Study on the Removal of Copper Ion (Cu^{2+}) From Industrial Wastewater by Using Ion Exchange Technique

by

Muhammad Taufiq bin Roslan

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Chemical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(CHEMICAL ENGINEERING)

Approved by,

(Dr Usama Mohamed Nour Eldemerdash)

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TRONOH, PERAK

May 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD TAUFIQ BIN ROSLAN

ABSTRACT

Excess amount of copper (II) ion released through industrial wastewater to the environment is very harmful. Presence of high concentration of copper (II) ion in human body may lead to death and cause severe damage to other living species. Ion exchange process is widely used nowadays and it is chosen for this study to treat copper (II) from industrial wastewater in order to enhance water quality. Ion exchange is a reversible chemical reaction wherein ion from the solution is exchanged for a similarly charged ion attached to the resins. In this study, removal of copper (II) ion using a strong acid and strong base resin is done in batch mode. The aim of this study is to determine the optimum condition for copper (II) ion removal from industrial wastewater based on certain criteria; effect of resin dose, initial metal concentration, and pH. Experiments are performed under various condition for resin dose effect (2g, 4g, 6g, 8g, and 10g) followed by the effect of initial metal concentration (1000ppm, 1500ppm, 2000ppm, 2500ppm, and 3000ppm). The experiment continues for different pH value (4, 7, and 10). The result of removal efficiency is shown in graph and kinetic of the process also been calculated. The effect of waste water treatment to the characterization of the resins is determined by using Scanning Electron Microscope (SEM) and Fourier Transform Infrared Spectroscopy (FTIR). Results from this project can help to design an appropriate heavy metal removal technique by using ion exchange process in order to minimize the negative impacts caused by industrial waste water.

ACKNOWLEDGEMENT

First and foremost, I would like to express my praises to ALLAH for His blessing.

My deepest appreciation and gratitude is extended to my supervisor, Dr. Usama Mohamed Nour Eldemerdash for being very encouraging, supportive and responsive throughout the whole process of completing this final year project to fulfill the university requirement. Without his constant supervision and guidance, I may not be able to complete this project successfully.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wastewater is the spent water after homes, commercial establishments, industries, public institutions and similar entities have used their water for various purposes. The keyword in the definition of wastewater is "used" or "spent". That is, the water that has been used or spent now it has become waste water [1]. Wastewater treatment is a group of unit processes designed to separate, remove, and destroy undesirable substances carried by wastewater from industrial sources [2].

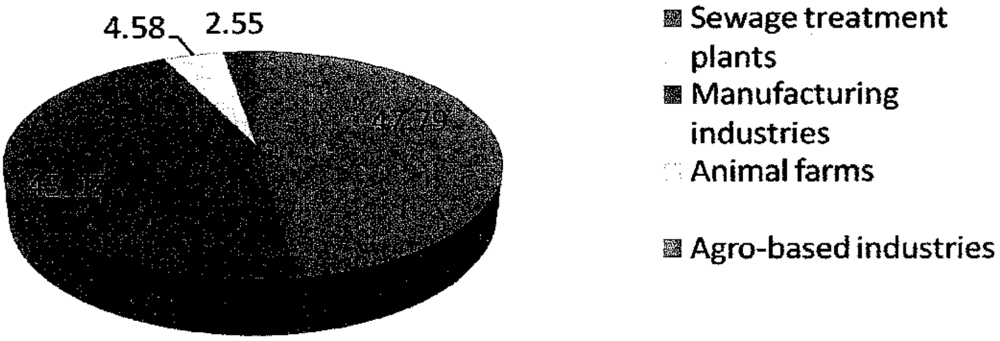


Figure 1: Registered water pollutant point sources 2006

Obtained from Department of Environment, Ministry of Natural Resources and Environment webpage.

Based on the above chart, it is clearly shown that manufacturing industries contribute a lot in polluting our environment. Water often contaminated with heavy metal ions such as copper, cobalt, nickel, zinc, lead, cadmium, etc, which are detected in the waste stream from the electronic, electroplating, and photographic industries. Those heavy metals considered toxic to all living systems, including human being if present in sufficient high concentration. Copper causes various acute and chronic disorders such as haemochromatosis and gastrointestinal catarrh [3]. Human intake of excessively large doses of copper lead to severe musocal irritation and corrosion, widespread capillary damage, hepatic and renal damage, central nervous system irritation followed by depression and possible necrotic changes in the liver and kidney could occur [4].

Removing pollutants from water is an important process and is becoming more important with the increasing of industrial activity. In order to solve heavy metal pollution in the ecosystem, it is important to bring applicable solutions to the subject. Several techniques such as chemical precipitation, oxidation, reduction, coagulation, solvent extraction, ion exchange, and adsorption have been commonly employed for the removal of metal ions. Among these, adsorption has been thought to be efficient and economically feasible as a wastewater treatment operation. Ion exchange resins with improved sorption capacity as well as adsorbents may have advantages over such non-specific adsorbents. In this regard, ion exchange resins hold great potential for the removal of heavy metals from water and industrial wastewater [4].

Industrial wastewater treatment is consisted of few stages which are pretreatment, primary treatment, secondary treatment, and advanced (tertiary) treatment. The pretreatment is mainly to remove large materials from the wastewater that may hinder the following treatment. In the primary treatment, the light particles or suspended solid is settled down in a sedimentation tank [5].

The secondary treatment is about removal of soluble materials that require oxygen for decay, as well as further removal of suspended solids. The processes involved in this stage are trickling filters, activated sludge, and clarifier. The secondary stage can remove up to 85% the BOD, suspended solids, and all the pathogen, yet tertiary treatment is still required to remove the remaining pollutant such as nitrogen, phosphorus, non-biological chemical oxygen demand, and heavy metals [5].

1.2 Problem statement

The most efficient process need to be determined for the removal of Cu^{2+} by ion exchange technique to make sure that the discharge wastewater follow the standards provide by Malaysian government and WHO. In this study, understanding of the concept of ion exchange and the affecting parameter of the process is very crucial in order to get the most efficient process with the most removal of Cu^{2+} ions.

1.3 Objective

The general objective of this project is to enhance the removal of copper ions (Cu^{2+}) from wastewater by using ion exchange method. Specifically, this project aims to:

i. To study the characteristics of ion exchange resin materials.

ii. To study on the effect of initial copper concentration of the solution, pH of the solution, and dose of resin used.

iii. To study the kinetics of the ion exchange process.

1.4 Scope of study

A small scale laboratory experiment will be performed in order to investigate the ability of the resins to remove copper ion (Cu^{2+}) from aqueous solution over a range of operating parameters and conditions. The project starts by identifying the suitable process to remove Cu^{2+} and suitable resins for the research. Optimum wastewater treatment condition is determined and selected by variation of Cu^{2+} concentration in the wastewater, pH, and resin dosage used. Wastewater model is prepared by dissolving $CuSO_4$ in distilled water. Concentration of Cu^{2+} is measured by UV-vis Spectrophotometer before and after the experiment. This was done to identify the efficiency of the resin in removing Cu^{2+}. The surface analysis was done to compare the characteristics of resin before and after the experiment. The analysis involved Scanning Electron Microscope (SEM) and Fourier Transform Infrared Spectroscopy (FTIR).

CHAPTER 2

LITERATURE REVIEW

2.1 Ion Exchange Process

Ion exchange is a separation process in which a solid containing mobile, replaceable ions is contacted with a solution of an ionizable species, when the mobile ions of the solid are exchanged by ions of similar charge (positive or negative) in the solution [5]. It also can be define as the exchange of ions for a stoichiometrically equivalent amount of other ions of same sign when the ion exchange resin is in contact with electrolyte solution. Carriers of exchangeable cation called cation exchanger and carrier for exchangeable anion called anion exchanger [6]. In early years, inorganic ion exchangers, mainly zeolites, were used. But synthetic ion exchange resin, developed by more than 60 years ago, have largely replaced the zeolite-type ion exchangers years ago [5].

Ion exchange now is a well established technology, particularly in water purification and the concentration and removal of hazardous substances at very low concentrations in chemical process industries [7]. For comparatively dilute solutions, besides, reverse osmosis, solvent extraction, and adsorption also can be applied. In general, reverse osmosis has high operating and maintenance costs and is subjected to fouling. Solvent extraction has high recovery capacity and selectivity but often suffers from solvent loss the problems of phase separation. Activated carbon adsorption is not so effective for this subject although it has been widely used for removal of organic contaminants. Therefore, ion exchange appears to be a more promising method for the treatment of such solutions in chemical process industries [8].

