

DEVELOPMENT AND IMPLEMENTATION OF ECOLOGICAL AND EFFECTIVE TECHNOLOGIES FOR PRECIOUS METAL EXTRACTION

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ABSTRACT. Pyrite concentrates contain precious metals from 5 to 10 g Au and from 20 to 50 g Ag per ton. Thiosulphate leaching is one of die environmentally friendly methods for precious metal recovery. Results from voltammetric investigations of the pyrite anodic dissolution at different thiosulphate concentrations are described in the paper. On the basis of results obtained, it is supposed that Au - bearing pynte behaves like a galvanic pyrite - gold cell. Laboratory experiments have been conducted with the thiosulphate solution in which the maximum pyrite dissolution cunent was obtained. Results from the thiosulphate leaching as well as the technological scheme are described.

INTRODUCTION

Hydrometallurgical thiosulphate leaching method for precious metals extraction from pyrite concentrates is rarely used (Berezowsky et al., 1979). A low degree of extraction can be achieved by means of cyanide and thiocarbamide leaching (CrrundweII,1988). Better results can be obtained by means of thiosulphate leaching. The application of the latter method results in 10-15 % higher Au extraction in die liquid phase, reached in ten times shorter time.

Pecularity of this method is the necessity to find the relationship among the particular raw material, precious metal content and reagent composition of the leaching solution The aim of this paper is to find the main dependencies concerning thiosulphate leaching of gold from pyrite products in order to perform successful practice of the process.

2.EXPERIMENTAL

The investigations were carried out by means of cyclic and linear sweep voltametry. EG&G 273 Princeton Applied Research Potentiostat and a conventional three - electrode cell was used. Potentiostatic investigations have been earned out with a stationary pyrite (Py) electrode-monocnstal (with dimensions 1x1x1 cm) Working electrodes were made of Au,Au-bearing Py powder and Py monocrystai by Cu wire. Cu was plated on the one of the mineral walls and a Cu wire was soldered Gold electrode had 1 cm² of working surface immersed in the solution and was soldered to a Cu wire Cu wires were out of the experiments and did not influence the results obtained. The experiments were earned out in a borate buffer (pH=8,4) (Une, 1971) and

working solution (37%(NH₄)₂S₂O₃ + 3 g/l CuSO₄.5H₂O + 40 ml 25 % NH₄OH), having the borate buffer as a supporting electrolyte . The experiments have been carried out at thiosulphate concentrations - 13 g/dm³; 26 g/dm³; 39 g/dm³. The solutions were prepared with distilled water and analytical grade reagents . The potential scanning covered the range from -600 to +700 mV at scan rate of 5 mV/s. The reference electrode used was silver-silver chloride electrode Potential values In the text and in the figures are converted and given versus saturated hydrogen electrode. The measurements were carried out at room temperature. Argon was used for purging . The results obtained are shown in Fig.1 and Fig 2. The chemical composition of the working solution is chosen on the basis of our preliminary experiments carried out to find its optimal composition (Panayotov et al, 1995).

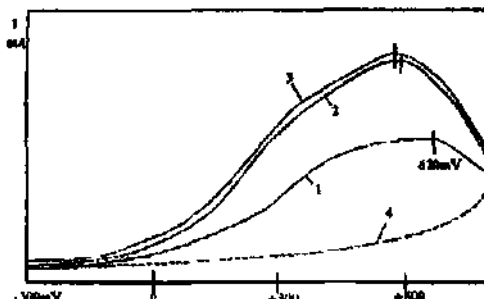


Figure I. Voltammetric curves for Au-beanng Pynte electrode in working solution with different concentrations of (NH₄)₂S₂O₃ ; 1 - 13 g/dm³; 2 - 26 g/dm³, 3 - 39 g/dm³, 4 - no thiosulphate.

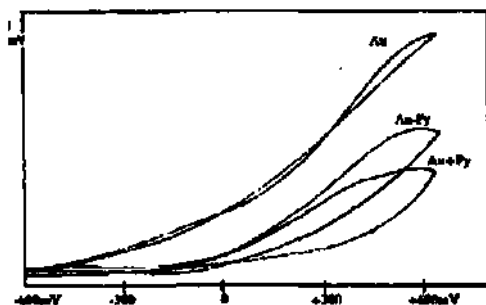


Figure 2. Voltammetric curves for Au, Au bearing Pyrite (Py-Au), Pyrite (Py+Au) electrode in thiosulphate solution

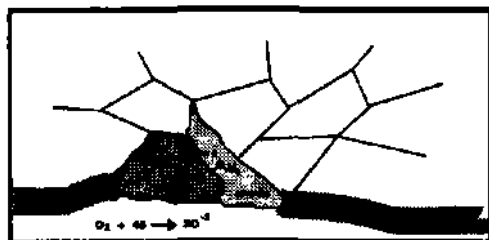
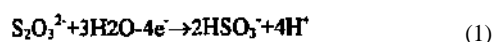


Figure 3. Au/Py corrosion galvanic cell

3.RESULTS AND DISCUSSION

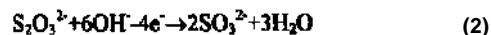
The voltammetric curves obtained with Au-bearing pyrite electrode are shown in Figure 1. An increase in the peak current at about 600 mV when increasing the concentration till 26 g/dm³ has been observed. Further thiosulphate concentration increase leads to insignificant increase of the peak current.

