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CONCENTRATION OF ORES BY FLOTATION

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This invention relates to the concentration of ores, minerals and the like by flotation, and involves the use of a new class of flotation agents.

One object of my invention is to improve on flotation processes by providing certain highly efficient flotation agents. Other objects will be apparent from the following description.

I have discovered that excellent results may be obtained in the recovery of ore values by flotation if there is used in the flotation process a substance belonging to the class of compounds known as mercapto-thiazoles, or the salts or oxidation products of such thiazoles. For example, recoveries of ore values, with high yields, have been obtained using as flotation agents such aromatic mercapto-thiazoles as mercapto-benzothiazole, 1-mercapto-3-methyl-benzo-thiazole, and mercapto-alpha naphthyl-thiazole. And instead of a mercapto-thiazole, a salt thereof may be used, as for example the sodium salt, or the zinc salt.

I have found that this class of compounds is unusually efficient and selective when used in the flotation of sulphide minerals. In some instances an exceptionally high recovery, accompanied by a high ratio of concentration, can be obtained. In other cases the ratio of concentration is unusually high, yet the recovery is very good. The amount of reagent required is small; in some cases satisfactory results are obtained using the reagent in the proportion of .02 lb. per ton of dry ore.

The following examples give typical flotation results obtainable in the practice of the present invention.

Example I

350 cc. of water, 500 g. of ore from the Utah Copper Co., and 2.2 g. of lime (sufficient lime used to give a slightly alkaline tailing) ground in jar mill and then transferred to the Janney flotation machine. During the transfer 450 cc. of water is used, making a total of 800 cc. present. The pulp is pre-agitated ½ min., and agitation is then stopped while .04 grams of pine oil and .025 grams of mercapto-benzo-thiazole are added. These reagents are pre-agitated with the ore pulp for 1 min., and then 1200 cc. more water is added which allows circulation of pulp and results in froth formation. Froth is removed for 7 min. This procedure gave a 0.16% copper tailing and a 12% copper rougher concentrate, the recovery being 86.2%.

When the above procedure was carried out with .02 lb. of mercapto-benzo-thiazole (instead of 0.10 lb.) per ton of dry ore a 0.21% copper tailing and a 12.5% copper rougher concentrate resulted.

When potassium ethyl xanthate is used in place of mercapto-benzo-thiazole a .20% copper tailing is the lowest grade that can be obtained (using either 0.10 lb. or 0.20 lb. per ton of dry ore) and the accompanying concentrate contains approximately 12.00% copper. These figures are given as a basis of comparison between the two reagents. Potassium ethyl xanthate is a standard flotation reagent which is now widely used.

Example II

Tests were made on ore from the Inspiration Consolidated Copper Co. according to the following general procedure. 750 cc. water, 750 g. ore and 0.7 g. lime ground in a jar mill for 20 min. and then transferred to a square glass jar with the addition of 1250 cc. water making a total of 2000 cc. of water. This pulp is pre-agitated with .04 g. pine oil and .034 g. of mercapto-benzo-thiazole for 1¼ min. and then transferred to the Callow cell containing 400 cc. of water. Froth is slowly overflowed for 10 min. This gave a 0.25% copper tailing with a 20% copper rougher concentrate giving a recovery of 75.3%.

Example III

Following the same procedure as in Example II, except that (1) .02 lb. of mercapto-benzo-thiazole per ton of dry ore was used instead of .09 lb. and (2) 2.9 lb. of lime was used instead of 1.9 lb., a .30% copper tailing resulted and an 18.% copper rougher concentrate, showing a recovery of 70.2%, was obtained.

As a basis of comparison several tests have been carried out with potassium ethyl xanthate using the same general procedure outlined above. In no case has a tailing been obtained which contained less than .27% copper with an approximately 20% rougher concentrate. Both 0.10 and 0.20 lbs. of potassium ethyl xanthate per ton of dry ore were used.

Example IV

Tests have been made using the sodium salt of mercapto-benzo-thiazole. In these tests the square glass jar preagitation noted above was omitted, the reagent and pine oil being added directly to the Callow cell. These tests showed that 0.03 lb. of the reagent gave a 0.36% copper tailing and a 25% copper rougher concentrate. This compares with a .34% copper tailing and a 13% copper rougher concentrate obtained with 0.10 lb. of potassium ethyl xanthate when added direct to the Callow cell.

Example V

Using Anaconda table tailings and employing .02 of a pound of 1-mercapto-3-methyl-benzo-thiazole per ton of ore a concentrate was obtained which contained 10.39% of copper and represented 94% recovery of copper from the ore. The tailings contained 0.13% copper.

The zinc salt of 1-mercapto-3-methyl-benzo-thiazole, when used in amounts of 0.02 pound per ton of copper concentrate, contained 12.32% of copper which is equivalent to 80.5% and the tailings contained 0.42% copper.

When .02 pound of mercapto-naphthyl-thiazole per ton of ore were used, a concentrate was obtained which contained 14.35% copper and was equivalent to 89% recovery. The tailings contained 0.32% of copper.

