

ENHANCEMENT OF NICKEL SULPHIDES LEACHING BY ACTIVATED CARBON

Mulak W., Chojnacka M., Sulek B.

Institute of Inorganic Chemistry and Metallurgy of Rare Elements,

Wroclaw University of Technology, 50-370 Wroclaw, Poland

ZVÝŠENIE LÚHOVATELNOSTI SULFIDOV NIKLU PRÍDAVKOM AKTÍVNEHO UHLIA

Mulak W., Chojnacka M., Sulek B.

Ústav anorganickej chémie a metalurgie vzácnych prvkov, TU Wroclaw, 50-370 Wroclaw, Poľsko

Abstrakt

Boli študované možnosť a účinnosť lúhovania Ni_3S_2 a $\beta\text{-NiS}$ v zriedených roztokoch kyseliny dusičnej a chlór vodíkovej v prítomnosti aktívovaného uhlíka.

Aktívované uhlíky boli pripravené z viacerých druhov uhlia. Otestoval sa vplyv 6 rôznych typov aktívovaného uhlíka na rýchlosť lúhovania. Vo všeobecnosti, prídavok aktívovaného uhlíka zabraňuje aby došlo k retardácii lúhovania Ni_3S_2 v zriedenej kyseline dusičnej pri teplote 80°C a podstatne zvyšuje výťažnosť niklu. Podobné výsledky sa získali pri lúhovaní $\beta\text{-NiS}$ v zriedenom roztoku kyseliny chlór vodíkovej.

Bolo zistené, že rýchlosť lúhovania Ni obidvoch sulfidov stúpa v závislosti od kapilárnej štruktúry aktívovaného uhlíka.

Abstract

The possibility and efficiency of the leaching of Ni_3S_2 and $\beta\text{-NiS}$ in dilute nitric acid and hydrochloric acid solutions in the presence of activated carbon were investigated.

Activated carbons were prepared from various types of coal. Influence of the addition of six various types of activated carbon on leaching rate was tested. In general, such an addition protects the retarding of Ni_3S_2 leaching in diluted nitric acid at 80°C , and considerably increases nickel extraction. Similar results were achieved for the leaching of $\beta\text{-NiS}$ in dilute hydrochloric acid solutions.

It was found that the leaching rate of nickel extraction for both sulphides increases depending on the capillary structure of activated carbon.

Key words: hydrometallurgy, millerite, leaching, activated carbon

1. INTRODUCTION

Activated carbon has found increased application in the field of hydrometallurgy, especially in the recovery of gold and silver from cyanide solutions. It has been applied both to solutions from heap leaching that are relatively free from solids and to leach slurries or pulps without prior solutions/solid separation. In the latter case it is referred as the CIP or carbon-in-pulp process [1]. There is still some uncertainty regarding the actual mechanism by which gold and silver are adsorbed by activated carbon [2-5].

The molecular structure of the starting materials, the nature and distribution of inorganic matter in this material, the activation atmosphere, the process temperature and reaction time all affect the final activity of carbon.

Chemical analysis of activated carbon reveals the presence of significant amounts of both hydrogen and oxygen and these may be attached to the lattice at the active sites forming various surface groups. The presence of carboxylate, quinone and hydroquinone groups have been detected [6].

The first studies of influence of activated carbon on leaching metal sulphides were connected with pressure leaching of chalcopyrite [7] and sphalerite [8]. It was found that addition of activated carbon to the leaching solutions increases the leaching rate of both sulphides. Nakazawa et al [9] reported that the dissolution rate of chalcopyrite concentrate in bioleaching was enhanced by activated carbon. They suggested that it could be due to galvanic interaction between activated carbon and chalcopyrite.

The aim of our study was to investigate the possibility and efficiency of the leaching of Ni_3S_2 and $\beta\text{-NiS}$ in dilute nitric acid and hydrochloric acid solutions in the presence of various types of activated carbon.

2. EXPERIMENTAL PROCEDURE

2.1 Preparation of activated carbon

Activated carbon was prepared by heating a variety of coals at temperature 600°C in the absence of air (pyrolysis) to produce a residue of carbon, whilst simultaneously volatilising other constituents. Activation was achieved subsequently by heating the carbon in steam at a temperature 800°C .

