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PROCESS FOR DRYING WOOD

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This application is made under the act of March 3, 1883, as amended by the act of April 30, 1928, and the invention herein described, if patented, may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to us of any royalty thereon.

This invention relates to the seasoning of wood, and particularly to the use of hygroscopic pastes in the seasoning process. The process consists essentially of completely coating the wood to be dried with a hygroscopic paste and then exposing said wood to a drying atmosphere until the desired degree of dryness is reached.

The principal object of our invention is to eliminate, or minimize, seasoning defects during the drying of refractory items of wood, such as occur with ordinary seasoning methods.

Other objects of our invention are to permit, for various woods, faster drying than can be obtained with ordinary seasoning methods and/or to permit less exacting control of humidity conditions than is required in other seasoning processes.

When unseasoned wood is exposed to a drying atmosphere, the moisture content of the outer zone soon becomes less than the moisture content of the interior. This difference in moisture is relied upon to produce transfusion of the moisture from the center to the surface and is known as a moisture gradient. Wood shrinks when it dries below its fiber saturation point, and the wood in the outer zone begins to shrink during the natural course of drying before the interior dries enough to shrink. It follows that, by shrinking, the outer zone of a piece of wood becomes too small to go around its green interior, and the wood is stressed and stretched. When the amount of stretch exceeds the inherent ability of the wood to stretch, the wood fails by checking. During the period of drying immediately before checking occurs, the wood takes on a set in the stretched condition, and because of this set, the exterior zone does not ultimately shrink as much as it would if the wood in the exterior zone had dried without restraint. When a checked piece begins to shrink as a whole, during a later stage of drying, the checks may close at the surface, because of the surface being set in the expanded condition, while they continue to enlarge in the interior. Thus, honeycomb checks are formed.

Various means have been used to eliminate checking and honeycombing during the drying of wood. For non-refractory species, and even for thin boards of some refractory species, such

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defects can be eliminated by drying the wood under the mild conditions of air seasoning, using proper piling methods and roofing the piles to protect the wood from rain and direct sunlight. The same may be accomplished by subjecting such non-refractory items of wood to controlled temperature and relative humidity conditions in a dry kiln. It is impossible, however, with such ordinary methods to season thick items of most woods, and especially thick items of refractory woods, without formation of checks and honeycombing.

We are aware that a process known as chemical seasoning has been used to eliminate, or minimize, the seasoning defects in thick items of refractory woods. The chemical seasoning process consists, essentially, of depositing hygroscopic and antishrink chemicals within the outer zone of a piece of green wood and then subjecting the treated wood to a drying atmosphere. The chemicals tend to keep the wood in the outer zone in a swollen condition and thus tend to prevent the formation of checks or the enlargement of checks that do form. It is not possible, however, with any of the known chemical-seasoning agents to completely eliminate checking of thick items of the most refractory woods, such as the oaks.

We are also aware that a process consisting of coating the wood to be dried with a moisture-retardant coating and then exposing the wood to a drying atmosphere has been used to eliminate checking and honeycombing during the drying of wood. While this latter process is very effective in preventing checking, its effectiveness depends upon materially slowing down the rate of moisture loss from the wood, so that it may take many years to season some items, and the process is not practical except for such uses as the seasoning of museum pieces.

Our invention obviates to a large extent the deficiencies of the prior art by utilizing a paste that, when applied to the exterior of the piece of wood to be dried, largely remains upon the surface of the wood during the first stages of drying and provides a layer of material that protects the wood from direct exposure to the drying atmosphere. The essential attributes of such pastes are that they have a loose heterogeneous structure, provided by the thickening agent and any chemical in the paste that joins with it, through which structure water can diffuse from the wood to the drying atmosphere. When first applied to the wood, the paste has a sufficient concentration of hygroscopic chemicals in it to maintain in the paste a suitable relative water-

