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(54) **Method for manufacturing facing product for structural boards and facing products**

(57) This invention relates to a method for treating sheeted base materials containing organic natural fibres or regenerated fibres. In the method, the base material, consisting of a first side and a second side, is firstly treated on its first side using a liquid treatment containing an antimicrobial agent and a binder. The base material is

dried and a layer containing wax is formed on the first side of the base material in a second treatment, after which the layer containing wax is absorbed into the base material at temperatures of 100-145 °C. This invention also relates to the treated base material and to its use.

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Description

[0001] This invention relates to a method for treating sheeted base materials containing organic natural fibres or regenerated fibres, and to a sheeted base material meant for use as a facing for wallboard, particularly gypsum board.

[0002] By "sheeted base materials", this application refers to materials which have a flat form, i.e. ones whose thickness is very small in relation to their width and length. Cardboard is one example of a sheeted base material. Sheeted base materials may be provided in sheet or web form for production purposes.

[0003] Many structural boards use facings with several separate or simultaneous functions. By "structural boards", this application refers to boards made of gypsum, wood fibre, concrete, cement or other materials, for which the use of facings is recommended due to their characteristics or production methods. Generally, these facings are based on paper or other fibres. The facing described in this invention is intended for indoor and outdoor use.

[0004] US patent 6,638,356 describes a gypsum board protected against the generation of hydrogen sulphide in the presence of sulphate-reducing bacteria. The solution uses anthraquinone or its compounds, accounting for approximately 100 ppm of the gypsum's weight. US patent 6,680,127 (Temple-Inland Forest Products) proposes antifungal protection for gypsum boards in the form of cetylpyridinium chloride. The fungicide agents can either be freely present or be encapsulated in order to release their chemical properties over time. Anthraquinone is a typical, known oxidation and reduction catalyst.

US patent 6,773,822 (Temple-Inland Forest Products) further describes how a fungicide can release the active agent in a controlled fashion while being mainly encapsulated into the gypsum itself. Some 200 compounds are listed as fungicides, including ones which are toxic to living organisms. US patent 6,770,354 by G-P Gypsum Corporation describes the production of moisture-tolerant gypsum panels or boards. Here, the panel is faced with a mat consisting of glass fibres, pigments, mineral binder and a polymer latex adhesive binder. Further, the publication defines that the mat must allow water to evaporate from the gypsum during drying. This is achieved by binding the facing and its fibres with a binder which apparently contains sufficient inorganic adhesive, such as cement, and only a limited amount of polymer adhesive, and by ensuring that this binder binds the mat fibres so that essentially all fibres are covered.

[0005] US patent 6,833,137 describes a treatment of the cardboard facing for gypsum board against termites and other insects, with CIF amino-sulphinylpyrazole. These agents are toxic to humans.

[0006] US patent 6,800,361 describes a gypsum board faced with nonwoven fabric with a certain resistance level. The idea is that the nonwoven fabric is polymer-based, so that it cannot act as a nutrient medium to fungi, as

paper can. US patent 6,893,752 describes a fungicide solution where the treatment agent is pyrrithione, which is mixed into the gypsum, forming calcium salts at a concentration of at least 100 ppm.

[0007] Publication 6,767,647 addresses the same issue - mould prevention - with a gypsum board faced with nonwoven fabric and containing at least two different agents in the gypsum. These agents include for instance propiconazole and sodium pyrrithione. They are used at concentrations of 50-1,200 ppm in the facing or 80-1,200 ppm in the gypsum core.

[0008] The above description shows that mould prevention and other protective measures are considered very important in relation to gypsum board products.

[0009] Previously, gypsum boards and other boards have routinely been faced with cardboard with a weight of 180-210 g/m². The cardboard used in this cardboard-only solution is so porous that the water vapour formed during drying is easily released from the gypsum. US patent 6,770,354, referred to above, says that "said coated mat has a porosity which allows water to evaporate from the gypsum core during preparation of the panel", but does not explain this. As we can see from the patents listed above, these products have problems in relation to mould prevention and the sufficient porosity of the facing.

