Supplementary Materials

High-Pressure Oxidative Leaching and Iodide Leaching followed by Selective Precipitation for Recovery of Base and Precious Metals from Waste Printed Circuit Boards Ash

Altansukh Batnasan[1,*], Kazutoshi Haga[1], Hsin-Hsiung Huang[2] and Atsushi Shibayama[1,*]

[1] Graduate School of International Resource Sciences, Akita University, 1-1 Tegata-Gakuen machi, Akita, 010-8502, Japan; altansux@gipc.akita-u.ac.jp (A.B), sibayama@gipc.akita-u.ac.jp (S.B), khaga@gipc.akita-u.ac.jp (K.H)

[2] Department of Metallurgy and Materials Engineering, Montana Technological University, 1300 West Park Street, Butte, MT 59701, United States; hhuang@mtech.edu (H.H)

*Correspondence: altansux@gipc.akita-u.ac.jp; altansukh.b2008@gmail.com;
sibayama@gipc.akita-u.ac.jp;
Tel.: +81-18-889-3296 (A.B); Tel.: +81-18-889-3051 (S.B)

Contents

Table S1. The thermodynamic data for individual species for the construction of an Eh-pH diagram.

Species	dGo kcal (25 °C)	Notes	Species	dGo kcal (25 °C)	Notes
H^+ A	0	NBS	**$Au(OH)_4^-$ A**	-108.85	NBS
H_2O 0 L	-56.675	NBS	**$Au(OH)_3$ 0 A**	-67.727	NBS
K^+ A	-67.703	NBS	**Au 0 S**	0	NBS
KOH 0 A	-104.5	NBS	**$Au(OH)_3$ 0 S**	-75.746	NBS
I^- A	-12.326	NBS	**Au(OH) 0 A**	-25.928	Helgeson Sup Crt
I_2 0 A	3.92	NBS	**$Au(OH)_2^-$ A**	-65.905	Mironov
I_3^- A	-12.285	NBS	**AuI_2^- A**	-11.323	Bard
IO_3^- A	-30.593	NBS	**AuI_4^- A**	-10.561	Bard
IO_4^- A	-13.982	NBS	**AuI 0 S**	-0.120	Bard
Au^+ A	39	NBS	**H_2Oc 0 A**	-170.060	Ascorbic acid, H_2Asc
Au^{3+} A	103.6	NBS	**HOc^- A**	-164.371	$HAsc^-$
$Au(OH)_6^{3-}$ A	-182.406	NBS	**Oc^{2-} A**	-147.587	Asc^{2-}
$Au(OH)_5^{2-}$ A	-147.337	NBS	**Oc 0 A**	-153.918	DHA

References:

1. Schmid, G.M. Chapter 11: Copper, Silver, and Gold. In *Standard potentials in aqueous solution*, 1st ed.; Bard, A.J., Parsons, R., Jordan, J., Eds.; Marcel Dekker: New York, United States, 1985; pp. 313–320.
2. Mironov, I.V., Belevantsev, V.I. Hydroxogold(I) complexes in aqueous Solution. *Russ. J. Inorg. Chem*., **2005**, *50*, 7, pp. 1210–1216.
3. Matsui, T.; Kitagawa, Y.; Okumura, M.; Shigeta, Y. Accurate standard hydrogen electrode potential and applications to the redox potentials of vitamin C and NAD/NADH, *J. Phys. Chem. A* **2015**, *119 (2)*, pp. 369–376. doi: 10.1021/jp508308y.

4. Merck Index, 11th ed., Entry #855. https://www.rsc.org/merck-index

$$H_2Asc(a) = HAsc^- + H^+; \quad Ka1 = \frac{[H^+][HAsc^-]}{[H_2Asc]} = 10^{-4.17}$$

$$HAsc^- = Asc^{2-} + H^+; \quad Ka2 = \frac{[H^+][Asc^{2-}]}{[HAsc^-]} = 10^{-11.57}$$

5. https://www.chemeo.com/cid/57-757-9/L-Ascorbic%20acid.pdf

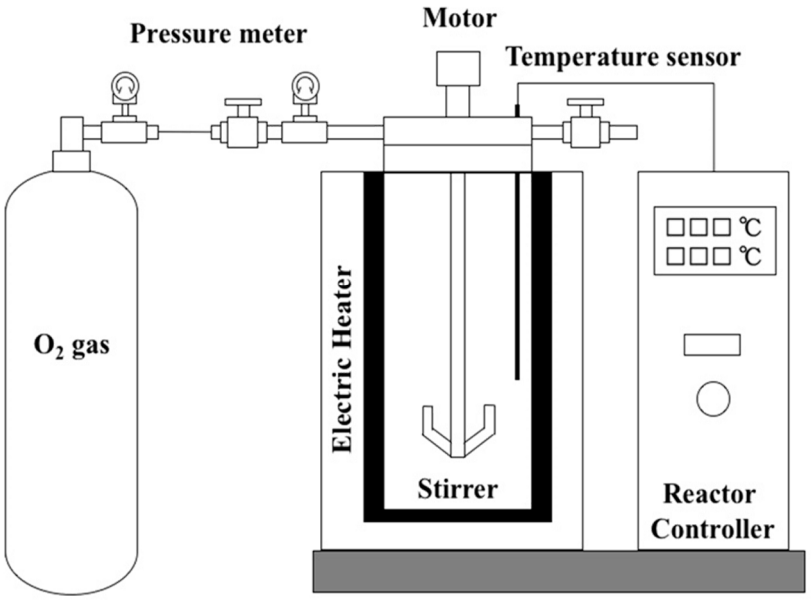

Figure S1. A schematic diagram of an autoclave used in this study.

