

BUILDING MATERIAL PLATE, MANUFACTURING METHOD OF THE SAME, AND DOOR SHEET STRUCTURE

This application claims the benefit of Taiwan application Serial No. 104140809, filed Dec. 4, 2015, and the benefit of Taiwan application Serial
5 No. 105134757, filed Oct. 27, 2016, the subject matters of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates in general to a building material plate,
10 a manufacturing method thereof, and a door sheet structure using the same.

Description of the Related Art

[0002] Building material plate possessing excellent total light transmittance and haze as well as practicality and privacy protection has long been searched in the building industry. For example, glass material is often used as
15 a material of the door sheet structure. However, glass material not only weighs heavier but also incurs higher manufacturing cost. Therefore, it has become a prominent task for the industry to provide a door and window material which weighs lighter and incurs lower manufacturing cost.

[0003] Current building material plate may possess excellent total light

transmittance but inadequate haze, and therefore may easily cause privacy problem. Or, the building material plate may possess excellent haze but inadequate total light transmittance. Such building material plate, despite providing privacy protection, lacks practicality, because the light cannot pass through and the indoor is dim and gloomy. Or, the building material plate, despite possessing excellent total light transmittance and haze, may have poor practical performance. For example, when the surface of the building material plate is moisturized by the rain, the building material plate may become transparent and cause privacy problem. Therefore, how to provide a building material plate possessing excellent total light transmittance and haze as well as practicality and privacy protection has become a prominent task for the industries.

SUMMARY OF THE INVENTION

[0004] The present invention is directed to a building material plate, a manufacturing method thereof, and a door sheet structure using the same.

[0005] According to one embodiment of the present invention, a building material plate is provided. The building material plate includes a transparent substrate and a light diffusion layer. The light diffusion layer is located on at least one surface of the transparent substrate. The light diffusion layer includes an optical material and a plurality of first light diffusion particles. The first light diffusion particles have an average particle size of 6-100 micrometers (μm), and a ten-point mean roughness (R_z) of the light diffusion

layer is 11-28 μ m.

[0006] According to another embodiment of the present invention, a manufacturing method of a building material plate is provided. The manufacturing method of the building material plate includes following steps.

5 A first transparent thermoplastic resin is provided. A light diffusion layer material including a second thermoplastic resin and a plurality of first light diffusion particles is provided, wherein the first light diffusion particles have an average particle size of 6-100 micrometers (μ m). The first transparent thermoplastic resin and the light diffusion layer material are co-extruded by
10 performing a co-extrusion process to form a transparent substrate and a light diffusion layer of the building material plate respectively, wherein the ten-point mean roughness (Rz) of the light diffusion layer is 11-28 μ m.

[0007] According to an alternate embodiment of the present invention, a door sheet structure is provided. The door sheet structure includes a frame
15 and a sheet plate. The sheet plate is disposed in the frame. The sheet plate includes the aforementioned building material plate.

[0008] The above and other aspects of the disclosure will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment (s). The following description is made with
20 reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a schematic diagram of a building material plate according to an embodiment of the present invention.

[0010] FIG. 2 is a schematic diagram of a building material plate according to another embodiment of the present invention.

[0011] FIG. 3 is a schematic diagram of a building material plate according to an alternate embodiment of the present invention.

[0012] FIG. 4 is a schematic diagram of a building material plate according to another alternate embodiment of the present invention.

[0013] FIG. 5 is a schematic diagram of a building material plate according to a further embodiment of the present invention.

[0014] FIG. 6 is a schematic diagram of a building material plate according to another further embodiment of the present invention.

[0015] FIG. 7 is a schematic diagram of a door sheet structure according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] A number of implementations of the present invention are disclosed below with reference to accompanying drawings. It should be noted that the

structure and description of the implementations of the present invention are for exemplary purpose only. The scope of protection of the description of the present invention is not limited to the above implementations. Although the present invention does not illustrate all possible embodiments, a person
5 ordinary skilled in the technology field can make necessary modifications or adjustments to fit actual needs without breaching the spirit and scope of the present invention. Therefore, the embodiments of the present invention can also be used in other implementations not disclosed in the present invention. Therefore, the specification and drawings are for explaining and describing
10 the embodiment only, not for limiting the scope of protection of the present invention.

[0017] FIG. 1 is a schematic diagram of a building material plate according to an embodiment of the present invention. As indicated in FIG. 1, the building material plate 10 includes a transparent substrate 100 and a light diffusion
15 layer 110. The light diffusion layer 110 is formed on the transparent substrate 100. For example, the light diffusion layer 110 is located on at least one surface of the transparent substrate 100. The light diffusion layer 110 includes an optical material and a plurality of first light diffusion particles. The first light diffusion particles have an average particle size of 6-100 micrometers (μm).
20 The light diffusion layer 110 has a ten-point mean roughness (R_z) of 11-28 μm . In an embodiment, the light diffusion layer 110 has a square mean roughness (R_q) of 2-6 μm . In an embodiment, the light diffusion layer 110 has a maximum height (crest to valley) roughness (R_y) of 16-25 μm . In an embodiment, the

light diffusion layer 110 has a surface average roughness (Ra) of 1.5-5.5 μ m.

