Study on Recovery of Associated Copper Oxide Ore by Bacterial Leaching

Heyong Zhao

School of Chemistry and Engineering, Wenshan University, Wenshan, Yunnan, 663009, China

E-mail: 152945636@qq.com

Keywords: Bacteria; Leaching; Copper Oxide; Recovery

Abstract: Bacterial leaching technology has the advantages of low cost, low investment, simple process, low environmental pollution and suitable for the processing and utilization of low-grade ores. The research and production application of recovering copper from low-grade copper oxide ore by bacterial leaching are increasing. Bacterial leaching of fine copper concentrate can accelerate the release rate of copper, but with very fine ore powder, strong agitation and air containing carbon dioxide should be introduced during leaching. It is imperative to strengthen the research and application of bacterial copper leaching technology, economically and rationally develop and utilize copper resources, recover copper from copper ore or waste tailings as much as possible, and improve the copper self-sufficiency rate. In this paper, the influence factors and influence levels of bacterial leaching of copper oxide ore are studied experimentally, the change rule of copper leaching rate with time under the optimal leaching conditions is revealed, and the recovery test mechanism of associated copper oxide ore leached by bacteria is discussed.

1. Introduction

Copper is one of the earliest metals discovered by human beings, with purple metallic luster, second only to steel and aluminum in the consumption of metallic materials, and is an indispensable basic material and strategic material in the fields of national economy and people's livelihood, national defense engineering and high-tech [1]. The research and production application of recovering copper from low-grade copper oxide ore by bacterial leaching are increasing day by day. Leaching fine copper ore concentrate by bacteria can speed up the copper leaching rate, but extremely fine ore powder is used. During leaching, strong agitation and introduction of air containing carbon dioxide are required [2]. The actual leaching system often contains surfactants, various heavy metal ions, etc. When its content exceeds a certain concentration, it will inhibit bacterial growth and even cause thallus death [3]. Copper and its processing extension industry are industries that cannot be replaced in any period of the national economy. The importance of copper to human society is determined by its nature. China is a big consumer of copper resources. At the same time, copper resources are also lacking, forming a series of sharp contradictions and resource shortages.

With the depletion of copper resources, people have paid more and more attention to the research and application of wet copper smelting technology. This method has a good effect on secondary copper oxide ore and some copper oxide ore. For the original copper ore with the largest content in copper ore, the leaching time is long and the effect is poor [4]. Trace impurities have a decisive influence on the conductivity of copper. Arsenic and antimony are commonly used impurities in refined copper, which is extremely harmful to the conductivity of copper. In order to maintain the normal growth and oxidative activity of the leaching bacteria, it is necessary to pre-wash the ore with an acid agent [5]. However, due to the presence of alkaline calcium-magnesium gangue minerals, acid consumption is greatly increased and economically unreasonable. Strengthening the research and application of bacterial copper immersion technology, economically and rationally developing and utilizing copper resources, recovering copper from copper ore or abandoned tailings as much as possible, extending the life of copper mines, and increasing the self-sufficiency rate of copper is imperative [6]. In this paper, the influencing factors and influence levels of copper

  DOI: 10.25236/swcas.2019.013

leaching in copper oxide ore were studied, and the variation of copper leaching rate with time under optimal leaching conditions was revealed. The mechanism of recovery of copper oxide ore associated with bacterial leaching was discussed.

2. Copper Oxide ore Treatment Method

The selection of bioleaching method is related to ore grade, mineral composition, leaching difficulty and leaching conditions. The contact and adsorption between bacteria and minerals are the premise of direct action. Bacteria adsorb on the ion insertion point and dislocation point on the crystal surface by physical or chemical adsorption, which causes corrosion on the mineral surface [7]. Activator is obtained after a series of screening tests. The price of activator is moderate and can be reused. It is an economically acceptable reagent for treating low-grade copper oxide ore. Leaching sites are mostly located on impervious hillsides. The ore mined or crushed to a certain size is piled up, and leaching agent is sprayed on the surface of the heap. When leaching agent seeps through the heap, copper is leached and leaching solution flows to the collector. Using atomic absorption spectrophotometer to measure the absorbance of atomic vapor can qualitatively obtain the types of elements in the sample to be measured and quantitatively measure the concentration of the elements. After filtering the leached liquid, analyze the acidity and the mass and concentration of each element, wash and dry the leached residue, analyze the copper mass fraction and calculate the copper leaching rate.

