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(71) Applicant: **Nouryon Chemicals International B.V.**
6824BM Arnhem (NL)

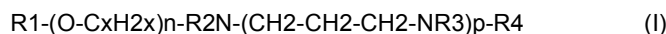
(72) Inventors:
• **LEWIS, Andrew Clist**
SE-471 93 Källekärr (SE)

- **WANG-GEISSLER, Wan**
Danbury, CT Connecticut 06810 (US)
- **ZHOU, Qiong**
Hopewell Junction, NY New York 12533 (US)
- **BAAN, Willem Hendrikus**
NL-7397 NV Nijbroek (NL)
- **NORDBERG, Henrik**
SE-444 53 Stenungsund (SE)
- **GUSTAFSSON, Jan Olof**
SE-442 42 Kungälv (SE)
- **GOLETS, Mikhail**
SE-444 85 Stenungsund (SE)

(74) Representative: **LKGlobal UK Ltd.**
Cambridge House, Henry Street
Bath BA1 1BT (GB)

(54) **PROCESS TO TREAT ORES AND COLLECTOR COMPOSITION THEREFOR**

(57) The present invention relates to a process to treat metal or mineral ores with a collector composition that comprises a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10 ,

R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group $-(CH_2-CH_2-CH_2-NH)q-CH_2-CH_2-CN$ or $-(CH_2-CH_2-CH_2-NH)r-H$ or $-(C_xH_{2x}-O)n-R1$,

wherein q is 0 to 10 and r is 0 to 10

at least one of R2-R4 is a group $-(CH_2-CH_2-NH)q-CH_2-CH_2-CN$, and R1, x and n as defined above.

The invention also relates to collector composition containing the above nitrile group-containing compound and at least one further collector or frother compound.

EP 3 636 346 A1

Description

[0001] The present invention relates to a process to treat ores, such as iron-containing or sulfide ores, and to collector compositions that are suitably used in such processes.

[0002] 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 to those particles that were previously rendered hydrophobic. The particle-bubble combinations then rise to the froth phase from where the flotation cell is discharged, 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.

[0003] In a froth flotation process besides collectors, also frothers can be used. Frothers have 3 main functions, namely they aid formation and preservation of small bubbles, they reduce bubble rise velocity and they aid formation of froth. In this sense they have a completely different role from collectors, which generally need to impart lipophilicity to minerals in order to float them. Surfactants achieve this by adsorbing onto mineral surfaces rendering them water repellent, reducing the stability of the hydrated layer separating the mineral from the air bubble to such a level that attachment of the particle to the bubble can be made. For this reason, frothers are characterized by needing to have a much lower log P value than collector components, or to say it in other words, frothers are generally much more hydrophilic than collectors.

[0004] The iron ore industry uses a number of depressants for processing iron in flotation. The depressants are used to depress iron oxides while flotating the gangue material such as silica, phosphorous, sulphides etc. Common depressants include polysaccharides, e.g. dextrin, starch, such as maize starch activated by treatment with alkali, or synthetic polymers such as polyarylamides. Other examples of (hydrophilic) polysaccharides are cellulose esters, such as carboxymethylcellulose and sulphomethylcellulose; cellulose ethers, such as methyl cellulose, hydroxyethylcellulose and ethyl hydroxyethylcellulose; hydrophilic gums, such as gum arabic, gum karaya, gum tragacanth and gum ghatti, alginates; and starch derivatives, such as carboxymethyl starch and phosphate starch. The depressant is normally added in an amount of about 10 to about 1000 g per tonne of ore.

[0005] The copper processing industry uses a large quantity of gangue depressants like, sulfur dioxide and sulfites for depressing galena (PbS), cyanide salts for depressing sphalerite (ZnS), sodium hydrosulfite and sodium sulfides for depressing copper to float molybdenite (MoS₂).

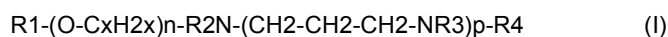
[0006] Presence of sulfur (sulfur to include further compounds that are based on sulfur such as sulfides) in ore concentrates, such as in iron ore concentrates, causes problems in downstream processes like smelting processes. Separation of sulfur impurities (such as pyrite, chalcopyrite, marcasite and pyrrhotite) and/or purification of ore concentrates would prevent or reduce such problems.

[0007] Metal ores, most prominently sulfuric iron ores, as disclosed in Vahid Soltanmohammadi et al, "Influence of flotation parameters on decreasing sulfur and phosphorus content in the GOL-e-GOHAR iron ore concentrate" in Physicochem. Probl. Miner. Process. 46(2011) 173-190, and Bahram Rezaee et al, "Sulfur reduction in Sangan iron ore by flotation" in E3S Web of Conferences 18 , 01023 (2017), MEC2017 in recent years were established to be very effectively floated using potassium amyl xanthate (PAX) as collector. The above documents both disclose that using PAX as a collector results in a very effective removal of the sulfur impurities from the iron. PAX has however some disadvantages in that it has been found to be combustible and that it has been found to decompose into compounds that impose human health risks (like CS₂).

