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FLOTATION OF ORES USING ADDITION POLYMERS AS DEPRESSANTS

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This invention relates to froth flotation and more particularly to the flotation of ores having gangue slimes.

Many ores have finely-divided gangue constituents present as slimes which interfere with flotation of the desired mineral values. The presence of gangue or slimy materials creates difficulties in flotation by reason of contamination of the concentrate by the gangue or by the action of the gangue on the mineral values which prevents their flotation and hence reduces recoveries. In some ores the slimes are present as ordinary gangue minerals of a siliceous nature, while in other ores a carbonaceous gangue is present. While it is often possible to deslime ores prior to froth flotation, this is not always possible because in many cases certain components of the gangue carry with them recoverable values and in other cases it is often necessary to grind the feed to such a very fine size that practically all of the feed may be considered as a slime.

In the past, dextrin, sodium silicate, glue and other organic protective colloids have commonly been used for the depression of gangue during flotation. These colloids are frequently deflocculating agents and function to keep the slimy gangues in a highly dispersed state so as not to interfere with the flotation of the mineral values. Such colloids, while in widespread use, are not completely satisfactory, however, because they frequently cause the depression of certain of the desirable constituents of the ore as well as the gangue and hence decrease recoveries of the valuable mineral values.

In accordance with the present invention, it has been found that froth flotation of ores is greatly improved when it is carried out in the presence as a gangue depressant of water-soluble anionic, linear, addition polymers of a monoethylenically unsaturated compound, and water soluble salts thereof, having an average molecular weight of at least 10,000.

It is a surprising feature of the present invention that the linear, addition polymers and salts act as selective depressants for the gangue slimes without depressing to any appreciable extent, and thus preventing the recovery of, the desired mineral values. In making a choice between optimum grade and maximum recovery, slight losses in recovery are taken occasionally but in such cases the economic advantages of the high concentrate grade far outweigh the losses of recovery. Losses incurred by the use of the polymers of the present invention are considerably less than with gangue depressants in use at the present time.

It is a further surprising feature of the present invention that the linear, addition polymers work so effectively in depressing gangue during flotation because the mineral dressing art has heretofore considered that the slimes must generally be in a highly dispersed condition or otherwise the desired separation could not take place. In the practice of the present invention, however, these polymers which when used in the soil conditioning art are known to be strong flocculants for surface soils, have been found to produce remarkable results in depressing gangue during

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flotation by a mechanism which is not clearly understood but the net result of which appears to be directly contrary to that which was heretofore considered to be necessary in the mineral dressing field, namely, a dispersed condition of the slimes. It is an observable fact, however, that by the use of the polymers or salts of the present invention, greatly improved metallurgical results are obtained on many ores with resultant improvement in concentrate grades and in many cases with added mineral recovery apparently by reason of the fact that the interfering gangue slimes which hinder flotation of the desired mineral values are effectively depressed.

It is an advantage of the present invention that it is applicable to gangue slimes of the most varied types of ores such as siliceous gangue present in metallic or sulfide ores, for example, lead, zinc, copper, pyrite, lead-zinc ores, precious metal ores, etc. It is also applicable to the various gangues present in non-metallic ores such as, for example, those of tungsten, manganese, barite, fluorspar, limestone and phosphate rock. Talcs, micas, clays, sericites, limonites, fine carbon and on occasion fine calcite are examples of gangues which interfere with flotation especially when these are present as slimes, and other minerals when in the form of slimes frequently are harmful.

It is a further advantage of the present invention that the linear, addition polymers or salts may be added at any convenient point in the ore treatment operation. Thus, for example, they may be introduced prior to and/or during the flotation operation. The point at which they are introduced may frequently depend on the particular ore being floated. Good results have been obtained when the polymers have been added to the grinding operation or to the conditioning step prior to flotation. In other cases, the polymers have been introduced into flotation circuits at the start and/or during flotation operations. Stage feeding during flotation has been very effective. The polymers are generally fed as solutions but may be added in dry form or as concentrated gels, if so desired.