[0018] In an embodiment, the thickness of the transparent substrate 100 is larger than 3mm, and when the transparent substrate 100 has a thickness of 3-4 millimeters (mm), the transparent substrate 100 has a total light transmittance preferably above 85%, most suitably above 88%, optimally above 90%, and more superiorly above 92%. For example, the transparent substrate 100 has a total light transmittance of such as 85-99% or 90-99%. Preferably, the transparent substrate 100 does not contain any light diffusion particles. With the integration of the transparent substrate 100 and the light diffusion layer 110, the building material plate of the present invention possess even better optical properties and provides elegant texture of glass on the appearance.

[0019] In an embodiment, the optical materials of the transparent substrate 100 and the light diffusion layer 110 are organic resin substrates possessing light-transmitting properties. In an embodiment, the optical materials of the transparent substrate 100 and the light diffusion layer 110 may be separately and independently formed of a material selected from a group consisting of methyl methacrylate-styrene copolymer (MS), polymethylmethacrylate (PMMA), polystyrene (PS), acrylonitrile-styrene (AS), cyclo-olefin copolymer, polyolefin copolymers (such as poly-4-methyl-1-pentene), polyethylene terephthalate, polyolefin copolymers, polyester, polyethylene, polypropylene, polyvinyl chloride, ionomer and polycarbonate (PC). Among the above, PC, PS, PMMA, and MS are preferable, and PMMA and MS are even more

preferable. In one embodiment, MS is a copolymer including methyl methacrylate (MMA) units and styrene units formed by copolymerizing MMA monomers and styrene monomers. The weight ratio (MMA/SM) of methyl methacrylate (MMA) to styrene (SM) is more preferably 30/70-40/60.

5 **[0020]** In an embodiment, the light diffusion layer 110 may further include a plurality of second light diffusion particles having an average particle size of 0.5-5 micrometers (μm).

10 **[0021]** In an embodiment, the light diffusion particles (the first light diffusion particles and/or the second light diffusion particles) are used to adjust optical properties and practical performance to achieve an equilibrium level that can meet the requirements of the industries. For example, the surface roughness and the total light transmittance can be adjusted at the same time to meet the required optical properties and provide practical performance including shielding effect and anti-water-caused-penetration.

15 The first light diffusion particles and the second light diffusion particles of the present invention can be formed of inorganic micro-particles or organic micro-particles, and organic micro-particles are better than inorganic micro-particles. Examples of inorganic micro-particles include glass micro-particles, barium sulfate (BaSO_4), calcium carbonate (CaCO_3) and

20 alumina (Al_2O_3). Examples of organic micro-particles include PS resin, (methyl) acrylic resin, and silicone resin. Of the said organic micro-particles, crosslinked organic micro-particles have better performance. The organic micro-particles are partly crosslinked during the manufacturing process, and

the crosslinked micro-particles will not be deformed during the manufacturing process of the translucent resin, and still remain in a micro-particle state. The crosslinked organic particles that will not be melted in the translucent resin even when being heated to the formation temperature of the translucent resin are preferred, and the organic micro-particles of the crosslinked (methyl) acrylic resin or the silicone resin are even more preferred. Particularly suitable examples include the core/shell polymer composed of a core formed of the polymeric micro-particle poly (butyl acrylate) using partly crosslinked methyl methacrylate as the base and a shell formed of the poly (methyl methacrylate), the core/shell polymer composed of a core and a shell formed of the rubbery ethylene polymer (Paraloid EXL-5136 of the Rohm and Hass Company), and the silicone resin composed of the crosslinked siloxane group (Tospearl 120 of the Toshiba Silicone Co., Ltd.).

[0022] In an embodiment, the first light diffusion particles and the second light diffusion particles, such as organic materials, may include crosslinked polymer. Examples of the crosslinked polymer include at least one of polysiloxane, PMMA, MS and PS.

[0023] The first light diffusion particles and the second light diffusion particles are preferably formed of different materials. For example, the first light diffusion particles are preferably formed of a material selected from PS, PMMA or MS. The second light diffusion particles are preferably formed of a material selected from silicone resin containing crosslinked siloxane group.

