Eradicating of Cu^{2+} and Fe^{2+} ions in Single and Binary System Using Microcrystalline Cellulose Extracted from Gossypium Hirsurtum Plant

Mohammad Abdullah, Nur Nazifa Rahmat, Muhammad Afiq Zainal, Mohamad Aiman Hakim Zul'idham

Faculty of Chemical Engineering, UiTM Johor Pasir Gudang Campus, 81750 Masai, Johor, Malaysia

Abstract

In this vast developing world, the presence of heavy metals in water such as river, ocean and lake which were discharged by industrial work arise severe environmental problem especially to human health, water ecosystem and fauna biology. Heavy metals such as copper, iron and others are very dangerous if exposed to the living things thus drinking or inhaling them could brought to very serious acute diseases. Nowadays, most of the wastewater treatment are less effective in treating this contaminant. In this case, to improve the efficiency of water treatment plant, the adsorbent polymer is used to remove copper (II) and iron (II) as heavy metals. The adsorbent used is microcrystalline cellulose which were analysed to get the results on removing both the heavy metals in binary system. The efficiency of the adsorption of microcrystalline cellulose was then assessed on Field Transform Scanning Microscopy (FESEM) to determine the structured morphology due to the adsorption effect. The last result measure the percentage of removal of the adsorbent by using Inductively Coupled Plasma (ICP) as the microcrystalline cellulose is very efficient absorbent in removing copper (II) and iron (II) from aqueous solution. The analysis on Fourier Transform-Infra Red (FT-IR) were assessed to determine the molecular bonding and functional groups in cellulose materials since the cellulose molecules contained different vibration frequencies. The presence of the functional groups in cellulose samples will be record on FTIR. As the adsorption of copper (II) and iron (II) ions into adsorbent is affected by the amount of dosage, the objective is achieved. Thus, the use of microcrystalline cellulose shows a good potential as a adsorbent for removing copper (II) and iron (II).

Keywords: Copper (II); Iron (II); Biosorption; Microcrystalline; Cellulose; Binary System

1. Introduction

Nowadays, our country having a serious pollution that bringing a lot of heavy problems that can give terrible effect not only to environment and ecosystem, but humans too. There are many type of pollution which can be discovered in Malaysia such as noise pollution, air pollution, and the most critical one is water pollution. All of this bad pollution can give various type of terrible effect towards the environment where it reduces the healthy environment condition. The main causes of water pollution in Malaysia are caused by the rapid industrialization that generated heavy metal contamination such as fossil fuel combustion, smelting and mining activities have intensified the invasion of heavy metal into surface and underground water (Singha & Guleria, 2014).

The general properties of heavy metals are metals with relatively high densities with atomic weight ranging from 63.5g/mol to 200.6g/mol (Srivastava & Majumder, 2008) and atomic density greater than $6g/cm^3$ (Thornton & Ramsey, 1995). Heavy metal are most harmful contaminants that can highly damage human health and other living organisms. Reducing the heavy metals content of wastewater before discharging to the water environment is a best way to handle this main environmental problem. Besides that, heavy metals are consist of iron, copper, cadmium, chromium, mercury, etc. In this study, the heavy metal that were supposed to be remove was copper (II) and iron (II) or known as ferrous ion.

Majority of the heavy metals are essential micronutrients to living organisms. However, higher concentrations of heavy metals can cause negative effects to human health and aquatic life. For an instance, when human are being exposed to high amount of copper for a short period of time, stomach and intestinal problem occur and for the long term exposure, it leads to kidney and liver damage (Amoyaw, 2008). In addition, when there is too much iron in the human body, it can damage the liver and the heart and also lead to another diseases such as diabetes and arthritis. Industries that discharge copper (II) are mining, electronics, chemical and metallurgical industries, where they discharge copper (II) waste in leachate at landfill. Meanwhile, the occurrence of iron in water can also have an industrial origin; mining, iron and steel industry, metals corrosion and many more (Gupta & Bhattacharyya, 2012).

