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Research paper

Using Waste from Food Cans as Electrode in Electrocoagulation for Wastewater Treatment

Chanchanok Soonsorn, Kulyakorn Khuanmar, Surapol Padungthon, Panomchai Weerayutsil*

Department of Environmental Engineering, Faculty of Engineering, Khon Kaen University, Khon Kaen 40000, Thailand
**Corresponding Author: P.Weerayutsil*
**Corresponding author E-mail: wpanom@kku.ac.th*

Abstract

Wastes from soda and milk cans which contain metals can be used as electrode in Electrocoagulation (EC) technique. The study used wastewater from dyeing and finishing process of textile factory. Both the electrodes made from soda cans and milk cans were compared to the conventional electrodes made from aluminium sheet. Characterization of aluminium (Al) element in electrode showed 67.28% in aluminium sheets, 4.99% in soda cans, and 0% in milk cans. Nevertheless, only milk cans contain iron (Fe) and tin (Sn) at 45.87% and 23.87%, respectively. Based on treatment efficiency in COD removal from the real wastewater, it turned out that the highest efficiency was from aluminium sheets, at 83.57%, whereas soda-can electrodes and milk-can electrodes were 80.71% and 71.14%, respectively. This could result from the fact that soda-can electrodes contain high percentage of aluminium while milk-can electrodes have no aluminium, leading to its low efficiency. Although Fe in milk can function as electrodes, the efficiency cannot be compared to electrodes made from soda cans. Therefore, soda cans make an efficient material for electrodes because of its high percentage of aluminium. Analysis of SEM images demonstrated compactly agglomerated sludge from aluminium electrodes and soda-can electrodes. The image from testing milk can material demonstrated in contrast loosely agglomerated sludge. It can be concluded that the use of electrodes containing aluminium produces relatively more effective sedimentation.

Keywords: *Electrocoagulation, Aluminium electrode, Electrode from metal waste, COD removal*

1. Introduction

Nowadays, there are multiple environmental problems from trash and wastewater. Pollution from trash tends to increase with the expansion of world population and increasing demands for food consumption. This leads to a greater amount of trash in daily life, including trash from metal-packaging products such as cans. Thus, there have been various ideas to reuse these materials and hence reducing pollution from trash. For instance, metal wastes can be reused as orthoses and prostheses, containers, decorating items, art works, etc. Beside the environmental problem from trash, there is another problem of industrial wastewater which has various treatment techniques depending on its characteristics. For wastewater containing refractory substances, one treatment alternative is the use of Elecetrocoagulation (EC) technique. EC is composed of a current generator and electrodes that are in general made from aluminium (Al), stainless steel (SS) and iron (Fe) [1, 2].
Electrocoagulation treatment is effective for many types of wastewater [3] such as wastewater contaminated by oil [4], acid dyes [5], pharmaceutical products [6], pulp and paper manufacturing [7], phosphate-contaminated surface water [8]. The principle of EC is oxidation reaction at Anode and reduction at Cathode [9] which can be represented in Equations (1-4):

$$\text{Anode;} \quad M(S) \rightarrow Mn+ (aq) + ne- \tag{1}$$

$$2H2O\ (l) \rightarrow 4H+ (aq) + O2\ (g) + 4e- \tag{2}$$

$$\text{Cathode;}\ Mn+ (aq) + ne- \rightarrow M(S) \tag{3}$$

$$2H2O\ (l) + 2e- \rightarrow H2\ (g) + 2OH- \tag{4}$$

Electrocoagulation reaction will create metallic hydroxide floc from metal ions from electrodes that react with OH- in wastewater resulting in coagulants, which in turn, clean and treat the wastewater. In general, metal electrodes are cost effective and hence this study attempted to use electrodes made from soda and milk can wastes.
This study aimed at characterization of the materials used in three types of electrodes, comparing electrodes from aluminium sheet and electrodes from soda cans and milk cans to determine the COD removal efficiency, and examining the sludge components and morphology using EDX and SEM techniques.

