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(54) **PROCESSES AND MANUFACTURING METHODS TO PRODUCE AN AQUEOUS THERMOSETTING FIRE-RATED FIRE-RETARDANT POLYMERIC ADHESIVE COMPOSITION FOR MANUFACTURING INTERIOR OR EXTERIOR FIRE-RATED CELLULOSIC PRODUCTS**

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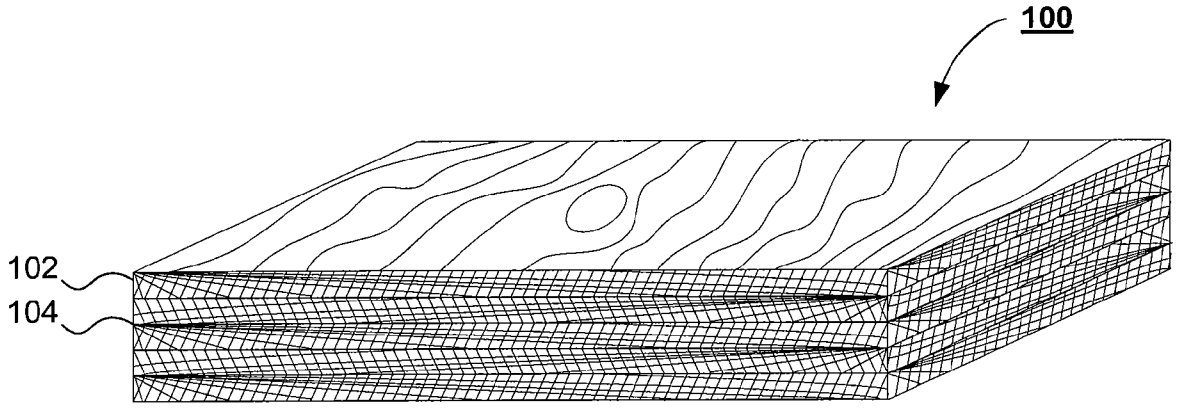
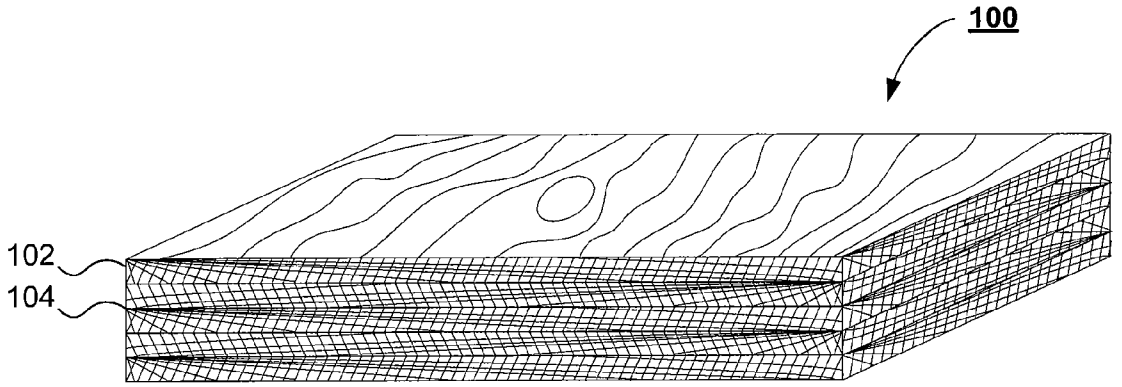
(57) **ABSTRACT**

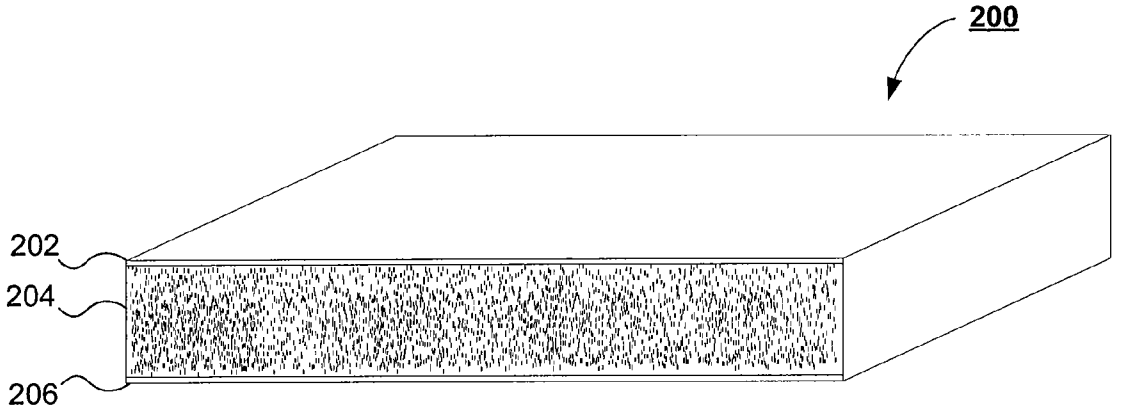
Disclosed is a fire-retardant non-corrosive composition, as well as a process for the production of porous materials, wherein the process is conducted in the presence of the said fire-retardant, non-corrosive composition. The fire-retardant, non-corrosive composition of the subject application includes a flame-retardant agent, preservative composition, casein liquid modified melamine resin adhesive, and a monomeric-polymeric MDI catalyst. The composition material and the product resulting from the process of the subject application have fire retardant, non-corrosive properties and protection from fungus and insects.






