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FROTH FLOTATION OF ORES WITH
AROMATIC ALCOHOL

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1

This invention relates to an ore flotation process and, more particularly, to a process for efficiently concentrating minerals by froth flotation in the presence of a secondary or tertiary aromatic alcohol having between 9 and 12 carbon atoms.

It is well known that pine oil, cresylic acid, creosote, and amyl alcohol are effective flotation reagents. This invention involves the utilization of new flotation agents which have been found to bring about a more efficient separation than the above-mentioned flotation agents, and, in most cases, less agent is required to bring about a good separation.

2

calcareous gangue and containing about 1.7 to about 1.8% lead, was prepared in a 2000-gram flotation machine. Then, 0.15 pound of sodium sulfide per ton of ore, 0.05 pound of isopropyl xanthate per ton of ore, and the frother, as listed in Table I, were added. Air was drawn through the pulp, and the concentrate was removed for a period of 10 minutes. The results are listed in the following table. A control was run, using 25% amyl alcohol and 75% of hard wood creosote as the frothing agent, in which case almost twice as much frother was used as in Examples 1 and 2.

Table I

Example	Frother	Pound Per Ton	Per Cent Lead in Tailing	Per Cent Lead in Concentrate	Per Cent Lead Recovery
1.....	8-p-cymenol ¹	0.11	0.10	43.8	94.5
2.....	8-p-cymenol ¹	0.04			
	Hard wood creosote.....	0.10	0.11	51.2	93.9
Control..	25% amyl alcohol, 75% hard wood creosote.....	0.20	0.11	51.7	93.6

¹ The 8-p-cymenol was prepared by air-oxidation of p-cymene and contained about 10-15% of p-methyl acetophenone.

In accordance with this invention, it has been discovered that ores may be concentrated by subjecting a pulp or slurry of a ground ore to froth flotation in the presence of a secondary or tertiary aromatic alcohol having between 9 and 12 carbon atoms per molecule as a flotation agent in a more facile, efficient, and economical manner than heretofore possible.

The nature and purpose of the invention have been generally indicated, and the following examples illustrate preferred embodiments.

EXAMPLES 1-2

Lead ore flotation pulp, containing about 2500 grams of ore, composed of galena in a siliceous,

EXAMPLES 3-5

A 1010-gram sample of lead ore (same as in Examples 1-2), which is retained by an 8-mesh screen, was ground in a ball mill for 10 minutes with 1000 cc. of water. The ground ore was screened through a 48-mesh screen and then transferred to a 1000-gram flotation machine. Water was added to dilute the pulp to about 20% solids. Then 0.10 pound potassium isopropyl xanthate and 0.15 pound sodium hydroxide were added, and the pulp was conditioned for 10 minutes. The frothers given in Table II were added, and a concentrate was removed for 10 minutes. The results are given in Table II.

Table II

Ex-ample	Frother	Pound Per Ton	Per Cent Lead in Tailing	Per Cent Lead in Concentrate	Per Cent Lead Recovery
3.....	α -p-dimethyl-benzyl alcohol.....	0.12	0.55	63.7	87
4.....	α , α -dimethyl-benzyl alcohol.....	0.12	0.64	65.2	84
5.....	α , α , α' , α' -tetramethyl- α , α' -p-xylenediol.....	0.12	0.53	65.0	87

EXAMPLES 6-8

A 1010-gram sample of a copper ore was ground for 15 minutes in a ball mill with 1000 cc. of water. The copper ore contained about 0.9% copper, chiefly in the form of chalcopyrite and pyrite in a greater abundance than the copper mineral and gangue composed of siliceous minerals. Lime was added in the amount given in Table III. The ground ore was screened through a 48-mesh screen and then transferred to a 1000-gram flotation machine. The pulp was diluted to about 20% solids with water, and then 0.04 pound potassium cyanide per ton of ore was added and the pulp conditioned for 10 minutes. Then 0.04 pound of sodium dithiophosphate was added as the collector and the various frothers as given in Table III. The concentrate was removed for 10 minutes.

Table III

Example	Frother	Pound Per Ton	Lime Pound Per Ton	Copper in Tailing	Copper in Concentrate	Copper Recovery	Insoluble in Concentrate
6	8-p-cymenol ¹	0.18	3	Per Cent	Per Cent	Per Cent	Per Cent
7	73-8-p-cymenol, ¹ 27- amyl alcohol	0.18	3	0.17	28.2	81	21.8
8	8-p-cymenol (pure)	0.24	2.5	0.17	29.4	81	20.7
				0.17	31.8	82	17.0

¹ The 8-p-cymenol was prepared by air-oxidation of p-cymene and contained about 10-15% of p-methyl acetophenone.

