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FLOTATION PROCESS

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9 Claims. (Cl. 209—166)

This invention relates to froth flotation processes and more particularly to froth flotation processes for separating metallic minerals wherein a blended pine oil or pine oil derivative is utilized as a frothing agent.

In the separation of metals from metal-bearing minerals or ores by froth flotation processes, the percentage of recovery of the metals is largely due to the character of the frothing reagents employed. Nowadays it is desirable to get a very high recovery of metals in a very rapid and most efficient manner. For example, today a recovery under 80%, in most cases is considered poor, while years ago, a recovery of 60% was considered good. With the increase in efficiency of flotation processes, competition has become extremely keen and the successful operation of ore dressing or metallurgical plants may depend upon an increase in the recovery of metal of only a few percent. This is particularly so if the mineral or ore to be dressed is of the low metal bearing quality or the plant operates on a small margin of profit.

Heretofore fatty acids, soaps, sulfonated products, pine oil, cresylic acid, and special aliphatic alcohols have been utilized as frothing reagents. The first three mentioned frequently were quite unsatisfactory because the desired selectivity could not be obtained and more particularly because the gangue would float in large concentrations. An excessive amount of reagents was often required to get a good recovery. This presented a serious economical problem, particularly when pine oil was used as a frother. Pine oil at times was not readily available on the market because the demand was greater than the supply and the prices thereof increased to an extent which made its use prohibitive.

An object of the present invention is to overcome the foregoing difficulties.

Another object is to improve froth flotation processes and increase the recovery of metals or minerals.

Another object is to decrease the cost of froth flotation processes by utilizing frothing reagents which are inexpensive, are readily available on the market at all times, and need not be used in large quantities.

A further object is to utilize frothing agents under conditions to produce a maximum concentration and a more efficient separation of the minerals and metals.

Other and further objects will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

These objects are accomplished by frothing an aqueous suspension of minerals or ores in the presence of a blended pine oil or pine oil derivative acting as a frother and containing an emulsifying agent and a hydrocarbon. In addition, if desired, the blend may be cut with suitable hydrocarbons and may be used in conjunction with suitable flotation agents. Preferably, the blend comprises equal volumes of pine oil or the like and hydrocarbons mixed with about 10% of an emulsifying agent, although good results may be attained with other proportions of materials as will be pointed out hereafter.

In accordance with the invention, I have found that pine oil or the like, suitably blended, can be used advantageously as a froth flotation agent. When pine oil is referred to herein and in the appended claims, I mean pine oil of the commercial grade, synthetic pine oil, and pine oil derivatives prepared by air oxidation of terpene hydrocarbons and containing alcohols, ethers, oxides, etc., such as terpinyl methyl ether or air oxidized acyclic terpene hydrocarbons.

I prefer to blend the pine oil and hydrocarbons with an emulsifying agent which may be sulfonated pinene-cresol condensate, sulfonated pinene-phenol condensate, sulfated dehydroabietyl alcohol, sulfonated higher fatty acid esters, such as sulfonated castor oil, or a compound (sold under the trade name of Hercota) which is made by heating ethanolamine or triethanolamine and vegetable oils, such as castor oil.

In the pine oil-emulsifying agent-hydrocarbon blend, I may use aliphatic or aromatic hydrocarbons, or mixtures thereof. I have found that hydrocarbons having a boiling range between 100° C. and 300° C., but preferably between 150° C. and 250° C., are suitable, for example, kerosene or products sold under the trade names of Solvesso, Nos. 2, 3, and 4 (chiefly aromatic hydrocarbons) and Troluoil (chiefly aliphatic hydrocarbons having a boiling range equivalent to toluol). The boiling ranges of these hydrocarbons are as follows:

Troluoil	115 to 125° C.
Solvesso No. 2	134 to 185° C.
Solvesso No. 3	185 to 215° C.
Solvesso No. 4	215 to 282° C.
Kerosene	183 to 255° C.

The froth flotation reagents, that is, the pine oil blends, may comprise pine oil and from 1 to 25%, but preferably from 5 to 10% emulsifier, and hydrocarbons in any desired proportions, although mixtures of equal volumes of pine oil and hydrocarbon are preferred. The reagents, preferably are prepared by mixing them prior to adding them to the flotation tank to assure thorough admixture of the ingredients and to facilitate controlling the concentration thereof in the course of the flotation process, but may be added individually to the tank, if so desired. In practice, where minerals or ores, particularly of the metallic type are froth floated, small amounts of salts such as sodium cyanide or a thiophosphoric acid containing 6% thiocarbanilide (Aerofloat No. 31) or other materials as indicated hereafter, may be utilized to assist in increasing the effectiveness of the frothing reagents.