[0008] There is a continued need to find better collectors for metal or mineral ores, such as iron or sulfide ores. It has now been found that nitrile based collectors and a flotation process using such collectors can provide an improved reduction of sulfur content in iron ore while simultaneously achieving a high iron recovery and grade.

[0009] The present invention provides an improved process to treat metal or mineral ores, such as iron or sulfide ores, and collector compositions for use therein which provide an improved grade and recovery. The present invention also provides for a reduced need to employ a frother. The present invention additionally in embodiments provides an improvement in that there is a reduced need for the addition of a depressant and reduces the risks associated with PAX, i.e. it provides an improvement in toxicity and combustibility.

[0010] The invention provides a process to treat metal or mineral ores with a collector composition that comprises a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10,

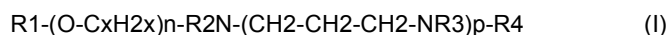
R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group $-(CH_2-CH_2-CH_2-NH)_q-CH_2-CH_2-CN$ or $-(CH_2-CH_2-CH_2-NH)_r-H$ or $-(C_xH_{2x}-O)_n-R_1$,

wherein q is 0 to 10 and r is 0 to 10,

provided that at least one of R2-R4 is a group $-(CH_2-CH_2-NH)_q-CH_2-CH_2-CN$, and wherein R1, x and n are as defined above.

[0011] The invention furthermore provides collector compositions containing as component (a) 1 wt% to 99 wt% of a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10,

R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group $-(CH_2-CH_2-CH_2-NH)_q-CH_2-CH_2-CN$ or $-(CH_2-CH_2-CH_2-NH)_r-H$ or $-(C_xH_{2x}-O)_n-R_1$,

wherein q is 0 to 10 and r is 0 to 10,

provided that at least one group of R2-R4 is a group $-(CH_2-CH_2-NH)_q-CH_2-CH_2-CN$, and wherein R1, x and n as defined above, and

as component (b) 1 to 99 wt% of at least one of a collector selected from the group of nitrile, xanthate, dithiophosphate, thionocarbamate, thiocarbamate, mercaptobenzylthiazole, monothiophosphate, dithiophosphinates, hydroxamate collectors, fatty amines (primary, secondary, tertiary), ether(di)amines, quaternary amines, carboxylates, and ethoxylated alcohols or a frother selected from the group of phenols, alkyl sulfates, aliphatic alcohols, generally C5 - C8 cyclic alcohols, alkoxyalkanes, polypropylene glycol ethers, polyglycol ethers, polyglycol glycerol ethers, pyridine base, natural oils such as terpeneol (as in pine oil) and cresols, mixed ethers, aldehydes and ketone co-products of oxo alcohol production, and ethoxylated alcohols.

[0012] It should be noted that a few documents already disclose the use of nitrile collectors for ore flotation processes.

[0013] US 2,166,093 discloses that nitrile collectors are effective in flotating copper ores but discloses the use of a compound having a single nitrile-functional group with a hydrophobic aliphatic component of 10 or less carbons. US 2,175,093 discloses the use of aliphatic dinitriles (of a general structure of $CN-R-CN$, wherein R is an alkylene group) as froth flotation agents in copper ore flotation.

[0014] US 4,532,031 discloses a froth flotation process to treat a copper ore. The process involves using a frother compound of the formula $R-W-C_n(XY)-Z$ wherein R is an alkyl group with up to 12 carbon atoms, W may be inter alia an oxygen, imino or substituted imino and Z may be inter alia a nitrile group. In the Examples the frother can be for example isobutyl cyanoethylamine or isobutyl cyanoethyl ether, i.e. compounds wherein the alkyl chain is isobutyl (an alkyl group with 4 carbon atoms). These frother compounds used in the examples have a log P value of below 1, i.e. in the working embodiments very hydrophilic compounds are used, which makes them suitable for use as a frother.

[0015] WO 2007/059559 discloses a process to treat copper ores using a collector composition containing a nitrile compound. The nitrile compounds tested in the document are hexyl dinitrile and several alkyl mononitriles containing an alkyl chain of at least 4 carbon atoms. It was shown that 11 or more carbons in the hydrophobic component attached to a nitrile were more efficient in flotating copper sulfide, Au, Ag and platinum group elements (PGE). Examples given for the hydrophobic component are derived from coconut and tallow fatty acids.