[0010] Methods of mould prevention which do not involve agents that are toxic to humans do exist, and they are described in this invention. The water-repelling properties of the board facing are an important factor. At the same time, the board should be porous, not only during production but optimally also at other times. The board and/or its facing must have fungicidal properties without being toxic to humans.

[0011] Our understanding is that buildings should not contain any structures which release toxic substances, because these might come into contact with humans.

[0012] The solution described in this invention is such that no changes are required to normal gypsum board production lines in order to achieve a water-repellent, breathable facing with long-term antifungal protection.

The facing protects the boards, increases their bending resistance, prevents dust formation, can be painted or printed on, and protects the boards from denting. This kind of facing is particularly important for gypsum board. Suitable surface friction properties are required for the facing process at the production plant, for transport and when the boards are moved at the installation site. Further, the boards must have antifungal protection on their surface and, optimally, the facing must in many cases be porous to water vapour so that excess water can be evaporated out of the core material behind the facing, for instance in the case of gypsum and cement boards. In the case of gypsum board, the hydration process increases the board's temperature to at least +66 °C, while drying increases it further to over 100 °C, so mould contaminations always come from the outside.

[0013] Also, the friction coefficient between the boards'

surfaces should be optimal. In board-to-board contact, air should be allowed to escape from between the boards to prevent sliding. The friction coefficient must be high enough to hold a pile of boards steady during transport, but low enough that it is easy to remove boards from the pile at the installation site. The prevention of water absorption reduces damage caused by mould and keeps fungicides that have not been encapsulated into the product from being washed out of the board.

[0014] Our invention, which applies mainly to gypsum and cement boards but can apply to any boards that are manufactured by casting the core on top of a facing and from which excess moisture must be removed, solves the abovementioned problems, among others, affordably and without being toxic to humans. Further, the facing described in this invention can be used as a coating for various fibreboards. The board facing described in this invention also allows various moisture barriers, particularly ones consisting of water-emulsion polymer binders, to be spread on top of the facing. Such boards are used underneath tiles in wet rooms.

[0015] According to the invention, a base material produced of wood or chemical pulp fibre, or a combination of the two, typically 250-350 μm and optimally approximately 300 μm in thickness, is treated with an antimicrobial agent such as sodium benzoate, which is a sodium salt of benzoic acid. In addition to the aforementioned wood or chemical pulp fibres, the base material may include regenerated fibres such as viscose.

[0016] As is widely known, benzoic acid is a natural preservative that prevents fungal growth, present for instance in lingonberries and cranberries. Benzoic acid (E210) and its salts (E211, E213) are widely used as preservatives in foods. In wood and pulp fibre structures, sodium benzoate causes swift absorption of water and more expansion of the fibres than the use of pure water does. In the invention, the antimicrobial agent, e.g. benzoate, is added at the same time as the binding agent (which can be e.g. an acrylic polymer emulsion adhesive), typically at a rate of 2-4 g/m^2 . Mould prevention tests have indicated that the fungicidal properties of benzoic acid salts work best when the pH of the surface of the paper facing has first been reduced to 3-6.5 using e.g. sulphuric acid, boric acid, alum, phosphoric acid, adipic acid, tartaric acid, citric acid or another similar acid, optimally with mild sulphuric acid at a concentration of <1 % by weight or with alum or boric acid at a concentration of 1-3 % by weight. Optimally, the acidulation treatment should be completed before the treatment with the antimicrobial agent and binder. The acidulation treatment can also be left out of the process, because the product will be functional without it.

[0017] It is evident that the polymer binder can be any other kind of binder that emulsifies in water, such as polyvinyl acetate. Pigments and one or more fungicides can be mixed in with the polymer binder. In order to work properly, their HLB (hydrophile-lipophile balance) value must be within a certain range. On a scale of 1-20 (related

to how many per cent of polyethylene oxide are needed for emulsification or dissolution), polymer binders may, depending on the manufacturer, have HLB values ranging between 8 and 12. According to the invention, the optimal joint HLB value for the polymer binder and pigment compound should be between 8 and 11 (equivalent to values of 28-32 g/m^2 , optimally approx. 30 g/m^2 , obtained using the Cobb₆₀ method). Then, the pigment will not dissolve from the polymer into the water, and a second water-repellent layer may be applied on top of this layer.

