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# 3,300,372
# FIRE-RESISTANT BUILDING BOARD AND PROCESS

Donald R. Bauer, St. Helens, Oreg., assignor to Kaiser Gypsum Company, Inc., Oakland, Calif., a corporation of Washington

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This invention relates to the production of a fibrous product such as a building board; and more particularly to the production of a fire-resistant board.

In the manufacture of fiber boards for structural, including acoustical or sound-absorbing, purposes a great problem has been the retention of various additives in the fibrous mass upon removal of the slurry water by drainage, e.g., on a screen; and concomitant problems have been the provision of such boards of desired strength and density. In one wet method of making such boards, a slurry of wood or lignocellulose, or mineral fibers or mixtures thereof in water along with clay, and, if desired, other additives, the slurry having low solids content, e.g., 3% thereof, is pumped to a forming device, such as a wire screen of well known type, and water is drained off, leaving a mass of the fibers in generally board form. However, in order to avoid loss of additives through the screen, some means of retention must be provided. One known means has been the incorporation of a substance which will coagulate or flocculate the additive to form agglomerates of such size that they will not pass through the fibers and screen, and thus are retained. Another means has been to use additive such as formaldehyde resin which will react with the fiber, especially wood fiber, to improve retention. Other means for improving retention of additives have been known in making fibrous board products, but the prior art methods have required heating to fuse addition agents or have required chemical reaction of the various addition agents; and this art has desired a simple, inexpensive method for dispersing materials in water slurry and for retaining additives, with production of a strong, resistant board, and particularly to produce a self-sustaining, strong board, exhibiting high fire-resistance.

According to the present invention there is obtained a strong, fibrous board of desired density and uniform composition consisting essentially of a major amount of mineral fibers, a minor amount of lignocellulose fibers, clay, starch, sizing agent and a cationic surface active agent. A suitable aqueous slurry of these components is prepared, and is then formed into board on a forming machine, suitably of conventional type well-known in this art. The formed board or mat is then processed and dried in the known manner. Preferably the board or product consists essentially of from 60% to 70% mineral fibers, from 1% to 10% lignocellulose fibers, from 10% to 30% clay, from 5% to 15% starch, from 0.5% to 4% sizing agent and from 0.2% to 2.25% of a cationic surface active agent. The product has good strength, exhibits the desired density and is fire-resistant.

The mineral fibers useful herein include any artificially formed or synthetic inorganic fibrous material such as mineral wool, slag wool, glass wool, spun glass filaments, or the like and admixtures of such fibers with each other. In a preferred embodiment there is employed mineral wool, glass wool, or spun glass filaments or admixtures of these with each other and, if desired, with a small amount, up to about 5%, of asbestos fiber added thereto. Chrysotile asbestos has given good results in such composition.

The lignocellulose fibers employed herein include wood fibers, bagasse fibers or other vegetable fibers, for example, wood fibers derived from wood chips or the like. The lignocellulose fibers can be very coarse fibers, but preferably are finer or more highly refined fibers such as paper fibers or the like. It is preferred that such refined fibers exhibit a Canadian 3-gram freeness of greater than 350.



There is employed in the present composition and article any desired starch, such as milo starch, corn starch or the like; and very good results have been obtained in one embodiment of present invention using uncooked tapioca starch. If desired, in one mode of operation, a cationic starch is employed, as will be further discussed below. The starch can be added in dry state or it can be slurried in water and such slurry then added to the fibrous slurry or furnish.

The clay which is employed is preferably a non-swelling clay, such as kaolin, ball clay or the like. Excellent results are obtained when using clay of very small ultimate particle size, such as a ball clay which slurries readily in water. The clay can be pre-milled or it can be incorporated in as-received state in the aqueous fibrous slurry and it has been found that the clay is broken down, upon mixing into such slurry, into very fine particles and becomes well dispersed through the mass. One such clay which is found to be very useful herein is known as Klondike clay and another is Tennessee ball clay.

There is also included from 1% to 4% of a sizing agent, which can be any desired sizing agent known in this art. For instance, there can be employed an aqueous bituminous or asphalt emulsion such as that known as Bitusize or as described in U.S. Patent 2,481,734, issued September 6, 1949, in the names of Watts et al. A very good size is an aqueous wax emulsion or aqueous wax-rosin emulsion.

