Two-stage SART process: A feasible alternative for gold cyanidation plants with high zinc and copper contents.

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THE SART PROCESS

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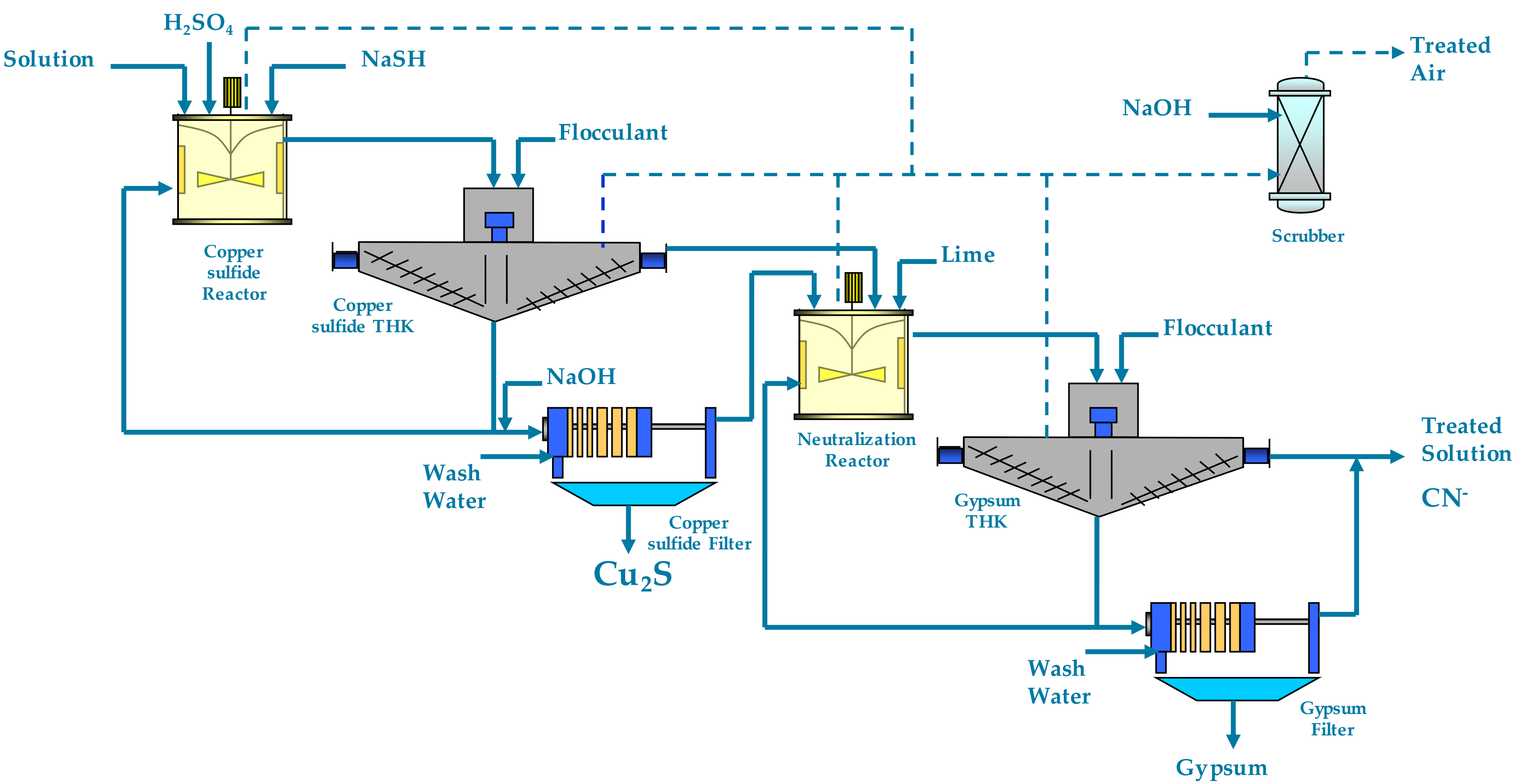
The SART (Sulfidization, Acidification, Recycling and Thickening) process has been designed to recover cyanide and copper from gold cyanidation processes.



$$2Cu(CN)_3^{-2} + 3H_2SO_4 + S^{-2} \leftrightarrow Cu_2S_{(s)} + 6HCN_{(aq)} + 3SO_4^{-2}$$

THE SART PROCESS

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- The SART process can precipitate zinc as ZnS

$$Zn(CN)_4^{-2} + 2H_2SO_4 + S^{-2} \leftrightarrow ZnS_{(s)} + 4HCN_{(aq)} + 2SO_4^{-2}$$

- When gold plants have high zinc and copper content in their solutions, the SART process could produce a relatively low grade precipitate, decreasing the sale price.