EXAMPLE 9

One thousand twenty grams of zinc ore, which was retained by an 8-mesh screen, was ground in a ball mill for 7 minutes with 1000 cc. of water. The zinc ore contained about 12% zinc as the sulfide, sphalerite. Pyrite and siliceous gangue were also present. The ground ore was screened through a 35-mesh screen and then transferred to a 1000-gram flotation machine. The pulp was diluted with water to about 20% solids and conditioned for 10 minutes with 5.5 pounds of lime and 1.4-pounds of copper sulfate per ton of ore. Then 0.16 pound of ethyl xanthate per ton of ore and the frother shown in Table II were added. Air was drawn through the pulp, and a concentrate removed for 10 minutes. The following results, using 8-p-cymenol and using pine oil, clearly show the advantages obtained using the frother of this invention.

Table IV

Example	Frother	Pound Per Ton	Per Cent Zinc in Tailing	Per Cent Zinc in Concentrate	Per Cent Zinc Recovery
9	8-p-cymenol ¹	0.11	0.63	43.6	96.4
	Pine oil	0.22	0.85	42.1	94.7

¹ The 8-p-cymenol was prepared by air-oxidation of p-cymene and contained about 10-15% of p-methyl acetophenone.

In carrying out the froth flotation process, the ore or mineral to be concentrated is first finely ground in the presence of water to the desired size, depending upon the mineral to be treated, to insure that all of the gangue and the metalliferous components are liberated from each other. The ground mineral is then screened to remove the oversized materials. The resulting slurry or pulp is transferred to a flotation machine where it is mechanically agitated. The flotation reagents are added to the pulp either in the mill or in the flotation machine, depending on the ore that is treated. Water is added to adjust the pulp to the desired solids content. After the agents have been dissolved or dispersed, air or

other suitable gas is passed through the pulp. The desired minerals collect in the froth that is produced on the surface of the pulp, and then the froth is removed.

- 5 The flotation agent may be either a secondary or tertiary aromatic alcohol having between 9 and 12 carbon atoms per molecule. Monohydric tertiary aromatic alcohols having 9 or 10 carbon atoms and dihydric tertiary aromatic alcohols having 11 or 12 carbon atoms are preferable. The alcohols should have a balance between the polar and nonpolar part of the molecule so that good frothing is obtained. Suitable compounds include 8-p-cymenol, α , α -dimethylbenzyl alcohol, 15 α , α -dimethylbenzyl alcohol, α -ethyl- α -methylbenzyl alcohol, α -ethylbenzyl alcohol, α , α -dimethylcumyl alcohol, α -isobutylbenzyl alcohol,

- 30 α , α , α' , α' - tetramethyl - α , α' - p - xylenediol, and α , α , α' -trimethyl- α , α' -p-xylenediol.

Several of these alcohols may be prepared by oxidation of the corresponding hydrocarbons. For example 8-p-cymenol, α , α -dimethylbenzyl alcohol and α , α , α' , α' -tetramethyl- α , α' -p-xylenediol may be prepared by air-oxidation of p-cymene, cumene, and diisopropyl benzene, respectively. The aromatic alcohol may be used either in the pure form or it may be mixed with other oily products obtained from the air-oxidation of the corresponding hydrocarbon. For example, the products used in accordance with this invention may be the oily products obtained by oxidizing p-cymene or a mixture of p-cymene and p-methane in the liquid phase, an aqueous medium, or an alkaline medium with oxygen or air. The acids and unreacted p-cymene are separated from the oily oxidation product. This oily product contains 8-p-cymenol and p-methyl acetophenone. The p-methyl acetophenone also acts as a frothing agent. It is preferable to use an agent which contains at least 75% of the aromatic alcohol.

The flotation agent should be added in amounts from about 0.005 to about 5 pounds per ton of ore but, preferably, in amounts of 0.01 to 0.5 pound per ton of ore. The frothing agents are operable over a wide pH range.

