Extraction and recovery of nitric acid and copper from leach liquor of waste PCBs

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ABSTRACT

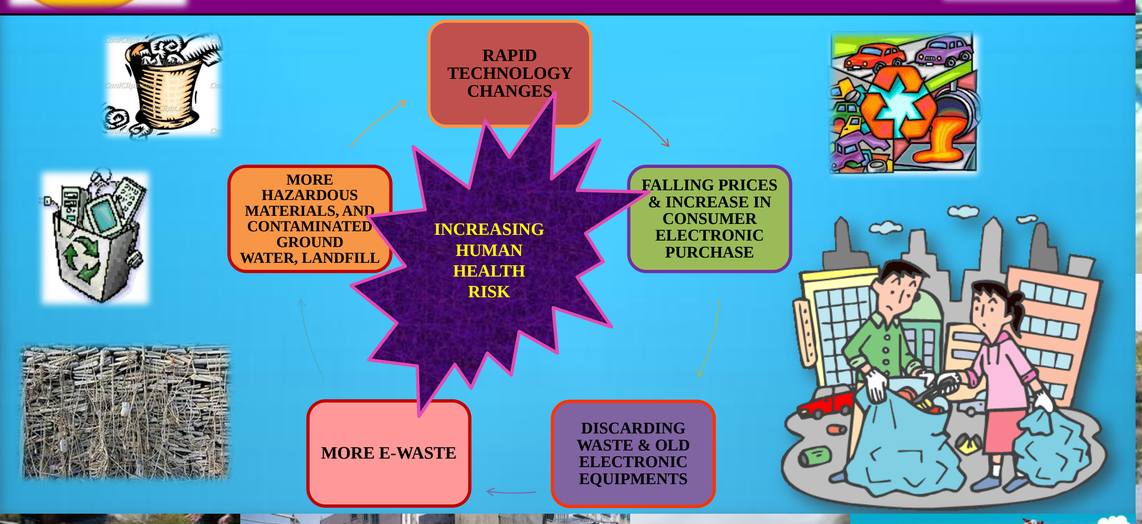
The disposal of large quantities of electronic scrap worldwide is causing an enormous harm to environment as well as to mankind. Therefore, efforts have been made to develop a suitable hydrometallurgical process for the extraction of metals from electronic scraps. The leach liquor of waste PCBs was generated containing 18.78 g/L Cu, 0.38 g/L Fe, 0.13 g/L Ni,1.34 g/L Pb and 6.3M HNO_3. Initially, HNO_3 was extracted from the leach liquor using TBP as an extractant. Various process parameters such as time, concentration of extractant, O/A ratio etc were studied for the extraction of HNO_3. It was observed that the extraction of HNO_3 increased from 8.1– 39.6% with increase in TBP concentration from 10 to 100%. The plot of log D vs. log [TBP] gives a straight line with slope ~1 indicated that the 1 mole of TBP used for the extraction of 1 mole of HNO_3. The McCabe–Thiele Plot was drawn to investigate the stage required for maximum acid extraction. After extraction of HNO_3 from leach liquor, extraction of copper was investigated using LIX 84 IC. Various parameters such as effect of pH, phase ratio, stripping etc. were studied to investigate the optimum experimental condition for the extraction of copper. The extraction of Cu increased from 37 to 88% with the increase in the pH range from 0.7 to 2.0. The optimum equilibrium pH for Cu extraction was found to be ~2.0. The McCabe – Thiele Plot for Cu extraction indicated that 2 counter current stages is enough for its complete removal from acid free leach liquor at O/A = 1.2/1 maintaining equilibrium pH~2.0. The present study reports removal of acid and Cu from the leach liquor of waste PCBs in an eco-friendly manner.

Keywords: Electronic Scrap, Leaching, Nitric acid, Copper, TBP, LIX84-IC.

