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FEASIBILITY STUDY OF PCB MOBILES PHONES AND RECYCLING THROUGH MANUALDISMANTLING AND HYDROMETALLURGICAL METHOD

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ABSTRACT

Mobile phones and batteries have relatively short life cycle and quickly seen as outdated by consumers, especially teenagers. It is not easy to dispose or discard in everywhere because mobile phones and battery have a range of hazardous and precious metals which are lead, copper and precious metals such as gold, silver, aluminum, copper and others. This study was to investigate the rate of solution hazardous metals and from PCB mobile phone and batteries using hydrometallurgical methods. Hydrometallurgical method is the method used by the process of dissolution of metal with a sample to be tested must be separated between metal and non-metal materials. Leaching processes is a major step in the hydrometallurgical method. The solution has been taken should be analyzed using laboratory equipment which is ICP to determine the total concentration of hazardous metals. Findings of this study is the total concentration of hazardous metals contained in the highest sample is Lead. The hazardous metals lead and copper have many negative impact to the human body. So, everyone should have an awareness to ensure the proper disposal method for each component of electrical and electronic equipment such as mobile phones.

Keywords: mobile phones, hazardous metals, hydrometallurgical, dissolution, leaching.

INTRODUCTION

Every year, we can see significant progress and prosperity that can be enjoyed by the citizens along with population growth. The use electrical and electronic equipment is increasing. In fact, the creation of electrical and electronic products has various additional functions to provide convenience to the user. In 2008, the Department of the Environment has issued a guideline on e-waste, titled and quot; Guidelines for the Classification of Used Electrical and Electronic Equipment in Malaysia and quot; and at the international level, Malaysia has joined the Basel Convention Movement Control and Disposal of Hazardous Materials Across 1989. In this convention, e-waste has been listed as A1180 and the A210 in the bottom of the list An in Annex VIII [1]. E-waste is a general term referring to the electronic product waste that comes from electrical and electronic equipment that is no longer usable and it needs to dispose [2]. Scheduled waste is waste that can endanger human health, environmental damage that require specific disposal method. Value of common metal contained in the e-waste is very high at 1 tone e-waste contains up to 0.2 tons of copper, which can be sold at a price of 500 euro according to the current world market prices [2]. Mobile phone is type two way communication tool between the listener and the receiver to communicate and receive information between each other. Despite having an important function, structure and composition of the material inside is too complicated [3]. Mobile phone and the battery has a metal content of the main components hazardous such as lead, copper (9g), while other precious metals such as silver is (250mg), gold (24mg) and palladium (9mg) [4]. In a mobile phones, there are several components of which are printed circuit board (PCB), liquid crystal display (LCD), batteries, plastic casing and other components such as antenna, loudspeaker and keypad [5]. PCB usually made of copper soldered on the board by using protective coatings and adhesives. Board is made of fiberglass and coated with gold plating. Among other hazardous metals contained in the PCB is arsenic, cadmium and lead. LCD have liquid crystal is embedded between layers of glass and transistors for lighting and electrical charge. Liquid crystal materials containing toxic substances such as mercury. The battery is a combination of cells or more electrochemical cells, used to convert stored chemical energy to produce electricity. It is an important component in mobile phones. If you look on a battery it has two poles positive terminal and a negative terminal. Battery divided into two types such as primary battery and secondary battery. There are hazardous metals and also various precious metals in e-waste. To obtain precious metals from e-waste such as PCB, one method that can be used by using hydrometallurgical methods. Nowadays, recycling technology can use two methods, which enhance the metal content by pre-treatment mechanical methods and also electrometallurgy or pyrometallurgy methods. However, through the process of pyrometallurgy, also known as conventional methods it is difficult to get back some metals such as aluminum and iron [6]. In our previous study, the re-utilization of industrial waste had been investigated [7-9]. Thus, the current study is to investigate the recycling process of E-waste through the manual dismantling process and hydrometallurgical process.

