Gold Separation of Computer Circuit Board scraps (CCBs) By Sodium Metabisulphite as a Precipitant

Drastinawati[1]. Yusnimar Sahan [2,] .
[1&2] Chemical Engineering Department, Riau University, Kampus Bina Widya, Pekanbaru 28293, Indonesia
E-mail: dratina.wati@yahoo.com

ABSTRACT

In the electronic and telecommunication industries, gold has been applied for sinyal strength than other metals such as copper. Gold recovered on electronic scraps namely computer circuit main board, printed circuit board, handphone printed circuit board. Based on characterization results, computer circuit board scraps (CCBs) contains gold and other metals such as copper, lead, alumunium, ferous, nickel, zinc, and silver. It is essential to separate the precious metal of CCBs. Generally, gold separation has been done by cyanide and amalgamation methods. Separation by these methods produce a high gold's purity (>80%) and it can be done in a simple way. Yet, mercury and cyanide are very toxic for living things, causes death for them. In this research, gold separation of computer circuit boards (CCBs) has been done by leaching and precipitation methods. In general, recovery gold of electronic scraps has been done by pyrometallurgy and hydrometallurgy methods The method was applied in gold separation processes from modificated methods already existence. This paper reports a promosing method to separate gold of CCBs. Aqua regia and HNO_3 solutions ıwere used in the leaching processes, and sodium metabisulphite **(**$Na_2S_2O_5$) was applied in the precipitation process. Silver, Copper, ferous, alumunium, lead etc. are relatively instable ions and dissolved in HNO_3, but gold is stable as a solid residue in HNO_3 solution. Gold separation of solid residue by leaching with aqua regia. Gold formed a brown solid with the amount precipitated is 0.089g in the 5g CCBs samples was treated, also gold found high purity 98.9% .

Key words: *computer circuit board scraps (CCBs); gold; leaching; precipitation.*

INTRODUCTION

Gold, a precious metal with two important characteristics, it ha zero resistant to corrosion and for many years, it has been used in hundreds of industrial applications. Properties of gold such as it's hardeness ± 2,5 – 3 Mohs scale, inert, with melting point 1000^oC , also as the best conductor than other metals [1]. In the electronic and telecommunication industries, gold has been applied for sinyal strength than copper [2]. Gold content recovered from

computer circuit main board, printed circuit board, handphone printed circuit board [3, 4, 5, 4 & 5].

Generally, gold separation has been done by cyanide and amalgamation methods. Advantages of those methods are high gold's purity (>80%) and the amount of gold recovered higher than other methods, also it can be done in a simple way. Yet, mercury compounds used in amalgamation methods, also cyanide substances used in cyanide methods. Cyanide and mercury compounds are very toxic for living things, causes death for them.

In this research, gold separation of computer circuit boards (CCBs) has been doation procesene by leaching and precipitation methods. These methods applied in gold separation processes from modificated methods already existence [3, 6 & 7]. In general, recovery gold of electronic scraps has been done by pyrometallurgy and hydrometallurgy methods [3, 5, 6, 7, 8, 9, 10, 11 & 12].

EXPERIMENT

Materials are used HNO_3, H_2SO_4, HCl, NaOH, $Na_2S_2O_5$, Aqua demineralisation (aqua DM). This research has been done using several steps namely sample preparation, leaching processes, gold precipitation and pemurnian. Gold content of sample is deremined by Atomic Absorption Spectrophotometer (AAS) Shimadzu AA 7000 with method SMHW for standard solution preparation (Figure 1). Computer Circuit boards (CCBs) is cut into 10 mm - 3 mm particle sizes. This particle was analyzed by XRF (Philips Magix) and AAS to determine the metals contents of sample. Sample 5g was leaching with HNO_3 while it heated at 70 ^oC, then the solid residue is separated from filtrate.

