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# Synthesis of Copper Particles from Printed Circuit Boards using Organic Acids

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***Abstract – Many methods are reported in the literature for the synthesis of copper particles from Waste Printed Circuit Boards (WPCB's). In this present study, the synthesis of copper particles was achieved using Hibiscus rosa-sinensis plant extracts from the leachate product of Waste Printed Circuit Boards (WPCB's) using organic acids. Natural citric acid and tartaric acid were used for the separation of the copper particles from WPCB's. The investigation was carried out at different time periods. The influence of time was found to be significant on the leaching capacity of the acids, which was found to increase with increase in temperature. The synthesis of copper particles was analyzed using SEM and EDAX. The optimum conditions for the leaching of copper were found to be at 60° C, 120 rpm and 24hr.***

***Keywords— watershed, factors, erosion, hypsometry***

## I. INTRODUCTION

The growth of science and technology has increased in the past decade. Along with the increase in the population, several electronic devices were introduced to the mankind. Apart from the benefits the electronic products provide human race, they cause problems to the environment as well. The waste from these electronic devices are hazardous to the environment. Around 30% of the total waste generated consists of E-waste. The primary and major source of e-wastes are personal devices that consists of Printed Circuit Boards(PCB's). These PCB's are made of metals, plastics and glass fibres. The printed circuit boards are the main bearers of precious metals. It contains copper (Cu), lead (Pb), nickel (Ni), tin (Sn) and Zinc (Zn) (Cayumil et al., 2014).

E-wastes are generally dumped on lands or openly burned. This produces dioxins and furans and produces harmful waste/runoff that contaminate soil, air and water (Askari, 2014). Pyrometallurgical and hydrometallurgical processes had been attractive to the researchers for the proper treatment and disposal of e-waste (Yazici et al., 2014).These methods results in the emission of $SO_3$, $NO_X$ and other toxic gases into the environment which is hazardous to the environment, Hence an environmentally favorable and suitable leaching process using inorganic acids is the need of the hour.

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Weak acids like citric and tartaric acid also can dissolve copper from the WPCB's. The leachate produced using inorganic acids can be treated easily since they are easily degradable and water soluble (Li et al., 2010). Using large pieces of PCB for metal leaching will make it easier to reuse the remaining board (non - metallic part), which will otherwise be difficult to use when using pulverized PCBs (Adhapure et al., 2013,2014). Hence, pieces of PCB's were used during the present study.

## II. MATERIALS

### *COLLECTION OF SAMPLES*

The Waste Printed Circuit Boards(WPCB's) of different sizes composing of metals, glass fibers and polymers were collected from the Green Era e-waste recyclers. Approximately 2 kg of computer printed circuit boards were brought for this study. Generally, PCB's can be dismantled manually or mechanically. In this study the PCB's were dismantled manually using pliers and hammers.

### *PRE-TREATMENT*

The collected plates were washed with pure water to remove the dirt from the WPCB. The collected printed circuit boards were depopulated, crushed and shredded to smaller pieces from 19 cm x 11.7 cm to 1cm x 1cm(approximately) manually using pliers and hammer. The depopulated and shredded PCB's were washed thoroughly with double distilled water. Then, the boards were oven dried for 15 mins at 30°C.

### *REMOVAL OF EPOXY COATINGS*

The PCB's generally have a protective layer made up of synthetic plastic polymers called epoxy resins. These epoxy coatings inhibit the leaching capacity of the acids (Senophiyah et al., 2018). The epoxy coatings are used as protective layers in the PCB's due to the properties such as corrosion and heat resistance, strong adhesive nature, ductility and high linkage strength with good electrical resistivity. These epoxy coatings are organic, to which bromine is added to make them fire resistant. (Amirudin, 1995). Brominated epoxy resins consists of 5-15% of bromine, which when exposed to chemicals are hazardous to the environment (Xing et al., 2013).Hence these epoxy coatings has to be removed for further treatment.

In this study, 1M of NaOH had been used to remove the epoxy coatings. In order to prepare 1M of NaOH, 40gm of sodium hydroxide pellets were dissolved in 1000 mL of distilled water. Ten grams of WPCB's was added to 100 mL of NaOH in 500 mL

Erlenmeyer flask and kept in orbital shaking for 8 hrs at 160 rpm and at 60 °C. Then the samples were washed with distilled water and kept at room temperature for drying.