EXPERIMENT PROCEDURE

Figure-1 shows the waste mobile phone used in the study. It is a common mobile phone that can be easily found at home or mobile phone shops. The mobile phones were manually dismantled and the time required to dismantle all parts was measured. The dismantled parts were then categorized into ferrous, non-ferrous and plastic parts. For this experiment is to investigate the leaching behavior of PCB mobile phone. Then, in order to investigate the leaching behavior of the PCB, the PCB were collected from several numbers of mobile phones and the leaching test of the PCB was conducted. The leaching test of the PCB was carried out according to Figure-2. The parameters of the leaching test are shown in Table-1.

Figure-1. Mobile phone used.

The ratio between samples and leachant is 1:100. 10g samples were inserted into glass beaker and then the leachant which is rain water with the pH adjusted to be 6.0. After that, adjust the rotational speed of 100 rpm. The test was conducted in ambient air. 50 mlliquid samples were collected every 1, 3, 6, 12, 24 and 48 hours by syringe and filtered by filter paper. When finished the leaching process, samples of water should be analyzed contents by using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

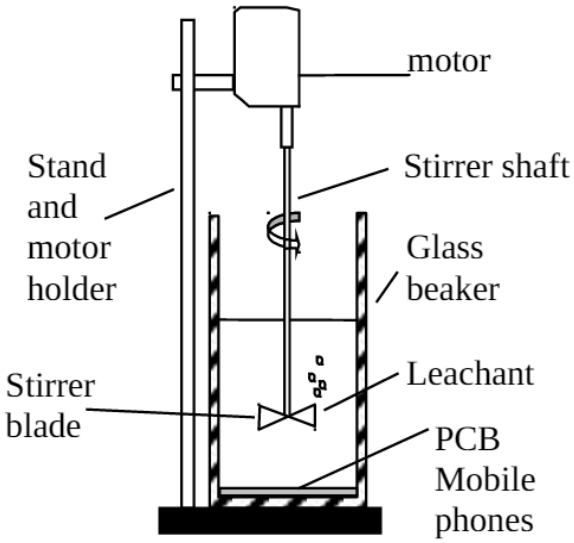

Figure-2. Schematic of the leaching test.

Table-1. Parameters of leaching test.

Leaching Time (Hours)	**1, 3, 6, 12, 2 and 48**
pH	4 and 6

RESULTS AND DISCUSSIONS

Dismantling process of mobile phones

Figure-3 shows the dismantling process of mobile phones. The dismantling process was conducted manually using screw driver. The sequences of dismantling processes are as follows: (a) Rear housing (b) Battery and rear housing (c) Front housing and frame(d) Screw and frame (e) Others (f) Keypad housing and LCD. Time required for each processes is shown in Table-2. The total time required to dismantle all components is about 458 seconds or 8minutes. The process that required longest time is the process to separate the screw and from the body or frame. If this process can be simplified, the overall dismantling time can be reduced and it can ease the recycling process. After that, the components weight must be compute for every part are shown in Table-3. There are three types of parts consisted in the mobile phones such as printed circuit board, batteries, liquid cyristal display and others as shown in Figure-4. The weight contributions of each type of parts are 14.9 g, 21.2 g, 9.3 g and 44g respectively. Then, the PCB from the mobile phone that want use for leaching test must be crushed for obtain the smaller size according to Figure-5.

Table-2. Time required for the dismantling process.

Process	**(a)**	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**Total**
Time (s)	1	3	32	120	62	240	458

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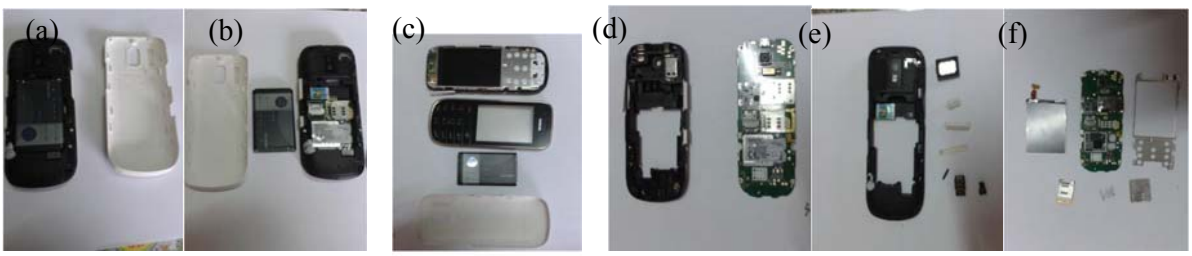

Figure-3. Dismantling process of mobile phones.

