Research on an Innovative Bromination Leaching System for Gold Leaching Technology

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Abstract. An innovative bromination leaching system for gold leaching technology research. The conventional liquid bromine+sodium bromide leaching system has an acidic pH value and high leaching temperature requirements. At the same time, liquid bromine is highly toxic, volatile, and has strong irritation and corrosiveness to the mucosa. To solve this problem, the laboratory has studied a new bromination leaching system that can make bromine basically non volatile while retaining its oxidation ability, and dibromodimethylhydantoin can be regenerated through electrolysis. Experimental research has shown that using a new bromination leaching gold system to treat a certain mine's flotation raw ore, the leaching rate is 83.43% under the conditions of grinding fineness of -200 mesh accounting for 86% and leaching time of 30 minutes, which is 10.86% higher than cyanide leaching (leaching time of 48 hours). The system achieves the same cyanide leaching rate under normal temperature and neutral pH conditions, and the leaching rate is higher under acidic conditions. The leaching system can use carbon adsorption and resin adsorption for gold recovery from precious liquids, with a carbon adsorption rate of 99.5% and a resin adsorption rate of 97.8%. This technological research has opened up new ideas and directions for non cyanide leaching.

Keywords: Non cyanide leaching, Bromination leaching, Leaching rate, Precious liquid gold recovery

1 Introduction

Domestic and international research has found that compared to the leaching of bromine, cyanide, and thiosulfate, bromine leaching of gold has the advantages of fast dissolution rate and high leaching rate[1-3]. The liquid bromine content, pH value, and potential are the main factors affecting the bromination leaching of gold. The dissolution reaction formula of gold is as follows[4-7].

$$2Au + 3Br_2 + 2Br^- \leftrightarrow 2AuBr_4^-$$

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During this process, gold is complexed with bromine ions (Br^-) and oxidized by bromine (Br_2); Bromine can also be hydrolyzed to form hypobromic acid, which then oxidizes gold. The reaction formula is as follows[8-10].

$$Br_2 + H_2O \leftrightarrow HOBr + H^+ + Br^-$$

$$2Au + 3HOBr + 5Br^- + 3H^+ \leftrightarrow 2AuBr_4^- + 3H_2O$$

It should be noted that liquid bromine is highly toxic and volatile, with strong irritation and corrosiveness to the mucosa. Bromination leaching of gold to treat oxidized ore requires moderate reagent consumption[11-14].

In this report, research was conducted on conventional bromination leaching and new bromination leaching systems, and the Au recovery methods of the new bromination leaching gold system were explored, analyzing the advantages and disadvantages of this system. The principle flowchart of the new catalytic system explored in this study is shown in Figure 1.

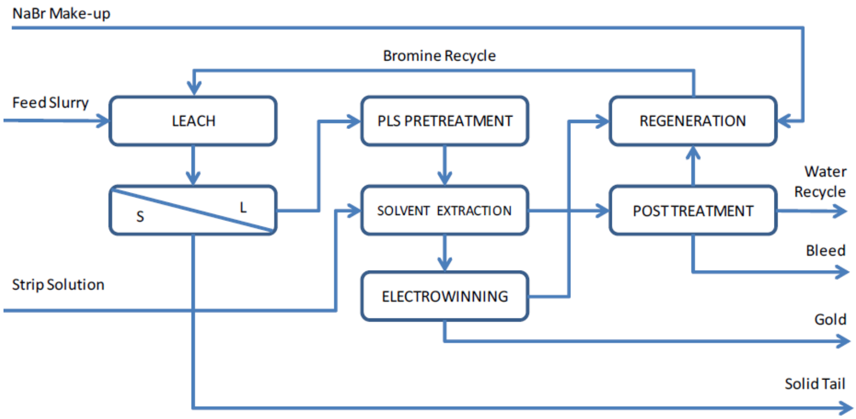

Fig. 1. Principle flowchart of a new bromination leaching system

The new bromination leaching process shown in the figure includes room temperature and atmospheric pressure bromination leaching, solid-liquid separation, noble liquid purification and concentration by noble liquid extraction method, gold recovery by electrolytic deposition method, followed by bromine leaching agent regeneration, and the final tailings are leached filter cakes. This system can successfully solve the problem of high toxicity and volatility of liquid bromine, achieving the same leaching rate as cyanide leaching under normal temperature and neutral pH conditions, and higher leaching rate than cyanide leaching under acidic conditions.

