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PLATY TALC BENEFICIATION

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The present invention relates to a method of beneficiating talc to increase its platy talc content. More particularly, the invention relates to treatment of a mixture of platy, fibrous, and granular talc by froth flotation in the presence of a synthetic organic wetting agent to preferentially concentrate platy talc by flotation.

For many years high-grade talcs have been used in the form of powder for applications to the skin. The talc in its finely divided form is well suited for this purpose because of its smooth feel. Finely divided talc thus has found wide application in the cosmetic industry and as a powder for treating tender skin, such as that of infants, to prevent chafing or other irritation as would occur from diapers or wet clothing. For such uses, particularly when sold as a baby powder, it is highly desirable to have the talc as free as possible from foreign matter and any irritating particles. The smooth feel of the talcum powder is readily apparent by taking a pinch of the powder between the thumb and forefinger and sliding the fingers relative to each other. The presence of any small granular or gritty particle can immediately be noticed, as it gives the powder a slightly rough or gritty feel. The present invention is directed to producing a highly useful talc powder which is substantially free from foreign matter and irritating particles.

The presence of impurities in finely divided talcs results in poor feel or impaired lubricity. The impurities tend to reduce the slip and give a somewhat granular, chalky, and unsatisfactory feel to the powder, even though all the particles in the powder are finely ground. Accordingly, in the past the best powders have been made from the purest natural talc deposits available, any improvement in the slip or feel of the talc powder being obtained through selection of talcs of higher quality. Today the highest quality talcum powders are made from high-quality substantially pure, natural talcs containing less than 4–5 percent impurities.

However, not only is the purity of the talc important with respect to obtaining talcum powders of the most lubricous nature, but the form in which the talc is present is also highly important. Talc in its natural state occurs in three major forms, these being platy talc, fibrous talc, and granular talc. Even though a talcum powder may have the desired particle size and be almost 100 percent pure talc the presence of small quantities of granular or fibrous talc substantially reduces the smooth feel or lubricity of the talcum powder. The desirable lubricous nature of the talc results in a large part from the talc being present primarily in the platy form. As a result, a powder containing granular or fibrous talc will not have as desirable a slip or feel as does a talcum powder of the same order of talc purity with a substantially higher platy talc content. The highest grade natural talcs presently in general use in this country as talcum powders have at least 10 percent by weight relatively rough or gritty nontalc impurities and nonplaty talc particles. Generally, these talcum powders have a granular or fibrous talc content of about 8–10 percent by weight.

Since talc has many uses requiring different grades of purity, it has been the practice to separate the talc to a varying degree from impurities with which it may be associated in its natural state. After mining, the customary milling practice consists of grinding and sizing

with beneficiation generally being obtained by hand sorting and cobbing. Also, because of its ready floatability, froth flotation has been employed to separate talc from gangue materials, such as tremolite and the alkaline earth carbonates. However, all of these previously employed methods of beneficiation have been used to remove nontalc impurities from the talc rather than to separate one form of talc from the other.

Talc has native flotability and lends itself readily to a flotation process whereby it is separated from other minerals. Talc floats so readily that it can be floated in water without the use of reagents. However, the prior art contains no recognition of a satisfactory method for separating platy talc from the granular and fibrous talc with which it is associated in its natural state. It is surprising that under certain conditions not only can platy talc selectively be separated from the other forms of talc and from other minerals and gangue but that a superior preferential flotation of platy talc may be obtained in the presence of a synthetic organic wetting agent.

It is an object of the present invention to provide a superior recovery of platy talc by a flotation process whereby granular and fibrous talc are separated from platy talc. It is another object to provide a relatively inexpensive and commercially useful process of upgrading the platy talc content of a powdered talc. It is a further object to provide a method of beneficiating talc to increase the platy talc recovery through a preferential froth flotation of the platy talc in the presence of an effective amount of a synthetic organic wetting agent. These, and other objects and advantages, will become apparent from the following description.

In accordance with the present invention, talc products or increased platy content are obtained from mixtures of platy and other forms of talc, with which the platy form is naturally associated, by preferential flotation of platy talc particles in water. In the flotation, there generally is used a relatively dilute feed of a solids content of less than about 30 percent by weight. The talc is ground to a sufficient fineness to liberate the platy from the other forms of talc and permit flotation. Where the final product is to be used as a baby powder, it is generally preferred to grind to a particle size of about —100 Tyler mesh or smaller, although flotation can be obtained with particles ground to only about —20 mesh. A substantial portion of the particles of size smaller than about 10–15 microns preferably are removed prior to flotation. A small amount of a water-soluble frother may be added. Although satisfactory separation of the platy from the nonplaty talc is obtained without the use of depressants, the addition of small amounts of certain materials to the feed acts to selectively depress the nonplaty talc so that a somewhat higher degree of separation is obtained. Selective depression of nonplaty talc particles also is obtainable by adjusting the hydrogen ion content of the flotation slurry. It is essential in the flotation process, to provide the advantages of the invention, that a synthetic organic wetting agent be employed in the feed slurry to provide an advantageous greater recovery of platy talc from the feed solids. The froths from the flotation, containing the beneficiated platy talc, are processed by conventional means to separate and dry the enhanced platy talc product.

As is customary in any flotation process, the mineral being treated must be sufficiently fine to permit froth flotation. Comminution of the talc not only serves to provide talc particles of a sufficiently fine size to make it possible for froth bubbles to carry solid particles to the surface, but also serves to physically free the platy talc from adhering gangue so that the floated product is not contaminated by gangue adhering thereto. Although

preferential platy talc flotation may be obtained with a particle size of about —20 mesh Tyler it generally is preferred to grind to at least —150 mesh Tyler to ensure liberation of talc platlets. This grinding is done by conventional means. The finely divided talc, after the grinding operation, contains substantially the same proportions of platy talc to granular and fibrous talc and to other nontalc impurities as is found in the unground natural talc.

