/Per/IX/1990 and Permenkes RI No: 061/Menkes/Per/1991, good swimming pool should meet the quality water that has been established physically, chemically, bacteriologically.

In general, pool water treatment is using chlorination method with chlorine ($Ca(OCl)_2$), but if the chlorine dosage is not suitable, it will have an impact on health. Based on the pool owner's explanation, the amount of chlorine that is put into the water do not have the specific dose. Chlorine as a disinfectant mainly works in form of hypochlorite acid (HOCl) and partly in the form of hypochlorite (OCl^-). At pH 2 chlorine is in the form of chlorine (Cl_2), at pH 2-7 chlorine mostly in the form of HOCl, whereas at pH 7.4 chlorine is not only present in the form of HOCl, but also in the form of OCl^- (Hefni Effendi, 2003: 138). When hypochlorite is subjected to acids or ammonia, it will turned into hypochlorite acid which can then be converted into chlorine gas. The Exposion of chlorine gas that is released during the use of hypochlorite may result respiratory disorders. Meanwhile, hypochlorite in low concentrations can be affect lung function (Magee, 2011: 259).

Due to the existence of these problems, then the necessary methods is needed to overcome them. The method that can be applied in the problem is Electrocoagulation method. The electrocoagulation process is formed by dissolution of the metal from the later anode interacting simultaneously with hydroxy ions and hydrogen gas produced by the cathode (Prabowo, et al, 2012. The use of electrocoagulation method has several advantages among them, such as a simple method, efficiency, reducing the formation residu because there is no addition of chemical, and effectively removes suspended solids (Siringo-ringo & Sunarya, 2013: 98).

Electrode used in this research is Aluminum electrode as source ion Al^{3+} in the anode and serves as a coagulant in the coagulation-flocculation process occurs inside the cell. The cathode used graphite electrode. The efficiency of electrocoagulation can also be seen from the mass changes of the electrodes aluminum which is used as anode. The change is a mass reduction electrode aluminum, because aluminum is oxidized to Al^{3+} (Suyanta, et al, 2018). Graphite is an electrode that has mechanical properties such as light metals as well as from an economic point of view, artificial graphite is available abundant and cheap.

RESEARCH METHOD

Research Subject

The subjects in this study are electrical potential and optimization time of electrocoagulation efficiency on the reduction of hypochlorite ions (OCl^-).

Procedure

The first stage of the study was the determinating of the standard solution used to know the correlation of hypochlorite concentration with absorbance. 1 mL solution $Ca(ClO)_2$ (1 mg/L) was piped into a 10 mL measuring flask and 1 mL HCl 2M was added. Then adding 1 mL KI 2% and 0.5 mL Rhodamin B 0.05%, as well as 2 mL buffer pH 4. Next adding the aquades to the boundary mark and shuffling the mixture up homogeneous. After that the solution was put into the cuvette and measured the absorbance using a uv-vis spectrophotometer with a wavelength of 556 nm. The same thing was performed for variation of $Ca(ClO)_2$ 2 mg/L, 3 mg/L, 4 mg/L, and 5 mg/L. The blank used is aquades.

The next step was to do swimming pool electrocoagulation process with variation of electric

potential of 4 volts, 6 volts, 8 volts, 10 volts, and 12 volts for one hour. Then doing electrocoagulation process of swimming pool water with time variation are 2 hours, 4 hours, 6 hours, and 8 hours with electric potential of 12 volts.

RESEARCH RESULT AND DISCUSSION

This research was conducted to determine the optimum condition of electrocoagulation method in the reduction of hypochlorite ion levels in pool water. The study was conducted at chemistry research laboratory FMIPA Yogyakarta State Univercity. The sample used is swimming pool water taken from the Hercules Maguwoharjo General Pool by taking samples main pool water. Sampling is done by taking a number water in the main pond which is then mixed until homogeneous.