Copper oxide minerals have poor floatability. When copper in the ore is in the form of refractory chrysocolla, cuprite and copper minerals impregnated with ferric hydroxide and manganese aluminosilicate or in the form of bound copper. The surface of bacterial thallus has many chemical functional groups, through which bacteria can be adsorbed on the mineral surface. Researchers generally believe that the adsorption of bacteria on mineral surface is a prerequisite for direct oxidation [8]. The bacterial leaching process of metal minerals is different from the chemical leaching process of minerals. Bacterial leaching is a more complicated reaction process. In this process, there are not only bacterial growth and reproduction and biochemical reactions, but also chemical reactions of leaching agents and minerals. The larger the liquid-solid mass ratio is, the more leaching agents per unit mineral in the system are obtained, and the more copper is leached out, so that the copper leaching rate is higher [9]. Since the growth and reproduction speed of bacteria is much slower than the chemical leaching reaction of minerals, the growth status of bacteria is the control link of the whole bacterial leaching process. Bacterial leaching is sometimes dominated by direct action and sometimes by indirect action. However, in the process of leaching, both functions exist simultaneously and cannot be excluded.

3. Factors Affecting Bacterial Leaching of Associated Copper Oxide Ore

During the heap leaching of bacteria, it is found that most of the bacteria are adsorbed on the ore, and the content of bacteria in the solution flowing out of the ore heap is not high, indicating that the bacteria themselves have greater surface activity. Because the oxidation degree of ore is relatively high, sulfide flotation is adopted, and sodium sulfide is mainly used as vulcanizing agent in practice. Regarding ore particle size, for bacterial heap leaching, the smaller the ore particle size, the better, as long as it does not affect the air circulation and the seepage speed of the solution, the faster leaching speed and higher leaching rate can be obtained for small-size ores [10]. Sulfuric acid is used as an adjusting agent in copper oxide ore dressing, which can eliminate the inhibitory effect of sodium sulfide on copper oxide ore when it is excessive. Excessive temperature will directly lead to the decomposition of urea, thus causing ammonia-producing bacteria to lack metabolic energy substances, and the whole leaching process cannot be carried out normally. Bacteria and their metabolites can regulate the surface properties of ore particles, so they are studied and used as collectors, inhibitors and flocculants in the flotation process.

In the process of bacterial leaching, the ore is observed regularly and locally under a polarized light microscope at a fixed time interval to observe the changes of its morphology and

characteristics. The biological inhibition effect of chemicals is usually related to the changes of the kinetic constants α and K when chemicals are present or not. Its form can be expressed as follows:

$$Y_i = \alpha + \sum_{j=1}^{k} \beta_j \cdot X_{ji} \tag{1}$$

Then take the reciprocal of the equation and get:

$$u_1^{\beta} = y(m_1 + c) + (1 - y)m_1 = m_1 + yc \tag{2}$$

It can be obtained from the intercept and slope of the line:

$$u_2^{\beta} = xm_2 + (1 - x)m_2 = m_2 \tag{3}$$

The number of bacteria was determined by timed sampling, and it was found that the growth rate of the bacteria was not always the same, but it changed regularly with time. As shown in Figure 1.