A cationic surface active agent is also incorporated in the composition and process of this invention. There is employed as such agent, for example, an aliphatic long carbon chain polyamine, such as that known as Duomac which is made and sold by Armour Industrial Chemical Company, Chicago, Illinois, and which has the formula $R\cdot(NH_2\cdot CH_2\cdot CH_3\cdot CH_2)_x\cdot NH_2$, where R is a hydrophobic group having from 8 to 22 carbon atoms and $x$ is an integer of from 1 to 3, or a water-soluble salt thereof, as described in U.S. Patent 2,862,880 issued December 2, 1958, in the name of Harry J. Clemens. Other cationic surface active agents useful herein include a mono-alkyl quarternary ammonium compound, e.g. such a compound as that known as Arquad also sold by Armour Industrial Chemical Company, above-mentioned. Alternatively, there can be employed a strongly cationic high molecular weight polymer which is the reaction product of an alkylene polyamine and a polyfunctional halohydrin, known as Nalco 632, made and sold by Nalco Chemical Company, Chicago, Illinois; or another cationic agent such as lauryl trimethyl ammonium chloride or bromide, cetyl pyridinium bromide or the like. The cationic surface active agent is used in an amount of from 0.2% to 2.25% based on the total dry weight of the composition.

In one embodiment of the process of the invention there is prepared a dilute furnish or slurry of the lignocellulose fibers in water; and there is separately prepared a slurry in water of mineral fibers, the clay and a portion, preferably less than 50%, of the cationic surface active agent. The starch is separately made into a slurry in water. The lignocellulose furnish is admixed with the mineral fiber-containing slurry and the sizing are added thereto. The remainder, or at least 50% of the total, of cationic agent, preferably in dilute water solution, e.g., containing about 1% concentration of such agent, is then mixed with the fibrous slurry just prior to feeding to the board-forming zone or device, where the slurry is formed


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into board in the known way with removal of water. In another embodiment of the present process, the steps above are also practiced except that, instead of admixing the clay with the mineral fiber slurry, the clay is made into a slurry with the starch and then mixed into or with the fibrous slurry. Other variations can also be practiced. However, it is preferred to admix a minor portion, or less than 50% of the total, of cationic surface active agent, prior to or at the same time as the addition of the clay, and to add at least 50% of such agent just prior to feeding to the forming zone. For instance, the latter amount can be added in the fan pump normally disposed just prior to introduction to the Fourdrinier machine or in the slurry flowing from the machine chest, where the starch and size are added, to the fan pump or the like, or it can be admixed in the tray water recycled from the forming machine to the slurry flowing to the fan pump.

In practicing the process of the invention, it has been found that at least a portion, preferably at least 50% of the cationic agent must be added just prior to introduction of the slurry to the forming machine, that is to say, after all violent or turbulent mixing or treatment has been completed, in order to effect good retention in the formed board of the additives, including the clay. It is believed that the cationic agent in part attaches itself to the fibers of the mass and in part to the particles which it is desired to retain, by electrostatic or ionic bonds or forces, and that these are easily broken or disrupted by mechanical stresses. On the other hand, the addition of the cationic agent effects excellent dispersion of the mineral fibers in the slurry and it is advantageous to add a minor proportion, or less than 50% of the total, thereof in the slurry at an earlier stage, or during preparation of the primary mineral fiber slurry. The cationic agent is added as a dilute solution in water in order to obtain good and rapid dispersion in the furnish and maximum effectiveness, and preferably at not over about 1% by weight concentration in water. It has been found herein that a cationic surface active agent which acts on the mineral fibers to provide good dispersion, also effects good retention of the clay, and other additives. It is believed that the cationic agent acts as a means of bonding the fibers and additive particles into a composite mass; and it has been found herein that these desired effects are especially effectively attained when the cationic agent is added in the amounts and manner shown herein. It has also been found that the incorporation of a small amount, up to 5%, of asbestos fibers improves the behavior of the board under fire tests, reducing sag at high temperatures and having other good effects. The addition of a minor amount of wood fibers also aids in effecting rapid dispersion of the mineral fibers, especially mineral wool, in the water of the slurry.

