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(54) Title: PROTEIN BASED WOOD FINISHES AND METHODS OF PRODUCING THE SAME

(57) Abstract: Wood finishes and methods of production and application of wood finishes are provided. The finishes may contain biologically produced components, such as proteins, and specifically may include whey proteins derived from dairy processing. The wood finishes are environmentally friendly as they use reduced levels of solvents and provide a safe and protective coating for wood and wood products.

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**PROTEIN BASED WOOD FINISHES AND METHODS OF PRODUCING THE
SAME**

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GOVERNMENT SUPPORT

This invention was made in part with government funding under the U.S. Department of Agriculture Cooperative State Research, Education, and Extension Service; Project No. VT-NS-029SG and VT-NS-033SG. The government may have certain rights in this invention.

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FIELD OF THE INVENTION

The invention relates to wood finishes containing naturally occurring products and, more specifically, to wood finishes containing proteins.

BACKGROUND OF INVENTION

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A variety of finishes can be used to coat wood products such as furniture, toys, flooring and interior house trim. Typically, these finishes are based on binder resins such as acrylate or urethane based resins, and include volatile organic carbon (VOC) solvents. These formulations allow the resins to form a protective film after evaporation of the solvents. The solvents, however, may be toxic to those applying the finishes. Toxicity is also a concern to those who may be exposed to the finished product, particularly young children who may place toys or furniture in their mouths.

20

The dairy industry produces large amounts of whey as a byproduct in the production of cheese and other dairy products. Whey can include protein, fats, and carbohydrates such as lactose. Uses for this whey are limited and typically the whey is disposed of. This disposal can lead to significant environmental problems due to the increase in biological oxygen demand (BOD) released into the environment when the whey is disposed of.

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Some limited uses for whey have been developed. For example, whey proteins can be used in photographic emulsions, and a saponified whey protein, at an elevated pH, can be used to protect the lignin component of wood shavings from attack by pests. The wood shavings can then be used as heat insulation in construction (United States Patent No. 5,476,636). The saponified whey is allowed to penetrate the wood shavings and it is believed that the high pH preserves the wood chips from biological attack. The whey, which contains

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protein, fat and lactose, is saponified with an alkali and is then allowed to soak into wood shavings that can be preserved and then used as insulation material.

SUMMARY OF THE INVENTION

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Wood finishes and methods of producing and using wood finishes are provided.

In one aspect, a wood finish is provided. The wood finish comprises protein.

In another aspect, a wood finish solution is provided, the wood finish solution comprising at least 1.5%, by weight, of protein and a resin.

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In another aspect, a method is provided in which a wood finish solution is produced by denaturing a protein to produce a denatured protein and mixing the denatured protein with water and a resin to produce a wood finish solution.

In another aspect, a method is provided, the method comprising applying a wood finish solution to a wooden substrate wherein the wood finish solution comprises protein.

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In another aspect, a kit is provided wherein the kit includes a container of wood finish solution and instructions for applying the wood finish solution and wherein the wood finish solution comprises a protein.

Other aspects, embodiments, and features of the invention will become apparent from the following detailed description. All references incorporated herein are incorporated in their entirety. In cases of conflict between an incorporated reference and the present specification, the present specification shall control.

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BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a bar graph showing test results from water vapor permeability testing and puncture strength testing.

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FIG. 2 is a graph showing the relationship between viscosity and shear rate for seven finish formulations containing varying amounts of WPI.

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DETAILED DESCRIPTION

A wood finish is provided that incorporates proteins into the finish. The wood finish may provide a coating that is protective, water-resistant, hard, resistant to scratching, and environmentally friendly.

In one aspect, a variety of proteins may be incorporated into a wood finish solution and a wood finish. As used herein, a "wood finish" is a dry, smooth, hard film on the surface of a wood product such as furniture, toys and finished carpentry. The film of a wood finish is typically greater than 5 μm thick and is often 10-40 μm thick when applied to wood products. The film can be clear and colorless and may be used to protect wood from the effects of exposure to the elements. A wood finish can also improve the appearance of a wood substrate by, for example, providing an even sheen to the surface of the wood. A "wood finish solution" is a liquid solution, emulsion, suspension mixture or other flowable liquid that can be applied to a wood product and result in a wood finish after curing.

A number of biological compounds can be incorporated into a wood finish. These compounds include polysaccharides such as cellulose and starches, gums, proteins including collagen, gelatin, soy protein, wheat gluten, cornzein, casein, sodium caseinate, egg albumen, and others. In one embodiment, a protein (or proteins) obtained from dairy whey may be used. The whey protein may be used as a powder or in a solution, such as an aqueous solution. The whey protein may be a whey protein concentrate (WPC) or a whey protein isolate (WPI) and may be denatured. Denaturing may be achieved by methods known to those skilled in the art, such as by thermally denaturing.

The protein component, or components, of the wood finish may be incorporated into the wood finish solution formulation in quantities of from 1 to greater than 60%, by weight, of the solution, and preferably is used in quantities greater than or equal to 10%, 20%, 30%, 40% or 50%, by weight, of the wood finish solution.

As whey proteins are available in large quantities and have historically presented a disposal problem, embodiments that employ whey proteins are of particular interest to both the wood finish and the dairy industries. In the United States alone, over 3.97×10^{10} pounds of sweet whey (pH greater than 5.6) and 3.75×10^9 pounds of acid whey (pH less than 5.1) are produced per year. Sweet whey generally results from rennet-coagulated cheese manufacture while the bulk of the acid whey produced comes from the production of cottage cheese. The

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quantities produced, in combination with the high biological oxygen demand (BOD) of the whey, provide important opportunities for processes that can use acid whey, sweet whey or both.

In addition to making use of a substance that is typically a waste product, the
5 incorporation of whey protein into a wood finish solution can provide for an improved wood finish, as well as improved methods of production and application. When compared to equivalent wood finishes that do not contain whey protein, a whey protein based wood finish can have, for example, increased density, viscosity, reduced VOC content, a harder and more scratch resistant film, better water resistance, low toxicity, low cost and is amenable to the
10 inclusion of a variety of additives that can be used to alter the aspects of both the wood finish solution and the wood finish. In one embodiment, the protein component of a wood finish solution may consist partially or totally of protein derived from whey. The protein may consist essentially of whey protein.

In one embodiment, whey protein isolate (WPI) is used at a purity of greater than 90%
15 protein in order to provide for a more durable and clearer finish. Preferably, the purity of the whey protein isolate is greater than 95, greater than 98 or greater than 99% protein. As raw whey contains fats and carbohydrates as well as other contaminants, it is preferred that these components be removed from the whey protein to produce the WPI prior to its incorporation into a wood finish solution. These materials can be isolated by methods known to those
20 skilled in the art such as membrane filtration and ion exchange.

The use of whey proteins in a wood finish solution can provide a solution having a viscosity of up to 1000 mPa-s. The increased viscosity of a wood finish solution can provide for easier application to a surface resulting in a protective finish of desired thickness on wood
25 products such as furniture, toys and carpentry. Whey proteins can be added to finishes to arrive at viscosities of greater than 20, greater than 50, greater than 100, greater than 200, greater than 400, or greater than 500 mPa-s. This can eliminate the need for the addition of thickeners and other additives that can increase cost and can affect the performance of the final finish. Of course, if viscosity is too high, the finish solution cannot be easily applied and may not result in a preferred finish.