Examples of water-soluble, anionic, linear, addition polymers of a monoethylenically unsaturated compound are polymers of unsaturated aliphatic monocarboxylic acids, such as acrylic acid, methacrylic acid, vinyl acetic acid, etc., and water-soluble salts thereof. These polymers may be obtained by polymerizing the acid itself or by polymerizing derivatives having groups which are hydrolyzable to acids, such as, for example, acrylonitrile, acrylamide, esters of acrylic and methacrylic acid, etc. The unsaturated monocarboxylic acids may be polymerized by themselves to form homopolymers or they may be copolymerized with compounds such as vinyl pyridine, vinyl acetate, styrene, vinyl ethers, vinyl halides, or even unsaturated hydrocarbons such as isobutylene. Polymers of polybasic unsaturated acids are also included, although here it is difficult to obtain a homopolymer. For example, maleic anhydride itself will not polymerize, but it copolymerizes readily with such materials as styrene, vinyl acetate, acrylates and the like.

Among the various polymers and water-soluble salts thereof useful in the practice of the present invention are hydrolyzed polyacrylonitrile, polyacrylamide, polyacrylic acid, $\frac{1}{2}$ calcium salt of hydrolyzed 1:1 copolymer of vinyl acetate-maleic anhydride, hydrolyzed styrene-maleic anhydride copolymer, ammonium polyacrylate, sodium polyacrylate, ammonium polymethacrylate, sodium polymethacrylate, diethanol ammonium polyacrylate, guanidinium polyacrylate, dimethylaminoethyl polymethacrylate, acrylamide-acrylonitrile copolymer, methacrylic acid-dimethylaminoethyl methacrylate copolymer, sodium polyacrylate-vinyl alcohol copolymer, hydrolyzed methacrylic acid-acrylonitrile copolymer, vinyl acetate-maleic anhydride copolymer, vinyl formate-maleic anhydride

copolymer, vinyl methyl ether-maleic anhydride copolymer, isobutylene-maleic anhydride copolymer, styrene-maleic anhydride copolymer, ethyl acrylate-maleic anhydride copolymer, vinyl chloride-maleic anhydride copolymer, hydrolyzed acrylonitrile-vinyl acetate copolymer, hydrolyzed acrylonitrile-methacrylonitrile copolymer, hydrolyzed acrylonitrile-methacrylonitrile-vinyl acetate terpolymer, hydrolyzed acrylonitrile-methacrylic acid copolymer, vinyl pyridine-acrylonitrile copolymer, etc.

Among the best linear, addition polymers are those which are obtained by hydrolyzing polymeric material containing polyacrylonitrile. These compounds are cheap and give excellent results. Here again, the polymer may be a homopolymer or the acrylonitrile may be copolymerized with small amounts of other materials, such as vinyl pyridine, acrylic esters and the like. It should be noted that the products obtained by hydrolyzing polymers such as polyacrylonitriles are not completely identical with the corresponding polymers obtained by polymerizing acrylic acid. Both types are, however, useful in the present invention.

It is an advantage of the present invention that the preferred type of linear, addition polymers, namely, hydrolyzed polyacrylonitriles, may be of very low grade. It is thus possible to use polyacrylonitriles which have insufficient purity for other uses, such as fibers, to prepare the polyacrylic acid of the present invention. The possibility of using these normally discarded, off-grade products makes a source of very cheap material available for use in the present invention. Where the amount of by-product, off-grade material is not sufficient to supply the demand and the linear polymers must be made directly, it is usually found that the homopolymer of acrylonitrile is somewhat cheaper to make than the copolymers.

The water-soluble polymers and water-soluble salts thereof as described hereinabove may be added to the ores being floated in amounts ranging from 0.001 lb. ton to 1.0 lb. ton but it has been found that with most ores optimum results are obtained by the use of 0.01 lb./ton to 0.2 lb./ton.

For optimum beneficial effect, the molecular weight of the linear, addition polymer is of some importance in selectively depressing the gangue constituents of the ores. It appears that the molecular weight should be at least about 10,000 in order to secure the desired results. The upper molecular weight limit does not appear to be at all critical and is set only by the practical difficulty of making extremely highly polymerized polymers. Polymers having molecular weights ranging upward to about 500,000 appear to be quite satisfactory in the practice of the present invention. Those polymers having molecular weights much in excess of 500,000 are difficult to get into solution or to form dispersions thereof in water. Thus, the insoluble or non-dispersible polymers are not included herein. However, so long as the polymer is water- or water-dispersible it is operable in carrying out the present invention.