1. Determination of Hypochlorite Ion

Determination of the standard curve aims to determine the relationship between concentrations solution with absorbance value, so that the sample concentration can be known. This determination uses a uv-vis spectrophotometer with a wavelength of 556 nm, which has been optimized. On making a standard solution uses a solution of $Ca(ClO)_2$ concentrations of 1, 2, 3, 4, and 5 mg/L with Rhodamin B complexing, and added KI reagents and pH 4 buffers on acidic media.

Based on Figure 1, at a concentration of 1 mg/L hypochlorite solution has an absorbance value of 0.166. At concentration of hypochlorite solution 2 mg/L absorbance 0,145, concentration 3 mg/L absorbance 0,113, concentration 4 mg / L absorbance value 0,094, while at concentration of hypochlorite solution 5 mg/L absorbance 0,065.

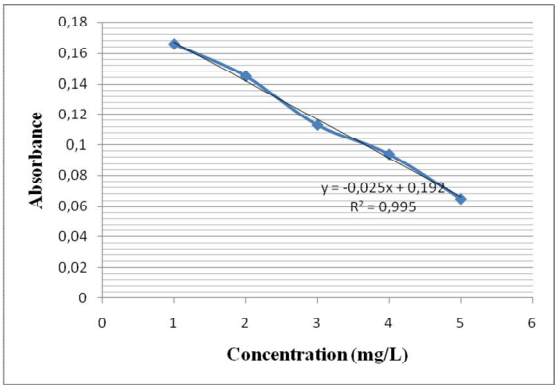

Figure 1. Graph of Relation Concentration with Hypochlorite ion Absorbance

Based on Figure 1, it can be seen that the optimum potential of swimming pool electrocoagulation process using aluminum-graphite electrode is 12 volt potential with the decreasiy of hypochlorite ion from 6,63 mg/L to 4,617 mg/L.

The result of the relationship between concentration value and absorbance that can be seen in Figure 1 shows that as the concentration increases, resulting in a decrease in absorbance value. This happens because Rhodamin B is sensitive to the presence of hypochlorite ions, resulting in decreased absorbance values.

Figure 1 obtained a equations of lines relationship between concentration and absorbance hypochlorite in the concentration range 1-5 mg/L. Linear equation obtained, that is y = -0.025x + 0.192 with correlation coefficient $R^2 = 0.995$. From these results prove that Rhodamin B can detect hypochlorite quantitatively with sensitivity = 0,025.

2. Electrical Potential Optimization

The variation of electric potential in electrocoagulation aims to determine the optimum potential in the electrocoagulation process of water swimming pool with Aluminum-Graphite electrode. The potential obtained is then used as the magnitude of the electrical potential for the test influence time to electrocoagulation process. Variations of electrical potential used are 4 volts, 6 volts, 8 volts, 10 volts, and 12 volts. In this study, the process of electrocoagulation was done for 1 hour. Parameters used are the levels of hypochlorite ions in water swimming pool. The results obtained from the measurement of hypochlorite levels in swimming pool water after electrocoagulation process can be seen in Figure 2 which shows that the higher the electrical potential, the hypochlorite ion content will decrease.

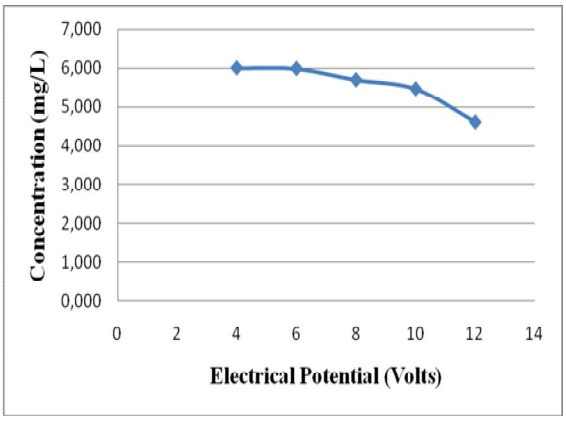

Figure 2. Graph of Relation Potential Electricity with Hypochlorite ion Concentration