PLYWOOD

*FIGURE 1*




GYPSUM BOARD

*FIGURE 2*

# PROCESSES AND MANUFACTURING METHODS TO PRODUCE AN AQUEOUS THERMOSETTING FIRE-RATED FIRE-RETARDANT POLYMERIC ADHESIVE COMPOSITION FOR MANUFACTURING INTERIOR OR EXTERIOR FIRE-RATED CELLULOSIC PRODUCTS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation-in-part application and is based on and claims priority to U.S. Provisional Patent Application Ser. No. 60/846,712, which was filed on Sep. 22, 2006, the entirety of which is incorporated herein by reference; and U.S. patent application Ser. No. 11/671,761, filed Feb. 6, 2007, the entirety of which is herein incorporated by reference.

## BACKGROUND OF THE INVENTION

**[0002]** Cellulosic materials have many desirable properties and for this reason are widely used in wood composite construction materials. Typical construction materials, which are generally defined as manufactured fire-rated cellulosic products, necessitate performance-based tests that strictly comply with approved and mandated fire and quality control testing procedures promulgated by the relevant legislative and regulatory bodies. End use performance-based tests of fire-rated cellulosic products dictate by what means the fire-rated cellulosic products should be manufactured.

**[0003]** Examples of such products include, but are not limited to, oriented strand board (OSB), medium density fiber board, particle board, fiber mat, pressboard, gypsum fiber board, fiber board, cement fiber board, and the like. Typical fire-retardant compositions currently in use include salt compositions, such as phosphates and sulfates, or active ingredients, such as ammonium sulfates. However, the latter have been found to be corrosive to metal, including any metal fasteners, such as staples or nails, used to secure the treated materials.

**[0004]** Natural wood is also known to be a material of choice for building construction due to its strength, appearance, durability, accessibility and non-corrosive nature. However, being highly flammable and having no natural resistance to fungal and/or insect permeation, natural wood also requires special treatment for obtaining specific properties stipulated by the above-mentioned standards.

## SUMMARY OF THE INVENTION

**[0005]** This application is directed to fire rated, flame-resistant, aqueous thermosetting, high-density, structural adhesive materials and to methods for incorporating these materials into products through the manufacturing process. The subject application also relates to compositions used to impart fire, fungal and insect resistance to a wide range of cellulosic materials including wood-based fibers and particles, cellulose wafers, wood strands, straw, cane, organic waste products and inorganic waste products.

**[0006]** Thus, in accordance with the present invention, there is provided an aqueous, non-corrosive, fire-retardant composition, which is also resistant to a variety of fungi and insects. This composition includes a pre-blended combination of: i) flame-retardant; ii) a preservative composition; iii) a casein liquid modified melamine resin adhesive; and iv) a monomeric-polymeric ethylene diphenyldiisocyante (MDI) catalyst. This composition may be applied to a variety of wood products. The amounts of flame retardant, preservative composition, casein liquid modified melamine resin adhesive, and monomeric-polymeric MDI catalyst in the composition is determined by stipulated design factors for a given type of wood product. The monomeric-polymeric MDI catalyst includes a liquid mixture comprising pure MDI and higher homologs.

**[0007]** In one embodiment, the weight ratio of the flame-retardant to the MDI catalyst ranges from approximately 50:1 to 300:1, wherein the weight ratio of the casein liquid modified melamine resin adhesive to the preservative composition ranges from approximately 1:1 to 1:10.

**[0008]** In another embodiment, the preservative composition comprises 98% disodium octaborate tetrahydrate, and 2% inert $Na_2B_8O_{13}$, $4H_2O$. In yet another embodiment, the casein is a liquid, modified melamine resin adhesive and is selected from the group consisting of a modified melamine, (free formaldehyde concentration of less than 0.5% by weight) and 2,4,6-triamino symtriazine.