INTRODUCTION

- **E-waste is the fastest growing waste stream** in the industrialized and urbanized world.
- E- wastes are **all electronics whether discarded/ improperly disposed by their original owners.**
- **Rapid technology changes** are forcing the consumers to dispose the old and purchase new electronic products.
- **Major source of E-waste is the disposal of the hardware and electronic items including the imported E- waste volume.**
- **Main challenge in India is to create awareness of the environmental, social and economic aspects of E-waste.**
- **E-waste is hazardous and toxic,** although it contains valuable metals.
- E-waste is **posing a greater threat for environmental degradation** in the developing countries as organized recycling technology is not available.

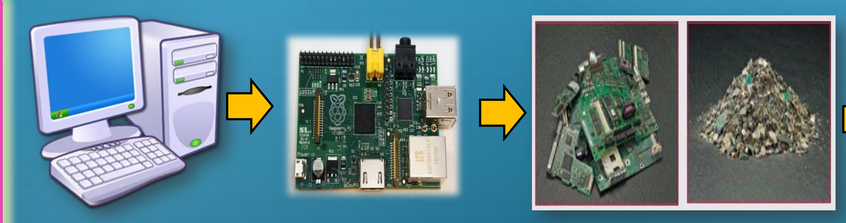
ISSUES & PROBLEMS



PRESENT SCENARIO

- Appropriate technologies and adequate infrastructures are available in developed countries to process the end-of-life electronic products .
- The developed countries transfer the manufacturing or processing technology to countries like India where operation costs are low.
- Lack of E-waste disposal, collection and processing awareness in India.
- This has enhanced the E-waste generation alarmingly.

MATERIALS AND METHODS



EXPERIMENTAL PROCESS

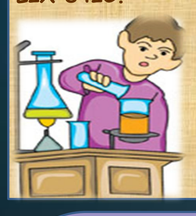
✓The leach liquor containing HNO_3 was initially extracted using TBP as an extractant.

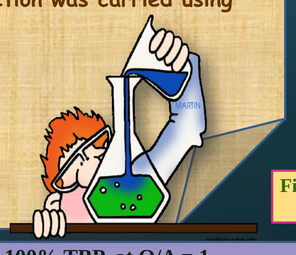
✓ Various process parameters such as time, concentartion of extractant, O/A ratio were studied.

✓The leach liquor of PCBs composed of 22.97g/L Cu, 0.15g/L Ni, 1.08 g/L Pb, 0.521g/L Al, 0.33g/L Zn, 0.42g/L Fe after extraction of Nitric Acid.

✓Then suitable solvent extraction reagent was used for separation & recovery of Copper.

✓Then systematic study of Copper extraction was carried using LIX 84IC.