[0016] Pending patent application PCT/EP2018/056932 discloses treating metal or mineral ores with a collector composition that comprises a nitrile group-containing compound wherein the compound contains a single amine, amide, ether or ammonium moiety.

[0017] WO 87/032222 discloses collector compositions for the froth flotation of mineral values, especially for separating nonferrous metal-containing minerals from a sulfidic ore. The collectors are said to be chosen from a large group of compounds of the formula $R_1-X-(R)_n-Q$, including (as group Q) besides all sorts of amines, imines and amides, also nitriles, wherein the compounds can contain alkyl chains as small as C1 alkyl (as group R1), and the compounds can contain a nitrogen atom-containing moiety, like an amine moiety (as group X). In the Examples copper ores are flotated

but no nitrile-functional collector components are used but instead use is made of thiol functional amines and amides. Compounds containing one or more nitrile moieties and more than one further nitrogen atom containing moiety are not covered by WO '222.

[0018] When in the formula (I) of the present invention p is >1 , not all groups R_3 need to be the same group, they can all be independently selected from the groups $-(CH_2-CH_2-CH_2-NH)q-CH_2-CH_2-CN$ or $-(CH_2-CH_2-CH_2-NH)r-H$ and $-(C_xH_{2x}-O)n-R_1$. If more than one group R_1 is present in the formula (I) (which is the case if one or more of R_2 to R_4 is a group $-(C_xH_{2x}-O)n-R_1$), not all groups R_1 need to be the same, each R_1 group can be independently selected from a hydrogen, C1-C26 alkyl or C1-C26 alkenyl group.

[0019] Furthermore, in embodiments in the collector compositions of the present invention more than one nitrile group-containing compound of formula (I) is present.

[0020] In preferred embodiments the nitrile group-containing compound has a log P value of higher than 3, preferably higher than 4. The log P value is preferably lower than 10.

[0021] Log P stands for partition-coefficient (P) and reflects the ratio of concentrations of a compound in a mixture of two immiscible phases at equilibrium. This ratio is therefore a measure of the difference in solubility of the compound in these two phases. One of the solvents is the hydrophilic solvent water while the second solvent is the hydrophobic 1-octanol. Hence the partition coefficient measures how hydrophilic ("water-loving") or hydrophobic ("water-fearing") a chemical substance is. Log P values for the purpose of this specification are calculated using the online ALOGPS 2.1 software available via the website <http://www.vcclab.org/lab/alogps/> as existent in February 2018. The document R Mannhold, G Poda, C Ostermann, I Tetko, "Calculation of Molecular Lipophilicity: State of the Art and Comparison of Log P Methods on More Than 96000 Compounds", Journal of Pharmaceutical Sciences 2009, 98(3), 861-893 provides further information on log P.

[0022] Preferably in formula (I) n is 0 to 4, most preferably n is 0 or 1. It should be understood that n does not have to be an integer but can represent an average degree of alkoxylation in a mixture of compounds.

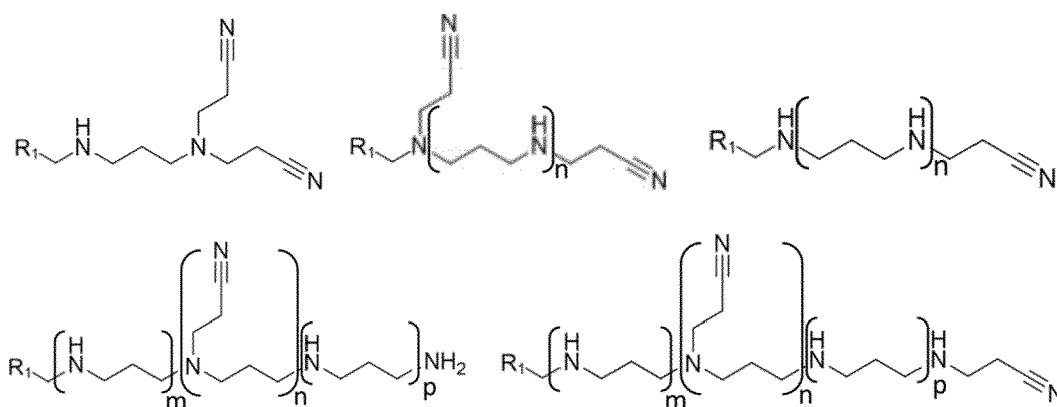
[0023] In another preferred embodiment p is 1 to 4, even more preferably 1 to 3.

