

Study on Gold Extraction from Thiosulfate-Ethylenediamine-Copper Ion System

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Abstract: A gold mine in Myanmar is used as the research object in this paper. The thiosulfate-ethylenediamine-copper ion process conditions are discussed from the three aspects that affect the leaching effect: thiosulfate concentration, ethylenediamine concentration and copper ion concentration. It has certain significance for enriching the theory and practice of the system. The leaching conditions are: grinding fineness $-74\mu\text{m}$ 95%, ammonium thiosulfate concentration is selected as 0.3mol/L, copper ion concentration is selected as 0.005mol/L, ethylenediamine concentration is selected as 0.06mol/L, and the pH value is adjusted to about 10, liquid to solid mass ratio of 3:1, stirring and leaching at room temperature for 7h, on this basis, the gold leaching rate is 81.05%.

1. Introduction

Thiosulfate is one of the most promising green gold leaching reagents that can replace cyanide. Its advantage is that it can form stable complexes with gold. It has the advantages of fast gold leaching speed and non-toxicity. However, there are also many problems with thiosulfate systems, including the large consumption of thiosulfate, the system is unstable, the components of the leachate are complicated, and the recovery is difficult [1-2].

Thiosulfate-ammonia-copper ion is the standard system for thiosulfate extraction of gold. This system is thoroughly studied in theory and practice, but the ammonia used in the process is toxic and volatile, so some scholars [3-5] Seeking a new system to replace the thiosulfate-ammonia-copper ion system. The thiosulfate-ethylenediamine-copper immersion gold system is a polyamine compound Cu (II) complex ion formed by the polyamine compound ethylenediamine and Cu (II), thus replacing the copper ammonia complex ion. In the practice of the sulfate-ethylenediamine-copper ion immersion gold system, there have been references to systematic research on the practice of thiosulfate-ethylenediamine-copper ion immersion gold system [6]. Xiang Pengzhi et al. [7] found that thiosulfate-ethylenediamine-copper ion did not produce precipitation in a wider pH range than the standard copper ammonia system, showing better stability and thiosulfate consumption the rate is about 17% to 18%. From the above analysis, it can be seen that thiosulfate-ethylenediamine-copper ions have potential application value. This

paper uses a gold mine in Myanmar as the research object. From the most influential leaching effect, the concentration of thiosulfate, ethylenediamine and the three aspects of copper ion concentration to explore the thiosulfate-ethylenediamine-copper ion process conditions have certain significance for enriching the system theory and practice.

2. Test

2.1 Reagents and samples

The copper sulfate pentahydrate, ethylenediamine, ammonium thiosulfate and sodium hydroxide are analytically pure; the test water is deionized water; the ore is a high-sulfur primary gold mine of Myanmar grade 14.6g / t The main components of gold-bearing minerals are pyrite and toxic sand.

2.2 Test method

For ore fineness of -74 μm 95% high-sulfur primary gold ore, roasted at 700°C for 2 hours as the leaching sample. The leaching test conditions were combined with the literature according to the following conditions: the ammonium thiosulfate concentration was selected to be 0.005 to 0.5 mol/L. The copper ion concentration is selected from 0.002 to 0.01 mol / L, the ethylene diamine concentration is selected from 0.01 to 0.1 M, the pH value is adjusted to about 10, the liquid to solid volume ratio is 3:1, and the mixture is leached at room temperature for 6 hours. After leaching for a certain period of time, suction filtration, drying are performed, the gold concentration is measured, and the gold leaching rate is calculated.

2.3 Analysis method

The reference [8-9] used the atomic absorption spectrophotometry (AA320, Shanghai Instrument Electric Science Instrument Co., Ltd.) to measure the gold content in the filter residue and the leaching solution, respectively, to determine the gold leaching rate; the pH value was measured using a PHS-25 pH meter (Shanghai Instrument Electric Science Instrument Co., Ltd.).