2. Material and Method

Electrode preparation: Conventional Aluminum Grade 1100, 2 mm thick was used as electrodes to compare with electrodes made from soda cans and milk cans cut to 3 cm × 12 cm size. These electrodes were analyzed using EDX to investigate the components of elements in the electrodes. As shown in Table 1, there are 67.28% aluminium (Al) element in the aluminium sheet, 4.99% in the soda can, and 0% in the milk can. However, only the milk can contains iron (Fe) and tin (Sn) at 45.87% and 23.87%, respectively. Fe in milk cans can function as electrodes similar to Al. Figure 1 shows the electrode using in the experiment i.e., aluminium sheet, soda can, and milk can.

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Table 1. Components of elements in the 3 types of electrodes

Materials	Percentage of the main elements
Aluminium sheet	25.19: 6.66: 67.28 (C: O: Al)
Soda can	84.66: 10.21: 4.99 (C: O: Al)
Milk can	23.87: 30.26: 45.87 (Sn: O: Fe)



Figure 1. Electrodes using in the experiment

Characteristics of wastewater: Industrial wastewater was from dyeing and finishing processes of a textile factory, which was collected from equalization pond at one time for all experiments. As shown in Table 2, the parameters of the wastewater were as follows: COD = 1120 mg/l, conductivity = 4120 µS/cm, turbidity = 150 NTU, and pH = 7.37.

Table 2. Wastewater characteristics from dyeing and finishing process

Characteristics	Value
COD (mg/l)	1120
Conductivity(µS/cm)	4120
Turbidity (NTU)	150
pH	7.37

Experimental set-up: DC power supply (KPS3010D; 30V, 10A) was set up in monopolar alignment by connecting Anode and Cathode with a distance between electrodes of 1 cm in all of the three types of electrodes, as shown on Figure 2. For all experiments, the effective area of 21 cm^2 each of electrodes was immersed in 500 ml wastewater in the beaker. Then 20 V of electric power was applied for 60-minute electrolysis, during which the wastewater was stirred with a magnetic stirrer (IKA C-MAG HS 7) using speed of 200 rpm. After 60 minutes, the wastewater was left to precipitate for one hour. The clear water was taken to measure the COD, conductivity, turbidity, and pH. The sludge was dried at 70˚C for 2 hours before its morphology was investigated by SEM. The elements in the sludge were analyzed by EDX.

Analytical methods: COD measurements were determined according to the standard methods for examination of water and wastewater (APHA, 1992). The COD samples were analyzed using a COD reactor (HACH DRB200). Conductivity was determined by a portable multi-meter (HACH HQ40D). The pH was measured by pH meter (METROHM 713 pH-Meter). SEM (Hitachi S-3000N) was used to explore the structure of metallic hydroxide flocs, while EDX (HORIBA EMAX x-act) was used for analyzing the elements in electrodes and metallic hydroxide flocs.

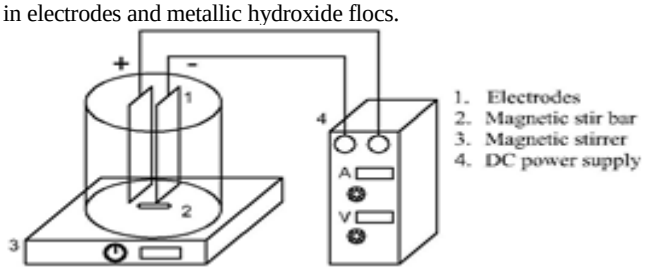


Figure 2. Schematic view of experimental setup

3. Results and Discussion

EDX and SEM analysis: As revealed by the Table 3, the EDX investigation showed that percentages of Al in 3 types of electrodes: aluminium sheet, soda cans, and milk cans. Only aluminium sheet and the soda can contained Al element, while the milk can contained Fe. Both Al and Fe induced metal ions in EC. After the experiment, at the aluminium electrode, the percentage of Al decreased both at Anode and Cathode, i.e., to 39.51% and 21.72%, respectively. For the soda can, Al at Anode decreased to 4.26%, whereas Al at Cathode increased to 8.65%. While the milk can has no Al at electrodes, Al was unexpectedly traced slightly in Anode. This was possibly due to contamination. However, after the experiment, both of the milk can's Anode and Cathode still maintained high percentages of Fe as before the experiment, i.e., 47.51% and 49.35%, respectively.