[0024] In an embodiment, the first light diffusion particles have an average particle size of 6-100 micrometers (μm), preferably 10-80 μm , most suitably 20-75 μm , optimally 25-75 μm , and more superiorly 30-70 μm . The second light diffusion particles have an average particle size of 0.5-5 μm , preferably 0.5-4.5 μm , most suitably 0.5-4 μm , and optimally 1-3.5 μm . The average particle size of the transparent micro-particles (that is, the first light diffusion particles and the second light diffusion particles) is a weight average particle size obtained using a particle counting method, and the measuring device is a particle number · particle size distribution analyzer MODEL Zm of the Nikkaki Bios Co., Ltd. When the weight average particle size of the first light diffusion particles is less than 6 μm , the obtained light diffusion is insufficient and the luminescence of the light-emitting surface is poor. When the weight average particle size of the first light diffusion particles is greater than 100 μm , the obtained light diffusion is insufficient and the surface being too rough will affect optical properties and aesthetics of the appearance. Moreover, when the weight average particle size of the second light diffusion particles is less than 0.5 μm , the obtained light diffusion is insufficient and the luminescence of the light-emitting surface is poor. When the weight average particle size of the second light diffusion particles is greater than 5 μm , the obtained light diffusion is insufficient and insufficient light diffusion will result in insufficient transparency.

[0025] The usage amount of the first light diffusion particles preferably is 10-30 weight parts based on 100 weight parts of the optical material, most

suitably between 15-25 weight parts, and optimally between 18-23 weight parts. The usage amount of the second light diffusion particles preferably is 0-5 weight parts based on 100 weight parts of the optical material, most suitably between 1-4 weight parts, and optimally between 2-3 weight parts.

5 When the usage amount of the first light diffusion particles is less than 10 weight parts, light diffusion of the building material plate will be insufficient. Under such circumstance, the light can directly pass through the building material plate, the object behind the film will be viewed, and the privacy behind the building material plate cannot be protected. On the other hand,
10 when the usage amount of the first light diffusion particles is greater than 30 weight parts, the total light transmittance of the building material plate will be reduced, and the total light transmittance will be too low. Under such circumstance, the object behind the building material plate will be unrecognizable, causing inconvenience of use. When the usage amount of
15 the second light diffusion particles is greater than 5 weight shares, the light transmittance of the building material plate will be reduced and the total light transmittance will be reduced. Under such circumstance, the total light transmittance will be too low and the object behind the building material plate will be unrecognizable, causing inconvenience of use. In short, the surface
20 roughness of the first light diffusion particles of the building material plate can be adjusted, and the haze of the second light diffusion particles of the building material plate can be adjusted. Actually, the first light diffusion particles and the second light diffusion particles are correlated. For example, when the two light diffusion particles are added at the same time, optical properties of the

building material plate including total light transmittance and haze can be achieved by adjusting the addition ratio of the two light diffusion particles to be within an optimum range. Within the optimum range, the building material plate can provide practical performances including shielding effect and anti-water-caused-penetration.

[0026] According to the embodiments of the present invention, the building material plate possesses excellent optical properties including total light transmittance and haze, provides practical performances including shielding effect and anti-water-caused-penetration, and has a higher structural intensity.

[0027] In the embodiments, the optical material and the transparent substrate 100 can have substantially the same refractivity.

[0028] According to the embodiments of the present invention, the transparent substrate 100 may exclude any light diffusion particles, and therefore may produce a sense of transparency similar to that of a glass material. The haze provided by the light diffusion layer 110 can achieve expected effects including shielding effect and anti-water-caused-penetration.

[0029] As indicated in FIG. 1, in the embodiment, the ratio ($T1/T2$) of the thickness $T1$ of the light diffusion layer 110 to the thickness $T2$ of the transparent substrate 100 is such as 0.02-0.9, preferably such as 0.05-0.7, more superiorly such as 0.07-0.5, and optimally such as 0.08-0.3. In the embodiment, the thickness $T1$ of the light diffusion layer 110 is such as

50-5000 μm , preferably such as 100-3000 μm , more superiorly such as 100-1000 μm , and optimally such as 100-500 μm .

[0030] As indicated in FIG. 1, the light diffusion layer 110 has surface that is a rough surface 110a. In an embodiment, the rough surface 110a has a square mean roughness (R_q) of preferably 2-5.5 μm , optimally 2.5-5.3 μm . In an embodiment, the rough surface 110a of the light diffusion layer 110 has a ten-point mean roughness (R_z) of preferably 11-28 μm , optimally 12-27 μm . In an embodiment, the rough surface 110a of the light diffusion layer 110 has a maximum height roughness (R_y , the maximum peak to lowest valley vertical distance within a single sample length) of 16-25 μm , preferably 17-24.5 μm , optimally 20-24 μm . In an embodiment, the rough surface 110a of the light diffusion layer 110 has a surface average roughness (R_a) of such as 1.5-5.5 μm , and preferably such as 1.6-5 μm . In an embodiment, a hard coating layer can be coated on the rough surface 110a of the light diffusion layer 110 to increase the surface hardness of the light diffusion layer 110. The hard coating layer has a thickness of such as 10-30 μm , and preferably 10-20 μm .

