THE APPLICATION OF EMULSION LIQUID MEMBRANE (ELM) ON THE CHROMIUM EXTRACTION

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Abstract

One of heavy metal compounds that widely used in industry is Chromium. Chemical or biological treatments are not yet able to deal with the problems caused by heavy metal pollution. Taking the expensive heavy metal such as chromium, nickel, and mercury from the waste water and then re-used the recovered heavy metal is the effective method in treating waste water with expensive heavy metal on it. One of the methods that can be applied is by using Emulsion liquid Membrane (ELM).The objectives of this research were to determine the most influencing variable and to determine the optimum condition of the extraction process. The process variables tested in this research conducted were carrier concentration, external phase acidity and stripper concentration on the internal phase. While the fixed variables were ratio of emulsion and external phase volume and agitation time of the permeation step. The research was conducted in a stirred tank and divided into three major step which were the membrane stability test, the determination of the variable that gave the most dominant influence to the chromium recovery on the membrane condition which was achieved from the first step, and the third step was optimization of the most influencing variable on the chromium extraction process, while the optimum condition for the chromium extraction from liquid waste water were the concentration of chromic acid in the external phase was 600 mg/L, the stripper concentration in the in internal phase was 3 M, agitation time was 15 minutes, the volume ratio of the emulsion and the external phase was 1:3 and the carrier concentration was 0.049%.

Key words : chromium, emulsion liquid membrane, extraction

Introduction

Heavy metal pollution is one big issue that is world wide observed, because in a small concentration, heavy metal can cause a high fatality on human life. The common method that is applied in heavy metal pollution is chemical method. The treatment includes neutralization, coagulation and flocculation, while the biological method uses life cell to absorb the pollutant.

Chemical or biological treatments are not yet able to deal with the problems caused by heavy metal pollution. In chemical treatment, the addition of coagulant and flocculants will only increase the volume of the waste water. The weakness of the biological treatment is the limited ability of the life cell to absorb the pollutant, in this case, the heavy metal.

Chromium is one of heavy metal compounds that widely used in industry because of its natural properties such as a strong oxidation agent and its ability to produce long life color. However, if chromium is thrown away to the environment and entering the human tissue, the effect is very dangerous because the compound is a carcinogenic material. Waste water that contains chromium compound must be treated properly in order to avoid such a dangerous impact on human tissue.

The most proper way of treating wastewater which contains heavy metal with chromium is recovery. Heavy metal recovery from liquid wastewater that has to be re-used has many benefits such as minimizing the environmental damage caused by heavy metal pollution and reducing the purchasing cost of the chemical compound.

The effective method in treating waste water with expensive heavy metal on it such as chromium, nickel, and mercury is by taking the expensive heavy metal from the waste water and then re-used the recovered heavy metal. One of the methods that can be applied is by using Emulsion liquid Membrane (ELM). Researchers dealing with the possibility of using ELM in heavy metal pollution treatment are continuously developed. This technique is effective, efficient, simple, rapid, low-cost and impact positively to the environment. Process variables that influence the heavy metal extraction process using Emulsion Liquid Membrane are carrier

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concentration, external phase pH, the ratio of emulsion and external phase volume, agitation time of the permeation step and feed concentration on the external phase. The objectives of this research were to determine the influencing variable and determine the optimum condition of the extraction process. Based on that data, we hoped that the treatment on heavy metal pollution using emulsion liquid membrane can reduce the problems caused by heavy metal pollution.