Except as otherwise defined herein, the making up of the various slurries is carried out according to usual good practice in this art. For instance, the wood fiber-water slurry contains generally from 2% to 5%, preferably about 3%, by weight solids; the aqueous slurry of clay, cationic agent and mineral fiber, when admixed in this manner, generally contains from 2% to 6%, preferably about 3.5% mineral fiber, and preferably about 4.0% total solids in suspension. The aqueous starch slurry contains about 3.5 lbs. dry starch solids per gallon of water, but this can be varied as desired. The dry size is, if desired, directly admixed into the starch slurry. As is known, it is generally preferred that the final slurry going to the forming zone, e.g. to the Fourdrinier machine, have a total solids content of about 1% to 4% by weight.

However, the process of this invention comprises admixing a small amount of wood fiber slurry with a mineral fiber slurry and incorporation of a minor portion of a total amount of cationic surface active agent therewith, prior to or simultaneously with admixture of additives such as clay, starch or size. At least 50% of the total amount of cationic surface active agent is incorporated with gentle mixing just prior to introduction to the forming zone and after all turbulent mixing has been effected.

The board produced according to this invention is a self-sustaining, strong product of good fire-resistance and desired density, suitable for wall panels or acoustical board or tile. It can be prepared in any desired thickness, e.g. of ½" to 1" thickness. The board, after forming in the usual way on a Fourdrinier or other machine, is dried at 200° F. to 600° F., preferably at temperatures of 300° F. to 500° F., and is then ready for use. Preservatives or fungicides can also be incorporated in the board composition, if desired, in the known manner.

In one mode of carrying out the method of this invention from 60% to 70% synthetic mineral fibers, from 10% to 30% clay and from 0.1% to 0.5% cationic surface active agent are admixed with water to form a primary slurry containing about 4% solids. From 1% to 10% lignocellulose fibers are separately slurried in water preferably to about 3% fibers in water; and the primary slurry and the lignocellulose slurry are intimately admixed. There is then added thereto from 5% to 15% of starch as a water slurry, e.g. containing about 4 lbs. starch per gallon of water, and from 0.5% to 4% sizing agent to form a furnish containing not over about 4%, preferably about 3%, solids; and then there is intimately admixed with such furnish, just before going to a fan pump, i.e. just prior to introduction to the Fourdrinier screen, from 0.1% to 1.75% of cationic agent. The total slurry is then fed to the forming machine and formed into board in the usual way, with removal of most of the water by drainage, and, if desired, by passage through pressing rolls, followed by heating. The heating temperatures are from 200° F. to 60° F., and, where uncooked starch is incorporated in the furnish, such heating serves also to cook it in this drying step. The percentages of the various components shown above are based on the total dry composition.

In another mode of carrying out the process of this invention, there is prepared an aqueous slurry of wood fibers, e.g. as derived from wood chips by steam digestion followed by refining; and there is separately prepared an aqueous slurry of mineral fibers and from 0.1% to 1.0% cationic agent, all in concentrations and of the type described elsewhere herein. To the admixture is then added a slurry of starch, size and clay which has been separately prepared by admixing such agents with water. To this admixture, after thorough mixing, there is added a second amount of the cationic surface active agent to make a total amount thereof of from 0.5% to 2.25%, the second amount being at least 50% of the total. It will be understood that more than one cationic surface active agent can be employed to constitute the total amount.

It is an advantage of the present invention that a strong board product of suitable density and acoustical properties is obtained. It is a further advantage that the additives provided in the furnish are efficiently retained in the fibrous mass upon drainage of water; and a further advantage is that the board is of substantially uniform consistency, with excellent interdispersion of the components and freedom from matting or excessively dense portions. Board of half-inch thickness made according to this invention exhibits tensile strengths of at least 1500 lbs. per sq. ft.; and not over 5% by volume water absorption.

The following example will illustrate one mode of carrying out the method of this invention.