2.2 Ion Exchange Equilibria

Generally, an ion exchange 'reaction' can be expressed in the following form.

$$A^+ + B^+R^- + X^- \rightarrow A^+R^- + B^+ + X^-$$

Here the ions A^+ and X^- are formed in solution by dissociation of the compound AX; B^+R^- and A^+R^- stand for the cation exchange resin. The resin changes from B-form (B^+R^-) to the A-form (A^+R^-) on exchange of the cation B^+ in the resn by A^+ from the solution. The anion X^- remains in the solution all along [5].

The removal of copper from wastewater can be represent as below

$$Cu^{2+}\,(aq) + 2\,R^-H^+\,(s) \rightarrow CuR_2 + 2\,H^+\,(aq) \qquad (R^- = \text{resin anion})$$

Copper ion (Cu^{2+}) will replace hydrogen ion (H^+) from the resin and H+ will be release to the solution and been treated with anion resin. The treatment can be represented as below.

$$H^+\,(aq) + R^+OH^-\,(s) \rightarrow R^+ + H_2O\,(aq) \qquad (R^+ = \text{resin cation})$$

After some times, both anion and cation resins will get exhausted and in order to maintain the efficiency of the adsorption, those resins need to be regenerate. Regeneration of cation resin will use H_2SO_4 while anion resin will use NaOH. The resins will be flash by their respective chemicals for a period of time.

2.3 Parameters Affecting Process

Since this research is about the removal of hazardous substance at very low concentrations in chemical process industries, it is important to identify the parameter affecting this process and study the kinetics of the process in order to obtain the most efficient process. In this research, several parameters will be studied which is the initial concentration of the solution, pH of the solution, and resin dosage.

For pH effect, it is known that amount of metal exchanged (q_e) increases sharply with the increasing pH. This is due to competitive binding between Cu^{2+} and H^+ for the binding sides of the resin surface. When the initial pH value is below 2, an excess of H^+ ions compete effectively with Cu^{2+} for binding sites, to result in lower level of metal uptakes, so the final pH becomes higher after exchange. But at an initial pH of 4-5, the final pH becomes lower after exchange [7].

Resin dosage also produce significant effect to the exchange process as the increasing the adsorbent dose (resin dose) the removal efficiency increases but adsorption density decrease. The decrease in adsorption density can be attributed to the fact that some of the adsorption sites remain unsaturated during the adsorption process; whereas the number of available adsorption sites increases by an increase in adsorbent (resin) and this result in an increase in removal efficiency [4].

The effect of the initial concentration is referred to the percentage of sorption increased with the decrease in metal ion concentration while the uptake of metal ions by sorbent increased with an increase in initial metal concentration [3].

2.4 Characterization of the resin

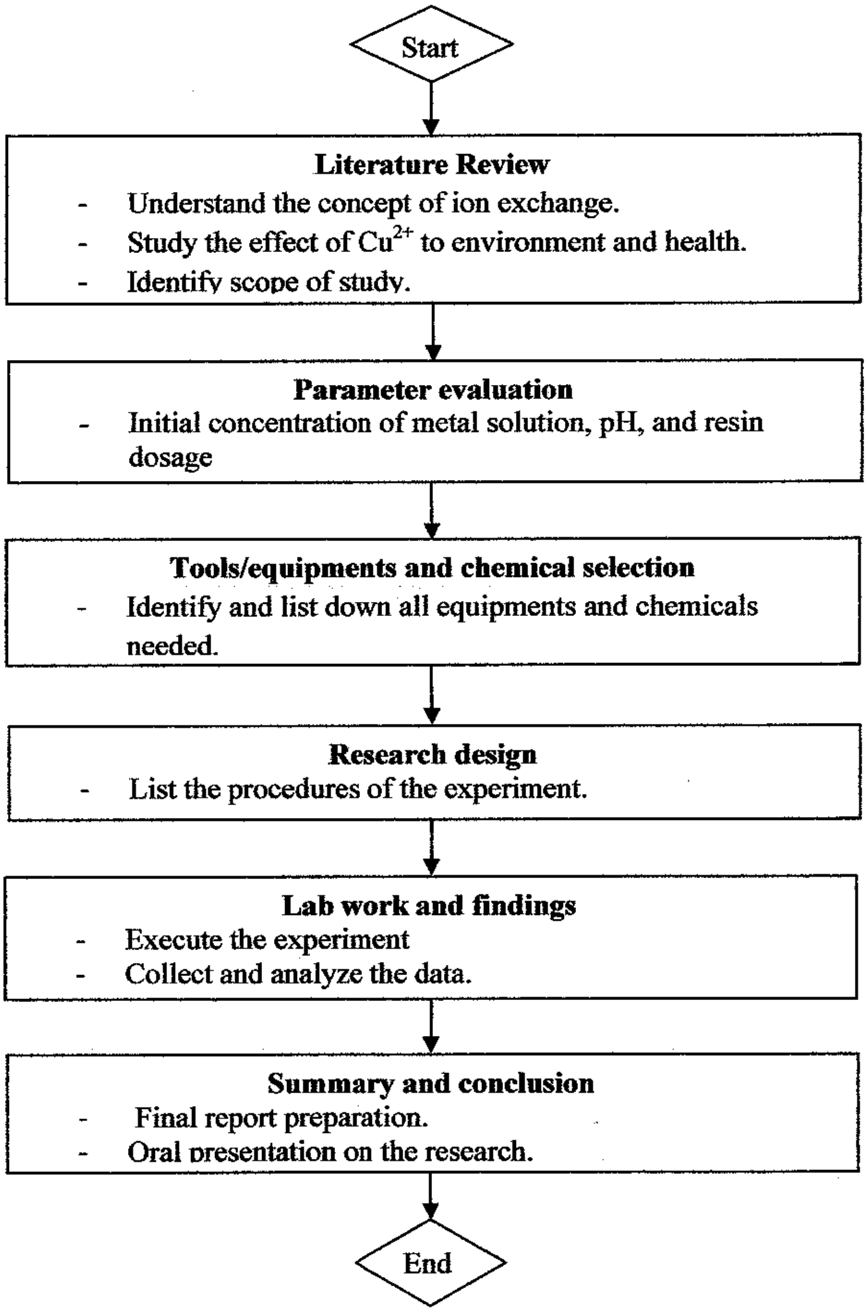
Table 1: Method of Characterization Study for Ion Exchange Resin

Method	Purpose	Working principle
Scanning Electron Microscope (SEM)	To observe the surface structure for the particle. SEM shows very detail 3 dimension image that can be magnified up to 500 000 times.	The magnified image is produced by scanning the particle with high-energy beam of electrons in a raster scan pattern.
Fourier Transform Infrared Spectroscopy (FTIR)	To provide information regarding the amount of elements in the particle based on the functional group. To identify unknown material in the sample.	FTIR Spectrum is produced by the different in IR radiation that passed through the sample.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology



Literature Review

- Understand the concept of ion exchange.
- Study the effect of Cu^{2+} to environment and health.
- Identify scope of study.

Parameter evaluation

- Initial concentration of metal solution, pH, and resin dosage

Tools/equipments and chemical selection

- Identify and list down all equipments and chemicals needed.

Research design

- List the procedures of the experiment.

Lab work and findings

- Execute the experiment
- Collect and analyze the data.

Summary and conclusion

- Final report preparation.
- Oral presentation on the research.

3.2 Project Methodology

3.2.1. Overview

The experiment started by preparing the model of the wastewater by dissolving CuSO4 with distilled water. Then the process of pre-treatment of the resin take place where the resin is washed using NaOH (1 mol/dm3) followed by HCl (1 mol/dm3) and n-Hexane. Lastly, the resin is rinsed using distilled water.

First experiment will be the study of the effect of resin dose. Five different amounts of resin, 2g, 4g, 6g, 8g, and 10g respectively, are placed in conical flak together with 150 mL of CuSO4 with 1000 ppm concentration. The solution is stirred at 350 rpm for an hour and every 15 minutes, a sample will be withdraw and test the amount of copper ion in the solution. The optimum dose of the resin will be analyzed through the data obtained.