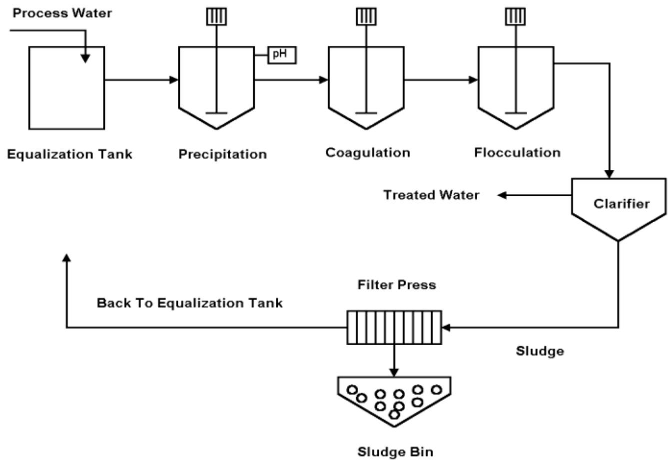


Figure1. General Waste Water Treatment

Liquid membrane is a thin layer that lay between two other liquid phases. The layers are not soluble in each other with the layer that lay on each side. This layer is selective to a certain compound. This method can minimize two step of the conventional treatment which are extraction and stripping step into one step. The basic Principle of this method is taking the advantage of the solubility difference between aromatic and paraffin compound on the polar solvent. The profile and the working method of the emulsion liquid membrane are simplified in Fig.2.

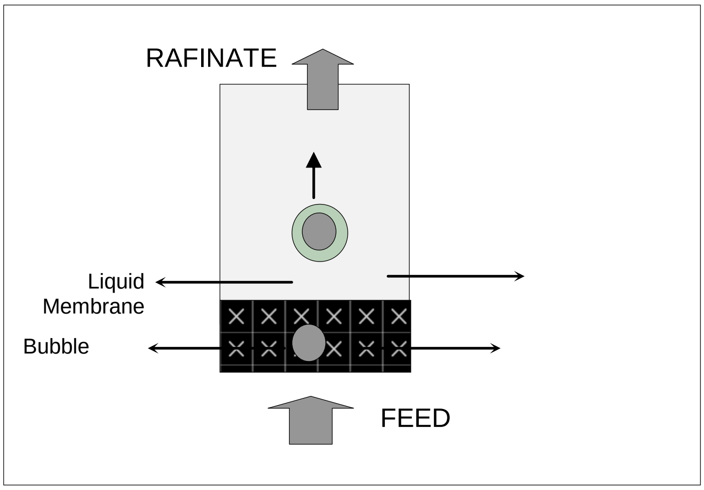
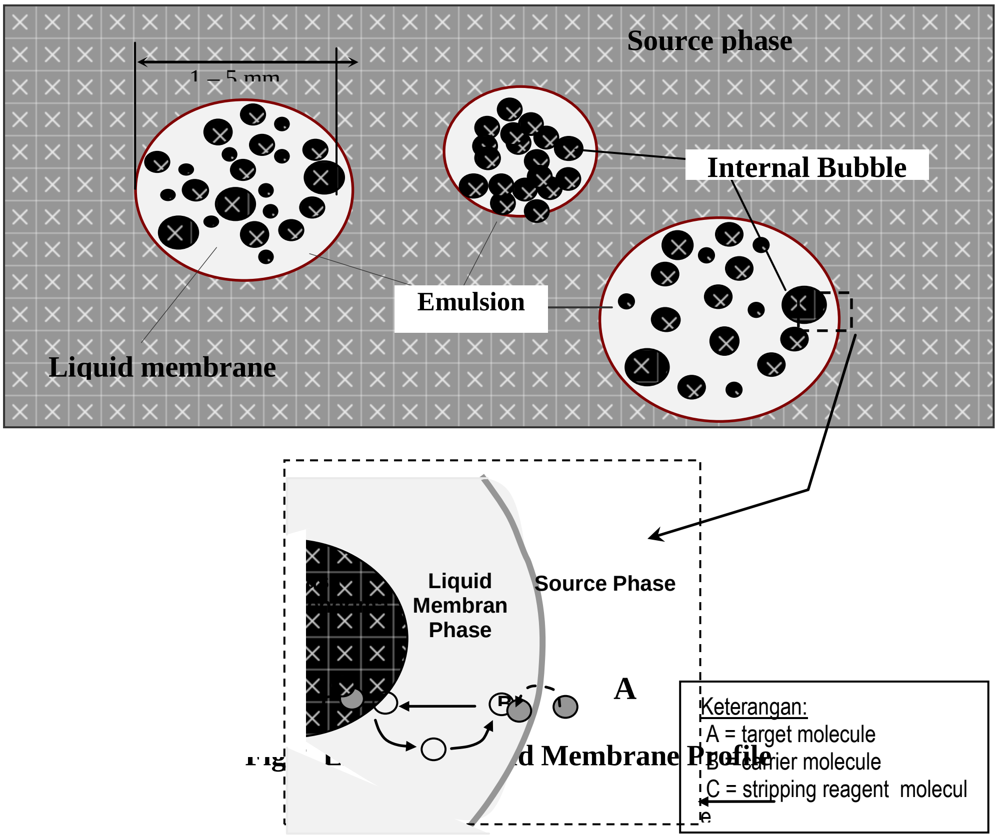