Approximately 700 lbs. of mineral wool, 150 lbs. of Tennessee ball clay, of minus 100 micron particle size, and 1.4 lbs. of Duomac T as described above are admixed with water to form a slurry, called for convenience a primary slurry. A separate dilute slurry in water is prepared with 30 lbs. of wood fibers, or broke pulp. The primary slurry and the wood fiber slurry are then thoroughly mixed together, and there are also incorporated about 13 lbs. of an asphalt emulsion commercially available and known as Bitusize, and containing approximately 7.3

lbs. asphalt solids, about 125 lbs. of tapioca starch and about 1.5 lbs. arsenic trioxide as preservative, to give a furnish containing about 3% total solids. This furnish enters the fan pump where there is added about 3.3 lbs. of Duomac T (described above) as a 1% solution in water and the whole is fed through the fan pump to the forming machine. In the forming zone, the water drains off, the board passes under a pressing belt and then through the usual rolls to squeeze out more water and reduce the thickness of the board. The board then goes to a heated drier, and the final dried product exhibits very good strength and is at least 85% noncombustible. It exhibits good fire-resistance and acoustical qualities, and low water absorption after being finished, for example after hot calendering, painting and punching, or otherwise finishing, as desired.

It will be understood that various modifications and variations can be made herein without departing from the spirit and scope of the claims. The clay used herein is a non-swelling clay, i.e., one that does not swell when admixed with water. All percentages and parts are by weight unless otherwise indicated. As a cationic active agent there can be employed a cationic starch, available in commerce, such as Cato 8, made and sold by National Starch and Chemical Company, Plainfield, Michigan; and when used, it is, if desired, pre-cooked in water with a portion of another cationic agent as described hereinabove, and the pre-cooked mass is admixed with the fibrous slurry just prior to introduction to the forming zone. The non-cationic or dry starch, such as tapioca or other starch, disclosed hereinabove, is added as a binder; and it has been found advantageous in one embodiment to add it in uncooked state, whereby it cooks or gelatinizes during the drying step when the formed board is subjected to the drying temperatures described hereinabove. The minor amount of lignocellulose fibers is believed to facilitate rapid and complete dispersion of the synthetic mineral fibers to form a uniform slurry thereof in water. The addition of a portion of the total cationic active agent in the mineral fiber slurry also facilitates dispersion of fibers therein and, additionally, it acts to bond all fibers, clay and starch together. It is believed that this bonding action is not strong and it tends to break down upon vigorous agitation; and, therefore, a further amount of cationic surface active agent is added, with gentle agitation, just prior to forming to effect adequate bonding and to enable retention in the fibrous mass or board of the starch, clay and other additives incorporated in the slurry feed. The term "furnish" as used herein designates a slurry in water of the ingredients mentioned.

Having now described the invention, what is claimed is:

**1.** A self-sustaining, fibrous board consisting essentially of a major portion of synthetic mineral fibers, a minor portion of lignocellulose fibers, from 5% to 15% starch, from 10% to 30% clay, 0.5% to 4.0% sizing agent, and from 0.2% to 2.25% of cationic surface active agent.

**2.** A board as in claim **1** wherein said lignocellulose fibers are refined fibers having a Canadian 3-gram freeness of at least 350.

**3.** A self-sustaining, fibrous board consisting essentially of a major amount of synthetic mineral fibers, a minor amount of lignocellulose fibers, from 5% to 15% starch, from 10% to 30% clay, 0.5% to 4.0% sizing agent, a small amount, up to 5% asbestos fibers, and from 0.2% to 2.25% cationic surface active agent.

**4.** A self-sustaining, fire-resistant board consisting essentially of from 60% to 70% synthetic mineral fibers, from 1% to 10% lignocellulose fibers, from 5% to 15% starch, from 10% to 30% clay, from 0.5% to 1.0% sizing agent, and from 0.2% to 2.25% of a cationic surface active agent.

**5.** A board as in claim **4** wherein said synthetic mineral fiber is mineral wool.

**6.** A board as in claim **4** wherein said clay is ball clay.

**7.** A board as in claim **4** wherein said lignocellulose fibers are refined fibers having a Canadian 3-gram freeness of at least 350.

**8.** A board as in claim **4** wherein said cationic surface active agent is selected from the group consisting of a long carbon chain aliphatic polyamine and water soluble salts thereof.

**9.** A self-sustaining, fibrous board consisting essentially of from 60% to 70% synthetic mineral fibers, from 5% to 15% starch, from 1% to 10% lignocellulose fibers, from 10% to 30% clay, from 0.5% to 4.0% sizing agent, a small amount, up to 5%, asbestos fibers, and from 0.2% to 2.25% cationic surface active agent.