vapor pressure, that is, a vapor pressure which is somewhat less than that of pure water, so as to promote diffusion of water from the wood to the paste, but is not low enough to cause excessive loss of water and consequent checking of the wood. When the moisture of the air in which the wood is being dried has a lower relative vapor pressure than the water in the paste, water evaporates from the paste to the air. The water which has diffused into the paste from the wood tends to increase the water-vapor pressure in the paste adjacent to the wood. The loss of water from the paste to the air tends to lower the vapor pressure of the water in the portion of the layer of paste which is adjacent to the air. As a result, a vapor-pressure gradient is set up in the paste with a consequent diffusion of water through the paste from the side adjacent to the wood to the side adjacent to the air. The net result is that drying is accomplished in an environment not conducive to checking of the wood. Such a paste allows the wood to dry at a much faster rate than is permitted by a coating sufficiently water resistant to be effective in preventing checking of refractory items of wood in the practice of the prior art.

It is essential that the components of the paste be such that a major portion of the paste remains in a water-swollen gel condition on the surface of the wood as long as the wood has an average moisture content high enough to require such protection. Such moisture content values are usually in the neighborhood of 30 to 35 percent, based on the oven-dry weight of the wood. A part of the chemicals dissolved in the water of the paste may diffuse into the wood where they may act as chemical seasoning agents, assisting in the control of checking, but it is essential that the major portion of the chemicals remain in the layer of paste, so as to maintain suitable relative vapor pressure conditions. After the critical period for check formation has been passed, it is desirable that as much as possible of the paste disappear. This is partially accomplished by further diffusion of the chemicals into the wood, and with the lowering of the relative vapor pressure of the paste and loss of water to the drying atmosphere during the last stages of drying, the paste loses its moisture, and only a small residue of thickening agent and dry chemical remains on the surface. Chemicals and thickening agents, as well as drying conditions, can be selected so as to set up with any particular kind of wood an ideal set of equilibria whereby the wood can be dried at as fast a rate as is possible, consistent with the inherent rate of moisture diffusion through that particular wood, without the occurrence of drying defects.

It is not necessary, however, to start out with "ideal" conditions, or to maintain such conditions throughout the drying period. The use of a suitable hygroscopic paste permits wide latitude in the initial drying conditions. If the vapor pressure of the drying atmosphere is low, the chemicals will become more concentrated and thus lower the vapor pressure of the paste adjacent to the air, so that evaporation will not be too rapid. Always, the paste maintains a diffusion gradient within itself, protecting the wood from the atmosphere. The paste can shrink or swell in a direction perpendicular to the surface of the wood, but does not impose any structural stress upon the wood itself.

A further advantage of the process is that it adjusts itself to fluctuations in drying condi-

tions such as occur during the air seasoning of wood. When the vapor pressure of the air is excessively low, as during the hot part of the daytime, the paste protects itself as described above. When the vapor pressure of the air rises above the vapor pressure of the water in the paste, as during the cooler part of the nighttime, the paste absorbs moisture from the air and returns to its normal condition, or may even become wetter. Except during extended periods of complete drouth or saturated humidity, the vapor pressure in the paste adjacent to the wood remains about the same and tends to keep the wood drying at a steady, slow rate. In extended rainy, humid weather, the paste would tend to dilute itself considerably, thus raising the vapor pressure so that drying would slow up considerably until normal weather again appeared. In extended dry weather, the paste might become so concentrated that it would tend to cause too rapid drying, thus itself causing the wood to fail. When such weather conditions ultimately change the desired relative vapor pressure of the paste adjacent to the wood, the change is much less and the rate of change much slower than such changes in the atmosphere; thus the wood is protected from excessive damage. Chemicals can be selected that will polymerize and precipitate out of solution before the vapor pressure of the solution becomes too low. In the event that the paste dries up completely under very severe drying conditions, such polymerized chemicals may form a coating resistant to the passage of water.

While the effectiveness of the pastes in controlling drying defects is greatest when the pastes are applied to the wood before any seasoning has taken place, the process also is applicable to wood which has been permitted to dry partially before the paste can be applied.

