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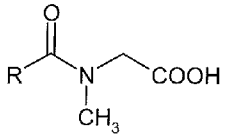

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(57) Abstract: This invention relates to a collector composition for the direct froth flotation of nonsulfide ores comprising a) 50 - 99 wt.-% of a mixture of fatty acids and b) 1 - 50 wt.-% of an N-acyl derivative of sarcosine of the formula (I) wherein R is a saturated or unsaturated hydrocarbon chain with 7 to 21 carbon atoms, wherein the mixture of comprises 10.0 - 35.0 wt.-% of fatty acid having a saturated C_{11} hydrocarbon group, 2.5 - 15.0 wt.-% of fatty acid having a saturated C_{13} hydrocarbon group, 10.0 - 25.0 wt.-% fatty acid having a monounsaturated C_{17} hydrocarbon group and 20.0 - 45.0 wt.-% fatty acid having a bisunsaturated C_{17} hydrocarbon group.

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COMPOSITION OF FATTY ACIDS AND N-ACYL DERIVATIVES OF SARCOSINE FOR THE IMPROVED FLOTATION OF NONSULFIDE MINERALS

This invention relates to a novel collector composition comprising a mixture of at least two fatty acids and at least one N-acyl derivative of sarcosine and its use in the direct froth flotation of nonsulfide minerals. The use of the novel collector composition provides improved flotation efficiency.

Froth flotation is a physico-chemical process used to separate mineral particles considered economically valuable from those considered waste. It is based on the ability of air bubbles to selectively attach onto those particles previously rendered hydrophobic. The particle-bubble combinations then rise to the froth phase from where it discharges the flotation cell whilst the hydrophilic particles remain in the flotation cell. Particle hydrophobicity is, in turn, induced by special chemicals called collectors. In direct flotation systems, it is the economically valuable minerals which are rendered hydrophobic by the action of the collector. Similarly, in reverse flotation systems, the collector renders hydrophobicity to those mineral particles considered waste. The efficiency of the separation process is quantified in terms of recovery and grade. Recovery refers to the percentage of valuable product contained in the ore that is removed into the concentrate stream after flotation. Grade refers to the percentage of the economically valuable product in the concentrate after flotation. A higher value of recovery or grade indicates a more efficient flotation system.

The use of mixtures of fatty acids and sarcosine derivatives for the froth flotation of nonsulfide minerals is well-known.

In DD-300730 the use of a collector composition for the froth flotation of fluorite comprising an N-acyl derivative of sarcosine and a saturated or unsaturated fatty acid having a hydrocarbon chain with 14 to 24 carbon atoms is described.

In US-5147528 a process for the direct flotation of phosphate is described where an oxidized intimate mixture of a fatty acid containing 12 to 36 carbon atoms, a tall

oil pitch, an amine derived from a plant, sarcosine and a fuel oil or furnace oil is used as collector.

US-4514290 describes a collector composition comprising a fatty acid or salt thereof, an amidocarboxylic acid or amidosulfonic acid containing an organic hydrophobic group, or a salt thereof, and a partial ester of phosphoric acid and at least one alkoxylated alcohol. Such composition is claimed to show improved efficiency for the froth flotation of minerals containing alkaline earth metals, such as apatite, scheelite, magnesite and barite. The fatty acid in the preferred compositions has 14 to 22 carbon atoms.

WO-2014040686 describes a flotation agent for phosphate ore, comprising at least one fatty acid and at least one N-acyl derivative of sarcosine.

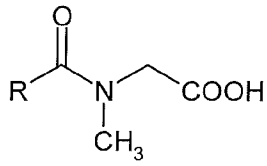
The present invention is related to a novel collector composition comprising a mixture of at least two fatty acids and at least one N-acyl derivative of sarcosine and its use for the beneficiation of nonsulfide minerals. The composition of at least two fatty acids and at least one N-acyl derivative according to the present invention affords in comparison to the collector compositions described by the state-of-the-art an improvement of the flotation efficiency. Under improved flotation efficiency is meant that higher mineral recovery and/or purity are achieved. Furthermore, the collector composition according to the present invention is very easy to prepare by simply mixing and not require any additional treatment, like for example an oxidation step, in order to show excellent improvement of the flotation efficiency.