For preferential froth flotation of talc platelets, natural talc particles in excess of about —20 mesh are separated by screening, cyclone separating, or other conventional means and returned for further grinding. Desirably, the grinding process should avoid overgrinding and the resultant production of large amounts of very fine particles. In addition to formation of troublesome slimes and froths, objections to the presence of extremely fine particles include inhalation problems and other discomforts from extremely fine particles dispersed in the air upon dispensing talcum powder. Desirably and preferably, a substantial portion of the ground particles of a size finer than about —10 microns is removed. This may be accomplished in any conventional manner, although a hydraulic classification employing a hydrocyclone separator is preferred.

In the platy talc beneficiation process, relatively dilute feeds of a solids content of less than about 30 percent by weight are used for the flotation. Where fines have been removed, the feed slurry to the flotation cell can contain up to as high as about 30 percent solids. Frequently more dilute feeds (i.e., a solids content less than about 15 percent by weight) are used and are preferred. At these more dilute feeds not only is a product of a higher platy content obtained, but also the beneficiated product generally contains a lower dolomite content. Choice of a particular pulp density is made with due consideration of the particular platy content of the talc being beneficiated, of whether —10 micron particles have been removed from the talc being beneficiated, of whether dolomite content in the product be minimized, and of whether flotation reagents such as frothers, depressants and the like, are to be used. Where fines have not been removed, a suitable solids content in the feed slurry to the flotation cell depends on the initial platy content of the talc being beneficiated. With domestic natural talcs of platy contents up to about 50 percent, a satisfactory preferential flotation of talc platelets to obtain a talc product of increased platy content is possible with feeds of about 30 percent by weight. With such a low-platy-quality talc, the use of a lower pulp density results in a sharper separation and a floated talc product of somewhat higher platy content. Preferably, the solids content does not exceed about 8 percent, if the preferential separation of platy talc is to be made from higher quality talcs having a platy content of more than about 80 percent, such as imported, natural talcs having platy contents of 90 percent or more. Natural talcs of intermediate platy quality (i.e., 50–80 percent platy content) are beneficiated by using solids contents intermediate 8–30 percent with it being preferred that the solids content not exceed about 15 percent. With low platy-quality and intermediate-platy-quality talcs, it is desirable to carry out more than one flotation beneficiation with the beneficiated talc product of a first flotation being subjected at a lower pulp density to a second flotation benefication to obtain a talc product of extremely high platy content. The only limit to dilution is the practical limit of excess fluid handling. Generally a slurry is not used, if it has a solids content of less than 1 percent, although separation can still be obtained.

When flotation reagents, such as frothers, depressants and the like, are added, pulp densities the same as or slightly higher than without flotation reagents are useful. With these flotation reagents, equivalent quality or superior quality platy separation generally is obtained and frequently with some over-all increased recovery of

platy talc. A small amount of a water-soluble frother may be added. The amount of the frother should not exceed 0.10 pound per ton of solids in the flotation system, otherwise significant separation of platy from nonplaty talc is not obtained. The frother generally is added in amounts of 0.03 to 0.08 pound per ton of solids. In one manner of practicing the process, the initial froth is formed without the addition of any frother, and a frother is added only after the initial froth formed has been removed and the amount of froth being formed during the flotation treatment is substantially reduced. Frother then is added again to build up the froth to increase the over-all yield of high platy content. Frothers useful in the platy talc flotation beneficiation are those which are substantially or completely water-soluble and include polypropylene glycol methyl ethers, ethyl alcohol, methyl alcohol, n-butyl alcohol and the like. Among the suitable water-soluble frothers are the 100 percent water-soluble poly-propylene glycol methyl ethers having the general formula $CH_3—(O—C_3H_6)_x—OH$, such as Dowfroth 250, which has an average molecular weight of 250, and Dowfroth 200, which has an average molecular weight of 200.

Although separation of the platy from the nonplaty talc is obtained without the use of flotation reagents, the addition of a small amount of certain reagents serves to selectively depress the nonplaty talc so that a somewhat higher degree of separation can be obtained. Small amounts of depressants such as starch, glue, dextrin (for example Dextrine 603), and guar gum (for example, Guartec) are useful. Dextrine 603 is a finely divided (over 97 percent —200 mesh), acidified white corn dextrin of the formula $(C_6H_{20}O_5)_x$. Guartec is a powdered, industrial grade guar gum, a hydrophilic colloid from the guar bean found chiefly in India. The major portion of Guartec is a polysaccharide having a long chain of D-mannopyranose units linked β-1,4 and on the average of every other D-mannopyranose unit a D-galacto-pyranose unit attached by an α-1,6 linkage. Depressants, when used, are used with care, since, if present in too large amounts, they also act to depress the flotation of talc platelets. These depressants should not be used in excess of the equivalent of one pound of dextrin per ton of feed solids.

Control of the pH of the flotation system also is another means by which platy talc can be preferentially separated from granular and fibrous talc in much the same way as where a depressant is added. If the pH is maintained near neutral or at about 6.8 to 8.0 during the flotation, the granular and fibrous talc only appear in the froth in either a trace or limited quantity. Care must be taken that the pH not drop too much below 6.0. Poor separations of the platy form of talc are obtained when treating domestic talcs at a pH of about 6.0 or lower. When treating talcs having a platy content of about 90 percent or higher at such a low pH, little or no benefication in platy content is obtained. Desirably and preferably the pH is maintained near neutral, and within the pH range of 6.8 to 8.0. In the preferred practice, the pH is controlled through the addition of hydrochloric acid in the amount necessary to keep the talc slurry at the desired pH, a near neutral slurry generally being preferred. In place of hydrochloric acid, such acids as hydrofluoric acid, hydrobromic acid, nitric acid, and the like, may be used. It is not necessary to add a frother, or an acid or other depressant to obtain separation of platy talc from nonplaty talc, although a somewhat better separation frequently is obtained through their use.