3. Results and discussion

3.1 Effect of thiosulfate concentration

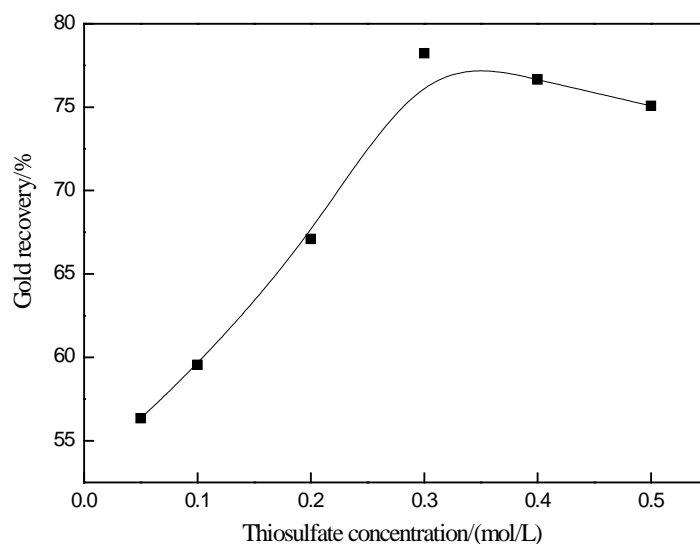
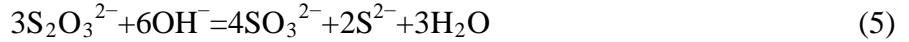
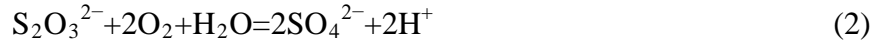
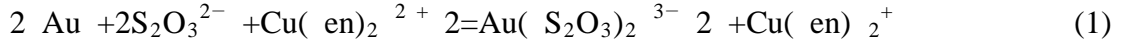


Figure. 1 Effect of thiosulfate concentration on gold leaching



In the gold extraction process of thiosulfate system, $\text{S}_2\text{O}_3^{2-}$ combined with gold as complexing agent as shown in Equation (1), $\text{S}_2\text{O}_3^{2-}$ was oxidized by oxygen as shown in Equation (2). The reaction of copper ammonium ions with thiosulfate will lead to a large consumption of thiosulfate in the process of gold leaching. In addition, the pH of the solution will also affect the consumption of thiosulfate, because $\text{S}_2\text{O}_3^{2-}$ is prone to disproportionation as equation (3)-(5). Studies by Deng et al. [10] showed that the gold leaching rate remained basically unchanged when the thiosulfate content exceeded 0.1 mol/L, but the gold leaching rate decreased as the thiosulfate further increased, the reason may be the ions such as sulfur ions that are decomposed easily precipitate with the heavy metal ions in the pulp when the thiosulfate is added too much. The precipitate will cover the surface of the ore and cause troubles for further leaching. Gao Peng et al. [11] showed that the optimal amount of thiosulfate is 0.3 mol / L in process of leaching gold from a Carlin-type gold. Too much thiosulfate will destroy the stability of $\text{Cu}(\text{en})_2^{2+}$ which reduced the gold leaching rate, Liu Lin [12] found that the thiosulfate in the leaching solution was generally selected to be 0.1 mol / L, which would not have a significant effect on the displacement effect. It can be found from the literature that the optimal concentration range of thiosulfate should be 0.05 to 0.5 mol / L, but under the conditions of leaching, a lower concentration of thiosulfate should be selected.

Feng [13] investigated the effect on leaching of gold concentrates using different thiosulfates the results showed that $(\text{NH}_4)_2\text{S}_2\text{O}_3$ is more suitable for treating high-sulfur ore. The ammonium thiosulfate used in this test was used to examine its effect on leaching of gold. The leaching conditions are as follows: the copper ion concentration is selected as 0.005 mol/L, the ethylenediamine concentration is selected as 0.05 mol / L, the pH value is adjusted to about 10, the liquid-solid volume ratio is 3: 1, and the leaching is performed at room temperature for 6h. The results are shown in Fig. 1. It can be seen from Figure 1 that the gold leaching rate increases as the thiosulfate concentration increases. When the concentration is 0.3 mol / L, the gold leaching rate reaches the maximum and it is 78.23%; but the leaching rate decreased slightly as the thiosulfate concentration continued to increase, because the excessive thiosulfate concentration caused excessive reduction of $\text{Cu}(\text{en})_2^{2+}$, which affected $\text{Cu}(\text{en})_2^{2+}$ concentration. Feng [14] believes that $\text{Au}(\text{S}_2\text{O}_3)_2^{3-}$ can be adsorbed by ore, and this adsorption effect can be eliminated by moderately increasing the concentration of $\text{S}_2\text{O}_3^{2-}$. Combined with the above analysis, the concentration of $\text{S}_2\text{O}_3^{2-}$ was selected as 0.3 mol / L.

