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LIGNOCELLULOSE BOARD

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The present invention relates to composite products comprising particles of wood or other lignocellulose material and, as a binding and water repellant constituent, defibrated coniferous lignocellulose rich in acetone soluble content from coniferous species of trees and characterized by solubility in organic solvents.

In making composition boards and similar consolidated fibrous products, wood or other lignocellulose material such as cane, corn stalks, straw and the like conventionally are reduced to fiber or particle form. The resulting finely divided material is formed into a felt or mat, which then is heated with or without the application of substantial pressure. When substantial pressure is not applied during the heating operation, the product is porous and of low density and finds its principal application as insulation board. Where, however, substantial pressure is applied during the heating operation, the particles of lignocellulose material are consolidated to form a board of relatively high density which is used extensively as hardboard, panel board, flooring, and the like.

The strength and water resistance of fibrous composition products such as consolidated fiber boards obviously are of primary importance in determining their suitability for use in the customary applications. To improve the strength of the products, it is usual practice to incorporate therein substantial amounts of binders such as phenolic resins, urea resins, decayed wood and the like. These may be added to and intimately mixed with the finely divided material prior to its formation into a felt and consolidation. Alternatively, they may be sprinkled or sprayed on the felt, after which the latter is pressed to form the final product. Similarly, in order to prevent the swelling and warping of the fibrous products upon their exposure to moist environments, materials conventionally are incorporated therein which prevent the absorption of water and thus impart dimensional stability to the products. A variety of such materials commonly are employed, the usual ones being paper maker's sizing materials such as rosin, sodium rosinate, waxes, starch, dextrin, various gums, albumin, casein, and the like.

Where sizing materials are used, they customarily are mixed with the fiber before being formed into boards. Substantial amounts are employed, i. e. amounts of several per cent by weight, in order effectively to coat the fibers and prevent the absorption of moisture into the same by capillary attraction. A common method of incorporating the size comprises adding it to the aqueous pulp suspension in the pulp chest just ahead of the head box of the wet forming machine. To facilitate a thorough dispersion throughout the pulp, it usually is added in the form of sodium rosinate, if a rosin size is employed, or as an aqueous alkaline wax dispersion, if a wax size is used. After the addition of the sizing agent, the mixture then is agitated thoroughly, after which alum or mineral acid is added in amount sufficient to adjust the pH of the pulp mixture to a level of pH 4 to pH 5.5. This converts the sodium rosinate to insoluble rosin in the one case, and destroys the water miscible wax emulsion in the other case, so that the sizing agent is deposited on the fibrous material.

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In addition to the use of sizing agents, other devices frequently are resorted to for improving the water repellancy of fiber boards. For example, the board may be conditioned in a drying oil followed by a heat treatment. Alternatively, the board may be subjected to high temperatures without the use of a drying oil. Still further, resins and other materials may be used as water repelling agents. It will be obvious, however, that these various expedients for increasing the strength and water resistance of the boards add materially to the cost of their manufacture, because of the added expense of the necessary materials, labor and equipment.

We now have discovered that fiber boards and other composite fibrous products of high strength and water resistance may be formed by the inclusion in the products of the extractive material present in the woods of coniferous species of trees, and characterized by solubility in acetone and other neutral organic solvents. Such species include the Ponderosa pine, the sugar pine, the Idaho white pine, the Jeffery pine, the long leaf pine, and other southern pines, the Douglas fir, the Noble fir, the hemlocks, the spruces, the redwoods, and the like.

As used herein, the terms "acetone-soluble content" and "wood extractive materials," comprehends the non-integral elements of the cell structure of wood tissue which are soluble in neutral organic solvents such as acetone. They comprise a complex mixture of organic substances, including fatty acids, phenolic compounds, volatile terpenes, esters, sterols, fats, waxes, resin acids, and the like. Such materials, as compared with the cellulose, hemicellulose and lignin do not form an integral part of the cell structure of the wood. They normally

are found distributed throughout the sap wood or heart wood of the coniferous species of trees in amounts of from 2% to 4% by weight, or less. They are concentrated, however, in other fractions of the wood such as the knots, which may contain from 25% to 43% by weight of wood extractives, the stump heartwood which may contain from 11% to 36% by weight of wood extractives, and the massed pitch areas which may contain up to 50% of these materials. These extractive rich wood fractions are known colloquially in certain areas of the United States as "light wood" or as "fat wood."

