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## FLOTATION PROCESS

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This invention relates to flotation processes and more particularly to frothing agents for the froth flotation of ores.

For dressing ores by froth flotation, it is necessary to use collectors and frothing agents, in addition to regulating reagents. Heretofore, terpene alcohols in industrial form, for example pine oil, have played an important role as frothing agents. Further known frothing agents are the homologues of phenol, particularly fractions of tar acid rich in xlenol, and aliphatic alcohols of medium molecular weight such as amyl alcohol, hexanol and heptanol.

Although the above mentioned aliphatic alcohols were in part superior to the terpene alcohols as regards their surface activity, i.e. their ability to reduce the interface tension of water/air, and though they yield pure concentrates, they could not equal the terpene alcohols in importance since the flotation froths produced by these aliphatic alcohols break up more readily and possess only little bearing strength.

It has also been known, heretofore, that higher oxethylated reagents with relatively long aliphatic chains, for example fatty alcohols oxethylated with at least 6 mols of ethylene oxide and similar products which are used as textile auxiliaries and washing agents, froth very much with water. These substances are, however, not adapted for use as frothing agents for flotation processes, since the froths obtained therewith are very voluminous and so stable that they do not break up as rapidly as is desired after they have left the cell in which the flotation is carried out. Furthermore, froths obtained from flotation pulps in the presence of these reagents contain only relatively small quantities of ores. Products of this kind, therefore, do not constitute suitable frothing agents.

Now I have found that by addition of short



chains to saturated monohydric aliphatic alcohols of medium length of chain, i.e. to at least one alcohol of 4 to 8, preferably 5 to 8 carbon atoms, for example butyl, amyl, hexyl or octyl alcohol, reagents can be obtained which are excellent frothing agents for flotation processes, while the surface activity of the starting alcohols is changed only insignificantly, if at all, and which are far superior not only to the starting alcohols but even to the terpene alcohols. The substances used according to the present invention contain at least 1 mol and preferably not more than 5 mols of ethylene oxide (hereinafter sometimes referred to as EO) in the form of the grouping  $\text{—CH}_2\text{—CH}_2\text{—O—}$  per mol of alcohol. In addition, in accordance with the present invention, substances obtained by reacting ethylene oxide with a mixture of alcohols or with branched alcohols such as tertiary butanol, isobutanol, isoamyl alcohol, isoheptanol or iso-octanol may also be used.

In this connection, there are also known frothing agents for flotation processes which have been obtained by addition of propylene oxide to lower alcohols, for example

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methanol. In these frothing agents, however, the necessary surface activity is obviously produced, in the main, by the ether chain itself, since the starting alcohols such as methanol are not sufficiently surface-active to be suitable for use as frothing agents for flotation processes. It, therefore, could not be foreseen that by addition of the shorter chains of ethylene oxide which are richer in oxygen and poorer in hydrocarbon to aliphatic alcohols of sufficient surface-activity but insufficient frothing properties, there are obtained—without essential alteration of the surface-activity of the basic alcohol—reagents which are better frothing agents than the basic alcohols, the terpene alcohols and also the polypropylene glycol ethers mentioned above. This was the more surprising since substances which have been obtained by addition of a few mols of ethylene oxide to terpene alcohols or to xlenol are not better but, on the contrary, rather less adapted for use as frothing agents than the starting products which have not been reacted with ethylene oxide.

The frothing agents according to the present invention are especially applicable to sulfidic ores, primarily ores of the metals lead, zinc, copper, molybdenum, nickel, cobalt or antimony, which are often associated with other elements such as silver, mercury, gold, cadmium or arsenic. If desired, the frothing agents of the present invention can also be used for oxidic ores or those of carbonate or silicate nature, for example, of the above mentioned elements or the elements tin, tungsten or uranium. They can further be used for the flotation of salts, for example of potassium chloride, or for the flotation of fluor spar (fluorite) or phosphorite. Furthermore, the frothing agents of the present invention can be employed in the flotation of iron pyrites and they are of special importance in the flotation of sulfidic lead ores or sulfidic lead-zinc ores as well as of simple or complex sulfidic copper ores.

