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(71) Applicant: **UNITED STATES GYPSUM COMPANY**
 [US/US]; 550 West Adams Street, Chicago, Illinois 60661-3676 (US).

(72) Inventor: **ROHLF, Evan Vincent**; 25400 Barsumian Drive, Tower Lakes, Illinois 60010 (US).

(74) Agents: **CRAIN, Lawrence et al.**; Greer, Burns & Crain, Ltd., 300 S. Wacker Dr., Suite 2500, Chicago, Illinois 60606 (US).

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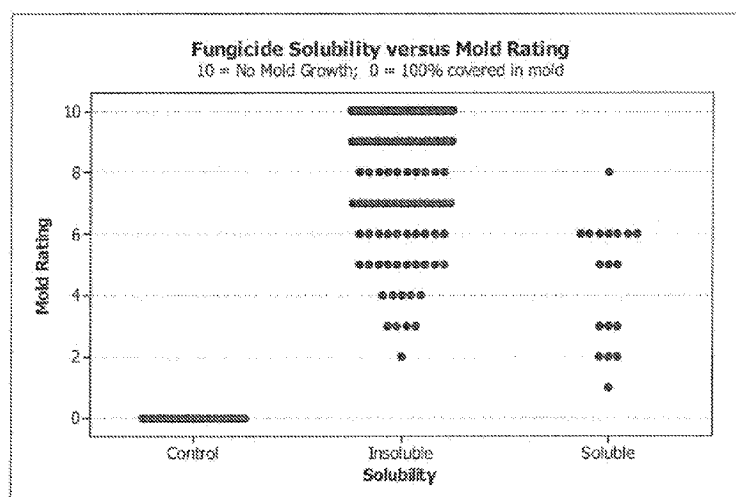


FIG. 1

(57) Abstract: A mold-resistant paper is provided. The paper is coated on at least one surface with an anti-microbial coating which includes polymerized siloxane and a fungicide. An antimicrobial paper coating and related methods are provided as well. A gypsum panel with improved resistance to mold and mildew is provided as well.

MOLD-RESISTANT PAPER AND GYPSUM PANEL, ANTIMICROBIAL PAPER COATING AND RELATED METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of US Patent Application No. 14/095,499 filed December 3, 2013 and US Provisional Application No. 61/858,698 filed July 26, 2013, which are incorporated herein by reference in their entireties.

5 FIELD OF THE INVENTION

This invention relates to paper resistant to microbial growth. An antimicrobial coating composition is also provided. The invention also relates to methods for making mold-resistant paper and gypsum panels.

BACKGROUND

10 Gypsum boards, also known as gypsum panels, drywall and wallboards, are popular construction materials with desirable properties for indoor applications. Manufacturing of gypsum boards includes forming a gypsum core from a slurry of calcium sulfate hemihydrate, water and additives. The slurry is continuously deposited on a conveyor and sandwiched between two cover sheets of
15 paper. One paper sheet is called a face sheet and the other paper sheet is called a back sheet. Each of the two paper sheets has two sides or surfaces. One side is the back or bond side contacting the gypsum slurry and is known as the "bottom or back paper side." The other side of each paper sheet that is not in contact with the gypsum slurry is known as the "top or face side." The resultant assembly is formed
20 into the shape of a panel. Calcium sulfate hemihydrate reacts with water to convert the hemihydrate into a matrix of interlocking calcium sulfate dihydrate crystals, causing the slurry to set and become firm. This forms a continuous strip of hardened material. The continuous strip moves on the conveyor until the calcined gypsum is sufficiently set to withstand handling and movement from the conveyor. The
25 continuous gypsum strip is then cut to the appropriate length, and then the excess water that is not needed for hydration of the calcined gypsum is evaporated from the gypsum panel in a kiln where the panel is exposed to high temperature.

Microbial growth favors environments where spores find moisture and nutrients to metabolize. Water vapor and spores are unavoidable in environments where gypsum panels are used. In addition to moisture that is present in the environment, products used in interior construction sometimes encounter water due to seepage, leaky roofs or pipes, flooding, condensation, and the like. These exposures occur without any defects in the gypsum board manufacture or use.