Second experiment which is the effect of initial concentration will require five solution with different concentration; 1000 ppm, 1500 ppm, 2000 ppm, 2500 ppm, and 3000 ppm. An amount of optimum dose of the resin will be placed in the conical flask together with the solution and they are stirred at 350 rpm for an hour. Sample is taken every 15 minutes and the amount of copper ion will be determined.

The effect of pH of the solution will be studied next. Five solutions with pH 3,5,7,9 and 11 respectively will be test to determine which pH is the optimum condition for the ion exchange to take place. The pH is adjusted using 0.1 M HCl and 0.1 M NaOH. The amount of resin and concentration of the solution is based on the previous experiment. Every solution will be stirred at 350 rpm for an hour and a sample is withdrawn every 15 minutes to test for the amount of copper ion.

Each sample is tested using UV-vis Spectrophotometer to find the initial and final concentration of copper ion.

3.2.2 Resin Pretreatment

Prior to use, several steps below must be apply. The steps are:

1. Resins need to be washed by NaOH (1 mol/dm^3) followed by HCl (1 mol/dm^3) and finally *n*-hexane. The purpose of these steps is to remove possible organic and inorganic impurities so that the adsorption process taking place efficiently.
2. Then, resins must be washed with deionised water (DI water) three times to remove the excess chemicals used in Step 1.

Resins need to be dried in vacuum oven at 60°C before it can be used.

3.3 Tools and Materials

3.3.1 Instrument

The copper concentration measurement was carried out using HACH UV-vis Spectrophotometer (model DR 5000). pH meter was used to measure the pH of the solution. Conductivity meter was used to quantify the total ion content in the liquid.

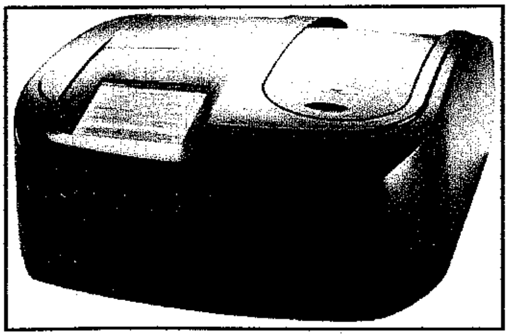


Figure 2: HACH UV-vis spectrophotometer (model DR 5000)

3.3.2 Materials

i. Resin

Synthetic resin was used in experimental studies. Cation resin used in this experiment is Lewatit S1467, produced by Lanxess. The resin is in Na^+ ionic form and was from sulfonic acid functional group. The resin is light brown, gel type beads that have crosslinked polystyrene matric. Anion resin is a strongly basic anion exchange resin with pale yellow translucent beds. The resin is based on crosslinked polystyrene and contains Chloride (Cl^-) ionic form.

Table 2: Physical and Chemical Properties

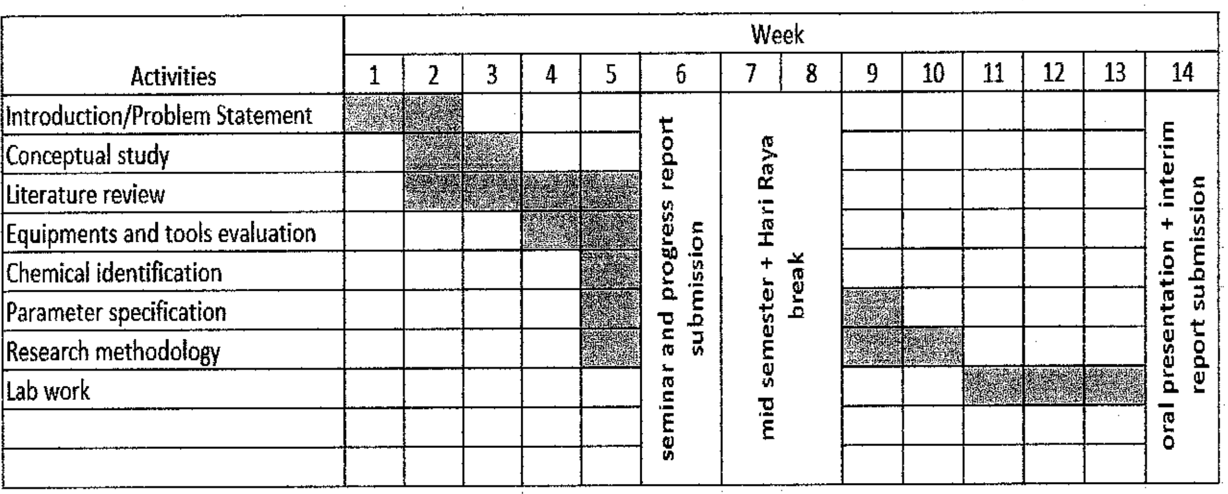
	Lewatit S 1467	**Amberlite IRA 402**
Total Capacity	2.0 eq/L	1.3 eq/L
Mean Bead Size	0.60 mm	0.60 mm
Maximum Swelling	8% (Na^+ to H^+)	30%(Cl^- to OH^-)
Bulk Density	8.20 g/l	670 g/l

ii. Chemicals

Copper (II) sulfate ($CuSO_4.5H_2O$) made by Bendosen was used to prepare the model of wastewater. As for pretreatment process of the resin, Hydrochloric Acid (HCl) manufactured by JT Backer, n-Hexane manufactured by Merck Chemical and Sodium Hydroxide produced by R&M Chemicals were used.

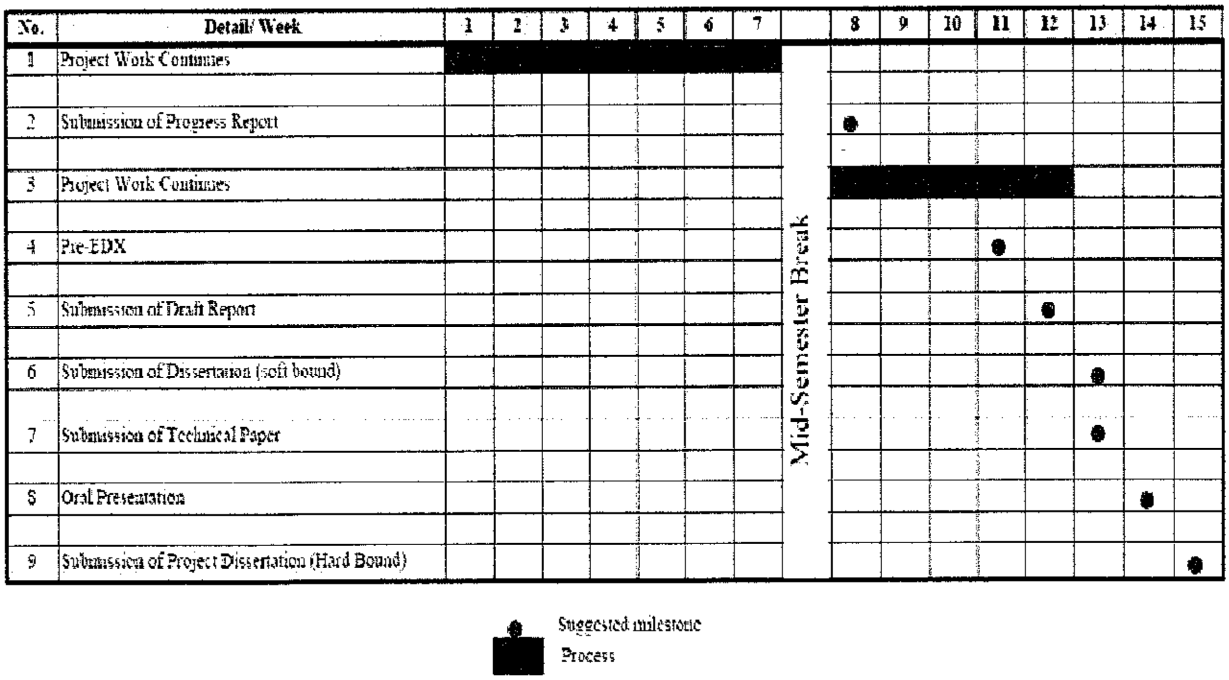
3.4 Key Milestone/Gantt Chart

This project is divided into two parts and completed in Two Semester period. The research work is done in Final Year Project I, while the experimental work is been carried out in Final Year Project II. At the end of the project, the parameters will be verified accordingly and the results will be studied and analyzed thoroughly. Gantt chart for both parts are shown in figure below.



Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Introduction/Problem Statement	▨	▨				seminar and progress report submission	mid semester + Hari Raya break							oral presentation + interim report submission
Conceptual study		▨	▨											
Literature review		▨	▨	▨	▨									
Equipments and tools evaluation				▨	▨									
Chemical identification					▨									
Parameter specification					▨				▨					
Research methodology					▨				▨	▨				
Lab work											▨	▨	▨	

Figure 3: Gantt chart for Final Year Project I (July 2010)



No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Project Work Continues	■	■	■	■	■	■	■	Mid-Semester Break								
2	Submission of Progress Report									●							
3	Project Work Continues									■	■	■	■	■			
4	Pre-EDX												●				
5	Submission of Draft Report													●			
6	Submission of Dissertation (soft bound)														●		
7	Submission of Technical Paper														●		
8	Oral Presentation															●	
9	Submission of Project Dissertation (Hard Bound)																●

● Suggested milestone
■ Process

Figure 4: Gantt chart for Final Year Project II (May 2011)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Effect of Resin Dosage

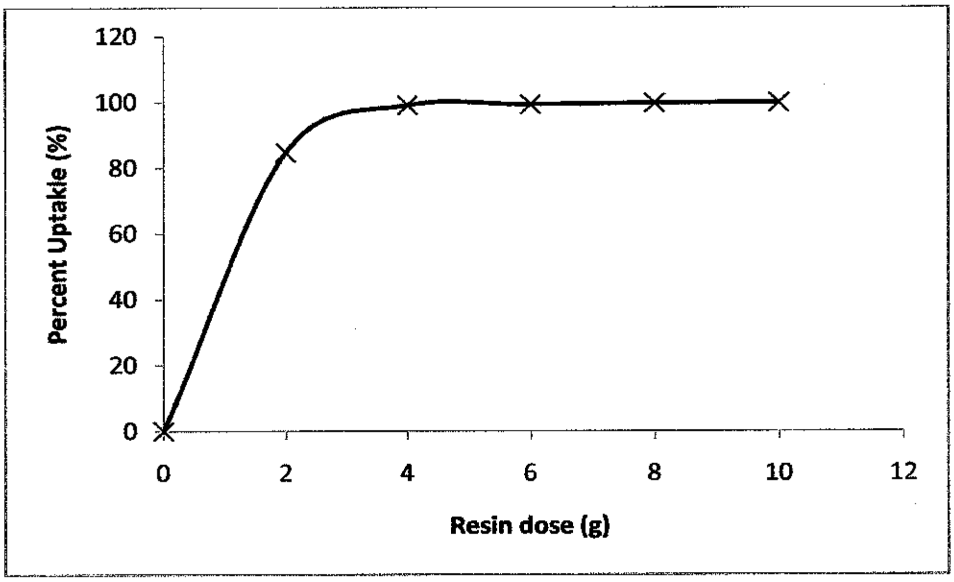


Figure 3: Effect of resin dose on the removal of copper by ion exchange resin Lewatit S 1467

Figure 3 represents the removal of Cu^{2+} as a function of resin dosage by Lewatit S 1467. Resin dosage was varied by 2.0 to 10.0 g and equilibrated for 1 hour. Increasing resin dosage increased the percent removal of Cu^{2+}. It shows that for the quantitative removal of Cu2+ from 150 ml solution containing 1000 ppm of Cu^{2+}, a minimum dosage of 4 g/150 ml of Lewatit S 1467 is required for the maximum removal of Cu^{2+}. The result also clearly indicates the removal efficiency increases up to the optimum dosage beyond which the removal efficiency has no change with the resin dosage. It may be concluded that by increasing the resin dose the removal efficiency increases but metal exchange density decreases. The decrease in metal exchange density can be attributed to the fact that some of the metal exchange sites remain unsaturated during the ion exchange process; whereas the number of available metal exchange site increases by an increase in resin and this result in an increase in removal efficiency [9]. Therefore in the subsequent studies 4 g of resin was used.

4.2 Effect of Initial Metal Concentration

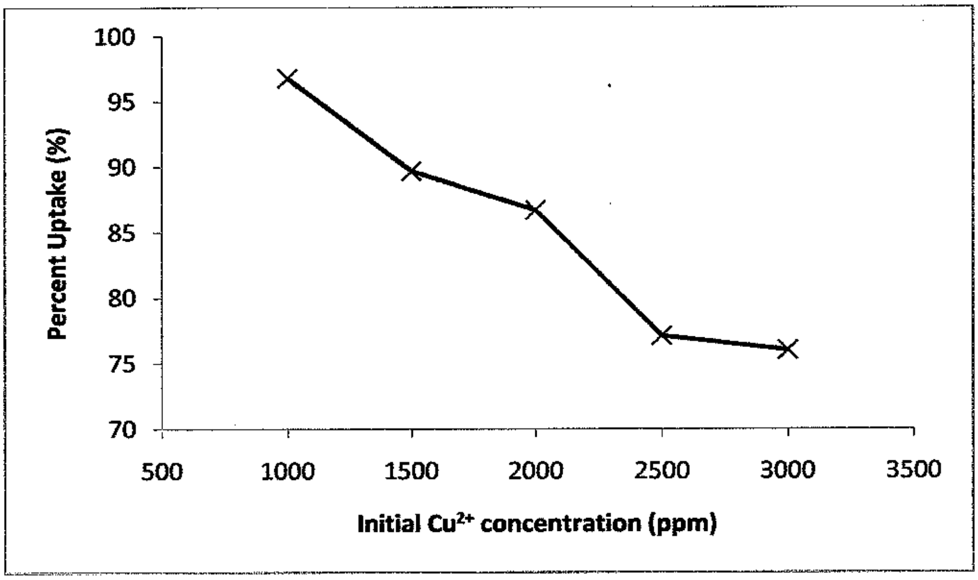


Figure 4: Effect of initial concentration towards the removal of copper by ion exchange resin Lewatit S 1467

The exchange isotherm was obtained as shown in Figure 5. The amount of metal exchanged (q_e) was determined using the relation:

$$q_e = \frac{(C_o - C_e)V}{m}$$

where C_o and C_e is the initial and final concentration of Cu^{2+} , V is the volume of aqueos solution, and m is the mass of resin. In general, relationship between q_e and C_e is important to describe how metals ion interact with the resin and so critical in optimizing the use of resin. From the graph in Figure 5, it is clearly shown that as the initial concentration increase, the exchange capacity also increases. The same pattern of result also shown by L. –C. Lin *et al* [3] [4]. However, Figure 4 shows that the percentage uptake of Cu^{2+} decreasing, as the initial concentration increasing. This might be due to the resin is saturated with Cu^{2+} after 1 hour meanwhile high amount of Cu^{2+} is left in the solution.

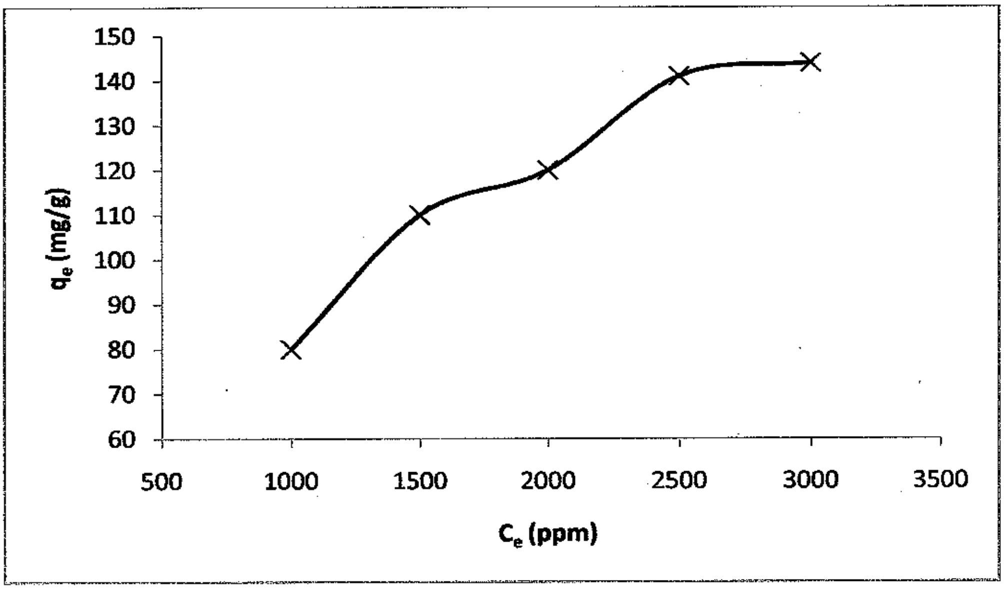


Figure 5: Metal concentration exchange onto resin

In order to optimize the design of a sorption system for the removal of metals from effluents, it is important to establish the most appropriate correlation for the equilibrium curves. Two isotherm equations have been tested in the study: Langmuir and Freundlich Isotherm.

