



BAM-M505a - Electronic Scrap (E-Waste)

Summary

The application note summarizes the digestion of BAM-M505a, an electronic scrap (e-waste) certified reference material, using ColdBlock Digestion Pro Series Technology. A 20-minute HNO₃-rich leach recovered 10 of 12 certified elements, including gold, silver, copper and palladium, at 91-100% of the certified values. Targeted modifications to the method were then used to improve chromium recovery and platinum precision.

Instrument:	ColdBlock CBM Pro Series, chiller, ICP-OES (confirmed by ICP-MS)
Published:	October 2026
Digestion Time:	20-minutes (30-minutes for Cr method)
Acid Used:	HNO ₃ , HCl (H ₂ SO ₄ for Cr method)
Average ColdBlock Recovery vs. CRM:	- 100% Gold - 100% Copper - 95% Palladium - 95% Silver

Why E-Waste Analysis Matters

Electronic waste is one of the fastest-growing waste streams in the world, and printed circuit boards are among its most valuable components. They often contain gold, silver and palladium at concentrations well above those of primary ores, alongside large amounts of copper and tin. Accurate analysis determines the value of recycled material for trade and settlement, guides recovery processes, and verifies that hazardous elements such as Pb, Cd, As, Be and Cr are measured for regulatory compliance.

E-waste is also one of the most difficult materials to digest:

- **Mixed matrix:** metals, glass fibre, ceramics, epoxy resins, plastics and flame retardants in a single sample, each requiring different chemistry.
- **Heterogeneity:** precious metals occur as thin platings and discrete particles, so small sample masses can give variable results (the "nugget effect").
- **Resistant phases:** stainless steel, Cr-bearing alloys and plated components can passivate in nitric acid and resist dissolution.
- **High metal load:** copper at percent levels consumes acid and reacts vigorously, while the organic fraction can foam or char.
- **Element-specific losses:** Ag can precipitate as AgCl without enough chloride, Sn can hydrolyze in nitric acid, and Pb forms insoluble sulfates in sulfuric acid.

A practical digestion method must balance these competing requirements while remaining fast enough for routine work.

ColdBlock sample digestion provides a fast, flexible solution for preparing e-waste samples: a single 20-minute digestion delivers accurate results for precious, base and hazardous metals, and the method can be adapted for difficult elements such as chromium and platinum.



App Notes

Methodology

Method 1 - General e-waste digestion (n = 5)

1. The chiller temperature was set to 0 °C.
2. Approximately 0.5 g of each sample was accurately weighed and transferred into a ColdBlock digestion vessel.
3. 15 mL of HNO₃ and 5 mL of HCl (3:1 v/v) were added to each vessel.
4. Samples were digested at 100% power for 60 seconds to ramp up heat, followed by 60% power for 1140 seconds (20 minutes total).
5. Digestates were allowed to cool, then quantitatively diluted to a final volume of 50 mL using 20% HCl.

Method 2 - Chromium: H₂SO₄ pre-digestion (n = 3)

1. Approximately 0.25 g of sample was weighed into a ColdBlock digestion vessel.
2. 10 mL of H₂SO₄ was added and digested at 100% power for 900 seconds.
3. 20 mL of aqua regia was then added and digested at 50% power for a further 900 seconds (30 minutes total).
4. Digestates were allowed to cool, then quantitatively diluted to a final volume of 50 mL using 20% HCl.

Method 3 - Platinum: increased sample mass (n = 5)

1. As Method 1, with the sample mass increased to approximately 1.0 g. Acid volumes and the digestion program were unchanged.



Figure 1. BAM-M505a digestates following ColdBlock HNO₃/HCl digestion (Method 1).

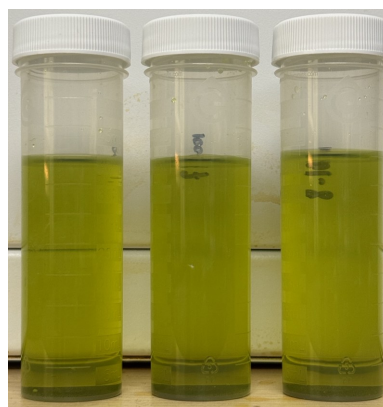


Figure 2. BAM-M505a digestates following ColdBlock H₂SO₄ pre-digestion and aqua regia (Method 2).



App Notes

Discussion

- Digestates were analyzed on an Agilent 5100 VDV ICP-OES, and results were confirmed on an Agilent 7850 ICP-MS.
- Using Method 1, 10 of the 12 certified elements recovered within $\pm 10\%$ of the certified value, from 91% (Be) to 100% (Au, Cu). Precision was strong, with % RSD at or below 3.1% for every element except Au (7.6%) and Pt.
- Copper, the dominant matrix element at $\sim 17\%$ w/w, recovered at 100% with 0.2% RSD, confirming that the excess nitric acid fully oxidized the metallic fraction of the sample. Gold recovered at 100% and palladium at 95%.