3.2 Effect of ethylenediamine concentration

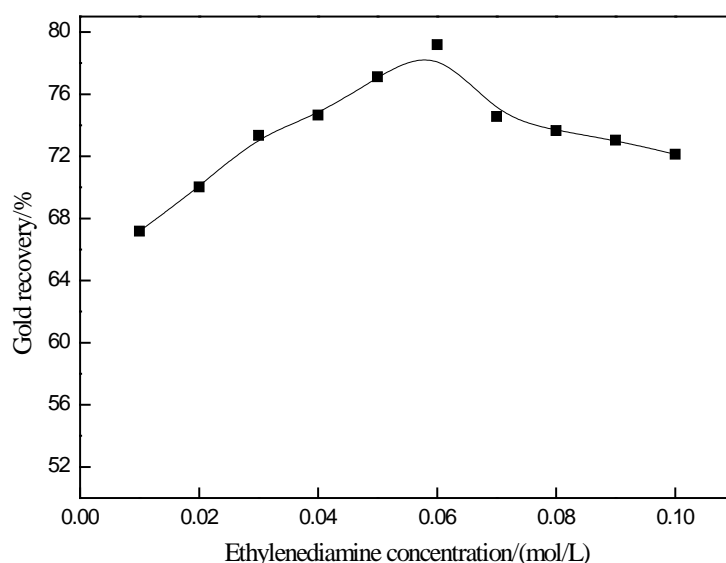
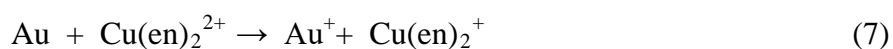


Figure. 2 Effect of ethylenediamine concentration on gold leaching



In the thiosulfate-ethylenediamine-copper ion immersion gold system, as shown in the equation (6), ethylenediamine and copper ions form stable ethylenediamine Cu (II) complex ions. Two N atoms can be used as coordination atoms, which can simultaneously coordinate with Cu^{2+} with a coordination number of 4 to form a chelate compound $\text{Cu}(\text{en})_2^{2+}$ with a cyclic structure. $\text{Cu}(\text{en})_2^{2+}$ can directly oxidize Au, Its equation is (7), and the effect of leaching conditions on the concentration of ethylenediamine is examined: the concentration of ammonium thiosulfate is selected as 0.3mol/L, the concentration of copper ion is selected as 0.005mol / L, the pH is adjusted to about 10, The volume-to-mass ratio is 3: 1, and leaching is carried out at room temperature for 6 hours. The results are shown in Fig. 2. It can be seen from Figure 2 that the gold leaching rate increases when the ethylenediamine concentration increases. When the ethylenediamine concentration is 0.06mol/ L, the gold leaching rate reaches the maximum, which is 79. 19%; but after the ethylenediamine concentration continued to increase, its leaching rate decreased. This is because ethylenediamine is a Cu^{2+} complexing agent. When the concentration is too low, the $\text{Cu}(\text{en})_2^{2+}$ generated is not enough to leach more gold; and when the concentration is too large, the solution's leaching potential will be lowered, so that Consuming too much thiothiosulfate is not conducive to the further leaching of gold. Therefore, the optimal concentration of ethylenediamine is selected as 0.06mol / L.

3.3 Copper ion concentration affects

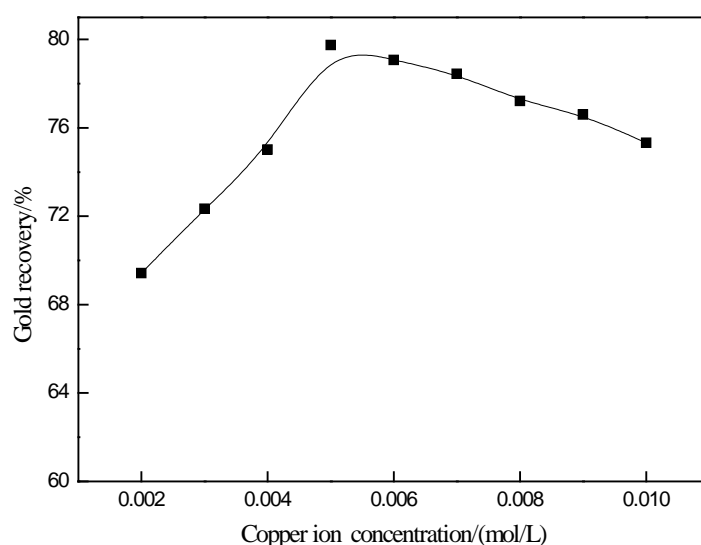
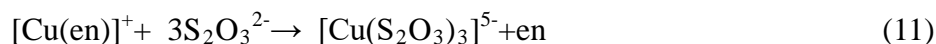
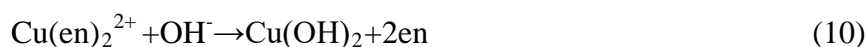