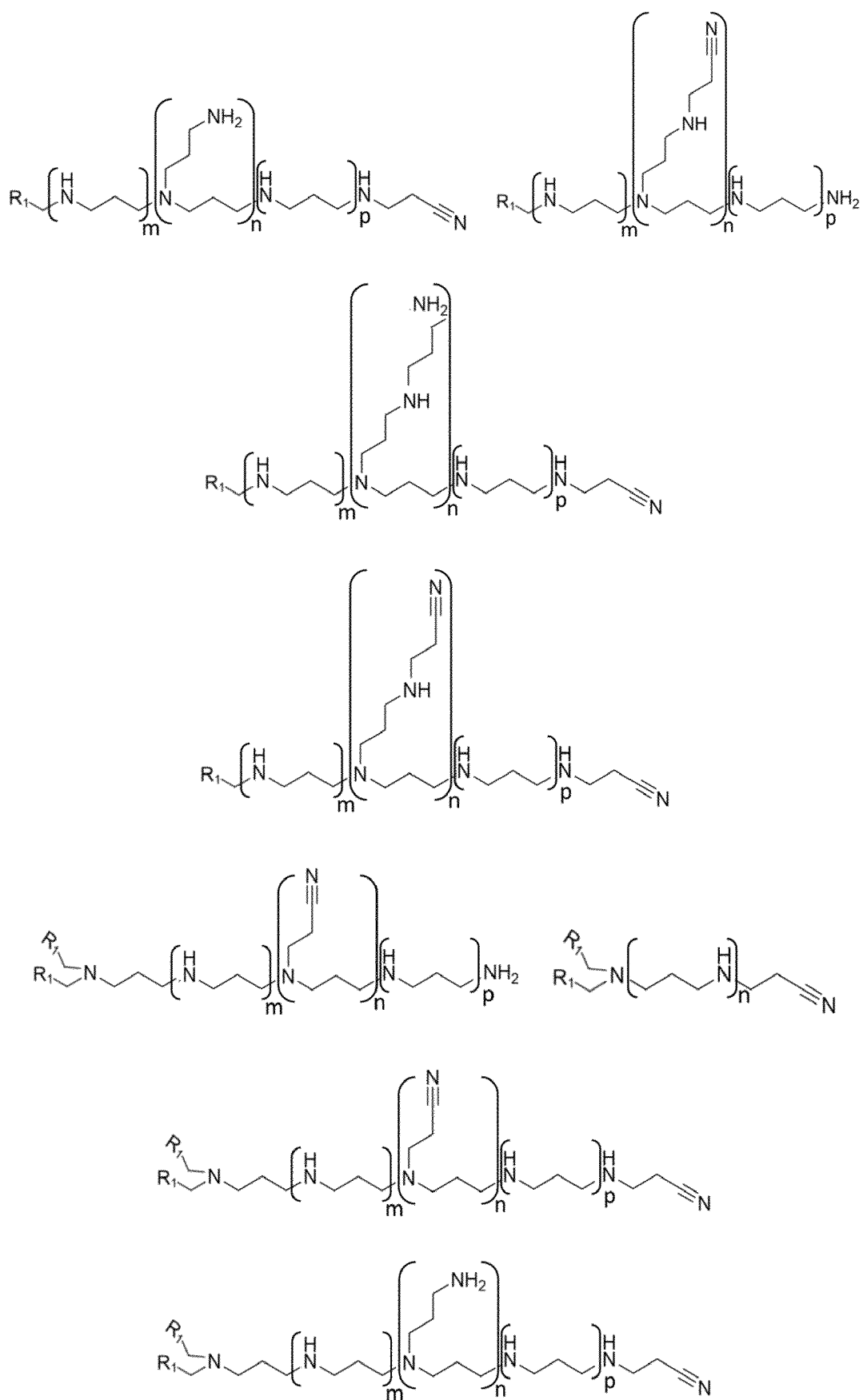
[0024] In yet another preferred embodiment q is 0 to 4, and/or r is 0 to 4, even more preferably q is 0 to 2, and/or r is 0 to 2.

[0025] In formula (I) x is a number 2 or 3, when x is 3 the group may be propyl or isopropyl. A combination of x is 2 and x is 3 is also possible when n is higher than 1. Preferably x is 2.

[0026] When R_1 is an alkyl or alkenyl group, it is a C1 to C26, branched or linear, alkyl or alkenyl group. Preferably, R_1 is an alkyl group or an alkenyl group with 0 to 3 unsaturated bonds, even more preferably a linear alkyl or alkenyl group, yet even more preferably a C8-C22, C10-C20, or even more preferably a C13-C20 alkyl or alkenyl group; most preferably a fatty alkyl chain such as one that can be derived from coco, tallow, palm oil, palm kernel oil, soya oil, rape seed oil, cotton seed oil, corn oil. As indicated, mixtures of different R_1 groups within a nitrile group-containing compound are possible.