*ACID LEACHING TEST*

Copper can also be dissolved by weak acids such as citric acid and Tartaric acid. The metal leaching experiments were carried out by immersing WPCB piece(1×1cm) in citric acid and Tartaric acid solutions in 500-ml in Erlenmeyer flask (500 mL). The flasks containing the acid solutions with the WPCB's were kept for 8h orbital shaking incubator at 120 rpm and at 60 °C. Then the acid leachate containing the precious metals was separated and the leftover elements were kept separately. Hence an attempt has been made to use natural citric acid and tartaric acid for the extraction of copper. The equations showing the reaction of copper with citric acid and tartaric acid are given below.

$3CuO + 2C_6H_8O_7 \longrightarrow Cu_3(C_6H_5O_7)_2 + 3H_2O$

$C_4H_6O_6 + Cu \longrightarrow C_4H_4CuO_6$

*PREPARATION OF Hibiscus rosa-sinensis LEAF EXTACT*

The young Hibiscus rosa-sinensis leaves were collected. The leaves have been manually shredded and then washed with distilled water twice in order to remove any contaminants. The thoroughly washed leaves were left for one day at room temperature for the removal of moisture content. Then 20g of dried Hibiscus rosa-sinensis was heated at 80˚C with 200 mL of distilled water in the water bath for 4hrs. Then it was allowed to be cooled down till it reached room temperature. The filtrate was then obtained by filtering the extract using filter paper Whattman No.1

*GREEN SYNTHESIS OF COPPER PARTICLES*

The prepared leachate was diluted with distilled water (10 mL acids: 90 mL of distilled water). The diluted leachate was added with 100 mL of citric acid and stirred with magnetic stirrer. To this solution, 50 mL of leaf extract was added. The solution was then stirred in an orbital shaking incubator for 5hrs at room temperature at a rpm of  Finally, the stirred samples were centrifuged at 4˚C for 20 min at 8000 rpm. The results were classified into two categories: supernatant and pellets. For characterizing the synthesized copper particles, the samples were dried in hot air oven for 45 min at 75˚C.The resultant particles were given for further analysis to atomic absorption spectroscopy to determine the concentration of copper in the acid leachate.

## III. RESULTS AND DISSCUSSIONS

*LEACHING OF COPPER*

The ability of acids in dissolving copper were shown to be influenced by the ability of the leaching reagents to promote reactions including precipitation, complexation, acidification and hydrolysis.

*EFFECT OF TIME*

The reaction rate was slower at the beginning, it needed hours to reach high dissolution efficiency. The rate of dissolution increased with increase in time. The PCB's were immersed in the Citric and Tartaric acid for various time period of 8h, 12h, 16h and 24h at a constant temperature of 60˚C and 120 rpm. The concentration of copper for each time period was determined using Atomic absorption spectroscopy. Table 1 and 3 show the concentration of copper for each time period in Citric and Tartaric acids respectively.

| TIME (hours) | CONCENTRATION mg/l |
|---|---|
| 8 | 394 |
| 12 | 584 |
| 16 | 697 |
| 24 | 796 |

**Table 1 Concentration of copper in Citric acid**

The concentration of copper with respect to the time of immersion in citric acid are shown in Fig 1

From the figure, it can be seen that the rate of leaching decreases with respect to time and the increase in the leaching beyond twenty hours is only marginal

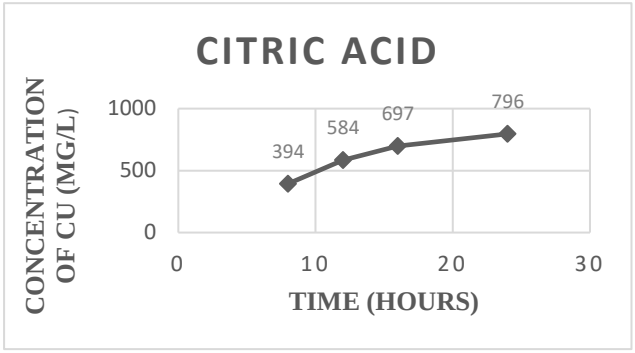


**Fig.2. Leaching of copper with various time period using Citric acid**

The concentration of copper with respect to time of immersion in tartaric acid are shown in Fig 2

| TIME (hours) | CONCENTRATION mg/l |
|---|---|
| 8 | 46 |
| 12 | 184 |
| 16 | 188 |
| 24 | 190 |

**Table 2 Concentration of copper in Tartaric acid**

From the figure, it can be seen that beyond 12 hours of immersion, there is no significant improvement in the leaching of copper.