The properties desirable in chemicals or combinations of chemicals suitable for this invention are that they lower the vapor pressure of the water in which they are dissolved to a vapor pressure that will dry wood slowly without the formation of checks. Experience has indicated that the relative vapor pressures suitable for use in this process lie between 65 and 90 percent, but it is conceivable that in some instances relative vapor pressures outside of this range might be useful. The most useful relative vapor pressures lie within the range of 75 to 85 percent.

The hygroscopic chemicals and the thickening agents should be compatible with each other. The chemicals should have large enough molecules, or should combine with each other to form large enough molecules, so as to prevent rapid diffusion into the wood from the paste, or should form with the thickening agent a gel that tends to maintain itself upon the surface without diffusing to any great extent into the wood during the early stages of drying. The chemicals must not combine too readily with themselves and form polymers lacking in hygroscopic properties or having too rigid a structure during the early stages of drying. It is necessary that the pastes maintain themselves in a wet paste or soft gel condition for a period of time somewhat longer than that required for the wood to dry beyond the stages of moisture distribution when the stresses are the greatest and where checking is likely to be most severe. It is desirable that, when the paste is subjected to very low humidities, a soft crust forms over

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the surface of the paste to resist moisture loss from the paste. The paste underneath the crust then remains relatively unchanged.

It is desirable, but not always necessary, for the chemicals to eventually form a non-hygroscopic polymer within the outer layers of the wood or over the surface. It is contemplated that the formula can be varied, depending upon the kind and size of the wood and the nature of the drying conditions, so as to achieve the fastest possible drying without incurring drying defects and yet leave a minimum of residue upon the surface of the wood.

Urea-formaldehyde-borax-starch pastes possess these properties to a high degree. Other hygroscopic resinoids, such as phenol-formaldehyde, can be used in the process. Such resin-forming compounds ultimately polymerize to form non-hygroscopic resins, so that wood treated with them and dried does not sweat in humid weather. Under some circumstances, non-resin forming chemicals, such as urea and molasses, or urea and invert sugar when combined in a paste, would possess enough properties to be useful in this process, although such combinations maintain their hygroscopic properties at the end of the drying period and must be removed if the wood is to be made suitable for use in damp climates.

In carrying out the invention, any thickening agent which will increase the viscosity of the solution can be used; for instance, cornstarch, methylcellulose, bentonite, or a combination of such agents. Any other hydrophilic thickening agent may be used.

The borax in the above-mentioned combination serves a dual purpose; it acts as a buffer in holding the mixture in the pH range of about 8 to 10.5 and also acts as a gelatinizing agent to increase the swelling of the thickening agent over that which would occur if no gelatinizing agent were used. Other buffering agents and other gelatinizing agents could be used, separately or in combination, to accomplish the same results.

Dimethylolurea is a condensation product of urea and formaldehyde in a convenient form for use in preparing urea-formaldehyde pastes. Uncombined urea and formalin solutions, or any other forms of urea or formaldehyde, also are suitable for preparing the pastes. The relative amounts of any urea-formaldehyde chemicals used can be expressed in terms of the relative equivalent amounts of urea and formaldehyde, regardless of the forms used. The presence of methyl alcohol as a stabilizing agent in formalin solution may require slight modifications of the formula and technique of forming the paste.

The paste which we have found to be the most effective in practicing this invention consists of an aqueous buffered urea-formaldehyde solution thickened with cornstarch. The solution consists of approximately 50 percent by weight urea and formaldehyde in the proportions of 6 mols of urea to 4 mols of formaldehyde buffered to a pH of about 9. A formula for making the solution is as follows:

	Parts by weight
Water	422
Borax ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$)	39
Dimethylolurea (containing 11 percent by weight water)	236
Urea	253

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Dissolution of the chemicals is facilitated by heating the water to not more than 160° F. and stirring. To thicken the solution, cornstarch is added to a small portion of the solution which has been removed and cooled to 100° F. Commercial-grade cornstarch, which may have a moisture content of approximately 10 percent, can be used. An amount of starch equivalent to 2.5 percent of the total weight of solution plus starch is dispersed in the cooled portion of the solution. The starch suspension is then transferred, with rapid stirring, into the main portion of the solution, which is maintained at a temperature of 150° F. for five minutes, or longer, after the addition of the starch. The resulting paste is cooled to room conditions.