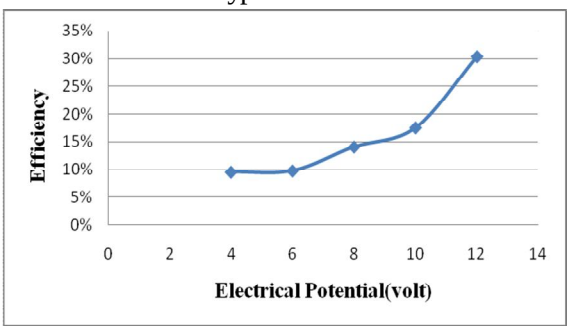

Figure 3. Graph of Relation Between Efficiency and Potential Electricity

Base on Figure 1 and 2, the use of a 4 volt electric potential, it can lower the hypochlorite ion level from 6.63 mg / L to 5.997 mg/L has an efficiency of 9.55%. At 6 volt electric potential, capable of reducing the hypochlorite ion level from 6.63 mg/L to 5.982 mg/L has an efficiency of 9.77%. At 8 volt electric potential, it can decrease hypochlorite ion level from 6.63 mg/L to 5.697 mg/L has an efficiency of 14.07%. At 10 volt electric potential, it can lower the hypochlorite ion level from 6.63 mg/L to 5.467 mg/L has an efficiency of 17.54%. While the 12 volt electric potential, can reduce the levels of hypochlorite ions from 6.63 mg/L to 4.617 mg/L has an efficiency 30.36%.

The greatest electric potentials to decreasing of hypochlorite ion lavels is 12 volt. The decrease from 6.63 mg/mL to 4.617 mg/L. The decrease of hypochlorite ion levels is maybe due to the reduction that occurs in the hypochlorite ions to the Cl^- ions at the cathode, then the ion is possibilty to be swept and settled with colloids ($Al(OH)_3$) and other particles.

Reduction: $ClO^-(aq) + H_2O(l) + 2e^- \longrightarrow Cl^-(aq) + 2OH^-(aq)$

Oxsidationi: $4OH^-(aq) \longrightarrow 2H_2O(l) + O_2(g) + 4e^-$

Total Reaction: $2ClO^-(aq) \longrightarrow 2Cl^-(aq) + O_2(g)$

In the electrocoagulation process is formed precipitate or flock. Flock formation occurs because of the electrochemical process, ie the release of Al^{3+} from plate electrode (anode), so forming a precipitated $Al(OH)_3$ deposit particles in the pond water pool. In the electrocoagulation process the following reaction occurs:

Anode: $Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$

Cathode: $2H_2O(l) + 2e^- \longrightarrow 2OH^-(aq) + H_2(g)$

If the potential of the anode is greater, then the secondary reaction will occur.

$2H_2O(l) \longrightarrow O_2(g) + 4H^+(aq) + 4e^-$

The presence of hydrogen gas can cause the formed flocs to rise to surface. Stirring process in continuous electrocoagulation process resulting in the number of flocs that formed more and more collide. The collision between flocks causes the flock's weight to increase, in part of flock will fall and settle in the form of sludge.

The Al^{3+} ion is produced from the oxidation reaction at the anode undergoing a spontaneous hydrolysis reaction resulting in some of the following reaction monomers.

$Al^{3+}(aq) + H_2O(l) \longrightarrow Al(OH)^{2+}(aq) + H^+(aq)$

$Al(OH)^{2+}(aq) + H_2O(l) \longrightarrow Al(OH)_2^+(aq) + H^+(aq)$

$Al(OH)_2^+(aq) + H_2O(l) \longrightarrow Al(OH)_3(s) + H^+(aq)$

The highest electrical potential, the more flocks are formed. This occurs because of the relationship with the current that occurs in the

electrocoagulation process. If the electric potential rises, it will cause a rise in current. In accordance with the law ohm that is I = V / R. Increased flow will also increase the oxidation of aluminum electrodes according to Faraday's Law I, where the mass of the substances produced in the electrodes will be directly proportional to the amount of electrical charge provided. This indicates that the precipitate of $Al(OH)_3$ formed increases.