Langmuir equation is given by:

$$q_e = \frac{Q_o b C_e}{1 + b C_e}$$

Where Q_0 is the Langmuir constant for maximum adsorption capacity and b is the Langmuir constant related to rate of adsorption.

Rearrange the equation gives:

$$\frac{C_e}{q_e} = \frac{1}{Q_o b} + \frac{1}{Q_o} C_e$$

As shown in Figure 6, C_e against C_e/q_e is plotted and gives the value of $Q_o = 250$ and $b = 5.01 \times 10^{-4}$

Freundlich proposed that if the concentration of solute in the solution at equilibrium, C_e, is raised to power n, the amount of solute absorbed being q_e, then C_e^n/q_e is a constant at a given temperature. The Freundlich isotherm is derived by assuming a heterogeneous surface with a nonuniform distribution of heat of adsorption over the surface. Hence the empirical equation can be written [9]:

$$q_e = K_F . C_e^n$$

where K_F is the Freundlich constant and n the Freundlich exponent. Therefore a plot of log q_e vs. log C_e enables the constant K_F and exponent n to be determined. Rearrange the above equation will produce:

$$\log q_e = \log K_F + n \log C_e$$

Figure 7 shows log q_e vs. log C_e. Value of K_F from the graph is 1.35 and $n = 0.537$.

The correlation of both Langmuir and Freundlich is 0.971 and 0.966 respectively which shows not much different. Both plot give straight line for all concentration, implies that the ion exchange is well fitted to both isotherm.

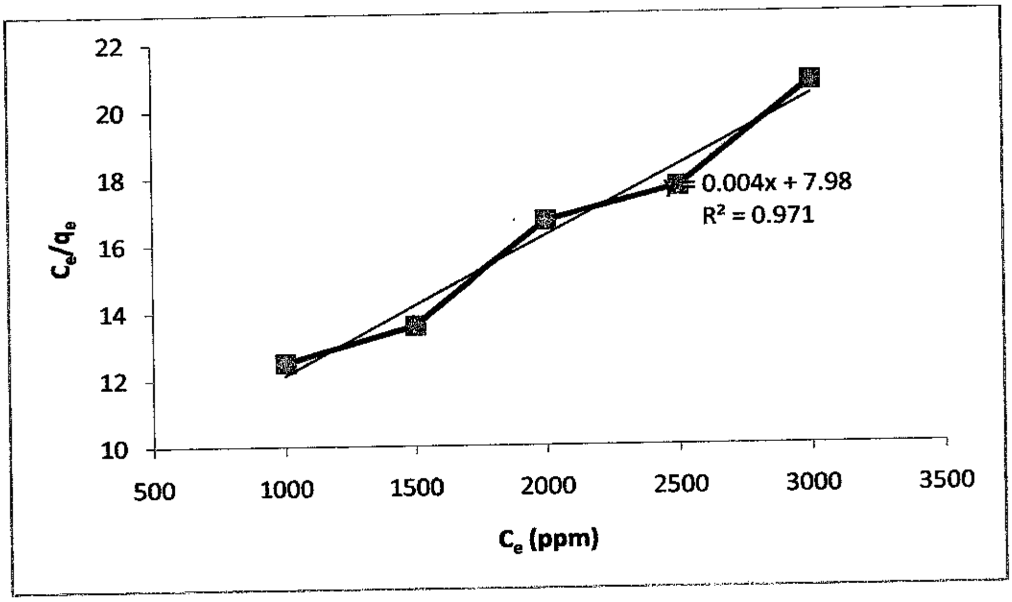


Figure 6: Langmuir Isotherm for removal of copper

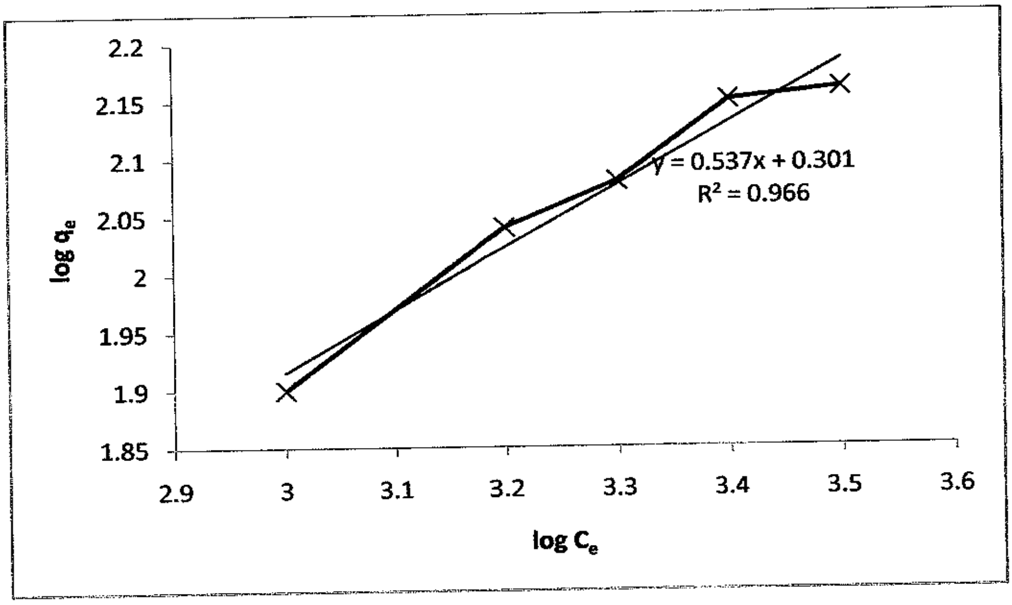


Figure 7: Freundlich Isotherm for the removal of copper

The adsorption isotherm coefficients obtained from the slopes and interscepts of linear plots are listed in Table 3. As shown by R^2 in Table 3, the Langmuir adsorption isotherm provides a better fit to the experimental data of copper compared to Freundlich approach.

Table 3: Summary of isotherm parameters for Cu^{2+} on Lewatit S 1467 ion exchange resin system

Isotherm	Constant		
Langmuir	Q_o (mg/g) 250	b (*l*/mg) $5x10^{-4}$	R^2 0.971
Freundlich	K_F (mg/g) 1.35	n 0.537	R^2 0.966