A number of conventional froth-flotation reagents are detrimental to the preferential flotation of talc platelets. Certain conventional reagents tend to hinder and usually make it not possible to preferentially and selectively float platy talc in substantial amounts. For example, fuel oil, commonly used as a collector for readily floatable minerals such as sulfur, graphite, and coal, and pine oil, used as a frother for flotation of talc and sulfides, are substan-

tially nonselective in platy talc froth flotation and are to be avoided. In general, for successful practice of the invention one should avoid the use of the natural substances commonly classed as oils, fats, and waxes of mineral, animal, and vegetable origin. These detrimental materials are numerous, natural organic substances of varied composition and include such natural substances as paraffinic hydrocarbons, petroleum fuel oils, petroleum lubricating oils, paraffin and microcrystalline waxes, other similar petroleum products, fatty acids and fatty acid esters, fatty acid glycerides, castor oil, tung oil, neat's-foot oil, lard, linseed oil, cottonseed oil, rapeseed oil, terpineol, pine oils, eucalyptus oils, and many other natural materials of a like nature. In general, these natural materials are noticeably devoid of significant wetting powders and tend to float or depress all natural forms of the talc in the talc flotation process. However, many of these natural materials, upon chemical treatment, yield synthetic organic, surface-active agents having significant wetting properties and these synthetic agents then are useful in the process of the invention. For example, the sulfonated oils, such as sulfonated castor oil; the sulfates of long-chain alcohols prepared by the hydrogenation of fats; the conventional alkali fatty-acid soaps (sodium or potassium salts of higher fatty acids) from saponification of the fatty acids; metal salts of sulfonated glycerides; and numerous other similarly derived synthetic organic, surface-active agents well known in the art, no longer are natural materials per se, but are synthetic organic, surface-active agents having significant wetting properties. In the preferred practice of the invention, the process is carried forth with a talc slurry substantially free from natural oils, fats, and waxes of mineral, animal, and vegetable origin.

In the process of the present invention, it is necessary to include in the pulp an effective amount of a synthetic organic wetting agent. The effective amount generally rages betwe about 0.01 to 2.00 pounds per ton of feed solids in the feed pulp to ensure an increased recovery of platy talc. It is to be understood that all of the useful agents for the process of the invention are not fully equivalent, that is the amounts to produce equivalent results may vary, the action of some may be more rapid and produce greater effects, and the like. Amounts of the agent less than about 0.01 pound per ton of feed solids fail to provide a significant increase in the recovery of platy talc. Amounts of the agent in excess of about 2.00 pounds per ton of feed solids are unnecessary to provide the advantages of the invention and only increase cost without a proportional increase in recovery of platy talc in comparison with the cost of the additional agent. The effective amount for the purposes of the invention is from 0.01 to 2.00 pounds per ton of feed solids. Preferably the agent is added in amounts of 0.05 to 1.50 pounds per ton of feed solids for individual flotation benefications with the total amount employed for a first flotation benefication of a feed talc plus subsequent flotation benefications of the platy product of the first benefication being less than about 2.00 pounds per ton of the original feed talc. Preferably, the amount of the employed agent is about the minimum effective amount to provide a product of a desired platy content not only for economic operation, but also because of an apparent lowering of the dolomite content of the product.

Depending on the amount and nature of the particular agent and the particular flotation conditions, the process of the invention provides a superior recovery of platy talc in the form of a product of increased platy talc content, or in the form of an increased amount of a beneficiated platy talc product, or preferably in both of these forms as an increased amount of product having an increased platy talc content. The superior recovery of platy talc is provided upon flotation of the feed talc in the presence of the agent whether or not flotation reagents, such as frother, depressant, acid, and the like, or combinations of these reagents, are used in the flotation. A convenient manner of illustrating the superior recovery of platy talc is by means of a recovery factor. The recovery factor integrates the yield of the talc product obtained and the platy talc content of the beneficiated product and the flotation feed talc. The recovery factor is defined as the arithmetical product of the yield of beneficiated platy talc product (expressed as percent of the flotation feed talc) times the ratio of the platy talc content of the product to the platy talc content of the flotation feed talc. Recovery factors with and without a synthetic organic wetting agent for otherwise substantially identical flotation beneficiation processes permit a ready comparison and well illustrate the superior recovery of platy talc by the process of the invention.

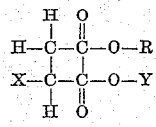
Synthetic organic wetting agents useful in the invention in general are recognized surface-active agents, which have been used elsewhere as detergents, wetting agents, foaming agents, penetrating agents, emulsifying agents, dispersing agents, softening agents, etc. These agents, not found, per se, in nature, are synthesized, and are synthetic compounds recognized as having utility in diverse fields because of their effect on interfacial or surface tension. In general, these synthetic compounds consist of a hydrophobic hydrocarbon portion and one or more strongly hydrophilic groups. The hydrocarbon portion usually is a long straight chain, or an alkyl aromatic ring, or sometimes aromatic, hydroaromatic and aliphatic rings. Since synthetic agents containing a hydrocarbon portion have been found to be useful in the invention, the useful agents for the invention are deemed synthetic organic agents. The hydrophilic groups are numerous and varied and have been classified as groups containing oxygen and sulfur with or without hydrogen, groups containing nitrogen, groups containing halogens, groups containing sulfur and oxygen or phosphorus and oxygen, and the like. By suitable selection and balance of the hydrophobic hydrocarbon portion and the hydrophilic groups in synthetic organic agents, various properties, such as wetting and solubility, are enhanced and diminished.

Conventional surface-active agents frequently are divided into the classes of anionic, cationic, nonionic, and amphoteric agents. Surface-active agents of each of these classes are useful in the process of the invention. In the class of anionic agents, there are included such agents as the alkali fatty-acid soaps, the soaps of water-soluble amines, the sulphonated oils, the sulphonated fatty alcohols, the fatty alcohol sulfates, the sulfonaphthenates, petroleum sulfonates, the aromatic sulfonates, the sulfosuccinic acid esters, the aryl-alkyl sulfonates, the sulfonated amides, sulfonated phenols, as well as many other sulfated, phosphated, or borated compounds. The class of cationic agents includes such agents as the salts of long-chain aliphatic amines, certain half-amines of diamines, long-chain guanidines, long-chain quaternary ammonium salts, and certain hydroxyalkyl amine esters, such as esters of triethanolamine. The class of nonionic agents includes such agents as partial esters of polyhydric alcohols with long-chain carboxylic acids, partial and complete esters of certain water-soluble hydroxyalkyl ethers of polyhydric alcohols with long-chain fatty alcohols, ethers of polyhydric alcohols with long-chain fatty alcohols, short-chain hydroxyalkyl ethers of polyhydric alcohols esterified with long-chain fatty alcohols, long-chain alcohols with a number of free hydroxyl groups, esters of long-chain alcohols with polyhydroxy acids, long-chain acetals of polyhydric alcohols, condensation products of fatty acids with protein decomposition products, amides prepared from long-chain amines and polyhydroxy acids. Amphoteric agents contain both an acidic and basic function in their structure with this class of agents, including such agents as those containing either carboxy or phosphoric ester as the acidic group and nonquaternary nitrogen as the basic group, those containing amino-sulfonic

acid or amino-sulfonate groups, long-chain betaines, and the like.