30 In another embodiment, a wood finish solution exhibits lower VOC emissions than many commercially available wood finish solutions. The addition or substitution of protein to synthetic resin formulations, preferably as an aqueous solution of whey protein, can

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provide a wood finish solution requiring, for example, 50%, 75%, or 90% less organic solvent, while maintaining or improving the properties of the solution and the resultant finish. For example while many commercially available acrylic and urethane based finishes contain VOCs in a range of from 250 to 450 g/l, the use of a whey protein in a similar wood finish
5 formulation can reduce the VOC content to less than a 100 g/L, less than 80 g/L, less than 60 g/L. Importantly, this reduction can be achieved while maintaining or improving other characteristics of the wood finish and wood finish solution. For example, this can provide for a safer environment for those applying the wood finish, can reduce the quantity of the solvents being emitted to the atmosphere, can reduce the flammability of the wood finish
10 solution and can also reduce the cost of the product by decreasing the total amount of VOCs required to manufacture it. At the same time, improvements in appearance and durability of the finish can be realized.

The pH of a wood finish solution may be varied by substituting or replacing components with a protein. For example, wood finish solutions including proteins may have a
15 pH of less than 9, less than 8, less than 7 or less than 6. In one embodiment, the pH of the wood finish solution may be between 6 and 7.

Whey protein can be used to supplement or replace currently used resins in wood finish coatings. The whey protein can be added to any waterborne, resin based wood finish formulation including acrylic and urethane based resins. Preferably, the whey proteins are
20 used in conjunction with either acrylic or urethane based resins and interact with these resins to form a durable finish. By substituting whey protein for a portion of a synthetic resin, the amount of synthetic resin used in the wood finish solution can be reduced from 70% by weight down to 30, 20, 10% or less in some embodiments. Preferably, the amount of synthetic resin used is from 40-70% by weight of the finish solution. Most preferably, the
25 synthetic resin content is from 45-60% by weight. The protein component of the solution preferably forms from 10-60%, by weight, of the solution and more preferably is from 10-40% of the solution. The ratio of whey protein to resin used in a wood finish solution can be, by weight, from 1:10, or less, up to 1:1, or greater. Most preferred are ratios of from about 1:2 to 1:4. Specific ratios of whey protein to synthetic resin can be tuned to maximize
30 specific properties such as hardness, color, adhesiveness, ease of application, cost and water resistance.

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Whey proteins can be pretreated in a number of ways prior to their incorporation into a wood finish solution. For example, a whey protein isolate (WPI) can be formed from a raw whey product. Some naturally occurring components of whey can be reduced or removed to form the WPI. A WPI may be made from either a sweet or an acid whey and may contain
5 less than 5, less than 4, less than 3, less than 2 or less than 1% fat as well as less than 5, less than 4, less than 3, less than 2 or less than 1% carbohydrates.

Raw whey contains a number of components including proteins, lactose, minerals and lipids. The protein fraction can be separated from the other components by techniques known to those skilled in the art such as a stirred tank or a packed column ion exchange.

10 These methods can be used to isolate the whey protein (primarily beta-lactoglobulin, alpha-lactalbumin, bovine serum albumin, immunoglobulin G, and proteose-peptones) from the other components. Once separated from the impurities such as carbohydrates, minerals and lipids, the protein fraction can be dried into a powder providing greater than 90% protein with the remainder being moisture.

15 Purification techniques may include membrane separation and ion exchange, with ion exchange typically capable of producing a protein of higher purity. Typical membrane separation techniques such as ultra filtration and diafiltration use semi-permeable membranes to separate components having molecular weights of less than 50 kDa. The resulting protein product, typically at a purity of less than 90%, is referred to as whey protein concentrate
20 (WPC). Alternatively, ion exchange methods known to those skilled in the art can produce a protein powder having a purity of greater than 90% that is generally referred to as whey protein isolate (WPI).

Protein fractions such as WPI and WPC can be denatured prior to their use in a wood finish solution. Denaturing can unfold globular whey proteins and results in the
25 polymerization of the whey proteins, by disulfide crosslinking, within a protein molecule and across protein molecules. It is believed that this disulfide crosslinking is important in producing strong, resistant protein films that help to achieve the attributes that make a favorable wood finish.

Denaturing can be achieved by thermally treating protein or a protein solution, such as
30 a WPI solution. Denaturing results in an increase in viscosity of the solution and it is preferred that the protein content be kept below about 15%, by weight, to prevent gelation that can result from the denaturing process. Thermal denaturing can be efficiently achieved

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using a 10% by weight aqueous protein solution at a pH of 7 and exposing the solution to a temperature of 90°C for about 30 minutes.

Although protein fractions such as WPI and WPC can be dispersed directly into a cold-treated water mixing tank, they may, under some conditions, be difficult to uniformly
5 disperse in water. Therefore, the following procedure has been developed to aid in dispersion. The protein component, for example WPI, is added to a one-to-one mixture of ice and water that has been previously ground in a blender. The protein and ice water are then ground in the blender for about 15 seconds after which the solution is manually mixed for 30 seconds and followed by an additional 15 seconds of blending. Finally, the solution is mechanically
10 stirred using an electric motor driven propeller for about 8 minutes to result in a uniform protein solution. This uniform protein solution can then be denatured, for example, by thermally treating as described above, and then can be stored or immediately incorporated into a wood finish solution. When compounding a wood finish solution, the protein component can be added as a dry powder or in the form of a solution. Typically, the protein
15 content of a wood finish solution will be referred to by the percent of the total solids in the solution that comprises protein or the percent of the total solution that comprises protein.

Wood finishes incorporating 10, 20, 30 or 40% WPI by weight exhibit gouge and scratch resistance comparable or superior to that of commercially available products such as polyacrylic, polyurethane and acrylic polyurethane finishes. In addition, puncture strength,
20 water vapor permeability and general water resistance of the finishes incorporating WPI are also comparable or superior to that of the commercially available finishes. For example, when cured finishes are evaluated using ASTM D3363 for scratch hardness, hardness ratings of B, HB, or better, can be obtained. This compares favorably to scratch hardnesses of 4B and 2B for commercially available acrylic and polyurethane based finishes.

25 In addition, finishes incorporating WPI may recover from water whitening at a faster rate than equivalent finishes that don't incorporate WPI. When tested using ASTM D1647, tinsplate panels coated with WPI-based finishes recovered original clarity at a rate that was faster than, or equivalent to, recovery rates measured for identical panels treated with similar finishes that did not incorporate WPI.

30 Wood finish solutions incorporating a whey protein such as a WPI are also compatible with other additives including biocides, mar resistant additives, UV additives, flattening agents, plasticizers, anti-setting agents, anti-floating agents, leveling agents,

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glossing, flattening, penetrating, wetting and stabilizing agents. Generally, any additives that can be used with waterborne formulations can also be used with the wood finish solutions disclosed herein.