**10.** A board as in claim **9** wherein said lignocellulose fibers are refined fibers having a Canadian 3-gram freeness of at least 350.

**11.** An aqueous slurry suitable for forming a self-sustaining, fibrous board consisting essentially of from 60% to 70% synthetic mineral fibers, from 1% to 10% lignocellulose fibers, from 5% to 15% starch, from 10% to 30% clay, from 0.5% to 4.0% sizing agent, and from 0.2% to 2.25% cationic surface active agent, all said amounts being percent by weight on the dry basis, and sufficient water to make a dilute slurry.

**12.** Slurry as in claim **11** wherein said mineral fibers are mineral wool.

**13.** Slurry as in claim **11** wherein said lignocellulose fibers are refined fibers having a Canadian 3-gram freeness of at least 350.

**14.** A fire-resistant fibrous board consisting essentially of from 60% to 70% mineral fibers, from 1% to 10% lignocellulose fibers, from 10% to 30% clay, from 5% to 15% starch, from 0.5% to 4% sizing agent and from 0.2% to 2.25% of a cationic surface active agent.

**15.** Process for producing a fibrous board comprising (a) preparing a slurry of lignocellulose fibers in water, (b) separately preparing a slurry of synthetic mineral fibers and a cationic surface active agent in water, (c) admixing said two slurries together, (d) admixing with said admixture a suspension of clay and starch in water, (e) adding to said last-mentioned admixture a sizing agent, (f) then admixing therewith with gentle agitation a further amount of a cationic surface active agent, (g) introducing the resulting mixture to board-forming zone and (h) forming into board with removal of water, said lignocellulose fibers being present in minor amount and said mineral fibers being present in major amount, based on the total dry weight of the mass.

**16.** Process for producing a fibrous board comprising (a) preparing a slurry of lignocellulose fibers in water, (b) separately preparing a slurry of synthetic mineral fibers, clay and a cationic surface agent in water, (c) admixing said two slurries together, (d) admixing starch and a sizing agent with said admixed slurries, (e) then admixing therewith with gentle agitation a further amount of a cationic surface active agent, (f) introducing the resulting admixture to a board-forming zone and (g) forming into board with removal of water, said lignocellulose fibers being present in minor amount and said mineral fibers being present in major amount, based on the total dry weight of the mass.

**17.** In a process for producing a fibrous board wherein there is prepared a water slurry of a major portion of synthetic mineral fibers, a minor portion of lignocellulose fibers, starch, clay and a sizing agent, and said slurry is formed into board with removal of water, the improvement which comprises separately preparing a slurry of said lignocellulose fibers in water, separately preparing a water slurry of said synthetic mineral fibers and a cationic surface agent, admixing said two slurries together, adding with gentle agitation a further amount of cationic surface active agent to the total slurry just prior to introduction to the forming zone, then introducing the resulting admixture to a board-forming zone and forming said slurry into board with removal of water.

**18.** Process as in claim **17** wherein less than one-half

of the total amount of said cationic surface active agent is added in said first-mentioned mineral fiber water slurry, and the remainder of said total agent is added just prior to said introduction to said forming zone.

19. In a process for producing a fibrous board wherein there is prepared a water furnish containing a major portion of synthetic mineral fibers, a minor portion of lignocellulose fibers, starch, clay and a sizing agent, and said furnish is formed into board with removal of water, the improvement which comprises preparing a water slurry containing said lignocellulose fibers in an amount to provide from 1% to 10% thereof in the total dry mass, separately preparing a water slurry containing said synthetic mineral fibers in an amount to provide from 60% to 70% thereof in the total dry mass, and from 0.1% to 0.5%, based on total dry mass weight, of a cationic surface active agent, admixing said two slurries together,



then incorporating therein said starch, clay and sizing agent, then adding with gentle agitation a further amount of said cationic surface active agent to provide a total thereof of from 0.2% to 2.25%, based on total dry mass weight, and thereafter introducing said admixture to a board-forming zone.

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DONALL H. SYLVESTER, *Primary Examiner.*

H. CAINE, *Assistant Examiner.*


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