**[0009]** Further, another embodiment of the present invention comprises a finely divided material selected from the group consisting of cellulosic material, mineral material, organic waste material, and inorganic waste material. The composition further comprises: i) a flame-retardant; ii) a preservative composition; iii) a casein liquid modified melamine resin adhesive; and iv) an MDI catalyst. The relative amounts of flame-retardant, preservative, casein liquid melamine resin adhesive, and MDI catalyst are determined by stipulated design factors for a given composition material and are known to those skilled in the art.

**[0010]** Still further, in accordance with the present invention, there is provided a process for production of porous materials selected from the group consisting of cellulosic products, such as wood, lumber, plywood, modified density overlay plywood, wood particle board, oriented stand board, mineral fiber board, wood substrates, and cellulose insulation including fiber and panel-type isolations, wherein the process is conducted in the presence of the fire-retardant composition. The amount of the fire-retardant composition is determined by stipulated design factors for a given porous material.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0011]** The subject application is described with reference to certain figures, including:

**[0012]** FIG. **1** is an illustration depicting a cellulosic product according to one embodiment of the subject application; and

**[0013]** FIG. **2** is an illustration depicting a gypsum product according to one embodiment of the subject application.

## DETAILED DESCRIPTION OF THE INVENTION

### Definitions

**[0014]** 1) "Wood material/composite" is defined as a composite material that comprises wood and one or more other additives, such as adhesives or waxes. Non-limiting examples of wood composite materials include oriented strand board ("OSB"), waferboard, chipboard, particleboard, fiberboard, and plywood. As used herein, "flakes", "strands", and "wafers" are considered equivalent to one another and are used interchangeably.

**[0015]** Preferred wood composite materials utilized in this invention are derived from naturally occurring hard or soft woods, singularly or mixed, whether such wood is dried (having a moisture content of between about 2 wt % and about 12 wt %) or green (having a moisture content of between about 30 wt % and about 200 wt %). Preferably, the wood composite materials comprise dry wood parts having a moisture content of about 3 to about 8 wt %. Typically, the raw wood starting materials, either virgin or reclaimed, are cut into strands, wafers or flakes of desired size and shape, which are well-known to one of ordinary skill in the art.

**[0016]** 2) Polymeric MDI is defined as a mixture of pure monomeric-polymeric MDI, used as a catalyst, (ethylene diphenyl diisocyanate) and higher polyisocyante homologues, where n=1-20. A typical polymeric MDI consists of approximately 50% pure MDI, 30% triisocyanate, 10% tetraisocyanate, 5% penta-isocyanate, and 5% higher homologues. The average functionality of a standard polymeric MDI is about 2.7, with a typical viscosity of about 200 mPa at 25° C. An example of a polymeric MDI is Lupranate M20 FB™ manufactured by BASF Corporation of Wyandotte, Mich.

**[0017]** 3) Pure MDI (methylene diphenyl diisocyanate) consists mainly of two isomers: 2,4'-MDI and 4,4'-MDI.

**[0018]** The present invention is directed to fire-retardant materials and to methods for incorporating fire-retardant qualities into products through manufacturing processes. This invention also relates to compositions used to impart flame, fungi and insect resistance to a wide range of cellulosic materials, including, but not limited to, wood-based fibers and particles, cellulose wafers, wood strands, and organic waste products.

**[0019]** The aqueous, non-corrosive, fire-retardant compositions of the present invention also impart to these products resistance to fungi and insects. These fire-retardant compositions include a pre-blended combination of: i) a flame-retardant; ii) a preservative composition; iii) casein; liquid modified melamine resin adhesive; and iv) monomeric-polymeric MDI catalyst. The relative amounts of flame-retardant, preservative composition, casein liquid modified melamine resin adhesive and monomeric-polymeric MDI catalysts are determined by stipulated design factors for a given composition material.

**[0020]** In addition, the fire-retardant composition of the present invention provides a combination of strength properties as well a significant increase in the structural design value of any fire-rated manufactured cellulosic product.

**[0021]** Manufactured products incorporating the subject application must satisfy and conform with all applicable Building Code Procedures and design requirements promulgated by accredited, accepted and approved testing bodies and quality control agencies, including but not limited to the following:

**[0022]** 1. ASTM Designation: D 2559-00: Standard Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet Use) Exposure Conditions.

**[0023]** 2. ASTM Designation: D 3801-00: Standard Test Method for Measuring the Comparative Burning Characteristics of Solid Plastics in a Vertical Position.

**[0024]** 3. ASTM Designation: D 635-03: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position (Vol. 08.01).

**[0025]** 4. ASTM Designation: E 662-03: Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials (Vol. 04.07).

**[0026]** 5. ASTM Designation: D 3014-04: Standard Test Method for Flame Height, Time of Burning, and Loss of Mass of Rigid Thermoset Cellular Plastics in a Vertical Position (Vol. 08.01).

