Eco-friendly Recycling Technology Applied to Malaysia's Electronic Waste

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This study provides a method that how to recycle the precious metal from electronic wastes by using eco-friendly SnST-550A Tin stripper and UW-860 Gold stripper in Malaysia. By comparing with traditional methods of precious metal's recovery, the green process is a fast and safe way to de-solder and take off the components from boards without damaged the substrate. After purification process, more than 99.99% pure gold can be collected. The most important is, this method provides a safer, no pollution way to recover gold than using aqua regia or cyanide. It achieves the goal of environment protection and circular economy.

Keywords: Malaysia, Urban mining, E-waste, Gold stripping, Tin stripping, Circular economy

1. Introduction

Malaysia is a country located in Southeast Asia, having an excellent geographical location with no natural disasters and locating on the important routes of waterways and airways of Southeast Asia. Malaysia is the third largest economy among the 10 ASEAN countries, follow on the heels of Indonesia and Thailand, having a higher economic growing rate than the global level for the past 10 years. According to the 2017/2018 Economic Report by the Finance Ministry of Malaysia, manufacturing industry of the country is expected to grow by 5.3% for the year, and the stable demand of electronics and electrical appliances, refined petroleum and wood products give impetus to the exportation activities in Malaysia. So far in 2017, electronic and electrical appliances are the major importation and exportation product of Malaysia, showing its importance to the country's economy. With the increasing popularity of electronic appliances in this era, electronic waste in Malaysia increasing rapidly too. Unfortunately, most Malaysian do not know how the recyclers do to dispose electronic wastes. They would think that they are doing the right thing to protect the environment as long as they did not throw the wastes anywhere and give them to the recyclers. They never investigate, or more accurately, they never know that these recyclers are probably illegal. Most of them do not know that only legal recyclers used formal and safe methods to dispose the wastes. If this kind of waste does not dispose by correct ways, it will release harmful substances and damage both the environment and human being. Therefore, this issue should get all Malaysians' concern to ensure that the country is clean and safe to live.

According to the Department of Statistics Malaysia (DOSM)'s statistics report, 97.7% Malaysian are the phone users and 69.8% Malaysian are the computer users [1], while the report of Department of Environment (DOE) shows that cell phone batteries are Malaysia's largest electronic wastes in year 2010 to 2020, follow by cell phones and laptops [2]. The maturation of smart phones technology nowadays causes a huge amount of smart phones with different features and prices being produce, which means that everyone can effort one of it. However, this is causing the average service life of the smart phones decrease to about two years because it is easy to displace. People change their phone mostly because of the problem of lagging after the mobile phone has been used for a long time, while some users are looking for better performance on camera shooting, gaming fluency or memory capacity. Most people would repair their device only if it was being use for less than two years, or they would rather buy a new one. Hence, economy status, device performance and trend would be the reasons of people changing their device. The issue of environment protection would not be the main decision of someone while changing their device since most people have low awareness on defects that electronic wastes will cause. As a result, the amount of electronic wastes increasing day by day.

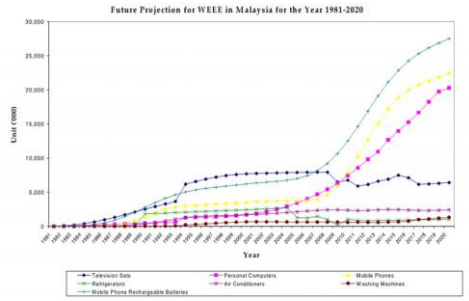

Fig 1: Future projection for WEEE in Malaysia for the year 1981-2020，from "The E-waste Inventory Project in Malaysia"

There are 1 million tonnes of electronic waste every year in Malaysia. Burning and burying are the two main ways to treat the wastes [3]. However, toxic chemical substances and gases will be released if the wastes are treated by improper ways and this will cause serious pollution to the environment. The toxic substances will penetrate into the land or underground water or through the air will damage human's nervous system.

For example, Guiyu, the town that is the largest electronic waste site in China, illegally collecting billion tonnes of scrapped computer, television and electronic application every year since 1980. There are about two hundred thousand people living in this town, while 80% of the villagers of a village located near the wastes burning factory name Meihua, have passed away because of cancer. In the light of this, Malaysian should have more consideration to treat their electronic wastes. Giving the electronic wastes to legal recyclers but not throwing them anywhere or selling them to illegal recyclers would be a good way to prevent serious environmental and health problem in the country.

Urban mining is a concept of recycling precious metals from electronic wastes by using eco-friendly technology. It can prevent the increasing activities of mining and achieve the goal of circular economy for a country. Malaysian communications and multimedia commission (MCMC) promotes concept of urban mining these years by encouraging Malaysian recycle their electronic wastes through the correct way.

According to the report, Malaysia has around 1892 tonnes of scrapped cell phones in 2015. One gram of gold cost about RM159 (or USD40) while one tonne of cell phone wastes contain 400 to 700 grams of gold, which means that Malaysia has at least RM120,000,000 (or USD 30,000,000) of gold could be recycled. Beside of gold, metals such as silver, copper, palladium and tin can be recycled from the e-wastes too.

Fig 2: Precious metals can be refined from scrapped cell phones

Recyclers in Malaysia mostly used aqua regia or cyanide to strip gold and polluted the environment. There are seldom recyclers use legal and complete recycling system to handle the wastes since the cost are higher than the profits, especially the government do not provide any allowance to the recyclers. Besides that, around 70% Malaysian would treat their old mobile phone as a spare device but not to recycle it, this is actually ignoring the valuable resources that can be recycle.