Although we have found the above-described paste to be the most useful one for the drying of refractory items of lumber, some changes in the physical or chemical properties of the paste may be desirable to use the process most economically by suiting only the minimum requirements of the lumber and the drying conditions. The composition of a number of urea-formaldehyde-borax-starch pastes is given in Table I. Information on the physical characteristics of these pastes when freshly made is given in Table II. The behavior of the pastes when exposed in glass dishes to various relative humidities at 80° F. is given in Table III.

When the pastes are applied to unseasoned wood, moisture is supplied by the wood to the portion of the paste adjacent to the wood, polymerization of the resin-forming chemicals is delayed considerably, and many of the pastes remain jelly-like for a much longer time than when they are exposed in open dishes. Table IV gives information on the behavior of the pastes when applied on unseasoned redwood slats and exposed to various relative humidities at 80° F. One of the pastes was still moist at the end of a 3½-month exposure period, and several were apparently in good enough condition to absorb moisture during periods of high humidity and to provide some protection for lumber at the end of the 114-day period. The pastes retained their desirable properties longest when exposed continuously to 80 percent relative humidity, or alternatively to high and low relative humidity conditions. Pastes continuously exposed to 90 percent relative humidity or above tended to dilute themselves and become watery, and if exposure to such high humidities were prolonged, the pastes would become fluid enough to run off of vertical surfaces, though they would remain fairly well on horizontal faces, even downward-facing surfaces. Pastes having the greatest amounts of formaldehyde had the lowest relative vapor pressures and tended to absorb the most moisture and drip the most when continuously exposed to high relative humidities; but after a few days of exposure to alternate low and high relative humidities, such pastes were best able to withstand high relative humidities without dripping. Pastes with less than 4 mols of formaldehyde to 6 mols of urea tended to diffuse readily into the wood. Although the pastes with small amounts of formaldehyde thus would not be as satisfactory for check prevention during the drying of thick items of refractory woods, they provide enough protection to be of assistance in drying less refractory items and leave the surface of the wood in better condition for surfacing and painting.

The greater the consistency of the paste, the greater the thickness of the layer of paste that

can be applied to the wood, and consequently, the greater the amount of paste that will cling to a piece of lumber dipped in the paste. Also, the greater the consistency, the longer the paste will remain soft and effective. The smoother the paste, the more effective its protective action. Smooth pastes are obtained by following the mixing procedure described above.

A non-resin forming combination which we have found to have properties suitable for use in this process consists of a paste made by thickening a solution containing water 30 per cent, borax 3 percent, molasses (80 percent solution) 30 percent, and urea 37 percent with cornstarch, the amount of starch used being 2 percent of the total weight of the paste. This paste remained moist, or wet, for 3 months when exposed continuously, on unseasoned redwood and hard maple slats, to 65 or 80 percent relative humidity at 80° F. When continuously exposed to 30 percent relative humidity at 80° F., it remained moist for a month. When alternately exposed to 30 and 90 percent relative humidity, the paste maintained its ability to regain moisture at the end of the 3-month exposure period.

In practicing this invention, the paste is applied to the lumber or other items of wood by dipping in the paste, by brushing, or spraying, or by other means. After any excess paste has been allowed to drain, the treated lumber is piled on stickers and exposed to a drying atmosphere. Other means of supporting and separating other items of wood for drying may be used, such as trays or self-stickering, and short, blocky items such as shoe lasts may be bulk piled. The exposure may consist of piling the treated lumber in the open as in ordinary air seasoning; exposure in a roofed but otherwise open shed; exposure in a dry kiln; or exposure in rotation to a combination of any of the above-described conditions. When exposed to the weather, the piles of treated lumber are protected from the rain by roofing the pile. It may be particularly advantageous to pile the treated lumber on stickers on kiln trucks; allow the lumber to stand in a shed for a week to allow the resin-forming chemicals to enter the first stage of condensation at normal air temperatures and relative humidities; and then to move the lumber into a dry kiln and complete the drying. The lumber is left in the drying atmosphere until it has dried to the desired moisture content. Customary practices of using conditioning periods at the end of the drying period to equalize the moisture distribution in the lumber may be employed.