Gold separation in solid residue has been done. The solid residue is leaching with aqua regia (30 ml HCl : 3 ml HNO_3) under condition ratio solid to leachtant (1:3) and it is heated at 70 ^oC. Afterward, this mixture is diluted with aqua DM until it's volume 50ml, and $Na_2S_2O_5$ is poured into mixture until solid brown appear. This solid is separated from mixture, in order to get Au metals then it is purified by burning it with oxy-butane gases.

Gold separation in filtrate done namely, **r**eaction identification for Cu(II), Ni(II), Pb(II), Al (III), Fe(III), and Zn (II) ionics has been done in the filtrate. Then, filtrate is added with 7 ml H_2SO_4, and it heated at 145 ^oC until it's volume remaining 5 ml. Afterward, it is added with 3 ml HCl and heated until it's volume remaining 4 ml, then it is diluted with aqua DM until it's volume 50 ml. In this solution gold is formed as an ionic complex $[AuCl_4]$, then it is reacted with sodium metabisulphite ($Na_2S_2O_5$) to get Au solid in a mixture solution.

ISBN : 978-602-73367-0-4

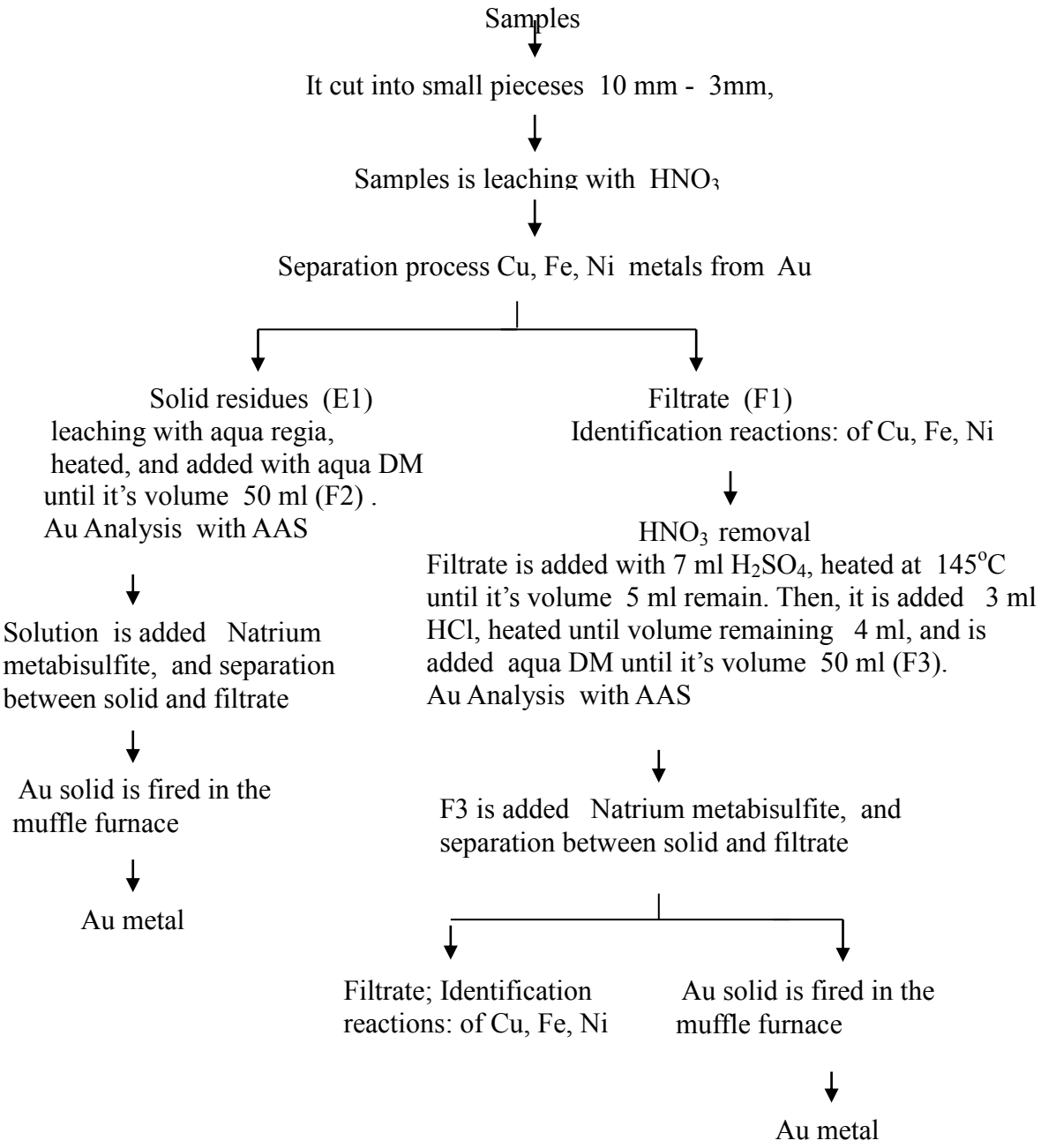

Figure 1. Gold separation process by using leaching and precipitation methods.

Determine Gold Content by AAS