In carrying out the froth flotation process, the ore or mineral to be dressed, concentrated, or classified is first ground to a pulverized or finely divided state and is fed to a flotation tank of any well-known design which contains water. The minerals and water are mechanically agitated and air or other suitable gas is bubbled therethrough. A desired amount of flotation reagents is added and these reagents are active to separate the desired materials from the undesired materials either by floating the material to be recovered or by froth floating the waste material and concentrating the desired material in the tank.

The application of the process in accordance with the present invention is illustrated more particularly by the following examples:

Example I

A volume of a lead ore flotation pulp, corresponding to about 2500 g. of ore, was transferred to a 2000 g. flotation cell. Then 0.008 lb. of sodium cyanide per ton of ore, 0.06 lb. of Aerofloat No. 31 (a thiophosphoric acid + 6% thiocarbanilide) and the frother as listed below, were added. Air was passed through the pulp and a concentrate was taken off for 20 minutes.

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
0% of equal vol. of pine oil and kerosene+10% Hercota	0.12	38.6	92.4
90% of same blend+10% sulfonated castor oil	0.12	43.1	92.3
90% of same blend+10% sulfonated pinene-phenol condensate, Na salt	0.12	42.2	92.4

Example II

The same procedure as in Example I was followed.

Sodium cyanide ____ lb. per ton of ore __ 0.008
Aerofloat No. 31 ____ do ____ 0.047
Flotation time ____ minutes __ 20

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
90% of equal vol. of pine oil and kerosene+10% sulfonated castor oil	0.12	61.9	93.9
95% of same blend+5% sulfonated castor oil	0.12	62.1	93.0
85% of same blend+15% sulfonated castor oil	0.12	59.3	93.5
80% of same blend+20% sulfonated castor oil	0.12	61.3	93.5

Example III

The same procedure as in Example I was followed, except neither collector (Aerofloat No. 31) nor sodium cyanide was added. The frother was the only reagent present. Flotation time 20 minutes.

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
90% of equal vol. of pine oil and kerosene+10% Hercota	0.15	43.7	88.4
Same as above	0.17	49.8	91.1
90% of equal vol. of pine oil and kerosene+10% sulfonated castor oil	0.15	49.8	87.9
Same as above	0.17	47.1	88.8

Example IV

One thousand ten (1010) g. of St. Joseph Lead Company's Bonne Terre, Missouri, minus 8 mesh lead ore were ground in a ball mill for 12 minutes with 1000 cc. of distilled water. The ground ore was screened through a 65 mesh screen and then transferred to a 1000 g. flotation machine, and further diluted to about 20% solids. To the pulp were added the following frothers, but no other reagents. The tests were carried out for 20 minutes.

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
90% of equal volume of pine oil and kerosene+10% Hercota	0.20	68.88	80.3
90% of above blend+10% sulfonated castor oil	0.20	68.70	75.6
90% pine oil+10% sulfonated castor oil	0.20	43.73	76.3

Example V

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
90% of equal volume of pine oil +kerosene+10% sulfonated pinene-phenol condensate, Na salt	0.20	65.89	88.4
90% of above blend+10% sulfonated pinene-cresol condensate Na salt	0.20	64.25	86.2
90% of equal volumes of terpinyl methyl ether+kerosene+10% sulfonated pinene-phenol condensate, Na salt	0.20	64.91	85.7
90% of above blend+10% sulfated dehydroabietyl alcohol, Na salt	0.20	60.41	93.4
90% of above blend+10% Hercota	0.20	65.41	94.8

In the above, it will be noted that tests were made with blends containing a terpene ether (from terpineol and methyl alcohol) in place of pine oil. These gave satisfactory results.

Example VI

Bonne Terre lead ore was processed by following the same procedure as in Example IV, except that the ore after grinding was screened through a 48-mesh screen instead of a 65. Then 0.05 lb. of sodium cyanide per ton of ore, 0.11 lb. of Aerofloat No. 31, and the frother as given below, were added. Air was passed through the pulp and a concentrate was taken off for 20

minutes. The metallurgical results obtained were as follows:

Frother	Pounds per ton	Percent Pb in concentrate	Percent Pb recovery
90% of equal vol. of pine oil and kerosene+10% sulfonated castor oil	0.12	55.06	94.7
90% of equal vol. of air oxidized Solvenol (hydrocarbon removed) and kerosene+10% sulfonated castor oil	0.12	38.92	96.0
90% of above blend+10% Hercota	0.12	42.32	95.9

Example VII

About 830 g. of minus 8 mesh Matahambre copper ore from Santa Lucia, Cuba, were ground in a ball mill for 14 minutes with 1000 cc. of distilled water. The ground ore was screened through a 48-mesh screen and then transferred to a 1000 g. flotation cell and further diluted to about 16% solids. In addition to the frother, the following materials were added to the pulp:

Sodium cyanide	lb. per ton of ore	0.10
Lime	do	1.20
Potassium ethyl xanthate	do	0.13

Air was passed through the pulp and a concentrate was taken off for 10 minutes.