2 Research on Conventional Bromination Leaching Test

2.1 Applicability Test of Conventional Bromination Leaching System for Ores

Different types of ore, such as low sulfur concentrate, high copper concentrate, raw ore from a certain smelting company, and roasted raw ore, were selected for liquid bromine+sodium bromide system leaching experiments to verify the applicability of the bromination leaching system. The reagents used were sodium bromide, liquid bromine, iron sulfate, sulfuric acid, etc. The experimental pH was maintained at 1.3-2.0, the temperature was maintained at 70 °C, the amount of liquid bromine was 0.1mol/L, the amount of sodium bromide was 2.0mol/L, and the liquid-solid ratio was 4:1. The test results are detailed in the table 1.

Table 1. Validation Test Results of Different Ore Types for Conventional Liquid Bromine+Sodium Bromide System

Ore type	Raw ore Au grade/$g \times t^{-1}$	Au grade of leaching residue/$g \times t^{-1}$	Leaching rate/%
High copper concentrate	347.87	297.96	14.35
Low sulfur concentrate	9.99	8.44	15.52
Raw ore	2.91	0.57	80.41
Roasted raw ore	2.96	0.3	89.86

The experimental results and phenomena indicate that the bromination leaching rate of raw ore and roasted raw ore is very fast, approaching the maximum leaching rate within 4 hours; The leaching rate of high copper concentrate and high sulfur concentrate is poor due to the high sulfur content in their components and the consumption of leaching agents. Comparatively speaking, the leaching rate of the liquid bromine+sodium bromide system for roasted pre treated ore is higher at 89.86%, but still lower than the leaching rate of sodium cyanide (92%).

2.2 Recovery Test of Precious Liquid Au in Conventional Bromination Leaching System

Exploratory experiments were conducted on the Au recovery process for conventional bromination leaching of precious liquids. Strong alkaline anion resin and activated carbon were used for adsorption experiments using chromatography columns, with a dosage of 50g and an Au content of 0.65mg/L in the precious liquid. The results of carbon adsorption test are shown in Table 2, and the results of resin adsorption test are shown in Table 3.

Table 2. Test on Carbon Adsorption and Recovery of Au from Conventional Bromination Leaching Precious Liquor

Precious liquid volume/ml	Gold content in precious liquid/mg×L^{-1}	Gold content in lean solution/mg×L^{-1}	adsorption rate/%
15.00	0.65	0.063	90.31
20.00	0.65	0.064	90.15
25.00	0.65	0.086	86.77
30.00	0.65	0.108	83.38

Table 3. Conventional Bromination Leaching Precious Liquid Resin Adsorption and Recovery of Au Test

Precious liquid volume/ml	Gold content in precious liquid/mg×L^{-1}	Gold content in lean solution/mg×L^{-1}	adsorption rate/%
20.00	0.65	0.036	94.46
30.00	0.65	0.037	94.31
40.00	0.65	0.045	93.08
50.00	0.65	0.052	92.00

The test results show that the adsorption rate of using strong alkaline anion resin is slightly higher than that of activated carbon adsorption, with the highest adsorption rate reaching 94.46%.

3 Innovative bromination gold leaching system

The bromination leaching system with conventional liquid bromine and sodium bromide as the main reagents has an acidic leaching pH value and high leaching temperature requirements. At the same time, liquid bromine is highly toxic, volatile, and has strong irritation and corrosiveness to the mucosa. To address this issue, the laboratory has developed a dibromodimethylhydantoin (containing 54.5% active bromine) and calcium bromide leaching system, which can make bromine basically non volatile while retaining its oxidation ability. Additionally, dibromodimethylhydantoin can be regenerated through electrolysis[14-18].

An experimental study was conducted on the leaching system of dibromodimethylhydantoin and calcium bromide using a flotation raw ore from a certain mine. The sample has an Au grade of 1.75g/t, with a grinding fineness of -200 mesh accounting for 86%. Under the condition of cyanide leaching time of 48 hours, the Au grade of the leaching residue is 0.48g/t, and the Au leaching rate is 72.57%. Explored parameters such as pH value, dosage of reagents, and leaching time.