Table 3. The analytical results of electrodes by EDX

Elements	Aluminium sheet			Soda can			Milk can		
	Before use	Anode	Cathode	Before use	Anode	Cathode	Before use	Anode	Cathode
C	25.19	44.38	13.38	84.66	83.72	82.45	-	26.20	-
O	6.66	15.04	63.09	10.21	11.82	8.73	30.26	23.71	20.50
Al	67.28	39.51	21.72	4.99	4.26	8.65	-	0.31	-
Si	0.32	0.38	0.30	0.05	0.06	0.05	-	-	-
Fe	0.30	0.31	0.62	-	0.02	-	45.87	47.51	49.35
Sn	-	-	-	-	-	-	23.87	1.97	30.15
Others	0.25	0.38	0.89	0.09	0.12	0.12	-	0.3	-

The sediment was dried at 70˚C for 2 hours and analyzed by EDX technique. Dried sludge from the aluminium sheet was found with high percentage Al, at 20.00%, whereas Al in dried sludge from the soda can was 19.11%. None was found in the milk can because it was void since the beginning. However, Fe was detected in the milk can sludge owing to its Fe dominance from the start. The quantities of elements in sludge after treatment are shown in Table 4.

Table 4. The analytical results of sludge by EDX

Elements	Aluminium sheet	Soda can	Milk can
C	-	-	11.63
Fe	0.09	0.06	25.15
O	73.02	78.07	59.99
Al	20.00	19.11	-
Na	3.24	-	1.58
Others	3.65	2.76	1.66

From SEM images of sludge from 3 types of electrodes (Figure 3), it can be seen that each electrode shows different characteristics of sludge. Aluminium sheet electrode and soda can electrode have compactly agglomerated sludge compacted together owing to Al components in both types of electrodes. This type of compact demonstrates good sedimentation. The sludge from milk can electrode, on the contrary, is fluffy and hard to sediment due to its major component of Fe.

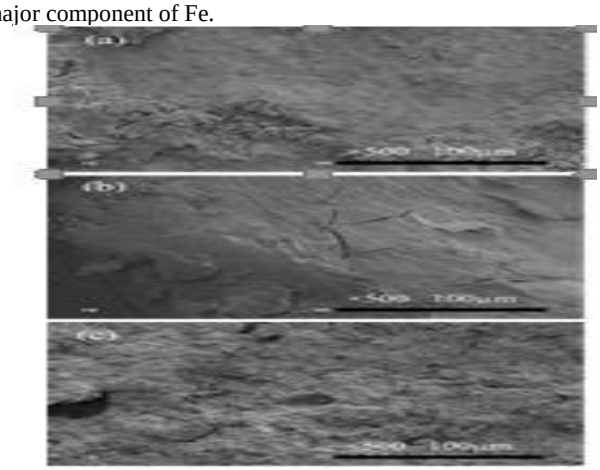


Figure 3. SEM images (500×magnification) of sludge after treatment: (a) aluminium sheet, (b) soda can, and (c) milk can

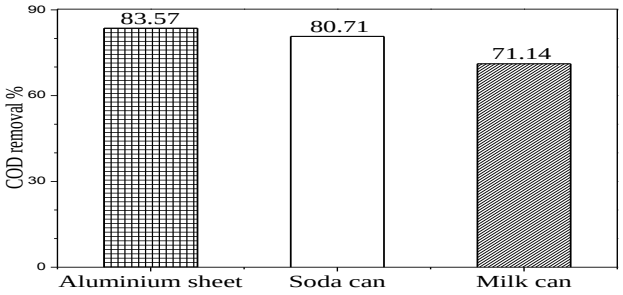


Figure 4. COD removal efficiency

COD removal effficiency: As show on figure 4, the COD initial concentration of real wastewater from a textile industry was 1120 mg/l. The highest efficiency of treatment based on electrocoagulation was found at aluminium sheet electrodes, at 83.57%, which was close to the efficiency of electrodes made from soda can, i.e., at 80.71%, because Al was the major component of aluminium sheet and soda can electrodes that resulted in coagulants of aluminium hydroxide that has the property of good coagulation and sedimentation. The milk can's treatment efficiency, in contrast, was 71.14% because it did not contain Al. Although it has Fe, which could act as coagulant, the efficiency still is incomparable to the materials containing Al.

