

THE RECOVERY OF GOLD FROM A PREAGNANT GOLD-THIOSULFATE LEACH SOLUTION USING ION EXCHANGE RESIN

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ABSTRACT

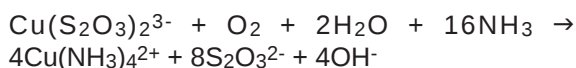
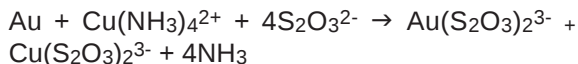
The loading of gold and copper from a pregnant gold thiosulfate leach solution onto ion exchange resin and the subsequent elution of these metals have been investigated. In this study, strong basic resins of Amberjet-4200 and IRA-400 were used and thiocyanate was used as eluent. It was found that on Amberjet-400, the gold loading reached about 2-3 kg/t, in correspondence to 0.4 ppm gold in the effluent. On IRA-400, the performance was almost exactly the same loading as on Amberjet-4200 but with the effluent gold concentration being slightly higher. In leach solutions, copper is present in much higher concentrations than gold, since it is added as a catalyst for gold dissolution. The maximum Cu loading obtained on Amberjet-400 was about 22 kg/t while it was about 24 kg/t on IRA-400. These results indicate that gold can be removed from thiosulfate solutions rapidly and loaded on resins to very high concentrations. Subsequent gold elution with thiocyanate ions was very efficient; the concentration of gold on resin was reduced from about 2-3 kg/L down to less than 10 ppm (99,9% elution) under ambient temperature in 2-4 hours.

Keywords: gold, copper, thiosulfate, loading, ion exchange resin, elution

1. INTRODUCTION

The current use of cyanidation techniques to leach gold from its various ores is undesirable from an environmental perspective. In recent years, many countries such as Japan, Turkey, the Czech Republic, the states of California, Colorado, Wisconsin in the USA, have banned the use of cyanide (Mineral Policy Centre, 2000). This is due predominantly to the acute toxicity of cyanide. The use of alternative lixiviants for gold extraction has been studied and developed, and has been discussed in numerous reviews (e.g. Fleming et.al., 2003; Aylmore and Muir, 2001). The process of leaching with thiosulfate solution can be considered as a promising alternative to cyanide leaching. In the presence of ammonia and copper in solution, gold can be readily leached by thiosul-

fate at alkaline condition to form a gold-thiosulfate complex. A possible mechanism for the leaching reaction has been proposed as (Nicol and O'Malley, 2002):



Compared to the conventional cyanidation process, thiosulfate leaching offers the advantages of much lower toxicity, lower reagent costs and faster leaching rate, particularly for some refractory ores, e.g. some carbonaceous gold ores. For those reasons, thiosulfate leaching has been considered to be the most promising method to re-

place the cyanidation process in commercial application. However, the recovery of gold from thiosulfate leaches remains difficult. It has been shown that the gold-thiosulfate complex is very poorly loaded onto activated carbon (Gallagher et.al., 1990). This renders the widely accepted carbon-in-pulp technology useless for the thiosulfate system. Recent publication (Fleming et al., 2002) has shown the possibility of using ion exchange resins to recover gold from thiosulfate solution. Therefore, the loading and elution behavior of gold has been investigated in the current work using ion exchange resin and the results are now presented.

2. MATERIALS AND METHOD

In this research, initial test work involved small scale experiments in the laboratory. In these experiments, the thiosulfate leachings were optimized and thiosulfate consumption was minimized (Suratman et.al, 2006) to obtain a pregnant gold thiosulfate solution as a feed onto resin. Commercially available strongly basic anion exchange resins of Amberjet-4200 and IRA-400 were obtained in their wet forms and used without treatment. The ion exchange column was constructed with a 1000-mL burette with small glass wool plugs both at the bottom and on the top of the resin bed. The volume of the bed was approximately taken as 200, 300, 400, and 600 ml of wet resin. The solution was pumped in through a rubber stopper on the top of the burette using a peristaltic pump. The effluent was collected from the tip at the bottom. Figure 1 shows the configuration of ion exchange column. All loading experiments were carried out at room temperature and pH 11. Such a pH was found to be optimal for the following reasons. Firstly, the Cu-ATS solution tends to decompose at lower pHs, forming copper sulfides, while at higher pHs the chance for copper hydroxide precipitation increases. Secondly, the resins can be prevented from poisoning at pH 11 since tetrathionate, which may be formed prior to and during the loading, is not stable in strongly alkaline solutions and quickly decomposes to thiosulfate and sulfite (Zhang and Dreisinger, 2003).