It is to be understood that since the herein-described polymers and salts serve solely as depressing agents for the interfering slimes, a suitable mineral collector must be used in the froth flotation process. The choice of promoter is not critical and is dictated solely by the mineral which is desired to be floated. Thus, suitable anionic promoters such as the xanthates, dithiophosphates, naphthenic acids, fatty acids, resin acids and mixtures thereof, the alkali soaps of such acids and their mixtures may be suitably employed. Cationic reagents such as long chain amines and amine derivatives may suitably be employed when the ore being treated is of the type that responds to such agents. Hydrocarbon oils and frothers such as pine oil, cresylic acids, higher alcohols and other frothing agents may also be used.

The invention will be described in greater detail in conjunction with the following specific examples in which the parts are by weight unless otherwise specified.

Example 1

A sulfide lead-zinc ore containing 3.7% Pb and 6.0% Zn in a siliceous gangue was ground to 20% plus 200 mesh in the presence of 0.25 lb. per ton of sodium cyanide and 1.5 lb. per ton zinc sulfate. The resulting pulp was diluted to about 22% solids and conditioned with 0.10 lb. per ton ammonium dicresyl dithiophosphate and 0.05 lb. per ton of a higher alcohol frother. The lead sulfides were then floated off to produce a concentrate which assayed 24.75% Pb and 4.59% Zn and contained 98.2% of the total lead and 10.5% of the total zinc. The tailing from the lead flotation was conditioned with 2.5 lb. per ton lime, 1.0 lb. per ton copper sulfate and 0.1 lb. per ton technical sodium diisopropyl dithiophosphate and 0.05 lb. per ton of a higher alcohol frother. The tailing was then floated to remove zinc, producing a concentrate assaying 0.36% Pb and 39.8% Zn and containing 1.2% of the total lead and 79.7% of the total zinc. The final flotation tailing assayed 0.03% Pb and 0.86% Zn.

A similar test was conducted on this ore using 0.1 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, which was added to the grinding operation. In the lead float, the concentrate assayed 31.41% Pb and 3.94% Zn and contained 98.5% of the total lead and 7.8% of the total zinc. The zinc concentrate contained 0.25% Pb and 39.79% Zn and contained 1.1% of the total lead and 90.4% of the total zinc. The flotation tailings contained 0.02% Pb and 0.14% Zn.

The results of these tests indicate that the use of the polymer effected a considerable improvement in the grade of the lead concentrate without loss of recovery of lead, a decrease in the zinc losses into the lead concentrate and a marked improvement in the zinc recovery.

Example 2

Flotation tests were conducted on a gold bearing pyrite ore containing 0.5 oz. Au per ton. This ore which contained a feldspar-granite gangue was ground to 2.4% +100 mesh and floated with 0.1 pound per ton sodium secondary butyl xanthate and 0.1 pound per ton of a 1:1 mixture of pine oil and a higher alcohol as frother. The metallurgical results are given in the following table. In the first test, no polymer was used. In the next 3 tests, the sodium salt of hydrolyzed polyacrylonitrile was used in amounts ranging from 0.01 to 0.10 lb. per ton.

	Assay, Oz. Au/ton	Percent Distri- bution Au	Lb./ton Polymer
Test 1:			
Concentrate.....	14.64	87.9	none
Tailing.....	0.064	12.1	
Test 2:			
Concentrate.....	15.92	88.8	0.01
Tailing.....	0.063	11.2	
Test 3:			
Concentrate.....	15.26	88.5	0.05
Tailing.....	0.062	11.5	
Test 4:			
Concentrate.....	16.22	88.9	0.10
Tailing.....	0.062	11.1	

The use of the polymer gave improved concentrate grade without causing gold losses.

Example 3

A Missouri sulfide lead ore was ground at 60% solids, diluted to 22% solids and conditioned with 0.015 lb. per ton sodium isopropyl xanthate and 0.16 lb. per ton amyl alcohol frother. The lead was floated to produce a concentrate assaying 57.7% Pb and containing 90.8% of the total lead. The flotation tail contained 0.47% Pb.