The quantity of frothing agent to be used depends on the ores, the quantity of water employed, the size of the grains of the ores, the gangue, the working conditions (for example preliminary enrichment) and the frothing agent used. In the case of galena or sulphidic lead zinc ores the quantity of frothing agent, for example, preferably amounts to more than 20 grams per ton of ore.

In the case of various sulphidic lead zinc ores, for which the frothing agents of the present invention are particularly suitable, the quantity of frothing agents necessary for obtaining the same effect can vary between about 7 and 125 grams per ton of ore. As compared with the known frothing agents, in all these cases a considerably smaller quantity of the frothing agents according to the present invention is required; the reduction, in general, amounts to 40 to 70 percent of the quantity of the known frothing agents.

Hence, the frothing agents according to the present invention are much more efficient than the known frothing agents.

Due to the selective properties of the frothing agents of the present invention it is possible to separate minerals which cannot be separated otherwise. For example, copper pyrites can be separated to a large extent from gersdorffite (a sulfidic iron-nickel arsenic mineral) even in ores which are very poor in metal (for example 1.7 percent of Cu:0.1 percent of Ni).

In the following Table 1 the effect of two known frothing agents (Nos. 1 and 2) is compared with that produced by the frothing agents according to the present invention (Nos. 3–6). The tests were made with pure galena in a 50 gram mineral separation cell and in 4 series of experiments 12.5, 25, 50 and 75 grams each of frothing agent per ton of ore were added. In each case 100 grams of potassium ethyl xanthate per ton of ore were added as collector.

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TABLE 1

Yield in percent obtained in the flotation of galena

Frothing agent	12.5 g./t. of ore	25 g./t. of ore	50 g./t. of ore	75 g./t. of ore
1. terpeneol.....	39.8	55.5	82.2	93.2
2. tetra - propylene - glycol - monomethyl ether.....	38.4	61.6	83.4	94.6
3. amyl alcohol + 2 EO.....	38.2	76.4	88.3	95.0
4. amyl alcohol + 4 EO.....	49.2	84.8	92.5	96.6
5. hexyl alcohol + 2 EO.....	39.3	83.4	91.2	95.8
6. hexyl alcohol + 4 EO.....	47.7	83.9	92.2	97.0

The superior properties of the compounds according to the present invention can also be seen from Table 2 in which the weights of the concentrates of galena are indicated, which weights were obtained under constant conditions in flotation experiments in the Fagergren-laboratory-cell. 600 grams of an industrial lead ore containing 13.5 percent of galena (~11.7 percent of Pb) were subjected to flotation with the frothing agents indicated in Table 1. The quantity of galena discharged by the froth flowing over was determined. As collector 50 grams of potassium ethyl xanthate per ton of ore were added.

TABLE 2

Frothing agent (150 g./t.)	concentrate of galena in g.
1. terpeneol.....	25.4
2. tetra-propylene-glycol-monomethyl ether.....	45.6
3. amyl alcohol + 2 EO.....	53.0
4. amyl alcohol + 4 EO.....	57.4
5. hexyl alcohol + 2 EO.....	59.1
6. hexyl alcohol + 4 EO.....	63.5

Table 3 shows the results of flotation tests in an industrial flotation plant for lead zinc ore, the quantities of frothing agents required per ton of ore being indicated. The consumption of frothing agents was determined in a 24 hour operation per ton of ore charged. From this table, too, it can be seen that the frothing agents according to the present invention are superior to the known compounds serving as frothing agents.

TABLE 3

Metal content: 6% Pb and 2.5% Zn

Frothing agent	consumption/t.
pine oil.....	61
tetra-propylene-glycol-monomethyl ether.....	65
hexyl alcohol + 2 EO.....	59

Table 4 shows some results ascertained in tests in industrial plants with respect to the different effect produced by known frothing agents and the frothing agents according to the present invention, sulphidic lead ores or sulphidic lead-zinc ores having been subjected to the flotation process. In general these ores are floated in a selective manner. The tests were in part carried out in the zinc circuit and in part in the lead circuit as well as in both stages of flotation at the same time.

