

UNITED STATES PATENT OFFICE

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CONCENTRATION OF ORES BY FLOTATION

No Drawing.

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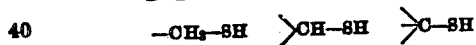
This invention relates to the separation of minerals and the concentration of ores by flotation processes and is particularly directed to such separation and concentration carried out with the utilization of certain organic sulfur compounds as flotation agents.

According to the present invention the separation of minerals and the concentration of ores by the flotation operation is carried out with the aid of a thioalcohol. The invention enables improved results to be obtained, these being manifested sometimes in better recoveries, sometimes in producing a higher grade concentrate, sometimes in reducing the time required for carrying out the flotation operation, and sometimes in effecting the usual recoveries with a lesser quantity of frothing agent than ordinarily required.

The flotation agents or adjuvants employed in the process of the present invention comprise the thioalcohols having a mercapto group, $-SH$, attached or bound to a saturated carbon atom as represented by the following grouping:



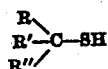
in which the carbon atom in said grouping is attached to three hydrogen atoms, or to two hydrogen atoms and one carbon atom, or to one hydrogen atom and two carbon atoms, or to three carbon atoms, said carbon atoms being components of organic hydrocarbon radicals which may or may not contain substituents. They may be further classified as comprising in their composition one of the following groups or groupings:



wherein the carbon atom is a saturated carbon atom.

In particular, the present invention contemplates the employment as flotation agents

of the thioalcohols represented by the following formula:



wherein R , R' and R'' each respectively denotes a hydrogen atom or a hydrocarbon radical, e. g. an aliphatic or an aromatic radical, which may or may not contain substituents, and wherein the mercapto group, $-SH$, is bound to a saturated aliphatic carbon atom. The thioalcohols of the aliphatic and of the aromatic series which contain the grouping, $-CH_2SH$, or the grouping,



and more especially the former grouping, are of particular importance. The thioalcohols which contain no nitrogen in their composition are also of particular importance.

In general, the thioalcohols employed may be prepared by the action of an alkali metal hydrosulfide on an organic halide in which the halogen is attached to an aliphatic carbon atom, or by the action of an inorganic hydrosulfide on an alkali metal salt of an alkyl-sulfuric acid, or by the reduction of the sulfonylchlorides in which the sulfonylchloride residue is attached to an aliphatic carbon atom, or by the hydrolytic decomposition of the salts of the thiosulfuric acid derivatives of the hydrocarbons in the presence of an acid or an alkali, or by other suitable and well known methods. While they may be used in the impure condition, they are preferably employed in a pure or purified state.

In carrying out the flotation process, the flotation agent comprising the thioalcohol body may be incorporated with the ore or the mineral pulp in any suitable manner and at any suitable time which will insure a satisfactory flotation operation. For example, it may be introduced in the free state or as a salt into the mill in which the ore is being

ground, or it may be dissolved, suspended or dispersed in any suitable solvent or dispersing agent as, for example, in one or more of the usual flotation oils or oil mixtures, or in water or in an alkali or alkaline reagent, and incorporating the resulting suspension, solution or dispersion with the ore or the ore pulp. While the agents of the present invention show marked action as flotation agents in ore concentration, they possess little, if any, frothing qualities and therefore are used to advantage in conjunction with any suitable or well known frothing agent, e. g., pine oil, crude turpentine, tar acids, etc. They may be also sometimes used to advantage in conjunction with other flotation agents.

The process of the present invention can be carried out in any suitable apparatus, for example, those of the pneumatic type such as the Callow cell, or those where the air is incorporated with the mixture by mechanical agitation such as the Janney apparatus, or the like.

It is of advantage in many cases, as with certain copper ores, to subject the ore pulp to the action of an amount of alkali sufficient to give it a neutral or alkaline reaction before subjecting it to flotation with the aid of the flotation agents of the present invention. The alkali may be, caustic alkali such as caustic soda, or an alkaline salt such as soda ash, or it may be calcium oxide or hydrate.