In the activation step the small pore structure of the coke is developed by burning away some of the remaining material to create new pores and enlarge others. After activation carbon was cooled in argon atmosphere.

Measurements of surface area of capillary structure of activated carbons were made by a standard BET multipoint technique employing benzene. Table 1 gives characteristic of activated carbons, which were tested in leaching process. It was assumed that effective diameter of micropores is lower than 1.5 nm, but for mesopores r is between 1.5 and 100 nm.

2.2 Material and leaching experiments

The synthetic nickel sulphides were used for the leaching. Preparation of Ni_3S_2 and $\beta\text{-NiS}$ are described in previous works [10,11].

In each experiment a flask containing 400 cm³ leaching solution was submerged in a water bath, the temperature of which was kept constant to within 0.1°C. When the required temperature has been reached a charge of 0.2 g of nickel sulphide and 0.1 g of activated carbon was added and stirring started.

The leaching was carried out for 3 hours, during which seven 1 cm³ samples of the solution were taken for determination of nickel concentration by the atomic absorption method.

Table 1 Characteristic of activated carbons

3. RESULTS AND DISCUSSION

3.1 Leaching of Ni₃S₂ in nitric acid solutions

To investigate the effect of activated carbon addition on the leaching of Ni₃S₂ experiments were carried out in 1.0 M HNO₃ solutions at constant temperature of 80°C. The results are shown in Fig.1.a. During the leaching of Ni₃S₂ without addition of activated carbon, retardation of dissolution rate was observed after 30 min of leaching time (Fig.1a curve 7) and H₂S gas was evolved. The reason for this seems to be the covering of the sulphide surface and saturation of the leaching solution with H₂S gas. Figures 1a (curves 1- 6) shows the effect of addition of various types of activated carbon (number of curves correspond to the numbers of activated carbon according to Table 1).

Addition of activated carbon eliminates the evolution of H₂S and greatly accelerates the dissolution rate. Increase of the dissolution rate of Ni₃S₂ in the presence of activated carbon causes a lowering of concentration of H₂S in the solution and a corresponding shift in the equilibrium between H₂S dissolved and absorbed on the surface of Ni₃S₂.

The best result was obtained for activated carbon No 3 (see Table 1). In this case after 150 min leaching in 1.0 M HNO₃ solution nickel extraction rises from 18 to 55 percent. The linearity of the rate plots shown in Fig.1a suggests that reaction area of Ni₃S₂ grains remains constant during the leaching, and their surface is not obstructed by the reaction products. Similar results have been obtained in the nitric acid leaching of Ni₃S₂ in the presence of ferric and cupric ions [12].

3.2 Leaching of β-NiS in hydrochloric acid solutions

Our earlier study on the acidic leaching of β-NiS [13, 14] shows that hydrogen sulphide evolved in the first step leaching produces a layer of nickel polysulphides at the phase border, which inhibits the dissolution process. The effect of activation carbon addition on efficiency of the leaching of β-NiS in 2.0 M HCl solutions at 80°C is presented in Figure 1b.

Acceleration effect of activated carbon addition on nickel extraction was observed. The best results was obtained for activated carbon which had highest surface area of mesopores (see Table 1 No 3). Efficiency of nickel extraction (after 180 min) without activated carbon in the leaching solution does not exceed 6% (Fig.1b curve 7). The extraction can be raised to 23% when activated carbon was added (Fig.1b curve 3).

Figures 2 and 3 show SEM photographs of the surface of the activated carbons indicated as No 3 and No 5. It is easy to notice a big difference in the appearance of surface of these activated carbons. Activated carbon No 3 shows high porosity because its starting material is a young coal (flame coal). The surface of activated carbon No 5 has in turn very low porosity because it is prepared from an old coal (anthracite).

Fig.2 SEM photograph of activated carbon No3 (x 3000)

Fig.3. SEM photograph of activated carbon No5 (x3000)

4. CONCLUSIONS

Addition of activated carbon protects the retarding of Ni_3S_2 and $\beta\text{-NiS}$ in diluted mineral acids probably due to adsorption of H_2S evolved during the leaching.

It is found that leaching rate of nickel extraction for both sulphides increases with increasing surface area of mesopores of the activated carbon. No correlation between the surface area of micropores and leaching rate was found.

The through understanding of the mechanism of acidic leaching of nickel sulphides in the presence of activated carbon requires further complex investigations.

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