As indicated above, the extractive materials may be isolated from the cell structure of the wood by extraction, with neutral organic solvents, by which is meant organic solvents which are neither acidic nor basic. Such solvents include broadly the hydrocarbon solvents, the alcohols, the esters, the ketones, and the ethers. Representative of the aliphatic hydrocarbon solvents are the hexanes, the cyclohexanes, the heptanes, the octanes, and the mixed hydrocarbon fractions including petroleum ether, naphtha, gasoline, kerosene, etc. Illustrative of the aromatic hydrocarbon solvents which may be used in the isolation of extractive materials from wood are benzene, toluene, the xylenes, the methyl ethyl benzenes, etc.

Typical of the alcohols which may be used for the purposes of the present invention are methyl alcohol, ethyl alcohol, propyl alcohol, isopropyl alcohol, n-butyl alcohol, isobutyl alcohol, the amyl alcohols and the like.

Illustrative esters which may be used in the isolation of extractive materials from wood are methyl acetate, ethyl acetate, propyl acetate, butyl acetate, methyl propionate, ethyl propionate, propyl propionate, butyl propionate, methyl butyrate, ethyl butyrate, propyl butyrate, butyl butyrate, etc.

Ketones which may be used to isolate extractive material from wood include acetone, methyl ethyl ketone, methyl propyl ketone, methyl isopropyl ketone, ethyl propyl ketone, ethyl isopropyl ketone, di-propyl ketone, di-isopropyl ketone, methyl n-butyl ketone, methyl isobutyl ketone and the like.

Typical ethers which may be used to isolate extractive materials from wood are: methyl ethyl ether, di-ethyl ether, methyl n-propyl ether, methyl isopropyl ether, ethyl n-propyl ether, ethyl isopropyl ether, methyl butyl ether, ethyl butyl ether, propyl butyl ether, etc.

The foregoing and other neutral organic solvents may be used singly or in combination with each other to remove the extractive materials from wood, by first reducing the wood to the form of small particles, and then treating the particles with the selected solvent or solvent mixture. The treatment preferably is effected in a continuous extraction apparatus, using the solvent at about its boiling temperature. After the extraction is complete, the solvent may be removed by distillation from the extractive materials, thus leaving the latter behind as an undistillable residue. Further details concerning the source, nature and method of separation of extractive materials from the wood of various coniferous species of trees are to be found in articles by Arthur B. Anderson in "Industrial and Engineering Chemistry," vol. 38, page 450 (1946), and vol. 39, page 1664 (1947).

The wood extractive materials characterized by the source and composition described above have, when incorporated in consolidated composition products, a most significant and desirable influence on the strength and water resistance of the latter. For example, as will appear more fully in the examples below, when a hardboard is made from Ponderosa pine wood having its normal extractive content of 3–4% by weight, the water absorption of the board is 51% by weight, and the modulus of rupture is 4580 pounds per square inch. However, a hardboard prepared from Ponderosa pine massed pitch wood containing 34% by weight extractives and prepared under similar conditions has a water absorption of only 4% by weight and a rupture modulus of 6700 pounds per square inch. Hence, without the use of added binder, or of added sizing material, but utilizing a material heretofore discarded as waste or left unharvested in the forest areas, it is possible to prepare a product having a strength far above the strength of the conventional commercial hardboards and a water resistance well within the usual specifications therefor (i. e. within the 20% water absorption required by Federal hardboard specifications).

Furthermore, the inclusion of wood extractive materials as disclosed herein in the manufacture of consolidated composite products made from woody materials overcomes completely one of the most troublesome technical difficulties accompanying their manufacture. This is the problem caused by the sticking of the consolidated products to the members of the hot presses in which they are formed and the fouling and clogging of the wire screens used in the presses to promote the removal of moisture from the product during pressing. In attempts to solve these difficulties, which commonly result in the production of defective consolidated products, numerous expedients have been employed. Thus special metals such as chromium, stainless steel, or iron coated with its magnetic oxide have been used to make the caul plates interposed between the material to be pressed and the platens of the press. Alternatively, the caul plates have been coated with lubricating materials designed to prevent the sticking of the pressed substance. Commonly used lubricants at the present time are the silicone resins which, at current prices, cost from $7 to $10 per pound. Use of these various expedients obviously adds substantially to the cost of the material, and even when they have been used, it has been necessary to interrupt the press schedules from time to time in order that the press platens, caul plates, and particularly the screens may be cleaned and freed from adhering sticky material.