RESULTS & DISCUSSION

THE EXTRACTION OF NITRIC ACID

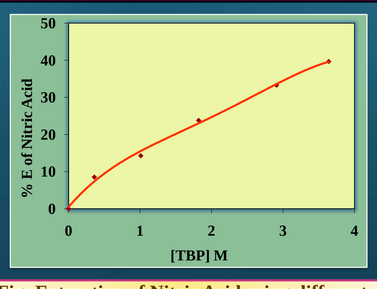


Fig: Extraction of Nitric Acid using different concentration of TBP

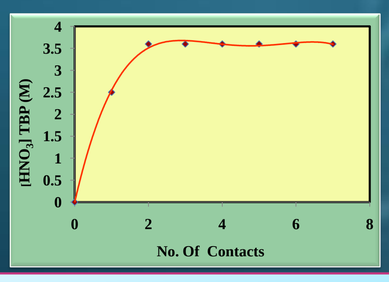


Fig: Loading Capacity of TBP

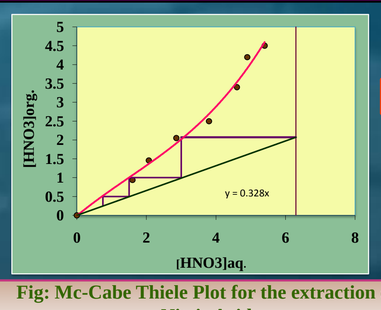


Fig: Mc-Cabe Thiele Plot for the extraction of Nitric Acid

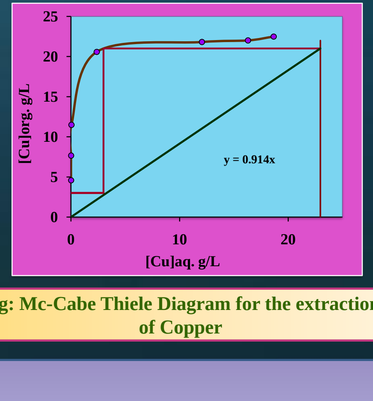


Fig: Mc-Cabe Thiele Diagram for the extraction of Copper

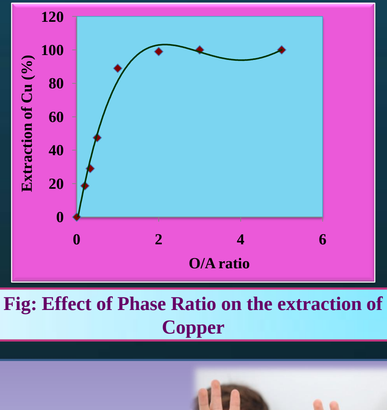


Fig: Effect of Phase Ratio on the extraction of Copper

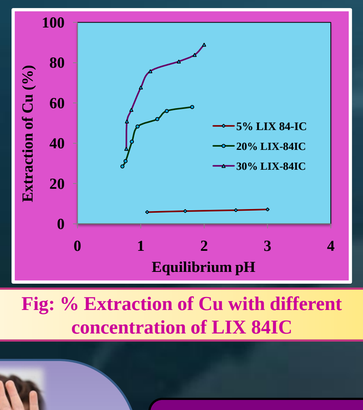


Fig: % Extraction of Cu with different concentration of LIX 84IC

THE EXTRACTION OF COPPER

- Maximum 41.3% nitric acid extracted with 100% TBP at O/A = 1.
- In two contacts, TBP got saturated & loading capacity was found to be 3.6 M acid
- Three counter current stages required for complete extraction of acid at O/A = 3 , equilibrium time = 15 minutes with undiluted TBP.
- Iron from the solution was removed by pH adjustment and air sparging.
- Concentration of LIX 84IC was varied from 5%(0.17 M) to 30% (1.07 M) maintaining O/A=1, equilibrium time = 5 minutes, and in this concentration range negligible amount of other metals were extracted along with Cu.
- With increase in pH from 0.77 to 2.00, Cu extraction increased from 37.2% to 89% at O/A = 1/1 & equilibrium time 5 minutes.
- In 3 contacts, 30% LIX 84IC got saturated & loading capacity of the solvent was found to be 22.97 g/L
- Mc-Cabe Thiele Plot for Cu extraction shows that at O/A = 1.2/1, equilibrium pH=2 and equilibrium time 5 minutes, two counter current stages were required for complete extraction of Cu from acid free leach liquor of PCBs.

CONCLUSION

❖ The complete extraction of Nitric Acid was accomplished in three counter current stages using 100% TBP at O/A=3 and equilibrium time 15 minutes.

❖Iron from the solution was removed by pH adjustment and air sparging as extraction with D2EHPA needed high acid concentration during stripping.

❖ The complete extraction of Cu was feasible in two counter current stages using 30% LIX 84IC at O/A=1.2 , equilibrium pH=2 and equilibrium time 5 minutes.

REFERENCES

❑Archana Agrawal *, M.K. Manoj, S. Kumari, D. Bagchi, V. Kumar, B.D. Pandey. , Extractive separation of copper and nickel from copper bleed stream by solvent extraction route, Minerals Engineering 21 (2008) 1126–1130

❑B. Ramachandra Reddy*, D. Neela Priya, Process development for the separation of copper(II), nickel(II) and zinc(II) from sulphate solutions by solvent extraction using LIX 84, Separation and Purification Technology 45 (2005) 163–16

❑Z. Zhu, W. Zhang, C.Y. Cheng, A synergistic solvent extraction system for separating copper from iron in high chloride concentration solutions, Hydrometallurgy 113–114 (2012) 155–159

❑Kathryn *C. Sole*.', J. Brent Hiskey,* Solvent extraction of copper by Cyanex 272, Cyanex 302 and Cyanex 3017, Hydrometallurgy 37 (1995) 129-147