Biocides can be added to protect a wood finish solution from spoilage by bacteria, yeast, and fungi. Biocides may form less than 1%, by weight, of the solution and preferably are present in the range of about 0.01 to 0.5% of the solution. Specific biocides that have been shown to be useful include 1,2-benzisothiazolin-3-one(BIT)-based biocides such as PROXEL[®] brand biocides available from Aveceia Inc. In addition, DOWICIL[®] brand biocides available from Dow Chemical, Polyphase[®] brand biocides from Troy Corporation and Busan[®] brand biocides from Buckman Laboratories can also be effective in protecting the finish solution from attack by a broad spectrum of yeast, bacteria, and fungi.

Mar resistant agents can be used with a whey protein wood finish solution in order to increase attributes such as hardness, scratch resistance and durability of the finish. These agents can be used in a variety of concentrations, for example, at 0.5%, .3% or .1% and specific mar resistant agents such as BYK 301 have been shown to be compatible with the WPI based wood finish solutions.

Additional additives known to those skilled in the art, such as UV additives, leveling agents, and stabilizing agents can be used in applications that call for the attributes of these additives.

The wood finish solutions disclosed herein can be made using any variety of techniques known to those skilled in the art. For example, using a conventional stirring apparatus, components may be added in any order. Process control agents, such as defoamers and coalescers may be added first. Defoamers may be used at any required concentration and are generally added in the range of less than about 0.5%, by weight of the solution. For example, a batch may be started by adding a defoamer such as Dehydran[®] 1293, available from Fitz Chem Corporation, to an acrylic resin system. Water can then be added to the system followed by the addition of a thermally denatured WPI solution, to, for example, a level of 10% protein, which can then be followed by the addition of coalescing solvents such as Dowanol[™] PnD[™] and/or Dowanol[™] DPnB[™] solvent systems, available from Dow Chemical Corporation. Coalescing solvents may be added at a concentration adequate to achieve the desired coalescing effect and are preferably used at a concentration of about 0-

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5%, of the solution, by weight. After the components are thoroughly mixed, the solution can be stored, packaged, or can be used immediately.

Alternative preparation techniques include starting with available finished solutions such as acrylic based mixes and adding thermally denatured WPI solution to the mixture to arrive at the final desired formulation, such as a 10% protein, by weight, solution. Thus, a WPI solution can be added at any time in the mixing process to obtain the desired wood finish formulation. The wood finish solution formulations may be stored in cans or drums to eliminate exposure to air and for extended storage of the finish solutions it is preferred that a biocide be added to the solution to inhibit microbial activity.

The wood finish solutions can be applied to a surface using any number of techniques known to those skilled in the art. For example, solutions may be applied by brush, by spraying or by dipping, and the technique employed can be determined by one skilled in the art after evaluating the product being coated as well as the characteristics of the finish solution being used. In some applications, additional coats of the finish solution may be desired, and improved adhesion and appearance of later coats can be aided by light sanding of previously applied layers. Finishes can be applied using one or more coats per article being coated. Wood substrates can be treated prior to finishing by using techniques known to those skilled in the art, such as staining, sealing and sanding.

After application to a substrate such as furniture, toys or finished carpentry, the finish may be formed (dry film) by allowing the finish solution to air dry at room temperature.

Alternatively, the curing process may be accelerated, for example, by applying heat to the surface. As the use of whey protein in a finish solution can allow for a higher solid loading of the finish solution, drying can proceed at a faster rate with the emission of fewer volatiles when compared to commercially available coatings based on, for example, acrylic or polyurethane based resins. This increased solids loading can be obtained using whey protein without adversely affecting the important properties of the finish solution, such as viscosity, flattening, or color. Thus, in addition to improving many characteristics of the commercially available products, the addition of whey protein to a wood finish solution can allow for increased finish coverage of a wood product, at an equivalent film thickness, for an equivalent volume of wood finish solution.

In another embodiment, a kit is provided. The kit may include a container, such as a can or bottle, containing a wood finish solution. The kit may also include instructions for the

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application of the wood finish solution to a wood substrate. The kit may also include information about the composition of the wood finish solution and may specifically include information stating that the solution contains protein, such as whey protein. Clean-up and disposal instructions may also be provided. The kit may be offered for sale in stores such as hardware, department and specialty stores.

It should be understood that not all of the above-identified advantages may be achieved in all embodiments of the present invention. The present invention will be further illustrated by the following examples, which are intended to be illustrative in nature and are not to be considered as limiting the scope of the invention.

EXAMPLE 1

In this example, two wood finish formulations were manufactured to show the applicability and usefulness of wood finish formulations incorporating WPI. In the first example, components of which are shown in Table 1, the amount of WPI solution, containing 10% protein, was varied between about 12 and 53% by weight of the wood finish solution. In the second example, the components of which are shown in Table 2, a different acrylic resin was used and the same WPI solution containing 10% protein was varied between 28 and 42%, by weight, of the wood finish solution. The WPI used was ALACEN[®] 895, 93.5% protein, from NZMP (North America) Inc., Santa Rosa, California. A 10% protein solution in water was made (100g ALACEN[®] 895 per 935 mL of solution) and was denatured by heating at 90°C for 30 minutes. The acrylic resins used in these examples were NeoCryl[®] A-634, an aqueous acrylic copolymer and NeoCryl[®] XK-12, a self cross-linking modified acrylic emulsion. Both of these acrylic-based resins are available from NeoResins, Wilmington, MA.

Each of the examples was produced by first adding a defoamer, either Patcote[™] 525 (Table 1) or Dehydran[™] 1293 (Table 2) to the acrylic resin system and then adding, in order, water, the thermally denatured WPI solution, coalescing solvents (for the examples using the solvents) such as Dowanol[®] PnB and Dowanol[®] DPnB and then adding other additives such as biocides (PROXEL[®] GXL), a mar-resisting agent (BYK[™] 301), a wetting agent (BYK[™] 348) and/or a flow and mar resistant agent (BYK[™] 307). As the WPI was added as a 10% aqueous protein solution, additional water was obtained through the addition of this component. Each of the formulations listed in Tables 1 and 2 was successfully coated onto a

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wood surface illustrating the concentration range of WPI that can be used to make an exceptional wood finish solution.

Table 1

Example	Ingredients (% weight)					
	NeoCryl A-634	Patcote 525	Water	WPI, 10% Pro	BYK 301	PROXEL GXL
1	65.71	0.4	21.54	12.0	0.3	0.05
2	62.25	0.4	13.0	24.0	0.3	0.05
3	60.17	0.4	7.88	31.2	0.3	0.05
4	58.79	0.4	4.46	36.0	0.3	0.05
5	46.02	0.4	0.0	53.23	0.3	0.05

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Table 2

Example	Ingredients (% weight)								
	NeoCryl XK-12	Water	Dehydran 1293	WPI, 10% Pro	BYK 348	BYK 307	Proxel GXL	Dowanol PnB	Dowanol DPnB
6	56.00	15.05	0.5	28.0	0.25	0.15	0.05	0	0
7	55.56	13.49	0.5	30.0	0.25	0.15	0.05	0	0
8	55.56	9.93	0.5	30.0	0.25	0.15	0.05	1.78	1.78
9	52.89	4.16	0.5	42.0	0.25	0.15	0.05	0	0

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Table 3 provides the trade names of many of the components used to produce examples of Tables 1 and 2 and also provides a description of the component's function, and the manufacturer from whom it is available.