Although it might be anticipated that the inclusion of substantial proportions of the wood extractive materials in the woody materials to be consolidated would increase, rather than decrease the problem of sticking, we have found exactly the contrary to be true. In spite of the sticky, pitchy nature of these materials at ordinary temperatures, when they are incorporated in a mass of woody material in substantial amounts and the resulting mixture is pressed at elevated temperatures, the extractive materials become fluid and act as very effective lubricating agents, preventing sticking of the consolidated products to the caul plates and the fouling and clogging of the screen.

Surprisingly, also, these extractive materials do not tend to develop undesirable properties when permitted to remain on the press as a series of boards or other products are made therein.

Whenever the press is cooled, the extractive materials solidify, forming a varnish-like coating over the caul plates. However, when the press is reheated, this coating again becomes fluid and, together with the extractive materials contained in the freshly inserted blanks, serve as effective lubricants to prevent the sticking of the latter. As a result, blank after blank may be consolidated in the press, each consolidated product being freely removable from both the caul plate and the screen.

It is interesting and significant to note that, although the extractive materials as originally incorporated in the mixtures to be hot pressed are sticky, gummy materials, the consolidated products resulting from the hot pressing operation have, at normal atmospheric temperatures, no sticky qualities whatsoever. On the contrary, they have smooth, glossy dry surfaces making them admirably adapted for use in the ordinary applications. In view of the very substantial amount of extractive materials used in the products, this indicates that, during the hot pressing operation, the extractive materials actually combine chemically with the lignin or other constituents of the woody materials. This conclusion is further buttressed by the very high strength values noted above which characterize the product formed by the practice of the present invention, and which indicate a very pronounced binding effect exerted by the extractive materials.

In making the composite fibrous products of the present invention, woody material from a suitable source and comprising, for example, wood particles, wood fiber, or fiber derived from vegetable sources such as corn stalks, sugar cane or straw is mixed with suitable proportions of the extractive material, and the resulting mixture formed into composite products by either wet forming or dry forming procedures. Sufficient of the extractive material is used to impart the desired degree of strength and water resistance to the products. The lower limit of such use comprises that value at which the striking effect on increasing these values of the extractive materials becomes apparent. This is about 5% of weight, based on the dry weight of the fibrous product. The upper limit of extractive use comprises that value at which, principally because of the pitchy, resinous character of the wood extractive material, difficulties such as blooming, off color, blistering, etc. are encountered during the forming operation. This is about 45% of weight based on the dry weight of the fibrous products. The preferred range within which the desirable properties of strength and water resistance are substantially fully developed in the case of extractive materials from most coniferous wood species lies between about 8% and about 25% by weight, based on the dry weight of the final product.

Although in the formation of the hardboard or other composite fibrous product the wood extractives from any of the indicated sources may be added per se, after isolation from the woody matrix in which it was developed, it is preferred to employ as a raw material the knots, stump wood, massed pitch and other wood fractions in which the extractive materials are concentrated. These thus are employed as sources not only of the extractive materials, but also of substantial amounts of the cellulosic fiber which comprises the principal substance of the product.

Hence the herein described composite products may be made by reducing to fiber or particle form a sufficient amount of extractive rich materials to provide from 5% to about 45% preferably from about 8% to about 25% by weight based upon the dry weight of the final product, of wood extractives and mixing therewith the desired amount of wood fiber or other lignocellulose material. Since no additional binder or size need be added, the steps of adding the binder, and of incorporating the size, may be omitted entirely. Instead, if a dry felting operation is employed, the woody material and the extractive rich material in the desired proportions may be comminuted or defiberized contemporaneously, as between serrated metal discs. This reduces the materials to fiber form while, at the same time, thoroughly intermixing the wood extractive material with the fiber. The resulting mixture then may be formed into a felt and pressed between the platens of a hot press at, for example, from about 200 to about 1,000 pounds per square inch and from about 100° C. to about 300° C. for a time of from about 10 minutes to about 30 minutes.