Unexpectedly it was found that a composition containing 50 - 99 wt.-% of a mixture of at least two fatty acids and 1 - 50 wt.-% of an N-acyl derivative of sarcosine show improved flotation of nonsulfide minerals expressed in terms of higher mineral recovery and/or higher purity.

The instant invention therefore relates to a collector composition comprising

a) 50 - 99 wt.-% of a mixture of fatty acids and

b) 1 - 50 wt.-% of an N-acyl derivative of sarcosine of the formula (I)



(I)

wherein

R is a saturated or unsaturated hydrocarbon chain with 7 to 21 carbon atoms, wherein the mixture of fatty acids comprises 10.0 - 35.0 wt.-% of fatty acid having a saturated C_{11} hydrocarbon group, 2.5 - 15.0 wt.-% of fatty acid having a saturated C_{13} hydrocarbon group, 10.0 - 25.0 wt.-% fatty acid having a monounsaturated C_{17} hydrocarbon group and 20.0 - 45.0 wt.-% fatty acid having a bisunsaturated C_{17} hydrocarbon group.

The inventive collector composition may comprise other fatty acids to balance to 100 wt.-%. The weight percentages refer to the total fatty acid content of the inventive collector composition as being 100 wt.-%.

In a preferred embodiment the mixture of fatty acids comprises fatty acids having

1.0 - 6.5 wt.-% of saturated C_7

1.0 - 4.0 wt.-% of saturated C_9

10.0 - 35.0 wt.-% of saturated C_{11}

2.5 - 15.0 wt.-% of saturated C_{13}

1.0 - 7.0 wt.-% of saturated C_{15}

0.0 - 1.0 wt.-% of monounsaturated C_{15}

0.0 - 1.0 wt.-% of bisunsaturated C_{15}

0.5 - 2.0 wt.-% of saturated C_{17}

10.0 - 25.0 wt.-% of monounsaturated C_{17}

20.0 - 45.0 wt.-% bisunsaturated C_{17}

0.0 - 2.0 wt.-% trisunsaturated C_{17}

0.0 - 1.0 wt.-% saturated C_{19}

0.0 - 4.0 wt.-% monounsaturated C_{19} hydrocarbon chains, and

0.0 - 7.0 wt.-% other fatty acids

The expression "saturated hydrocarbon chain" means preferably alkyl groups. The expression "monosaturated hydrocarbon chain" means preferably alkenyl groups. The expression "bisunsaturated hydrocarbon chains" means alkenyl groups having two double bonds.

Fatty acids are defined in the sense of this invention as mixtures of carboxylic acids bearing a long linear hydrocarbon chain, which can be saturated or unsaturated or multiply unsaturated. Especially effective for the scope of this invention is the use of fatty acids from vegetable oils and tall oil fatty acids. The preferred fatty acids in the sense of this invention are coconut oil fatty acid and tall oil fatty acid. Predominant carboxylic acids in the coconut oil fatty acid are lauric acid (saturated C_{11} hydrocarbon chain) with a content between 44 and 54 wt.-% and myristic acid (saturated C_{13} hydrocarbon chain) with a content between 13 and 20 wt.-%. The preferred quality of tall oil fatty acid has an acid value higher than 190 mg KOH/g and a content of rosin acids and unsaponifiables lower than 2.1 wt.-% and 2.0 wt.-%, respectively. Predominant carboxylic acids in the tall oil fatty acid are oleic acid (monounsaturated C_{17} hydrocarbon chain) with a content between 25 and 50 wt.-% and linoleic acid (bisunsaturated C_{17} hydrocarbon chain) with a content between 35 and 60 wt.-%.

The characterization of the alkyl chain distribution in fatty acids can be done via gas chromatography after conversion of the carboxylic acids in the volatile methyl ester derivatives according to the AOCS Method Ce 1 - 62, "Fatty Acid Composition by Gas Chromatography" AOCS Official Methods (2005) American Oil Chemists Society.