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Table 3

Ingredient	Primary Function	Manufacturer
NeoCryl [®] A-634	Aqueous acrylic copolymer. As a binder.	NeoResins
NeoCryl [®] XK-12	A self-crosslinking modified acrylic emulsion. As a binder.	NeoResins
WPI, 10% protein	Thermally denatured (90°C, 30 min) aqueous WPI solution. As a binder.	NZMP (North America) Inc.
Patcote [®] 525	Defoamer	American Ingredients Company
BYK 301	Mar-resistant agent	BYK-Chemie Inc.
PROXEL [®] GXL	Biocide	Avecia Inc.
Dehydran [®] 1293	Defoamer	Fitz Chem Corp.
BYK [™] 348	Wetting agent	BYK-Chemie Inc.
BYK [™] 307	Flow/mar aid	BYK-Chemie Inc.
Dowanol [®] PnB	Coalescing solvent	Dow Chemical Co.
Dowanol [®] DPnB	Coalescing solvent	Dow Chemical Co.
Water	Solvent	-----

EXAMPLE 2

5 Additional finish formulations were made using the same method as in Example 1 to obtain whey protein levels of 10% of solids, 15% of solids and 25% of solids, by weight, in the wood finish solution formulations. Each of the whey formulations used the NeoCryl[®] A-634 acrylic resin of Example 1 as a binder. The formulations were coated onto surfaces and compared to four commercially available wood finishes, C1, C2, C3 and C4, as well as to the

10 acrylic-based formulation absent the addition of whey protein. The three whey-based formulations F1, F2 and F3, that were tested, are provided in Table 4 below with the base acrylic coating formulation, F0, being equivalent to that used in the examples of Table 1 except that no whey protein was used in the formulation designated F0.

Table 4

Product Code	Description
F0	Acrylic-based coating formulation adopted from literature with little modification, 0% protein of total solids
F1	WPI-Acrylic coating formulation, 10% protein (of total solids)
F2	WPI-Acrylic coating formulation, 15% protein (of total solids)
F3	WPI-Acrylic coating formulation, 25% protein (of total solids)
C1	Commercial Minwax® polyacrylic protective finish, clear gloss.
C2	Commercial Benwood® Stays Clear® acrylic polyurethane, hi-gloss 422
C3	Commercial Cabot® water-based polyurethane varnish, 2203 gloss
C4	Commercial BEHR® No. 630 water-based polyurethane, clear hi-gloss

Selected properties of the wood finish solutions were measured and are provided in
 5 Table 5. The data show that the pH of the acrylic based coating formulation is significantly
 lower than that of the commercially available products and that as the protein content of the
 wood finish solution is increased, the pH of this solution also increases.

Table 5
 Selected properties of wood finish products

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Product ¹	pH	Density (g/cm ³)	Viscosity (mPa.s)	Total Solids (wt, %)	VOCs (g/l)
F0	6.29 ^f	1.0047 ^h	17.76 ^g	24.42 ^d	148.00
F1	6.44 ^e	1.0166 ^g	60.46 ^e	24.51 ^d	79.70
F2	6.46 ^e	1.0186 ^f	436.85 ^b	24.61 ^d	75.48
F3	6.61 ^d	1.0198 ^e	214.45 ^c	21.93 ^e	59.15
C1	7.99 ^a	1.0247 ^d	143.2 ^d	29.37 ^b	302
C2	7.94 ^b	1.0308 ^c	497.9 ^a	30.43 ^a	450
C3	7.51 ^c	1.0359 ^b	51.73 ^f	30.02 ^{ab}	350
C4	7.99 ^a	1.0372 ^a	213.55 ^c	25.53 ^c	295

¹Any two means in the same column followed by the same letter are not significantly ($P > 0.05$)
 different by Fisher's Protected LSD multiple comparisons.

Density readings show a concurrent increase in density with an increase in the amount
 15 of protein dissolved in the solution. It is notable that the density of solution F3 is higher than
 that of F2, F1 and F0, even though the total solids content of the solution is less.

The fourth column illustrates the viscosity measurements recorded for each of the
 eight wood finishing solutions and shows that even the more heavily loaded WPI based
 solutions are at viscosities within the range of those presented by the commercially available

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products. Viscosity measurements were made using an AR-1000™ Rheometer (TA Instruments, New Castle, DE) and results were obtained at a shear rate of 10s⁻¹.

The last column in Table 5, illustrates that the VOC content of the three formulations containing WPI is significantly less than those of the commercially available products. This demonstrates a less toxic, more environmentally sound wood finish solution. Data for VOCs were obtained by calculating the quantity added for those finishes that were compounded and were taken from manufacturer's product data for the commercially available formulations.

Drying time, thickness and two measures of hardness were also measured and recorded for each of the eight formulations. Drying time was determined using a DT-BK3™ Drying Time Recorder (Paul N. Gardner Co., Inc., Pompano Bch., FL) and the method used was that of ASTM D5895. Results are provided in Table 6.

Table 6
Drying time and hardness of wood finish samples

Products ¹	Dry-Through Time (min)	Dry Film Thickness (µm)	Gouge Hardness	Scratch Hardness
F0	83.5 ^d	26.16 ^d	7H	HB
F1	31.0 ^e	33.91 ^b	7H	HB
F2	18.5 ^f	25.53 ^d	7H	HB
F3	86.5 ^d	29.97 ^c	6H	B
C1	208.5 ^b	32.77 ^b	4H	4B
C2	262.5 ^a	35.52 ^a	4H	4B
C3	103.5 ^c	26.75 ^d	4H	4B
C4	89.5 ^d	28.70 ^c	5H	2B

¹Any two means in the same column followed by the same letter are not significantly ($P > 0.05$) different by Fisher's Protected LSD multiple comparisons

It is notable that all of the wood finish solutions containing the WPI component had faster dry time than did the commercially available products and that both F1 and F2 exhibited considerably faster dry times than did the acrylic based coating formulation of F0. These accelerated dry times may be partially accounted for by the lower level of VOCs contained in the WPI compounded samples.

The third column in Table 6 shows that the dry film thickness of the WPI containing formulations were comparable to those of the commercially available products. Dry film thickness was measured with an elcometer® Model 126 Dial Thickness Gage (Paul N. Gardner Co. Inc., Pompano Bch, FL). Gauge hardness was evaluated by determining the hardest pencil lead that would leave the film uncut for a stroke of at least 3 millimeters.

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Scratch hardness is defined as the hardest pencil lead that will not rupture or scratch the film. The apparatus used to record gouge and scratch results was a Scratch Hardness Tester model 3363 available from the Paul N. Gardner Co., Inc., Pompano Bch., FL. The method employed was ASTM D3363. In order of from softest to hardest the available pencil leads
5 are as follows: 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H.

Both the gauge hardness and scratch hardness results were noticeably better for the formulations containing the whey based proteins than for those of the commercially available products and were comparable to the results obtained for the acrylic based coating, F0.