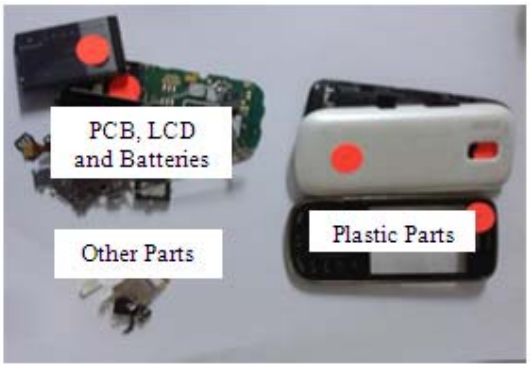

Figure-4. Dismantled parts by type.

Table-3. Weight of mobile phone components.

Type	Weight (g)
Printed Circuit Board	14.9
Batteries	21.2
Liquid Crystal Display	9.3
Others	44
Total	89.4

Figure-5. Sample of the PCB.

Characterization of the PCB

Table-4 shows the material composition in that have in the PCB. A typical PCB composition is 30% plastics, 30% refractory oxides and 40% metals. The most abundant metal is copper with a concentration between 10% and 30%. Metal compositions in PCBs are deference according to the manufacturer and the year of its manufacturing and technology [10].

Table-4. Material composition [10]

Element	Composition
Cu	10-26.8 (%)
Pb	0.99-4.19 (%)
Zn	0.16-2.17 (%)
Au	80-1,000
Au	110-3,301
Pt	.6-30 (g/t)
Pd	10-29 (g/t)

Leaching behavior of waste mobile phone PCB

Figure-6(a) shows the change in pH during the leaching test for rain water with rotational speed 100RPM. The initial pH was 6 and it increased as the leaching started and continuously increased up to 7.2 at the end of the leaching test. Figure-6(b) the change of pH versus time leaching process with different speed of 100RPM and 300 RPM. At a speed of100RPM, the pH value reaches the highest value is within the 48 hour is 7.2. For the last speed of300RPM, the pH recorded the highest number is 7.2 also within 48 hours. Looking on the trends of pH changes for both cases, it is expected that by prolonging the leaching time, the final pH would be increased.

Figure-6(c) shows the dissolved concentration of PCB during the leaching test. Pb shows the highest dissolved concentration during the initial stage of leaching. However, it gradually decreased after 12hours of leaching and increased and gets the highest concentration leaching test after 24 hours. The dissolution of Pb was more high in the early stage of leaching before decreased and increased afterward. The concentrations for Mn and Cr were very low throughout overall leaching test. Figure-6(d) shows the behavior of dissolved concentration of each element with changes in pH of the leachant. Pb are decreased until pH 6.6 and after that increased after pH 7.2. On the other hand, concentration of Mn and Cr were very low even with the increasing pH. It can be concluded that there is a high potential of recycling of waste PCB mobile phone by utilizing the leaching test and hydrometallurgical method. However, more effort has to be putted on reducing the dismantling time of the PCB.