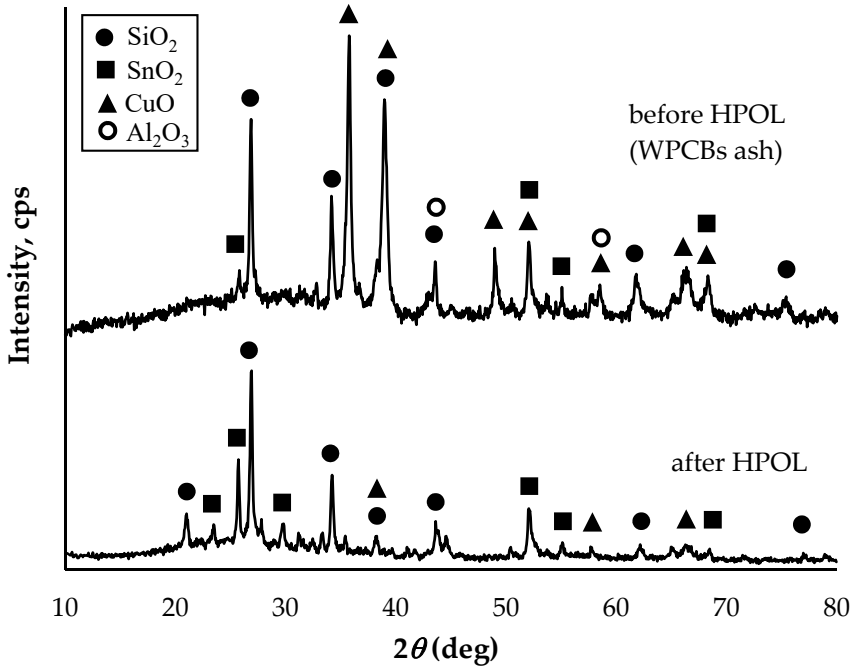

Figure 2. A comparison of the XRD pattern of the leach residue of HPOL. with WPCBs ash sample

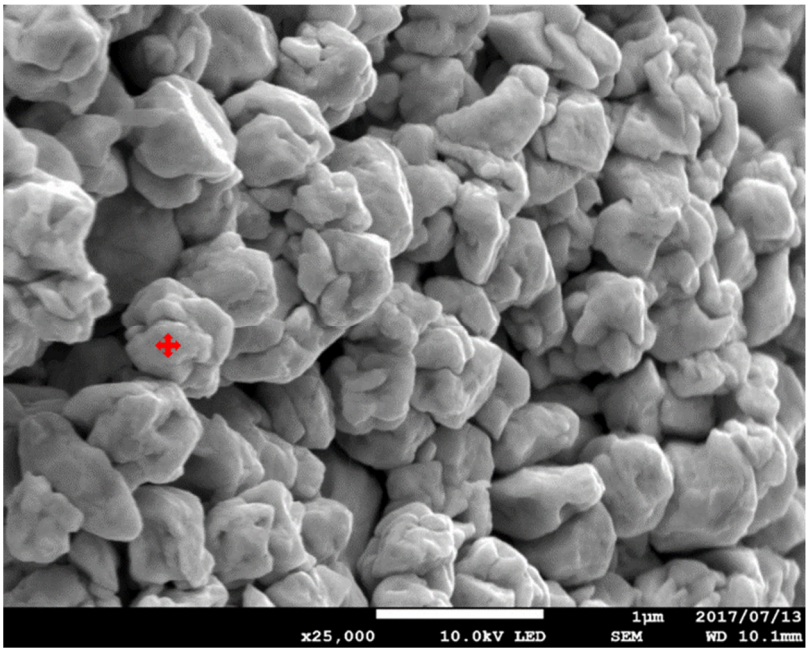

Figure S3. FE/SEM image of gold particles precipitated from solution by reductive precipitation with L-AA

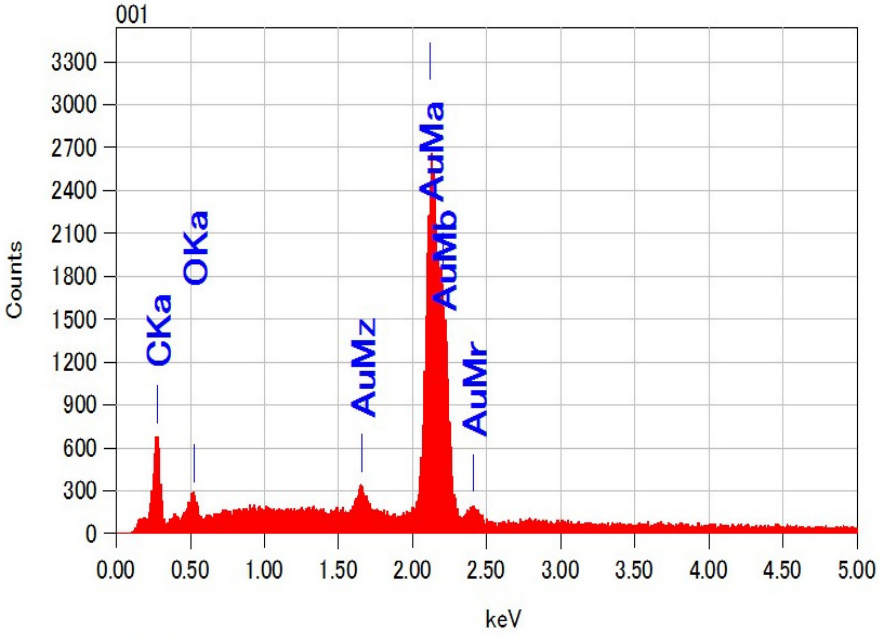

Figure S4. EDS spectra of gold particles precipitated from the solution by reductive precipitation with L-AA