- There are some studies that propose a **two-stage SART process**, recovering copper and zinc separately, based on the pH conditions where ZnS, Cu_2S is formed, in order to increase the selling price of these precipitates.

TWO-STAGE SART PROCESS

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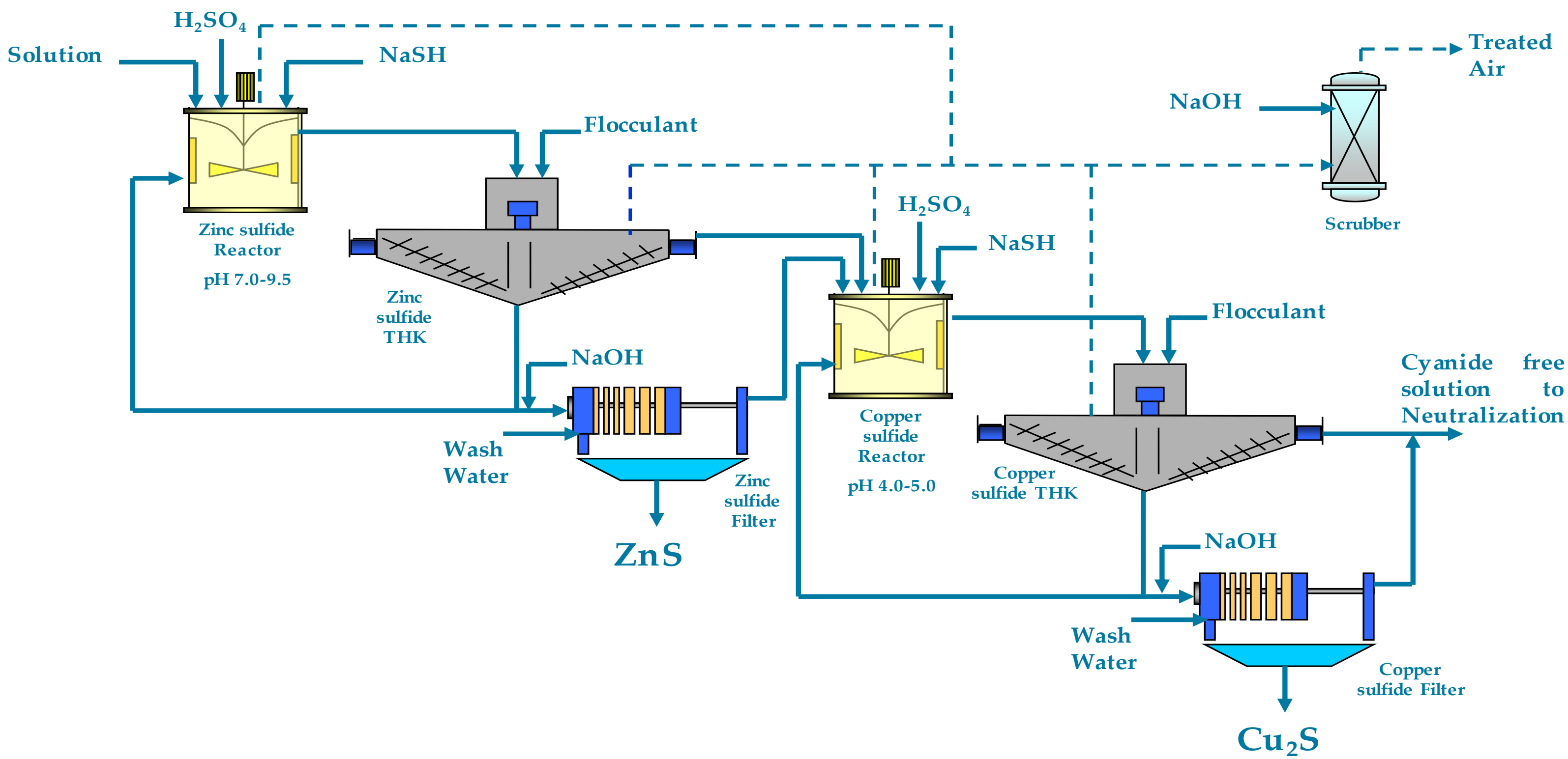