**[0027]** 6. ASTM Designation: D 2863-06: Standard Test Method for Measuring the Minimum Oxygen Concentrate to Support Candle-Like Combustion of Plastics (Oxygen Index) (Vol. 08.01).

**[0028]** 7. Underwriters Laboratories, Inc.: Test Standard and Method UL 94 Vertical Burning Test; 94V-0.

**[0029]** 8. ASTM Designation: D 1037: Standard Test Method for Evaluating Properties of Wood-Base Fiber and Particle Materials I—Accelerated Aging-Per Section 112-118.

**[0030]** 9. APA—The Engineered Wood Association: APA Product Standard PS-2 APA Quality Assurance Policies for Structural-Use Panels Qualified to PRP-108.

**[0031]** 10. National Building Code of Canada (NBCC) CSA 0112.7-M:ANSI/AHC A190.1.

**[0032]** 11. 2003 International Building Code and Standards (IBC): Chapter 23 SECTION 2303—STANDARDS OF QUALITY 7. Adhesives and glues, 7.2. ASTM D 2559, Wet Use Adhesives.

**[0033]** 12. 2005 California Building Code and Standards (CBC): Chapter 23 SECTION 2303—STANDARDS OF QUALITY 7. Adhesives and glues, 7.2. ASTM D 2559, Wet Use Adhesives.

**[0034]** 13. ICC-ES Acceptance Criteria for Thermoplastic Composite Lumber Products (AC 109) dated June 2006.

**[0035]** 14. ICC-ES Acceptance Criteria for Foam Plastic Insulation (AC 12) Approved June 2006.

**[0036]** 15. American Wood Preservers' Association Standard (under the jurisdiction of AWPA subcommittee T-7): STANDARD FOR QUALITY CONTROL INSPECTION OF NON-PRESSURE PRESERVATIVE TREATED COMPOSITE WOOD PRODUCTS.

**[0037]** 16. American Wood Preservers' Association Standard (under the jurisdiction of AWPA subcommittee T-8): COMPOSITES.

**[0038]** 17. Underwriters Laboratories, Inc. Follow-Up Service Procedure (Type R) for a Recognized Component Treatments for Flammability Reduction: Evaluation Testing for Fire-Retardant Composition.

**[0039]** 18. Underwriters Laboratories, Inc. Test Title: UL 723

**[0040]** ASTM Designation: E-84

**[0041]** Canadian Standard: CAN/ULC-S102M

**[0042]** Test for Surface Burning Characteristics of Building Materials and Classification.

**[0043]** Flame Spread and Smoke Developed values for cellulosic structural products applicable to numerical ratings not more than 25

**[0044]** Flame Spread Index (FSI): 25

**[0045]** Smoke Density Index (SDI): 25

The Flame-Retardant

**[0046]** The flame-retardant is any appropriate substance that is applied to a combustible material to suppress the flame. Flame-retardants function by reducing the burn rate. There are two types of flame retardants: ones that work well with materials that have a substantial amount of amount of oxygen,

such as cellulose; and certain synthetic polymers, that carry out the function in the material itself. And there are those that are effective for materials with carbon-based polymers, such as polyethylene or polyvinyl chloride. Compounds of phosphoric or sulfuric acid are most commonly used as flame retardants for the first class materials. As long as wood, paper, and polymers are in normal use, the acid is neutralized by simple organic substances that vaporize the onset of fire. The other type of flame retardant is made of materials that decompose in the fire intervening with the burning process.

**[0047]** In the present invention, a flame-retardant is a phosphate-based, nitrogen-liberating compound, which releases nitrogen in the presence of a flame. Phosphate-based flame-retardant materials include polyphosphates, such as ammonium polyphosphate (APP). In another embodiment, a flame retardant of the invention comprises ingredients selected from the group consisting of phosphate and nitrogen-based fire-retardants, such as melamine (i.e., 1,3,5-triazine-2,4,6-triamine phosphate).

**[0048]** Another example of a flame-retardant is a boric acid phosphate, having a viscosity of about 20-40 $mm^2/s$ (20° C.), a pH ranging from about 3 to about 8, a specific gravity (density) of about 1.0 to about 1.4 $g/cm^3$ (at 20° C.). The flame-retardant is preferably from about 5% to about 70% of the total composition (weight by volume ("w/v"). An example of a suitable flame retardant includes, but is not limited to Melflam 136/12/FR2, manufactured by Degussa Corporation.

Polymeric Methylene Diphenyl Diisocynate (MDI)

**[0049]** The fire-retardant composition further includes polymeric MDI. The polymeric MDI is preferably a liquid mixture containing pure methylene diphenyl diisocyanate and polyisocyanates. An example of a polymeric MDI is Lupranate M20 FB® manufactured by BASF Corporation of Wyandotte, Mich.