When Utah Copper Company ore was employed and 0.1 of a pound per ton of 1-mercapto-3-methyl-benzo-thiazole was used, a concentrate containing 11.2% of copper resulted, which is equivalent to 82.3% recovery. The tailings contained 0.20% copper. When a similar quantity of zinc salt was used the concentrate contained 13.35% copper, which is equivalent to an 83.5% recovery; the tailings also contained 0.20% copper.

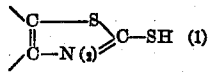
The mercapto-benzo-thiazole used in Examples I, II, and III was prepared by heating thiocarbanilide and sulphur to a temperature of about 225–250° C. in an autoclave in a manner similar to that described by Sebrell and Bedford in their article on the preparation and properties of 1-mercapto-benzo-thiazole, its homologues and derivatives, which was published in Vol. 45, on page 2390 of the Journal of the American Chemical Society. The reaction mixture obtained from the autoclave was treated with warm dilute sodium hydroxide, and this alkaline solution was submitted to steam distillation to remove any free aniline. The solution was then acidified fractionally and in the latter fractions a pure-mercapto-benzo-thiazole was obtained. In some of our experiments the sodium salt of mercapto-benzo-thiazole was used, and these solutions were prepared either by solution of the mercapto-benzo-thiazole in sodium hydroxide, or the original reaction mixture, after being freed from anilin by steam distillation, was filtered and used directly in the flotation tests.

1-mercapto-3-methyl-benzo-thiazole was prepared by heating equimolecular amounts of sulfur and di-ortho-tolyl-thio-urea for four hours at 250° C. in an autoclave. The charge was then cooled and any residual pressure released. The reaction product was extracted with warm dilute caustic soda solution and then steam distilled to remove any ortho-toluidine. The solution of the sodium salt of 1-mercapto-3-methyl-benzo-thiazole was then filtered and the free mercapto-methyl-benzo-thiazole isolated by acidification with hydrochloric acid. This crude product was purified by re-solution in warm dilute caustic soda, filtration and reprecipitation with hydrochloric acid. The product was then filtered, washed with water and dried at 90° C.

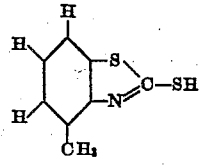
The mercapto-alpha-naphthyl-thiazole was prepared by heating equimolecular amounts of alpha-naphthylamine, carbon disulphide and sulfur for four hours at 250° C. in an autoclave. At the end of this time the charge was cooled, the pressure released and the material was extracted with warm dilute caustic soda solution and then filtered. The mercapto-naphthyl-thiazole was precipitated by acidification with hydrochloric acid. The crude product was re-dissolved in dilute caustic soda solution, filtered and reprecipitated by means of hydrochloric acid. This product was filtered, washed and dried at 90° C.

Although my invention has been described with reference to certain specific flotation agents, it will be understood that these specific flotation agents are merely typical, and that my invention is not limited thereto, but includes the use in ore flotations, and particularly in sulphide mineral flotations, of mercapto-thiazoles broadly, the molecules of

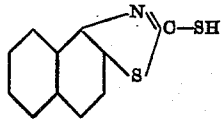
these mercapto-thiazoles containing the following atomic grouping:—



The 1-mercapto-3-methyl-benzo-thiazole has probably the following structural formula:



The 1-mercapto-alpha-naphtho-thiazole has probably the structure shown in the following formula:



The ore-flotations carried out in accordance with my invention normally require a froth-producing agent. In place of the pine oil for this purpose mentioned in Example I, I may use other frothing agents such as hard wood creosote or terpineol.

In Example I the ore pulp is made alkaline with lime, but I may also practice my invention with ore pulp in a non-alkaline condition.

I claim:

1. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a mercapto-thiazole.

2. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting a sulphide ore in the form of a pulp to a froth flotation operation in the presence of a mercapto-thiazole.

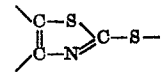
3. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a mercapto-benzo-thiazole.

4. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of 1-mercapto-3-methyl-benzo-thiazole.

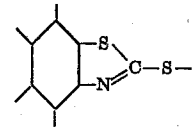
5. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a sodium salt of a mercapto-thiazole.

6. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a metal salt of a mercapto-thiazole.

7. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a flotation operation in the presence of a froth-producing agent and in the presence of a flotation agent whose molecules contain the following atomic grouping:



8. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a flotation operation in the presence of a froth-producing agent and in the presence of a flotation agent whose molecules contain the following atomic grouping:



9. A process of concentrating ores and minerals as set forth in claim 8 in which less than one-tenth of a pound of flotation agent is used per ton of dry ore.

10. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of 1-mercapto-benzo-thiazole.

11. The process of concentrating a complex ore, which includes agitating pulp of the ore with a mercapto thiazole and a frothing agent to form a mineral-bearing froth relatively rich in one of the minerals and separating the froth so obtained.

12. The process of concentrating a complex ore, which includes agitating a pulp of the ore with 1-mercapto benzothiazole and a frothing agent to form a mineral-bearing froth relatively rich in one of the minerals and separating the froth so obtained.

13. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of a mercapto-naphtho-thiazole.

14. In the process of concentrating ores and minerals by flotation, the step which comprises subjecting the ore in the form of a pulp to a froth flotation operation in the presence of 1-mercapto-alpha-naphtho-thiazole.

In testimony whereof I affix my signature.

ELMER K. BOLTON.