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## PLASTIC OR SPREADABLE FIBER-BINDER COMPOSITION AND METHOD OF MAKING SHEETS, BOARDS, AND MOLDED ARTICLES THEREFROM

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This invention relates to a plastic or spreadable fiber-binder composition and to a method of making sheets, boards, molded articles, or the like therefrom. It deals more especially with a composition whose fiber content has been individualized, homogenized, and otherwise conditioned with slimy soap solution for admixture with binder so as to yield a fluffy or foamy, plastic fiber-binder composition lending itself to spreading and molding operations without releasing free water by drainage. The consistency of the plastic or spreadable fiber-binder composition hereof is comparable to that of heavy cake-frosting; and, like such frosting, the composition hereof contains entrapped therein considerable air or foam, in consequence of which not only is its spreading facilitated to yield a layer of highly porous or cellular structure when dried in the substantial absence of pressure, but such layer is capable of being controlled in its porosity or density by the application of pressure thereto either in the course of drying or afterwards.

While not limited thereto, the plastic or spreadable composition hereof is eminently suitable for the fabrication of a board or sheet of the nature of wallboard or insulating board. An economical and satisfactory fibrous mixture for such board may, for example, consist in terms of dry weight of 12½ parts of mineral wool (rock wool) and 12½ parts of any one or a mixture of such cellulosic fibrous materials as kraft pulp, wood pulp screenings, newsprint, cotton or rag fiber, etc. Such fibrous mixture may be admixed and vigorously agitated with about 30 parts by weight of an aqueous soap solution prepared by dissolving about 5 parts by weight of a fatty acid soap, such as sodium oleate, in about 25 parts by weight of water, preferably heated to a temperature of about 150° to 212° F. The admixture of the fibrous material and the slimy fatty acid soap solution may be continued for a period of about 10 to 15 minutes, at the end of which time the desired smooth, plastic mass reminiscent of heavy frosting is realized. It might be noted that, during the initial stages of mixing, the aqueous mixture is lumpy and gives no appearance of being convertible to the smooth, fluffy, plastic mass ultimately attained. It is evidently the case that, as mixing or vigorous agitation continues and air is whipped into the mixture, the individual fibers are segregated and individually protected or coated by the soapy slime or lubricant. To the resulting mass is then added a suitable aqueous binder, for instance, sodium silicate solution, which lends a fire-resistant quality to the finished board producible from the composition. Typically, about 10 to 100 parts by weight of 40° Baumé sodium silicate solution may be admixed with the plastic fiber-soap mass, depending upon the stiffness or hardness and other characteristics desired in the finished board.

The resulting plastic, binder-containing composition may readily be spread to form a layer, which, in the course of drying, may be pressed or calendered under heat to yield a hard, stiff, finished board simulating binder-containing boards such as are fabricated on a papermaking machine. The soap in the composition hereof evidently also promotes fusion or fluxing of the sodium silicate under heat. The soap may thus serve a double role, namely, that of initially lubricating the fibers and promoting fiber-individualization and that of a flux in the final pressing under heat of the spread composition or board. The sodium silicate is of value in that it imparts the desired strength and tenacity to the finished board, as well as such desired qualities as stiffness and fire-resistance.

The plastic, binder-containing composition hereof need not necessarily be pressed to any marked degree in the course of its drying or afterwards. Indeed, one of the advantages of the composition hereof is that it is possible to fabricate therefrom a wallboard or insulating board of much lower density than that attainable on a papermaking machine, for instance, a density corresponding to a weight of only 10 to 15 pounds per cubic foot. Thus, a finished wallboard made pursuant to the present invention may have such comparatively low density and a thickness of, say, about ¼ to ½", and thus be characterized by its light weight, high thermo-insulating value, fireproofness, porosity or cellular structure, uniformity of texture, etc. The mineral wool component of such a board also renders it vermin-proof, particularly when used in substantial amount, for instance, in amount equal to, or exceeding, the vegetable fiber component of the board.