**[0050]** The polymeric MDI serves as a catalyst, initiating polymerization of the composition. The polymerization-curing process is suitable for electronic as well as hot press bonding. Not being bound by theory, it is thought that when the cellulosic wood products are treated with a casein liquid modified melamine resin adhesive, the casein liquid modified melamine resin adhesive increases the strength properties of the cellulosic wood products. The casein liquid modified melamine resin adhesive also provides an impervious moisture barrier for the cellulosic product, suitable for exposure in outdoor/exterior applications. Further, the casein liquid modified melamine resin adhesive included in the fire-retardant composition provides non-corrosive properties allowing application of the fire-retardant composition to wood products that are used together with metal fasteners, such as nails, staples, bolts, truss plates, steel connectors, and the like. The monomeric-polymeric MDI catalysis generally comprises from about 0.0005% to about 10% of the total composition (w/v).

**[0051]** The casein liquid modified melamine resin adhesive generally comprises from about 100:1 to about 1:1 relative to the amount of monomeric-polymeric MDI catalysis. Higher amounts of the monomeric-polymeric MDI catalyst will cause the casein liquid modified melamine resin adhesive to react very quickly at lower reaction temperatures, while lower amounts of monomeric-polymeric MDI catalysis will require longer reaction times and higher reaction temperatures.

The Casein Liquid Modified Melamine Resin Adhesive

**[0052]** The casein liquid modified melamine resin adhesive generally comprises a waterproof melamine resin adhesive, such as 1,3,5-triazine-2,4,6-triamine phosphate.

**[0053]** The casein liquid modified melamine resin adhesive is the wood material bonding agent. The monomeric-polymeric MDI catalyst causes the casein liquid modified melamine resin adhesive to polymerize, with the wood material under high pressure, high temperature, and specified time.

**[0054]** The casein liquid modified melamine resin adhesive is characterized by a viscosity (at 70-78° F.) ranging from about 600-1000 cP, a pH ranging from about 8.0-10, a free formaldehyde concentration of less than about 0.5% by weight, and a specific gravity of about 1.24 Kg/liter. An example of a suitable casein liquid modified melamine resin adhesive includes, but is not limited to, that manufactured by National Casein of Jersey City, N.J., in accordance with delamination requirements and specifications that must comply with ASTM Designation: D 2559-00. Standard Specification for Adhesives for Structural Laminated Wood Products for Use Under Exterior (Wet-Use) Exposure Conditions.

**[0055]** The amount of casein liquid modified melamine resin adhesive used in the fire-retardant composition is generally within the range of about 100:1 to about 1:1, relative to the amount of monomeric-polymeric MDI catalyst. Higher amounts of the monomeric-polymeric MDI catalyst will cause the casein liquid modified melamine resin adhesive to react very quickly at lower reaction temperatures, while lower amounts of monomeric-polymeric MDI catalyst will require longer reaction times and higher reaction temperatures.

The Preservative

**[0056]** The preservative is comprised of disodium octaborate tetrahydrate. An example of a suitable preservative agent includes, but is not limited to, that manufactured by Quality Borate Co. of Cleveland, Ohio. The preservative agent included in the fire-retardant composition in combination with above described agents, provides resistance to fungi and insects, as well as increased structural rigidity for the treated cellulosic products. The preservative generally constitutes from about 1% to about 80% (w/v) of the total fire-retardant composition.

**[0057]** Additional water-soluble liquid wood preservatives may also be used.

Use of the Fire-Retardant Composition with Cellulosic Materials

**[0058]** An example of the fire-retardant composition used in combination with a cellulosic material would typically include the said composition, used to treat a finely divided cellulosic material selected from the group consisting of wood-based fibers and particles, cellulose wafers, wood strands, straw, cane, organic waste products, and inorganic waste products. The fire-retardant composition also provides product resistance to fungi. The amount of fire-retardant composition used to treat the cellulosic material is determined by stipulated design factors for a given composition material. Those skilled in the art will appreciate that the relative

amounts of particular agents of the fire-retardant composition are also determined by design factors for a given composition material.