4.3 Effect of pH

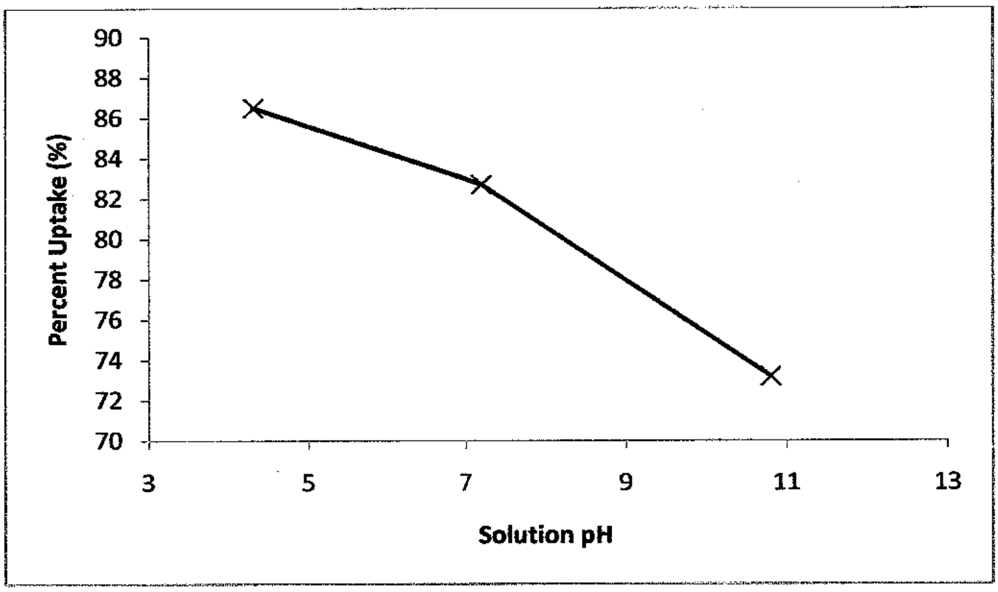


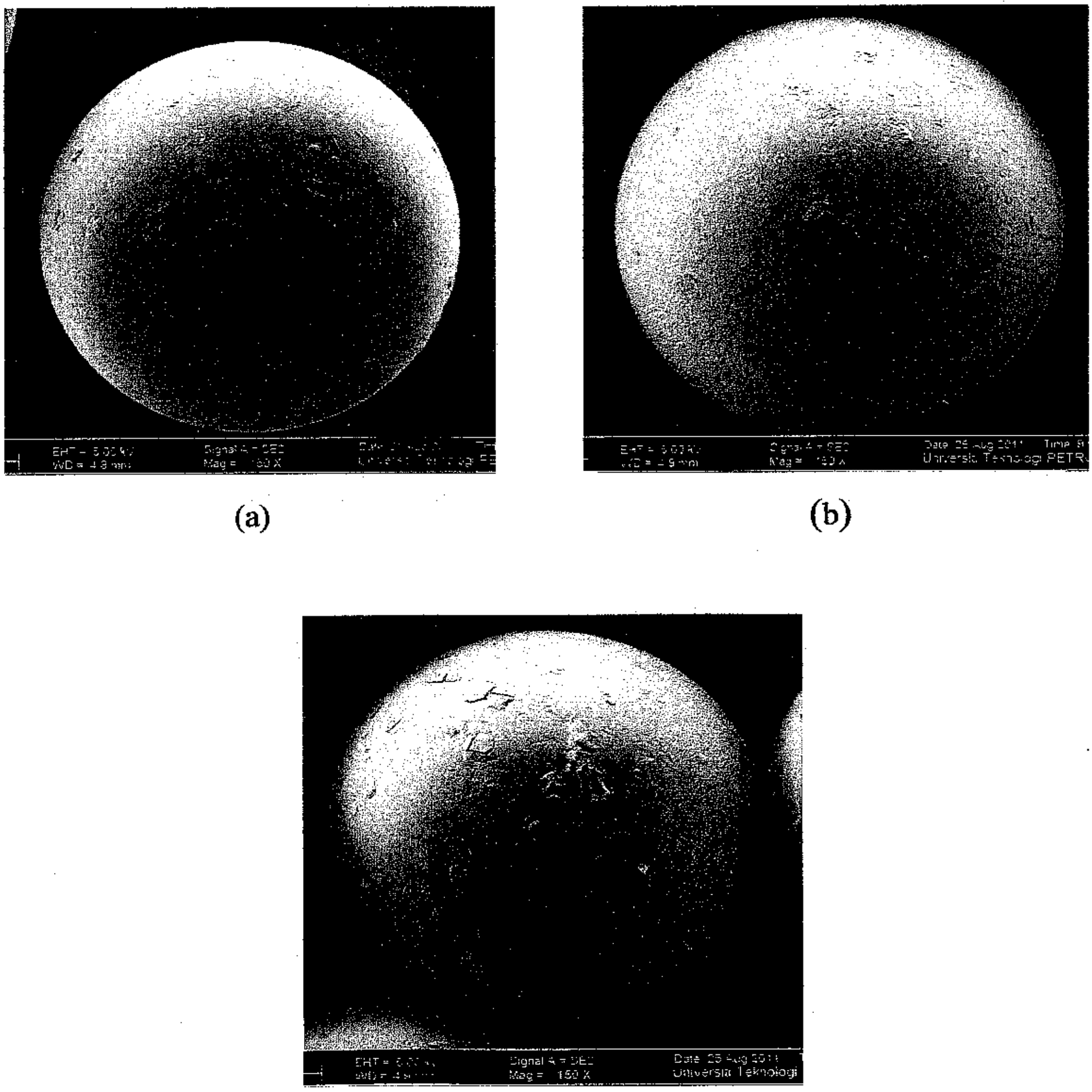
Figure 8: Effect of pH of the solution on the removal of copper ion

The effects of initial pH of the solution on the removal of Cu^{2+} were investigated. pH was varied from 4 to 11 indicates three different conditions of solution: acidic, basic and neutral. It is shown in Figure 8 that percentage uptake by the resin decreases rapidly when pH increased above 7 due to the formation of a copper precipitate at higher pH values [9]. Additional of NaOH to the solution in order to get higher value of pH leads to this condition. The resin is effective for the maximum removal of Cu^{2+} at low pH range (acidic condition).

4.4 Resin Characterization

4.4.1 Analysis of cation resin by SEM

Four samples are taken to be analyzed by Scanning Electron Microscope (SEM) in order to study the surface structure of the resins. The samples are taken from fresh resin, resin after pretreatment and resin after treatment with Cu^{2+} solution.



(a)

(b)

(c)

Figure 9: SEM structure; (a) Fresh resin, (b) Resin after pretreatment, (c) Resin after treatment with Cu^{2+}.

The SEM images in Figure 9 show the different surface structure after resin undergoes different processes. Figure 9 (a) shows the surface of fresh resin which had minimum flakes because no exchange between ions occurred yet. After pretreatment with various chemicals, resin's surface become smoother because the impurities is being wipe out as shown in Figure 9 (b). However Figure 9 (c) shows flakes and cracks appear more visible on the surface of the resin after treatment.