[0031] In an embodiment, the interface 100a between the light diffusion layer 110 and the transparent substrate 100 can be a planar surface or a curved surface as indicated in FIG. 1 and FIG. 2. In the present embodiment, the interface 100a between the light diffusion layer 110 and the transparent substrate 100 is a planar surface.

[0032] As indicated in FIG. 1, the transparent substrate 100 has a surface 100b opposite to the interface 100a between the light diffusion layer 110 and the transparent substrate 100. In an embodiment, the surface 100b has a surface average roughness (Ra) of such as 0.002-0.5 μ m, more superiorly such as 0.01-0.3 μ m and optimally such as 0.02-0.2 μ m. In an embodiment, a hard coating layer can be coated on the surface 100b of the transparent substrate 100 to increase the surface hardness of the transparent substrate 100. In an embodiment, the hard coating layer has a thickness of such as 10-30 μ m, and preferably such as 10-20 μ m.

[0033] In an embodiment, the aforementioned hard coating layer can be realized by such as a polymethacrylate-based composition containing silica and a poly (meth) acrylate-based compound. In an embodiment, examples of the poly (meth) acrylate-based compound include: isooctyl polyacrylate, acrylic acid isooctyl-styrene copolymer, isooctyl acrylate-dimethylaminoethyl methacrylate copolymer, isooctyl acrylate-ethylene vinyl acetate copolymer, polyethylmethacrylate, polyisobutylmethacrylate, polycyclohexyl acrylate, poly isooctyl methacrylate, polydecyl methacrylate, poly octadecyl methacrylate, polybenzyl methacrylate, polyethoxyl methacrylate, polyhydroxyl methacrylate, polydimethylaminoethyl methacrylate, and etc.

[0034] According to an embodiment of the present invention, the building material plate has a transmittance of 50-98%, preferably such as 60-97%. In addition, the building material plate has a haze of 70-99%, preferably such as 75-99%.

[0035] The optical properties of the building material plate vary with the applied locations. For example, bathroom used door-plates and kitchen used door-plates require a higher light transmittance to create the sense of space, and therefore require a light transmittance of 70-98% and preferably 75-90%.

5 Moreover, the building material plate has a haze of 75-98%, and preferably 77-96%. Private spaces such as bedroom used door-plates and conference room partitions or door-plates need more privacy protection and therefore require a light transmittance of 50-90% and preferably 60-86%. Besides, the building material plate has a haze of 85-99% and preferably 90-97%.

10 **[0036]** Most commonly, the building material plate formed by a transparent substrate and a single-layered light diffusion layer, such as the illustrated structure of FIG. 1~3, are used in bathroom and kitchen, the building material plate formed by a transparent substrate and two light diffusion layers, such as the illustrated structure of FIG. 4~6, are used in bedroom or conference room
15 partition or office partition.

[0037] According to an embodiment of the present invention, the building material plate has a thickness of 1-20 millimeters (mm), preferably 2-15mm, more superiorly 3-10mm, and optimally 3-5mm.

[0038] According to an embodiment of the present invention, the building
20 material plates 10-30 can be manufactured by performing a co-extrusion process. The manufacturing method of the building material plate may include following steps. A first transparent thermoplastic resin for forming the

transparent substrate 100 is provided. A light diffusion layer material for forming the light diffusion layer 110 is provided. A co-extrusion process is performed to co-extrude the first thermoplastic resin and the light diffusion layer material for forming the transparent substrate 100 and the light diffusion layer 110 of the building material plate 10-30.

[0039] For example, a first transparent thermoplastic resin (the material of the transparent substrate 100) is heated, pressed and extruded by a first extrusion device (not illustrated). A second transparent thermoplastic resin (the material of the light diffusion layer 110) containing the first light diffusion particles (with an average particle size of such as 6-100 μ m) and the second light diffusion particles (with an average particle size of such as 0.5-5 μ m) is extruded by a second extrusion device (not illustrated) at an extrusion temperature equivalent to that of the first extrusion device. Then, the building material plate 10 containing the light diffusion layer 110 and the transparent substrate 100 can be formed by co-extruding a first extruded product from the first extrusion device and a second extruded product from the second extrusion device using a multi-manifold die (not illustrated). In the embodiments, the first transparent thermoplastic resin and the second transparent thermoplastic resin may be the same material or different materials.

[0040] In other embodiments, the extruded product of the first extrusion device and the extruded product of the second extrusion device are co-extruded using a feedblock type die (not illustrated).