The mixtures of fatty acids which are especially effective in the collector compositions according to the present invention contain between 0.3 and 1.7 weight parts of fatty acids from vegetable oils to 1 weight part of tall oil fatty acid. The most preferred ratio for the mixture of fatty acids according to this

invention is 1 weight part of coconut oil fatty acid to 1 weight part of tall oil fatty acid.

Especially preferred are N-acyl derivatives of sarcosine where R is a saturated or unsaturated hydrocarbon chain with 11 to 19 carbon atoms. The most preferred N-acyl derivative of sarcosine is N-oleoylsarcosine.

Especially preferred collector compositions according to the present invention contain 65 - 99 wt.-% of a mixture of fatty acids (component a) and 1 - 35 wt.-% of an N-acyl derivative of sarcosine (component b). Most preferred collector compositions contain 80 wt.-% of a1:1 weight mixture of coconut oil fatty acid and tall oil fatty acid and 20 wt.-% of N-oleoylsarcosine.

The composition of the invention is for use as collector in direct froth flotation processes of nonsulfide ores. It was found that the composition of the invention is especially suitable for the direct froth flotation of nonsulfide ores containing alkaline earth metals, as apatite, calcite, scheelite, fluorspar, magnesite and barite. Most surprisingly it was found that the composition of the invention is also especially suitable for the direct froth flotation of ilmenite, a titanium-iron oxide mineral of formula $FeTiO_3$ which is the most important source for titanium.

Furthermore, the present invention also relates to a process for beneficiation of nonsulfide minerals, the process comprising the steps of bringing the collector composition according to the present invention in contact with an aqueous suspension of the nonsulfide mineral and frothing the so formed mineral pulp. The collector composition according to the present invention is preferably used in amounts between 100 and 1000 g/t of solid ore for the direct froth flotation of nonsulfide ore. It is also possible to add other flotation reagents to the mineral pulp, if these are required. Examples of these reagents are frothers as for example pine oil, polyglycols, polyoxyparaffins or alcohols, depressants as for example starch, carboxymethylcellulose or sodium silicate and pH-regulators as for example sodium hydroxide or sodium carbonate.

Examples

1. General procedure for preparation of collector compositions according to this invention:

Distilled coconut fatty acid sample was warmed to 35 °C until it was entirely melted and then added to tall oil fatty acid at room temperature. The fatty acid mixture was then homogenised by a slow stirring action. Finally, N-oleoylsarcosine was slowly added to the fatty acid mixture. The mixture was thereafter homogenised for a further 10 minutes. The procedure is completed when a clear, yellow-coloured liquid solution is obtained.

2. Collector compositions according to this invention prepared following used the procedure describer under 1.

Composition 1:

Component a:

80 wt.-% of a mixture of 1 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

3.25 wt.-% of saturated C_7 hydrocarbon chain
2.85 wt.-% of saturated C_9
25.65 wt.-% of saturated C_{11}
8.60 wt.-% of saturated C_{13}
4.45 wt.-% of saturated C_{15}
0.02 wt.-% of monounsaturated C_{15}
0.20 wt.-% of bisunsaturated C_{15}
1.25 wt.-% of saturated C_{17}
19.10 wt.-% of monounsaturated C_{17}
28.5 wt.-% bisunsaturated C_{17}
0.60 wt.-% trisunsaturated C_{17}
0.05 wt.-% saturated C_{19}
1.25 wt.-% monounsaturated C_{19}

4.3 wt.-% others

Component b:

20 wt.-% N-oleoylsarcosine

Composition 2:

Component a:

80 wt.-% of a mixture of 0.33 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

1.62 wt.-% of saturated C_7 hydrocarbon chain

1.42 wt.-% of saturated C_9

12.82 wt.-% of saturated C_{11}

4.30 wt.-% of saturated C_{13}

2.37 wt.-% of saturated C_{15}

0.04 wt.-% of monounsaturated C_{15}

0.30 wt.-% of bisunsaturated C_{15}

1.17 wt.-% of saturated C_{17}

24.70 wt.-% of monounsaturated C_{17}

42.15 wt.-% bisunsaturated C_{17}

0.90 wt.-% trisunsaturated C_{17}

0.02 wt.-% saturated C_{19}

1.87 wt.-% monounsaturated C_{19}

6.40 wt.-% others

Component b:

20 wt.-% N-oleoylsarcosine

Composition 3:

Component a:

80 wt.-% of a mixture of 1.66 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

4.10 wt.-% of saturated C_7 hydrocarbon chain

3.59 wt.-% of saturated C_9

32.32 wt.-% of saturated C_{11}

10.84 wt.-% of saturated C_{13}

5.53 wt.-% of saturated C_{15}

0.02 wt.-% of monounsaturated C_{15}

0.15 wt.-% of bisunsaturated C_{15}

1.29 wt.-% of saturated C_{17}

16.19 wt.-% of monounsaturated C_{17}

21.40 wt.-% bisunsaturated C_{17}

0.44 wt.-% trisunsaturated C_{17}

0.06 wt.-% saturated C_{19}

0.92 wt.-% monounsaturated C_{19}

3.21 wt.-% others

Component b:

20 wt.-% N-oleoylsarcosine

Composition 4:

Component a:

67 wt.-% of a mixture of 1 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

3.25 wt.-% of saturated C_7 hydrocarbon chain

2.85 wt.-% of saturated C_9

25.65 wt.-% of saturated C_{11}

8.60 wt.-% of saturated C_{13}

4.45 wt.-% of saturated C_{15}

0.02 wt.-% of monounsaturated C_{15}

0.20 wt.-% of bisunsaturated C_{15}

1.25 wt.-% of saturated C_{17}

19.10 wt.-% of monounsaturated C_{17}

28.5 wt.-% bisunsaturated C_{17}

0.60 wt.-% trisunsaturated C_{17}

0.05 wt.-% saturated C_{19}

1.25 wt.-% monounsaturated C_{19}

4.3 wt.-% others

Component b:

33 wt.-% N-oleoylsarcosine

Composition 5:

Component a:

75 wt.-% of a mixture of 1 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

3.25 wt.-% of saturated C_7 hydrocarbon chain

2.85 wt.-% of saturated C_9

25.65 wt.-% of saturated C_{11}

8.60 wt.-% of saturated C_{13}

4.45 wt.-% of saturated C_{15}

0.02 wt.-% of monounsaturated C_{15}

0.20 wt.-% of bisunsaturated C_{15}

1.25 wt.-% of saturated C_{17}

19.10 wt.-% of monounsaturated C_{17}

28.5 wt.-% bisunsaturated C_{17}

0.60 wt.-% trisunsaturated C_{17}

0.05 wt.-% saturated C_{19}

1.25 wt.-% monounsaturated C_{19}

4.3 wt.-% others

Component b:

25 wt.-% N-oleoylsarcosine

Composition 6:

Component a:

84 wt.-% of a mixture of 1 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

3.25 wt.-% of saturated C_7 hydrocarbon chain

2.85 wt.-% of saturated C_9

25.65 wt.-% of saturated C_{11}

8.60 wt.-% of saturated C_{13}

4.45 wt.-% of saturated C_{15}

0.02 wt.-% of monounsaturated C_{15}

0.20 wt.-% of bisunsaturated C_{15}

1.25 wt.-% of saturated C_{17}

19.10 wt.-% of monounsaturated C_{17}

28.5 wt.-% bisunsaturated C_{17}

0.60 wt.-% trisunsaturated C_{17}

0.05 wt.-% saturated C_{19}

1.25 wt.-% monounsaturated C_{19}

4.3 wt.-% others

Component b:

16 wt.-% N-oleoylsarcosine

3. Comparative collector compositions

Composition 7:

80 wt.-% of tall oil fatty acid with a hydrocarbon chain distribution as follows:

0 wt.-% of saturated C_7 hydrocarbon chain

0 wt.-% of saturated C_9

0 wt.-% of saturated C_{11}

0 wt.-% of saturated C_{13}

0.30 wt.-% of saturated C_{15}

0.05 wt.-% of monounsaturated C_{15}

0.40 wt.-% of bisunsaturated C_{15}

1.10 wt.-% of saturated C_{17}

30.30 wt.-% of monounsaturated C_{17}

55.80 wt.-% bisunsaturated C_{17}

1.20 wt.-% trisunsaturated C_{17}

0 wt.-% saturated C_{19}

2.50 wt.-% monounsaturated C_{19}

8.50 wt.-% others

and

20 wt.-% N-oleoylsarcosine

Composition 8:

80 wt.-% of distilled coconut fatty acid with a hydrocarbon chain distribution as follows:

6.50 wt.-% of saturated C_7 hydrocarbon chain

5.70 wt.-% of saturated C_9

51.30 wt.-% of saturated C_{11}

17.20 wt.-% of saturated C_{13}

8.60 wt.-% of saturated C_{15}

0 wt.-% of monounsaturated C_{15}

0 wt.-% of bisunsaturated C_{15}

1.40 wt.-% of saturated C_{17}

7.90 wt.-% of monounsaturated C_{17}

1.20 wt.-% bisunsaturated C_{17}

0 wt.-% trisunsaturated C_{17}

0.10 wt.-% saturated C_{19}

0 wt.-% monounsaturated C_{19}

0.10 wt.-% others

and

20 wt.-% N-oleoylsarcosine

Composition 9:

100 wt.-% of tall oil fatty acid with a hydrocarbon chain distribution as follows:

0 wt.-% of saturated C_7 hydrocarbon chain

0 wt.-% of saturated C_9

0 wt.-% of saturated C_{11}

0 wt.-% of saturated C_{13}

0.30 wt.-% of saturated C_{15}

0.05 wt.-% of monounsaturated C_{15}

0.40 wt.-% of bisunsaturated C_{15}

1.10 wt.-% of saturated C_{17}

30.30 wt.-% of monounsaturated C_{17}

55.80 wt.-% bisunsaturated C_{17}

1.20 wt.-% trisunsaturated C_{17}

0 wt.-% saturated C_{19}

2.50 wt.-% monounsaturated C_{19}

8.50 wt.-% others

Composition 10:

100 wt.-% of a mixture of 1 weight part of distilled coconut fatty acid and 1 weight part of tall oil fatty acid with a hydrocarbon chain distribution as follows:

3.25 wt.-% of saturated C_7 hydrocarbon chain

2.85 wt.-% of saturated C_9

25.65 wt.-% of saturated C_{11}

8.60 wt.-% of saturated C_{13}

4.45 wt.-% of saturated C_{15}

0.02 wt.-% of monounsaturated C_{15}

0.20 wt.-% of bisunsaturated C_{15}

1.25 wt.-% of saturated C_{17}

19.10 wt.-% of monounsaturated C_{17}

28.5 wt.-% bisunsaturated C_{17}

0.60 wt.-% trisunsaturated C_{17}

0.05 wt.-% saturated C_{19}

1.25 wt.-% monounsaturated C_{19}

4.3 wt.-% others

4. Flotation test results

Example I: Apatite ore containing 16.1 % P_2O_5, 47.9 % SiO_2, 21.4 % CaO,and 0.7 % MgO.

A 390 g portion of the ore sample was ground in a laboratory stainless steel mill for 5 minutes at 50 rpm and 66 % solids. This resulted in the following particle size

distribution for the flotation feed: P_{50} = 17 µm and P_{80} = 47 µm. On completion of the grinding stage, the milled slurry was transferred to a 2.5 L capacity flotation cell, where the percentage solid was adjusted to approximately 15 % by addition of the appropriate amount of water. The flotation device was a Denver D-12 flotation machine and the impeller speed set to 1100 rpm. The flotation pulp was thereafter conditioned for 4 minutes and 3 minutes with the depressants sodium silicate (Na_2SiO_3, 550 g/t) and sodium carbonate (Na_2CO_3, 280 g/t) respectively – in the indicated order. Next the collector mixture, which was freshly prepared as a 1 % solution prior to starting each flotation test, was added and conditioned with the flotation pulp for 3 min. Finally, the air flow rate was set to 2 L/min and the resulting froth collected for 12 minutes.