3.1 PH test

The pH value of a flotation raw ore in a certain mine was explored using a dibromodimethylhydantoin and calcium bromide leaching system experiment. Based on the experimental data, the relationship curve between pH value and Au leaching rate was plotted as shown in Figure 2.

The research results indicate that the leaching system has a residue grade of 0.52g/t and a leaching rate of 70.29% under the condition of pH value=7. With the continuous decrease of pH value, the leaching rate continuously increases, and tends to stabilize when it decreases to pH=4, with an Au leaching rate of 80.57%. Conduct experimental research under pH=4 conditions in the later stage.

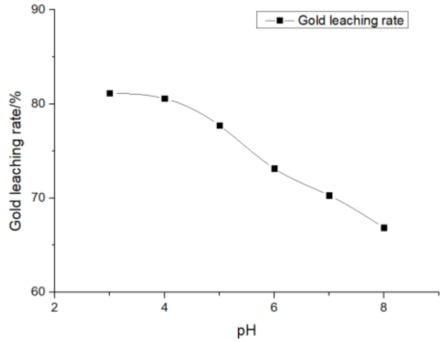

Fig. 2. Relationship curve between pH value and Au leaching rate

3.2 Calcium bromide dosage test

The exploratory experiment of calcium bromide dosage was conducted using pH=4 determined in the early stage. Based on the experimental data, the relationship curve between calcium bromide dosage and Au leaching rate was plotted as shown in Figure 3.

The experimental data shows that with the continuous increase of calcium bromide dosage, the leaching rate of Au continues to increase. When the addition amount is 80kg/t, continuing to add calcium bromide does not significantly increase the leaching rate of Au. Based on comprehensive comparative analysis, the optimal dosage of calcium bromide is determined to be 80kg/t.

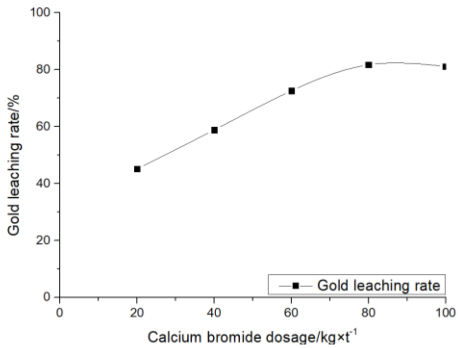

Fig. 3. Relationship curve between calcium bromide dosage and Au leaching rate

3.3 Dosage test of dibromodimethylhydantoin

A preliminary experiment was conducted to explore the dosage of dibromodimethylhydantoin using pH=4 and 80kg/t calcium bromide. Based on the experimental data, the relationship curve between the dosage of dibromodimethylhydantoin and Au leaching rate was plotted as shown in Figure 4.

The experimental data shows that with the continuous increase of the dosage of dibromodimethylhydantoin, the leaching rate of Au continues to increase. When the dosage is 100kg/t, continuing to add dibromodimethylhydantoin does not significantly increase the leaching rate of Au. Based on comprehensive comparative analysis, the optimal dosage of dibromodimethylhydantoin is determined to be 100kg/t, which is the main leaching agent for this leaching process.

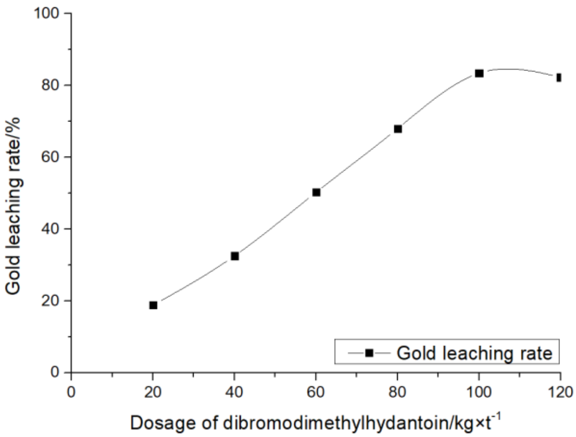

Fig. 4. Relationship curve between the dosage of dibromodimethylhydantoin and the leaching rate of Au

3.4 Iron sulfate dosage test

Exploratory experiments were conducted using pH=4, calcium bromide dosage of 80kg/t, and dibromodimethylhydantoin dosage of 100kg/t, respectively. Based on the experimental data, the relationship curve between iron sulfate dosage and Au leaching rate was plotted as shown in Figure 5.