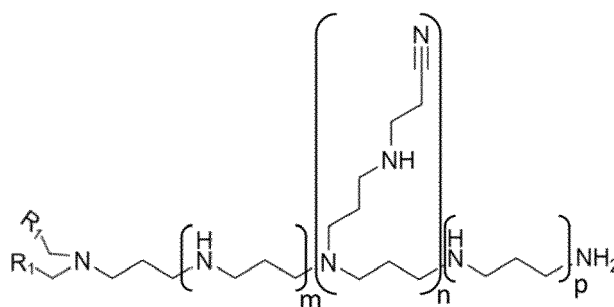
[0027] Exemplary compounds of formula (I) are





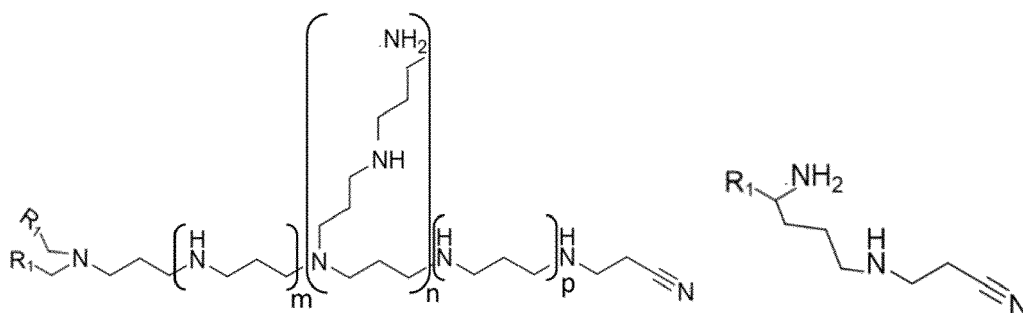
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[0028] The process of the invention can be a direct or a reverse flotation process. When flotation sulfidic iron ores to separate iron from the sulfur impurities a reverse flotation is performed. In another example, in an ore containing copper sulfide and zinc sulfide the zinc is depressed and the copper is floated off the zinc sulfide. The process in an embodiment is a reverse flotation of zinc sulfide. When copper ore is floated, the process in an embodiment is a direct flotation.

[0029] The process of the invention in some preferred embodiment may contain one or more additional steps chosen from the group of pH adjustment steps, magnetic separation steps, screening or classification steps, fractionation steps and desliming steps. In another preferred embodiment it is beneficial to repeat one or more steps during the process, like the flotation step. It is within the skills of a person in the art to add any of the above steps and to time any of these steps to obtain the best result.

[0030] If component (b) in the collector compositions according to the invention is a nitrile collector, it should be understood that it is a nitrile compound different from the nitrile-containing compound as component (a). Preferably, component (b) is a xanthate, dithiophosphate, thionocarbamate, or amine (fatty amine (primary, secondary, tertiary), ether(di)amine, quaternary amine) collector.

[0031] The metal or mineral ore in some embodiments may be a metallic sulfide ore containing iron, copper, gold, platinum, silver, nickel, molybdenum, arsenic sulfides, cobalt, zinc, lead, tin, antimony, preferably, copper, zinc, lead, gold, platinum, or silver. The ore is preferably an iron ore containing a sulfuric component, such as pyrite, chalcopyrite, marcasite or pyrrhotite.

[0032] The process of the invention may involve other additives and auxiliary materials which are typically present in a froth flotation process; they can be added at the same time or, preferably, separately during the process. Further additives that may be present in the flotation process are further collectors (such as thiol-based collectors, like xanthate, dithiophosphate, thionocarbamate, thiocarbamate, mercaptobenzylthiazole, monothiophosphate and dithiophosphinates and hydroxamate, amine or other nitrile collectors as also mentioned above), depressants (such as lime, starch, dextrin, chromate, cyanide, sodium sulfide, zinc sulfate, sulfur dioxide, sodium hydrosulfide, polysulfides, copper sulfate, sodium hydrosulfide, polyphosphates, chromates, starch, cellulose-based reagents, oxygen, hydrogen peroxide, ozone), dispersants (such as sodium silicate and polyacrylic acid (PAA)) and activators (such as copper sulfate, iron sulfate, sodium sulfide, sodium hydrosulfide, oxygen, hydrogen peroxide, ozone), frothers/froth regulators/froth modifiers/de-foamers (such as aliphatic alcohols such as MIBC, Flottec FX120-01 and ethyl hexanol, polypropylene glycols and their ethers such as Dowfroth 200, Dowfroth 250, Dowfroth 1012, Flottec FX160-01, FX160-05, F160, F150; polyethylene glycols and their ethers such as FlottecFX120-02, Nassaco MasFroth240 and Sasol NovelFrother234), and pH-regulators (such as sodium hydroxide, lime or sodium carbonate). In preferred embodiments, lime is used in an amount of about 10 to about 1,000 g/t of ore as a pH modifier.