- In the first stage, zinc precipitation occurs at pH 7.5.
- The second stage precipitates copper at pH values ranging between 4.0 and 4.5.
- This process could imply higher operation and capital costs.

METHODS

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Estimation of operational parameters using a thermodynamic model

Speciation curves of metal and cyanide complexes were developed for copper and zinc in the sulfidization stage in presence of HS^- content, using the Hydra / Medusa software. Equilibrium constants were modified using the following data.

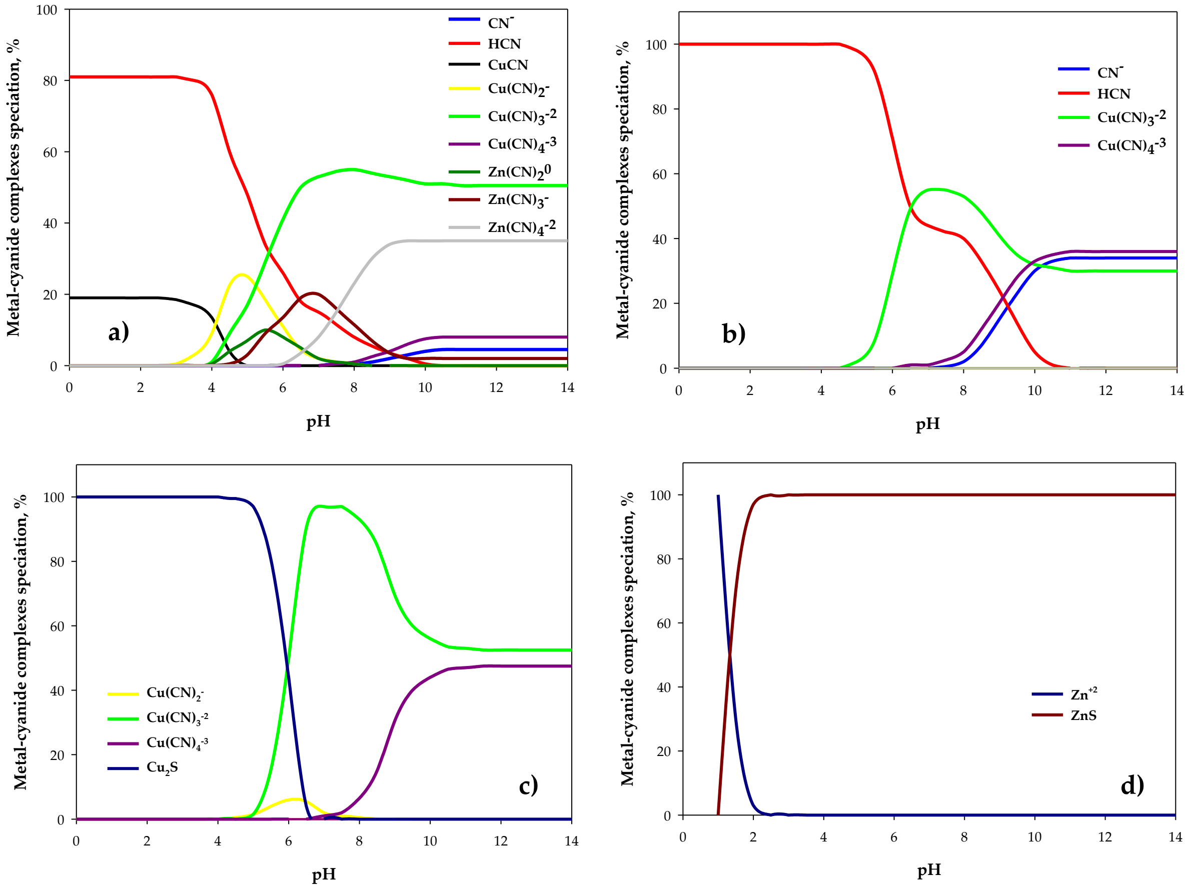
Reaction	$\log K_i$
$Cu^+ + CN^- \leftrightarrow CuCN$	20
$CuCN + CN^- \leftrightarrow Cu(CN)_2^-$	3.94
$Cu(CN)_2^- + CN^- \leftrightarrow Cu(CN)_3^{-2}$	5.3
$Cu(CN)_3^{-2} + CN^- \leftrightarrow Cu(CN)_4^{-3}$	1.5
$Zn^{+2} + 2CN^- \leftrightarrow Zn(CN)_2^0$	11.07
$Zn(CN)_2^0 + CN^- \leftrightarrow Zn(CN)_3^-$	4.98
$Zn(CN)_3^- + CN^- \leftrightarrow Zn(CN)_4^{-2}$	3.57
$H^+ + CN^- \leftrightarrow HCN$	9.21
$2Cu^+ + S^{-2} \leftrightarrow Cu_2S$	47.3
$Zn^{+2} + S^{-2} \leftrightarrow ZnS$	23.08
$H^+ + S^{-2} \leftrightarrow HS^-$	13.9
$H^+ + HS^- \leftrightarrow H_2S$	7.02