In the present invention, the wood is preferably exposed to the drying atmosphere immediately after treatment, whereas in previously disclosed chemical seasoning processes, the paste-treated wood is stored in a solid pile for several days before being exposed to the drying atmosphere. The present invention eliminates the solid piling step, and most of the paste remains on the surface as a protective layer between the wood and the atmosphere; whereas in the chemical seasoning, the hygroscopically active chemicals diffuse into the wood where the protective action takes place, in the outer zone of the wood itself. Besides eliminating one step in the seasoning process, the present invention prevents the formation of numerous very small checks which occur on the surface of wood which has been treated with urea-formaldehyde by the processes ordinarily used in chemical seasoning.

Table I.—Composition of various aqueous urea-formaldehyde-borax-starch pastes

Paste No.	Concentration (percentage by weight) of chemicals in solution			Molal ratio of formaldehyde to urea	Concentration (percentage by weight) of starch in paste
	Dimethylol-urea (11% water)	Urea	Borax		
	Per cent	Per cent	Per cent		Per cent
1	14.3	31.6	3.9	2:6	1.75
2	21.5	28.5	3.9	3:6	1.75
3	28.6	25.3	3.9	4:6	1.75
4	28.6	25.3	3.9	4:6	2.00
5	28.6	25.3	3.9	4:6	2.25
6	28.6	25.3	3.9	4:6	2.50
7	35.7	22.1	3.9	5:6	1.75

Table II.—Physical characteristics of urea-formaldehyde-borax-starch pastes

Paste No.	Viscosity at 80° F. ¹			Retention of paste on surface of unseasoned lumber	Relative vapor pressure of paste
	Apparent viscosity	Time viscosity remains unchanged	Time viscosity stays below 60 seconds		
	Seconds	Days	Days	Pounds per 1,000 sq. ft.	Percent
1	22	>9	>9	120	84.5
2	23	>9	>9	135	82.0
3	23	3	>9	130	80.4
4	26	2	5	180	-----
5	36	<1	3	265	-----
6	58	<1	<1	260	-----
7	29	<1	<1	270	-----

¹ Stormer viscometer, submerged paddle modification, 150 gram weight, 100 revolutions.

Table III.—Behavior of various urea-formaldehyde-borax-starch pastes when exposed in open dishes to various humidity conditions at 80° F.

Paste No.	General condition of paste after 14 days of exposure to a relative humidity of—				Moisture loss (—) or gain (+) per day during first 4 days of exposure to a relative humidity of—			
	30%	65%	80%	90%	30%	65%	80%	90%
	Percentage of original moisture of paste							
1	Crust over soft gel	Watery gel	Watery gel	Watery gel	—16.7	—7.6	—1.4	+5.2
2	do	Soft gel	Soft gel	do	—19.3	—7.1	—0.5	+5.6
3	do	do	do	do	—21.1	—7.6	—0.5	+6.0
4	do	do	do	do	—20.6	—7.6	—0.5	+6.5
5	do	do	do	do	—20.0	—7.0	—0.5	+6.5
6	do	do	do	do	—20.6	—6.5	—0.5	+6.5
7	Crust over semisolid gel	Semisolid gel	Semisolid gel	do	—18.6	—8.1	—1.2	+7.0

Table IV.—Behavior of various urea-formaldehyde-borax-starch pastes applied to unseasoned redwood and exposed to various humidity conditions