For preparation a [$HAuCl_4$] 1000ppm solutions has done by destruction of gold metals with aqua regia then diluted it with aqua DM. The equation reaction;

$$Au(s) + 4HCl(aq) + HNO3(aq) \rightarrow HAuCl4(aq) + NO(g) + 2H2O(l)$$

ISBN : 978-602-73367-0-4

A series $[HAuCl_4]$ solutions namely 100, 200, 300, 400, dan 500 ppm are prepared, then the absorbance are measured respectively on AAS at 242,8 nm wavelength. Based on these data it is drawn the curve calibration standard in order to determine the Au concentration in CCBs**.**

RESULTS AND DISCUSSION

Gold concentration determined by AAS as $[HAuCl_4]$ complex ionic shown in Figure 1. The curve calibration standard of gold as a $[HAuCl_4]$ comples ionnic is significan well done with $R^2 = 0.999$. Based on the linear equation $y = 0.001x - 0.003$, the gold content of a CCBs sample is calculated (Table 1).

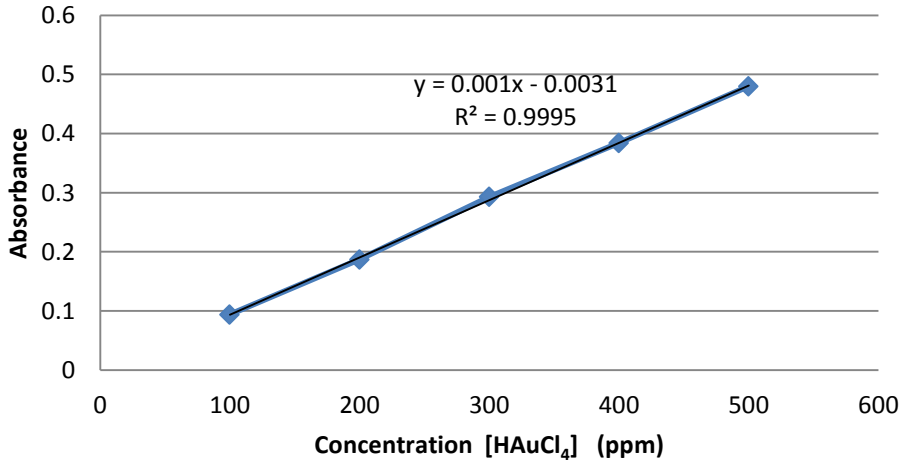

Figure 1. The standard calibration curve of $[HAuCl_4]$

Computer circuit boards (CCBs) contains many precious metals such as gold (Au), silver (Ag), copper (Cu), nickel (Ni), lead (Pb), Alumunium (Al), ferous (Fe), zinc (Zn). Result, based on AAS and XRF analysis of several metals in the CCBs as shown in Table 1.