Economic comparison between conventional and Two-stage SART process options

The economic evaluation was carried out comparing the differences of conventional SART processes and two stages. This means that capital and operating costs have been estimated based solely on the differences between two options.

Results and discussion

Operational conditions and metal recoveries



Speciation curves a) cyanide solution fed into the SART process; b) treated solution by one-stage SART process using 120% stoichiometric NaHS addition; c) Copper species distribution for the treated cyanide solution in the SART process; d) Zinc species distribution for the treated cyanide solution in the SART process.

Results and discussion

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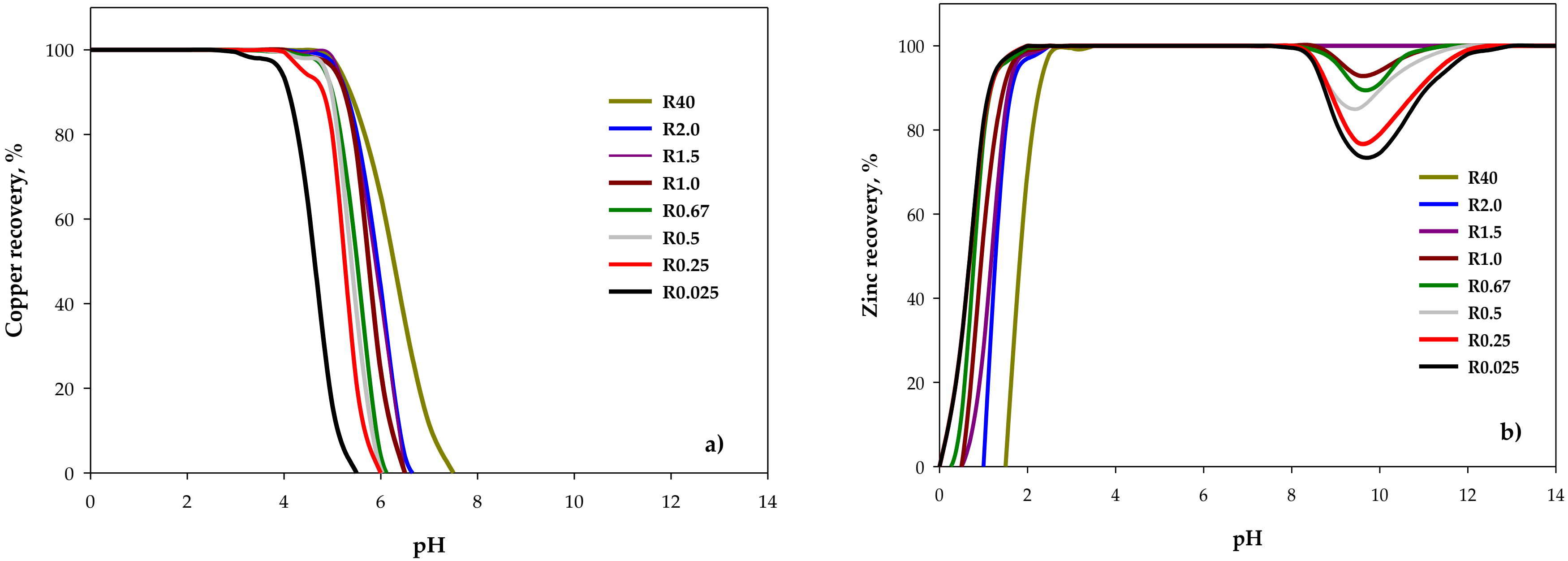
Operational conditions and metal recoveries