Cover paper sheets for gypsum panels, also known as facers, facing material, paper facers, etc., are made by a paper manufacturing process that begins with preparation of a dilute pulp of fibers from wastepapers, chemical additives and water. The wastepaper is separated from contaminants, pulped, thickened, refined and then drained through a screen to form a mat of random fibers. Additional water is removed by pressing the mat or applying suction. Informally, the “wet end” refers to the paper-making process before water is removed from the thin stock, followed by paper forming and pressing. The stage of the process after pressing to the hope reel is called the “dry end.” Once drained and pressed, the mat is then moved through a dryer section where the remaining water is evaporated. The paper sheet is then processed by a calender stack that increases the moisture content (4 – 9%) and polishes the surface of the fibrous sheet.

Attempts to make gypsum boards resistant to microbial growth have been made by incorporation of a biocide, such as a salt of pyrrithione, into the gypsum core, the facers, or both, as revealed in U.S. Patent Number 6,893,752 entitled “Mold Resistant Gypsum Panel and Method of Making Same,” incorporated herein by reference. However, obtaining a mold-resistant paper suitable for a gypsum panel has been proven to be difficult and expensive. Methods previously known in the art add a water-soluble or dispersible biocide during the wet end of a paper making process. The bulk of the biocide is then lost during the forming stage when water is drained and pressed out of the paper mat. The remaining biocide degrades further during the dryer stage at the paper mill and board kiln. Thus, there remains an ongoing need for obtaining paper that retains a fungicide in the amount sufficient to suppress microbial growth.

SUMMARY

A mold-resistant paper is provided which retains an active fungicide in the amount sufficient to suppress microbial growth such as for example, mold and mildew. A method is provided for producing the mold-resistant paper having an antimicrobial coating, as well as a method of applying the coating to a paper sheet. A gypsum panel with improved antimicrobial properties and a method of making the panel are also provided.

One embodiment provides a mold-resistant paper coated on at least one surface with an anti-microbial coating including polymerized siloxane and a fungicide. In some embodiments, the fungicide may include at least one of the following: 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol, octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole, 3-(3,4-dichloropheny)-1,1-dimethylurea.

Various paper grades, including Manila and Newslined, can be formulated as mold-resistant by calendering with an antimicrobial composition including a polymerized siloxane and at least one fungicide such as 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol, octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole, 3-(3,4-dichloropheny)-1,1-dimethylurea. Suitable antimicrobial compositions include those in which fungicide particles are larger than 1 micron, but smaller than 30 microns. At least in some embodiments, an antimicrobial coating composition further includes a binder, including binders such as carboxymethylcellulose, polyvinyl alcohol, styrene acrylic latexes, styrene butadiene, casein and starches.

In further embodiments, a gypsum panel resistant to mold and mildew is also provided. The panel is made by sandwiching a gypsum core between two mold-resistant sheets of paper obtained by coating the paper sheets on at least one side with an antimicrobial coating composition with a polymerized siloxane and a fungicide.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates that resistance of a gypsum panel to mold is improved with a water-insoluble fungicide; and

FIG. 2 illustrates that resistance of a gypsum panel to mold is improved with variations in the size of water-insoluble fungicide particles.

DETAILED DESCRIPTION

Various paper grades can be used in mold-resistant gypsum panels, including those disclosed in US Patent Publication US 2012/0088114 "Mold-resistant gypsum panel," the teachings of which are incorporated herein by reference.

Suitable paper further includes Manila or face paper with a smooth calendered finish and Newslined or back paper with a rougher finish. Both paper grades are multi-ply with at least one liner ply and several filler plies. The Manila liner plies typically use recycled paper from hardwood pulp with shorter fibers as compared to the filler plies in which longer fibers are used. The shorter fiber length from the hardwood pulp provides a smoother surface for painting and decorating. Newslined paper typically has the same fiber type in its liner ply as that used in its filler plies.

It has been unexpectedly determined that various papers can be formulated as mold-resistant. Such papers include, but are not limited to, a multi-ply paper which includes at least one liner ply and at least one filler ply. Such papers also include, but are not limited to, Manila and Newslined grades of paper.