[0041] In other embodiments, the first extrusion device and the second extrusion device may have different extrusion temperatures, but the discharging temperature at which the first extruded product leaves the first extrusion device is equivalent to the discharging temperature at which the second extruded product leaves the second extrusion device. The first extruded product and the second extruded product have a discharging temperature of 220 °C-290 °C, and preferably 240 °C-270 °C.

[0042] FIG. 2 is a schematic diagram of a building material plate according to another embodiment of the present invention. FIG. 3 is a schematic diagram of a building material plate according to an alternate embodiment of the present invention. For the components of the two embodiments identical or similar to that of previous embodiments, identical or similar designations are used, and related descriptions can be obtained with reference to above disclosure and are not repeated here. The two embodiments are different from the embodiment of FIG. 1 mainly in that the interface 100a is a curved surface.

[0043] As indicated in the building material plate 20 of FIG. 2, the interface 100a between the light diffusion layer 110 and the transparent substrate 100 is a curved surface indented towards the transparent substrate 100. As indicated in the building material plate 30 of FIG. 3, the interface 100a between the light diffusion layer 110 and the transparent substrate 100 is a curved surface protruded towards the light diffusion layer 110.

[0044] As indicated in the building material plates 20 and 30 of FIGS. 2-3, the transparent substrate 100 has a surface 100b opposite to the interface 100a between the light diffusion layer 110 and the transparent substrate 100. In an embodiment, the surface 100b has a surface average roughness (Ra) of such as 0.002-0.5 μ m, more superiorly such as 0.01-0.3 μ m, and optimally such as 0.02-0.2 μ m.

[0045] FIG. 4 is a schematic diagram of a building material plate according to another alternate embodiment of the present invention. For components of the present embodiment identical or similar to the above embodiments, identical or similar designations are used, and related descriptions can be obtained with reference to above disclosure and are not repeated here.

[0046] As indicated in the embodiment of FIG. 4, the light diffusion layer 110 of the building material plate 40 is formed on two opposite surfaces (the interface 100a and the surface 100b) of the transparent substrate 100. In the present embodiment, two interfaces (the interface 100a and the surface 100b) are located between the transparent substrate 100 and the light diffusion layer 110.

[0047] According to the present embodiment, the building material plate is formed by performing a co-extrusion process. The manufacturing method of the building material plate 40 is almost the same with that of the aforementioned building material plates 10-30, and the difference is that a splitting process is performed on the second extruded product from the

second extrusion device, such that the second extruded product can form two light diffusion layers respectively on two opposite surfaces of the transparent substrate; or, the above can be achieved by using a third extrusion device (not shown).

5 **[0048]** FIG. 5 is a schematic diagram of a building material plate according to a further embodiment of the present invention. FIG. 6 is a schematic diagram of a building material plate according to another further embodiment of the present invention. For the components of the two embodiments identical or similar to that of previous embodiments, identical or similar
10 designations are used, and related descriptions can be obtained with reference to above disclosure and are not repeated here. The two embodiments are different from the embodiment of FIG. 4 mainly in that the interface 100a is a curved surface.

15 **[0049]** As indicated in the building material plate 50 of FIG. 5, two interfaces (the interface 100a and the surface 100b) between the two light diffusion layers 110 and the transparent substrate 100 both are curved surfaces indented towards the transparent substrate 100. As indicated in the building material plate 60 of FIG. 6, two interfaces (the interface 100a and the surface 100b) between the two light diffusion layers 110 and the transparent
20 substrate 100 both are curved surfaces protruded towards the light diffusion layer 110. In another embodiment, two interfaces (the interface 100a and the surface 100b) between the two light diffusion layers 110 and the transparent substrate 100 can be curved surfaces respectively indented towards the

transparent substrate 100 and protruded towards the light diffusion layer 110 (not shown).

[0050] FIG. 7 is a schematic diagram of a door sheet structure according to an embodiment of the present invention. As indicated in FIG. 7, the door sheet structure 70 includes a frame 710 and a sheet plate 720 disposed in the frame 710. The sheet plate 720 includes the aforementioned building material plate.

[0051] According to the embodiments of the present invention, the door sheet structure formed of the building material plate of the embodiment has excellent optical properties including total light transmittance and haze, and at the same time has higher structural intensity, and therefore can meet a higher standard of safety.