Material Production Process

**[0059]** Also described is a process for the production of porous materials selected from the group of cellulosic products, where the cellulosic products are selected from the group consisting of oriented strand board, medium density fiber board, wood particle board, fiber mat, pressboard, gypsum fiber board, fiber board, cement fiber board, wood, lumber, wood substrates, structural laminated veneer lumber, scaffold planks, laminated glu-lam structural wood beams, plastic laminate(s), pipe insulation, hydraulic additive, foam insulation panel(s), paper, structural plywood, mineral fiber board, modified density overlay, cellulosic installation, insulation(s), including loose fill or panel-type applications. The production process is conducted in the presence of a fire-retardant, non-corrosive aqueous solution. The fire-retardant non-corrosive aqueous solution includes in combination a flame-retardant agent, preservative composition, casein liquid modified melamine resin adhesive, and a monomeric-polymeric MDI catalyst in an amount sufficient for polymerization of the combination of a flame retardant agent, preservative composition, casein liquid modified melamine resin adhesive. The amount of the fire-retardant non-corrosive aqueous solution is determined by stipulated design factors for a given porous material.

**[0060]** As will be appreciated by those skilled in the art, the flame-retardant agent, preservative composition, casein liquid modified melamine resin adhesive, and monomeric-polymeric MDI catalyst, in the composition material of the subject application, are selected analogous to that as described above with reference to the fire-retardant non-corrosive composition. Those skilled in the art will further appreciate that no modification to the process for production of porous materials is necessary other than adding the fire-retardant, non-corrosive aqueous solution of the subject application to a current manufacturing process. No special equipment or machinery is required. The product resulting from the process of the subject application has fire-retardant, non-corrosive properties and is also resistant to fungus and insects. Those skilled in the art will further appreciate that the fire-retardant, non-corrosive composition of the subject application can be applied to existing wood or wood structural members during retrofit or renovation projects as well as manufactured products which are selected from the group consisting of oriented strand board, medium density fiber board, wood particle board, fiber mat, pressboard, gypsum fiber board, fiber board, cement fiber board, wood, lumber, wood substrates, structural wood assemblies, wood particle board doors and wood frames, structural laminated veneer lumber, scaffold planks, laminated glu-lam structural wood beams, plastic laminate (s), pipe insulation, hydraulic additive, foam insulation panel (s), paper, structural plywood, mineral fiber board, modified density overlay, and insulation and combinatios thereof.

**[0061]** The following examples are provided to demonstrate a preferred method of preparing and using the fire-retardant non-corrosive compositions in accordance with the subject application.

EXAMPLE 1.1

Preparing a Fire-Retardant Non-Corrosive Composition

**[0062]** The subject application features a stable, non-corrosive composition for imparting fire, insect and fungus resistant qualities and comprises an aqueous solution selected from a group of fire-rated, flame-resistant constituents and resin adhesive materials.

**[0063]** Relative proportions of the blended fire-retardant, non-corrosive constituents can be adjusted to optimize results based upon the stipulated design factors and the desired characteristics and qualities of the end-use physical and fire-rated cellulosic product. Those skilled in the art will be able to determine, through routine experimentation, the most effective relative percent by weight amounts of the constituents set forth above to create their preferred fire-rated non-corrosive composition.

EXAMPLE 1.2

Preparing a Liquid Mixture of a Fire-Rated Flame Resistant Aqueous Thermosetting High-Density Structural Adhesive

**[0064]** Using the methodology described below, the indicated percent amounts of the blended constituents (flame retardant agent, preservative composition, casein liquid modified melamine resin adhesive; and a monomeric-polymeric MDI catalyst, total weight by volume) together form a liquid mixture of the fire-rated, flame-resistant aqueous thermosetting high-density structural resin adhesive composition.

**[0065]** A. To a mixing tank, add 48.98 percent (w/v) of the liquid flame-retardant component Melflam 136/12/FR2®.

**[0066]** B. Add about 30.5 percent (w/v) of the preservative composition Disodium Octaborate Tetrahydrate.

**[0067]** C. Continue mixing with constant stirring until a smooth liquid mixture results.

**[0068]** D. Add 20.33 percent (w/v) of the casein liquid modified melamine resin adhesive wood material bonding agent. MB 4650.

**[0069]** E. Continue mixing with constant stirring until a smooth liquid mixture results.

**[0070]** F. Add 0.18 percent (w/v) of the monomeric-polymeric MDI catalysis: BASF Lupranate M20 FB.

**[0071]** G. Continue mixing with constant stirring until a smooth liquid mixture results.

**[0072]** H. Transfer blended fire-retardant adhesive composition to holding tank and store until ready for use.

EXAMPLE 1.3

Application of a Fire-Retardant Adhesive to a Cellulosic Material

**[0073]** The following example is conducted in compliance with EN ISO 9001:2000; BS EN ISO:2000; ANSI/ASQ Q9011:2000; for the following scope of registration; 8734 (US): TESTING LABORATORIES (per test conducted by CRT LABORATORIES, INC., ORANGE, CA [an UNDERWRITERS LABORATORIES, INC. registered firm, A3135, LWR NO: 16756-R1] on Sep. 15, 2006).

