

## UNITED STATES PATENT OFFICE

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## FROTHING AGENTS FOR THE FLOTATION OF ORES

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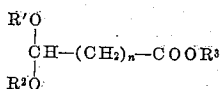
9 Claims. (Cl. 209—166)

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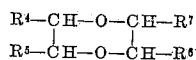
Froth flotation processes for the concentration and purification of many materials such as metallic and non-metallic ores and coal are well known. In such processes water containing frothing agents is added to the materials and separation is effected by selective flotation.

The object of the invention is to provide a process which is carried out with the aid of new frothing agents, whereby greater efficiency is obtained.

The present invention is for a method of effecting the concentration of minerals by flotation which comprises the steps of adding to the mineral pulp, in the capacity of a frothing agent, a mixture of an alkoxy ester compound of the formula:



and a dioxan compound of the formula:



wherein  $R^1$ ,  $R^2$  and  $R^3$  are alkyl radicals, the same or different,  $n$  is zero or an integer,  $R^4$  is an alkoxy radical and  $R^5$ ,  $R^6$  and  $R^7$  are selected from the group consisting of hydrogen, alkyl radicals and alkoxy radicals, or an alkoxy ester compound as defined above, or a dioxan compound as defined above, and subjecting the resulting mixture to a flotation operation. The alkyl radicals referred to above may be for example methyl, ethyl, propyl or butyl radicals; the alkoxy radicals may be for example, methoxy, ethoxy, isopropoxy or butoxy radicals.

Compounds which have been found particularly suitable for use in the process of the present invention are alkoxy ester compounds of the formula indicated above in which  $R^1$ ,  $R^2$  and  $R^3$  are the same and are each methyl or ethyl radicals and  $n$  is an integer in the range 2-8, such as ethyl-4:4-diethoxy-butane-1-carboxylate and ethyl-5:5-diethoxypentane-1-carboxylate, and 2:3:5:6-tetraisopropoxy-1:4-dioxan. Other suitable compounds include methyl-3:3-dimethoxypropane-1-carboxylate, methyl-4:4-dimethoxybutane-1-carboxylate, methyl-5:5-dimethoxypentane-1-carboxylate, methyl-8:8-dimethoxyoctane-1-carboxylate, ethyl-3:3-diethoxypropane-1-carboxylate and ethyl-8:8-diethoxyoctane-1-carboxylate.

The compounds employed according to the present invention as frothing agents may be used either in pure form, or in impure form as for

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example admixed with the by-products co-produced with them, or alternatively admixed with compounds having frothing properties, for example the tetra-alkoxy derivatives of paraffins such as 1:1:2:2-tetraethoxyethane, 1:1:2:2-tetranormalpropoxyethane, 1:1:2:2-tetraisopropoxyethane, 1:1:2:2-tetrabutoxyethane, 1:1:2:2-tetranormalpropoxypropane, 1:1:4:4-tetramethoxybutane and 1:1:5:5-tetraethoxypentane.

One noteworthy advantage of the froth flotation agents according to the present invention is that satisfactory frothing is obtained with the aid of a very much smaller proportion thereof than as compared with previously used froth flotation agents, such as steam distilled pine oil.

The froth flotation agents according to the present invention are capable of producing a froth that is not noticeably brittle or weeping and which obviates the need for the addition of froth-stiffening substances.

The present invention for the treatment of minerals by froth-flotation is of particular application in the treatment of sulphidic ores such as copper-containing sulphidic ores, but is also applicable to the treatment of other ores such as lead, zinc, iron, molybdenum, nickel and gold sulphide and non-sulphide ores and also to mineral ores such as coal ores.

The froth flotation process may be carried out as used or described in the art, the frothing agents herein disclosed being suitable for use with or without collecting agents, modifying agents, activating agents and other froth flotation reagents, and otherwise applicable to the processes generally employed. The conditions most suitable for operation, that is the amount of the frothing agent, the particle size of the ore, the temperature, the pH of the mixture, the proportion of ore in the pulp, the addition of other agents and adjuncts for the process, are readily determinable by one skilled in the art. We have found the use of amounts of the froth flotation agents of our invention in the range 0.0001% to 0.05%, and preferably about 0.0007% by weight based on the weight of the ore satisfactory.

In the flotation of sulphidic and oxidised metallic ores, compounds such as the xanthates, such as ethyl xanthate, dithiophosphates, such as phosphocresylic acids, and diphenyl thiourea, are frequently used as collecting agents, while in the flotation of non-metallic ores, fatty acids and fatty acid soaps are normally used as collecting agents.

The following example is given to illustrate

the process of the present invention. The parts and percentages referred to are by weight:

#### Example

520 parts of a siliceous copper ore containing chalcocite, chalcopyrite and bornite, is ground with 200 parts of water in a rod mill to minus 80 mesh particle size. The pulp is transferred to a Fagergren flotation machine and 0.05 part of potassium ethyl xanthate are added thereto. The pulp is diluted with 3000 parts of water, 0.0037 part of ethyl-5:5-diethoxypentane-1-carboxylate is added thereto as frothing agent, and the mixture is then conditioned without aeration for four minutes. The pH of the pulp is about 7.2. Aeration is then applied, and the froth is removed for 10 minutes.

