Performance of Sodium Mercaptobenzothiazole (NMBT) Collector on the Flotation of Black Mountain Ore

Adeshina G. Ikotun, Edison Muzenda, Freeman Ntuli and Mohamed Belaid

***Abstract*—**This paper investigated the performance of Sodium Mercaptobenzothiazole (NMBT) as a collector in the flotation of Black Mountain ore. The ore contains metals such as lead, copper and zinc and the associated minerals of economic importance are chalcopyrite, galena and sphalerite respectively, with traces of silver. The study evaluated the effectiveness of the collector and how pH affects the recovery of minerals in particular copper. The performance of the collector was influenced by mineral surface chemistry. The experimental test work was conducted at varying pH levels using Denver flotation cell in order to investigate the collector performance in a basic medium. The experiments were conducted at two different test runs of slightly basic solutions of pH 8.5 and 9.0. The results of both fresh ore and floated ore samples were analysed using XRF. Although Black mountain ore contains small quantities of copper as compared to other ores, a significant amount w recovered (±78% of the available copper in the ore), as an indication of the performance of NMBT.

***Keywords*—**Black Mountain ore, copper metal, performance, pH levels, sodium Mercaptobenzothiazole.

I. Introduction

FLOTATION is well known as the most common process in mineral separation to recover valuable minerals from gangue and most widely used method for the concentration of fine-grained minerals. It is a way of separating valuable suspended solids from a medium such as a mixture constituted by solids and water by taking advantage of the different physiochemical surface properties of minerals—in particular, their wettability, which can be a natural property or artificially changed by chemical reagents. The process introduces fine air bubbles into the slurry so that the air bubbles attach to the valuable particles, and transport them to the surface [1]. The particles to be floated are rendered hydrophobic by the addition of the appropriate chemicals. By altering the hydrophobic (water-repelling) or hydrophilic (water-attracting) conditions of their surfaces, mineral particles suspended in water can be induced to adhere to air bubbles passing through a flotation cell or to remain in the pulp. The air bubbles pass to the upper surface of the pulp and form froth, together with the attached hydrophobic minerals [1], [2].

For these purposes, the use of the appropriate collector will determine the effectiveness of valuable mineral recovery. Consequently, investigation of the interaction of collectors with mineral and metal surfaces has been an ongoing area of research, as adsorption of a collector is the key chemical step in the flotation process [3]-[11]. The potential dependent adsorption of an organic collector onto a mineral surface has been utilised in the selective floating of minerals for over a century [10]. pH of a medium is also an important factor that influences flotation. Control of pH is one of the most widely applied methods of modulation of mineral flotation. If possible, flotation is usually carried out under basic conditions because most collectors are stable at higher pH values. pH also determines the ratio of molecule to ion concentrations as well as the solubility of a collector [2].

Sodium mercaptobenzothiazole is classified as an organosulphur compound (chemical formula: $C_7H_4NNaS_2$). It is widely used in refineries, steam crackers, aromatic extraction and petrochemical manufacturing. Used primarily as a vulcanization accelerator in the production of rubber, to inhibit corrosion of copper and as an ingredient in cutting of oils and petroleum products [12]. However, it can also be used as a collector introduced in flotation process by atomization. Black Mountain Ore is rich in iron and silicon and constitutes small percentage of copper metal. The minerals of economic importance in this ore are chalcopyrite which contains copper, galena with lead, sphalerite with zinc and small traces of silver.

The performance of sodium mercaptobenzothiazole collector (NMBT) in recovering copper from the flotation of Black mountain ore at two different pHs was investigated in this study. Most of the minerals found in black mountain ore (Galena, Spalerite and Chalcopyrite) are said to be sulphide minerals as shown by their chemical formulae: PbS, (Zn,Fe)S and $CuFeS_2$. This study focused on the recovery of copper

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from Chalcopyrite under slightly basic conditions.

II. Methodology

A. Samples Milling

3kg of coarse Black Mountain ore was divided into sizes of 1kg; each 1kg sample was then taken to the rod mill with 13 rods, and milled for 4 hours, to give a fine texture of about 106µm, with 80% pass.

B. Sieve Screening

Milled ore samples were weighed and losses during milling were observed. Sieves of sizes 106, 75, 53 and 38µm were used on the mechanical sieve shaker, and stacks of sieves were used in such a way that the smallest sieve was placed at the bottom. The ore was then sieved for 30 minutes on the shaker. In this study, particles sizes of 75µm and below were used.

C. Flotation Procedure

After the required size fraction of 75µm and below was obtained by screening after milling, 1kg (per batch) of ore was put into the flotation cell and mixed with 2L tap water by means of an agitator which was slowly immersed into the cell. The agitator was started after closing the valve and agitation was performed for 5 minutes. The initial pH of the solution was measured with a calibrated pH meter prior to addition of any reagents. The initial pH was found to be around 7.8 and 0.05g of CaO (lime) was added to adjust the pH to the desired value (8.5). Then solution was conditioned for 5 minutes. Thereafter, other reagents: activator ($CuSO_4$), collector (NMBT) and lastly frother (Senfroth XP 200) were each added at intervals of 5 minutes conditioning time. Flotation was started by opening air valve. The froth was then collected using a plastic scraper, into the concentrate pans for a period of 15 minutes until all the concentrate was collected. Once the flotation was completed, both the concentrate and the tailings were filtered and put in an oven to dry for 2 hours. The same procedure was followed for a pH of 9.5

D. Post Flotation Sample Preparation

The dry caked samples of both concentrates and tailings were removed from the pans and crushed (pulverised) using a porcelain mortar and pestle while avoiding any contamination of fine material. The concentrate and tailings were weighed for dry mass determination subsequent to flotation. The samples were then placed in marked, separate plastic containers/bags which were then sealed to minimise any surface contamination, or oxidation caused by air. Quantitative determination of the major elements present in the samples was achieved through XRF analysis.