A fraction collector was used to take solution samples during either loading or elution. In other experiments, the loading or elution effluents were collected as a whole only for the final results. Gold

and copper in solution were analyzed by chemical analytical laboratories using AAS. The loading Q , presented as the amount of a metal on unit mass of wet resin, as well as the elution efficiency, could then be calculated. Yet, more reliable loading values could be determined from elution, i.e. from the total amount of metals eluted and remained, the latter being found out by resin assay. Accordingly, the elution efficiencies could be calculated on the same basis.

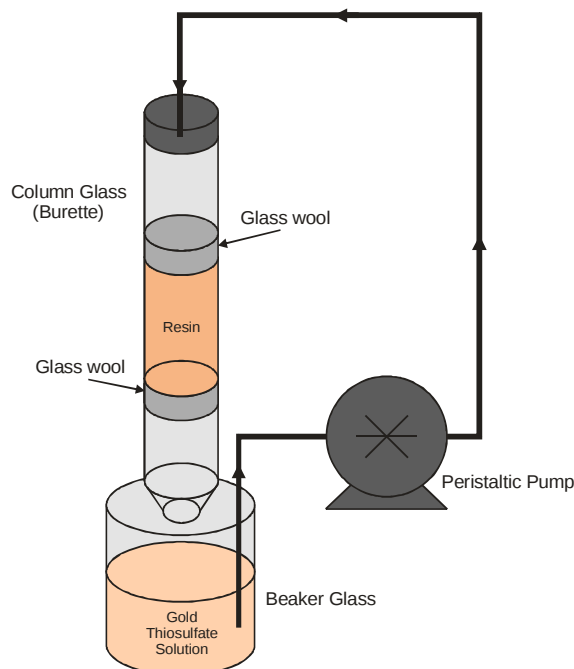


Figure 1. Ion exchange column configuration

The elution of gold and copper from resins was carried out with an eluant solution composed of 0.2 M thiocyanate, with a flow rate of 100 ml/min, pH 2, at room temperature.

3. RESULTS AND DISCUSSION

3.1. Characteristics of Resins Used

Amberjet-4200 and IRA-400 resins are gel types with a polystyrene divinylbenzene matrix and ammonium functional groups. The physical and chemical properties of Amberjet-4200 and IRA-400 resins are presented in Table 1.

Table 1. The physical and chemical properties of the resins used (Grosse et.al., 2003)

Resin	Type	Meq/g	Matrix	[SO ₂ O ₃ ²⁻]	[NH ₃]	pH
Amberjet 4200	Quaternary ammonium	3.7	Gel	0.05 M	0.2 M	9.5
IRA 400	Quaternary ammonium	3.8	Gel	1.0 M	0.1 M	9-12

3.2. Gold Loading

The results for gold loading from the pregnant gold-thiosulfate leach solution containing 0.1 M ammonium thiosulfate (ATS) and 10 mg/L Au onto the columns of Amberjet-4200 and IRA-400 resins are shown in Fig. 2. The effluent was collected in fractions at different times in order to observe the kinetics of the loading process.

not saturated. These results indicate that gold can be removed from leach solutions rapidly and loaded on resins to very high concentrations.

3.3. Copper Loading

In pregnant gold leach solutions, copper is present in much higher concentrations than gold, since it is added as a catalyst for gold dissolution. There-