The amount of flotation agent required to be used in the flotation process will vary, it depending partly on the character and composition of the ore, partly on the particular thioalcohol employed, and partly on other factors. With many of these agents, one-fifth to one-half of a pound per ton of dry ore will be sufficient. Larger or smaller amounts than this, however, can be used.

The invention will be further illustrated by the following specific examples, but it will be understood that the invention is not limited thereto. The parts are by weight.

Example 1.—500 parts of a copper sulfide ore (of the Miami Copper Company) assaying 1.20 percent copper was ground in a ball mill with 300 parts water and 0.75 parts hydrated lime (equivalent to 3 pounds hydrated lime per ton of ore) until practically all of the mixture was sufficiently fine to pass a 40 mesh screen. The ground pulp was diluted with sufficient water to give a pulp containing about 16 percent solids and subjected to flotation in a Janney flotation apparatus, with the addition of a solution containing 0.0625 parts of ethyl mercaptan (equivalent to one-fourth pound per ton of ore) dissolved in an equivalent amount of normal caustic soda. After agitating for two or three minutes, a small amount e. g. about 0.02 to 0.04 parts of pine oil was added. A satisfactory mineral froth was produced.

During the next 25 minutes of agitation, an equal amount of pine oil was added or enough to make a total of about 0.04 to 0.08 parts in all, i. e., about one-sixth to one-third pound per ton of ore. Mechanical agitation of the pulp was continued for about 5 minutes after all of the pine oil had been added. 19.4 parts of a concentrate assaying 22.4 percent copper was obtained. A recovery of 72.8 percent of the copper was therefore obtained in the concentrate. The tailings assayed 0.34 percent copper. It will be noted that the equivalent of 25.7 tons of ore were required to give 1 ton of concentrate.

In a duplicate test with 500 parts of the same ore and using 0.0625 parts of isopropyl mercaptan in place of 0.0625 parts of ethyl mercaptan, there was obtained 20.9 parts of concentrate assaying 21.75 percent copper which is a recovery of 76.0 percent. The tailings assayed 0.30 percent copper. In this test, the equivalent of 24.1 tons of ore gave 1 ton of concentrate.

Example 2.—500 parts of a copper sulfide ore (of the Miami Copper Company) assaying 1.25 percent copper was treated as described in Example 1 except that 0.0624 parts benzyl mercaptan was used in place of ethyl mercaptan. 20.15 parts of concentrate assaying 23.3 percent copper was obtained. This is a recovery in the concentrate of 76.1 percent copper. The tailings assayed 0.31 percent copper. In this example the equivalent of 24.3 tons of ore gave 1 ton of concentrate.

In a duplicate test with 500 parts of the same ore and using isoamyl mercaptan in place of benzyl mercaptan, there was obtained 20.7 parts of concentrate assaying 22.8 percent copper which is a recovery of 76.2 percent. The tailings assayed 0.31 percent copper. In this test, the equivalent of 23.9 tons of ore gave 1 ton of concentrate.

Example 3.—500 parts of a copper sulfide ore (of the Miami Copper Company) assaying 1.22 percent copper was treated as described in Example 1 except that 0.0625 parts normal butyl mercaptan was used in place of ethyl mercaptan. 19.5 parts of concentrate assaying 23.6 percent copper was obtained which is a recovery of 76.4 percent. The tailings assayed 0.31 percent copper. In this example, the equivalent of 25.5 tons ore gave 1 ton of concentrate.

In a similar test, when using 500 parts of ore (of the Miami Copper Company) assaying 1.21 percent copper and 0.0625 parts of normal propyl mercaptan there was obtained 22.5 parts of concentrate assaying 20.9 percent copper. This is a recovery of 78.7 percent. In this example, the equivalent of 22.2 tons of ore gave 1 ton concentrate.

The concentrates obtained in the above examples were "rough" concentrates, that is,

they were concentrates which were not "cleaned" by re-treatment or re-flotation.