[0033] In another aspect, the present invention relates to a pulp comprising crushed and ground ore, a collector composition as defined herein, and optionally further flotation aids. This pulp can be prepared by first grinding the ore and then adding collector composition or by adding at least part of the collector composition to the ore and milling the ore to pulp in the presence of at least part of the collector composition.

[0034] Metallic and sulfide ores that can be used in the process of the invention may include itabarite, magnetite, hematite, goetite, martite, stibnite, arsenopyrite, bismuthinite, greenockite, cobaltite, carrollite, linnaeite, chalcocite, bornite, cocellite, tennantite, tetrahedrite, enargite, argyrodite, pyrrhotite, pyrite, galena, jamesonite, cinnabar, molybdenite, penlandite, millerite, heazlewoodite, argentite, acanthite, patronite, sphalerite, wurtzite and marmatite-containing ores.

[0035] The amount of collector used in the process of reversed flotation of the present invention will depend on the amount of impurities present in the ore and on the desired separation effect, but in some embodiments will be in the range of from 1-1000 g/ton dry ore, preferably in the range of from 5-500 g/ton dry ore, more preferably 10-300 g/ton dry ore.

Examples

Example 1

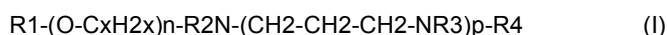
[0036] This Example demonstrates the superior flotation performance of the nitrile compound according to the invention R-NH-C₃H₆-NH-C₂H₄-CN wherein R is the hydrocarbyl group derived from tallow, against PAX (potassium amyl xanthate) collector in the flotation of sulfide from iron oxide ores to upgrade iron grade.

[0037] The dry flotation feed from the ore contains -49% Fe in the form of mainly iron oxides, mostly magnetite, and 6.6% of Sulfur in the form of pyrrhotite / pyrite. The flotation tests were conducted at room temperature using a Denver D12 laboratory flotation machine with cell volume of -1.4 Liter. Besides collector, copper sulfate in 10% aqueous solution was added as activator at the dosage of 300 g/t in each flotation test by pipet, and frother of MIBC in neat was added at the dosage of 80 g/t by micro pipet. When used, PAX was added as 5% aqueous solution by pipet, and the nitrile compound was added as 5% solution in IPA (iso-propanol) by pipet. The flotation tests were done at pulp density of 30-40%, at rotor speed of 900rpm, with air flow of 4.5 liter/minute. The collector was added step-wise, after each addition and conditioning of 2 minutes, the flotation was run till exhaustion. Flotation froth was collected and put in oven to dry up the ore for elemental analysis of interested elements by XRF. Cumulative flotation performance of the collector at different dosages can be calculated by combining the flotation froth from each step.

[0038] As can be seen from the figures 1 and 2, the nitrile compound of the invention can float out much more impurities of sulfide of pyrrhotite / pyrite from iron oxides than PAX at equal dosages, resulting in much lower residual sulfur in the flotation concentrate.

Claims

1. Process to treat metal or mineral ores with a collector composition that comprises a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10,

R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group -(CH₂-CH₂-CH₂-NH)_q-CH₂-CH₂-CN or -(CH₂-CH₂-CH₂-NH)_r-H or -(C_xH_{2x}-O)_n-R1,

wherein q is 0 to 10 and r is 0 to 10

at least one of R2-R4 is a group -(CH₂-CH₂-NH)_q-CH₂-CH₂-CN,

and R1, x and n are as defined above.

2. Process of claim 1 wherein n is 0 to 4, preferably 0 or 1.

3. Process of claim 1 or 2 wherein p is 1 to 4, preferably 1 to 3.

4. Process of any one of claims 1 to 3 wherein x is 2 or a combination of x is 2 and x is 3 when n is higher than 1.

5. Process of any one of claims 1 to 4 wherein q is 0 to 4 and r is 0 to 4, preferably q is 0 to 2 and r is 0 to 2.

6. Process of any one of claims 1 to 5 wherein R1 is an alkyl group or an alkenyl group with 0 to 3 unsaturated bonds, preferably a linear C13-C20 alkyl or alkenyl group.

7. Process of any one of claims 1 to 6 wherein the metal or mineral ore is a metallic sulfide ore containing iron, copper, gold, platinum, silver, nickel, molybdenum, arsenic sulfides, cobalt, zinc, lead, tin, antimony, copper, gold, platinum, or silver.