Paste No.	Length of time 80 per cent or more of surface area of paste remained moist when exposed						Percentage of surface area of paste retaining ability to absorb moisture at the end of 114 days of exposure alternately to relative humidities of—	
	To winter air seasoning conditions	To kiln drying at 90° F. and 40 per cent relative humidity	Continuously in a humidity room at 80° F. to a relative humidity of—			Alternately in humidity rooms at 80° F. to relative humidities of—	30 and 80 per cent	30 and 90 per cent
			30 per cent	65 per cent	80 per cent			
	Days	Days	Days	Days	Days	Days	Per cent	Per cent
1-----	7	1	6	4	4	2	0	0
2-----	24	3	17	7	17	8	13	0
3-----	24	4	10	24	17	17	15	75
4-----	60+	6	17	45	45	52	17	100
5-----	60+	17	6	45	60	52	32	100
6-----	60+	10	10	52	114+	78+	49	100
7-----	60+	10	24	52	52	52	13	100

Specific examples of how our invention may be practiced are as follows:

Example I

A paste was made by adding 0.18 pound of commercial grade cornstarch to the following solution, using the technique described above:

	Pounds
Water -----	4.19
Borax -----	.31
Dimethylolurea (13 percent water) -----	2.94
Urea -----	2.56

Eight unseasoned white oak boards, 1 by 6 inches by 2½ feet, were coated with the paste at the rate of 210 pounds of solid ingredients per thousand board feet of lumber. The lumber was piled on stickers in a dry kiln in which a temperature of approximately 90° F. was maintained and the relative humidity was kept at 38 percent for 5 days; then at 52 percent for 5 days more; then at 65 percent for 3 days; then at 70 percent for 3 days; and then at 41 percent for the rest of the drying period.

In two weeks the boards that had been treated with the buffered urea-aldehyde paste dried to 25 percent moisture content without checking. When the boards were allowed to dry to a moisture content of approximately 12 percent under the final humidity conditions, no checks were found. Eight unseasoned white oak boards, closely matched to those described above and of the same size, were similarly coated with a urea-borax-starch paste and exposed at the same time to the same drying atmosphere. Within two days the paste had dried and left a deposit of crystalline urea and starch on the surface. Within 2 weeks, seven of the eight boards checked; the length of checking of the seven boards varied from 2 to 33 inches per board.

Example II

A paste was made by adding 0.62 pounds of commercial grade cornstarch to the following solution, using the technique described above:

	Pounds
Water -----	10.30
Borax -----	.95
Dimethylolurea (11 percent water) -----	6.98
Urea -----	6.15

Five unseasoned white oak planks, 3 by 8 by 26 inches, were coated with the paste at the rate of 160 pounds of paste per thousand board feet of

lumber. The ends of the pieces were coated with a water-resistant coating to limit end checking.

- 25 The boards were exposed to the weather at Madison, Wisconsin, during late winter and spring in a roofed pile until they had dried to a moisture content of approximately 28 percent, well beyond the moisture content of maximum checking. The average length of checking per piece is given in Table V, along with the results for matched untreated pieces and matched pieces treated with urea by the dry spreading, solid piling method, at the rate of 100 pounds of urea per thousand board feet of lumber, and matched pieces which had been soaked 9 days in a buffered urea-formaldehyde solution as in ordinary chemical seasoning.

Table V.—Moisture content and surface checking of 3- by 8- by 26-inch white oak specimens

Treatment	Moisture content at the end of 179 days of air seasoning	Total length of surface checking per specimen
	Percent	Inches
Buffered urea-formaldehyde paste-----	28.9	85
Buffered urea-formaldehyde solution-----	29.7	1 240
Urea-----	27.4	295
Untreated-----	26.9	265

¹ Much of this checking consisted of very small short checks.

This application contains, in part, subject matter disclosed in Loughborough application Serial No. 581,821, filed March 9, 1945, now Patent Number 2,455,427.