[0018] After the process described above is complete, a new layer, typically containing 1/3-1/5 parts microcrystalline wax, is spread on the surface. The molecular structure of microcrystalline wax is mainly that of a branched hydrocarbon wax. Typically, the melting point of microcrystalline wax is 60-100 °C. In addition to microcrystalline wax, the layer may include linear wax and/or compounds formed between these and typical polymer binders. Hereafter, this layer will be referred to as the "wax layer". Suitable linear waxes include paraffin wax.

[0019] The purpose of the wax layer is to make the surface UV- and ozone-resistant and suitably water-repellent. After spreading on the wax layer, any excess wax is scraped off with a sharp doctor blade and the wax layer is absorbed using the same method as that used for the previous acrylate+benzoate+pigment layer, such that the surface temperature of the drying cylinder is optimally 125-130 °C. By "suitably water-repellent" we mean that the surface should not be so water-repellent that a moisture-proofing layer consisting of a water emulsion, required for use under tiles in wet rooms, cannot be spread or applied onto it.

[0020] The wax layer penetrates the board to a depth of 90-150 μm . Approximately 12 g/m^2 of wax is applied or allowed to penetrate. Typically, the wax layer is scraped at a temperature of 125-130 °C. A new layer which is properly porous to air and water vapour is formed. After scraping, there is no "free" wax on the surface as a continuous layer. According to the invention, the correct HLB value for the wax layer is between 10 and 12 (cf. Figure 1, which shows loose fibres). The penetration of the wax layer to the other side can be stopped by cooling the web so that its temperature optimally falls to below 30 °C. Cooling can be achieved using one or more cooling cylinders.

[0021] The permeability of water vapour is nearly the same in the finished product as in the original cardboard, i.e. ~300 g/m^2 , 23 °C, RH 50 % = sd <0.1 m (ISO 2428: 1995). The durability of the surface (Dennison/KCL 129: 65) improves by about 15%.

[0022] If a typical paper product, used to manufacture the product in accordance with the invention, has water absorption levels of 20-25 g/m^2 (measured with the Cobb₆₀ method, ISO 535:1991), this level increases typically to 50-60 g/m^2 during the acrylate+benzoate treatment, and decreases to approx. 12-14 g/m^2 in the final product, after the "waxing" treatment.

[0023] The air permeance of paper or cardboard, measured with a Guerley device (ISO 5636-5:1986), is approximately 60-70 $\mu\text{Pa}\cdot\text{s}$ for base papers, and approx. 200 $\mu\text{Pa}\cdot\text{s}$ after the benzoate+acrylate treatment. The benzoate attaches to the acrylic polymer in the treatment described above. In typical conditions, the sodium benzoate penetrates a fibrous product to a depth of 50-60 μm . These typical conditions are created when the fibrous product is dried immediately after the acrylic+benzoate is spread on, by putting it into direct contact with the surface of a drying cylinder so that the treated surface is against the hot surface of the cylinder. The swift release of steam (30% acrylate and benzoate + ~70% water) makes the surface porous.

[0024] In optimal conditions e.g. sodium benzoate is present at a concentration of 2-4 g/m^2 , optimally 3 g/m^2 , and present in the surface layer at a level of 7-9% of the weight of the surface layer. A surprising observation has been that an identical board, manufactured and faced in the same way but without sodium benzoate, produces a significantly lower friction coefficient, meaning that the products do not stay piled up very well and are therefore difficult to transport. With the addition of sodium benzoate, the friction increases to the desired value.

[0025] This is explained by the fact that the sodium benzoate improves the penetration of water into the fibres, which causes the fibres to swell and the surface to roughen. Naturally, this can be achieved with other known chemicals that cause fibres to swell. Optimally it should be one which also has fungicidal properties.

[0026] Although the cardboard used in experiments was calendered, the benzoate treatment caused the surface to roughen more than a simple water treatment did. Clearly, a similar roughening might be achieved with other substances which simply reduce the surface tension. The static friction coefficient for base cardboard was 0.36; for "waxed" cardboard without a sodium benzoate treatment it was 0.28; for "waxed" cardboard treated with sodium benzoate (3 g/m^2) it was 0.36 (friction values measured using an Instron 4665 device in accordance with the applicant's quality manual).