The term "mold-resistant" paper is used in this specification in its broad meaning and includes any paper that retains a fungicide in the amount sufficient to suppress, delay or prevent microbial growth either completely or partially. The term "microbial growth" is also used broadly and includes growth of bacteria, fungi, yeast, mold, mildew, algae and the like. The term "antimicrobial" is used broadly and means anti-bacterial, anti-fungal, anti-yeast and the like. Further, all percentages disclosed in this specification are calculated by weight. The resistance of paper to mold can be determined by a standard test for resistance to growth of mold on the surface of interior coatings in an environmental chamber, known as standard mold-resistance test ASTM D3273-12. Under this standard, a paper is classified as mold-resistant if it receives a rating of 8 (11 to 20% of the surface is defaced and covered with mold, hereafter simply defacement), 9 (1 to 10% defacement) or 10 (0% defacement) in an ASTM D3273-12 testing during which the paper is exposed to soil inoculated with mold. The same standard test ASTM D3273-12 can be used to

determine mold resistance of a gypsum panel. Under this standard, a gypsum panel is classified as mold-resistant if it receives a rating of 8 (11 to 20% defacement), 9 (1 to 10% defacement) or 10 (0% defacement).

At least in some embodiments, a mold-resistant paper is made with recycled materials, including recycled newspaper. Hereafter, the recycled materials are called News. The paper may include as much as up to 100% of News. At least in some embodiments, the paper is made of 70% of News and 30% Fly Leaf fibers which are short fibers ranging in length between 0.8 to 1.5 mm and with the ash content typically between 20 – 25%. At least in some embodiments, the mold-resistant paper may include up to 80% of News and 20% of Fly Leaf fibers. In some other embodiments, the mold-resistant paper may include up to 90% of News and 10% of Fly Leaf fibers. The liner for the back paper may be old corrugated containers (OCC) or double lined Kraft (DLK) wastepaper. These wastepaper fibers typically have 2/3 of the fiber ranging in length between 2.5 to 3.6 mm for the softwood Kraft liners, and 1/3 of the fibers ranging from 0.8 to 1.5 mm for the hardwood medium between liners.

A mold-resistant paper is prepared by applying an antimicrobial coating to at least one or both of the two paper sides (face and bottom) during the calender stack stage. In some embodiments, a mold-resistant paper is made such that both sides are covered with the coating. In other embodiments, the coating is applied only to one side. In further embodiments, only the face side of paper is coated. In further embodiments, only the bottom side of paper is coated. Yet in other embodiments, an antimicrobial coating is applied to both paper sides: the face and bottom sides.

At least in some embodiments, an antimicrobial composition includes polymerized siloxane and a fungicide. Various fungicides can be used in an antimicrobial coating formulation. Fungicides which are insoluble in water or only poorly soluble in water are particularly preferred. The term “insoluble fungicide” is used in this specification broadly and includes fungicides which are hydrophobic and do not dissolve well in water. In some embodiments, insoluble fungicides have the water solubility as low as no more than 35 parts per million (ppm). Fungicides soluble in water are not preferred.

FIG. 1 reports surprising results showing that mold resistance of a gypsum panel depends on whether a water-insoluble or water-soluble fungicide is used in a paper-coating composition. Mold-resistant paper was prepared with various coating compositions in which a water-insoluble fungicide and siloxane were used as described in this specification. Gypsum panels were then prepared with the coated paper or uncoated control paper or paper coated with a combination of siloxane and a water-soluble fungicide. All gypsum panels were then tested in a mold resistance standard test D3273-12. As shown in FIG. 1, a control gypsum panel which was made with paper without a fungicide is not resistant to mold and scored 0 (91 to 100% defacement) in the mold resistance test. See FIG. 1, control. A gypsum panel made with paper which was coated with a combination of siloxane and a water-soluble fungicide had only a slightly improved resistance to mold, with the majority of samples scoring between 2 (71 to 80% defacement) and 6 (31 to 40% defacement). See FIG. 1, soluble.

Gypsum panels made with paper which was coated with a combination of siloxane and a water-insoluble fungicide as described in this specification were also tested. See FIG. 1, insoluble. It was unexpectedly discovered that these gypsum panels had a greatly improved resistance to mold with many samples scoring at least 8 (11 to 20% defacement) and higher. Some samples with water-insoluble fungicide showed no defacement at all and scored at 10. See FIG. 1, insoluble.