Figure. 3 Effect of Copper ion concentration on gold leaching



When the copper concentration is less than 5 mmol/L, the leaching rate is not controlled by Cu (II) diffusion; while at high thiosulfate concentrations, Cu (II) diffusion is controlled. Jiang Tao et al. [15] believed that in the process of thiosulfate leaching gold, copper ammonia complex ions are the main factor to obtain a high leaching rate, which is indispensable, which indicates that the complex ions formed by copper and complexing agent have an effect on gold. Leaching is crucial. Copper ions and ethylenediamine form diethylenediamine copper ions. If the copper ion concentration is too high, many side reactions will occur, such as copper hydroxide precipitation according to equation (8)-(10), as shown in Fig.3: the gold leaching rate increases as the Cu^{2+} concentration increases. When the Cu concentration was 0.01 mol/L, the gold leaching rate reached the maximum at 79.75%; but the Cu^{2+} concentration continued to increase and the gold leaching rate decreased instead. This is because when the Cu^{2+} concentration is very low, the $\text{Cu}(\text{en})_2^{2+}/[\text{Cu}(\text{en})]^+$ potential is low, and Au can not be effectively oxidized, and the leaching rate is very low; but the Cu^{2+} concentration is too high, which is not good for $\text{S}_2\text{O}_3^{2-}$. It will cause more $\text{S}_2\text{O}_3^{2-}$ to be oxidized, increase the consumption of thiosulfate, increase the complexity of the system, and bring trouble to the subsequent recovery of gold ions [14].

3.4 Leaching time

Examine the effect of leaching time on gold leaching under the given leaching conditions, the given leaching conditions were: grinding fineness -74 μm 95%, and ammonium thiosulfate concentration was selected as 0.3mol/L, the copper ion concentration is selected as 0.005mol/L, the ethylenediamine concentration is selected as 0.06M, the pH value is adjusted to about 10, the

liquid-to-solid volume ratio is 3: 1.As shown in Fig.4,it was found that gold recovery reached maximum in seven hours which is 81. 05%, the gold recovery has little change after 7 hours, then, the leaching time is selected as 7h.

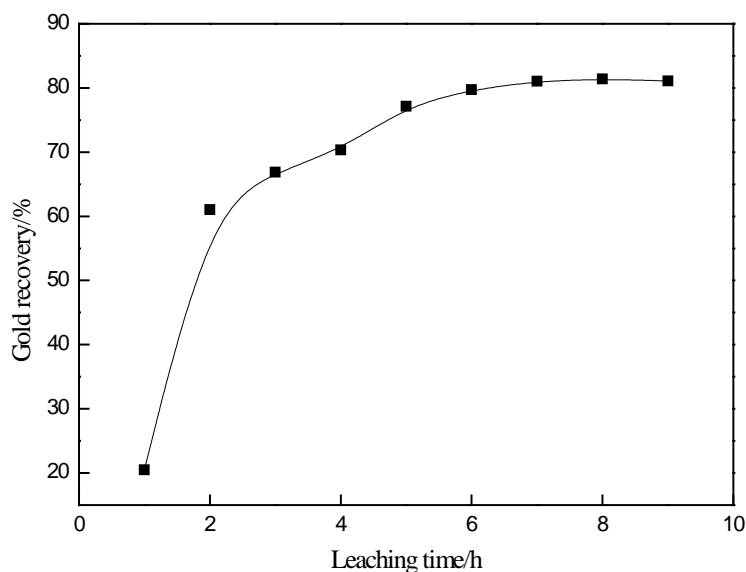


Figure. 4 Effect of leaching time on gold leaching

4. Conclusion

A high-sulfur primary gold mine with a grade of 14.6g / t in Myanmar was roasted at 700°C for 2h as a leaching sample. The leaching conditions were: grinding fineness -74 μm 95%, and ammonium thiosulfate concentration was selected as 0.3mol/L, the copper ion concentration is selected as 0.005mol / L, the ethylenediamine concentration is selected as 0.06M, the pH value is adjusted to about 10, the liquid-to-solid volume ratio is 3:1, and the mixture is leached at room temperature for 7h. The gold leaching rate is 81. 05%.

Acknowledgements

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