In using the plastic or spreadable composition hereof for the fabrication of wallboard, the composition may advantageously be spread as a layer of the desired thickness on a backing of cheap paper, such as chipboard, and the composite sheet dried, preferably with rolling or smoothing of the spread layer while it is still damp. If desired, a facing ply of cheap paper, such as chipboard, may be bonded to the still-

plastic or adhesive composition as it is being carried as a layer on the backing or paper base. The backing and facing paper plies become strongly bonded to the spread layer of composition during drying by reason of the adhesiveness of such composition. The spreading of the composition may be performed progressively, as on any suitable form of spreading machine, while the backing ply of paper is being withdrawn progressively from a supply roll and is receiving the composition thereon; and, so, too, the facing paper ply may be progressively withdrawn from a supply roll and applied under suitable pressure to the spread layer of composition. The composite sheet containing a backing and, if desired, also a facing paper ply may then be dried with or without the application of pressure thereto during the drying operation.

In the event that comparatively dense or stiff finished sheets, for instance, sheets similar to fiberboard, are desired, the spread plastic layer, while carried by its backing, may be compressed or calendered at the appropriate stage of its drying. Such compression or calendering may be effected gradualy or in stages by the action of two or more sets of rolls, which may, if desired, be heated, to promote drying of the spread layer and fluxing of its binder and soap contents. Such compressing or calendering treatment may reduce the thickness of the spread layer very considerably, for instance, from a thickness of about 0.250" to about 0.020", in which case the density of the compressed layer may correspond to a weight of about 50 to 60 pounds per cubic foot. It is to be understood, of course, that the spread layer may vary widely in its original thickness and be reduced to various final thicknesses, depending upon the density and hardness desired in the finished sheet or board.

It is possible to use various alkali-metal stearates, palmitates, oleates, and other water-soluble fatty acid soaps for the purposes hereof; and it is also possible to vary the amount of soap employed in conditioning the fibrous material for admixture with the binder so as to yield the desired smoothly spreadable or homogeneous plastic composition hereof. About 1 to 5% of the soap, based on the weight of fibrous material, usually suffices for the purposes hereof, the particular amount of soap employed in a particular case depending upon the particular fibrous material and its particular physical condition. For instance, with such fibrous material as dried kraft pulpboard, newsprint, and clumped mineral wool, it is usually desirable to employ about 2½ to 5% of soap, based on the dry weight of such material, but with wet fibrous material, such as kraft or sulphite pulp in the form of lap stock, it is possible to use satisfactorily as little as about 1% to 2% of soap, based on the dry weight of such material. In any event, however, the amount of water employed in forming the slimy soap solution for admixture with the fibrous material is limited to such amount as conduces to the desired plasticity, as opposed to fluency, of the spreadable binder-containing composition hereof. Taking into consideration such water as may be introduced along with the aqueous binder as well as such water as enters into the preparation of the slimy soap solution, it is generally desirable to restrict the amount of water in the composition to an upper limit of about 300%, based on the weight of the dry fibrous material. In the course of conditioning the fibrous material for admixture with binder, it is necessary to restrict the amount of the aqueous medium of the soap solution so that the mixture of fibrous material and soap solution contains as a maximum not more than about 150% water, based on the dry weight of fibrous material. Under such conditions, the mixture of fibrous material and slimy soap solution is sufficiently viscous so as to enable sufficient work to be done during mixing and agitation to individualize and lubricate substantially all the fibers and to impart to the mixture the desired fluffy or foamy qualities. Once the desired fiber-soap mass has been developed, it is possible to increase the water content of such mass, as during the addition of binder thereto, without providing free water therein, for the mass absorbs water while still remaining plastic. Indeed, when the soap content of the plastic fiber-soap mass is sufficiently high, say, distinctly greater than 5% of the dry weight of the fibrous material, and such mass has the consistency of very heavy cake frosting, it is possible to cause such mass to absorb and hold in non-draining form much more than about 300% water, for instance, as high as about 500%, based on the dry weight of fibrous material. For practical purposes, however, it is unnecessary and usually undesirable to produce the spreadable, binder-containing compositions hereof at a soap content greater than 5% and a water content greater than 300%, based on the dry weight of fibrous material.