Synthetic organic wetting agents useful in the process of the invention are members of one of the aforedescribed recognized classes of anionic, cationic, nonionic, and amphoteric surface-active agents. A large number of these agents are explicitly named and further illustrated by specific examples. Other recognized surface-active agents, not explicitly named or illustrated by example, also are useful and are included in the invention. For example, John W. McCutcheon in a published report entitled "Surfactants Listed . . . Fourth Revision of Synthetic Detergents and Emulsifiers," 1958, available from John W. McCutcheon, Inc., New York, New York, lists numerous commercially available surface-active agents.

Particularly useful and preferred are alkyl sulfosuccinates surface-active agents having from 18 to 26 carbon atoms. It is found, when these agents have much below 18 or about 26 carbon atoms, that these agents are not as suitable for the purposes of the invention. These agents have molecular weights ranging between about 340 to about 530. A useful agent may be prepared by reacting maleic anhydride with a straight- or branched-chain aliphatic alcohol or mixture of these alcohols to form a diester, mixed ester, half-ester, or mixture thereof of succinic acid, which ester is then reacted with an inorganic bisulfite to provide the surface-active agent. The preferred alkyl sulfosuccinate surface-active agents have the structure,



in which the sum of the carbon atoms in the structure is from 18 to 26 carbon atoms, and wherein —R is an alkyl radical containing from 5 to 20 carbon atoms, —X is the sulfonate group —SO_3 Me in which Me is a cation selected from the group consisting of sodium potassium, lithium, and ammonium cations, and —Y is selected from the group consisting of the alkyl radical R and the cation Me. The structure of these agents includes a nucleus of a succinic acid group with one hydroxyl radical of the succinic acid group being replaced with a nonpolar portion of an alkoxy group from an esterification by a branched- or straight-chain aliphatic alcohol, with a hydrogen atom on an α carbon atom of the succinic acid group being replaced by a polar portion of a metal sulfonate group, and with either the hydroxyl radical of the second carboxyl group of the succinic acid group being replaced with a nonpolar portion of an alkoxy group from esterification with a branched- or straight-chain aliphatic alcohol or with the acidic hydrogen of the second carboxyl group being replaced with a metal cation. The alcohols useful in preparation of these agents provide straight- or branched-chain alkoxy radicals of between 5 to 20 carbon atoms so as to provide a nonpolar portion of the agent containing from 14 to 22 carbon atoms. Preferably, these agents include in their polar portions the sodium cation for the metal cation or cations, although potassium, lithium, and ammonium cations are also useful. Preferred agents are the alkyl esters of sodium sulfosuccinic acid. The following is a partial listing of some of these surface-active agents useful in the invention: di-(1-methyl-4-ethylhexyl) sodium sulfosuccinate; mono 2-ethylhexyl, mono 1-methylheptyl sodium sulfosuccinate; mono 2-ethylhexyl, mono 1-methyl-4-ethylhexyl sodium sulfosuccinate; di-(1-methylheptyl) sodium succinate; di-(2-ethylhexyl) sodium sulfosuccinate; di-(1-isobutyl-3-methylbutyl) sodium sulfosuccinate; di-(1-butylamyl) sodium sulfosuccinate; di-(n-heptyl) sodium sulfosuccinate; di-(n-octyl) sodium sulfosuccinate; di-(1-methylhexyl) sodium sulfosuccinate; di-(1-methylhexyl) sodium sulfosuccinate; mono n-octadecyl disodium sulfosuccinate. A number of these agents are available commercially. N-octadecyl disodium sulfosuccinate is sold as Aerosol 18 and di-(2-ethylhexyl) sodium sulfosuccinate is sold as Aerosol OT by the American Cynanamid Co., New York, New York, with these agents of commercial grade purity being suitable.

Excellent separation of platy talc is obtained using conventional city water such, for example, as that found at Columbus, Ohio, which has an average total hardness of 95 p.p.m., and an average total solids of 261 p.p.m., and also is obtained using demineralized water, demineralized to a resistance of 100,000 to 150,000 ohms per cubic centimeter.

The tailings from the flotation cell may be recirculated for further removal of platy talc or this by-product sold for uses other than as body powders such, for example, as in the preparation of lacquers, paints, papers, insecticides, textiles, ceramic compositions, rubber plastics, etc. These tailings, particularly where the feed material is a good grade talc, are excellent grade talcs for many uses and are a valuable by-product although they do not contain the high platy content which is so desirable for powder for body application.

The froths from the flotation cell are processed in the usual manner for flotation froths to obtain a dried beneficiated mineral product. In the preferred process, the froths are passed to a thickener, allowed to settle, and the excess water removed. The thickened slurry then is passed to conventional filters where the beneficiated talc is removed.

After filtering, the filter cake is removed and dried by any conventional drying process. If desired, the dried cake may be broken into powder form. Preferred practice is drying in a spray dryer by first forming a slurry of the filtered talc and then spraying the slurry into a heated chamber. Desirably, the time, during which the talc is kept in the water in forming the slurry and spraying, is kept to a minimum with the filter cake being slurried in fresh water and immediately sprayed into the drying chamber. The drying chamber into which the slurry of talc is sprayed generally is at a temperature of about 300 to 900° F., the temperature being sufficiently high that the powder is dried while still suspended in the air. The temperature in the drier should not exceed about 1100° F.; otherwise the dried product will lost some of its attractive appearance.