Additional test were run to evaluate the color values and whiteness index of the wood
10 finishes (Bolin H.R. and Huxsoll, C.C. 1991. *J. Food Sci.* 56:416-8.). Results are provided in Table 7. The second column labeled "L" reflects the color value, with black being equivalent to 0 and white being equivalent to 100. Results were comparable for all formulations from F0 through C4. The third column labeled "a" provides the amount of greenness or redness
15 attributable to the coating. A negative number indicates greenness, a positive number redness. Each of the WPI containing finishes, F1, F2 and F3, showed a slight tendency towards greenness but less so than the acrylic based resin absent the WPI and less than commercially available products C2 and C3. Color measurements were made in triplicate
20 using a HunterLab ColorQuest® Spectrophotometer (HunterLab, Reston, VA). In the fourth column, "b" represents the blueness or yellowness of the coating. A -b indicates blueness and a +b, yellowness. Each of the WPI containing solutions tended towards yellowness rather than blueness but less so than the acrylic based finish absent the WPI and less than commercial products C2 and C3. The fifth column, labeled "ΔE" was calculated as follows and represents the total color difference.

Table 7

Hunter L, a, b color values, total color difference (ΔE), yellowness index (YI), and whiteness index (WI) of wood finish films.

Products ¹	L	a	b	ΔE	YI	WI
F0	92.56 ^d	-2.75 ^d	3.31 ^b	4.23 ^b	5.11 ^b	91.40 ^d
F1	93.07 ^{ab}	-1.91 ^c	1.43 ^d	2.76 ^d	2.20 ^d	92.67 ^{ab}
F2	92.90 ^{abc}	-1.93 ^c	1.56 ^{cd}	2.96 ^{cd}	2.39 ^{cd}	92.47 ^{bc}
F3	92.76 ^{cd}	-1.97 ^c	1.78 ^c	3.14 ^c	2.74 ^c	92.29 ^c
C1	92.56 ^d	-1.37 ^a	0.36 ⁱ	3.17 ^c	0.56 ⁱ	92.43 ^{bc}
C2	92.59 ^d	-2.72 ^d	3.45 ^b	4.27 ^b	5.32 ^b	91.39 ^d
C3	92.82 ^{bcd}	-3.17 ^e	4.52 ^a	5.00 ^a	6.95 ^a	90.95 ^e
C4	93.09 ^a	-1.67 ^b	0.96 ^e	2.65 ^d	1.47 ^e	92.82 ^a

5 ¹Any two means in the same column followed by the same letter are not significantly ($P > 0.05$) different by Fisher's Protected LSD multiple comparisons.

$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{0.5} \quad (1)$$

10 A yellowness index was calculated as follows:

$$YI = 142.86 \text{ b/L} \quad (2)$$

The whiteness index was calculated according to:

15

$$WI = 100 - [(100 - L)^2 + a^2 + b^2]^{0.5} \quad (3)$$

Where $\Delta L = L_{\text{standard}} - L_{\text{sample}}$; $\Delta a = a_{\text{standard}} - a_{\text{sample}}$; $\Delta b = b_{\text{standard}} - b_{\text{sample}}$.

20 In total, the color values indicate that the addition of the WPI to the acrylic based finish improves the color values and makes them comparable to and better than some of the commercially available products that contain high levels of VOCs.

EXAMPLE 3

25 The finishes were also evaluated to determine their response to immersion in water. Test were conducted using ASTM method D1647. Coated samples were immersed in water

for 18 hours and each experiment was performed in duplicate. Results are provided in Table 8.

Table 8

Results ²	Wood Finish Products							
	F0	F1	F2	F3	C1	C2	C3	C4
Not visibly affected								
Whitening disappears within 20 min	↔	↔	↔	↔	↔	↔		
Whitening does not disappear within 20 min, but disappears within 2 h							↔	↔

5

While each of the finishes tested showed some whitening in response to the exposure to water, the whitening disappeared from the WPI products in less than 20 minutes. Two of the commercially available products, C3 and C4 remained white past the 20 minute period and improved in less than 2 hours. This shows that a wood product coated with the WPI containing finishes can recover faster than, or in an amount of time equivalent to, the commercially available products.

The products were also evaluated for water vapor permeability as well as for puncture strength. Water vapor permeability was determined according to the WVP Correction Method (McHugh T.H., Avena-Bustillos, R., and Krochta, J. M. 1993. *J. Food Sci.* 58(4):899-903). Puncture strength test was performed using a miniature universal material tester sold as the Vitrodyne® V-1000 from Liveco of Burlington, VT. Results are presented in Fig. 1. As shown in Fig. 1, water permeability increased as the amount of WPI increased in the wood finish formulation. WPI containing formulation F1 was comparable to or better than the commercially available products but water permeability increased for formulations F2 and F3.

Puncture strength results show that the puncture resistance of the three WPI containing formulations to be equivalent to or better than those of the commercially available products and were not significantly different from the acrylic based resin absent the WPI.

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EXAMPLE 4

Another finish was formulated using a two binder component system including an oil modified polyurethane dispersion and denatured whey proteins. Both the finish and the resulting cured coating were evaluated.

5 The oil modified polyurethane dispersion was SPENSOL™ F97-MPW-33, from Reichhold, Inc., Morris, Illinois. The whey protein isolate (WPI) was the same as that used in previous examples, ALACEN® 895 WPI, 93.5% protein content from NZMP (North America), Santa Rosa, California. The following additives were also used in the formulations. Surfactant BYK-345, BYK Chemi USA Inc. (Wallingford, CT) was employed
10 to improve, for example, recoatability. Rheology modifier, ACRY SOL™ RM-2020 NPR, from Rohm & Haas (Bridgeport, NJ) was used to improve film buildup and defoamer dispersion. The defoamer used was DREWPLUS™ L-405, Ashland Canada, Inc., and biocide PROXEL® GXL, Avecia Inc. (Wilmington, DE) served as a preservative. The base control formulation is provided in Table 9. Component quantities were consistent across the
15 test formulations unless otherwise stated.

 The oil modified polyurethane dispersion, Spensol F97-MPW 33, was used for its compatibility with water and for its toughness and durability characteristics. Spensol F97-MPW 33 is made up of 60% Water, 33% Polyurethane Resin. 5.0% 1-Methyl-2-Pyrrolidinone (organic solvent used to disperse the urethane in water) and 1.5% N,N-
20 Diethylethanamine (used as a chain extension). As in prior examples, the WPI was made into a 10% protein solution and was denatured by heating at 90°C for 30 minutes. In each of the formulations, the total solids (TS) were maintained at 21% TS by substituting WPI for resin on a one-to-one solids basis. Thus, as WPI increased in concentration, the amount of polyurethane decreased in concentration.

Table 9

Material Components	Control %
Spensol F97-MPW-33	91.23
10% WPI	0
H ₂ O	7.84
BYK 345	0.153
Acrysol TM RM-2020	0.71
Drewplus L-405	0.024
Proxel® GXL	0.05

5 The amount of WPI was varied from 0% (control) up to 31.5% of 10% aqueous WPI solution. The pH, specific gravity, density and viscosity for each of seven different formulations are provided in Table 10.