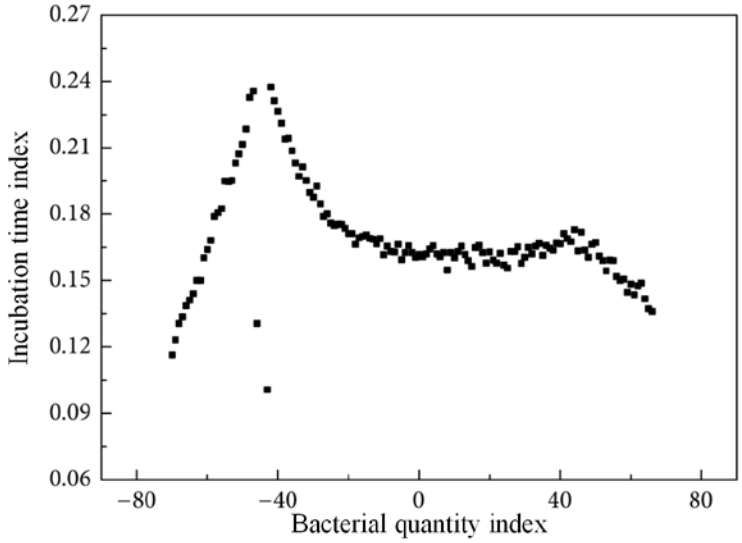

Fig.1. Relationship between bacterial count and culture time

The quality of bacteria in leaching system is an important factor affecting the process of bacterial leaching. The growth, reproduction and oxidative activity of bacteria will affect the leaching process. In the study of combined process and chemical method, the improvement of various process, the development of New Extractant and the introduction of new process have opened up a new way for the development and utilization of refractory copper oxide ore and mixed copper ore. In most copper oxide ores, in addition to copper oxide minerals, there are usually a small amount of natural copper and copper oxide minerals. The leaching of the latter two types requires the participation of oxygen. Compared with secondary sulfide ore, copper ore has higher lattice energy and slower bioleaching rate. In addition, in the process of bacterial leaching of copper ore, jarosite on the surface inhibits further leaching of copper ore, resulting in lower final copper leaching rate. The leaching rate of metal minerals is directly proportional to the concentration of bacteria in the leaching medium. In order to obtain a high leaching rate of minerals, it is necessary to maintain a high growth rate of bacteria. Therefore, it is necessary to provide sufficient nutrition necessary for bacterial growth to rise to a certain extent and begin to have adverse effects on the body. For example, if the temperature continues to increase, the cell function will drop sharply and even die, thus affecting the leaching process.

4. Conclusions

Almost all copper-bearing ores can be extracted from them by corresponding leaching methods. The choice of leaching method mainly depends on the nature, grade and occurrence state of the ore. The solution, temperature and concentration of metal ions in the solution are important factors that

affect the growth of bacteria. Acidity, temperature and ion concentration are the necessary objective conditions for bacterial growth and reproduction. The crystal form, crystal lattice structure, lattice energy and other crystal properties of copper ore itself are one of the factors affecting its bacterial leaching fruits. In the study of bacterial leaching of copper oxide ores, the effects of leaching time and ore size on copper leaching can be investigated by shaking flask test, small-scale leaching column leaching test and enlarged column leaching test. The most common type of copper ore is tetragonal variant with medium temperature. Therefore, the anodic dissolution oxidation leaching of copper ore includes vacancies in valence band and electron transfer in conduction band. Copper ore leaching is a complex mechanism, because the passivation film formed on its surface slows down the reaction. In the process of bacterial leaching of copper ore, the morphology of the surface products changes from granular to membrane, and the morphology of the membrane gradually changes from sparse porous to compact.

Acknowledgement

In this paper, the research was sponsored by the 1). Scientific research fund project of Yunnan education department 2013Y587; 2). Yunnan science and technology department applied basic research fund project 2015FD051.

References

[1] Baba A A, Ghosh M K, Pradhan S R. Characterization and kinetic study on ammonia leaching of complex copper ore. Transactions of Nonferrous Metals Society of China, 2014, 24(5):1587-1595.

[2] Wu A X, Hu K J, Wang H J. Effect of ultraviolet mutagenesis on heterotrophic strain mutation and bioleaching of low grade copper ore. Journal of Central South University, 2017, 24(10):2245-2252.

[3] Yaras A, Arslanoglu H. Leaching behaviour of low-grade copper ore in the presence of organic acid. Canadian Metallurgical Quarterly, 2018:1-9.

[4] Ding-Jun Z, Li D, Yong-Tong L. Copper leaching from waste printed circuit boards using typical acidic ionic liquids recovery of e-wastes' surplus value. Waste Management, 2018, 78:191-197.

[5] Copper leaching from waste electric cables by biohydrometallurgy. Minerals Engineering, 2015, 76:38-46.

[6] Oraby E A, Eksteen J J, Tanda B C. Gold and copper leaching from gold-copper ores and concentrates using a synergistic lixiviant mixture of glycine and cyanide. Hydrometallurgy, 2017, 169:339-345.

[7] Yang H Y, Li X J, Tong L L. Leaching kinetics of selenium from copper anode slimes by nitric acid-sulfuric acid mixture. Transactions of Nonferrous Metals Society of China, 2018, 28(1):186-192.

[8] Abdollahi H, Shafaei S Z, Noaparast M. Mesophilic and thermophilic bioleaching of copper from a chalcopyrite-containing molybdenite concentrate. International Journal of Mineral Processing, 2014, 128:25-32.

[9] Li X J, Yang H Y, Jin Z N. Extraction of selenium from copper anode slimes in a sealed leaching system. Russian Journal of Non-Ferrous Metals, 2017, 58(4):357-364.

[10] Enhancement in extraction of boron and phosphorus from metallurgical grade silicon by copper alloying and aqua regia leaching. Hydrometallurgy, 2016, 161:14-21.