Chromium

- Method 1 recovered only 59% of the certified Cr, but with excellent precision (0.6% RSD). A consistent low bias like this points to a chemically resistant Cr fraction rather than an uneven distribution of Cr in the sample.
- In e-waste, Cr is present mainly as stainless steel, Cr plating and Cr-bearing alloys. Concentrated HNO_3 passivates these materials by forming a protective Cr_2O_3 surface layer that resists further attack.
- Method 2 added a hot concentrated H_2SO_4 step before aqua regia. Sulfuric acid reaches a much higher temperature than HNO_3 or HCl and dissolves Cr-bearing alloys without passivating them. It also chars the polymer and epoxy in circuit board material, releasing encapsulated metal particles. Cr recovery increased to 95% (0.6% RSD). Small undissolved particles are visible at the base of the Method 1 digestates (Figure 1) and are not seen after the H_2SO_4 pre-digestion (Figure 2).
- H_2SO_4 forms insoluble sulfates with Pb, and can lower Ag recovery. Method 2 is recommended for Cr only, with Method 1 used for the remaining elements.

Platinum

- Method 1 recovered 88% of the certified Pt, but with high variability (30% RSD; individual results ranged from 3.6 to 7.5 mg/kg). Palladium from the same digests showed only 2.4% RSD.
- This contrast points to particle heterogeneity (the "nugget effect"). At 5.7 mg/kg, the Pt in e-waste is held in a small number of discrete particles, such as contacts, sensor elements and magnetic media. A 0.5 g portion may contain more or fewer of these particles. At this sample mass, the Pt concentration in solution is also low ($\sim 57 \mu\text{g/L}$), which adds measurement uncertainty. Gold shows the same effect to a lesser degree (7.6% RSD).
- Doubling the sample mass to 1.0 g (Method 3) improved recovery to 94%, within the certified range of 5.3-6.1 mg/kg, and reduced the RSD to 13%. Sampling theory predicts that doubling the mass alone would reduce the RSD to about 21%. The larger improvement observed reflects the higher Pt concentration in solution as well.
- For precious metal determinations in e-waste, sample masses of 1.0 g or more and an increased number of replicates are recommended.

Conclusion

These results demonstrate that ColdBlock digestion provides accurate and highly repeatable recoveries from a complex e-waste matrix. A single 20-minute digestion recovered 10 of 12 certified elements within $\pm 10\%$ of their certified values, with RSD of 3.1% or less for all elements except gold (7.6%). Gold and copper, two of the most commercially important elements in e-waste, recovered at 100%. Where the matrix demanded it, simple method adjustments raised chromium recovery from 59% to 95% and more than halved platinum variability.

Results

Table 1. ColdBlock Method 1 recoveries ($n = 5$) relative to the BAM-M505a certified values.



App Notes

ELEMENT	CERTIFIED VALUE (mg/kg)	COLDBLOCK AVERAGE $\pm$ 95% CI n=5 (mg/kg)	% RECOVERY	% RSD
Ag	633 $\pm$ 8	604 $\pm$ 11	95%	1.4%
As	372 $\pm$ 20	342.0 $\pm$ 5.5	92%	1.3%
Au	52.4 $\pm$ 0.9	52.5 $\pm$ 5.0	100%	7.6%
Be	6.8 $\pm$ 0.9	6.20 $\pm$ 0.24	91%	3.1%
Cd	16.4 $\pm$ 0.7	15.44 $\pm$ 0.47	94%	2.4%
Cr*	9800 $\pm$ 170	5745 $\pm$ 40	59%	0.6%
Cu	167600 $\pm$ 400	168190 $\pm$ 510	100%	0.2%
Ni	6940 $\pm$ 80	6853 $\pm$ 39	99%	0.5%
Pb	11300 $\pm$ 500	10755 $\pm$ 63	95%	0.5%
Pd	48.0 $\pm$ 0.8	45.7 $\pm$ 1.4	95%	2.4%
Pt*	5.7 $\pm$ 0.4	5.0 $\pm$ 1.9	88%	30%
Sn	4690 $\pm$ 150	4542 $\pm$ 30	97%	0.5%

* See Table 2 for the modified Cr and Pt methods.

ColdBlock uncertainties are 95% confidence intervals of the mean (Student's t, n - 1 degrees of freedom). Certified uncertainties are as stated on the BAM-M505a certificate.

Table 2. Method modifications for chromium and platinum.

ELEMENT	METHOD	MASS	n	CERTIFIED (mg/kg)	AVERAGE $\pm$ 95% CI (mg/kg)	% RECOVERY	% RSD
Cr	Method 1 - HNO ₃ /HCl	0.5 g	5	9800 $\pm$ 170	5745 $\pm$ 40	59%	0.6%
Cr	Method 2 - H ₂ SO ₄ + aqua regia	0.25 g	3	9800 $\pm$ 170	9360 $\pm$ 140	95%	0.6%
Pt	Method 1 - HNO ₃ /HCl	0.5 g	5	5.7 $\pm$ 0.4	5.0 $\pm$ 1.9	88%	30%
Pt	Method 3 - HNO ₃ /HCl	1.0 g	5	5.7 $\pm$ 0.4	5.33 $\pm$ 0.86	94%	13%

BAM-M505a, Electronic Scrap Certified Reference Material, Certificate of Analysis. Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany (www.bam.de).