There are many method had been found and introduced for the removal of heavy metal such as electrochemical treatment, chemical precipitation, membrane filtration, oxidation, reverse osmosis, flotation and adsorption and many more (Titi & Bello, 2015). Among of them, adsorption is the efficient method in the removing of heavy metal ions since it is low concentration of metal uptake and economically feasible properties. Adsorption is a very significantly economic, convenient and easy operation technique. It shows high metal removal efficiency and is applied as a quick method for all types of wastewater treatments (Saravanan & Ravikumar, 2015).

Due to the previous reason, using an adsorbent to adsorb the heavy metal is used to compare and determine whether it is suitable for adsorption purpose. Finally, absorbent has been used to adsorb the heavy metal to compare and determine whether it is suitable for adsorption purpose or not. Cellulosic materials are low cost and widely used, and very promising for the future. These are available in abundant quantity, cheap and have low or little economic value. Different forms of cellulosic materials are used as adsorbents such as fibres, leaves, roots, shells, barks, husks, stems and seed as well as other parts too. Natural and modified types of cellulosic materials are used in different metal detoxifications in water and wastewater. In this experiment, the adsorbent being used is a ready made cellulose extracted from Gossipium Hisurtum Plant. Therefore, microcrystalline cellulose are investigated to identify the suitability of being an adsorbent for the purpose of removing metal ions in the single batch solution and binary solution. The purpose for the binary solution because waste water that discharge from the industrial contains many type of heavy metal ions.

2. Methodology

2.1 Inductively Coupled Plasma (ICP)

Adsorption experiment were conducted by preparing 6 samples of 100mL of dilute copper (II) sulphate with 10 part per million (ppm) and 6 samples of 100mL of dilute iron (II) sulphate with 10 part per million (ppm) respectively. Each of the diluted sample of copper (II) sulphate was mixed with the diluted sample of iron (II) sulphate in order to produce a 200mL of binary solution respectively. The 0.2g, 0.4g, 0.6g, 0.8g, 1.0g and 1.2g of cellulose microcrystalline was placed into each sample and were left in the laboratory for about 1 day under room temperature. The suspension was filtered and inductively coupled plasma (ICP) was used to analyse the before and after adsorption of the adsorbent. This step was repeated by using 6 samples of 200mL of dilute copper (II) sulphate with 10ppm and 6 samples of 200mL of dilute iron (II) sulphate with 1 0ppm respectively in order to produce a primary solution.

2.2 Field Emission Scanning Electron Microscopy (FESEM)

The sample were coated with Au film 60 second prior to analysis. Observation of the sample of Cellulose Microcrystalline before and after adsorption of Cu^{2+} and Fe^{2+} ions was made using FESEM in magnification range of 1,000 X to 2,500 X. The experiment was conducted at Faculty of Mechanical Engineering Universiti Teknologi Malaysia (UTM), Skudai.

2.3 Fourier Transform Infra Red (FTIR) Spectroscopy

FTIR analysis can determine the molecular bonding and functional groups in the adsorbent which is microcrystalline cellulose. The presence of the functional groups in cellulose samples were recorded on FTIR (BRUKER, VERTEX 70) in the range limit 650-4500 cm^{-1}. The analysis was performed in room temperature with same condition.

3. Results and discussion

3.1 Inductively Coupled Plasma (ICP)

In the adsorption process of heavy metals, in order to gain the information on the most optimum condition for an adsorbent to work, several parameters have to be considered which is dosage, pH, temperature, concentration (ppm). Thus, ICP is conducted to prove this claim and to see the optimization of Microcrystalline Cellulose.

3.1.1 Effect of Dosage

Dosage of adsorbent plays an important part in adsorption, specifically in removing heavy metals. Dosage of adsorbent are varied from 0.2g, 0.4g, 0.6g, 1.0g and 1.2 g, under the condition of room temperature in the range of 25-27°C, into aqueous solution containing copper (II) ion and iron (II) ion. The removal of copper (II) ion and iron (II) ion increased as the dosage increased.

There is a significant rise of percentage removal using copper (II) ion between the dosage of 0.2g and 0.4g, 0.6g and 1.0g, and lastly between 1.0g and 1.2g which are 76.96%, 89.56% and 96.47% respectively. If iron (II) ion is being used, the percentage of each samples are in an average reading. However, the initial dosage between 0.2g and 0.4g, which is 72.16%, is slightly higher compared to other samples with an average reading of 66.25%. In the binary system, it is clearly shown that the results are almost equivalent to those copper (II) ion and iron (II) ion. Next, some observation had been conducted at which, as the dosage increase in both single and binary solution, the amount of percentage removal also increase except for iron (II) ion. This shows that the reading of cu (II) ion is unlikely to be unadsorbed. Equation that we used as shown in Equation 1 is to discover the percentage removal of the heavy metals.