Some Malaysian strive to solve the problem of electronic wastes, however, it does not go well since most Malaysian do not realise the importance of recycling the wastes. Therefore, besides of promoting urban mining, the government can also consult the laws and recycle system executing by other advanced countries, in case to handle the problem of electronic wastes effectively.

Taiwan was once known as Garbage Island. Now, it has an impressive recycling rate of 55%. It firstly sets up the waste management in East Asia and Southeast Asia together with Japan and Republic of Korea, established policies for the manufacturers and importers to take their responsibility. Besides that, Taiwan also provide allowance to recyclers who do the electronic

wastes' recycling (Table 1). This policy could be a reference to Malaysia too.

Item	Allowance （NTD）	Purchase price （NTD）
Discard dry batteries		
Primary Li-ion batteries	139 /kg	18.75-25 /kg
Secondary Li-ion batteries	55/kg	45-50 /kg
Discard electrical and electronic appliances		
Television	284 /unit	30-80 /unit
Washing machine	346.5 /unit	120-270 /unit
Refrigerator	635.5 /unit	240-460 /unit
Air-conditioner /Heater	500 /unit	21 /kg
Fan	33 /unit	20 /unit
Discard information technology equipment		
Printer	118 /unit	50 /unit
Keyboard	14 /unit	2 /kg
Monitor	207 /unit	Black and white: 60 /unit Color：100 /unit
Monitor (LCD parts)	199 /unit	80 /unit
Laptop	250 /unit	100 /unit
Tablet	146 /unit	30 /unit

Table 1: Allowance and purchase price for recyclable equipment, by Environmental Protection Administration, R.O.C. (Taiwan)

This study investigate the process of refining precious metal by de-soldering computer's mother board using eco-friendly SnST-550A Tin stripper, classify and collect the component that contain precious metal, and refine gold by using UW-860 Gold stripper. In the view of mass production, a lot of time can be saved by using the strippers in the process, while the most important is it provides a simple and safe way to achieve the goal of circular economy.

2. Method

2-1: De-soldering of PC board

This study use Tin stripper provided by UWin Nanotech. Co., Ltd. to de-solder PC board. The Tin stripper solution has configuration as Table 2. Put PC board into the solution under

Fig. 3: Recycling process of PC motherboard

ambient temperature for 50-60 minutes. Next, take out the board and collect the components by water rinsing and baking. Classify the components according to their composition.

Parameter	Operating range	Suggested parameter
68%HNO_3	200-300mL/L	250mL
SnST-550A	200-300mL/L	250mL
Water	400-600mL/L	500mL
Temperature	20-45˚C	35˚C

Table 2: Configuration of Tin stripper solution

2-2: Pre-treatment of chips (grinding and separation)

MLCC and IC chips are grinded into powder form and separated by hydrocyclone into part of plastic and metal.

2-3: Acid process and gold stripping

A gold solution can be obtain after the powder of MLCC and IC chips are treated through the following process:

1. Acid process: Prepare a solution of 68% HNO_3 and water by ratio of 3:7，react the powder with the solution at 40-60˚C for 30-60 minutes. Filter and collect the powder.

2. Gold stripping：Prepare suitable amount of UW-860 gold stripping solution，react with the powder for 2-4 hours.

2-4: Reduction and purification

Reduce the gold from the solution with adding the reducing agent, collect the gold slurry and use dilute HNO_3 to remove the impurities.

Filter and dry the gold mud. Sintered the gold mud at 1200 ˚C and a more than 99.99% gold can be refined.

Fig. 4: Pure gold and silver after sintered

3. Result and discussion

SnST-550A Tin stripper can be used in de-soldering pure Tin, Tin-Silver-Copper and Tin-Lead alloy solder. The whole process can undergoes at ambient temperature and the components on PC board can be easily collected after tin stripping. Hydrocyclone is used to separate the powder of grinded MLCC and IC into part of plastic and metal according to their weight, and the metal part is then collected for the gold stripping process while part without metal will be eliminated to save time and solution. The main function of acid process is to remove the impurities such as silver, copper or nickel in the powder. No toxic gas or liquid are produced during the whole experiment, only the acid need to be aware.

4. Conclusion

Some illegal recyclers will dismantle the components of PC boards by burning, and either aqua regia or cyanide are being use to refine valuable precious metals. Burning will release toxic gas such as dioxin into the air, while aqua regia and cyanide are harmful to the environment and human health. The eco-friendly tin and gold strippers use in this study provide the following advantages:

- Safe and simple to use
- Treatment of wastewater is simple
- Do not damage the substrate therefore complicated chemical reactions are avoided
- Refining time of precious metal can be shortened under the condition of environmental protection.

In fact, wastes in Malaysia are highly unseparated. It is not surprise to see that electronic wastes being discard in the garbage, causing difficultly for the country to refine precious metals. Hence, the first step to be done is to strictly implement the policy of waste separation for effective recycle process, together with the cooperation of the society and educational groups. Next, the collection point of electronic waste should set up more widely, while the importance to discard electronic waste correctly have to be promoted too. It is also possible to legislate, so the manufacturers and consumers will have responsibility in handling their wastes, in case to reduce the amount of waste produced and increase the recycling rate to achieve the aim of environmental protection. Malaysia is an important country in importation and exportation activities of electronic appliances. Its economic development is highly concerned by the countries all around the world. If the issue of electronic waste in Malaysia can be handle perfectly, it may not only enhance the image of the country, but also achieving the goal of circular economy, making Malaysia to become the leader in environmental protection among countries in Southeast Asia.

5. References

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