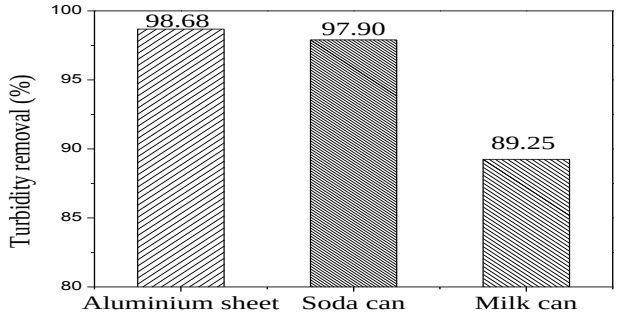


Figure 5. Turbidity removal efficiency

Turbidity removal efficiency: From the 3 types of electrodes, aluminium sheet and soda can electrodes still show the highest efficiency: 98.68% and 97.90% of turbidity removal, respectively (Figure 5). This is consistent with the images obtained showing ease of sedimentation into compactly agglomerated sludge. Likewise, this agrees with the image of the milk can that shows loosely acclomerated sludge resulting in hard sedimentation and inefficient turbidity removal at 89.25%.

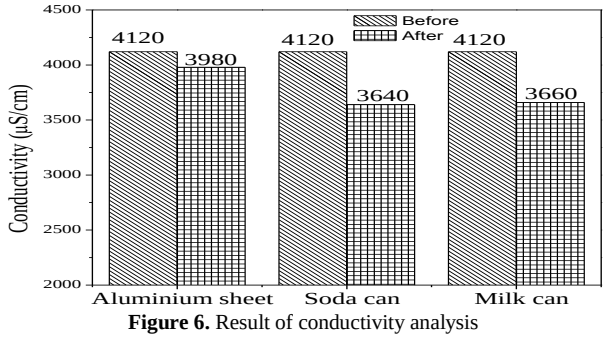


Figure 6. Result of conductivity analysis

Result of conductivity analysis: The initial conductivity of wastewater was 4120 µS/cm. The aluminum sheet electrodes show slight decrease of conductivity to 3980 µS/cm. The conductivity at the electrodes from soda can and milk can was reduced to 3640 µS/cm and 3660 µS/cm, respectively (Figure 6). If high conductivity percentage can be retained, EC system will function effectively. Therefore, if these scrap materials are to be used, conductivity should be adjusted by electrolytes such as Na2SO4, NaCl [10].

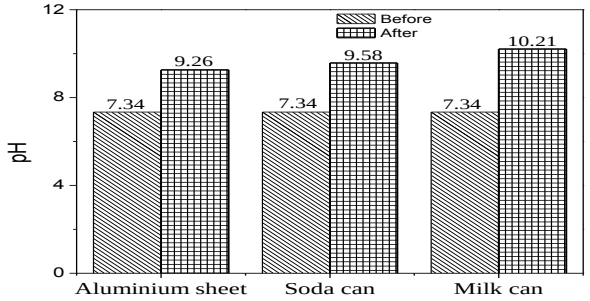


Figure 7. Result of pH analysis

Result of pH analysis: As show on figure 7, the initial pH in the wastewater was 7.34. After the experiment, all of the 3 types of electrodes showed higher pH, i.e., 9.26, 9.58 and 10.21, respectively. From the reaction at Cathode, OH- was produced during electrolysis, resulting in alkalinity in effluent [3, 11]. It can be seen that pH in milk can electrodes presented the highest pH. In real application, it is recommended that pH is adjusted to meet the standard (pH ~ 7) – high cost, however, will incur for this adjustment of the effluent.

4. Conclusion

The result of wastewater treatment with electrocoagulation of the electrodes made from aluminum sheet, soda cans, and milk cans showed that soda-can electrodes have potentiality and efficiency close to aluminium sheet both in terms of COD treatment and good sedimentation. pH of soda-can electrodes after treatment was also close to the final pH of aluminium sheet electrodes. However, when considering conductivity, if soda-can electrodes are to be used, electrolyte materials should be adjusted during treatment for higher treatment efficiency.

Further studies should be conducted on other waste materials containing Al as the major component in order to find the most appropriate waste material in place of aluminium sheet, which means expense in the use of EC. If an efficient waste material can be found, the expense will be reduced and the environment will be friendly.

Acknowledgments

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