Table 10

Sample (WPI%)	pH-level	Specific Gravity	Density (gm/cm³)	Viscosity (Pa.s)
0%	8.096	1.021	1.0162	0.393
10.50%	8.13	1.018	1.0172	0.182
13.13%	8	1.016	1.0013	0.357
16%	8	1.015	0.964	0.556
18.76%	8	1.016	1.0183	0.776
21%	8	1.018	1.0025	0.945
31.50%	7.9	1.016	1.0112	6.766

10

The pH, specific gravity and density varied only slightly, reflecting the compatibility of the formulations and the consistent 21% TS content of each formulation. At 10.5% WPI solution, a notable drop in viscosity was realized, but at 16% and greater, viscosity increased, presumably due to a reduction in water additive and a reduction in resinous binder. 15 The viscosity of each of these seven formulations at varying shear rates is provided in Fig. 2. At a WPI level of 31.5%, a large increase in viscosity was realized indicating that a free flowing limit would likely be approached at higher levels of WPI.

Formulations having 0, 10.5, 21 and 31.5% WPI were cast onto polystyrene Petri-dishes and conditioned in an environmental chamber at 23 ± 2° C and 55 ± 5% Relative 20 Humidity (RH) for at least 48 hours. Water vapor permeability (WVP), moisture content

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(MC), and puncture strength (PS) were determined and are reported in Table 11. Also provided are results for formulations C2 and C4, as described in Example 2 above.

Table 11

WPI Level (%)	WVP(gr.mm/h.m ² .kPa)	MC (%)	PS(N/mm)
Control (0%)	0.09	2.32	25.12
10.5	0.16	2.7	30.52
21	0.48	3.15	32.16
31.5	0.88	4.09	34.27
C2-Acrylic Polyurethane	1.06	5.31	53.41
C4-Water-based Polyurethane	1.12	5.07	64.49

5

As the protein content in the finish increased, the resulting cured coating became more permeable to water vapor. Both WVP and MC, however, were higher for both C2 and C4 (commercial urethane formulations) than for any of the formulations containing WPI. It is believed that the hydrophilicity of the film increases with increasing protein content. Thus, although the WPI formulations exhibited higher WVP and MC than did the control, they were lower than the commercially available acrylic polyurethanes tested. Also, there was a noticeable increase in puncture strength (PS) resulting from increasing WPI concentration.

Drying characteristics were also measured for each of the seven formulations using ASTM Method D5895 and are provided in Table 12. As the WPI concentration increased in successive formulations, the overall water content was reduced. This reduced water content was expected to lead to reduced drying times. Both the "dry hard" and the "dry through" times are provided and show that curing times for the WPI formulations are superior or comparable to those of commercially available non-WPI coatings. Overall, the formulated coatings containing WPI exhibited fast dry hard times and relatively slow dry through times.

15

- 21 -

For example, the dry hard time of the formulation containing 31.5% WPI was less than 30% of the dry hard time for the control containing no WPI.

Table 12

WPI %	Thickness (μ m)	Dry hard time (mins)	Dry through time (mins)
Control - no protein	34.4	22	268
10.50	23.6	16	263
13.13	26.2	16	246
15.75	20.0	15	254
18.36	38.8	13	165
21%	21.8	14	196
31.50%	17.2	6	137

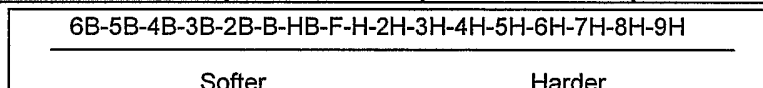
5

Hardness measurements for the seven formulations were also tested. These results are provided in Table 13 and show that up to 21% WPI there was no decrease in either gouge hardness or scratch hardness when compared to the polyurethane control. At 31.5% WPI, the gouge hardness and scratch hardness was reduced one level. It is notable that the results show a hardness range equivalent to that of commercial products (oil modified polyurethane) known for hardness and durability.

10

Table 13

WPI %	Thickness (μ m)	Gouge Hardness	Scratch Hardness
Control - no protein	34.4	H	F
10.50%	23.6	H	F
13.13	26.2	H	F
15.75	20.0	H	F
18.36	38.8	H	F
21%	21.8	H	F
31.50%	17.2	B	2B



5 As illustrated by the VOC data in Table 14, the already low VOC content of the water-based resinous binder is reduced even further by combining with WPI in the formulations tested. By incorporating 10.5% of WPI solution, a 34% reduction in VOCs was realized. At a 31.5% WPI solution, the VOCs were reduced by approximately 41%.

Table 14

WPI-%	Resin-%	VOC (gms/L)
0	91.26	185.6
10.5	60.45	122.95
13.13	59.66	121.34
15.75	58.86	119.71
18.36	58.07	118.11
21	57.27	116.48
31.5	54.09	110.01

These results indicate that by combining two different polymers, WPI and polyurethane, the positive attributes of both can be incorporated into a single wood finish that provides coating characteristics comparable to or better than 100% polyurethane formulation at significantly reduced VOC levels. It is also surprising to see the improvement in puncture strength with an increasing WPI content in the finish formulation.

EXAMPLE 5

The saponified whey wood treatment solution described in United States Patent No. 5,476,686 (the '686 patent) was duplicated so that its applicability as a wood finishing product could be evaluated. Example 2 of the '686 patent was duplicated using sweet whey powder and acid whey powder as starting material and a 45% caustic soda solution as the alkali for saponification.

The resulting pH for these formulations was about 12.2, making the formulations caustic. A formulation made from the sweet whey powder displayed a brown color and the one from the acid whey powder was not stable, as there was extensive precipitation at room temperature. Furthermore, the color changed from light green to brown overnight. Each of the solutions was watery and exhibited a low viscosity. The total solid content was less than

- 24 -

1.8%, indicating that excessive amounts of the caustic solution would need to be used if a protective coating was to be achieved.

Each of the formulations (sweet and acid) was cast onto a Petri dish in an attempt to form a film. Films could not be formed and a simple powdery deposition layer of solids was
5 observed upon drying. It was also noted that the formulation quickly absorbed moisture at a temperature of 23°C and a relative humidity of 50%. It is clear that this formulation cannot form a wood finish although it may be used for penetrating wood shavings in order to repel
pests. The high pH may be responsible for the repellent activity.

It should be understood that although particular embodiments and examples of the
10 invention have been described in detail for purposes of illustration, various changes and modifications may be made without departing from the scope and spirit of the invention. Accordingly, the invention is not to be limited except as by the appended claims.

We claim:

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CLAIMS

1. A wood finish comprising protein.
- 5 2. The wood finish of claim 1 comprising at least about 1.5%, by weight, of protein.
3. The wood finish of claim 1 comprising at least about 3%, by weight, of protein.
- 10 4. The wood finish of claim 1 comprising at least about 5%, by weight, of protein.
5. The wood finish of claim 1 wherein the protein is denatured.
- 15 6. The wood finish of claim 5, wherein the protein is thermally denatured.
7. The wood finish of claim 1, comprising non-saponified protein.
- 20 8. The wood finish of claim 1 having a gouge hardness of greater than 5H.
9. The wood finish of claim 1 further comprising a synthetic resin.
10. The wood finish of claim 9 wherein the synthetic resin is at least partially
25 interacted with the protein.
11. The wood finish of claim 9 wherein the synthetic resin comprises an acrylic resin.
- 30 12. The wood finish of claim 9 wherein the synthetic resin comprises a urethane resin.