3. Optimization of Electrocoagulation Time

Research on the influence of electrocoagulation time variation in the electrocoagulation process aims to determine the optimum time that can be used for process electrocoagulation of swimming pool water by using Al-Graphite electrode. The time variation used are 2 hours, 4 hours, 6 hours, and 8 hours with potential ones used is 12 volts. Parameters used is the levels of hypochlorite ions in water swimming pool. The results of the measurement of hypochlorite levels after the electrocoagulation process can be seen in Figure 4.

Based on Figure 4 and 5, in the electrocoagulation process for 2 hours can reduce the hypochlorite level from 6.63 mg/L to 5.714 mg/L, has an efficiency 13.82%. In the electrocoagulation process for 4 hours can reduce the hypochlorite level from 6.63 mg/L to 5.664 mg/L, has an efficiency 14.57%. The electrocoagulation process for 6 hours can decrease the hypochlorite level from 6.63 mg/L to 5.062 mg/L, has an efficiency 23.65%. While the electrocoagulation process for 8 hours can reduce the hypochlorite level from 6.63 mg/L to 4.681 mg/L, has an efficiency 29.40%.

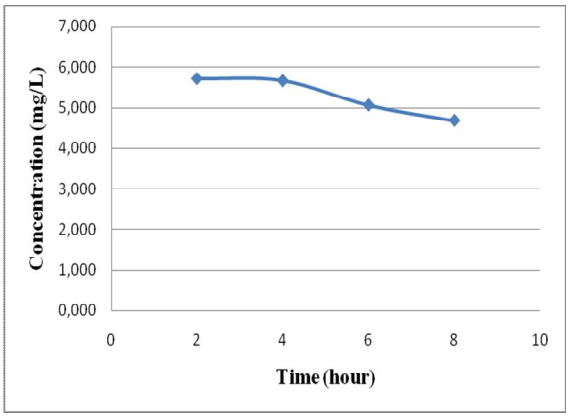

Figure 4. Graph of Relationship Between The Electrocoagulation Process Time with The Concentration Of Hypochlorite Ions

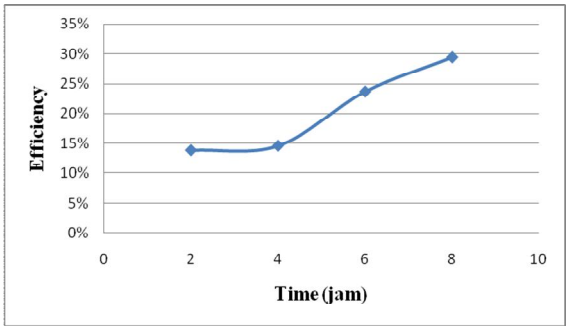

Figure 5. Graph of Relation Between Efficiency and Potential Electricity

Figure 4 shows that over time electrocoagulation grew longer hypochlorite ion decreases. Reduction of hypochlorite ion levels is possibly because the electrolysis process in electrocoagulation resulting in reduced hypochlorite ions become Cl^-, then it is maybe to be swept and settled with colloids ($Al(OH)_3$ and other particles..

The longer the electrocoagulation process of the formation of $Al(OH)_3$ deposit will be increased. This is in accordance with Faraday's Law I, that the mass of matter is formed proportional to time. In Figure 3 it can be seen that the optimum time of the process electrocoagulation was 8 hours with a reduction of hypochlorite levels of 6.63 mg/L being 4.681 mg/L.

CONCLUSIONS AND SUGGESTIONS

Conclusions

1. The largest potential of the electrocoagulation process using aluminum and graphite electrodes for the measurement of hypochlorite ions in pool water samples is 12 volts, when electrocoagulation is done with a potential range of 4 to 12 volts and obtained the efficiency of 30.36%
2. The longest time of the electrocoagulation process using aluminum and graphite electrodes for the measurement of hypochlorite ions in pool water samples is 8 hours, when electrocoagulation is done with a time range of 2 to 8 hours with an efficiency of 29.40%

3. The longer the electrocoagulation time and the higher the electrical potential, then reduction hypochlorite is also higher.

Suggestion

1. Need to do research with a larger scale.
2. Need to do further research with a longer time variation, size and the distance of the electrode.
3. Parameters used as pool water quality test should be multiplied.

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