A talc platelet can be readily distinguished from a nonplaty talc particle by its characteristic shape or form. Nontalc particles in a talc powder can be most conveniently identified, distinguished, and approximated by a physical method, such as a microscope count. The microscope count has been found to be the best means to date for determining the proportions of platy talc, nonplaty talc, and nontalc particles in a talc powder sample of high purity and is the method used in the present specification, all platy values in the specification and claims being based on the microscopic count method of determination. In this procedure a dry sample of the fine talc powder is dusted onto a glass slide which has been spotted with oil having a refractive index of 1.520. The talc dust is dispersed in the oil by stirring with a fine probe. The talc sample should be dry to obtain a uniform dispersion in the oil and the sample also should be well mixed so that a segregation of sizes is avoided. The oiled sample then is covered with a glass cover plate and placed in the field of a polarizing microscope with an objective and eyepiece selected for about a magnification of 75×. Light is adjusted to reflect through the sample to the eyepiece. The eyepiece having two crosshairs fixed at 90° to each other is focused on the field. Particles which coincide with the crosshairs are counted and classified as platy talc, fibrous talc, dolomite or tremolite, and sometimes accessory minerals. The crosshairs then are repositioned to a different location on the same sample and additional particles are counted and classified. Sufficient particles are counted and classified to obtain a minimum total count per sample in excess of 300 par-

ticles. Counting substantially less than this amount frequently will give erratic results. In low-quality talc powder samples having a low, true platy content, substantially higher counts should be made. Nearly whole and large talc platelets are relatively easily distinguished from fibrous or granular talc particles; however, the identification of only portions and extremely small talc platelets requires a high measure of skill and care.

The flotation may be carried out in any suitable flotation machine. The use of highly developed flotation machines of the mechanical type, such as Fagergren flotation machines, is desirable, but the invention is not limited thereto. The flotation equipment used for the specific examples was a standard Fagergren Laboratory flotation cell of 500 gram solids nominal capacity. The Fagergren cell is made up of a cylindrical glass bowl which will hold about 1.75 liters of pulp. The pulp is agitated by a rotor which is placed concentrically inside a stator, both of which are made up of multiple stainless steel rods in a rotunda configuration. As the rotor spins in the pulp, a partial vacuum created directly beneath it draws air through a concentric shaft and discharges it at the bottom of the cell. As the air enters the pulp, it is expelled with great shearing force between the rotor and stator and becomes diffused in the form of minute bubbles in the pulp.

In the following examples, carried out in the laboratory, pulverized talc and water are added to the flotation cell in suitable proportions to give the particular pulp density. The rotor is started and the pulp agitated until the talc solids are wetted. The synthetic organic wetting agent and selected flotation reagents, when used, are then added. The pulp is conditioned for a few minutes. The air then is turned on and the flotation started. The mineralized froth forming on the surface of the pulp is skimmed off with a paddle for a specified time or until no more froth forms. An additional amount of the synthetic organic agent and other selected reagents, when used, then are added for increased recovery of talc and additional froths removed. The froths from the various floats are then passed to a conventional filter where the beneficiated talc is filtered out and washed with fresh water. After filtering, the filter cake is removed and dried by a conventional drying process.

The greater recovery of platy talc from ground talcs containing both platy and fibrous forms of talc in accordance with the flotation beneficiation process of the invention is illustrated by comparison of examples within tabulated groups of examples in the following Table 1.

TABLE 1

Example No.	Flotation Reagents (lbs./ton solids)			Talc Slurry		Flotation Feed Talc		Beneficiated Talc			Recovery Factor [2]
	S.A. Agent	Frother	Acid [p]	pH	Solids (percent)	Platy Talc Content (percent)	Dolomite (percent) [1]	Platy Talc Content (percent)	Dolomite (percent) [1]	Yield (percent Feed Talc)	
Group A:											
1	None	[o] 0.06	3.1	7.4	8.6	67	20	97–98	0.4	38.2	55.6
2	[a] 0.14	[n] 0.06	3.0	7.8	8.9	67	20	99	0.8	46.1	68.1
Group B:											
3	None	0	0	7.6	8.6	67	20	99	0.7	51.1	75.5
4	None	0	3.1	7.4	8.5	67	20	97–98	0.5	50.5	73.5
5	[a] 0.34	[n] 0.31	3.5	7.1	7.6	67	20	99	2.1	63.3	93.5
Group C:											
6	[a] 0.16	0	2.8	7.0	8.0	67	20	98	0.3	41.9	61.3
7	[a] 0.16	[n] 0.07	0	6.7	8.5	67	20	99		39.5	58.4
8	[a] 0.16	[n] 0.07	3.5	7.6	8.0	67	20	97	0.5	46.9	67.9
Group D:											
9	None	[n] 0.05	0	6.9	6.3	95	1.9	97	0.2	47.8	48.7
10	[a] 0.16	[n] 0.04	0	7.2	7.3	95	1.9	98	0.9	65.9	68.0
Group E:											
11	None	0	1.79	6.4	7.2	95	1.9	96	0.2	34.4	34.8
12	[a] 0.33	0	1.75	6.8	7.3	95	1.9	98–99	0.6	68.8	71.0
Group F:											
13	None	[n] 0.04	1.79	6.7	7.0	95	1.9	95–96	0.3	51.3	51.6
14	[a] 0.16	[n] 0.04	1.82	6.8	7.1	95	1.9	99	0.4	61.3	63.9
15	[a] 0.26	[n] 0.04	1.73	6.8	7.4	95	1.9	99	0.4	70.8	73.2
16	[a] 0.17	[n] 0.04	1.38	6.6	8.7	95	1.9	98	0.3	71.4	74.0
17	[b] 0.56	[n] 0.04	1.66	6.8	7.6	95	1.9	99	0.5	64.6	67.3
18	[c] 0.47	[n] 0.046	1.38	7.2	8.6	95	1.9	97–98	0.8	93.0	95.4
19	[c] 0.058	[n] 0.045	1.37	7.0	8.7	95	1.9	99	0.3	70.8	73.8
20	[d] 0.08	[n] 0.047	1.42	7.2	8.4	95	1.9	98	0.2	56.5	58.3
21	[e] 0.05	[n] 0.047	1.4	7.1	8.4	95	1.9	98	0.3	69.3	71.5
22	[f] 0.12	[n] 0.045	1.37	7.2	8.7	95	1.9	98	0.3	70.8	73.3
23	[g] 0.23	[n] 0.044	1.35	6.9	8.8	95	1.9	98	0.2	71.0	73.5
24	[g] 0.23	[n] 0.044	1.35	7.4	8.8	95	1.9	98	0.3	75.6	78.0
25	[h] 0.45	[n] 0.043	1.31	7.6	9.0	95	1.9	96	0.7	88.1	89.0
26	[h] 0.11	[n] 0.043	1.32	7.5	9.0	95	1.9	97–98	0.3	71.2	73.1
27	[i] 0.17	[n] 0.048	1.35	7.3	8.9	95	1.9	99	0.3	70.9	73.9
28	[i] 0.46	[n] 0.045	1.36	6.8	8.8	95	1.9	99	0.3	77.2	80.5
29	[k] 0.47	[n] 0.046	1.39	7.2	8.6	95	1.9	98–99	0.2	72.8	75.5
30	[l] 0.14	[n] 0.046	1.39	6.7	8.6	95	1.9	99	0.2	72.9	76.0
31	[m] 0.45	[n] 0.043	1.32	7.0	9.0	95	1.9	98–99	0.5	82.6	85.6