The same procedure was followed on a second sample of this ore and 0.10 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile was agitated with the ore pulp for two minutes prior to the treatment with xanthate-frother as described above. In this test, 93.4% of the

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lead was recovered in a concentrate assaying 57.8% Pb. The flotation tailing in this test contained 0.35% Pb.

The use of the polymer in this test resulted in a higher recovery of lead in the flotation concentrate. This flotation feed contained a portion of its lead values as slimed lead sulfides and it will be noted that such values were not depressed by the use of the polymer, a factor which illustrates the selective action of these materials as gangue modifiers.

Example 4

A sulfide zinc ore from the southeastern part of the United States was ground at 60% solids, diluted to about 20% solids and conditioned with 0.5 lb. per ton of copper sulfate, 0.025 lb. per ton technical sodium diisopropyl dithiophosphate and 0.12 lb. per ton pine oil. The zinc was then floated off as a concentrate assaying 41.7% Zn and containing 96.1% of the total zinc contained in the ore.

In a second test on this ore, 0.1 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile was added after conditioning with the promoter-frother combination described above. Flotation of the zinc resulted in a concentrate assaying 42.1% Zn and containing 98.2% of the total zinc.

As in the foregoing examples improved metallurgy was also obtained in the treatment of this zinc ore.

Example 5

A sample of porphyry copper ore (0.8% Cu) was ground to minus 65 mesh in the presence of 0.1 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 1.5 lb. per ton lime, 0.04 lb. per ton technical sodium disecundary butyl dithiophosphate and 0.075 lb. per ton of higher alcohol frother. The ore was floated to produce a copper concentrate which assayed 22.1% Cu and contained 80.0% of the total copper. In a control test in which the polymer was omitted from the grind, a copper concentrate was produced which assayed 14.2% copper and contained 80.3% of the total copper in the ore. The main diluent in the copper concentrate in this test was fine gangue minerals.

It will be noted that a marked increase in concentrate grade was effected by the use of the polymer and that this was attained with essentially no loss in copper recovery. In certain other copper ores it is possible to use relatively large amounts of polymer, e. g. in the range of 0.75-1.0 lb./ton, without causing depression of copper values.

Example 6

A second copper ore similar to that used in Example 5 was also treated with 0.1 lb./ton of various polymers and water-soluble salts and the above-mentioned lime-frother dithiophosphate combination in a series of separate tests and floated to produce a copper concentrate. The polymers used together with the recovery of copper and concentrate grade in each test are listed in the following table:

Polymer Used	Concentrate, Percent Cu	
	Assay	Recovery
None	15.2	83.4
Guanidine salt of hydrolyzed polyacrylonitrile	20.7	83.9
Diethanol amine salt of hydrolyzed polyacrylonitrile	24.6	82.0
½ Sodium salt of 1:1 copolymer of vinyl acetate-maleic anhydride	22.4	82.0
Polyacrylic acid	22.1	83.0
½ Calcium salt of vinyl acetate-maleic anhydride copolymer	23.1	82.6
Polyacrylamide	23.2	82.2
Ammonium salt of hydrolyzed polyacrylonitrile	23.9	82.1
Hydrolyzed styrene-maleic anhydride copolymer	20.3	83.0
Sulfonated polystyrene	18.3	82.8
Sodium salt of copolymer of vinyl methyl ether-maleic acid	21.5	83.6
Ethyl acrylate-ammonium maleate	21.8	82.4
Styrene-ammonium maleate	19.8	83.1

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The marked improvement in the grades of the copper concentrates obtained in the treatment of this ore outweighs the indicated slight losses in recovery.

Example 7

A tungsten ore in which various tungsten minerals were associated with a siliceous gangue was ground to pass 65 mesh. This ore contained 0.9% WO₃. The pulp, after grinding, was conditioned with 5.0 lb. per ton sodium silicate, 8.0 lb. per ton sodium carbonate, 0.15 lb. per ton quebracho, 1.5 lb. per ton sodium resinate, and 1.2 lb. per ton oleic acid. A rougher flotation concentrate was produced and cleaned once. 90.5% of the tungsten was contained in the cleaner concentrate which assayed 24.96% WO₃.