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13. The wood finish of claim 1 comprising an anti-marring agent.

14. An article comprising the wood finish of claim 1 disposed on a wood substrate.

5

15. The article of claim 14 wherein the protein comprises a denatured protein.

16. The article of claim 14 wherein the finish comprises at least 10%, by weight, of protein.

10

17. The article of claim 14 wherein the finish exhibits a scratch hardness of greater than B.

18. The article of claim 14 wherein the finish comprises a clear film.

15

19. The wood finish of claim 1 wherein the protein comprises whey protein.

19. The wood finish of claim 19 comprising at least about 1.5%, by weight, of whey protein.

20

20. The wood finish of claim 19 comprising at least about 3%, by weight, of whey protein.

21. The wood finish of claim 19 comprising at least about 5%, by weight, of whey protein.

25

22. The wood finish of claim 19 wherein the whey protein is denatured.

23. The wood finish of claim 22, wherein the whey protein is thermally denatured.

30

24. The wood finish of claim 19, comprising non-saponified whey protein.

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25. The wood finish of claim 19 having a gouge hardness of greater than 5H.
26. The wood finish of claim 19 further comprising a synthetic resin.
- 5 27. The wood finish of claim 26 wherein the synthetic resin is at least partially interacted with the whey protein.
28. The wood finish of claim 26 wherein the synthetic resin comprises an acrylic resin.
- 10 29. The wood finish of claim 26 wherein the synthetic resin comprises a urethane resin.
30. The wood finish of claim 19 comprising an anti-marring agent.
- 15 31. An article comprising the wood finish of claim 19 disposed on a wood substrate.
32. The article of claim 31 wherein the whey protein comprises a denatured whey protein.
- 20 33. The article of claim 31 wherein the finish comprises at least 10%, by weight, of whey protein.
- 25 34. The article of claim 31 wherein the finish exhibits a scratch hardness of greater than B.
35. The article of claim 31 wherein the finish comprises a clear film.
- 30 36. A wood finish solution comprising:
at least 1.5%, by weight, of protein; and
a resin.

37. The solution of claim 36 wherein the pH of the solution is less than 9.
38. The solution of claim 36 wherein the protein comprises non-saponified
5 protein.
39. The solution of claim 36, wherein the protein comprises thermally denatured protein.
40. The solution of claim 36 comprising less than 50%, by volume, of VOCs.
10
41. The solution of claim 36 comprising less than 30%, by volume, of VOCs.
42. The solution of claim 36 comprising less than 20%, by volume, of VOCs.
15
43. The solution of claim 36 comprising less than 10%, by volume, of VOCs.
44. The solution of claim 36 having a viscosity of greater than 20 mPa-s.
45. The wood finishing solution of claim 36 comprising at least 3%, by weight, of
20 denatured protein.
46. The wood finishing solution of claim 36 comprising at least 5%, by weight, of
denatured protein.
47. The wood finish solution of claim 36 wherein the protein comprises whey
25 protein.
48. The solution of claim 47 wherein the pH of the solution is less than 9.
49. The solution of claim 47 wherein the whey protein comprises non-saponified
30 whey protein.

- 29 -

50. The solution of claim 47, wherein the whey protein comprises thermally denatured whey protein.
- 5 51. The solution of claim 47 comprising less than 50%, by volume, of VOCs.
52. The solution of claim 47 comprising less than 30%, by volume, of VOCs.
53. The solution of claim 47 comprising less than 20%, by volume, of VOCs.
- 10 54. The solution of claim 47 comprising less than 10%, by volume, of VOCs.
55. The solution of claim 47 having a viscosity of greater than 20 mPa-s.
- 15 56. The wood finishing solution of claim 47 comprising at least 3%, by weight, of denatured whey protein.
57. The wood finishing solution of claim 47 comprising at least 5%, by weight, of denatured whey protein.
- 20 58. A method comprising:
denaturing a protein to produce a denatured protein; and
mixing the denatured protein with water and a resin to produce a wood finish solution.
- 25 59. The method of claim 58 wherein the protein comprises less than about 2% fat and less than about 2% carbohydrate, by weight.
60. The method of claim 58 comprising mixing an additive into the wood finish solution wherein the additive is selected from biocides, mar reducing agents,
30 defoamers and coalescing solvents.
61. The method of claim 58 wherein the protein is thermally denatured.

- 30 -

62. The method of claim 58 wherein the wood finish solution comprises greater than about 1.5%, by weight, of protein.

5 63. The method of claim 58 wherein the wood finish solution comprises greater than about 3%, by weight, of protein.

64. The method of claim 58 wherein the wood finish solution comprises greater than about 5%, by weight, of protein.

10

65. The method of claim 58 wherein the resin comprises a waterborne resin.

66. The method of claim 65 wherein the resin is selected from acrylic resins, urethane resins, and mixtures thereof.

15

67. The method of claim 59 wherein the wood finish solution comprises greater than about 1.5% protein, by weight.

20

68. The method of claim 59 wherein the wood finish solution comprises greater than about 3% protein, by weight.

69. The method of claim 59 wherein the wood finish solution comprises greater than about 5% protein, by weight.

25

70. A method comprising:
denaturing a whey protein to produce a denatured whey protein; and
mixing the denatured whey protein with water and a resin to produce a wood finish solution.

30

71. The method of claim 70 wherein the whey protein comprises less than about 2% fat and less than about 2% carbohydrate, by weight.

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72. The method of claim 70 comprising mixing an additive into the wood finish solution wherein the additive is selected from biocides, mar reducing agents, defoamers and coalescing solvents.

5 73. The method of claim 70 wherein the whey protein is thermally denatured.

74. The method of claim 70 wherein the whey protein comprises a WPC or WPI.

75. The method of claim 70 wherein the whey protein comprises a WPI.

10

76. The method of claim 71 wherein the whey protein is thermally denatured.

77. The method of claim 70 wherein the wood finish solution comprises greater than about 1.5%, by weight, of whey protein.

15

78. The method of claim 70 wherein the wood finish solution comprises greater than about 3%, by weight, of whey protein.

79. The method of claim 70 wherein the wood finish solution comprises greater than about 5%, by weight, of whey protein.

20

80. The method of claim 70 wherein the resin comprises a waterborne resin.

81. The method of claim 80 wherein the resin is selected from acrylic resins, urethane resins, and mixtures thereof.

25

82. The method of claim 71 wherein the wood finish solution comprises greater than about 1.5% whey protein, by weight.

83. The method of claim 71 wherein the wood finish solution comprises greater than about 3% whey protein, by weight.

30

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84. The method of claim 71 wherein the wood finish solution comprises greater than about 5% whey protein, by weight.