[1] Percent dolomite is calculated from chemical analysis of CO_2 content.

[2] Recovery factor = $\frac{\text{platy talc content (percent) of product}}{\text{platy talc content (percent) of feed talc}} \times$ product yield (percent of feed talc).

[a] N-octadecyl disodium sulfosuccinate, such as Aerosol 18, sold by American Cyanamid Co., New York, New York.

[b] Di(2-ethylhexyl) sodium-sulfosuccinate, such as Aerosol OT, sold by American Cyanamid Co., New York, New York.

[c] Sodium lauryl sulfate, such as Duponal ME, sold by E. I. du Pont de Nemours & Co., Wilmington, Delaware.

[d] (Sub-amide) $C_{17}H_{33}CO\text{-}N(CH_3)C_2H_4SO_3Na$, such as Anatron L215, sold by General Aniline & Film Corp., New York, New York.

[e] Sodium di(2-ethylhexyl) phosphate, such as Tergitol P-28, sold by Union Carbide Chemicals Co., New York, New York.

[f] Sodium palmitoyl methyltaurate, such as Igepon T-73, sold by Antara Chemicals, a division of General Aniline & Film Corp., New York, New York.

[g] Lauryl trimethyl ammonium chloride, such as Arquad 12, sold by Armour & Co., Chicago, Illinois.

[h] Octylamine, such as Armeen 8D, sold by Armour & Co., Chicago, Illinois.

[i] Hexadecyl dimethyl amine, such as Armeen 160, sold by Armour & Co., Chicago, Illinois.

[j] Sorbitan monolaurate, such as Span 20, sold by Atlas Powder Co., Wilmington, Delaware.

[k] Polyoxyethylene sorbitan monolaurate, such as Tween 21 sold by Atlas Powder Co., Wilmington, Delaware.

[l] Secondary amide of lauric acid, such as Wetsyn, sold by E. F. Drew & Co., New York, New York.

[m] Noyl phenyl polyethylene glycol ether (condensation product of 10½ moles of ethylene oxide with 1 mole of nonylalkyl phenol), such as Tergitol NPX, sold by Union Carbide Chemicals Co., New York, New York.

[n] Polypropylene glycol methyl ether having the general formula $CH_3\text{-}(O\text{—}C_3H_6)_x\text{—}OH$ and an average molecular weight of 250 such as Dowfroth 250, sold by Dow Chemical Co., Midland, Michigan.

[o] Polypropylene glycol methyl ether having the general formula $CH_3\text{-}(O\text{—}C_3H_6)_x\text{—}OH$ and an average molecular weight of 200, such as Dowfroth 200, sold by Dow Chemical Co., Midland Michigan.

[p] HCl, reported as 36.5 to 38% HCl aqueous solution having a specific gravity of 1.185 to 1.192 at 60° F.

The results in this table include flotation beneficiations of several talcs with employment of a synthetic organic wetting agent and without employment of the agent in otherwise substantially identical flotation procedures. To permit ready comparison examples are tabulated in several groups. Comparisons are valid only between those examples within the same group, because of variances in flotation procedures for different groups of examples. For example, the flotation procedure for the examples in group B included collection of froth for 10 minutes, while the examples in group C included collection of froth for only 3 minutes. It will be noted from comparison of the recovery factors of various comparable flotation beneficiation examples that in each instance the process of the invention employing the synthetic organic agent provided a superior recovery of platy talc.

The following additional examples, including comparative examples, also serve to illustrate the invention.

Example I

A natural talc ore is ground to —200 mesh and more than 90 percent of the fines smaller than —10 microns are removed to provide a ground talc having a platy content of 67 percent, a non-platy fibrous talc content of 8 percent, and 25 percent by weight other impurities, consisting mainly of carbonates (about 20%). This ground talc is mixed in the Fagergren subaeration-type flotation cell with deionized water to prepare a slurry having a solids content of about 9 percent by weight. To this slurry are added small amounts of hydrochloric acid to adjust the diluted slurry to a pH of 7.8 and the resulting pulp is conditioned for 1–2 minutes. An alkyl sulfosuccinate surface-active agent consisting essentially of a commercially pure grade of N-octadecyl disodium sulfosuccinate, having a molecular weight of 495, in the amount of 0.14 pound per ton of flotation feed solids is added to this slurry. Then 0.06 pound per ton of flotation feed solids of a frother, such as polypropylene glycol methyl ethers of average molecular weight of 250, is added. The slurry containing the added flotation reagents and surface-active agent is subjected to flotation in the previously described flotation cell and the froth formed is removed. Deionized water is added to the removed froth to bring the solids content to about 4 percent by weight. This slurry now has a pH of between 7.2 and 7.4. Without adding additional flotation reagents and a surface-active agent, this slurry in a flotation cell is subjected to flotation for cleaning and upgrading and the froth formed is removed, filtered, and the filter cake dried. The filter cake, after drying, has a platy talc content of 99 percent and amounts to a recovery of 46.1 by weight of the talc feed into the first cell for a recovery factor of 68.1 percent.