It is possible and, in some cases desirable, to use aqueous binders other than sodium silicate solution in the spreadable composition hereof. Thus, starch, glue, casein, or the like may be added to the conditioned soap-fiber mass hereof in the form of suitable aqueous solutions or may even be added in appropriately pulverulent condition thereto and dissolved in situ therein under heat. Thus, a cooked starch solution of about 5% to 10% starch content or a glue or casein solution of about 5% to 10% solute content may be admixed with about 205 parts of the conditioned aqueous fiber-soap mass hereof containing about 100 parts of fiber and 5 parts of soap. Again, it is possible to admix with the conditioned fiber-soap mass hereof various other aqueous binders, such as rubber latex, aqueous rubber dispersions or emulsions, asphalt emulsions, nitrocellulose lacquer emulsions, artificial resin emulsions (e. g., phenol-formaldehyde resin emulsions), shellac solutions in water containing ammonia, borax, or other alkali, etc. In some instances, the dispersions or emulsions of binder may also be made in situ in the conditioned aqueous fiber-soap mass hereof, as when a solution of rubber in benzol or other rubber solvent is added to the mass or when molten asphalt, rosin, or other thermoplastic binder is added to such mass, preferably after heating such mass to a temperature at which the desired uniform mixing and dispersion of the binder occurs throughout the mass.

When a sheet containing fusible or thermoplastic binders of the nature of asphalt, artificial resins, etc. is prepared from the plastic or spreadable composition hereof, the pressing or calendering of the sheet under heat may be sufficiently intense to yield a dense and horny finished product useful for various purposes, for instance, for dielectric media, paneling, and the like. When sheets are formed from such plastic compositions hereof as contain rubber latex or similar elastic binder, they exhibit leather-like qualities and are hence useful, when compressed or reduced to ap-

propriate density, as leather-substitutes in such articles as shoe insoles, counters, box-toes, and the like. Of course, when the plastic composition hereof contains binder other than sodium silicate, starch, or the like, and is to be formed into sheets for particular purposes other than wallboard, the fibrous content of such composition may be varied from that hereinbefore given in the case of a wallboard. Thus, the fibrous element of a sheet to serve as an artificial leather would not contain such cheap fibrous components as newsprint, wood pulp screenings, or mineral wool, but, rather, would consist essentially completely of such high-grade fibers as chemical wood pulp, refined wood pulp, cotton, manila pulp, leather fibers, etc.

When sheets or boards are formed from the plastic, binder-containing composition hereof so that they have light weight and high porosity or sponginess, it is possible to subject such sheets or boards to after-impregnating treatments with various binders, such as asphalt, resins, rubber latex, etc., and thereby to impart to the sheets or boards such final characteristics as may be desired therein, including waterproofness, high toughness, density or hardness, etc. However, it is usually desirable and most economical to incorporate into the plastic composition hereof substantially all such binder as may be desired in the finished sheets or boards. The fact is that the present invention presents the important advantage that it is possible to incorporate into the plastic composition hereof much larger amounts of binder, fillers and pigments of all sorts, and other compounding ingredients than in such fiber furnishes as are formed into sheets or boards by the usual papermaking practice, as in such latter case the furnish or papermaking composition is delivered to the papermaking machine at high fluency and the amount of compounding ingredient appearing in the finished sheets or boards is limited by such retention of the compounding ingredient as results when large amounts of water, tending to carry away the compounding ingredient, are being drained during sheet or board formation on the wire of the papermaking machine.

