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FLOTATION OF MINERALS

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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 a mixture of substances containing certain organic sulfur compounds.

According to the present invention, improved results can be obtained in the separation of minerals and concentration of ores by carrying out the flotation operation with the addition to the mineral pulp or ore of the resultant organic product or composition of matter obtained by the hydrolytic decomposition in the presence of an acid of a metal salt of an aralkyl ester of thiosulfuric acid represented by the formula $R—S_2O_3M$ where R denotes an aralkyl group such as $C_6H_5CH_2$, etc., and M signifies a metal, particularly an alkali metal.

The flotation agent particularly employed in the present invention can be prepared by reacting benzyl chloride with sodium thiosulfate in substantially equal molecular proportions in the presence of water, and subsequently subjecting the sodium benzyl thiosulfate thus produced, and without isolation from the reaction mixture containing it, to hydrolytic decomposition by adding an acid thereto, such as hydrochloric or sulfuric acid, and heating the mixture, preferably to or near the boiling temperature as described in our co-pending application filed of even date herewith, which has matured into Patent No. 1,729,615, granted October 1, 1929. When the reaction is complete, two liquid layers are produced, an oily layer and an aqueous layer. The oily layer, which comprises the flotation agent particularly utilized in the present invention, is separated in any suitable manner. The flotation or modifying agent thus obtained is relatively insoluble in water but is soluble in alcohol, benzene, aniline, xylidine, cresol, pine oil, carbon tetrachloride and other organic solvents. It is comprised chiefly of benzyl mercaptan (about 60 to 75 percent) associated with dibenzyl disulfide (about 20 to 35 percent), together with relatively small amounts of other hydrolytic decomposition products of sodium benzyl thiosulfate. Analogous products can be obtained in a similar manner by the decomposition in an acid medium of the metal salts of other aralkyl thiosulfates obtained by the action of aralkyl halides on sodium thiosulfate. It will be understood, however, that the use in flotation operations of mixtures comprising an aralkyl mercaptan and a diaralkyl disulfide, whether said mixtures are prepared by mechanical or by chemical processes, are included within the scope of the present invention.

In carrying out the flotation process, the flotation agent comprising the product obtained by decomposing the metal salt of an aralkyl ester of thiosulfuric acid, such as sodium benzyl thiosulfate, in acid aqueous solution may be incorporated with the ore or 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 it may be dissolved, suspended or dispersed in any suitable solvent or dispersing agent such as, for example, water, caustic alkali, or one or more of the usual flotation oils or oil mixtures, or in any suitable organic solvent or medium such as, for example, an aromatic hydrocarbon or an aromatic amine or a phenol, and incorporating the resulting solution, suspension or dispersion with the ore or ore pulp. While the present flotation agent shows marked action as a flotation or collecting agent in ore concentration, it generally exhibits weak and usually insufficient frothing qualities and, therefore, is ordinarily used to advantage in conjunction with any suitable and well-known frothing agent, e. g., pine oil, crude turpentine, tar acids, etc. It may be sometimes used with advantage in conjunction with other flotation agents.

The process of the present invention may 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, such as with certain copper ores, to submit the pulp to the action of an amount of alkali to give

it a distinctly alkaline reaction before subjecting it to the flotation operation with the aid of the flotation agent 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.

In the differential separation of various minerals, such as zinc blende from associated minerals, the presence of an alkali metal cyanide, or of copper sulfate or other salts, is sometimes advantageous.

The amount of flotation agent required to be used in the flotation operation will vary, it depending partly on the character and composition of the ore, and partly on other factors. Ordinarily, about one-sixth to one-fourth pound of the flotation agent per ton of ore will be sufficient, while in other cases larger or smaller amounts than this may be required.

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 (from Butte, Montana) assaying 1.51 percent of copper was ground in a ball mill with 210 parts of water and 0.75 parts of hydrated lime (equivalent to 3 pounds 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 water to give about 16 percent solids and subjected to flotation in a Janney flotation apparatus with the addition in the free state of 0.042 parts (equivalent to one-sixth pound per ton of ore) of the flotation agent prepared by the hydrolytic decomposition of sodium benzyl thiosulfate as herein described. The mixture was agitated for 20 minutes during which time 0.04 parts of pine oil was introduced. 47.1 parts of a concentrate assaying 15.8 percent of copper was obtained which is a recovery in the concentrate of 96.5 percent of the copper. The tailings assayed 0.06 percent copper. It may be remarked that in this test 31.2 parts of a concentrate assaying 22.5 percent copper was obtained at the end of the first 10 minutes of agitation. During the next 10 minutes of agitation, 15.9 parts of a concentrate assaying 2.92 percent copper was obtained.