Collector composition	Coconut oil fatty acid (wt.-%)	Tall oil fatty acid (wt.-%)	N-Oleoyl sarcosine (wt.-%)	Dosage (g/ton)	Grade P_2O_5 (wt.-%)	Recovery P_2O_5 (wt.-%)
1	40	40	20	500	27.86	55.74
2	20	60	20	500	25.47	69.57
3	50	30	20	500	27.77	58.35
7 (C)	-	80	20	500	26.56	54.37
8 (C)	80	-	20	500	30.82	42.91

The results from the flotation tests show that the collector compositions according to this invention (1 to 3) show excellent flotation efficiency and in particular, notably improved mineral recovery in comparison with the reference compositions 7 and 8.

The P_2O_5 grade obtained with the inventive compositions is slightly lower than what was obtained especially with the reference 8 in the laboratory experiments. This difference in grade is considered negligible because industrial flotation plants typically put the rougher concentrate through two, three or even four cleaning steps. In this way, the grade of the final concentrate is typically increased.

Example II: Ilmenite ore containing on approximately 32 % TiO_2

Approximately 1.2 L of sample was collected from the flotation feed stream of an ilmenite flotation plant. The 1.2 L sample, which consisted of approximately 1785 g dry ore and 750 g water, was thereafter transferred to a 3.2 L capacity flotation cell. The collector was thereafter added as-is and conditioned for 10 minutes using a Denver D-12 flotation device with the impeller speed set at 1550 rpm. The percentage solids in the slurry was thereafter reduced from 71 % to 51 % by addition of 1.0 L of industrial water. Hereafter, the air flow rate was set to 8.5 L/min and resulting froth collected for 270 seconds. In the case of the ore in question, a fatty acid and paraffin was used as collector combination. The results are shown below.

Collector com-position	Coconut oil fatty acid (wt.-%)	Tall oil fatty acid (wt.-%)	N-Oleoyl sarcosine (wt.-%)	Collector dosage (g/ton)	Paraffin dosage (g/ton)	Grade TiO_2 (wt.-%)	Recovery TiO_2 (wt.-%)
1	40	40	20	840	360	37.4	81.1
9 (C)	-	100	-	840	360	36.8	76.0

The flotation results show that a 1:1 replacement of the fatty acid collector resulted in a 5.1 % increase in recovery in combination with a marginal increase in concentrate grade.

Example III: scheelite ore containing 0.20 % WO_3

The ground ore was conditioned with the depressants tannin (25 g/t), sodium silicate (350 g/t) and sodium carbonate (1000 g/t) after which the slurry pH was adjusted to pH 10 by adding the required amount of NaOH solution. The collector was then added as-is and conditioned with the flotation slurry for 2 minutes followed by addition of Clariant frother Flotanol 7026 and conditioning for a further

1 minute. Hereafter sufficient water was added to decrease the percentage solids in the flotation cell from 60% during the conditioning step to 35% in the flotation step. The air flow rate was now set to 5 L/min and the resulting froth collected for 2 minutes.

Collector composition	Coconut oil fatty acid (wt.-%)	Tall oil fatty acid (wt.-%)	N-Oleoyl sarcosine (wt.-%)	Dosage (g/ton)	Grade W_2O_3 (wt.-%)	Recovery W_2O_3 (wt.-%)
4	33.5	33.5	33	145	1.16	78.3
5	37.5	37.5	25	194	0.81	84.2
6	42	42	16	151	1.61	78.0
10 (C)	50	50	-	195	1.42	72.7
9 (C)	-	100	-	184	0.87	71.3
9 (C)	-	100	-	369	0.72	78.2

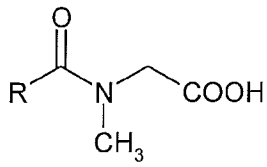
The use of the new collector mixture resulted in a significant increase in WO_3 grade as compared to the comparative product (100 % tall oil fatty acid collector). In addition, a similar WO_3 recovery value was obtained with 151 g/t dosage of the new collector blend as compared with 369 g/t dosage of the comparative tall oil fatty acid collector.