[0052] Depending on actual needs, a UV absorber can be used in the light diffusion layer 110. Examples of the UV absorber include a benzophenone UV absorber such as 2, 2'-dihydroxy-4-methoxy benzophenone, a triazine UV absorber such as 2- (4, 6-diphenyl-1, 3, 5-triazin-2-substituent) -5-hexyl hydroxy phenol, and a benzotriazole UV absorber such as 2- (2H-benzotriazole-2-substituent) -4-methylphenol, 2- (2H-benzotriazole-2-substituent) -4-third-octyl phenol, 2- (2H-benzotriazole-2-substituent) -4, 6-bis (1-methyl-1-phenylethyl) phenol, 2- (2H-benzotriazole-2-substituent) -4, 6-bis-tertiary amyl phenol, 2- (5-chloro group-2H-benzotriazole-2-substituent) -4-methyl-6-third-butylphenol, 2-

(5-chloro group-2H-benzotriazole-2-substituent) -2, 4-third-butylphenol or 2, 2'-methylene-bis[6- (2H-benzotriazol-2-substituted-yl) -4- (1, 1, 3, 3-tetramethylbutyl) phenol]. Preferably, the UV absorber is formed of 2- (2-hydroxy-5-methylphenyl) benzotriazole, 2- (2-hydroxy-5-tertiary-octylphenyl) benzotriazole, 2- (2-hydroxy-3, 5-diisopropylbenzene) phenylbenzotriazole, 2- (2-hydroxy-3-tert-butyl-5-methylphenyl) -5-chloro group benzotriazole, 2, 2'-methylene bis [4- (1, 1, 3, 3 tetramethylbutyl) -6- (2H-benzotriazole-2-substituent) phenol], 2-[2-hydroxy-3- (3, 4, 5, 6-phthalimide (PEI) methyl) -5-tolyl] benzotriazole, wherein, 2- (2-hydroxy-5-tertiary-octylphenyl) benzotriazole, or 2, 2'-methylene bis [4- (1, 1, 3, 3-tetramethylbutyl) -6- (2H-benzotriazole-2-substituent) phenol] is preferred. The above UV absorbers can be used separately or jointly.

[0053] Depending on actual needs, a fluorescent agent can be used in the light diffusion layer 110. The fluorescent agent is formed of stilbene-based, benzimidazole-based, benzoxazole-based, terephthalic acid (PEI)-based, rose erythroid-based, coumarin-based, or oxazole-based compounds and is used for changing the tone of synthetic resin to white or bluish white.

[0054] Depending actual needs, an antioxidant can be used in the light diffusion layer 110. The varieties of antioxidants include phenol-based antioxidants, thioether-based antioxidants, and phosphorus-based antioxidant. Typical examples of the phenol-based antioxidants include: octadecyl (3, 5-tert-butyl-4-hydroxyphenyl) -propionate, triethylene glycol bis [3- (3-tert-butyl-5-methyl-4-hydroxyphenyl) propionate], tetrakis [methylene-3- (3,

5-tert-butyl-4-hydroxyphenyl) propionate] methane, 2-tert-butyl 6-(3-hydroxy-6-tertiary-butyl-2-methylbenzyl) -4-methylphenyl acrylate, 2, 2'-methylene group-bis (4-methyl-6-tertiary-butyl-phenol), 2, 2'-thiobis (4-methyl-6-tertiary-butylphenol), 2, 2'-thio-diethyl support group-bis [3- (3, 5-bis tertiary-butyl-4-hydroxyphenyl) propionate], 2, 2'-ethylenedioxy amide-bis [ethyl-3- (3, 5-bis-tert-butyl-4-hydroxyphenyl) propionate].

Typical examples of the thioether-based antioxidants include: distearyl thiodipropionate XI, dipalmitate XI thiodipropionate, pentaerythritol-tetrakis-(β -dodecamethylcyclohexasiloxane-sulfur propionate), dioctadecyl sulfide.

10 Typical examples of the phosphorus-based antioxidants, such as phosphite-based antioxidants or phosphate-based antioxidants, include: tris (nonylphenyl) phosphite, dodecyl phosphite, cyclic neopentane tetrahydronaphthyl bis (octadecyl phosphite), 4, 4'-butylidene bis (3-methyl-6-tert-butyl-phenyl-bis tridecyl phosphite), tris (2, 4-t-butyl-phenyl) phosphite, tetrakis (2, 4-tertiary-butylphenyl) -4, 4'-biphenyl phosphite stretch) 15 -4, 4'-biphenyl phosphate stretch, 9, 10-dihydro-9-oxo-10-oxo support-10.

[0055] Descriptions of the embodiments of the present invention are disclosed below. However, the present invention is not limited thereto.

[0056] Evaluation items and methods are disclosed below.

20 **[0057]** a) Total light transmittance: Total light transmittance is measured by using the Haze meter NDH 2000 of the Nippon Denshoku Industries Co., Ltd. according to the JIS K-7361. In the present embodiment, a 4mm plate is

measured.

[0058] b) Haze: Haze is measured by using the Haze meter NDH 2000 of the Nippon Denshoku Industries Co., Ltd. according to the JIS K-7361. In the present embodiment, a 4mm plate is measured.