In most cases, in order to get the most efficient separation of the minerals from the ore, other flotation agents are used along with the frother. These may be (1) collectors, such as xanthates, mercaptans, organic sulfides, dithiophosphates, thiocarbonates, thioureas, thiocarbonilide, azo and diazo compounds, etc.; (2) activating and conditioning agents, such as copper sulfate and other salts of copper, lead, zinc, etc.; alkali metal sulfide, lime, sodium hydroxide, sodium carbonate, cyanides, alkali metal silicates, etc.; (3) inhibitors, such as glue, starch, gelatin, etc.

The flotation agents disclosed in accordance with this invention may be used generally for the dressing of ores, including sulfide ores, oxides, and nonmetallic ores. The invention is especially applicable, however, to metallic ores, particularly

ores containing sulfide minerals of zinc, lead, copper, iron, silver, etc., which may be simple or complex combinations.

Although the applicability of the flotation agent is general for conditioning ores or treating minerals, the conditions affecting the frothing operation are dependent, in addition to the froth flotation agent, on the size of the ore being treated, the temperature at which the treatment is being carried out, and the per cent solids in the pulp. In each case, the particular conditions may be adjusted so as to permit the flotation agent to perform in a most economical and efficient manner.

The physical characteristics of the froth produced by an aromatic alcohol having between 9 and 12 carbon atoms are excellent. The froth is made up of fine bubbles which have sufficient strength to support the weight of the mineral coating. The froths are clear in respect to fine, slimy gangue present. When using lead and zinc ores, about one-half as much of the alcohol is required to produce the same froth and metallurgical results as is needed when pine oil or a mixture of amyl alcohol and a hard wood creosote is used.

What we claim and desire to protect by Letters Patent is:

1. In the method of concentrating ores, the step which comprises subjecting to froth flotation an aqueous pulp of the ore in the presence of a collector and an aromatic alcohol selected from the group consisting of secondary and tertiary alcohols having between 9 and 12 carbon atoms per molecule.

2. In the method of concentrating ores, the steps which comprise adding a collector and an aromatic alcohol selected from the group consisting of secondary and tertiary alcohols having between 9 and 12 carbon atoms per molecule to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

3. In the method of concentrating ores, the steps which comprise adding a collector and 8-p-cymenol to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

4. In the method of concentrating ores, the steps which comprise adding a collector and between about 0.005 pound and about 5 pounds of 8-p-cymenol per ton of ore to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

5. In the method of concentrating ores, the steps which comprise adding a collector and α,α -dimethylbenzyl alcohol to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

6. In the method of concentrating ores, the steps which comprise adding a collector and between about 0.005 pound and about 5 pounds of α,α -dimethylbenzyl alcohol per ton of ore to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

7. In the method of concentrating ores, the steps which comprise adding a collector and $\alpha,\alpha,\alpha',\alpha'$ -tetramethyl- α,α' -p-xylene diol to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

8. In the method of concentrating ores, the steps which comprise adding a collector and between about 0.005 pound and about 5 pounds of $\alpha,\alpha,\alpha',\alpha'$ -tetramethyl- α,α' -p-xylene diol per ton of ore to an aqueous pulp of the ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

9. In the method of concentrating metallic sulfide ore, the steps which comprise adding a collector and 8-p-cymenol to an aqueous pulp of said ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

10. In the method of concentrating metallic sulfide ore, the steps which comprise adding a collector and α,α -dimethylbenzyl alcohol to an aqueous pulp of said ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

11. In the method of concentrating metallic sulfide ore, the steps which comprise adding a collector and $\alpha,\alpha,\alpha',\alpha'$ -tetramethyl- α,α' -p-xylene diol to an aqueous pulp of said ore, agitating and aerating said pulp to form a froth containing the desired mineral values of said ore, and separating said froth.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,302,466	Palmer	Nov. 17, 1942
2,302,467	Palmer	Nov. 17, 1942

OTHER REFERENCES

Gaudin, "Flotation," 1932 McGraw-Hill Co., pages 56 to 62.

Richards and Locke, "Textbook of Ore Dressing," 1940, page 249.

Certificate of Correction

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April 19, 1949.

WILLIAM T. BISHOP ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Columns 3 and 4, Table III, second column thereof, for "73- 8-p-cymenol,¹ 27- amyl alcohol", read *73% 8-p-cymenol,¹ 27% amyl alcohol*; same table, footnote 1, for "10-15-" read *10-15%*; column 6, line 59, list of references cited, for the numeral "62" read *63*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of October, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.