8. Process of any one of claims 1 to 7 wherein the collector composition in addition contains at least one of a collector selected from the group of nitrile, xanthate, dithiophosphate, thionocarbamate, thiocarbamate, mercaptobenzylthiazole, monothiophosphate, dithiophosphinates, hydroxamate collectors, fatty amines(primary, secondary, tertiary), ether(di)amines, quaternary amines, carboxylates, and ethoxylated alcohols, or a frother selected from the group of phenols, alkyl sulfates, aliphatic alcohols, such as C5 - C8 cyclic alcohols, alkoxyalkanes, polypropylene glycol ethers, polyglycol ethers, polyglycol glycerol ethers, pyridine base, natural oils, such as terpineol and cresols, mixed ethers, aldehydes and ketone co-products of oxo alcohol production, and ethoxylated alcohols.

9. Process of any one of claims 1 to 8 comprising the steps of

a) conditioning a pulped metallic or mineral ore, in an aqueous solution optionally, concentrating the medium with magnetic separation;

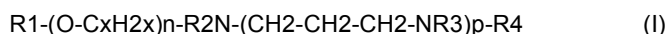
- optionally, adding frothers;
- optionally, conditioning the mixture with a flotation depressant or flotation activator;
- optionally, adjusting the pH

b) adding the collector composition as described in any one of the claims 1 to 8

c) optionally, adding other flotation aids to the pulp, and

d) performing a froth flotation process by introducing air into the conditioned water-ore mixture, and skimming off the froth formed to recover the mineral and/or metals.

10. Collector composition containing as component (a) 1 wt% to 99 wt% of a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10 ,

R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group $-(CH2-CH2-CH2-NH)q-CH2-CH2-CN$ or $-(CH2-CH2-CH2-NH)r-H$ or $-(CxH2x-O)n-R1$,

wherein q is 0 to 10 and r is 0 to 10

at least one of R2-R4 is a group $-(CH2-CH2-NH)q-CH2-CH2-CN$, R1, x and n are as defined above; and

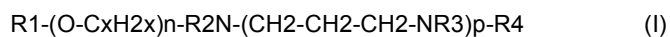
as component (b) 1 to 99 wt% of at least one of a collector selected from the group of nitrile, xanthate, dithiophosphate, thionocarbamate, thiocarbamate, mercaptobenzylthiazole, monothiophosphate and dithiophosphinates, hydroxamate collectors, fatty amines (primary, secondary, tertiary), ether(di)amines, quaternary amines, carboxylates, and ethoxylated alcohols, or a frother selected from the group of phenols, alkyl sulfates, aliphatic alcohols, such as C5 - C8, cyclic alcohols, alkoxyalkanes, polypropylene glycol ethers, polyglycol ethers, polyglycol glycerol ethers, pyridine base, natural oils such as terpineol and cresols, mixed ethers, aldehydes and ketone co-products of oxo alcohol production, and ethoxylated alcohols.

11. Collector composition of claim 10 containing 20 to 80 wt% of component (a) and 20 to 80 wt% of component (b).

12. Collector composition of claim 10 or 11 wherein n is 0 to 4, preferably 0 or 1.

13. Collector composition of any one of claims 10 to 12 wherein R1 is an alkyl group or an alkenyl group with 0 to 3 unsaturated bonds, preferably a linear C13-C20 alkyl or alkenyl group.

14. A pulp comprising the crushed and ground copper or sulfidic ore and a collector composition comprising a nitrile group-containing compound of the formula (I)



wherein

x is 2 or 3

n is 0 to 20,

p is 1 to 10,

R1 can be hydrogen, an alkenyl group or an alkyl group containing 1 to 26 carbon atoms,

each group R2 to R4 independently can be a group $-(CH_2-CH_2-CH_2-NH)_q-CH_2-CH_2-CN$ or $-(CH_2-CH_2-CH_2-NH)_r-H$ or $-(C_xH_{2x}-O)_n-R1$,

wherein q is 0 to 10 and r is 0 to 10

at least one of R2-R4 is a group $-(CH_2-CH_2-NH)_q-CH_2-CH_2-CN$, and
R1, x and n as defined above.