Patent claims

1. A collector composition for the direct froth flotation of nonsulfide ores comprising

a) 50 - 99 wt.-% of a mixture of fatty acids and

b) 1 - 50 wt.-% of an N-acyl derivative of sarcosine of the formula (I)



(I)

wherein

R is a saturated or unsaturated hydrocarbon chain with 7 to 21 carbon atoms, wherein the mixture of comprises 10.0 - 35.0 wt.-% of fatty acid having a saturated C_{11} hydrocarbon group, 2.5 - 15.0 wt.-% of fatty acid having a saturated C_{13} hydrocarbon group, 10.0 - 25.0 wt.-% fatty acid having a monounsaturated C_{17} hydrocarbon group and 20.0 - 45.0 wt.-% fatty acid having a bisunsaturated C_{17} hydrocarbon group.

2. Composition according to claim 1, wherein the fatty acid mixture comprises fatty acids having

1.0 - 6.5 wt.-% of saturated C_7 hydrocarbon chain

1.0 - 4.0 wt.-% of saturated C_9

10.0 - 35.0 wt.-% of saturated C_{11}

2.5 - 15.0 wt.-% of saturated C_{13}

1.0 - 7.0 wt.-% of saturated C_{15}

0.0 - 1.0 wt.-% of monounsaturated C_{15}

0.0 - 1.0 wt.-% of bisunsaturated C_{15}

0.5 - 2.0 wt.-% of saturated C_{17}

10.0 - 25.0 wt.-% of monounsaturated C_{17}

20.0 - 45.0 wt.-% bisunsaturated C_{17}

0.0 - 2.0 wt.-% trisunsaturated C_{17}

0.0 - 1.0 wt.-% saturated C_{19}

0.0 - 4.0 wt.-% monounsaturated C_{19}

0.0 - 7.0 wt.-% other fatty acids.

3. The composition of claim 1 and/or 2, wherein the component a) is a mixture of 0.3 to 1.7 weight parts of coconut oil fatty acid to 1 weight part of tall oil fatty acid.

4. The composition of one or more of claims 1 to 3, wherein the component b) is N-oleoylsarcosine.

5. The composition as claimed in one or more of claims 1 to 4, wherein the component a) is 80 wt.-% of a mixture of 1 weight part of coconut oil fatty acid and 1 weight part of tall oil fatty acid and component b) is 20 wt.-% of N-oleoylsarcosine.

6. A process for the direct froth flotation of nonsulfide minerals, the process comprising the steps of bringing the collector composition according to one or more of claims 1 to 5 in contact with an aqueous suspension of the nonsulfide mineral and frothing the so formed mineral pulp.

7. The process as claimed in claim 6, wherein the nonsulfide minerals is apatite.

8. The process as claimed in claim 6, wherein the nonsulfide minerals are selected from the group of calcite, scheelite, fluorspar, magnesite and barite.

9. The process as claimed in claim 6, wherein the nonsulfide mineral is ilmenite.

10. A direct froth flotation process according to claims 6 to 9, wherein the amount of collector composition added is an amount between 100 g and 1000 g per ton of ore.

11. Use of a composition according to one or more of claims 1 to 5 as collector for the direct flotation of non-sulfide ores in an amount between 100 and 1000 g per ton of ore.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/054291

A. CLASSIFICATION OF SUBJECT MATTER
INV. B03D1/008 B03D1/01
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 708 282 A1 (CLARIANT INT LTD [CH]; CLARIANT S A [BR]) 19 March 2014 (2014-03-19) claims 1-7; examples 1,2	1-11
A	US 5 147 528 A (BULATOVIC SRDJAN [CA]) 15 September 1992 (1992-09-15) cited in the application examples 7,9,11	1-11
A	DE 11 46 824 B (KLOECKNER HUMBOLDT DEUTZ AG) 11 April 1963 (1963-04-11) columns 4-6; figures 7-8	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 April 2016	09/05/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/054291

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