5 **[0059]** c) Observation of privacy protection: At a space with a luminance of 300 lux, a building material plate is erected in front of the human eyes at a distance of 30cm, and an object is placed, wherein the object is a pair of parallel lines, each line has a width of 5mm, and the two lines are separated by 5mm. The object is placed on a vertically opposite side of the human eyes
10 and the building material plate and is separated from the building material plate by 1cm. Then, the object is moved away from the building material plate and the human eyes, and the distance at which the human eyes cannot recognize the interval between the two lines is recorded. If the distance is less than 30cm, then the observation is denoted by ○. If the distance is 30-60cm,
15 then the observation is denoted by △. If the distance is greater than 60cm, then the observation is denoted by X.

[0060] d) Observation of anti-water-caused-penetration: Whether the penetrability of the building material plate is affected by the water adhered on the surface of the building material plate is determined. A building material
20 plate is erected in front of human eyes at a distance of 30cm, and an object is placed, wherein the object is a pair of parallel lines, each line has a width of 5mm, and the two lines are separated by 5mm. The object is placed on a

vertically opposite side of the human eyes and the building material plate and is separated from the building material plate by 5cm. Then, after the outer surface of the light diffusion layer of the building material plate (such as the light diffusion layer 110 of FIG. 1) is wiped with a wet rag, whether the two lines still can be clearly viewed from the wiping surface using naked eyes is determined. If the determination is negative, then the observation is denoted by ○. If the determination is affirmative, then the observation is denoted by X.

[0061] e) Measurement of surface roughness (Ra/ Ry/ Rq/ Rz): Surface roughness (such as Ra/ Ry/ Rq/ Rz) is measured by using the portable surface roughness tester SJ-210 of the Mitutoyo Corporation with the probe of the SJ-210 moving on the surface of the building material plate surface within a range of 4 millimeters (mm).

[0062] <Embodiment 1>

[0063] 100 weight parts of Chi Mei commercially available PM-500G MS and 15 weight parts of the first light diffusion particles [PMMA micro-particles having an average particle size of 45μm] are mixed and used as the material of the light diffusion layer. On the other hand, 100 weight parts of Chi Mei commercially available PM-500G MS are prepared and used as the material of the transparent substrate (the material formed as a plate having a thickness of 3mm has a total light transmittance of 92%). Both layers are processed using a co-extrusion molding machines. Meanwhile, the cylinder temperature is maintained at 240-270℃, and the mold temperature is

maintained at 250°C, such that the light diffusion layer can have a thickness of 200µm, and the building material plate containing a single-layered light diffusion layer can have a thickness of 4mm. The surface of the light diffusion layer of the building material plate has a surface average roughness (Ra) of 3.8µm, a ten-point mean roughness (Rz) of 17.2µm, and a maximum height (crest to valley) roughness (Ry) of 23.4µm. The surface of the building material plate opposite to the light diffusion layer has a surface roughness of 0.02µm. The performance of the building material plate in terms of total light transmittance, haze and naked eye observation is recorded in Table 2 below.

10 **[0064]** <Embodiment 2>

[0065] The differentiating features between Embodiment 2 and Embodiment 1 is that besides of the first light diffusion particles, the light diffusion layer of the Embodiment 2 contains additional 3.5 weight parts second light diffusion particles [silicone resin based transparent micro-particles, having an average particle size of 2.0µm] and the light diffusion layer has a thickness of 160µm. The surface of the light diffusion layer of the building material plate has a surface average roughness (Ra) of 3.1µm, a ten-point mean roughness (Rz) of 14.4µm, and a maximum height roughness (Ry) of 21.0µm. The surface of the building material plate opposite to the light diffusion layer has a surface roughness of 0.03µm.

[0066] <Embodiment 3>

[0067] The manufacturing method of Embodiment 3 is the same as that of Embodiment 2, and the differentiating features between Embodiment 3 and Embodiment 2 are listed in Table 2. The results of surface average roughness, total light transmittance, haze and observations using naked eyes of the building material plate containing the light diffusion layer are disclosed in Table 2.

[0068] <Embodiment 4>

[0069] The differentiating features between Embodiment 4 and Embodiment 2 is that the 4mm thick building material plate including two light diffusion layers is formed by using a 3 layered co-extruder. 20 weight parts of the first light diffusion particles and 0.6 weight parts of the second light diffusion particles are used. Each side of the light diffusion layers has a thickness of 400 μ m. The results of surface average roughness, total light transmittance, haze and observations using naked eyes of the building material plate containing the light diffusion layer are disclosed in Table 2.