For purposes of comparison the above process is repeated exactly as described above, with the exception that the 0.0037 part of ethyl-5:5-diethoxypentane-1-carboxylate is replaced by 0.010 part of pine oil.

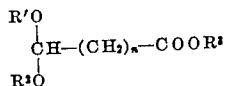
The results obtained in both cases are shown in the table below:

| Frother                                 | Percent Frother on ore | Percent Copper in ore | Percent Copper in concentrate | Percent Copper in tailings | Percent Recovery of copper |
|-----------------------------------------|------------------------|-----------------------|-------------------------------|----------------------------|----------------------------|
| Ethyl-5:5-diethoxypentane-1-carboxylate | 0.0007                 | 4.57                  | 62.3                          | 0.17                       | 96.5                       |
| Pine oil                                | 0.0019                 | 4.98                  | 59.1                          | 0.23                       | 95.6                       |

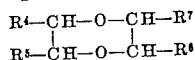
The process of the example is repeated exactly as described above using in place of the ethyl-5:5-diethoxypentane-1-carboxylate the same amount of one of the following compounds or mixtures of compounds: ethyl-3:3-diethoxypropane-1-carboxylate, ethyl-4:4-diethoxybutane-1-carboxylate, methyl-5:5-diethoxypentane-1-carboxylate, ethyl-5:5-diethoxypentane-1-carboxylate, 2:3:5:6-tetraisopropoxy-1:4-dioxan and a mixture of ethyl-5:5-diethoxypentane-1-carboxylate and 2:3:5:6-tetraisopropoxy-1:4-dioxan. The results obtained in each case are substantially the same as when using ethyl-5:5-diethoxypentane-1-carboxylate.

#### I claim:

1. In a method of effecting the concentration of minerals by flotation, the steps of adding to the mineral pulp, in the capacity of a frothing agent, a mixture of an alkoxy ester compound of the following formula:



and a dioxan compound of the following formula:

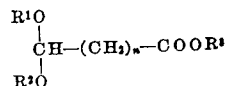


wherein  $R^1$ ,  $R^2$  and  $R^3$  are alkyl radicals selected from the group consisting of methyl and ethyl,  $n$  is an integer from 2 to 8 and  $R^4$ ,  $R^5$ ,  $R^6$  and  $R^7$  are each isopropoxy radicals, and subjecting the resultant mixture to a flotation operation.

2. A froth flotation process as claimed in claim 1, wherein the alkoxy ester compound is one in which  $R^1$ ,  $R^2$  and  $R^3$  are the same.

3. In a method of effecting the concentration

of minerals by flotation, the steps of adding to the mineral pulp, in the capacity of a frothing agent an alkoxy ester compound of the following formula:



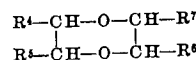
wherein  $R^1$ ,  $R^2$  and  $R^3$  are alkyl radicals selected from the group consisting of methyl and ethyl, and  $n$  is an integer from 2 to 8, and subjecting the resultant mixture to a flotation operation.

4. A froth flotation process as claimed in claim 3, wherein the alkoxy ester compound is one in which  $R^1$ ,  $R^2$  and  $R^3$  are the same.

5. A froth flotation process as claimed in claim 4, wherein the alkoxy ester compound is ethyl-4:4-diethoxybutane-1-carboxylate.

6. A froth flotation process as claimed in claim 4, wherein the alkoxy ester compound is ethyl-5:5-diethoxypentane-1-carboxylate.

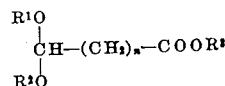
7. In a method of effecting the concentration of minerals by flotation, the steps of adding to the mineral pulp, in the capacity of a frothing agent, a dioxan compound of the following formula:



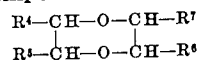
wherein  $R^4$ ,  $R^5$ ,  $R^6$  and  $R^7$  are each isopropoxy radicals, and subjecting the resultant mixture to a flotation operation.

8. A froth flotation process as claimed in claim 7, wherein the dioxan compound employed is 2:3:5:6-tetraisopropoxy-1:4-dioxan.

9. In a method of effecting the concentration of minerals by flotation, the steps of adding to the mineral pulp, in the capacity of a frothing agent, a material selected from the group consisting of alkoxy ester compounds of the formula:



and a dioxan compound of the following formula:



and mixtures of these compounds, wherein  $R^1$ ,  $R^2$  and  $R^3$  are alkyl radicals selected from the group consisting of methyl and ethyl,  $n$  is an integer from 2 to 8, and  $R^4$ ,  $R^5$ ,  $R^6$  and  $R^7$  are each isopropoxy radicals, wherein said material is admixed with another compound having froth forming properties, and subjecting the resultant mixture to a flotation operation.

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