Frother	Pounds per ton	Percent Cu in concentrate	Percent Cu recovery
90% of equal vol. of pine oil and kerosene+10% sulfonated castor oil	0.58	18.87	90.3
90% of same blend+10% Hercota	0.58	19.77	91.0

Example VIII

About 1030 g. of the same Matahambre copper ore were ground in a ball mill for 14 minutes with 1000 cc. of distilled water. The ground ore was screened through a 48-mesh screen and then transferred to a 1000 g. flotation cell and further diluted to about 20% solids. In addition to the frother, the following materials were added:

Sodium cyanide	lb. per ton of ore	0.08
Lime	do	1.00
Potassium ethyl xanthate	do	0.15

Air was passed through the pulp and a concentrate was taken off for 10 minutes.

Frother	Pounds per ton	Percent Cu in concentrate	Percent Cu recovery
90+ of equal vol. of pine oil and kerosene+10% sulfonated castor oil	0.48	18.52	89.5
Same as above	0.25	20.62	89.0
95% of equal vol. of pine oil and kerosene+5% sulfonated castor oil	0.25	22.86	85.5
90% of equal vol. of pine oil and Solvesso No. 2+10% sulfonated castor oil	0.25	20.86	84.3
90% of equal vol. of pine oil and Solvesso No. 3+10% sulfonated castor oil	0.24	21.97	85.1
90% of equal vol. of pine oil and Solvesso No. 4+10% sulfonated castor oil	0.48	17.23	91.5

The last four frothers were stage fed, ½ at start, and ½ after 5 minutes of the test.

From the foregoing description and examples, it will be seen that the present invention provides an improved froth flotation process for separating, collecting, or classifying minerals or ores, of the metal bearing type. The pine oil blends utilized in carrying out the process provide a relatively high recovery. Relatively small amounts of the blends are effective to separate the metals from the gangue in an expedient manner, thereby decreasing the cost of the frothing reagents and increasing the plant capacity.

It will be understood that the details and examples hereinbefore set forth are illustrative only and that the invention as broadly described and claimed is in no way limited thereby.

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

1. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and a hydrocarbon compound and a minor proportion of an emulsifying agent selected from the group consisting of sulfonated pinene-cresol condensate, sulfonated pinene-phenol condensate, sulfated dehydroabietyl alcohol, sulfonated higher fatty acid esters, ethanolamine-castor oil condensates and triethanolamine-castor oil condensates.

2. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and a hydrocarbon compound and a minor proportion of an ethanolamine-castor oil condensate.

3. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and a hydrocarbon compound and a minor proportion of a triethanolamine-castor oil condensate.

4. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and a hydrocarbon compound having a boiling range between about 100° C. and about 300° C. and a minor proportion of an emulsifying agent selected from the group consisting of sulfonated pinene-cresol condensate, sulfonated pinene-phenol condensate, sulfated dehydroabietyl alcohol, sulfonated higher fatty acid esters, ethanolamine-castor oil condensates and triethanolamine-castor oil condensates.

5. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and a hydrocarbon compound and from about 1 to about 25% of an emulsifying agent selected from the group consisting of sulfonated pinene-cresol condensate, sulfonated pinene-phenol condensate, sulfated dehydroabietyl alcohol, sulfonated higher fatty acid esters, ethanolamine-castor oil condensates and triethanolamine-castor oil condensates.

6. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent consisting of about 45% commercial pine oil, about 45% kerosene, and about 10% of an emulsifying agent selected from the group consisting of sulfonated pinene-cresol condensate, sulfonated pinene-phenol condensate, sulfated dehydroabietyl alcohol, sulfonated higher fatty acid esters, ethanolamine-castor oil condensates and triethanolamine-castor oil condensates.

7. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of terpinyl methyl ether and kerosene and a minor proportion of an ethanolamine-castor oil condensate.

8. A process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising substantially equal volumes of commercial pine oil and kerosene and about 10% of an ethanolamine-castor oil condensate.

9. In a process for the froth flotation of sulfide ores which comprises frothing an aqueous suspension of said ores in the presence of a frothing agent comprising major proportions of pine oil and kerosene and a minor proportion of sulfonated castor oil.

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CERTIFICATE OF CORRECTION.

Patent No. 2,286,374. June 16, 1942.

PHILIP A. RAY.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 51, in the table, for "0%" read --90%--; 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 28th day of July, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.