Figure 1 Residual sulfur content employing nitrile collector of the present invention in comparison with state of the art potassium Amyl xanthate collector for an iron / sulfur ore

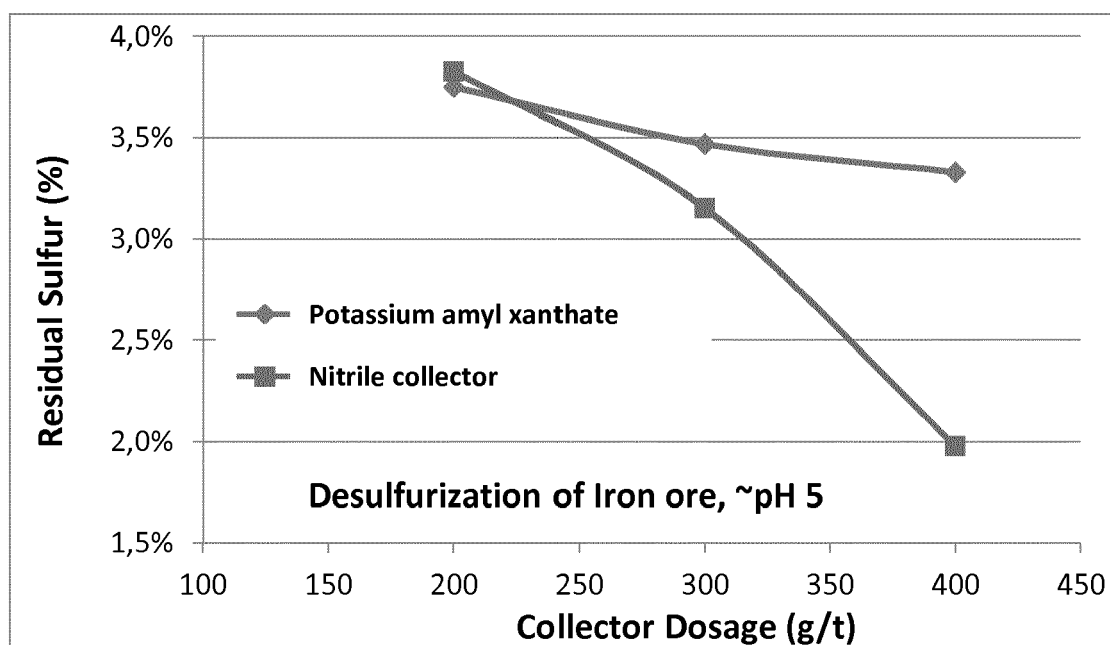
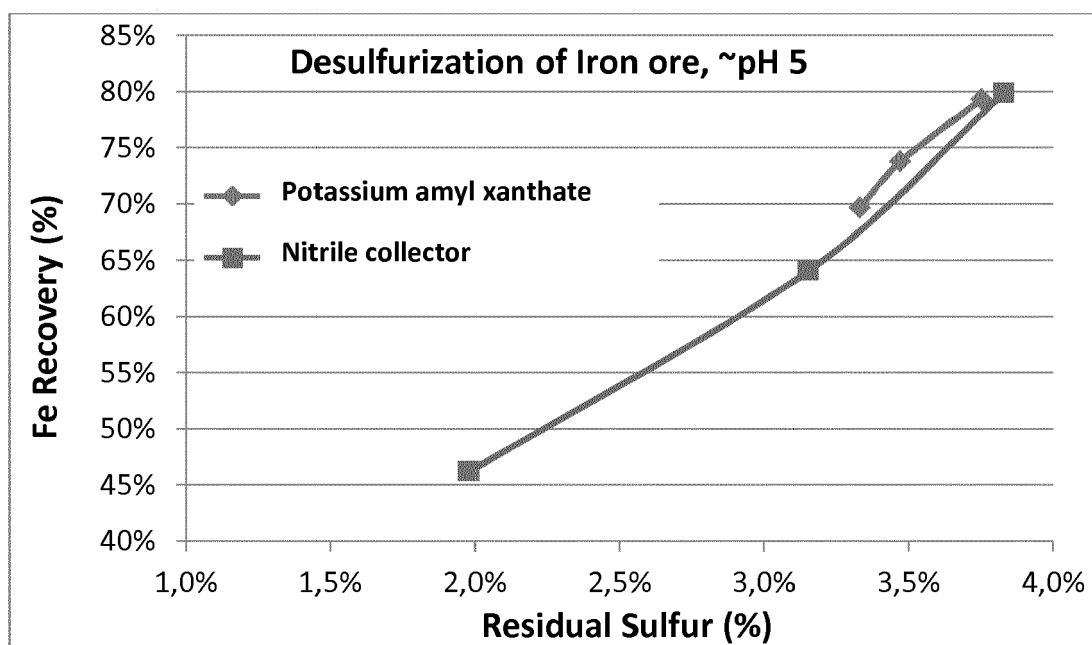


Figure 2 Iron recovery employing nitrile collector of the present invention in comparison with state of the art potassium Amyl xanthate collector for an iron / sulfur ore





EUROPEAN SEARCH REPORT

 Application Number
 EP 18 19 9044

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 April 2019	Examiner Baumlin, Sébastien
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