If a wet felting operation is contemplated, the mixture of wood extractive material and cellulosic fiber prepared as indicated above, but admixed with water to form a pulp, may be run onto a wire to form a wet lap in conventional manner. The latter after slight consolidation, may be dried in a dry room, oven or similar equipment to produce a porous insulation board. On the other hand, if it is desired to form a hardboard by wet forming techniques, the wet lap is consolidated between the platens of a hot press under the general conditions of time, temperature and pressure indicated above, preferably at from about 200 p. s. i. to about 500 p. s. i. and from about 150° C. to about 250° C. for from about 15 minutes to about 25 minutes. During the hot pressing of both dry felts and wet felts, it may be desirable to breathe the press from time to time to permit the escape of steam and volatile materials contained in the wood extractives and thus promote the formation of a product free from blisters and surface defects.

In the event that it is desired to insure thorough distribution of at least the acidic constituents of the wood extractive materials throughout the fibrous mass from which the composite products are formed, and thus insure the maximum degree of strength and water repellency, the mixture of cellulosic material and wood extractives may be subjected to a treatment with alkali, preferably during the steaming operation. This converts the acidic materials, which normally are water insoluble, to their water soluble salts which are dispersed thoroughly throughout the pulp mixture. Then, upon treatment with an acid, these salts are converted again to the free acids which are deposited uniformly on the cellulosic fibers.

Any basic material which is a sufficiently strong base to dissolve the acid constituents of wood extractives may be employed for this purpose. Although the basic acting compounds of the alkali metals, for example sodium hydroxide, potassium hydroxide, sodium carbonate and potassium carbonate are preferred, other bases such as ammonia, ammonium hydroxide, and the various strong, organic bases also may be employed.

Acids which may be used to regenerate the wood extractive acids and deposit them upon the cellulosic fibers in the manner indicated above comprise in general any acids which are stronger than the wood extractive acids and therefore

will replace them from their salts. Such acids include generally the stronger mineral and organic acids, such as hydrochloric acid, sulfuric acid, phosphoric acid, acetic acid, and the like. Strongly acid salts such as alum also may be used.

The composite fibrous products of the invention and their water resistance and strength qualities are illustrated in the following examples wherein the amounts of the constituents are expressed in parts or per cent by weight. In each example, the board products were made by reducing normal wood and the desired quantity of extractive rich wood to chip form. The chips then were defiberized, with or without prior steaming, and formed into a pulp. Extraneous size (if used for purposes of comparison) was added to the plup, after which the latter was wet formed on a screen and the wet sheet hot pressed under the indicated conditions of pressure, temperature and time.

The one-quarter-inch hardboards resulting from the foregoing procedure did not stick to the press, and when removed, were non-sticky themselves, had a density of about 1 and were of a uniform, light brown color. The strength and water repelling qualities of each sample were measured by standard test methods. The moisture absorption and thickness swelling were determined by soaking weighed samples in water at 70° F. for 24 hours and determining the increase in weight and increase in thickness at the end of this period. The moisture absorption then was expressed as per cent by weight of the original weight of the sample, and the thickness swelling as per cent increase of the original thickness. The strength characteristics were determined by subjecting the samples to the conventional test method for measuring the flexural strength (modulus of rupture on flexing) this being expressed in pounds per square inch.

Example 1

One part Ponderosa pine stump wood (31% acetone soluble extractives) and three parts Douglas fir wood chips were steam treated for 30 minutes at 100 pounds steam pressure in a rotating digester. The steamed chips then were defiberized and formed into a pulp in a serrated metal disc grinder. The resulting pulp mixture was wet formed and the wet sheet pressed at 500 p. s. i. for 20 minutes at 374° F. The one-quarter-inch hardboard formed in this manner had a water absorption of 3.6% whereas a board formed as a control under identical conditions from stump wood-free pulp had a water absorption of 49%.

Example 2

1 part Ponderosa pine knot chips (33% acetone soluble extract) and 3 parts Douglas fir wood chips were defiberized and pulped directly without pre-steaming between serrated metal discs. The resulting pulp mixture was wet formed and the wet mat pressed at 374° F., first at 500 p. s. i. for one minute and then at 50 p. s. i. for 19 minutes. The resulting one-quarter-inch hardboard had a water absorption of 15.2%.