This test was repeated with 0.1 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, which was added to the conditioning step along with the oleic acid collector. In this test, the cleaned concentrate contained 91.0% of the total tungsten in the ore and assayed 29.70% WO₃. Thus, an increase in grade of about 5% WO₃ was obtained without loss of tungsten recovery.

Example 8

A tungsten ore (0.4% WO₃) containing various tungsten materials and a gangue composed of garnet, limonite, calcite, and silicate minerals was ground to minus 65 mesh and conditioned with 0.04 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 4.25 lb. sodium silicate, 12.5 lb. per ton of soda ash, 0.2 lb. per ton quebracho, 1.0 lb. per ton sodium resinate and 0.5 lb. per ton oleic acid. The pulp was floated to remove a tungsten concentrate which was subjected to cleaning by refloatation. A final concentrate was produced which contained 83.1% of the total tungsten. The tungsten content of this concentrate was 37.6% WO₃. A control test on this ore was also conducted, in which the polymer was omitted. In this test a low grade tungsten concentrate resulted, which assayed only 5.5% WO₃. These test results illustrate the marked effect of the polymer on improving the grade of the tungsten concentrate.

Example 9

The tungsten ore described in Example 7 was employed in a series of comparative tests with various polymers. The reagents and testing methods were similar to those outlined in Example 7. The polymers used together with the tungsten recoveries and concentrate grades are given in the following table:

Polymer Used	Concentrate, Percent WO ₃	
	Assay	Recovery
0.01 lb./ton Polyacrylic acid	30.61	90.8
0.01 lb./ton ½ Calcium salt of vinyl acetate-maleic anhydride copolymer	31.20	82.6

A marked increase in concentrate grade was effected by the use of the polymers.

Example 10

A Michigan iron ore containing hematite in a quartz gangue was ground to minus 65 mesh, diluted to about 25% solids and deslimed incompletely in the presence of 0.5 lb. per ton sodium silicate. The deslimed pulp was conditioned with 0.02 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile and 0.75 lb. per ton low rosin tall oil fatty acids, and then floated to produce an iron concentrate. This concentrate was then subjected to two cleanings by refloatation. The final concentrate contained 80.3% of the iron and assayed 64.9% Fe and 5.6% SiO₂.

Example 11

A barite ore containing barite associated with quartz and iron oxides was ground to about 50% minus 200

mesh and conditioned with 0.02 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 3.9 lb. per ton sodium silicate, 2.8 lb. per ton of oil-soluble petroleum sulfonate and 0.06 lb. per ton of a seven carbon atom alcohol frother. A barite concentrate was then removed by flotation. 95.3% of the barite was removed in this concentrate which contained 98.9% BaSO₄.

Example 12

A Montana manganese ore containing about 17% Mn as rhodochrosite in a silicate gangue was ground and floated in the presence of 0.5 lb. per ton caustic soda, 1.5 lb. per ton sodium silicate, 1.2 lb. per ton oil-soluble petroleum sulfonate, 0.9 lb. per ton saponified cottonseed foos, and 0.005 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile. A manganese concentrate was removed containing 38.1% Mn. The recovery of manganese in this concentrate was 94.6%.

Example 13

Flotation tests were also conducted on Canadian fluorite ore, which contained fluorite, calcite, feldspar, and small amounts of sulfide and oxide iron minerals. This ore contained about 27% CaF₂. The ore was ground to about 45% minus 200 mesh, conditioned with 0.015 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 0.25 lb. per ton quebracho, 3.0 lb. per ton sodium silicate and 1.0 lb. per ton oleic acid and floated to remove a fluorite concentrate. 82.1% of the fluorite was recovered in a concentrate assaying 98.1% CaF₂.

Example 14

A Pennsylvania cement rock containing calcium carbonate in a gangue composed of quartz, sericite and carbon was ground to about 95% minus 200 mesh, diluted to 22% solids and floated in the presence of 1.0 lb. per ton crude calcium lignin sulfonate, 0.02 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 0.12 lb. per ton of higher alcohol frother and 0.76 lb. per ton vegetable fatty acid foos. The oleic acid promoter and frother were added in stages over an eight minute float. From a feed assaying 70.5% CaCO₃, a concentrate was produced which assayed 78.1% CaCO₃ and contained 97.8% of the total calcium carbonate.

