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FROTH FLOTATION PROCESS

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Froth flotation processes for the concentration and purification of many minerals such as metallic and non-metallic ores and coal are well known. In such processes water containing frothing agents is added to the minerals 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 step of adding to the mineral pulp, in the capacity of a frothing agent, an aliphatic monocarboxylic acid diester of the formula:

$$R^1.COO.R.OOC.R^2$$

wherein R is a saturated hydrocarbon or oxa-alkane chain which may bear alkyl, alkoxy or alkoxyalkyl substituents, and wherein R^1 and R^2 are alkyl or alkoxyalkyl groups, either the same or different.

The carboxylic acid forming the ester groups is either a fatty acid or an alkoxy substituted fatty acid. Examples of such acids are acetic, propionic, n-butyric, isobutyric, pentanoic, decanoic, stearic, 3-methoxypropionic, 3-ethoxy-2 - methoxybutyric and 5 - isopropoxypentanoic acids. Examples of diols forming the diester are ethylene glycol, 1:2-propylene glycol, 1:3-propylene glycol, butane-2:3-diol, butane-1:3-diol, pentane-1:5-diol, octane-11:8-diol, octane-4:5-diol, 2-methoxymethyl-2:4-dimethylpentane-1:5-diol, diethylene glycol, trimethylene glycol and triethylene glycol. In order to confer sufficient water-solubility on the diester, the chain lengths of the acid and diol should not be excessive. For instance if the acid residue is derived from a C_{10} to C_{20} acid, the diol residue should be fairly short or should contain sufficient ether groups, whereas if the acid residue is short, C_8 and C_{10} diols, or even higher diols if ether groups are present, may be used.

Examples of compounds which may be used in the process of the present invention are butane-1:3-diol diisobutyrate, pentane-1:5-diol diacetate, heptane-1:7-diol diacetate, 2-methoxymethyl-2:4-dimethylpentane-1:5-diol diacetate, 2-methoxymethyl-2:4-dimethylpentane-1:5-diol di(3-methoxypropionate),diethylene glycol diisobutyrate, triethylene glycol diisobutyrate.

The compounds employed according to the present invention as frothing agents may be used either in pure form, or in impure form, as for example admixed with the byproducts coproduced with them, or alternatively, admixed with compounds having frothing properties, for example the tetra-alkoxy derivatives of paraffins such as 1:1:2:2 - tetra-ethoxy-ethane, 1:1:2:2 - tetranormal-propoxy-ethane, 1:1:2:2-tetrabutoxyethane, 1:1:3:3-tetranormal-propoxypropane, 1:1:4:4-tetramethoxy-butane 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. I have found the use of amounts of the froth flotation agents of my invention in the range 0.0001% to 0.05%, and preferably about 0.0005 to 0.002% by weight based on the weight of the mineral satisfactory.

In the flotation of sulphidic and oxidised metallic ores, compounds such as the xanthates, such as ethyl xanthate, dithiophosphates, 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 examples are given to illustrate the process of the present invention. The parts and percentages are by weight.

Example 1

500 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 0.005 part of potassium ethyl xanthate is added thereto. The pulp is diluted with 3000 parts of water, 0.0031 part of diethylene glycol diisobutyrate is added as frothing agent, and the mixture is then conditioned without aeration for 2 minutes. The pH of the pulp is about 7.2. Aeration is then applied and froth is removed for 8 minutes. The froth obtained is not brittle or weeping and no stiffener is added thereto.

For purposes of comparison the process is repeated exactly as described above with the exception that the 0.0031 part of di-ethylene glycol diiso-butyrate is replaced by 0.0087 part of pine oil. The results obtained are shown in the table below:

Frother	Percent Frother on ore	Copper in ore (percent)	Copper in Concentrate (percent)	Copper in tailing (percent)	Recovery of copper in concentrate (percent)
Diethylene glycol diisobutyrate	0.0005	3.94	55.2	0.73	82.4
Pine oil	0.0017	4.23	60.4	0.82	81.5

Example 2

The process described in Example 1 is repeated with the pairs of frothers shown in the table below with the following results:

Frother	Percent Frother on ore	Copper in ore (percent)	Copper in Concentrate (percent)	Copper in tailing (percent)	Recovery of copper in concentrate (percent)
Heptane-1:7-diol diacetate	0.0005	4.24	58.2	0.91	79.6
Pine oil	0.0017	4.23	60.4	0.82	81.5
2-methoxymethyl-2:4-dimethyl-pentane-1:5-diol diacetate	0.0005	4.10	57.5	0.91	78.8
Pine oil	0.0017	4.23	60.4	0.82	81.5
2-methoxymethyl 2:4-dimethylpentane-1:5-diol di-(3-methoxy-propionate)	0.0005	4.05	57.7	0.83	79.9
Pine oil	0.0017	4.23	60.4	0.82	81.5
Triethylene glycol diisobutyrate	0.0006	4.11	59.5	1.03	76.1
Pine oil	0.0014	4.07	60.4	1.04	75.1
Pentane-1:5-diol diacetate	0.0020	3.92	56.4	0.20	95.1
Pine oil	0.0037	4.29	47.3	0.25	94.3

Butane-1:3-diol diisobutyrate was also tested and was found to be as good as any of the above diesters.

I claim:

1. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, an aliphatic mono-carboxylic acid diester of diethylene glycol of the formula:

$$R^1.COO.CH_2CH_2.O.CH_2.CH_2.OOC.R^2$$

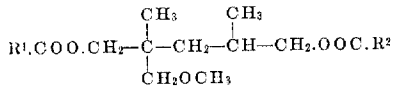
wherein R^1 and R^2 are selected from the group consisting of alkyl groups and alkoxyalkyl groups containing from one to nineteen carbon atoms.

2. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, an aliphatic mono-carboxylic acid diester of heptane-1,7-diol of the formula:

$$R^1.COO(CH_2)_7.OOC.R^2$$

wherein R^1 and R^2 are selected from the group consisting of alkyl groups and alkoxyalkyl groups containing from one to nineteen carbon atoms.

3. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, an aliphatic mono-carboxylic acid diester of 2-methoxymethyl-2,4-dimethylpentane-1,5-diol of the formula:



wherein R^1 and R^2 are selected from the group consisting of alkyl groups and alkoxyalkyl groups containing from one to nineteen carbon atoms.

4. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, an acetic acid diester of an aliphatic diol of the formula:

$$CH_3.COO.R.OOC.CH_3$$

wherein R is selected from the group consisting of a polymethylene chain, an alkyl substituted polymethylene chain, an alkoxyalkyl substituted polymethylene chain and an oxa-alkane chain containing from two to ten carbon atoms.

5. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, an isobutyric acid diester of an aliphatic diol of the formula:

$$(CH_3)_2.CH.COO.R.OOC.CH.(CH_3)_2$$

wherein R is selected from the group consisting of a polymethylene chain, an alkyl substituted polymethylene chain, an alkoxyalkyl substituted polymethylene chain and an oxa-alkane containing from two to ten carbon atoms.

6. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp in the capacity of a frothing agent, diethylene glycol diisobutyrate.

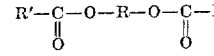
7. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, heptane-1,7-diol diacetate.

8. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, 2-methoxymethyl-2,4-dimethylpentane-1,5-diol diacetate.

9. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, 2-methoxymethyl-2,4-dimethylpentane-1,5-diol di-(3-methoxypropionate).

10. A method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, butane-1,3-diol diisobutyrate.

11. Method of effecting the concentration of minerals by flotation which comprises the step of adding to the mineral pulp, in the capacity of a frothing agent, a diester of the formula



wherein R contains from two to ten carbon atoms and is selected from the group consisting of a polymethylene chain, an alkyl substituted polymethylene chain, an alkoxy alkyl substituted polymethylene chain and an oxa-alkane chain, and wherein R' and R^2 are each selected from the group consisting of an alkyl group and an alkoxy alkyl group containing from one to nineteen carbon atoms, said ester containing a relatively small number of carbon atoms in the R group where this consists mainly of carbon and hydrogen and where the R' and R^2 groups each contain from ten to nineteen carbon atoms.

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