85. A method comprising:

5 applying a wood finish solution to a wooden substrate wherein the wood finish solution comprises protein.

86. The method of claim 85 wherein the wooden substrate comprises furniture.

10 87. The method of claim 85 wherein the wooden substrate comprises a toy.

88. The method of claim 85 wherein the wooden substrate comprises finish carpentry.

15 89. The method of claim 85 wherein the wood finish solution comprises less than about 200 g/L VOCs.

90. The method of claim 85 wherein the protein is denatured.

20 91. The method of claim 85 wherein the protein is thermally denatured.

92. The method of claim 85 wherein the protein comprises whey protein.

25 93. The method of claim 85 wherein the protein consists essentially of whey protein.

93. The method of claim 85 wherein the wooden substrate comprises furniture.

94. The method of claim 85 wherein the wooden substrate comprises a toy.

30

95. The method of claim 85 wherein the wooden substrate comprises finish carpentry.

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96. The method of claim 85 wherein the wood finish solution comprises less than about 200 g/L VOCs.
- 5 97. The method of claim 85 wherein the whey protein comprises WPI.
98. The method of claim 97 wherein the whey protein is denatured.
99. The method of claim 98 wherein the whey protein is thermally denatured.
- 10 100. A kit comprising:
a container of wood finish solution; and
instructions for applying the wood finish solution to a wood substrate wherein
the wood finish solution comprises protein.
- 15 101. The kit of claim 100 wherein the protein is denatured.
102. The kit of claim 100 wherein the protein comprises whey protein.
- 20 103. The kit of claim 102 wherein the whey protein comprises WPI.
104. The kit of claim 103 wherein the WPI is denatured.
105. The wood finish of claim 12 wherein the urethane is an oil modified
25 polyurethane.
106. The article of claim 17 wherein the scratch hardness is greater than HB.
- 30

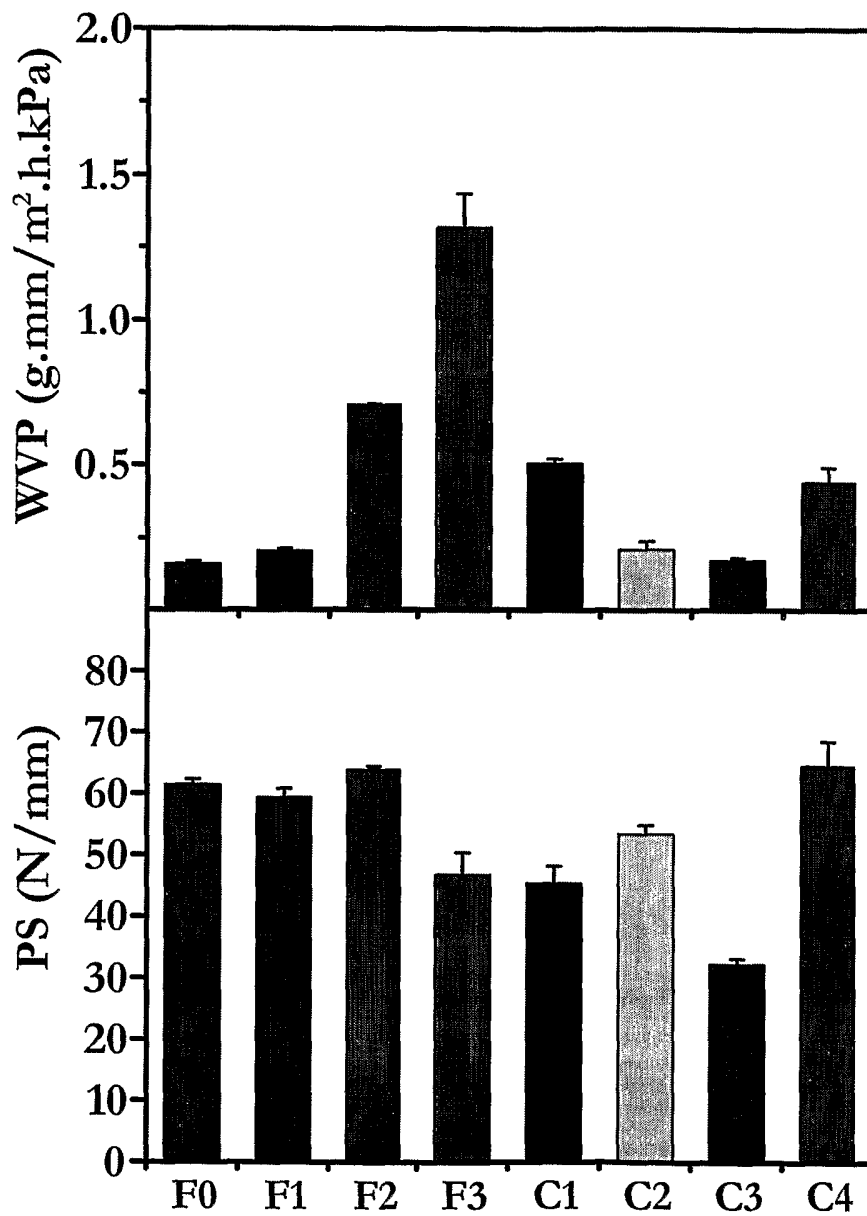


FIG. 1

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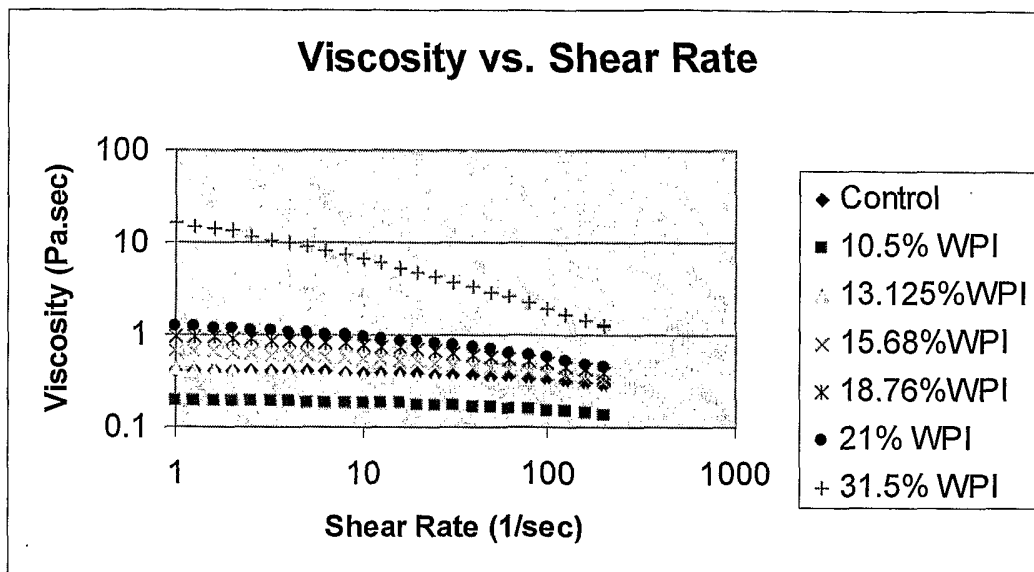


FIG. 2