[0027] The above descriptions make good figures in practice, but those skilled in the art will see that they are not necessarily optimal, and that many variations may be made. Such variations include replacing the sodium benzoate with its derivative parabens and their sodium, potassium and calcium salts, or with known paraben esters. These parabens are para-hydroxybenzoic acids (numbers E214-E219 in the list of food-grade additives). Examples of suitable substances are: ethyl-p-hydroxybenzoate; the sodium, potassium or calcium salts of ethyl-p-hydroxybenzoate; propyl-p-hydroxybenzoate; the sodium, potassium or calcium salts of propyl-p-hydroxybenzoate; methyl-p-hydroxybenzoate; and the sodium, potassium or calcium salts of methyl-p-hydroxybenzoate. Further suitable substances for use as antimicrobial agents are hexamethylenetetramine; ortho-phenylphenol; the salts, e.g. sodium, potassium or calcium

salts, of ortho-phenylphenol; and thiabendazole. Compounds of the substances listed above may also be used as antimicrobial agents.

[0028] The invention consists of many separate factors, which are described in the text above. However, there are certain major factors which are essential to the invention, such as the use of benzoic acid salts or their derivatives, or other substances listed in this application, as fungicides; and the treatment of a binder such as an acrylate polymer, and a wax layer on a hot surface so that the surface onto which the substance has been applied comes into direct contact with the hot cylinder surface.

This text refers to acrylic polymers, but any polymers which emulsify in water achieve the same ends in principle. Such polymers include polyvinyl acetate and the ammoniacal form of polyethylene terephthal sulphone (e.g. EvCote, Asia Pacific Specialty Chemicals, USA). As there are many viable polymers, they must be used together with additives which provide optimal HLB values. Hundreds of such additives are listed in bibliography.

[0029] The finished cardboard is attached to a gypsum board with gypsite, after which the finished boards are dried. This process further improves the cardboard's steam permeability and friction. Further, it has been observed that during drying, the wax penetrates deeper into the gypsum board, which improves the water tolerance of the cardboard/gypsum boundary layer. In practice this is a great advantage, as wax cannot be applied to the cardboard on the side to be attached to the gypsum board prior to the attachment to the gypsum board, because it would cause the adhesion of the gypsum board to the cardboard to deteriorate.

[0030] Below are descriptions of figures, in which

Figure 1 illustrates the surface of a product manufactured in accordance with the invention, and
Figure 2 illustrates the hydrophobic qualities of a product manufactured in accordance with the invention.

[0031] Figure 1 shows the surface of the product. A notable factor is that there are many free, vertical fibres. Figure 2 is a photograph of a gypsum board, onto which a drop of water has been applied. Although there are free fibres on the surface, the water's angle of contact is $>90^\circ$. It is also notable, that these samples were approximately one year old and had been stored in sunlight in the laboratory. Typically, waxes and oils become oxidised, which causes the moistening angle to decrease. In the examples produced for this invention, this problem has been addressed with branched microwaxes, which are known radical inhibitors, protecting the surface against ozone and UV rays. Those skilled in the art will see that other radical inhibitors, such as acrylated bisphenols and lactones, can also be used.

[0032] The text mentions that sodium benzoate pass-

es into the surface layer during drying. Benzoic acid derivatives and other salts behave similarly. On the basis of experiments, we have observed that water cannot flush benzoic acid or its derivatives out of the surface if its temperature is less than -60°C and its HLB values are as described above.

[0033] The acidulation of the paper product, mentioned above, means that its pH is reduced to <7 but ≥ 3 , because the fungicidal effects of sodium benzoate and its derivatives appear in acidic conditions but are very limited in neutral conditions. The aqueous solution of sodium benzoate is naturally slightly alkaline. At a pH of <3 , the paper begins to hydrolyze into sugars too quickly, also weakening in other ways. Any acids can be used which do not evaporate or break down, but sulphuric acid is the cheapest, while boric acid significantly improves fire-proofing and is a particularly good antimicrobial agent. Non-toxic substances such as melamine sulphate or zinc borate can also be used to improve fire-retardant qualities.