Example 3

1 part Ponderosa pine knot chips (33% acetone soluble extract), 2 parts Douglas fir bark, and 5 parts Douglas fir wood chips were steamed at 100 pounds pressure for 30 minutes, after which they were defiberized and pulped. The resulting pulp mixture was wet formed and pressed into one-quarter-inch hardboard following the procedure of Example 1. The board so produced had a water absorption of 12.7%.

Example 4

Ponderosa pine stump heart wood in chip form containing from 11% to 14% acetone soluble extractives was steamed at 100 p. s. i. for 30 minutes. The steamed chips then were defiberized, formed into a wet mat, and pressed at 375° F. for 20 minutes using a platen pressure-time cycle of 500–50–500 p. s. i. and for 2–3–15 minutes. The resulting board had a water absorption of 10.1%, a thickness swelling of 8.2%, and a rupture modulus of 6,170 p. s. i.

As a control, Ponderosa pine wood containing about 4% extractives was formed into a board under the same conditions as set forth in the above paragraph. The board had a water absorption of 51.0%, a thickness swelling of 24.5%, and a rupture modulus of only 4,580 p. s. i.

Example 5

Using the procedure outlined in Example 4, a one-quarter-inch hardboard was made using 50% massed pitch Ponderosa pine wood containing from 26% to 34% extractives and 50% normal Douglas fir wood chips containing 3% to 4% extractives. The water absorption of the resulting board was 5% and the modulus of rupture 6600 p. s. i.

Example 6

Again using the procedure of Example 4, another hardboard sample was made using 50% sugar pine knots containing 24 to 30% extractive materials and 50% normal Douglas fir wood chips. The modulus of rupture of the resulting board was 6,000 p. s. i.

Example 7

Again using the procedure of Example 4, another hardboard sample was made using 50% Ponderosa pine knots containing about 25% extractives and 50% Douglas fir wood chips. The water absorption of the board was 5% and the modulus of rupture 5,000 p. s. i.

Example 8

Another board product was made from 100% massed pitch Ponderosa pine wood containing 34% extractive materials. The procedure employed was the same as that employed in Example 4 except that the pressure in the press was applied intermittently, a pressure of 500 pounds per square inch and a temperature of 375° F. being employed for one minute, the press then breathed for two minutes, the same pressure and temperature applied for another minute, and the press then breathed for two minutes, this sequence being continued until a total of twenty minutes had elapsed. The hardboard formed as a result of the foregoing operations had a water absorption of 4% and a modulus of rupture of 6700 p. s. i.

A series of six boards was made using the foregoing procedure, without coating the caul plates with a special lubricant, or cleaning the plates or the screen between each pressing operation. In no instance did the boards stick to the press or the screen become fouled or clogged. Furthermore, at the end of the series, both screen and caul plates were clean and ready for application to the production of additional boards.

Example 9

To illustrate the deleterious effect of conventional sizing materials on the strength of consolidated fibrous products in which they are contained, a one-quarter-inch hardboard was prepared using the procedure of Example 1 from normal Douglas fir chips without added extractive rich materials and with and without the addition of 3% rosin size. The board in which size was omitted had a water absorption of 52% and a rupture modulus of 4400 p. s. i. The addition of the size reduced the water absorption of the product to 5.1%, but also reduced the strength of the board to 3100 p. s. i.

Example 10

1 part Ponderosa pine stump wood (31% acetone soluble extractive) and 7 parts Douglas fir wood chips together with 1% by weight soda ash were steamed at 100 pounds pressure for 30 minutes. The pressure was reduced to atmospheric and alum added until the mixture had a pH of 4.2. The mixture then was agitated for 10 minutes to precipitate on the fibers the acidic materials deriving from the wood extractives, which had been converted to their water soluble sodium salts by the action of the soda ash.

The resulting pulp mixture was processed into a one-quarter-inch board using the procedure of Example 2. The board product had a water absorption of 10.5%.