Figure 2. Emulsion Liquid Membrane on Difussion Coloumn

Emulsion Liquid Membrane (ELM) is a removal method that has many advantages compared to the conventional liquid membrane. The ELM technique operates simpler, more efficient. ELM has the potency of removing several metal ion and hydrocarbon from wastewater and the efficiency is relatively high. The removing mechanism of the emulsion liquid membrane is exposed in Fig.3.



Research Method

The research method that was applied in this research was divided into three major steps which were Membrane stability test, Factorial Design two levels and optimization of the most influencing variable in order to find the optimum condition of the chrome extraction process. The first step was the membrane stability testing, the main goal of the step was to determine the experiment condition that gave a stabile membrane. The second step was, tested the variables that gave the most dominant influence to the recovery chrome on the membrane stabile condition which was achieved from the first step. Variables tested in the second step were stripper concentration on the internal phase, external phase acidity and the carrier concentration. The third step was optimization to the most influencing variable. The extraction parameters were

- Chromic acid concentration on the external phase : 6000 mg/L
- Agitation time on the permeation step : 15 minutes
- Volume ratio of emulsion and external phase : 1:3

The variation of the extraction parameters were based on the parameters range found researchers prior this research. The range of the process parameters observed by past researchers was:

- Internal phase stripper concentration : 2-5
- External phase pH : 1.5-3
- Carrier concentration, %m : 0.005-0.05

The equipments that were used were pH meter, analytical balance, magnetic stirrer, vessel , high peed and medium speed stirrer and glass equipments, while the chemical reagents used in this research were : chromic acid, Sodium hydroxide as the stripper, red dye, sulphate acid as the acidity regulator and the emulsion liquid membrane material consist of pluronic L31, 1 ducodenol, sorbitan mono oleat, SPAN 80 and N-lauril 10%.

The research was conducted on three step which were the membrane stability test, factorial design 2 level on the stabile membrane and optimization of the most influencing variable

Data interpretation

In order to achieve the goal of the research, the data was then being interpreted by using Factorial Design Method. By calculating the main effect value ad the interaction effect, them the normal probability plot was then obtained. The graphic of the relation between the percentage of the probability value and the main and interaction effect was then plotted. The variable that influencing the extraction process was the variable that it's effect value was close to the linear regression between the percentage of the probability value and the main and interaction effect.

Table 2. Factorial Design 2^Y

Run	Y	Variable			Interaction
		A	B	C	
1	Y1	1	1	1	1
2	Y2	1	1	-1	-1
3	Y3	1	-1	1	-1
4	Y4	1	-1	-1	1
5	Y5	-1	1	1	-1
6	Y6	-1	1	-1	1
7	Y7	-1	-1	1	1
8	Y8	-1	-1	-1	-1

Result and Discussion

Membrane stability test

In order to obtain a stabile membrane condition, a variation of Sorbitan Monooleat SPAN 80 (surfactant) addition was conducted. The variation of the surfactant was divided into three different concentration which were 8%, 10% and 12%.The objective of the surfactant addition was to minimize the potency of the concentration decrease in the internal bubble, the concentration decrease of the recovered product and the destabilization of the internal bubble caused by the continuous water diffusion into the internal bubble. The observation was done visually by tracking whether there was or there was not a leaking of the red dye color that was used as the water indicator. The research showed that the surfactant addition in 10% concentration of SPAN 80, a stabile liquid membrane was obtained. The quantity data of the composition of the emulsion liquid membrane is summarized in Table 3