The experimental data shows that with the continuous increase of iron sulfate dosage, the Au leaching rate continues to increase. When the addition amount is 0.4kg/t, continuing to add iron sulfate does not significantly increase the Au leaching rate. Through comprehensive comparative analysis, it was determined that Fe3+is the main catalyst, and the optimal amount of iron sulfate is 0.4kg/t.

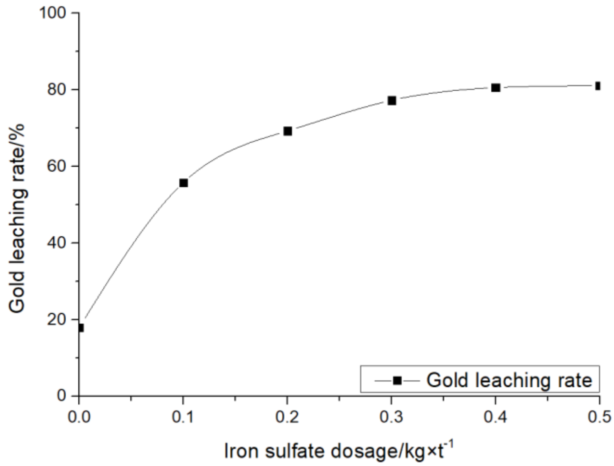

Fig. 5. Relationship curve between the amount of iron sulfate used and the leaching rate of Au

3.5 Immersion time test

Exploratory experiments were conducted using pH=4, calcium bromide dosage of 80kg/t, dibromodimethylhydantoin dosage of 100kg/t, and iron sulfate dosage of 0.4kg/t, respectively. Based on the experimental data, the relationship curve between iron sulfate dosage and Au leaching rate was plotted as shown in Figure 6.

The experimental data shows that with the extension of time, the Au leaching rate continuously increases. When the time is 30 minutes, the increase in Au leaching rate is not significant if the time is continued to be extended. Based on comprehensive comparative analysis, the optimal leaching time was determined to be 30 minutes.

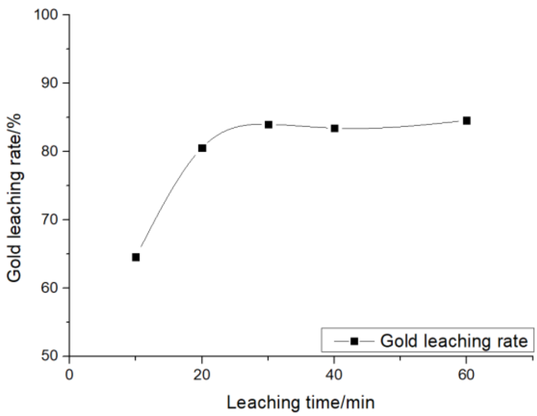

Fig. 6. Relationship curve between leaching time and Au leaching rate

3.6 Extraction of Precious Liquid Adsorption Experiment

Exploring the adsorption process for the leaching of precious liquid using a new type of gold leaching reagent system, using activated carbon and resin for adsorption experiments. The leaching system can use carbon adsorption and resin adsorption for gold recovery from precious liquids, with a carbon adsorption rate of 99.5% and a resin adsorption rate of 97.8%.

4 Conclusion

A system of dibromodimethylhydantoin and calcium bromide was used to treat the flotation raw ore of a certain mine. Under the conditions of grinding fineness of -200 mesh accounting for 86% and leaching time of 30 minutes, the leaching rate was 83.43%, which was 10.86% higher than cyanide (leaching time of 48 hours).

The system achieves the same cyanide leaching rate under normal temperature and neutral pH conditions, and the leaching rate is higher under acidic conditions.

The leaching system can use carbon adsorption and resin adsorption for gold recovery from precious liquids, with a carbon adsorption rate of 99.5% and a resin adsorption rate of 97.8%.

The leaching system has a high consumption of dibromodimethylhydantoin and calcium bromide reagents, resulting in high leaching costs.

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