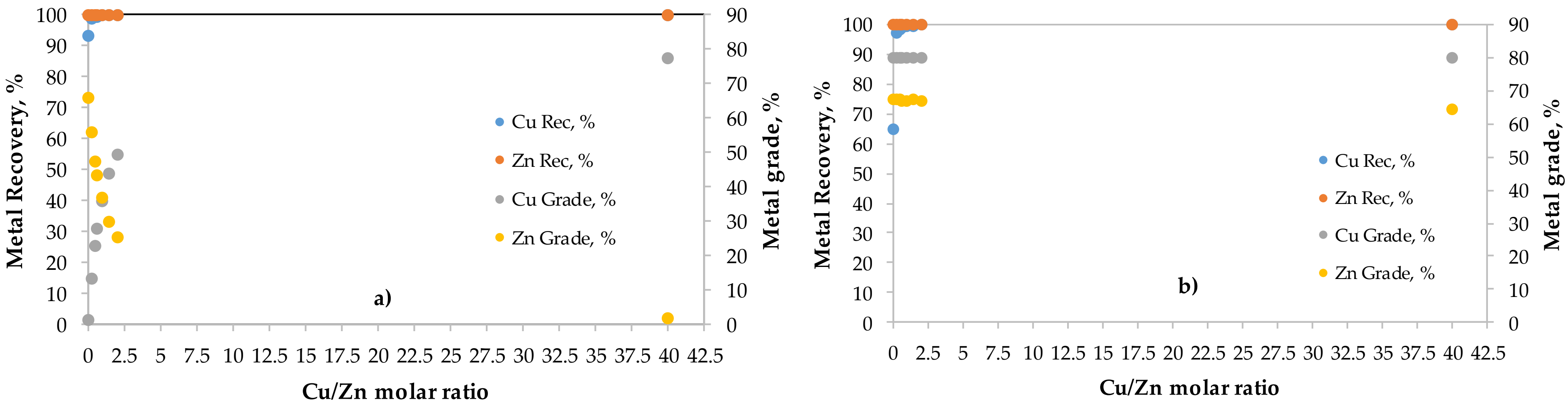


Metals recovery values in the one-stage SART process for different Cu/Zn molar ratio. a) Copper recovery; b) Zinc recovery.

- These results allow to define the pH operational conditions which maximize the metals recovery in both SART process options.
- Therefore, copper recovery can reach values over 95% at pH 4.0. At this condition, ZnS remains stable ensuring zinc recovery over 99%.
- In case of the two-stage SART process, the first stage of zinc precipitation can be operated at pH 7.5 or lower, where $Zn(CN)_4^{-2}$ specie is dissociated to ZnS and HCN under sulfide presence.

Results and discussion

Operational conditions and metal recoveries



Results of copper and zinc recoveries and grades in the precipitate for different Cu/Zn molar ratios. a) One-stage SART process; b) Two-stage SART process.

- The zinc recovery reaches 100% in both SART process option, instead copper recovery overcomes 90% in one-stage option for every Cu/Zn molar ratios simulated.
- Copper recovery falls up to 65% in the two-stage option for a Cu/Zn molar ratio of 0.025.
- The two-step option allows two different, high-grade, separable and salable precipitates for copper and zinc.
- Nevertheless, the additional capital and operational costs could limit the implementation of this technology.