In carrying out the process, the flotation agent can be used in the dry form, if desired, or it can be added to and ground with the ore. It may also be used in conjunction with other frothing agents or with other flotation agents, or with both. In general, it is preferably employed in solution in caustic alkali but its salts, for example, the sodium, potassium or ammonium salts, may be employed.

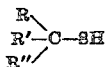
It will thus be seen that the present invention utilizes as flotation agents in the separation of minerals and the concentration of ores the thioalcohols; that said flotation agents may be incorporated in or with the ore in any suitable or well-known manner; that they may be used in conjunction with other flotation agents or with frothing agents or with both; and that they may be added in the dry state in the free condition or as salts, or in solution, suspension or dispersion in any suitable solvent or medium.

It will be understood that the present invention is applicable to the treatment of various kinds of mineral mixtures, both natural and artificial, which are amenable to concentration by flotation processes.

It will be further understood that the invention is not limited in this specification to the use of the particular agents or ingredients mentioned as examples, and that other agents of the class mentioned can be used.

We claim:

1. A method of effecting the concentration of minerals by flotation, which comprises subjecting a mineral pulp to a froth flotation operation in the presence of a thioalcohol which corresponds with the following formula:



wherein R denotes an aromatic hydrocarbon radical, and R' and R'' each denote a hydrogen atom or a hydrocarbon radical.

2. A method of effecting the concentration of minerals by flotation, which comprises subjecting the mineral pulp to a froth flotation operation in the presence of an aralkyl mercaptan.

3. A method of effecting the concentration of minerals by flotation, which comprises subjecting the mineral pulp to a froth flotation operation in the presence of a nitrogen-free aralkyl mercaptan.

4. A method of effecting the concentration of minerals by flotation, which comprises subjecting the mineral pulp to a froth flotation operation in the presence of benzyl mercaptan.

5. A method of effecting the concentration of minerals by flotation, which comprises mixing a mineral pulp with a thio-

alcohol which corresponds with the following probable formula:



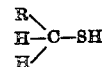
wherein R denotes an aromatic hydrocarbon radical, and R' denotes a hydrogen atom or a hydrocarbon radical, and subjecting the resultant mixture to a froth flotation operation.

6. A method of effecting the concentration of minerals by flotation, which comprises mixing a mineral pulp with a thioalcohol which corresponds with the following probable formula:



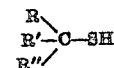
wherein R denotes an aromatic hydrocarbon radical which may contain substituents, and subjecting the resultant mixture to a froth flotation operation.

7. A method of effecting the concentration of minerals by flotation, which comprises mixing a mineral pulp with a thioalcohol which corresponds with the following probable formula:



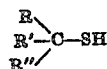
wherein R denotes a hydrocarbon radical of the benzene series, and subjecting the resultant mixture to a froth flotation operation.

8. A method of effecting the concentration of a copper sulfide ore, which comprises subjecting an alkaline pulp of the ore to froth flotation in the presence of a thioalcohol which corresponds with the following formula:



wherein R denotes an aromatic hydrocarbon radical, and R' and R'' each denote hydrogen or a hydrocarbon radical.

9. A method of effecting the concentration of a copper sulfide ore, which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of a thioalcohol which corresponds with the following formula:



wherein R represents an aromatic hydrocarbon radical of the benzene series, and R' and R'' each respectively denotes a hydrogen atom or a hydrocarbon radical.

10. A method of effecting the concentration of a copper sulfide ore, which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of

a thioalcohol which corresponds with the following formula:



5

wherein R represents an aromatic hydrocarbon radical.

11. A method of effecting the concentration of a copper sulfide ore, which comprises
10 subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of benzyl mercaptan.

In testimony whereof we affix our signatures.
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Certificate of Correction

Patent No. 1,904,460.

April 18, 1933.

FREDERICK G. MOSES, ET AL.

It is hereby certified that error appears in the printed specification of the above-numbered patent requiring correction as follows: Page 1, line 60, for the formula " $\geq$ C-SH" read $> CHSH$; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of June, A. D. 1933.

[SEAL]

M. J. MOORE,
Acting Commissioner of Patents,