Having thus described our invention, we claim:

1. A process for drying wood, comprising applying, to the surface only of the wood, a hygroscopic aqueous paste which minimizes drying and shrinking of the exterior of the wood before the interior dries, the paste remaining in a water-swollen gel condition on the surface of the wood as long as the wood has an average moisture content of 30 percent or higher, calculated upon the oven-dry weight of the wood, said paste comprising a mixture of hydrophilic thickening agent, and an unpolymerized resin-forming material which in the last stages of the drying forms a non-hygroscopic resin, the paste having a water vapor pressure, relative to pure water, of 65 to 90 percent and then open piling and substantially immediately kiln drying the coated wood without waiting for the paste to impregnate the wood, whereby diffusing of the paste into the

wood before the drying operation and during the early stages of the drying operation is avoided and minimized, the drying being to a moisture content of no more than about 25 percent.

2. The process of claim 1 in which the resin-forming material is a mixture of dimethylolurea and urea.

3. The process of claim 1 in which the resin-forming material is a mixture of urea and formaldehyde.

4. The process of claim 1 in which the resin-forming material is a mixture of urea and formaldehyde in the proportion of 1 to 5 mols of formaldehyde equivalent to 6 mols of urea equivalent.

5. A process for drying wood, comprising applying to the surface only of the wood a paste comprising an aqueous mixture of starch, a buffer to hold the mixture in the pH range of about 8 to 10.5, and an unpolymerized resin-forming material capable of forming a non-hygroscopic resin, the paste having a water vapor pressure, relative to pure water, of 65 to 90 percent and then open piling and immediately kiln drying the paste covered wood without waiting for the paste to impregnate the wood, whereby diffusing of the paste into the wood before kiln drying and during the early stages of drying is minimized, the drying being to a moisture content of no more than about 25 percent.

6. The process of claim 5 in which the buffer is borax and the resin-forming material is a urea-and-formaldehyde containing material.

7. The process of claim 5 in which the resin-forming material is a mixture of dimethylolurea and urea.

8. A process for drying wood, comprising coating the surface only of the wood with a paste comprising an aqueous mixture of cornstarch, a buffer to hold the paste in the pH range of about 8 to 10.5, and a material comprising urea and formaldehyde in the proportion of about 1 to 5 mols of formaldehyde to 6 mols of urea, the paste having a water vapor pressure, relative to pure water, of 65 to 90 percent, and open piling and drying the treated wood without waiting for the paste to impregnate the wood.

9. The process of claim 8 in which the buffer is borax.

10. The method of drying wood comprising coating the surface only of the wood with an aqueous paste comprising a concentrated solu-

tion of urea and formaldehyde, the formaldehyde being present in the proportion of 4 molecules per 6 molecules of urea, the solution buffered with borax to a pH of about 9, the whole solution thickened with starch, the paste having a water vapor pressure, relative to pure water, of 65 to 90 percent and containing about 50 percent by weight of urea and formaldehyde, and open piling and immediately exposing the open-piled wood in a kiln to a drying atmosphere to dry it to a moisture content of no more than about 25 percent drying atmosphere without waiting for the paste to impregnate the wood, whereby diffusing of the paste into the wood before drying and during the early stages of drying is minimized.

11. A process of drying wood at a controlled rate comprising subjecting the wood to a drying atmosphere while maintaining upon the surface of the wood an aqueous paste that protects the wood from direct exposure to the drying atmosphere, the water in the wood diffusing into the paste, the water in the paste diffusing into the atmosphere, the paste remaining in a water-swollen gel condition upon the surface of the wood as long as the wood has an average moisture content of 30 percent or higher, calculated on the oven-dry weight of the wood, the paste being buffered to the pH 8 to 10.5 and comprising an unpolymerized material capable of forming a urea-formaldehyde resin and having a water vapor pressure relative to pure water of 65 to 90 percent, the coated wood being open-piled and dried without waiting for the paste to impregnate the wood.

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LEIF DEDRICK ESPENAS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,901,373	Lionne	Mar. 14, 1933
2,275,845	Drake	Mar. 10, 1942
2,302,309	Glarum et al.	Nov. 17, 1942
2,346,286	Berliner	Apr. 11, 1944
2,402,331	Kvalnes	June 18, 1946
2,455,427	Loughborough	Dec. 7, 1948