III. Result and Discussion

A. Composition of Black Mountain Ore

Iron minerals are often associated with copper minerals in most ores. The Black mountain ore is rich in Iron and Silicon as shown in Table 1. Copper is available in small quantities, hence the amount of copper recovered was the lowest. In the flotation of Black Mountain ore, other metals such as iron, silicon, lead, and zinc were highly recovered in terms of both recovery value and grade.

TABLE I
COMPOSITION OF BLACK MOUNTAIN ORE

Components	%
Cu	0.341
Fe	28.237
Pb	3.559
Si	11.439
Zn	3.106
Fe_2O_3	40.371
SiO_2	24.471

B. Performance of sodium mercaptobenzothiazole collector (NMBT) on concentrates at pH 8.5 and 9.5.

The recovery of copper metal in concentrates using NMBT collector at both pH 8.5 and 9.5 is shown in Fig. 1. The results show that copper recovery was higher at a pH of 8.5, this was found to be 1.313% as compared to 0.499% for a higher pH of 9.5. This shows that as pH increases the recovery of copper decreases. Due to the presence of pyrite in the ore, this reduction in recovery could be due to the formation of precipitates at higher pH values which causes high mineral coverage during flotation. It has also been found that a decrease in recovery at higher pH values is as a result of the increase in the proportion of surface iron specie covering the hydrophobic specie [13].

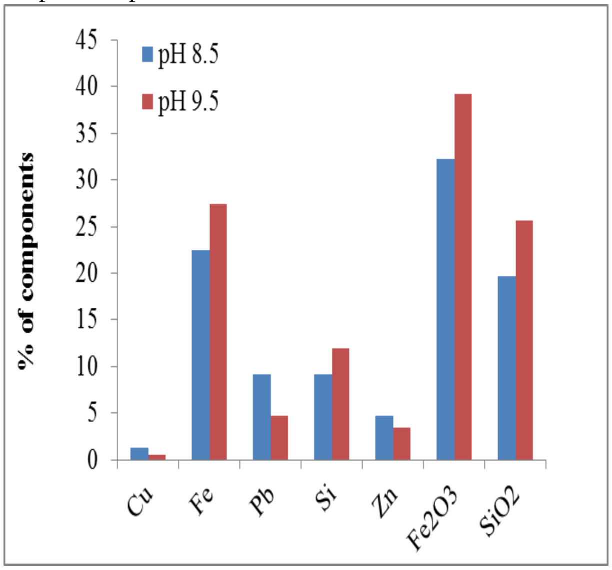

Fig. 1 Performance of sodium mercaptobenzothiazole collector (NMBT) on concentrates at pH 8.5 and 9.5

C. Performance of sodium mercaptobenzothiazole collector (NMBT) on tailings at pH 8.5 and 9.5

Tailing has less metals compared to concentrate, most of the metals in the tailing are recovered as shown in Fig. 2. Copper content in tailing is insignificant to other metals. Iron minerals, particularly pyrite, are often associated with copper sulphide minerals in ores. During grinding and conditioning, a variety of surface reactions can take place. For example, activation of pyrite (Iron) can occur as a result of dissolution of copper species from chalcopyrite. These copper species form hydrophobic species on the pyrite surface with sulphide and collector, and therefore promote pyrite flotation, which subsequently lower the overall copper grade in the recovery.

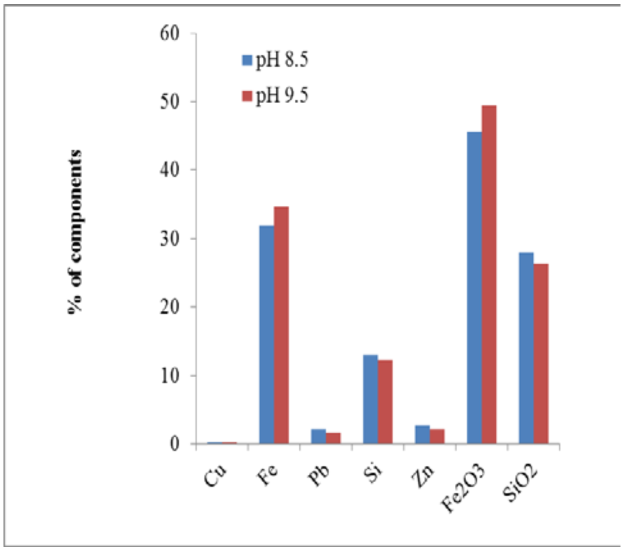

Fig. 2 Performance of sodium mercaptobenzothiazole collector (NMBT) on tailings at pH 8.5 and 9.5

IV. Conclusion

This study has shown that pH has a huge effect on the flotation recovery of mineral/meta. Sodium Mercaptobenzothiazole (NMBT) is an effective collector in a slightly basic solution (lower pH values) as higher pH causes mineral coverage, thus reducing the recovery of valuable metal (copper). Most of the copper was recovered at the pH of 8.5 which was the initial pH of Black mountain ore solution, without any additions of pH modifiers.

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