4.4.2 **FTIR Analysis**

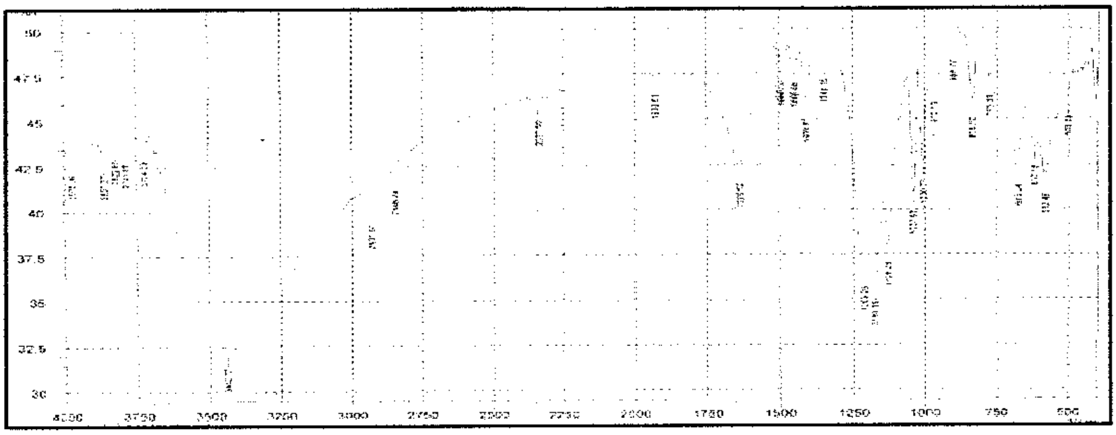


Figure 10: FTIR image for resins before treatment with Cu^{2+} solution

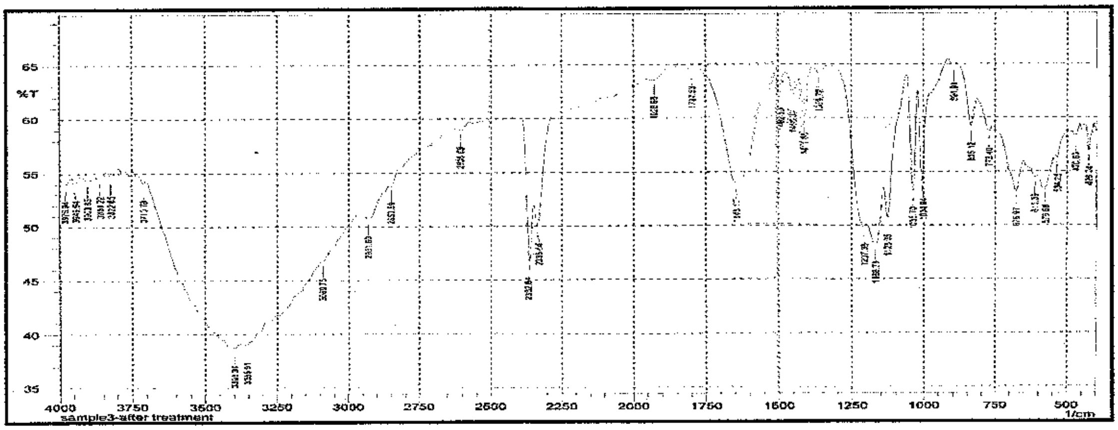


Figure 11: FTIR image for resins after treatment with Cu2+ solution

The preliminary quantitative analysis of the functional group available in the cation resin is determined by using FTIR Spectroscopy for cation before treatment with Cu^{2+} and cation after treatment with Cu^{2+}. FTIR image as shown in Figure10 shows that the broad and intense peak at around 2400 cm^{-1} was referring to OH group due to the present of free hydroxyl group and water in the resin. The band at 2931.60cm^{-1} indicates -CH_2- stretching vibration of acyclic raised by electronegative substituent in the solution from the used of plastic laboratory ware. Peak observed at 1635 cm^{-1} is the stretching vibration of primary amine –N-H- . The peak at 1209.28 indicates there is secondary amide group (N=H) available in the resin.

FTIR spectra of Cu^{2+} loaded resin in Figure 11, shows that a sharp decrease of the peak at the range around 2335.64 cm^{-1} to 2362.63 cm^{-1} which signifies NH_3^+ region. Due to the positive ions present in the resin, the ions have a tendency to exchange with other positive ions available in the solution. Thus, after the wastewater treatment cycle, the concentration of Cu^{2+} in the resin increased as the concentration of NH_3^+ keep on decreasing. The increasing and broad peak at 1800 cm^{-1} indicates the existent of carbonates group (C=O) in the resin. From the figures, the band had shifted from 3440.77, 2931.60, 2337.50, 1635.52 and 1209.28 cm-1 at Figure 10 to 3398.34, 2925.81, 2362.64, 1635.52 and 1215.07 cm-1 at Figure 11. This is due to the existence of predominant contributor for copper uptake in the bonds.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Among the heavy metal removal processes, ion exchange process is very effective to remove various heavy metals and can be easily recovered and reused by regeneration operation. A batch mode experiment is conducted to study the effect of resin dosage, initial metal concentration, and pH towards the removal of Cu^{2+}. Lewatit S 1467 cation resin and wastewater model was used in this study.

The effect of resin dosage is investigated over the range of 2-10g of resin dosage. It is found that 4 g of Lewatit S 1467 is the optimum amount of resin to remove Cu^{2+} from 150 ml of 1000 ppm solution. In subsequent studies, 4 g of resin was used.

From different initial concentration experiments, it shows that initial metal concentration does affect the exchange process. Based on the result, the optimum condition for the Cu^{2+} to be removed by using 4 g of resin is at initial concentration = 1500 ppm. Both Langmuir and Freundlich isotherms fit well with the ion exchange equilibrium data by producing straight line and correlation obtained is 0.971 and 0.966 respectively. However, Langmuir gives a better fit compare to Freundlich.

Besides, acidic condition (pH around 4 to 6) is the optimum pH for the removal of Cu^{2+}. At pH above 7, precipitation forms metal complex which is no longer considered removal via ion exchange process meanwhile at pH less than 2, high competition between H^+ and Cu^{2+} decreased the efficiency of Cu^{2+} removal.

5.2 Recommendation for Future Works

In order to improve the exchange capacity and efficiency of the process, it is suggested to modify the resin so that more space for metal exchange created. Fresh resin can undergo pretreatment process using tetrabutylammonium iodide, methanol and distilled water before they can be used for copper treatment. Other operating parameters such as temperature and contact time should be taken into consideration too.

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APPENDICES

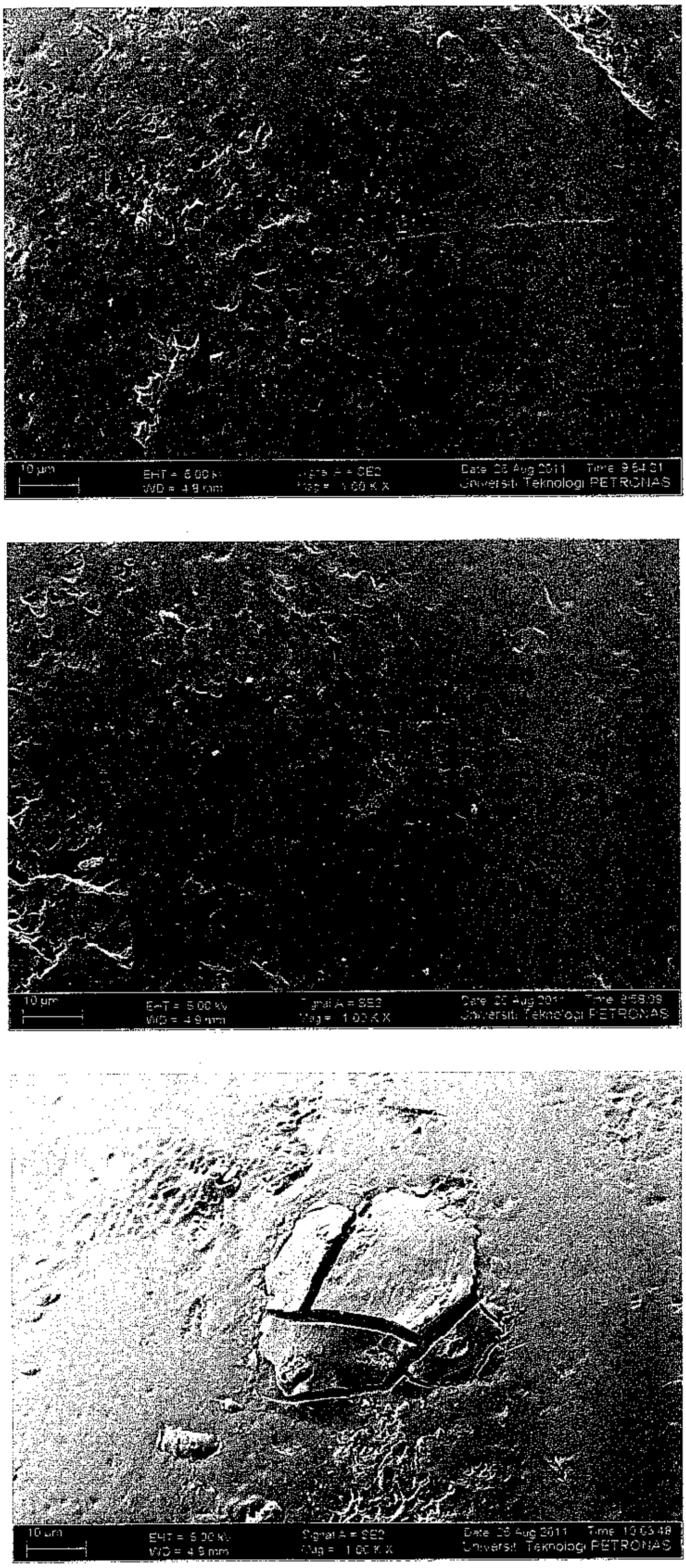

Figure A: Surface comparison between fresh resin (top), resin after pretreatment (middle) and resin after treatment with Cu^{2+}.