It has been also unexpectedly determined that the size of fungicide particles in an antimicrobial coating affects the potency of a mold-resistant paper in suppressing, delaying or preventing microbial growth either completely or partially. Suitable antimicrobial coating formulations include those with fungicide particle sizes in a range from about 1 micron to about 30 microns. In some embodiments, a coating formulation is made with a fungicide in which the fungicide particles are larger than 1 micron, but smaller than 15 microns. In further embodiments, an antimicrobial coating is formulated with fungicide particles such that at least 90% of the particles are larger than 1 micron, but smaller than 15 microns. In other embodiments, an antimicrobial coating is formulated with fungicide particles such that at least 90% of the particles are in the range between 8 and 15 microns. At least in some embodiments, an antimicrobial coating is formulated with fungicide

particles such that at least 90% of the particles are in the range from 10 to 26 microns. A fungicide in which the majority of particles are smaller than 1 micron or larger than 30 microns is not preferred.

FIG. 2 reports surprising results showing that mold resistance of a gypsum panel depends on a size of particles in a water-insoluble fungicide used in a paper-coating composition. Mold-resistant paper was prepared with various coating compositions in which a water-insoluble fungicide and siloxane were used as described in this specification. Gypsum panels were then prepared with the coated paper or uncoated control paper or paper coated with a combination of siloxane and a water-soluble fungicide. All gypsum panels were then tested in a mold resistance standard test D3273-12.

In FIG. 2, the same water-insoluble fungicide with two different particle sizes was tested. In the first formulation, 95% of fungicide particles were less than 1 micron and in the second formulation, 95% of fungicide particles were larger than 1 micron, but smaller than 5 microns. The second formulation provided a better resistance to mold as shown in FIG. 2, D(95% < 5 μ m) versus D(95% < 1 μ m). Further, a formulation with another water-insoluble fungicide in which 95% of particles were at about 13 microns ensured excellent mold resistance with the mold resistance rating of 10 (0% defacement). See FIG. 2, D(95% < 13 μ m). This result was a significant improvement over gypsum panels made with paper without a mold-resistant coating and gypsum panels made with paper with a mold-resistant coating in which a water-soluble fungicide was used.

Various fungicides are suitable for an antimicrobial coating formulation including, but not limited to, 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol, octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole and 3-(3,4-dichlorophenyl)-1,1-dimethylurea. These fungicides can be used either individually or in combination with each other. At least in some embodiments, zinc pyrithione can be used in combination with zinc oxide. In other embodiments, azoxystrobin can be used in combination with thiabendazol. One of the particularly preferred antimicrobial coating formulations includes a fungicide in which from 15 to 25% of thiabendazol is mixed with 10 to 20% of azoxystrobin. At least in some embodiments, a preferred fungicide is a dispersion of approximately 19.5% thiabendazol and approximately 15% azoxystrobin. In other

embodiments, a combination of azoxystrobin and thiabendazol is used as a first fungicide and at least one other compound is used as a second fungicide. In some embodiments, this second fungicide may be zinc pyrithione, zinc oxide or a combination of the two compounds.

5 In some embodiments, an antimicrobial coating includes from 1.0 to 10% by weight of a fungicide. In other embodiments, an antimicrobial coating includes from 1 to 6% by weight of a fungicide. In other embodiments, an antimicrobial coating includes from 1 to 4% by weight of a fungicide.

Various polymerized siloxanes can be used in an antimicrobial coating
10 formulation. The term "polymerized siloxane" is used broadly and includes a compound with the chemical formula $[R_2SiO]_n$, wherein "n" denotes a number of times the R_2SiO unit is repeated in a polymer. Each of the two R groups can be either different or the same. Each of the two R groups is selected from the group consisting of a hydrogen, halogen and an organic group. The suitable organic
15 groups include, but are not limited to, methyl, ethyl and phenyl. In some embodiments, a non-ionic polymerized siloxane is preferred. At least in some embodiments, the polymerized siloxane is poly-dimethylsiloxane.

In some embodiments, an antimicrobial coating includes from 1 to 10% by weight of a polymerized siloxane. In other embodiments, from 1 to 6% by weight
20 of a polymerized siloxane is used. In further embodiments, from 1 to 4% by weight of a polymerized siloxane is used.