Table 1. Results Analysis of the CCBs

Component	Amount
Au	398 ± 0.5 ppm*
Ag	0.16%
CuO	5.59%
NiO	0.46%
PbO	1.88%
Al_2O_3	3.53%
Fe_2O_3	0.87%

ISBN : 978-602-73367-0-4

ZnO	0.42%
Others	86%

*AAS Analysis result

Based on AAS analyzed results, the precious metal of Au found in CCBs approximately 398 ± 0.5 ppm. . Saadatjoo N., et. al**.** **(**2013 also found Au content of the CCBs was around 400 ppm maximally before Au separated from computer circuit board scraps (CCBs). .Furthermore, based on XRF analyzed result the other metal such as copper as CuO was found as the highest amount of metals than among metals in CCBs, following by alumunium, lead, ferous, nickel, zinc, and silver.

Gold separation from other metals has been done using HNO_3 as a solvent in leaching process, gold in the solid residues and others metals in the filtrate. Then Solid residue is separated from filtrate. Gold of solid residue is leaching with aqua regia and it turn into as an ionic complex $[HAuCl_4]$.

$$Au(s) + 4HCl(aq) + HNO3(aq) \rightarrow HAuCl4(aq) + NO(g) + 2H2O(l)$$

Based on molecules orbital theory, $[AuCl_4]^-$ complex is one of *point group* D_{4h} compound with planar square form [1] . The fourth ligands Cl^- have equal position of centre atomic [13]. Compound $[HAuCl_4]$ complexes is reacted with $Na_2S_2O_5$. Firstly, $Na_2S_2O_5$ is reacted with H_2O to produce sodium bisulphite;

$$Na_2S_2O_5\,(s) + H2O\,(aq) \rightarrow 2\,NaHSO_3\,(aq)$$

Then, sodium bisulphite is reacted with ionic complex $[AuCl_4]$ as a results Au is produced as a solid with reaction equation;

$$3\ NaHSO_3 + 2\ AuCl_3 + 3\ H_2O \rightarrow 3\ NaHSO_4\ (l) + 6\ HCl\ (l) + 2\ Au\ (s)$$

In order to get gold metal of samples, Au ions in mixture is treatment by several methods such as precipitation, solvent extraction, adsorption, and ion-exchange [9&10]. In this research, in order to get a gold metal of sample which treated, Au solid is heated at 1064 ° C (1947.52 ° F by using oxy-butane gas until gold metal is obtained.

ISBN : 978-602-73367-0-4

Table 2. Comparison Precipitation of gold in different reductants

Initial Au concentration (ppm)	Reductant	Temperature Reductant (^oC)	Time Reduction	Au content after reduction	Form of the precipitated Au	Purity (%)	References
485	$FeSO_4$ (10ml, 0.05g/)	70	20 min	0.012 g	Brown flakes	99.9	Saadatjoo
485	N_2H_4 (5ml, 35%)	70	20 min	0.011g	Brown flakes	99.9	Saadatjoo
700	$H_2C_2O_4$ (20ml, 2%)	70	17 h	1.05g	Au sand	99.5	Saadatjoo
400	$Na_2S_2O_5$	70	20 min	0.089g	Au sand	98.8	

As can be seen in Table 2, gold was succesfully separated by using precipitation process with $Na_2S_2O_5$. Amount of Au content after reduction is high and can be obtained in short time under the same temperature Reductant (^oC), also Au metals has high purity as well as using other precipitated methods. gold precipatation process by using $Na_2S_2O_5$ is a very significant method.

The effect of different reductants has been done in order to recovery of gold from computer circuit board scraps (CCBs) maximally [12]. They applied some reductants namely $FeSO_4$, N_2H_4 and $H_2C_2O_4$ in the precipitation process. Gold content after reduction of the CCBs found maximally around 1.05g with purity 99.5% by using . $H_2C_2O_4$ as a reductants of the precipitation process. But, it taken too long time 17 hours, expensive cost of course.