**[0074]** The composition materials listed in Example 1.2, combined as set forth therein, together to form a liquid mixture of the fire-rated flame resistant aqueous thermosetting high-density structural adhesive composition.

**[0075]** SAMPLE DESCRIPTION: Blended proprietary Fire-Retardant Adhesive (polymer) Component and Oriented Strand (OSB) cellulosic material.

**[0076]** TEST PROCEDURES: Underwriters Laboratories, Inc. Test Method UL 94V0 Vertical Flammability Test; Flame Temperature: 843° C. (1,550° F.).

**[0077]** PREPARATION: UL 94 fire test specimens; ½"×5" (1.60-1.64 mm thickness) were culled from a framed mold prepared with a 30 ton hot press operating at 204° C.

**[0078]** RESULTS: The fire-retardant adhesive and combined cellulosic oriented strand (OSB) material is non-flammable.

**[0079]** CONCLUSION: The blended Fire-Retardant Adhesive and Oriented Strand Board (OSB) material conforms to Underwriters Laboratories, Inc. requirements for a fire rating of UL94 V-O.

**[0080]** FIG. **1** shows an example of a cellulosic product manufactured in accordance with the methods described herein, and a fire-rated, flame-retardant, preservative adhesive composition in accordance with the subject application. As shown in FIG. **1**, the cellulosic product, depicted as a standard sheet of plywood **100**, comprises two or more thin sheets of wood **102** and a layer of adhesive **104** lying between the sheets. Thus, as will be understood by those skilled in the art, a first sheet of suitable wood, e.g., Douglas fir, southern yellow pine, pine, oak, maple, or the like, is coated on one surface with the fire-rated, flame resistant, preservative adhesive composition **104**. A second sheet of wood is then laid on top of the first sheet, whereupon the adhesive **104** on the top of the first sheet adheres to the bottom of the second sheet. This process is repeated until such time as the desired plywood thickness level is achieved, e.g., ¼", ½", ¼", 1", or the like. The last or top sheet, shown in FIG. **1** as the sheet **102**, is placed on the top of the stack, with one side in contact with an adhesive layer **104**. Thereafter, as will be understood by those skilled in the art of plywood manufacturing, the stacked sheets are compressed, heated and cut to the desired length and width (e.g., 4'×8").

**[0081]** FIG. **2** illustrates an example product manufactured in accordance with the methods described herein, and a fire-rated, flame resistant, preservative adhesive composition in accordance with the subject application. As shown in FIG. **2**, the product, is shown as a gypsum sheet or board **200**, also known as drywall, sheetrock, or the like. The gypsum board **200** includes two sheets of a suitable paper material, sheets **202** and **206**, between which is the material **204**. Preferably, the sheets **202** and **206** adhere to the material **204** using the fire-rated, flame resistant, preservative adhesive composition.

**[0082]** The foregoing description of preferred embodiments of the subject application has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the subject application to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiments were chosen and described to provide the best illustration of the principles of the subject application and its practical application to thereby enable one of ordinary skill in the art to use the subject application in various embodiments and with various modifications as are suited to the particular use contemplated.

What is claimed:

**1**. An aqueous, fire-retardant, non-corrosive composition for application to wood products, said composition comprising a pre-blended combination of: a) a flame-retardant agent; b) a preservative composition; c) a casein liquid modified melamine resin adhesive; and d) a monomeric-polymeric MDI catalyst; wherein the amounts of the flame-retardant agent, preservative composition, casein liquid modified melamine resin adhesive, and monomeric-polymeric MDI catalyst are determined by stipulated design factors for a given wood product.

**2**. The aqueous fire-retardant composition of claim **1** wherein the flame-retardant agent is an aqueous condensate, comprising 1,3,5-triazine-2,4,6-triamine phosphate.

**3**. The aqueous fire-retardant composition of claim **1**, wherein the preservative composition comprises 98% disodium octaborate tetrahydrate and 2% inert $Na_2B_8O_{13}$, $4H_2O$.

**4**. The aqueous fire-retardant composition of claim **1**, wherein the monomeric-polymeric MDI catalyst comprises a liquid mixture of monomeric methylene diphenyl diisocyanate isomers and polyisocyanates.

**5**. The aqueous fire-retardant composition of claim **1**, wherein the weight ratio of the flame-retardant agent to the monomeric-polymeric MDI catalyst ranges from approximately 50:1 to 300:1, and wherein the weight ratio of the casein liquid modified melamine resin adhesive to the preservative composition ranges from approximately 1:1 to 1:10.

**6**. The aqueous fire-retardant composition of claim **1**, wherein the casein liquid modified melamine resin adhesive comprises 2,4,6-triamino symtriazine.