As already stressed, the composition hereof is plastic and does not release water during the formation therefrom of sheets or boards. The term "plastic" is used herein in its essentially true or technical sense to mean that the composition hereof when formed up into particular body form, for instance, sheet form, retains such form during drying and afterwards, unless distorted by pressure or otherwise from such particular form. The plastic composition hereof hence also lends itself nicely to molding into various finished articles. For instance, a plastic composition hereof containing rubber latex or other elastic binder may be molded into such articles as insoles, outsoles, and other shoe parts. When the composition hereof contains such fusible or thermoplastic binders as asphalt, montan wax, rosin, or the like, it may be molded into so-called thermoplastic box toe stiffeners. Such other articles as roofing tile or shingles may be molded from the composition hereof when it contains such inexpensive binder as asphalt; and variously shaped dielectric articles may be molded from the composition hereof when it contains suitable artificial resin binders or the like. In fabricating molded articles from the composition hereof, the practice may be to spread the composition in a mold and then to dry the composition under heat in the mold until the composition has comparatively little residual plasticity, whereupon the molded composition may become compressed to the desired thickness and density either in the mold or after removal from the mold. While still in undried condition but after having lost considerable or most of its original plasticity, the molded articles made from the composition hereof are readily embossable. They may hence be embossed at the same time as they are being compressed to the desired final thickness or density, for instance, under heat, especially when the binder content of the composition is thermoplastic.

It might again be noted that the present invention enables the fabrication of uniformly textured sheets or boards having a structure and appearance much like such sheets or boards as are produced on papermaking machines. By the present invention, however, it is possible to control to better advantage such factors as thickness, density, porosity, binder content, etc. in the finished boards or sheets, since sheets or boards fabricated on a papermaking machine can have only such characteristics as are incident to the capacities of papermaking machinery. Thus, as already indicated, the binder or filler content of a sheet or board made on a papermaking machine is necessarily limited to such retention of binder or filler as comports with papermaking practice. Again, by papermaking practice, one cannot readily produce sheets or boards of a porosity greater than that incident to the compacting of the papermaking ingredients consequent to the drainage of large amounts of water from the wet sheet during its formation. Further, one cannot on a papermaking machine produce as a unitary layer or structure sheets of considerable thickness, since uniform texture or formation is impossible on a papermaking machine when sheet thickness becomes excessive; and it is hence understandable why the formation of thick sheets or boards on a papermaking machine usually involves the plying of separately formed comparatively thin plies, as on a so-called multi-cylinder machine. In contradistinction to the limitations of papermaking practice, the composition of the present invention may be spread as a layer of any desired thickness, for instance, a thickness of many inches, as when thermo-insulating blocks are to be formed from such composition.

Another important advantage of the composition hereof is that long-fibered fibrous material may be used as its fibrous element or component without undergoing disintegration or reduction in fibrous length, as by beating, such as would be necessary if such fibrous material were to be used for making sheets or boards on a papermaking machine. For instance, long-fibered cotton waste, wool waste, animal hair, mineral wool, asbestos, etc. may be used as the fibrous component of the composition hereof and at the same time yield a substantially homogeneous and readily spreadable fiber-soap mass for admixture with the binder content of the composition hereof. Because of the preservation of the fiber length of such fibrous material as enters into the compositions hereof, sheets or boards can be formed from such compositions with desired toughness, including high tear-resistance and tensile strength.

It has been indicated that the plastic, binder-containing composition hereof may be spread on a paper backing and may, if desired, be faced with a paper ply. In some instances, cloth or

other flexible sheet material may be used as the backing and, if desired, the facing material. When making an artificial leather sheet from a composition hereof containing as the binder rubber latex or the like, a cloth backing is of value in that it reinforces the product so that it may be put to rigorous service, as in the fabrication of luggage. Of course, the backing may be only temporary in the sense that it may be stripped from the spread layer made from the composition hereof after such layer has been dried and compacted thereon to such an extent as to dispense with any further need of a backing. In lieu of spreading the composition hereof on a flexible backing, it is possible to perform such spreading on a metallic belt or similar conveyor from which the dried and, if desired, compacted layer may be stripped in much the same way as it may be stripped from a cloth or other temporary flexible backing.

In speaking of the sheets, boards, or other articles formed from the plastic composition hereof as being uniformly textured, it is meant that the fibers are uniformly distributed throughout such articles and are in random arrangement or lay and, accordingly, that such articles are characterized by their substantially uniform strength, toughness, tear-resistance, etc. in substantially all directions. When, on the other hand, a sheet or board is formed on a paper-making machine, the fibers tend to arrange themselves predominantly in the so-called machine direction, in consequence of which the tear-resistance, toughness, and other qualities of the resulting sheet or board are apt to differ in the so-called machine direction and in the so-called across direction.