Tuncuk, A., et. al., **(** 2012) has been done study about some metals of e-scrap separation by an aqueos metal recovery techniques. An aqueos metal recovery techniques is one way of hydrometallurgy in recycling metals of e-scrap. Those techniques applied many studies, because the precious gold metal of CCBs has been separated by this promosing method.

IN CONCLUSION

Computer circuit board scraps (CCBs) contains gold, silver, copper, nickel, lead, ferous, aluminium and zinc metals. The precious gold metal of CCBs has been separated by a promosing method. Aqua regia and HNO_3 solvents were used in the leaching processes, and $Na_2S_2O_5$ was applied in a precipitation process. For 5g CCBs samples is treated. gold formed a brown

solid with the amount precipitated is 0.089g , also gold found high purity 98.9% .

ACKNOLEDGEMENT

This research funded by Riau University through Hibah Bersaing DIPA-UNRI in 2015. Thanks for the sponsor and all who given support, also suggestions to this research.

REFERENCES

[1] Lide, D. R., ed. (2005). *CRC Handbook of Chemistry and Physics* (ed. ke-86). Boca Raton (FL): CRC Press. ISBN 0-8493-0486-5

[2] Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellman, M., Boni, H., (2005). Global perspective on E-waste. Environ, Impact Asses. 25, 436 – 458.

[3] Oleszek, S., Grabda M., Shibata E. & Nakamura T.(2013). Distribution of Copper, Silver ang Gold during Thermal Treatment with Brominated Flame Retardants., Waste management. 13, 1835-1842, Journal homepage; www.elsevier. com/locate/wasmen.

[4] Montero, R., Guevara A., de la Torro E. (2012). Recovery of gold, silver, copper and niobium from printed circuit boards using leaching column. Journal of Earth Science and Engineering. 2, 590-595.

[5] Kinoshitaa , Alkitaa S., khobayashib N., Niib S., Kawazumih F., Takhashi K., . (2003). Metal recovery from non-mounted printed wiring boards via hydrometallurgical processing. Hydrometallurgy. 69, 73-79.

[6] Syed, S.(2012). Recovery of Gold from Secondary Sources-A review., Hydrometallurgy 115-116; 30-51., Journal homepage; www.elsevier.com/locate/ Hydromet.

[7] Park, Y. J. & Fray, D. J. (2008). Recovery of High Purity Precious Metals from Printed Circuit Boards. Journal of Hazardous Materials. 164, 1152-1158.

[8] Cui, L., Zhang, L.(2008). Metallurgical recovery of metals from electronic waste; a review, J. Hazard Mater. 158, 228 – 256.

[9] Quinet P. Proost, J. Van A.L., et al. (2005). Recovery of precious metals from

electronic scrap by hydrometallurgical processing routes. Min, Metals. Process, 22 (1),
17 - 22.
[10] Byoung J.K., Jeon W.A., Seong J.K., Tam T., Myong J.K. (2009). Processing
high purity gold from scraps using diethylene glycol di N-butyl ether (dibutyl carbitol). Hydrometallurgy 95, 262-266.
[11] Zhang, S., Forssberg, E.(1997). Electronic scrap characterization for materials
recycling. J. Waste Manage. Resource, Recov. 3, 157 – 167.
[12] Saadatjoo N., Heydari H., Abdullah A., Behzadi M. (2013). Recovery of gold from
computer circuit board scraps: the study of the effect of different reductants. Journal
of Applied Chemistry. Vol 8, N0.27, p. 55 – 60.
[14] Tuncuk, A., Stazi, V., Akcil, A., Yacizi, E.Y., Deveci, H.(2012). Aqueos metal
recovery techniques from e-scrap; hydrometallurgy in recycling, Minet. Eng. 25,
28 – 37.