**7**. The aqueous fire-retardant composition of claim **6** wherein the casein liquid modified melamine resin adhesive is a modified melamine having a free formaldehyde concentration of less than about 0.5% by weight.

**8**. A fire-retardant substance comprising: a) a finely divided material selected from the group consisting of cellulosic material, mineral material, organic waste material, and inorganic waste material; b) a flame-retardant agent; c) a preservative composition; d) a casein liquid modified melamine resin adhesive; and e) a monomeric-polymeric MDI catalyst; wherein the combination of the flame-retardant agent, the preservative composition, the casein liquid modified melamine resin adhesive; and the monomeric-polymeric MDI catalyst, are an aqueous solution; and wherein the relative amounts of the of the flame-retardant agent, the preservative composition, the casein liquid modified melamine resin adhesive, and the monomeric-polymeric MDI-catalyst, are determined by stipulated design factors for said finely divided material.

**9**. The fire-retardant substance of claim **8** wherein the flame-retardant agent comprises an aqueous solution of 1,3,5-triazine-2,4,6-triamine phosphate.

**10**. The fire-retardant substance of claim **8**, wherein the monomeric-polymeric MDI catalyst comprises a liquid mixture of monomeric methylene diphenyl diisocyanate and polyisoisocyanates.

**11**. The fire-retardant substance of claim **8**, wherein the weight ratio of the fire-retardant agent to the monomeric polymeric MDI catalyst ranges from approximately 50:1 to 300:1, and wherein the weight ratio of the casein liquid modified melamine resin adhesive to the preservative composition ranges from approximately 1:1 to 1:10.

**12**. The fire-retardant substance of claim **8**, wherein the preservative composition is 98% disodium octaborate tetrahydrate, and 2% $Na_2B_8O_{13}$, $4H_2O$.

**13**. The fire-retardant substance of claim **8**, wherein the casein liquid modified melamine resin adhesive comprises a 2,4,6-triaminosymtriazine.

**14**. The fire-retardant substance of claim **13**, wherein the casein liquid modified melamine resin adhesive is a modified melamine having a free formaldehyde concentrate of less than 0.5% by weight.

**15**. A method for production of a fire-retardant and fungus resistant product, comprising the steps of: a) receiving a product material for incorporation of a fire-retardant and fungus-resistant product; b) applying a pre-determined amount of an aqueous, non-corrosive, fire-retardant solution to the product material, wherein the solution includes a fire-retardant agent, a monomeric-polymeric MDI catalyst, in an amount sufficient for polymerization of the aqueous, fire-retardant, non-corrosive solution, a casein liquid modified melamine resin adhesive; and a preservative composition; and wherein the amount of the aqueous fire-retardant solution is determined by stipulated design factors for a given product material; and c) assembling a manufactured fire-retardant and fungus-resistant product.

**16**. The method of claim **15**, wherein the fire-retardant agent is an aqueous condensate, comprising 1,3,5-triazine-2, 4,6-triamine phosphate.

**17**. The method of claim **15**, wherein the monomeric-polymeric MDI catalyst comprises a liquid mixture of monomeric methylene diphenyl diisocyanate isomers and polyisocyanates.

**18**. The method of claim **15**, wherein the weight ratio of the flame-retardant agent to the monomeric-polymeric MDI catalyst ranges from approximately 50:1 to 300:1, and wherein the weight ratio of the casein liquid modified melamine resin adhesive to the preservative composition ranges from approximately 1:1 to 1:10.

**19**. The method of claim **15**, wherein the preservative composition is 98% disodium octaborate tetrahydrate, and 2% $Na_2B_8O_{13}$, $4H_2O$.

**20**. The method of claim **15**, wherein the casein liquid modified melamine resin adhesive is a 2,4,6-triaminosymtriazine.

**21**. The method of claim **20**, wherein the liquid melamine adhesive is a modified melamine having a free formaldehyde concentration of less than about 0.5% by weight.

**22**. The method of claim **15**, wherein the product material is selected from the group consisting of wood-based fibers, wood-based particles, cellulose wafers, wood strands, straw, cane, organic waste products, and inorganic waste products, and combinations thereof.

**23**. The method of claim **15**, wherein the manufactured product is selected from the group consisting of oriented strand board, medium density fiber board, wood particle board, fiber mat, pressboard, gypsum fiber board, fiber board, cement fiber board, wood, lumber, wood substrates, structural wood assemblies, wood particle board doors and wood frames, structural laminated veneer lumber, scaffold planks, laminated glu-lam structural wood beams, plastic laminate (s), pipe insulation, hydraulic additive, foam insulation panel (s), paper, structural plywood, mineral fiber board, modified density overlay, and insulation and combinatios thereof.

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