RECOVERY OF GOLD FROM ELECTRONIC WASTE THROUGH NON-CYANIDE BASED ELECTRODEPOSITION TECHNIQUE

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by

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TABLE OF CONTENTS

CHAPTER THREE: MATERIALS AND METHODS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF SYMBOLS

Symbol	Meaning	Unit
$	U.S Dollar	-
°	Degree	-
µm	Sample Size	Micro-meter or micron
A	Electrical Current	Ampere
C	Temperature	Celcius
C_c	Allowance for Corrosion	-
cm	Length	Centi-meter
cm^2	Area	Square centi-meter
e	electron	-
E°	Standard Potential	Volt
E_{final}	Potential last to scan in cyclic voltammetry (Final positive potential)	Volt
$E_{initial}$	Potential first to scan in cyclic voltammetry	Volt
E_j	Joint Efficiency	-
E_{prot}	Protection Potential	Volt
g	Mass	Gram
G	Gravity	Meter per square second
g/kg	Amount of metal in sample	Gram of substance per Kilo-gram of sample
g/L	Concentration of metal in sample solution	Gram of substance per Liter of leaching solution

g/mL	Concentration of metal in sample solution	Gram of substance per Milli-Liter of leaching solution
g/t	Amount of metal in sample	Gram of metal per tonne of sample
Hz	Amplitude	Hertz
K	Temperature	Kelvin
kg	Mass	Kilo-gram
kg per capita	Production mass of metal	Kilo-gram per capita
kV	Voltage	Kilo-Volt
L	Volume of solution	Liter
M	Concentration	Molarity
mA/cm^2	Current Density	Milli-Ampere per Square Centi-Meter
mg	Mass	Milli-gram
mg/kg	Mass concentration of metal	Milli-gram of metal per Kilo-gram of sample
mg/L	Concentration of metal in solution	Milli-gram of metal per Liter of sample solution
mins	Time duration	Minutes
mL	Volume of solution	Milli-Liter
mm	Length	Milli-meter
mM	Concentration	Milli-Molarity
mole/L	Concentration	Mole per Liter
mV	Voltage	Milli-Volt
mV/s	Scan rate	Milli-Volt per Second
$Ø_A$	Anodic peak in cyclic voltammetry	-
$Ø_C$	Cathodic peak in cyclic voltammetry	-

P	Operating Pressure of reactor	kilo-Pascal (kPa)
pH	Power of hydrogen ion	-
P_{max}	Maximum Allowable Pressure	kilo-Pascal (kPa)
ppm	Concentration of metal in solution	Parts per Million
P_s	Static Pressure caused by the solution	kilo-Pascal (kPa)
P_T	Total Pressure	kilo-Pascal (kPa)
R	Correlation Coefficient	-
r_i	Reactor Internal Radius	m, cm, mm
rpm	Stirring speed	Revolution per minute
s	Time duration	Seconds
S	Maximum Allowable Working Stress	kilo-Pascal (kPa)
t_w	Reactor Wall Thickness	m, cm, mm
V	Applied potential or potential	Volt
$V_{(pH=2)}$	Potential at pH = 2	Volt
V_S	Volume of Solution	L
V_{SCE}	Potential based on Saturated Calomel Electrode as reference electrode	Volt
V_T	Volume of Reactor	mL, L
w/v	Pulp Density	Weight of sample per Volume of leaching solution
wt. %	Weight percentage	-
x_s	Mesh size	mm, µm
ρ	Density	Mass per Volume
Φ	Dimension	-
$(SCN_2H_3)_2$	Formamidine disulphide	-

$[Au(CN)_2]^-$	Gold-cyanide complex ion	-
$[Au(S_2O_3)_2]^{3-}$	Gold-thiosulphate complex ion	-
$[FeSO_4 \bullet SC(NH_2)_2]^+$	Ferric sulphate-thiourea complex ion	-
Ag	Silver	-
Ag/AgCl	Silver/silver chloride reference electrode	-
Al	Aluminum	-
As	Arsenic	-
Au	Gold	-
$Au[SC(NH_2)_2]^{2+}$ / $Au(TU)^{2+}$	Gold(I)-thiourea complex ion	-
Au°	Elemental gold	-
Ba	Barium	-
Br_2	Bromine gas	-
C	Carbon	-
Ca	Calcium	-
Cd	Cadmium	-
Cl_2	Chlorine gas	-
CO_2	Carbon dioxide	-
Cr	Chromium	-
Cr^{6+}	Hexavalent chromium (Chromium (VI))	-
Cu	Copper	-
$Cu(TU)_n^+$	Copper-thiourea complex ion	-
Cu^{2+}	Cupric ion	-
Fe	Iron	-
Fe^{2+}	Ferrous ion	-

$Fe_2O_{12}S_3$	Ferric sulphate	-
$Fe_2O_{12}S_3.xH_2O$	Ferric sulphate hydrate	-
Fe^{3+}	Ferric ion	-
H^+	Hydrogen ion	-
H_2	Hydrogen gas	-
H_2O	Water	-
H_2O_2	Hydrogen peroxide	-
H_2SO_4	Sulphuric acid	-
HCl	Hydrochloric acid	-
$HClO_4$	Perchloric acid	-
Hg	Mercury	-
Hg_2Cl_2	Mercury(I) chloride (Calomel)	-
HNO_3	Nitric acid	-
Mg	Magnesium	-
Mn	Manganese	-
Na	Sodium	-
Na_2SO_3	Sodium sulphite	-
NaOH	Sodium hydroxide	-
NH_2CN	Cyanamide	-
Ni	Nickel	-
O	Oxygen	-
O_2	Oxygen gas	-
Pb	Lead	-
Pd	Palladium	-
Pt	Platinum	-
S	Sulphur	-
S^{2-}	Sulphide ion	-

$SC(NH_2)_2$	Thiourea	-
Si	Silicon	-
Sn	Tin	-
SO_4^{2-}	Sulphate ion	-
Ti	Titanium	-
Zn	Zinc	-

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrometry
ACS	American Chemical Society
AHP	Analytic Hierarchy Process
CE	Counter Electrode
CV	Cyclic Voltammetry
D	Diameter
DC	Direct Current
DOE	Malaysia Department of Environment
ED	Electrodeposition
EDX	Energy Dispersive X-ray
EEE	Electrical and Electronic Equipment
EIS	Electrochemical Impedance Spectroscopy
E-waste	Electronic Waste
FDS	Formamidine Disulphide
F_{scan}	CV Forward Scan
H	Height
HF	Hydrofluoric acid
IC	Integrated Circuit
ICP-MS	Inductive Coupled Plasma – Mass Spectrometry
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectroscopy
ICT	Information and Communication Technology
LSV	Linear Sweep Voltammetry
MYR/g	Malaysia Ringgit per gram
OCP	Open Circuit Potential