[0034] The waxing procedure used in the invention to waterproof the surface means that the fungicide agents attached to the polymer binder cannot be washed away as easily. Further, the lipophile balance of the surface and of the layer underneath the surface is improved e.g. by an acrylic binder, which also prevents the fungicidal agents from being washed away. The methods described in the technique, and the given basis weight and penetration depths are important parameters, because they cause e.g. the gypsum board side of the cardboard to stay in its original form, which binds the gypsum. At the initial stage of manufacture of the product, where e.g. the cardboard is acidulated slightly, suitable additives for use as fire retardants include zinc borate and melamine sulphate.

[0035] The calorimetric fuel value of a facing in accordance with the invention is $<4 \text{ MJ/m}^2$, taking into account all additives, if the pulling resistance of the base cardboard in the machine direction is at times at least 12-13 kN/m. In these conditions, the cardboard will typically be 190 g/m^2 in weight, fulfilling the normal requirements regarding durability.

[0036] By "wax" we mean a combination of waxes and/or polymers, whose characteristics include the HLB value mentioned above, and which contain radical inhibitors, i.e. agents which improve resistance to UV rays and ozone. They can also be other agents than the branched microwax mentioned above. Further, the joint HLB value of the polymer layer and the pigment and fungicide contained in it must be suitable, as described above, in order to allow the wax layer, which is applied later, to penetrate the surface as desired. The polymer layer and its additives can favourably be applied using known methods such as gravure coating, offset gravure coating, rod coating, airbrush coating, treating with a surface-size press, curtain coating, or controlled lick coating, feeding polymer emulsion onto the cardboard's surface from below.

[0037] The facing in accordance with the invention can be manufactured on the same production line as the base material. In other words, the treatment of the base material can be carried out using a paper or board machine.

5 The liquid substance, containing an antimicrobial agent and a binder, can be spread onto the base material for instance using a surface-size press. The wax layer can be spread at an elevated temperature, after which any excess is removed with a scraping method such as a trailing blade.

10 **[0038]** Finished surfaces can also be printed e.g. with logos using common printing techniques, as long as the HLB value of the printing ink is approx. 10.

15 **[0039]** The finished facing is attached to the surface of the construction board. If the board contains gypsum, this is done using gypsite. Usually, both sides of the construction board are faced.

20 Claims

1. Method for treating sheeted base materials containing organic natural fibres or regenerated fibres, in which method:

- 25
- a base material, consisting of a first side and a second side, is firstly treated on its first side using a liquid treatment containing an antimicrobial agent and a binder;
 - 30 - the base material is dried;
 - a layer containing wax is formed on the first side of the base material in a second treatment; and
 - 35 - the layer containing wax is absorbed into the base material at temperatures of $100-145^{\circ}\text{C}$.

2. A method in accordance with patent claim 1, **characterised in that** the antimicrobial agent is a benzoic acid salt, benzoic acid, a paraben, a paraben salt, a paraben ester, hexamethylenetetramine, ortho-phenylphenol, an ortho-phenylphenol salt, thiabendazole, or a compound of these.

3. A method in accordance with patent claim 2, **characterised in that** the benzoic acid salt or ortho-phenylphenol salt is a sodium, potassium or calcium salt.

4. A method in accordance with one of the patent claims above, **characterised in that** the binder contains an acrylic acid derivative such as acrylate, the ammoniacal form of polyethylene terephthal sulphone or polyvinyl acetate.

5. A method in accordance with one of the patent claims above, **characterised in that** the base material is dried such that its first side comes into contact with the surface of the drying cylinder.