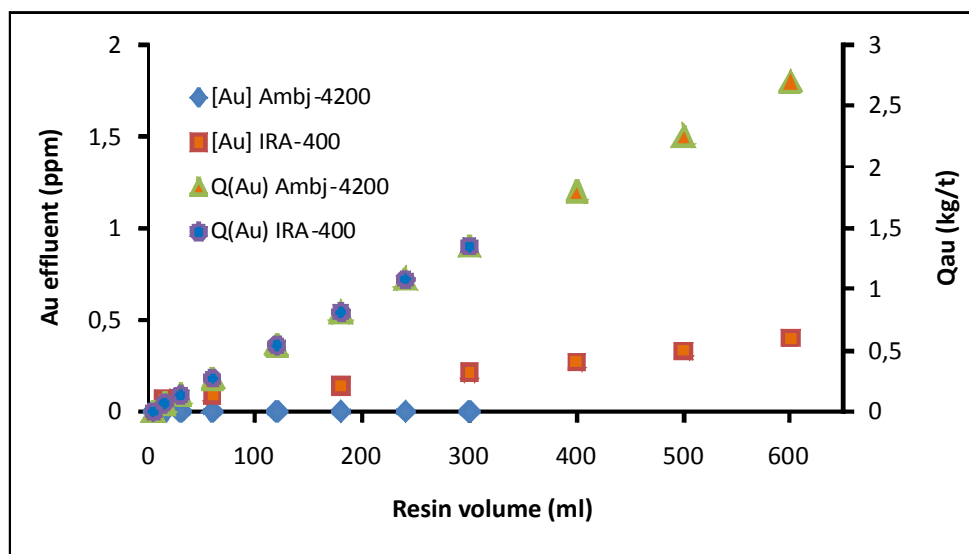


Figure 2. Gold loading onto Amberjet 4200 dan IRA-400 resins

On Amberjet-4200, 300 resin volume loading solution containing 10 ppm Au was pumped through the column at a rate of 100 ml/min and virtually no gold was detected in the effluent. This indicates that the ion exchange reaction was fast since the retention time of the solution in the resin bed was less than 10 min. On IRA-400, 600 resin volume solution was used and almost exactly the same loading as on Amberjet-4200 was obtained, but with the effluent gold concentration being slightly higher. As more solution passed through the column, gold loading increased almost linearly, reaching about 2-3 kg/t, in correspondence to 0.4 ppm gold in the effluent. Both columns were

fore, the interaction between copper and the resins was also investigated. Typical kinetic curves for the loading of copper on Amberjet-4200 resin from 0.1 M ATS containing 300 ppm Cu are presented in Fig. 3. As can be seen, the change in effluent Cu concentration underwent two stages as a total of 1500 ml solution passed through the column. In the first stage (0 - 200 ml), Cu concentration was maintained at about 300 ppm. This probably reflected the presence of some Cu(II) in the original loading solution since the cationic Cu(II)-amine complex would not be expected to load with the anion exchange resin.

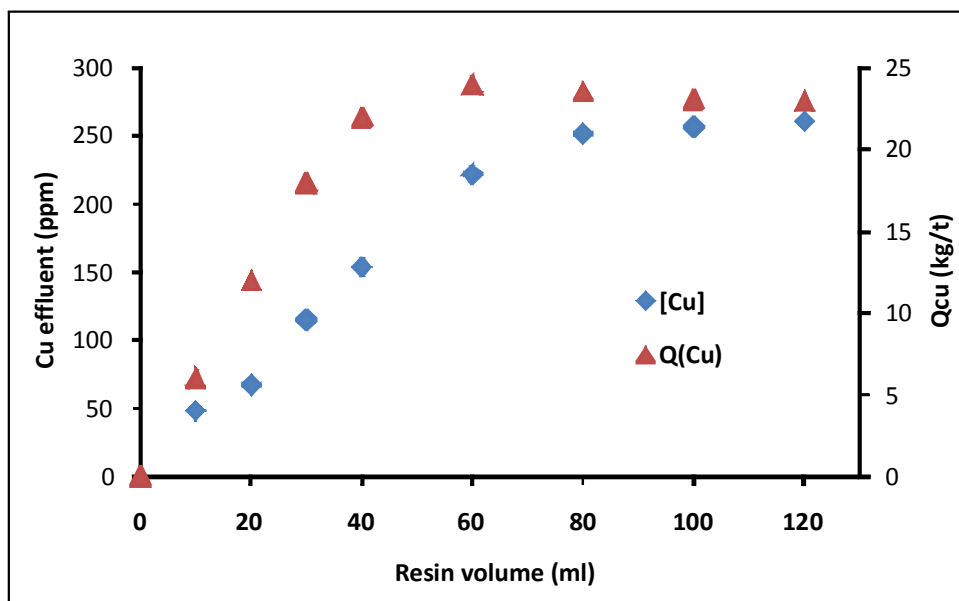


Figure 3. Loading of copper onto Amberjet 400 resin from gold leach solution containing 0.1 M ATS and 300 pp Cu at flow rate of 100 ml/minute, pH 11