Based on the previous study, by using polyethylene glycol and polyvinyl alcohol polymers (Al-Hwaiti & Salem, 2015), it shows the same result in terms of dosage where the removal percentage gradually shows increasing in value as the dosage increase.

$$Qe = \frac{Initial - Final}{Initial} x\ 100\% \qquad \textbf{- Equation 1}$$

Table 1: Initial, final dosage and the percentage of removal, Q_e of Cu^{2+} ion

Initial Dosage (g)	Final Readings of Solid (g)	Removal of Concentration,Qe (%)
0.2	0.00011520	76.96
0.4	0.00010060	79.88
0.6	0.00009485	81.03
1.0	0.00005220	89.56
1.2	0.00001765	96.47

*Initial Reading of Solid at 0.0g of dosage = 0.0005 g

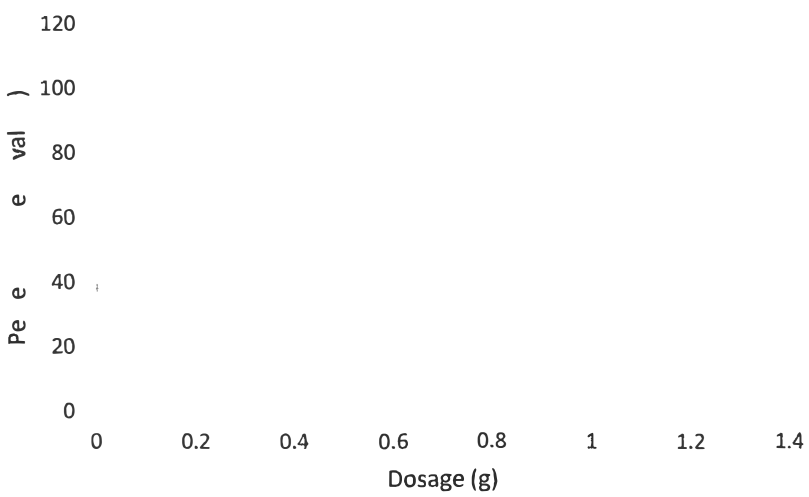

Figure 1: Percentage Removal against Dosage of Cu^{2+} ion

Table 2: Initial, final dosage and the percentage of removal, Q_e of Fe^{2+} ion

Initial Dosa e	Final Readin of Solid (	Removal of Concentration,Qe (%
0.2	0.0001467	72.16
0.4	0.0001831	65.25
0.6	0.0001827	65.33
0.8	0.0001847	64.95
1.0	0.0001663	68.44
1.2	0.0001725	67.27

***Initial Reading of Solid at 0.0g of dosage = 0.0005270 g**

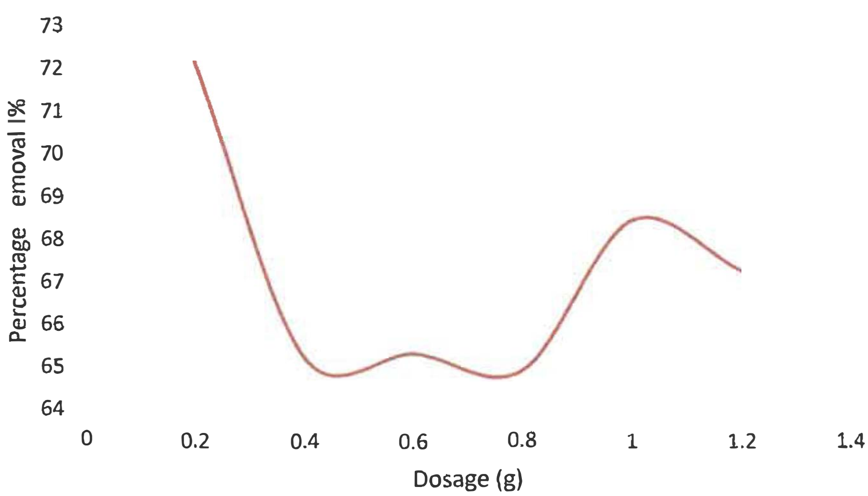

Figure 2: Percentage Removal against Dosage of Fe^{2+} ion

Table 3: Initial, final dosage and the percentage of removal, Q_e of Cu^{2+} ion in Binary Solution