I claim:

1. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such limited amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, while substantially avoiding drainable water therein; and incorporating throughout the mixture a binder while substantially maintaining said foamy, plastic consistency and substantial absence of drainable water in the resulting composition.

2. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such limited amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, while substantially avoiding drainable water therein, incorporating throughout the mixture a binder while substantially maintaining said foamy, plastic consistency and substantial absence of drainable water in the resulting composition, forming the resulting binder-containing composition into a body of the desired shape, and drying said body.

3. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such limited amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, while substantially avoiding drainable water therein, incorporating throughout the mixture an aqueous binder composition in such limited amount as substantially to maintain said foamy, plastic consistency and substantial absence of drainable water in the resulting composition, spreading the resulting composition as a layer of the desired thickness, compressing the layer to the desired density while in moist condition, and drying the layer to form sheet structure.

4. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, and a water content not exceeding about 150%, based on the dry weight of the fibers; and incorporating throughout the mixture a binder while substantially maintaining said foamy, plastic consistency and substantial absence of drainable water in the resulting composition.

5. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, and a water content not exceeding about 150%, based on the dry weight of the fibers; and incorporating throughout the mixture an aqueous binder composition while substantially maintaining said foamy, plastic consistency in the resulting composition and a water content therein in non-drainable form not exceeding about 500%, based on the dry weight of fiber.

6. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, and a water content not exceeding about 150%, based on the dry weight of the fibers, incorporating throughout the mixture a binder while substantially maintaining said foamy, plastic consistency and substantial absence of drainable water in the resulting composition, forming the resulting binder-containing composition into a body of the desired shape, and drying said body.

7. A process which comprises admixing and agitating a mass of fibers with slimy aqueous soap solution in such amount as to promote substantial individualization of the fibers of such mass and to impart to the mixture a foamy, plastic consistency, at which said mixture retains substantially such form as is imparted thereto, and a water content not exceeding about 150%, based on the dry weight of the fibers, incorporating throughout the mixture a binder while substantially maintaining said foamy, plastic consistency and substantial absence of drainable water in the resulting composition, spreading the resulting binder-containing composition as a layer of the desired thickness, compressing the layer to the desired density while in moist condition, and drying the layer to form sheet structure.

8. A spreadable, plastic composition comprising a mass of substantially individualized fibers, foamed aqueous soap solution enveloping said fibers, and binder dispersed throughout said composition, said composition being substantially

free from drainable water and retaining substantially such form as is imparted thereto.

9. A spreadable, plastic composition comprising a mass of substantially individualized fibers, foamed aqueous soap solution enveloping said fibers, and binder dispersed throughout said composition, said composition having a water content in substantially non-drainable form not exceeding about 500%, based on the dry weight of said fibers, and retaining substantially such form as is imparted thereto.

10. A spreadable, plastic composition comprising a mass of substantially individualized fibers, foamed aqueous soap solution enveloping said fibers, and binder dispersed throughout said composition, said composition having a soap content of about 1% to 5% and a water content in substantially non-drainable form not exceeding about 500%, based on the dry weight of said fibers, and retaining substantially such form as is imparted thereto.

11. A substantially uniformly textured article comprising the dried residue of a preshaped, plastic composition capable of retaining substantially such form as is imparted thereto containing substantially individualized fibers, foamed aqueous soap solution enveloping said fibers, and binder dispersed throughout said composition, the aqueous content of said composition being in substantially non-drainable form.

12. A substantially uniformly textured sheet comprising the dried residue of a pressed layer of plastic composition capable of retaining substantially such form as is imparted thereto containing substantially individualized fibers, foamed aqueous soap solution enveloping said fibers, and binder dispersed throughout said composition, the aqueous content of said composition being in substantially non-drainable form.

13. A substantially uniformly textured, artificial leather sheet comprising the dried residue of a compacted layer of plastic composition capable of retaining substantially such form as is imparted thereto containing substantially individualized fibers, foamed aqueous soap solution, and rubber dispersed throughout said composition, said composition having a water content in non-drainable form not exceeding about 500%, based on the dry weight of said fibers.

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