Example 2.—500 parts of a copper sulfide ore (from Butte, Montana) assaying 1.51 percent copper was treated as in Example 1 except 0.0625 parts (equivalent to one-fourth pound per ton of ore) of said flotation agent dissolved in a small amount of one-tenth normal caustic soda solution was used in place of the 0.042 parts of the agent in the free or undissolved state. 43.2 parts of concentrate assaying 16.165 percent copper was obtained, which is a recovery of 95.7 percent of the copper. The tailings assayed 0.07 percent copper.

It will thus be noted that the present invention contemplates the utilization as a flotation agent of the product obtained by the hydrolytic decomposition of a metal salt of an aralkyl ester of thiosulfuric acid, particularly sodium benzyl thiosulfate, in acid solution; that the flotation agent may be incorporated with the ore or mineral pulp in any well-known or suitable manner; that it may be used in the free state or in solution, suspension or dispersion in any suitable solvent or medium; that it may be used in the differential separation of minerals; and that it may be used in conjunction with a frothing agent or with other flotation agents, or both.

It may 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.

We claim:

1. In effecting the concentration of minerals, the process which comprises adding to the mineral pulp a flotation agent comprising the product relatively insoluble in water obtainable by the decomposition of a metal salt of benzyl thiosulfuric acid in the presence of water and an acid, and subjecting the mixture to a froth flotation operation.

2. In effecting the concentration of minerals, the process which comprises subjecting a mineral pulp to a froth flotation operation in the presence of the product relatively insoluble in water obtainable by the hydrolytic decomposition of sodium benzyl thiosulfate in the presence of water and an acid.

3. In effecting the concentration of minerals, the process which comprises incorporating with a mineral pulp an aralkyl mercaptan associated with a diaralkyl disulfide, and subjecting the mixture to a froth flotation operation.

4. In effecting the concentration of minerals, the process which comprises subjecting a mineral pulp to a froth flotation operation in the presence of an aralkyl mercaptan, a diaralkyl disulfide, and other organic products resulting from the hydrolytic decomposition of an aralkyl thiosulfuric acid.

5. In effecting the concentration of minerals, the process which comprises subjecting a mineral pulp to a froth flotation operation in the presence of benzyl mercaptan, dibenzyl disulfide, and other organic products resulting from the decomposition of sodium benzyl thiosulfate in the presence of an acid.

6. In effecting the concentration of minerals, the process which comprises incorporating with a mineral pulp a composition containing about 60 to 75 percent benzyl mercaptan and 20 to 35 percent dibenzyl disul-

fide, and subjecting the mixture to a froth flotation operation.

7. In effecting the concentration of minerals, the process which comprises subjecting an ore pulp to a froth flotation operation in the presence of the product relatively insoluble in water obtainable by decomposing sodium benzyl thiosulfate in aqueous solution in the presence of sulfuric acid.

8. In effecting the concentration of minerals, the process which comprises subjecting an ore pulp to a froth flotation operation in the presence of the product relatively insoluble in water which can be obtained by first reacting benzyl chloride with sodium thiosulfate in the presence of water with formation of a reaction mixture containing sodium benzyl thiosulfate and subsequently heating said reaction mixture in the presence of sulfuric acid.

9. In effecting the concentration of minerals, the process which comprises subjecting an ore pulp to a froth flotation operation in the presence of a mixed product containing benzyl mercaptan, said product being relatively insoluble in water and obtainable by heating sodium benzyl thiosulfate in aqueous solution in the presence of an acid added thereto.

10. In effecting the concentration of minerals, the process which comprises subjecting an ore pulp to a froth flotation operation in the presence of benzyl mercaptan associated with dibenzyl disulfide.

11. In effecting the concentration of a copper sulfide ore, the process which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of the product relatively insoluble in water which can be obtained by the decomposition of a metal salt of an aralkyl thiosulfuric acid in the presence of water and an acid.

12. In effecting the concentration of a copper sulfide ore, the process which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of the product relatively insoluble in water which can be obtained by the decomposition of sodium benzyl thiosulfate in the presence of water and of an acid.

13. In effecting the concentration of a copper sulfide ore, the process which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of an aralkyl mercaptan and a diaralkyl disulfide.

14. In effecting the concentration of a copper sulfide ore, the process which comprises subjecting an alkaline pulp of the ore to a froth flotation operation in the presence of benzyl mercaptan and dibenzyl disulfide.

In testimony whereof we affix our signatures.

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