Initial Dosage (	Final Reading of Solid (g)	Removal of Concentration Qe (%
0.2	0.00011770	76.46
0.4	0.00037400	72.60
0.6	0.00011180	77.60
0.8	0.00006560	86.88
1.0	0.00002525	94.94
1.2	0.00001900	96.20

*Initial Reading of Solid at 0.0g of dosage: 0.0005 g

Table 4: Initial, final dosage and the percentage of removal, Q_e of Fe^{2+} ion in Binary Solution

Initial Dosage (g)	Final Reading of Solid (g)	Removal of Concentration Qe (%)
0.2	0.000041000	91.80
0.4	0.000096800	80.60
0.6	0.000064850	87.02
0.8	0.000075495	84.90
1.0	0.000028100	94.38
1.2	0.000018200	96.36

*Initial Reading of Solid at 0.0g of dosage: 0.0005 g

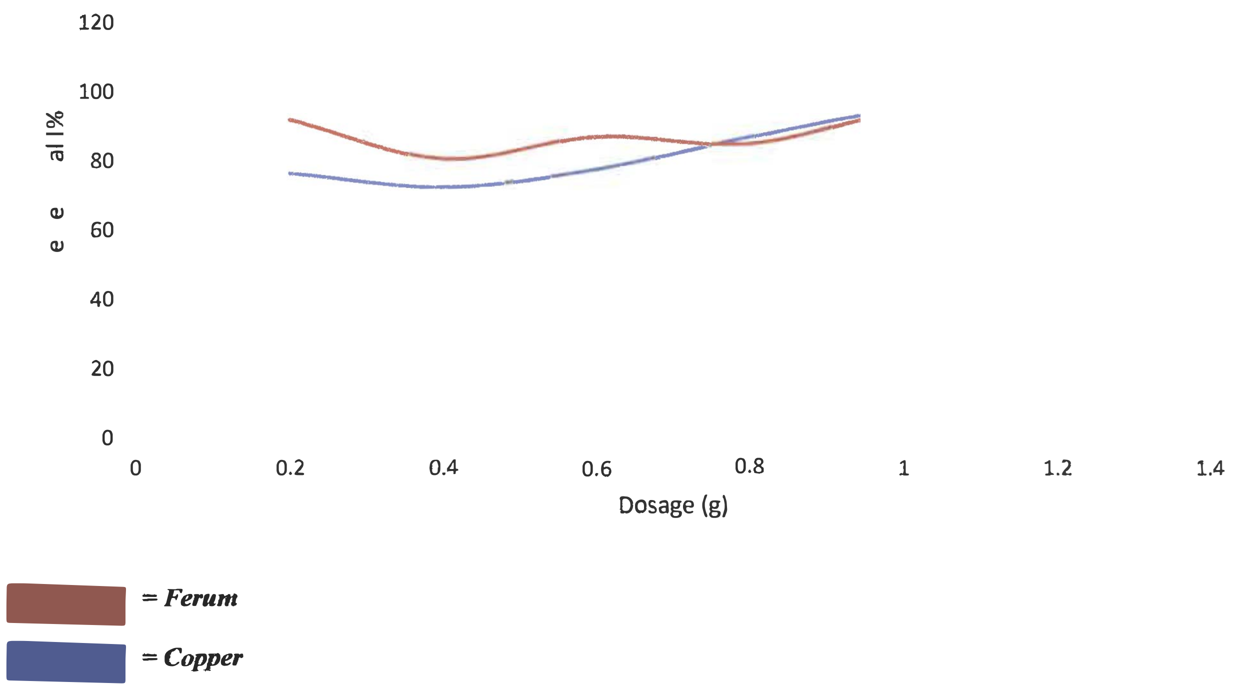

Figure 3: Percentage Removal against dosage of and cu^{2+} ion fe^{2+} ion in binary solution