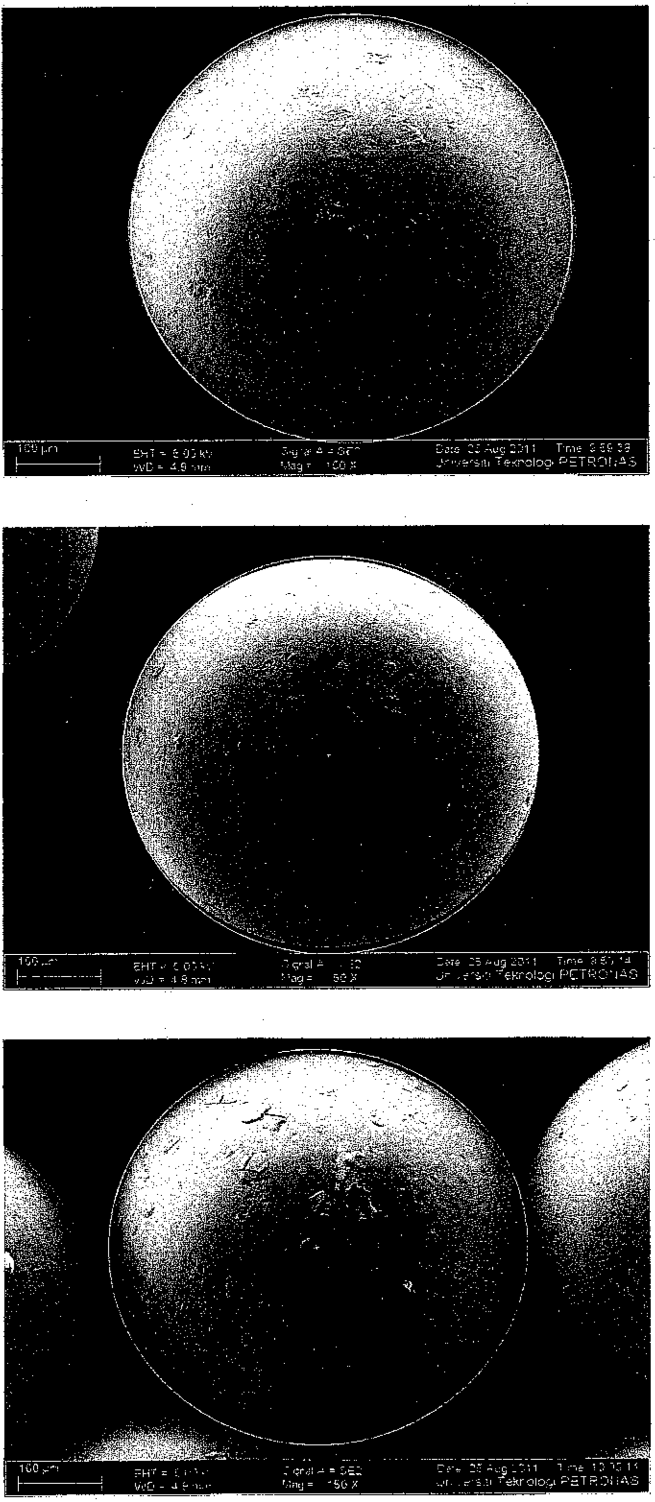

Figure B: Diameter difference between fresh resin (top, diameter = 495.8μm), resin after pretreatment (middle, diameter = 525.7 μm), and resin after treatment with Cu^{2+} (bottom, diameter = 500.3 μm)

Figure B: CuVer 1 Copper Reagent Powder Pillows dissolved in Cu^{2+} solution (purple solution) before being tested using UV-vis spectrophotometer

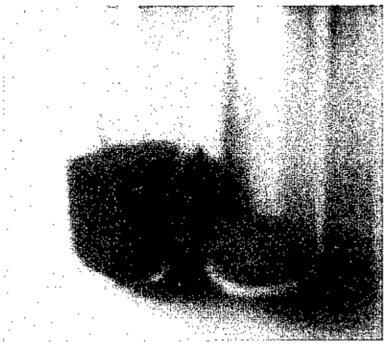

Figure C: Colour differences between resin before (right) and after the treatment (left).

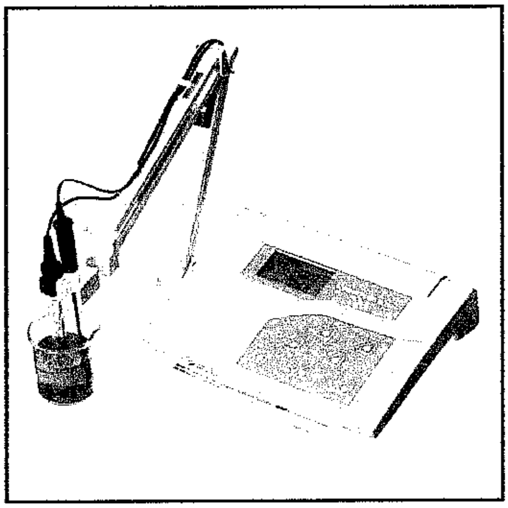

Figure C: Cyberscan pH meter

PRODUCT INFORMATION
LEWATIT® S 1467

LEWATIT
ION EXCHANGE RESINS

Lewatit® S 1467 is a Food grade, strongly acidic cation exchange resin with beads of uniform size (monodisperse) based on a styrene-divinylbenzene copolymer. The monodisperse beads are chemically and osmotically very stable. The optimized kinetics lead to an increased operating capacity compared to ion exchange resins with heterodisperse bead size distribution.

Lewatit® S 1467 is especially applicable for:

- » softening of industrial water
- » softening of drinking water

Lewatit® S 1467 is adding special features to the resin bed:

- » high exchange flow rates during regeneration and loading
- » good utilization of the total capacity
- » low rinse water demand
- » homogeneous throughput of regenerants, water and solutions; therefore a homogeneous working zone
- » nearly linear pressure drop gradient for the whole bed depth; therefore operation with higher bed depth possible

The special properties of this product can only be fully utilized if the technology and process used correspond to the current state-of-the-art. Further advice in this matter can be obtained from Lanxess, Business Unit Ion Exchange Resins.

Edition: 2009-09-29
Previous Edition: 2009-09-04

General Description

Ionic form as shipped	Na^+
Functional group	sulfonic acid
Matrix	crosslinked polystyrene
Structure	gel type beads
Appearance	light brown, translucent

Physical and Chemical Properties

		metric units	
Uniformity Coefficient*		max.	1.1
Mean bead size*		mm	0.60 (+/- 0.05)
Bulk density	(+/- 5 %)	g/l	820
Density		approx. g/ml	1.28
Water retention		wt. %	42 - 48
Total capacity*		min. eq/l	2.0
Volume change	$Na^+ \rightarrow H^+$	max. vol. %	8
Stability	at pH-range		0 - 14
Storability	of the product	max. years	2
Storability	temperature range	°C	-20 - 40

* Specification values subjected to continuous monitoring.

Edition: 2009-09-29
Previous Edition: 2009-09-04

Recommended Operating Conditions*

		metric units	
Operating temperature		max. °C	120
Operating pH-range			0 - 14
Bed depth		min. mm	800
Specific pressure drop	(15 °C)	approx. kPa*h/m²	1.0
Pressure drop		max. kPa	200
Linear velocity	operation	max. m/h	60
Linear velocity	backwash (20 °C)	approx. m/h	10 - 12
Bed expansion	(20 °C, per m/h)	approx. vol. %	4
Freeboard	backwash (extern / intern)	vol. %	60
Regenerant			NaCl
Counter current regeneration	level	approx. g/l	70 - 120
Regenerant	concentration	approx. wt. %	8 - 10
Co current regeneration	level	approx. g/l	200
Linear velocity	regeneration	approx. m/h	5
Linear velocity	rinsing	approx. m/h	5
Rinse water requirement	slow / fast	approx. BV	4

Additional Information & Regulations

Safety precautions

Strong oxidants, e.g. nitric acid, can cause violent reactions if they come into contact with ion exchange resins.

Toxicity

The safety data sheet must be observed. It contains additional data on product description, transport, storage, handling, safety and ecology.

Disposal

In the European Community Ion exchange resins have to be disposed, according to the European waste nomenclature which can be accessed on the internet-site of the European Union.

Storage

It is recommended to store ion exchange resins at temperatures above the freezing point of water under roof in dry conditions without exposure to direct sunlight. If resin should become frozen, it should not be mechanically handled and left to thaw out gradually at ambient temperature. It must be completely thawed before handling or use. No attempt should be made to accelerate the thawing process.

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This document contains important information and must be read in its entirety.

Edition: 2009-09-29
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