6. A method in accordance with one of the patent claims above, **characterised in that** the layer containing wax contains linear wax and microcrystalline wax.
7. A method in accordance with patent claim 6, **characterised in that** the linear wax is a paraffin wax. 5
8. A method in accordance with patent claim 6, **characterised in that** the layer containing wax contains at least 20% by weight of microcrystalline wax. 10
9. A method in accordance with one of the patent claims above, **characterised in that** the layer containing wax contains acrylated bisphenols or lactones. 15
10. A method in accordance with one of the patent claims above, **characterised in that** the pH of the cardboard is adjusted to between 3 and 6.5 before the first treatment. 20
11. A method in accordance with patent claim 10, **characterised in that** sulphuric acid, boric acid, alum or phosphoric acid is used to adjust the pH.
12. A method in accordance with patent claims 10 or 11, **characterised in that** fire retardant is absorbed into the cardboard in conjunction with the adjustment of the pH. 25
13. A method in accordance with patent claim 12, **characterised in that** the fire retardant consists of melamine sulphate and/or zinc borate. 30
14. A method in accordance with one of the patent claims above, **characterised in that** the base material is cardboard. 35
15. A method in accordance with patent claim 14, **characterised in that** the basis weight of the cardboard is 180-210 g/m². 40
16. A method in accordance with patent claim 14, **characterised in that** the cardboard is treated on the production line on which it is produced. 45
17. A base material treated in accordance with one of the patent claims above, **characterised in that** the base material contains one of the following antimicrobial agents: potassium benzoate, sodium benzoate, benzoic acid, paraben, a sodium, potassium or calcium salt of paraben, a paraben ester, hexamethylenetetramine, ortho-phenylphenol, a sodium, potassium or calcium salt of ortho-phenylphenol, thiabendazole, or a compound of these. 50
18. The use of the base material in accordance with patent claim 17 as a facing for a board containing gypsum. 55



Fig. 1.

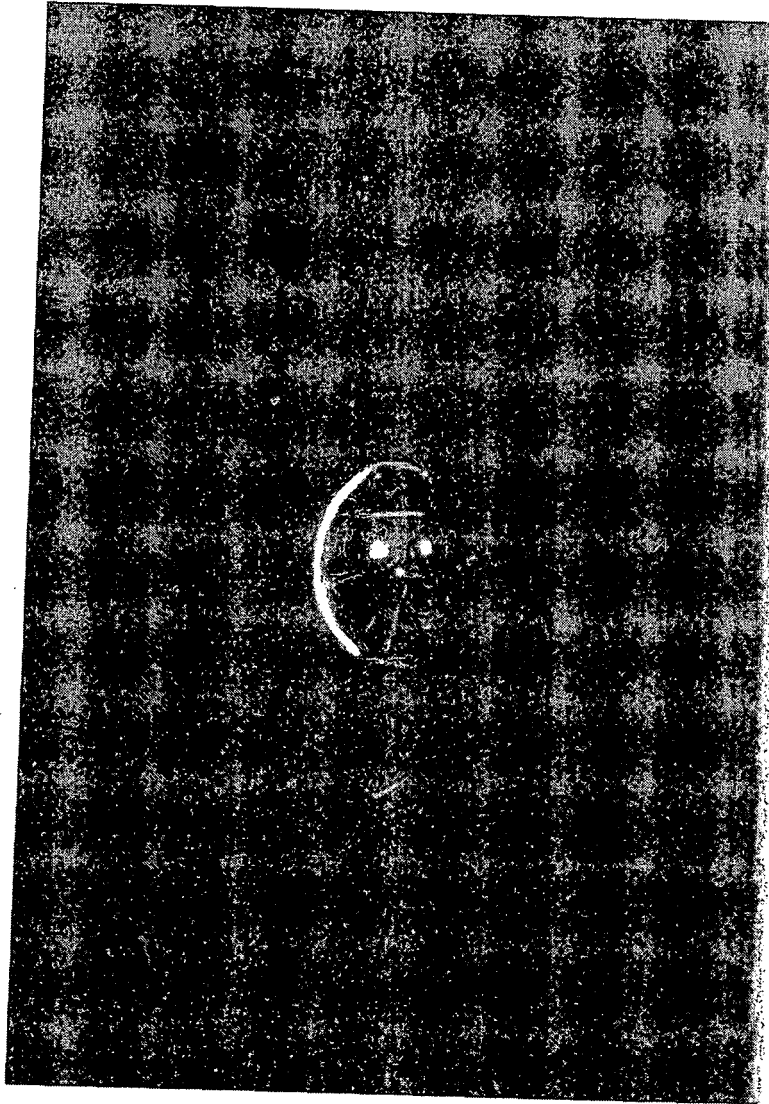


Fig. 2.

REFERENCES CITED IN THE DESCRIPTION

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