When the flotation procedure of this example is followed except for omission of the addition of the surface-active agent, the filter cake, after drying, has a platy talc content of 97 percent and amounts to a recovery of 39.6 percent by weight of the feed talc into the first cell for a recovery factor of 57.3 percent.

Example II

A natural talc is ground to —200 mesh. The ground talc is subjected to hydrocentrifugal separation to yield a ground talc product which contains less than 10 percent of —10 micron material. This talc with fines removed has a platy content of 95 percent, a non-platy fibrous talc content of 2.6 percent, and 2.4 percent by weight of other impurities, consisting mainly of dolomite and tremolite. This talc with fines removed is mixed with water to prepare a dilute slurry having a solids content between 7 and 8 percent by weight. To this slurry are added small amounts of hydrochloric acid to adjust the diluted slurry to a pH between 6.8 to 7.1 and the slurry is conditioned for about two minutes. Then an alkyl sulfosuccinate surface-active agent consisting essentially of a commercially pure grade of di(2-ethylhexyl) sodium sulfosuccinate having a molecular weight of 444 in the amount of 1.12 pounds per ton of flotation feed solids, followed by 0.04 to 0.07 pound per ton of flotation feed solids of a frother, such as polypropylene glycol methyl ethers of average molecular weight of 250, is added. The slurry containing the added flotation reagents and surface-active agent is subjected to flotation in a subaeration-type flotation cell of the same type as Example I and the froth formed is separated and collected. When little or no more froth forms, additional amounts of the surface-active agent, 0.56 pound per ton of solids, and between 0.14 and 0.28 pound per ton of solids of the frother are added to the slurry in the cell and the flotation continued with additional froth formed being separated and collected. After little or no froth continues to form, the accumulated collected froths are filtered, and the filter cake dried. The filter cake, after drying, has a platy talc content of 98 percent and amounts to a recovery of 85.2 percent by weight of the talc feed into the flotation cell for a recovery factor of 87.9 percent.

When the flotation procedure of this example is followed, except for omission of the additions of the surface-active agent, the filter cake, after drying, has a platy talc content of 97 percent and amounts to a recovery of 81.1 percent by weight of the talc feed into the flotation cell for a recovery factor of 82.8 percent.

Example III

Using the same ground natural talc as in Example II with fines removed and deionized water, a dilute slurry having a solids content of between 7 and 8 percent is prepared. To this slurry are added an alkyl sulfosuccinate surface-active agent consisting essentially of a commercially pure grade of N-octadecyl disodium sulfosuccinate having a molecular weight of 495 in the amount of 0.16 pound per ton of flotation feed solids, followed by 0.04 to 0.07 pound per ton of flotation feed solids of a frother such as polypropylene glycol methyl ethers of average molecular weight of 250. The slurry in deionized water has a natural pH of 7.2 to 8.6. Using the same apparatus as in Example I, the slurry is subjected to flotation and the froth formed is separated and collected. When little or no more froth forms, an additional amount of the surface-active agent, 0.45 pound per ton of solids, and 0.53 to 0.91 pound per ton of solids of the frother are added to the slurry in the cell and the flotation continued with additional froth formed being separated and collected. When little or no additional froth forms, the accumulated collected froths then are allowed to settle, filtered, and the filter cake dried. The filter cake, after drying, has a platy talc content of 97–98 percent and amounts to a recovery of 84.9 percent by weight of the talc feed into the flotation cell for a recovery factor of 87.0 percent.

When the preceding flotation procedure of this example is followed except for omission of the additions of the surface-active agent, the filter cake, after drying, has a platy content of 95–96 percent and amounts to a recovery of 83.0 percent by weight of the talc feed into the flotation cell for a recovery factor of 83.4 percent.

Example IV

Using the same ground natural talc as in Example II with fines removed, a dilute aqueous slurry having a solids content of between 5.5 and 7.6 percent is prepared. To this slurry are added small amounts of hydrochloric acid to adjust the diluted slurry to a pH between 6.5 and 6.7 and the pulp conditioned for about two minutes. An alkyl sulfosuccinate surface-active agent consisting essentially of a commercially pure grade of di(2-ethylhexyl) sodium sulfosuccinate having a molecular weight of 444 is added in the amount of 0.93 pound per ton of flotation feed solids to this slurry. Using the same apparatus as

in Example I the flotation froth formed is separated and collected. When little or no more froth forms, an additional amount of 0.93 pound of the surface-active agent per ton of solids is added to the slurry in the cell, and the flotation continued with additional froth formed being separated and collected. When little or no additional froth forms, the combined collected froths are filtered, and the filter cake dried. The filter cake, after drying, has a platy talc content of 98–99 percent and amounts to a recovery of 83.5 percent by weight of the talc feed into the flotation cell for a recovery factor of 86.6 percent.

When the preceding flotation procedure of this example is followed, except for omission of the additions of the surface-active agent, the filter cake, after drying, has a platy talc content of 96 percent and amounts to a recovery of 42.5 percent by weight of the talc feed into the flotation cell for a recovery factor of 42.9 percent.