Example 15

A sample of Florida phosphate rock typical of material treated by flotation was deslimed and conditioned at 60% solids with 0.6 lb. per ton tall oil, 3.0 lb. per ton fuel oil, 0.4 lb. per ton caustic soda and 0.015 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, diluted to about 20% solids and floated to produce a phosphate concentrate. From a flotation feed assaying about 32.9% bone phosphate of lime (BPL), a concentrate was produced which was cleaned twice. The final concentrate contained 72.3% BPL and 7.8% insoluble. This concentrate represented a phosphate recovery of 79.6%.

Example 16

Pennsylvania anthracite coal fines assaying 24.4% ash, were conditioned with 0.2 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 0.35 lb. per ton pine oil and 2.0 lb. per ton fuel oil #2, and floated to produce a rougher concentrate. This concentrate was subjected to a cleaning operation. The cleaned concentrate contained 14.3% ash and represented a weight recovery of 81.6% of the coal treated.

The use of 0.5 lb. per ton of the polymer with the above-mentioned oil-frother combination resulted in a weight recovery of 79.6% and gave a final coal concentrate assaying 12.6% ash.

Example 17

The various polymer products herein-described are also useful as modifying agents when used with cationic col-

lectors. The further beneficiation by flotation of a phosphate concentrate produced as described in Example 15 by the use of caustic soda—tall oil—fuel oil is a typical application of cationic reagents. A flotation concentrate (10.3% silica) obtained as described above by floating a sample of Florida phosphate rock was scrubbed with 1.0 lb. per ton sulfuric acid in order to remove flotation reagents. The resulting pulp was then diluted to about 20% solids and conditioned with 0.02 lb. per ton of the sodium salt of hydrolyzed polyacrylonitrile, 0.20 lb. per ton of tallow amine acetate, 0.12 lb. per ton of higher alcohol frother and 0.25 lb. per ton of kerosene and floated to remove silica. The silica content of the original flotation concentrate was reduced to 3.1% and a weight recovery of phosphate of 90.89% was obtained. The phosphate content of the phosphate concentrate was 78.5%.

We claim:

1. The method of concentrating ores containing gangue slimes which comprises subjecting an aqueous pulp of said ore to froth flotation in the presence of a collector and in the presence as a gangue depressant of water-soluble, anionic, linear, addition polymers of a polymerizable monoethylenically unsaturated compound having an average molecular weight of at least 10,000 and being present in an amount sufficient to depress substantially said gangue slimes.

2. The method according to claim 1 wherein the polymeric material is present to the extent of from about 0.001 lb./ton to about 1.0 lb./ton by weight.

3. The method according to claim 2 wherein the polymeric material is a polyacrylic acid.

4. The method according to claim 2 wherein the polymeric material is a polyacrylamide.

5. The method of concentrating ores containing gangue slimes which comprises subjecting an aqueous pulp of said ore to froth flotation in the presence of a collector and in the presence as a gangue depressant of a water-soluble salt of anionic, linear, addition polymers of a polymerizable monoethylenically unsaturated compound having an average molecular weight of at least 10,000 and being present in an amount sufficient to depress substantially said gangue slimes.

6. The method according to claim 5 wherein the polymeric material is present to the extent of from about 0.001 lb./ton to about 1.0 lb./ton by weight.

7. The method according to claim 6 wherein the polymeric material is a sodium salt of a hydrolyzed polymer of acrylonitrile.

8. The method according to claim 6 wherein the polymeric material is a calcium salt of a hydrolyzed copolymer of vinyl acetate and maleic anhydride.

9. The method according to claim 2 wherein the ore floated is a metallic ore.

10. The method according to claim 9 wherein the metallic ore is a sulfide ore.

11. The method according to claim 9 wherein the metallic ore is a copper ore.

12. The method according to claim 9 wherein the metallic ore is a zinc ore.

13. The method according to claim 2 wherein the ore floated is a non-metallic ore.

14. The method according to claim 13 wherein the non-metallic ore is a tungsten ore.

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