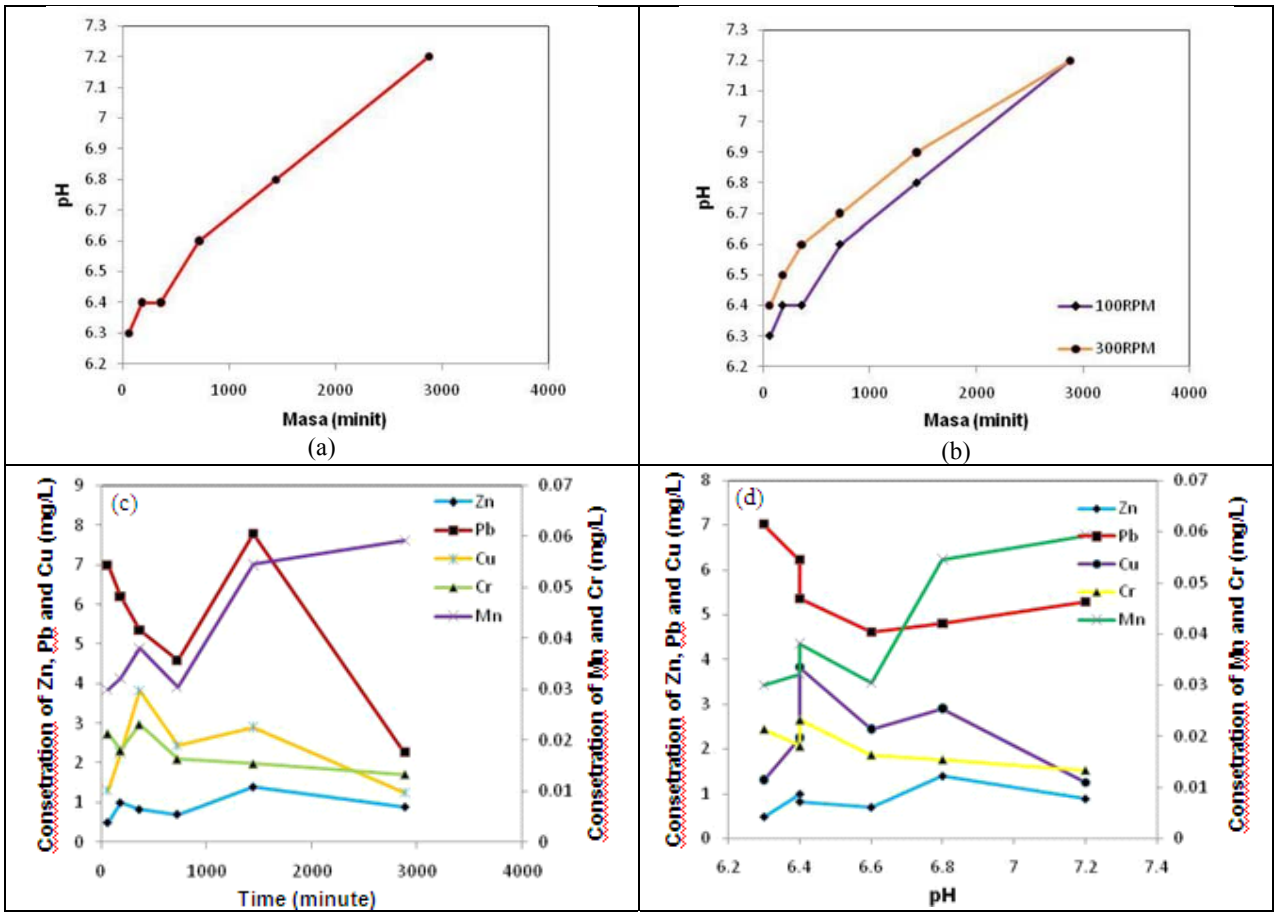

Figure-6. pH changes and dissolution behavior of main elements during the leaching test.

CONCLUSIONS

Overall this study was to investigate to investigate the dismantling processes and dissolution behavior of the waste. As we know, the waste of e-waste does have various hazardous metals that will bring negative impacts to the environment and the worst to human health. It was found that the longest dismantling time was contributed by the dismantling of armature windings. More efficient recycling technique can be achieved by reducing the dismantling time especially when it involved huge amount of PCB mobile phones. Dissolution of each main element in the PCB mobile phones was observed and it has affected to the increase of pH. The increase of pH has then led to the reduction of Pb concentration. Dissolved concentration of Pb must be controlled to ensure that it does not exceed the permissible amount.

ACKNOWLEDGEMENTS

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