The current increase (Fig. 2) and the beginning of a wide plateau together with the peak found at about +490 mV (470 - 510 mV) on the anodic curves registered with Au, Au-bearing powdered Py (Au + Py) and Py concentrate with Au electrodes (Au-Py), could be ascribed to the reaction (1):



By comparing the anodic curves obtained in working solution having a borate buffer as a supporting electrolyte (Figure 1 and Figure 2) drawn with Au, Au-bearing Py and Py connected by Cu wire with Au electrodes, a conclusion can be drawn that the peak

at about +570 mV (varying from +540 to +590 mV) is due to the reaction (2) (Avdohin, 1989):

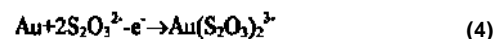


The width of the plateau found at about +620 mV and the subsequent current decrease (Figure 1) imply that the HSO_3^- and SO_3^{2-} , obtained in reaction (1) and (2) may be reduced.

The small minimum on the voltammogram found with Au electrode (Figure 2) (reverse sweep) could be related with a partial reduction of the $\text{S}_2\text{O}_3^{2-}$ described by the following reaction:



Having in mind the voltammograms obtained with pure Au (Fig.2) and especially the small prepeaks at about +180 - +200 mV and the clearly pronounced minimum at about +160 mV, the observed blue colored colloid's solution formed around Au electrodes at positive potentials more than +100 mV can be ascribed to the reaction:



On the basis of the experiments made, it can be supposed that the Au dissolution is due to the work of a corrosion galvanic cell (Fig. 3).

The significant shift of the Au electrode potential, towards more negative values (when the Au contacts with $\text{S}_2\text{O}_3^{2-}$) makes the Au behave as an anode (eg to dissolve) in the corrosion cell formed. The dissolution is accelerated by depolarizes the naturally available in the working solution such as $\text{O}_2, \text{Fe}^{3+}$. The corrosion current, consequently, the Au dissolution rate depends on the electrode polarization, i.e. on the working condition. The difficulty in the e^- exchange process is highly dependent on the nature of contacting materials.

Pyrite ore from the Chelopech deposit, Bulgaria has been used in the experiments. It contains 10 g/t Au, 47 g/t Ag, 1,24% Cu, 44,58% S and 0,20% As. Gold-bearing minerals in the sample were native gold, electrum, costovite, sylvanite and nagianite (Terziev, 1983). Besides in these minerals, Au occurs in the form of aggregates, with dimensions lower than 5-10 μm . Bornite, digenite, anilite, bantc, caolinite are gangue minerals (Kovachev et al., 1988).

The optimum thiosulphate regime has been found on the basis of voltammetric investigation. The optimum thiosulphate concentration found by means of voltammetric investigations has been confirmed by Au and Ag leaching experiments (Table 1). The process (under laboratory conditions) includes the following steps:

I. Grinding Pyrite concentrate in a laboratory ball mill to obtain 95% - 0,063 mm.

II. The leaching has been earned out in two stages, each one of 60 min. in a batch reactor with 1 dm³ volume. Air was introduced in the second stage. Pulp density is 20%.

The series of experiments have been carried out by changing thiosulphate concentration within 13 g/dm³, 26 g/dm³, 39 g/dm³. The basic experiment (No 2) has been carried out following the optimum reagents regime found by means of voltammetry : thiosulphate - 26 g/dm³ solution per 1 dm³; NH₄OH - 25% solution - 20 ml per 1 dm³, lime - 3 g per 1 dm³; CuSO₄ · 5H₂O - 3 g per 1 dm³. The other two experiments have been earned out with different thiosulphate concentrations (The quantity of other reagents remained unchanged) . Experiment No 1 was with 13g/dm³ thiosulphate solution per 1 dm³ and No 3 - with 39 g/dm³ thiosulphate solution per 1 dm³. Au and Ag concentrations in the liquid phase have been found by means of ICP - analysis. The results obtained are presented in Table I. From the results found, it can be seen that for this particular raw material, increasing thiosulphate concentration does not result in further increasing Au and Ag recovery. These results confirm the results obtained by means of voltammetric investigations and give a possibility to find an optimum reagents regime (for a particular stuff) using voltammetry

Table 1. Results about content and precious metals recovery

No	Concentration of thiosulphate, g/dm ³	Contents		Recovery	
		Ag, mg/l	Au, mg/l	Ag, %	Au, %
1	2	3	4	5	6
1	13	1.04	1.72	52.20	18.30
2	26	1.48	1.98	74.00	21.10
1	39	1.49	1.97	74.50	21.00

According to the results from Table 1, thiosulphate is appeared to be an effective leaching agent for gold contained in pyrite concentrate.

CONCLUSIONS

Some suggestions for the mechanism of die thiosulphate leaching of Au from Py were made on the basis of potentiostatic investigations of a Py concentrate and some model systems. It was found that except the role of the Au/Py galvanic cell the preliminary treatment of the Py concentrate and its destruction and oxidation play an important role in the leaching process. As a result, Au recovery of 91% and a Ag recovery of 25% were obtained in the production solution for 120 min.

The data we have obtained, although not so universal and thorough, are the base for the beginning of industrial and semi-industrial experiments to prove the thesis of effective leaching of Au and Ag in thiosulphate method

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