It is apparent from a consideration of the above examples that the inclusion in composite fibrous products of from 5% to 45% by weight, preferably from 8% to 25% by weight, of wood extractive materials is highly effective in increasing the water resistance and hence the dimensional stability of the products. As indicated in Example 1, the use of about 8% extractives derived from Ponderosa pine stump wood decreases the water absorption of hardboards made therefrom from 49% to 3.6%. Contemporaneously with the great increase in water resistance, there is a very significant increase in board strength. As is apparent from Example 4, the incorporation of from 11 to 14% of extractive materials increases the rupture modulus of the fibrous products in which they are contained from 4580 p. s. i. to 6170 p. s. i. The high strength imparted to the products also is apparent from Examples 5, 6 and 8, the products described therein having rupture moduli of 6600, 6000 and 6700 p. s. i., respectively. These results are particularly impressive when it is realized that the rupture moduli of comparable structural, untempered hardboards currently on the market lie within the range of 2500 to 4000 p. s. i. They lend strength to the theory that the wood extractive materials in addition to serving as water resistant agents, also serve as highly effective binders in the fibrous products in which they are contained.

The economic advantages stemming from our invention are immediately apparent. By utilizing our process, it is possible to form hardboard and other fibrous products of superior strength and water resistance while eliminating the use of extraneous binders and sizing agents. Hence the cost of these materials, and the very substantial cost of the labor, time and equipment necessary for their inclusion, is eliminated. In addition one of the most troublesome problems encountered in forming consolidated products from woody materials, i. e. sticking of the product to the press and clogging of the screens used

therein is overcome substantially completely. Furthermore, and of particular interest, is the fact that these desirable results are accomplished through the use of stump wood, knotty wood, massed pitch woods and similar materials which heretofore have been classed as logging and sawmill waste, and either not harvested, or discarded in the mill.

It will be apparent that our water resistant products are distinguishable from products containing conventional rosin size. In the first place, as has been brought out in detail, the wood extractive materials which are the subject matter of our invention are complex mixtures of substances including fatty acids, phenolic compounds, terpenes, esters, sterols, fats, waxes, resins and the like. Rosin size, on the other hand, consists almost solely of rosin acids. Furthermore, although rosin serves to increase the water resistance of fibrous products in which it is contained, it does not serve as a binder and, in fact, materially reduces the strength of boards and products in which it is contained (Example 9). The wood extractives, on the contrary, serve a definite binding function and impart a very high degree of strength to the products in which they are used.

Having thus described our invention in preferred embodiments, we claim:

1. A fibrous composition board essentially comprising difibrated lignocellulose consolidated with such proportion of defibrated coniferous lignocellulose rich in acetone-soluble content that the whole acetone-soluble content of the total lignocellulose material amounts to 5 to 45 per cent of the dry weight of the board.

2. A fibrous composition board essentially comprising defibrated lignocellulose of coniferous trees consolidated with such added proportion of defibrated coniferous lignocellulose rich in acetone-soluble content that the whole acetone-soluble content of the total lignocellulose material amounts to 8 to 25 per cent of the dry weight of the board.

3. A fibrous composition board essentially comprising defibrated lignocellulose of coniferous trees consolidated with such proportion of Douglas fir lignocellulose rich in acetone-soluble content that the whole acetone-soluble content of the total lignocellulose material amounts to 5 to 45 per cent of the dry weight of the board.

4. A fibrous composition board essentially comprising defibrated lignocelulose of coniferous trees consolidated with such added proportion of Ponderosa pine lignocellulose rich in acetone-soluble content that the whole acetone-soluble content of the total lignocellulose material amounts to 5 to 45 per cent of the dry weight of the board.

5. A fibrous composition board essentially comprising defibrated lignocellulose of coniferous trees consolidated with such added proportion of defibrated Southern pine lignocellulose rich in acetone-soluble content that the whole acetone-soluble content of the total lignocellulose material amounts to 5 to 45 per cent of the dry weight of the board.

6. A fibrous composition board essentially comprising defibrated lignocellulose of coniferous trees consolidated with an added portion of defibrated coniferous lignocellulose rich in acetone-soluble content, said portion of lignocellulose being selected from the group consisting of the stump wood, knots and massed pitch of coniferous trees and being in such proportion that the

while acetone-soluble content of the total lignocellulose material amounts to 5 to 45 per cent of the dry weight of the board.

7. A fibrous composition board essentially comprising defibrated lignocellulose of coniferous trees consolidated with an added portion of defibrated coniferous lignocellulose rich in acetone-soluble content, said portion of lignocellulose being selected from the group consisting of the stump wood, knots and massed pitch of coniferous trees and being in such proportion that the whole acetone-soluble content of the total lignocellulose amounts to 8 to 25 per cent of the dry weight of the board.

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