At least in some embodiments, an antimicrobial coating composition is made by mixing together 1 to 10 parts of at least one fungicide with 1 to 10 parts of a polymerized siloxane and 98 to 80 parts of water. In further embodiments, about 10
25 parts of at least one fungicide are mixed with about 4 parts of a polymerized siloxane and about 86 parts of water. In further embodiments, about 3 parts of at least one fungicide are mixed with about 4 parts of a polymerized siloxane and about 97 parts of water.

In some embodiments, an antimicrobial coating composition further
30 includes a binder. It has been unexpectedly determined that binders improve adhesion of fungicide particles to a paper sheet. It has been further unexpectedly determined that binders are particularly preferred in formulations with larger fungicide particles. In some embodiments, it is preferred that an antimicrobial

coating composition includes a binder if it is formulated with fungicide particles which are larger than 5 microns.

Various binders are suitable for an antimicrobial coating composition. These binders include, but are not limited to, carboxymethylcellulose (CMC),
5 polyvinyl alcohol (PVOH), styrene acrylic latexes, styrene butadiene, casein and starches. At least in some embodiments, an antimicrobial coating composition includes from about 0.01% to about 0.05% of a binder. In some other embodiments, about 0.03% of a binder is used.

At least in some embodiments, suitable carboxymethylcellulose is a
10 low molecular weight polymer. A suitable carboxymethylcellulose binder is available from Ashland Hercules, Inc. under the name AQUALON™ CMC-7LT with approximately 0.7 degree of substitution and a low viscosity. In some embodiments, carboxymethylcellulose can be used in an antimicrobial coating formulation in an amount ranging from about 2 to about 10 lb/ton. At least in some preferred
15 embodiments, carboxymethylcellulose is used at about 6 lb/ton.

Other suitable binders include partially hydrolyzed PVOH products with low to medium viscosity. Such binders are available from DuPont under the names ELVANOL™ 51-05, 52-22 and 50-42. These binders can be used in an amount ranging from about 2 to about 10 lb/ton and preferably at about 6 lb/ton.

20 Further embodiments of an antimicrobial coating include a colorant. Suitable colorants include, but are not limited to, phthalocyanine green from Chromatech, Inc., the USGRN pigment from Michelman, Inc. and Solar P Blue 42L from BASF, Inc. A colorant can be used in the amount from about 0.01% to about 2% in a resulting antimicrobial composition.

25 A mold-resistant paper is prepared during the calendering stage by coating a paper with an antimicrobial composition which can be pre-made in a mix-tank and then fed to the calender stacks from a run-tank with a pump. In some embodiments, the coating is applied in the amount from about 0.10 lb/MSF to about 2.50 lb/MSF. At least in some embodiments, the coating composition can be applied
30 only to one side of the paper. In further embodiments, the coating composition is applied to both sides. At least in some embodiments, the coating composition is applied only to the face side of the paper. In other embodiments, the coating composition is applied only to the bottom side of the paper.

The coating application or pickup rate on the calender stack is controlled by fiber type, wastepaper used to form the liner ply or plies, sheet porosity, sheet moisture entering the calender stacks, water resistance of the sheet, sheet density, coating solids, coating foam, coating temperature, paper machine speed and calender stack design or mechanics. The rate of coating pickup in the calender stacks is determined by some of the factors above and is similar for a particular paper grade on a particular paper machine. The coating formulation is adjusted in further embodiments so that a fungicide is applied at 300 ppm to about 4500 ppm.

At least in some embodiments, an antimicrobial coating composition is pre-heated from about 110°F to about 160°F prior to the application. In further embodiments, it is preferred that the coating composition is preheated from about 120°F to about 140°F.

Various tests can be conducted to determine the amount of active fungicide retained in the paper. These methods include, but are not limited to, UV spectrophotometry, analytical high pressure liquid chromatography (HPLC) and X-ray fluorescence tests.

Additional tests include a water resistance test which determines the amount of water absorbed by paper during a particular period of time. The results of the test are recorded as the Cobb specification in grams of water absorbed by a 100 cm² of paper. It has been unexpectedly determined that suitable mold-resistant paper includes that with the Cobb specification from 0.4g per 100 cm² of paper to 1.6g per 100 cm².