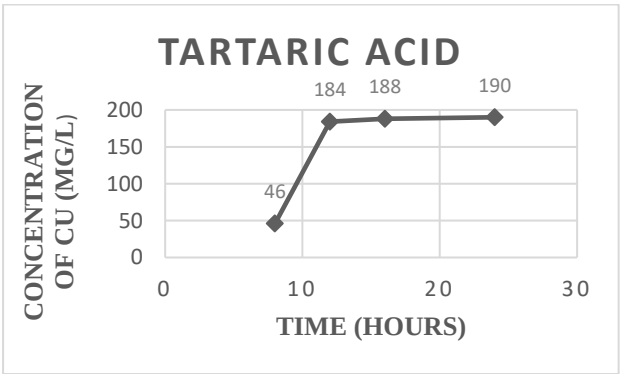


**Fig.2 Leaching of copper with various time period using Tartaric acid**


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## IV. MORPHOLOGICAL ANALYSIS

Scanning Electron Microscope (SEM): Figure 3 shows the SEM images of copper particles synthesized by Hibiscus rosa-sinensis flower extract. Scanning electron microscope (SEM) analysis can indicate the size and surface morphology of the synthesized particles. The SEM images indicated that the crystalline CuO is spherical.

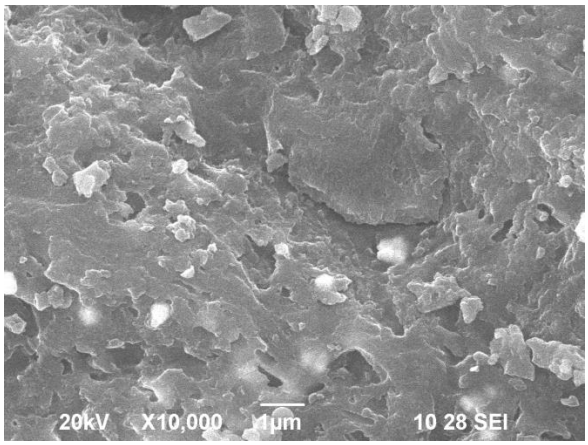


**Fig.10 SEM image of copper particles using Hibiscus rosa-sinensis flower extract.**

Analysis of Energy Dispersive X-ray spectroscope (EDX) may involve the quantitative and qualitative analysis of elements in the formation of particles of copper oxide. The EDAX image of the synthesized particles is shown in Fig 4.

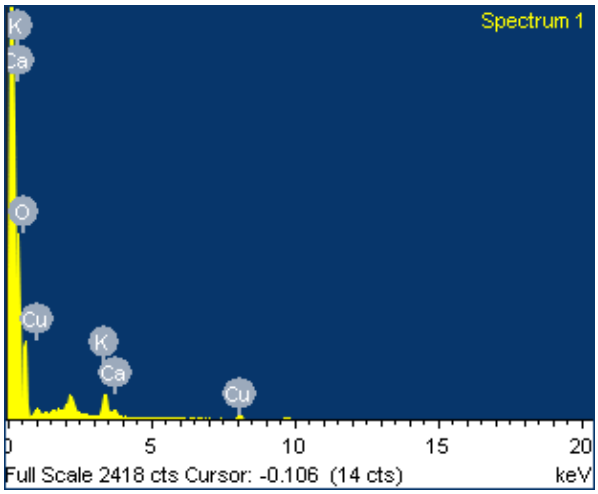


**Fig 4 EDAX diagram of synthsized particles**

From EDAX image, it is found that the percentage weight of copper particle is 20.21%.

| ELEMENT | WEIGHT % |
|---|---|
| O | 66.15 |
| Cu | 20.21 |
| Ca | 13.64 |

**Table 3 Atomic Weight percentage of Cu and O.**

## V. CONCLUSIONS

Based on the results of this study, it is concluded that orga nic acids also dissolve Cu from the WPCB's.The synthesizing capability of natural citric acid was found to be 3.5 times that of tartaric acid. The efficiency of citric acid is found to be 70% and that of tartaric acid is found to be 20%. This study also explored the possibility of synthesis of copper particles using Hibiscus-rosa-sinensis aqueous leaf extracts. It is found that Copper particles synthesis using Hibiscus-rosa-sinensis flower broth is an environmentally friendly, simple and effective method. The SEM images indicate the spherical nature of the crystalline CuO. From the analysis of EDX it can be concluded that the sample consists mainly of oxide and copper.

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