Results and discussion

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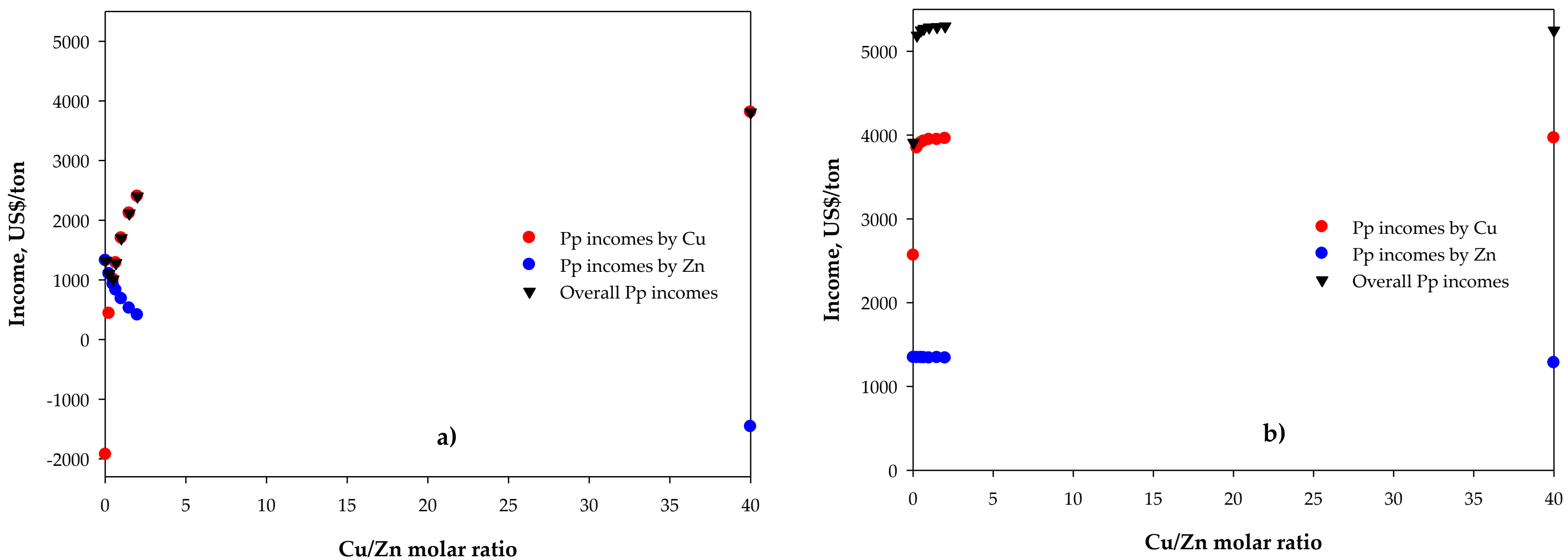
Economic results



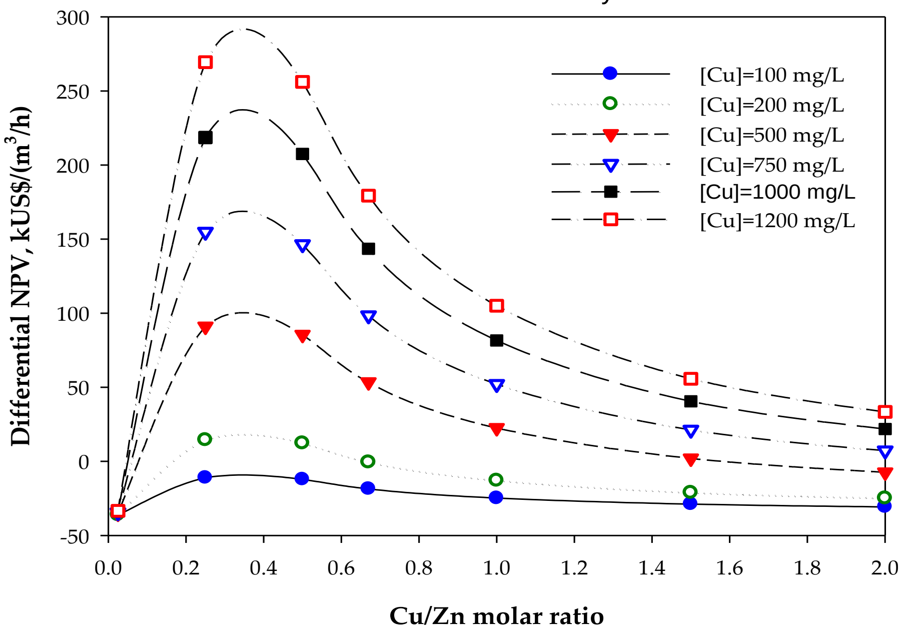
SART precipitate incomes for different Cu/Zn molar ratios. a) One-stage SART process; b) Two-stage SART process.