Various paper grades can be formulated as mold-resistant including Manila and Newslined grades. Manila is a hard sized sheet. Typically 8 to 10 lb/ton of alkenylsuccinic anhydride (ASA) size is applied to the top two liner plies, but the ASA size may be fed as low as 4 – 5 lb/ton. The filler plies contain ASA size between 3 to 7 lb/ton. Alum is fed to the liner and filler plies at 3 to 7 lb/ton, but typically at 5 lb/ton. The liner furnish is "news sections" which is TMP or groundwood which is a high yield furnish, but low in ash content. The sheet must be dried appropriately so that the ASA size forms covalent bonds to the cellulose. Standard paper making chemicals (retention aids, coagulants) and procedures are followed to obtain a well formed sheet. The average Manila basis weight is 44lb/MSF and typically a roll weighs 5530 lb and contains 125 MSF/roll.

In some embodiments, Manila grade paper can be formulated as mold-resistant by coating the paper with an antimicrobial coating composition including from about 1.5% to about 7% of a polymerized siloxane and from about 1 to about 7% of at least one fungicide. The coating is applied by a wet calender stack at about 300 ppm to about 4500 ppm of an active fungicide. In some embodiments, the coating is applied by a wet calender stack at about 300 ppm to about 1500 ppm of an active fungicide. Yet in other embodiments, the coating is applied by a wet calender stack at about 300 ppm to about 1500 ppm of an active polymerized siloxane.

Newslined is a hard sized sheet. Typically 8 to 10 lb/ton of ASA size is applied to the top two liner plies, but the ASA size may be fed as low as 4 – 5 lb/ton. The filler plies will contain ASA size between 3 to 7 lb/ton. Alum is fed to the liner and filler plies at 3 to 7 lb/ton, but typically at 5 lb/ton. The furnish is "old corrugated" or "double lined Kraft" waste paper. The same wastepaper grades used as filler plies for the Manila grade. The size concentration may be lowered to obtain the bond side Cobb specification. The sheet must be dried appropriately so the ASA size forms covalent bonds to the cellulose. Standard paper making chemicals (retention aids, coagulants) and procedures are followed to obtain a well formed sheet. The average basis weight is 42b/MSF and typically a roll weighs 5585 lb and contains 133.5 MSF/roll.

Newslined grade paper can be formulated as mold-resistant by coating the paper with an antimicrobial coating composition including from about 1.5% to about 7% of a polymerized siloxane and from about 1 to about 7% of at least one fungicide. The coating is applied by a wet calender stack so that the active fungicide concentration is from about 300 ppm to about 4500 ppm.

A gypsum panel with improved mold-resistance can be prepared by using a mold-resistant paper as facers. In some embodiments, mold-resistant paper sheets of Manila and Newslined grades are obtained as described above. A gypsum slurry is then prepared and sandwiched between a sheet of mold-resistant Manila paper on one side and a sheet of mold-resistant Newslined paper on the other side.

EXAMPLE 1

Antimicrobial Coating Composition

A coating was prepared according to the formulation in Table 1, where all parts were calculated by weight.

Table 1. Silicone Thiabendazol/Azoxystrobin/Zinc Pyrithione Coating

Component	Amount (Lb)	%
Water	1084	87.51
Zinc Pyrithione	32	2.58
19.5% Thiabendazol/15% Azoxystrobin	76.6	6.12
Polymerized Dimethylsiloxane	47	3.79
Total	1239.6	100

EXAMPLE 2

Mold-Resistant Manila Paper

Manila grade paper was prepared according to the grade specification. An antimicrobial coating composition was prepared as described in Table 1. The antimicrobial coating composition was then fed to a water run box and was applied to the paper by a wet calender stack at about 500 ppm Zinc Pyrithione, 950 ppm Thiabendazol and 750 ppm Azoxystrobin.

EXAMPLE 3

Mold-Resistant Newslined Paper

Newslined paper was prepared with a liner in which 30% Fly Leaf was blended with 70% of News. An antimicrobial coating was prepared by making a 6.5% polymerized dimethylsiloxane solution in water and mixing it with 3-iodo-2-propynylbutyl carbamate (IPBC) to obtain a 2% IPBC solution. The antimicrobial coating composition was then fed to a water box and was applied to the Newslined paper by wet calender stack at about 500 ppm active fungicide. An acrylic latex was applied to improve water resistance and bind the fungicide to the sheet.