However, this level varied in different experimental runs possibly because the ratio of Cu(II)/Cu(I) was not steady. It was believed that virtually all the anionic Cu(I)–thiosulfate complex in the original solution had been adsorbed by the resin in the first stage. As a result, the amount of copper loaded on the resin increased rapidly with increasing solution volume. In the second stage (200 - 600 ml), the breakthrough of Cu(I) occurred and the total Cu concentration in the effluent rose gradually to the same level as in the initial loading solution, suggesting the column was saturated. Accordingly the copper loading reached a maximum. In the last stage, Cu concentration in the effluent increased slowly exceeding the initial level and Cu loading declined slightly, indicating that some of the loaded copper returned to the solution. This may be attributed to the presence of a small amount of tetrathionate or trithionate in the original loading solution, which may have not completely decomposed under the given conditions. The deleterious species accumulated on the resin as more solution passed through the column, replacing some of the already loaded copper. Similar curves were recorded with IRA-400 resin, but with somewhat higher loading capacity. The maximum Cu loading obtained on Amberjet-4200 was about 22 kg/t while it was about 24 kg/t on IRA-400.

3.4. Elution

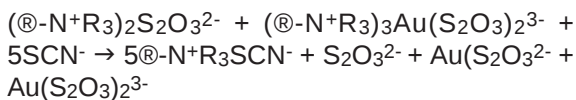
The elution was conducted immediately after the completion of the loading. In this experiment, thiocyanate was selected as an eluant since it strongly competes with the metals to adsorb onto the resins (Nicol et.al., 2002). Ammonium thiosulfate was added to the stripping solution to stabilize the eluted gold and copper. The results obtained are presented in Table 2.

Table 2. Elution of gold and copper with thiocyanate from strong base resin (eluant flow rate 100 ml/min, eluant pH 2 at room temperature)

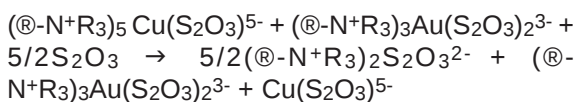
Sample analyzed	Au, ppm	Cu, ppm
Loaded resin	2,755	20,400
Copper eluate	1.14	53
Gold eluate	6	4.1
Eluted resin	3	9
Elution efficiency		
Copper elution, %	0.3	97.4
Gold elution, %	99.6	2.4
Total, %	99.9	

The results presented in Table 2 show that thiocyanate solution eluted 99.9 % of the gold and 99.8 % of copper from strong base resins in 3 – 4 hours under ambient conditions. A split elution technique would produce a pregnant eluate containing <10 ppm gold and copper. The equations describing the elution reactions of gold and copper are (Fleming et.al., 2003; Virnig and Mackenzie, 1998):

Gold elution:



Copper elution:



At the end of the gold elution step, all of the resin functional groups are occupied with thiocyanate ions because of the high affinity of strong base resins for this anion. Those results show that gold elution with thiocyanate ions was very efficient; the concentration of gold on resin was reduced from about 2-3 kg/L down to less than 10 ppm (99,9% elution) under ambient temperature in 2-4 hours.

4. CONCLUSION

Gold and copper can be loaded onto strongly basic ion exchange resin from a pregnant gold leach thiosulfate solutions rapidly and to high loading concentrations. For a typical gold leach solution of 0.1 M ATS with 10 ppm gold and 300 ppm copper, the operation pH of 11 was good and there was not much allowance for changes. Under such conditions, the adsorption of gold onto the resins was much stronger than copper. Effective elution of the loaded gold and copper can be achieved using a number of composite eluant solutions containing thiocyanate. Thiocyanate was the best eluant in terms of efficiency. It needs further study to observe loading/elution cycling capacity as to whether the resin can be used repeatedly without deterioration in the resin loading or elution performances.

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