Table 3. Stability condition of the emulsion liquid membrane

SPAN 80 concentration Permeation Time Internal Phase Volume	10% Volume 15 Minutes 380 ml 300 rpm
Agitation Speed Stripper Concentration Red Dye Concentration	20% Volume 10 ml

On 10% of the red dye concentration, the emulsion liquid membrane was stabile. It was assumed that at a medium concentration, the decreasing of the surface tension was not big enough to allow the red dye leak out from the emulsion area. Surfactant is a material that lowered a liquid surface tension, so the emulsion was stabilized by the addition of the surfactant. The addition of excess surfactant did not affect the to the membrane stabilization because the properties of the surfactant which is hydrophobic will interrupt the extraction and the stripping process. On the addition of 10% volume of surfactant, the solute transportation process to the acceptor phase was not interrupted, and swelling, which is the swelling of the emulsion bubble caused by the water diffusion from the feed phase to the emulsion bubble was minimized.

The determination of the most influencing variable

The determination of the most influencing variable was conducted in 8 run of laboratory experiments. The recovered chrome data obtained from the extraction process that were conducted on a variation of low and high level of stripper concentration, external phase acidity and carrier concentration were summarized on Table 4

Table 4. The Chrome Extraction on the Determination of the Most Influencing Variable

Run	Variables			Recovered Chrome (%b/b)
	Stripper Concentration(M)	External Phase acidity	Carrier Concentration	
1	5	3	0.1	0.45
2	5	3	0.01	0.43
3	5	1.5	0.1	0.29
4	5	1.5	0.01	0.31
5	3	3	0.1	0.57
6	3	3	0.01	0.63
7	3	1.5	0.1	0.41
8	3	1.5	0.01	0.55

The Factorial Design Method was uses to calculated the effect and percentage of the probability, the data were summarized on Table 5

Table 5. The Effect and Normal Probability Number

Effect (I)	% Probability
-0.666	16.25
-0.226	27.34
0.0133	57.83
0.173	61.22
0.455	70,16

The linier regression showed that the most influencing variable was carrier concentration, effect I_3, effect of the carrier concentration which its value -0.666 close to the regression line.

Optimization of the most influencing variable

The research showed that the recovered chrome on stripper concentration 3 M was bigger compared to the recovered chrome on stripper concentration 5 M. The recovered chrome on stripper concentration 3M and pH 3, the recovered chrome was bigger than the recovered chrome on stripper concentration 3 M and pH 1.5. Hence, the optimization was conducted on external phase chromic acid concentration 6000 ml/L. internal phase carrier concentration 3 M, agitation time on the permeation step :15 minutes, emulsion-external phase volume ratio 1-3, pH of the external phase 3.0 and the carrier concentration varied from 0.01-0.1 with 0.01 interval. The result of the carrier concentration optimization was tabelized on Table 6.

Table 6. Optimization of Carrier Concentration

Run	Carrier concentration (w%)	Recovered Chrome (w%)
1	0.01	0.526
2	0.02	0.548
3	0.03	0.577
4	0.04	0.607
5	0.05	0.618
6	0.06	0.598
7	0.07	0.590

The data showed us that the chrome recovered on several carrier concentrations. Along with the increasing of the carrier concentration, the recovered chrome was also increase, because the solubility of the chrome in the carrier is also increase, hence the more solute that was carried away in the carrier phase, in other way, the on the carrier concentration of 0.05% and above, the recovered chrome was tend o decrease, it was mean that the reactivity of the extraction was approach the equilibrium, and that was why the optimum recovered chrome was obtained on carrier concentration 0.049%m.

Conclusion

The research result showed that carrier concentration was the most influencing variable on the chrome extraction process. The optimum condition of the chrome extraction process was achieved at 0.049% of carrier concentration, the recovered chrome was 61,8% with the empirical model :

$$Y = -57{,}745\ X^2 + 5{,}6382\ X + 0{,}4679$$

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