While particular embodiments have been shown and described, it will be appreciated by those skilled in the art that changes and modifications may be made thereto without departing from the invention in its broader aspects and as set forth in the following claims.

What is claimed is:

1. A mold-resistant paper coated on at least one surface with an anti-microbial coating comprising from 1% to 10% polymerized siloxane and from 1% to 10% a water-insoluble fungicide selected from the group consisting of 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol,
5 octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole, 3-(3,4-dichlorophenyl)-1,1-dimethylurea and a combination thereof.
2. The mold-resistant paper of claim 1, wherein the polymerized siloxane is a compound with the chemical formula $[R_2SiO]_n$, wherein "n" denotes a number of times the R_2SiO unit is repeated in a polymer; and wherein each of the two R groups can be either the same or different and each R group is selected from
5 the group consisting of a hydrogen, halogen, methyl, ethyl and phenyl.
3. The mold-resistant paper of claim 1, wherein said paper is a multi-ply paper with at least one liner ply and at least one filler ply, and wherein the liner ply is selected from the group consisting of 100% New and a combination of 70% News and 30% Fly Leaf.
4. The mold-resistant paper of claim 1, wherein the fungicide comprises particles and wherein at least 90% of said particles are larger than 1 micron, but smaller than 15 microns.
5. The mold-resistant paper of claim 1, which further comprises a binder selected from the group consisting of carboxymethylcellulose, polyvinyl alcohol, styrene acrylic latexes, styrene butadiene, casein and starches.
6. A method of making a mold-resistant multi-ply paper, the method comprising:
feeding the paper to a calender stack;
feeding to the calender stack an antimicrobial coating composition
5 comprising from 1% to 10% of a non-ionic polymerized siloxane and from 1% to 10%

of a water-insoluble fungicide selected from the group consisting of 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol, octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole, 3-(3,4-dichlorophenyl)-1,1-dimethylurea and a combination thereof;

10 and

applying the antimicrobial coating composition to at least one surface of the paper with the calender stack.

7. An antimicrobial coating composition, the composition comprising from 1% to 10% of a non-ionic polymerized siloxane and from 1% to 10% of a water-insoluble fungicide selected from the group consisting of 3-iodo-2-propynylbutyl carbamate, zinc pyrithione, zinc oxide, azoxystrobin, thiabendazol, 5 octylisothiazoline, dichloro-octylisothiazoline, zinc dimethyldithiocarbamate, benzimidazole, 3-(3,4-dichlorophenyl)-1,1-dimethylurea and a combination thereof.

8. The antimicrobial coating composition of claim 7 further comprising a binder selected from the group consisting of carboxymethylcellulose, polyvinyl alcohol, styrene acrylic latexes, styrene butadiene, casein and starches.

9. A gypsum panel comprising a gypsum core sandwiched between two paper sheets, a front paper sheet and a back paper sheet, wherein each of the two paper sheets has a face side and a bottom side, wherein the gypsum slurry is in the proximity with the bottom sides and wherein the face sides are coated 5 with the antimicrobial coating composition of claim 7.

