

## **AMINO ACID LEACHING OF METALS FROM PRINTED CIRCUIT BOARD WASTE**

C Dorfling  
Stellenbosch University, South Africa

### **KEY FINDINGS**

The project investigated the use of amino acids as lixiviant for base and precious metal dissolution from waste printed circuit boards. Base metal leaching with glycine is technically feasible, but glycine is not a feasible alternative lixiviant for gold dissolution. This briefing note summarises the context and results of the project, and highlights further work originating from the findings.

### **INTRODUCTION**

The rate of electronic waste generation increases continuously; in South Africa, electronic waste has been identified as the fastest growing component of solid municipal waste. Appropriate waste treatment facilities are important to minimise the negative impact that this waste might have on the environment. Certain waste components, such as discarded printed circuit boards (PCBs), contain a relatively large amount of valuable metals such as gold and copper. There is thus also an economic incentive to treat these waste components in a manner that would allow the recovery of valuable metals. Currently, however, limited processing capacity exists in South Africa to economically recover metals from PCB waste.

Hydrometallurgical processes that have conventionally been proposed for metal recovery from waste printed circuit boards typically consist of multiple leaching stages: the first stage entails leaching of base metals with strong mineral acids, while precious metals (primarily gold) are recovered in subsequent leaching stages using lixivants such as cyanide or aqua regia. These conventional hydrometallurgical process routes introduce environmental management challenges of its own. This project evaluated the applicability of an oxidative amino acid leaching process for base and precious metal recovery from printed circuit board waste as an alternative to these conventional processes; this is a novel approach with a significantly

reduced environmental impact, and limited information about the leaching process is available.

### **APPROACH**

Bench scale leaching tests were performed with glycine to determine the rate, extent and selectivity of base and precious metal leaching at varying conditions; the effects of temperature, glycine concentration, pH, and oxidant addition on the leaching behaviour were investigated. The base metal leaching performance at the proposed operating conditions was subsequently verified in a small pilot-scale setup.

### **MAIN RESULTS**

#### **Base metal leaching**

The highest percentage copper leaching achieved was 81 % at 60°C and pH 11 with 1 M glycine and oxygen as oxidant. Although this extent of leaching was achieved within 24 hours in the bench-scale tests, mass transfer limitations in the small pilot-scale setup necessitated the use of two leaching stages (each with a residence time of 40 – 50 hours) to achieve the same extent of leaching. Reactor configuration, agitation speed and oxygen flow rate should therefore be considered carefully to minimise mass transfer limitations. In addition, further work can be done to better understand the leaching mechanism; determining whether the cuprous-cupric couple plays an important role in the overall leaching mechanism and reaction kinetics would be of particular interest.

Solubility of copper in the glycine system limited the solid-to-liquid ratio to 25 g/L. Similarly, operating the base metal leach at pH values below pH 11 resulted in excessive precipitation of copper species. At high pH values the anionic form of glycine dominates the system, while the zwitterion form becomes more dominating at lower pH values; the stability constant for the copper-zwitterion complex is significantly lower than the stability constant for the copper-anion complex. In this context, scope exists for work related to the measurement of solubility data for metal-glycine complexes in alkaline solutions.

### Precious metal leaching

Precious metal leaching tests were performed using the solid residue from the base metal leaching tests as the feed material. No significant gold dissolution was achieved at the range of conditions investigated (60 – 90°C, 0.1 – 0.5 M glycine, pH 11.5 – 12.5, with oxidation by hydrogen peroxide). Cyanide-glycine leaching tests confirmed the gold leachability, which suggests that further optimisation of the cyanide-glycine leaching system should be done or that

alternative lixivants such as thiosulfate should be considered more seriously.

### CONCLUSIONS

The project has highlighted key fundamental and technical aspects of the glycine leaching process that require further investigation for process optimisation. The results also serve as a basis for future projects that will compare the environmental impact and economic feasibility of the glycine base metal leaching process with conventional mineral acid based hydrometallurgical processes; this, in turn, will aid process selection and economic decision-making.

**Acknowledgements:** Funding for the project was received from the Department of Science and Technology through the Waste Research Development and Innovation Roadmap..

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This Briefing Note is produced as part of the Waste RDI Roadmap Briefing Note Series, an initiative of the Department of Science and Technology managed by the CSIR. The Note stems from the findings of a grant project funded under the Roadmap, entitled “Amino acid leaching of metals from printed circuit board waste”.