Example V

Using the same ground natural talc as in Example II with fines removed, a dilute aqueous slurry having a solids content of about 7 percent is prepared. This slurry in deionized water has a natural pH of about 7.5. An alkyl sulfosuccinate surface-active agent consisting essentially of a commercially pure grade of di(2-ethylhexyl) sodium sulfosuccinate having a molecular weight of 444 is added in the amount of 1.3 pounds per ton of flotation feed solids to this slurry. Using the same apparatus as in Example I the pulp is agitated in the flotation cell and the froth formed is separated and collected. When little or no more froth forms, an additional amount of 0.26 pound of the surface-active agent per ton of solids is added to the slurry in the cell and the flotation continued with additional froth formed being separated and collected. When little or no additional froth forms, the accumulated collected froths are filtered, and the filter cake air dried. The filter cake, after drying, has a platy talc content of 97 percent and amounts to a recovery of 84.6 percent by weight of the talc feed into the flotation cell for a recovery factor of 86.4 percent.

When the flotation procedure of this example is followed, except for omission of the additions of the surface-active agent, the filter cake, after drying, has a platy talc content of 95–96 percent and amounts to a recovery of 41.8 percent by weight of the talc feed into the flotation cell for a recovery factor of 42.0 percent.

Example VI

Alkyl sulfosuccinate surface-active agents are prepared by esterification of maleic anhydride with an aliphatic alcohol, addition of sodium bisulfite to the maleic ester, followed by evaporation of the solvent (C. R. Caryl, "Sulfosuccinic Esters," Industrial and Engineering Chemistry, vol. 33, No. 6, June 1941, pp. 731–737).

Using the same ground natural talc with fines removed, as in Example II, and substantially the same flotation procedure as in Example V, except for a replacement of the particular alkyl sulfosuccinate surface-active agent of Example V, with an effective amount of another surface-active agent, there are made flotation beneficiations. With each of the alkyl sufosuccinate surface-active agents, as follows, prepared according ot the above-mentioned Caryl process of preparation: di(1-methyl-4-ethylhexyl) sodium sulfosuccinate; mono 2-ethylhexyl, mono 1-methylheptyl sodium sulfosuccinate; and mono 2-ethylhexyl, mono 1-methyl-4-ethylhexyl sodium sulfosuccinate, there is obtained a superior recovery of platy talc as illustrated by the resulting recovery factors being larger than 42.0 percent, the recovery factor resulting from the same procedure with the identical feed talc except for the omission of the additions of the surface-active agent.

By the same procedure with the same talc, except for replacement of all of the surface-active agent with a small amount of a natural material, there are performed flotations. With each of the following natural materials, which are not deemed to be synthetic organic wetting agents: terpineol, pine oil, oleic acid, a SAE–10 petroleum lubricating oil, paraffin, kerosene, and caster oil, there is obtained no improvement in platy talc content, as illustrated by the resulting products having platy talc contents less than the 95–96 percent of the product obtained with the same talc by the same procedure except for the omission of additions of natural material and surface-active agent.

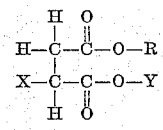
Although an important aspect of the present invention is the treatment of high platy quality natural talc to obtain still higher platy talc contents in increased amounts, the invention is not limited to this. The invention described herein is applicable to the treatment of low platy quality and intermediate platy quality talcs. If platy talc contents in excess of 90 percent are desired from such poorer grade platy talcs, it may be necessary to carry out the beneficiation in a series of floats and cleaning operations rather than a single float, which is all that is necessary for talc deposits of initial high platy talc content.

From the foregoing description of the invention and specific embodiments thereof, it is believed apparent that the invention may be embodied in other specific forms without departing from the true spirit, scope, and essential characteristics of the invention. Hence, in the present invention it is intended to be limited only to the extent set forth in the appended claims, and it is intended to embrace within these claims all modifications and variations as fall within the meaning, purview, and range of equivalency of these claims.

Having thus described my invention, I claim:

1. In a method of treating talc to obtain a talc of increased platy talc content the steps comprising: preparing an aqueous slurry of finely ground talc having most of the fines of a size less than 15 microns removed, said slurry having a solids content of less than 15 percent by weight of finely ground talc and containing a synthetic organic wetting agent in amounts of at least 0.01 pound per ton of solids and said slurry being substantially free from natural oils, fats, and waxes of mineral, animal, and vegetable origin, subjecting said aqueous slurry to froth flotation, and recovering in the froth formed a talc of enhanced platy talc content.

2. The method of claim 1 employing an alkyl sulfosuccinate surface-active agent having the structure



in which the sum of the carbon atoms in the structure is from 18 to 26 carbon atoms, and wherein —R is an alkyl radical containing from 5 to 20 carbon atoms, —X is the metal sulfonate group —SO_3Me in which Me is a cation selected from the group consisting of sodium, potassium, lithium, and ammonium cations, and —Y is selected from the group consisting of the alkyl radical —R and the cation —Me, as said agent.

3. The method of claim 1 employing N-octadecyl disodium sulfosuccinate as said agent.

4. The method of claim 1 employing di(2-ethylhexyl) sodium sulfosuccinate as said agent.

5. In the treatment of a finely ground talc ore containing both platy and fibrous talc to obtain a talc of enhanced platy talc content, the steps comprising: preparing an aqueous slurry, having a pH of 6.8 to 8.0, containing a solids content of less than 30 percent by weight of finely ground talc ore having most of the fines of a size less than 10 microns removed, and also containing a synthetic organic wetting agent in an amount of 0.01 to 2.00 pounds per ton of solids in the slurry; subjecting the aqueous slurry to froth flotation; and recover-

ing in the forth formed a talc of enhanced platy talc content.

6. The method of claim 5 employing a solids content of less than 15 percent by weight and an aqueous slurry substantially free from natural oils, fats, and waxes of mineral, animal, and vegetable origin.

7. The method of claim 6 employing an alkyl sodium sulfosuccinate of from 18 to 26 carbon atoms as said agent.

8. The method of claim 5 employing a solids content of less than 8 percent by weight.

9. The method of claim 8 employing a cationic surface-active agent as said agent.

10. The method of claim 8 employing an anionic surface-active agent as said agent.

11. The method of claim 8 employing a nonionic surface-active agent as said agent.

12. The method of claim 8 employing N-octadecyl disodium sulfosuccinate as said agent.

13. The method of claim 8 employing di(2-ethylhexyl) sodium sulfosuccinate as said agent.

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