- Figures show the income results developed for both SART options, considering the high value of the metal precipitate for the conventional SART process.
- In this context, when the Cu / Zn molar ratio is less than 0.5, the income of the one-stage SART process is maximized by selling the precipitate as a zinc sulfide concentrate.

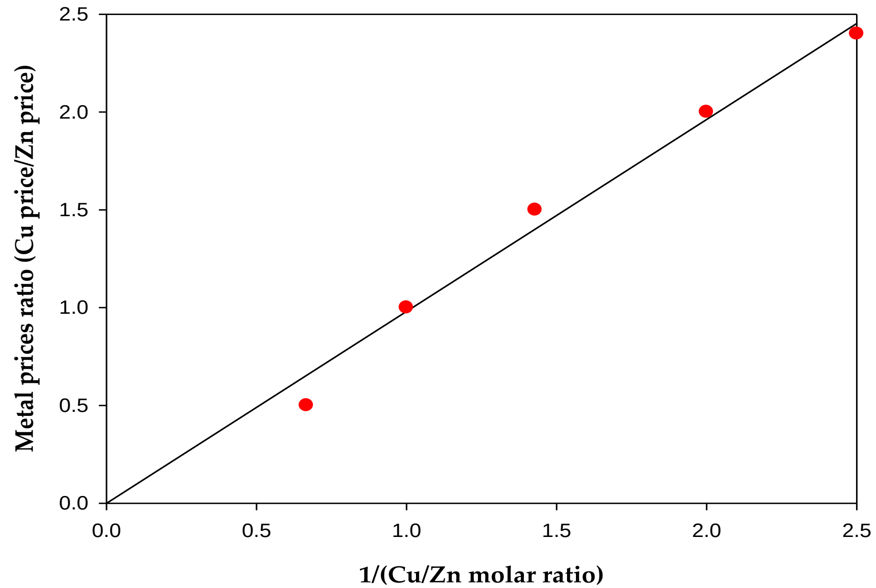
Results and discussion

Economic results

Differential NPV results for two-stage SART process, varying Cu/Zn molar ratio and metals concentration in a feed cyanide solution



Price ratio (Cu price/Zn price) v/s 1/(Cu/Zn molar ratio) at optimum NPV value



- When the metal concentration is higher than 200 mg/L and the Cu/Zn molar ratio is around 0.4, the differential NPV is optimal. This optimal value will be modified according to the values of metal prices. The optimum NPV value is reached when a factor defined as Optimal ratio (OR=Copper price/Zinc price x Cu/Zn molar ratio) is approximately 1.0.

- Therefore, a rapid estimation of the feasible range to apply the two-stage SART process is estimating the OR value.

Conclusion

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- This study has developed a methodology based on a theoretical and economic estimation using a modified Hydra/Medusa software which determines the feasible conditions to install a two-stage SART process in cyanidation plants having high copper and zinc contents in their solutions.
- Results suggest operational pH conditions of 7.5 and 4.0 for the first and second stage of the two-stage SART process, respectively.
- The economic results show the feasible range of application of the two-stage SART process for high zinc and copper concentration, over than 200 mg/L for both metals and a optimal condition when a OR parameter is close to 1.0.
- This SART option could be an excellent solution for gold cyanidation plants with Merrill-Crowe process installed in their flow-sheets which additionally contain high cyanide-soluble copper ores.

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