The tests were carried out as follows:

First, the average consumption of the known frothing agents which were used at that time in the plants concerned was determined. Subsequently, the flotation was carried out with a frothing agent according to the present invention and the average consumption per ton of material charged was determined in the same manner. Care was taken that all other flotation conditions were kept constant. The effect produced by the dressing process was constantly controlled by vanning and by microscopic evaluation of the concentrates and tailings.

In all the flotation plants concerned a smaller quantity of frothing agent according to the present invention per ton of material charged was used than of the known froth-

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ing agents, while the same result was obtained. The reduction in the quantity of frothing agent used amounted to as high as 75%. The variations are caused by—among other factors—the different character of the ores due to the individual ore deposits, furthermore by the working conditions (for example primary enrichment, degree of comminution and amount of water) and also by the efficiency of the individual frothing agents used for the purpose of comparison.

The values ascertained for the reduction in consumption could be verified in tests lasting several days.

When the frothing agents according to the present invention are used, there is no fear that working troubles or other difficulties will arise.

TABLE 4

Technical flotation tests with lead-zinc ores

Ore Percent Pb: Percent Zn	stage of flotation	known frothing agent, g./t.	frothing agent according to the present invention, g./t.	reduction in consumption, percent
1.5:0.....	Pb	frothing agent on the basis of tar oil-terpeneol, 30.	7.6	74.6
3:7.....	Pb	frothing agent on the basis of terpene alcohol, 71.	42	40.8
2.5:9.....	Zn	frothing agent on the basis of terpene alcohol, 106.	27	74.5
2.5:13.....	Zn	frothing agent on the basis of terpene alcohol, 115.	50	56.5

When the frothing agents of the present invention are used, known collectors, for example xanthates of alcohols containing up to about 6 carbon atoms, can be employed.

I claim:

1. The method of concentrating ores which comprises subjecting an aqueous pulp of said ore to froth flotation in the presence of a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and n is an integer from 1 to 5.

2. The method as claimed in claim 1 wherein R is a saturated aliphatic hydrocarbon radical having 5 to 6 carbon atoms and n is an integer from 2 to 5.

3. The method of concentrating sulfidic ores which comprises subjecting an aqueous pulp of said sulfidic ore to froth flotation in the presence of a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and n is an integer from 1 to 5.

4. The method of concentrating sulfidic lead containing ores which comprises subjecting an aqueous pulp of said sulfidic lead containing ore to froth flotation in the presence of a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and n is an integer from 1 to 5.

5. The method of concentrating sulfidic lead zinc ores which comprises subjecting an aqueous pulp of said sulfidic lead zinc ore to froth flotation in the presence of

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a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and  $n$  is an integer from 1 to 5.

6. The method of concentrating sulfidic copper containing ores which comprises subjecting an aqueous pulp of said sulfidic copper containing ore to froth flotation in the presence of a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and  $n$  is an integer from 1 to 5.

7. The method of concentrating ores which comprises subjecting an aqueous pulp of a sulfidic ore of an element selected from the group consisting of lead, zinc, copper, molybdenum, iron, nickel, cobalt, and antimony and mixtures of these elements with the elements silver, mercury, gold, cadmium, and arsenic to froth flotation in

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the presence of a collector and in the presence, as a frother, of at least one compound of the formula



wherein R is a saturated aliphatic hydrocarbon radical having 5 to 8 carbon atoms and  $n$  is an integer from 1 to 5.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

2,355,823	Schlegel	Aug. 15, 1944
2,591,289	Powell et al.	Apr. 1, 1952
2,611,485	Treter	Sept. 23, 1952
2,687,214	Powell et al.	Aug. 24, 1954
2,690,259	Anderson	Sept. 28, 1954
2,732,940	Hall et al.	Jan. 31, 1956
2,816,870	Lentz	Dec. 17, 1957

##### OTHER REFERENCES

Schwartz et al.: Surface Active Agents, 1949, Interscience, pages 202-203.

Bickerman: Foams: Theory and Industrial Applications, 1953, pages 250-252.