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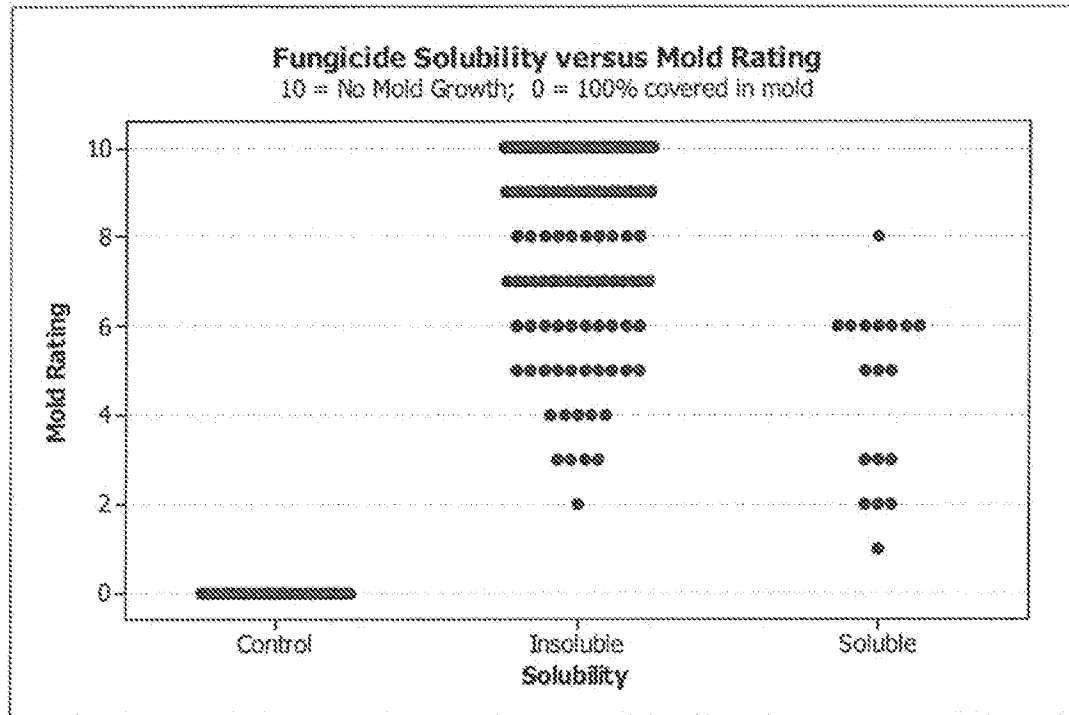


FIG. 1

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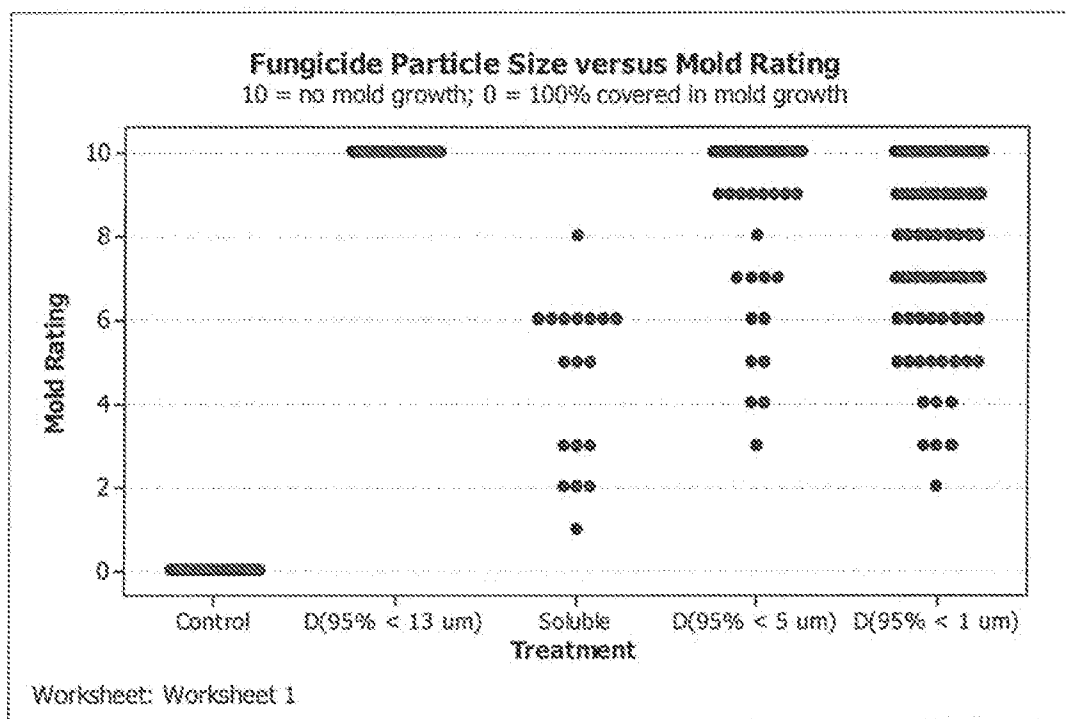


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/047115

A. CLASSIFICATION OF SUBJECT MATTER

INV. D21H25/14 D21H17/59 D21H19/32 D21H21/36
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

16 October 2014

Date of mailing of the international search report

28/10/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Karlsson, Lennart

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/047115

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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