[0070] <Embodiments 5-9>

[0071] The manufacturing methods used in Embodiments 5-9 are the same as that used in Embodiment 4, and the differences are listed in Table 1. The results of surface average roughness, total light transmittance, haze and observations using naked eyes of the building material plates containing the light diffusion layers are disclosed in Table 2.

[0072] <Comparison Example 1>

[0073] 100 weight parts of Chi Mei commercially available PM-500G MS, 15 weight parts of the first light diffusion particles [PMMA micro-particles having an average particle size of 45 μ m], and 1 weight part of the second
5 light diffusion particles [silicone resin based transparent micro-particles having an average particle size of 2.0 μ m] are mixed, and then the resin mixture is pressure-plate by using an extrusion molding machine. Meanwhile, the cylinder temperature is controlled at 240-270 $^{\circ}$ C, and the mold temperature is maintained at 250 $^{\circ}$ C, such that the formed building material plate can have a
10 thickness of 4mm. The performance of the building material plate in terms of total light transmittance, haze and naked eye observation is recorded in Table 2 below.

[0074] <Comparison Example 2>

[0075] Comparison Example 2 is different to Comparison Example 1 in
15 that the plate formed in Comparison Example 2 contains only the first light diffusion particles. The results of surface roughness, total light transmittance, haze and observations using naked eyes of the building material plate containing the light diffusion layer are disclosed in Table 2.

[0076] <Comparison Example 3>

20 **[0077]** Comparison Example 3 is different to Comparison Example 1 in that the plates formed in the Comparison Example 3 contains neither the first

light diffusion particles nor the second light diffusion particles. The results of surface roughness, total light transmittance, haze and observations using naked eyes of the building material plate containing the light diffusion layer are disclosed in Table 2.

5 [0078] Table 1

	Number of light diffusion layer	Thickness of light diffusion layer (μm)	First light diffusion particles (particle size/weight parts)	Second light diffusion particles (particle size/weight parts)
Embodiment 1	Single	200	45 μm /15	No addition
Embodiment 2	Single	160	45 μm /15	2 μm /3.5
Embodiment 3	Single	400	45 μm /15	2 μm /3.5
Embodiment 4	Double	300	45 μm /20	2 μm /0.6
		300	45 μm /20	2 μm /0.6
Embodiment 5	Double	400	45 μm /15	2 μm /1
		400	45 μm /15	2 μm /1
Embodiment 6	Double	400	45 μm /15	2 μm /1
		400	45 μm /15	2 μm /1

Embodiment 7	Double	Refer to Table 3	45μm/15 45μm/15	2μm/1 2μm/1
Embodiment 8	Double	400 400	45μm/40 45μm/40	No addition
Embodiment 9	Double	400 400	45μm/15 45μm/15	2μm/6 2μm/6
Comparison example 1	Single	4000	45μm/15	2μm/1
Comparison example 2	Single	4000	45μm/15	No addition
Comparison example 3	No	No	No	No

[0079] Table 2 [Tt denotes total light transmittance; Hz denotes haze]

	Tt	Hz	Shielding observation	Penetrating observation	Transparent substrate	Surface average roughness of diffusion layer (Ra) (μm)	Ten-point mean roughness (Rz) (μm) of the diffusion layer	Square mean roughness (Rq) (μm) of the diffusion layer	Max height roughness (Ry) (μm) of the diffusion layer
Embodiment 1	95	80	○	○	Yes	3.8	17.2		23.4
Embodiment 2	85	92	○	○	Yes	3.1	14.4		21.0

Embodiment 3	63	95	○	○	Yes	2.2	12.5	2.8	
Embodiment 4	78.13	95.78	○	○	Yes	2.579	13.514	3.17	
Embodiment 5	86	95	○	○	Yes	2.2 3.7	15.5 23.8	2.8 4.7	
Embodiment 6	77	96	○	○	Yes	2.6 3.1	13.4 15.1		17.3 20.5
Embodiment 7	Refer to Table 3	Refer to Table 3	○	○	Yes	Refer to Table 3	Refer to Table 3	Refer to Table 3	
Embodiment 8	91	94	△	○	Yes	3.3 3.87	19.9 26.5	4.1 5.1	
Embodiment 9	77	95	△	○	Yes	2.7 3.6	17.6 25.5	3.4 4.8	
Comparison example 1	49	97	○	X	No	NA	NA	NA	
Comparison example 2	91	93	○	X	No	2.3	3.87	19.4	
Comparison example 3	92	0.13	X	○	Yes	0.02	0.1	0.02	

[0080] In embodiment 7, the interfaces between the light diffusion layer and the transparent substrate both are curved surfaces, as illustrated in FIG.

5. Measurements of the thickness of the light diffusion layer and other experimental values at the left terminal point, the right terminal point and the central point of the building material plate are respectively measured and listed below.

5 [0081] Table 3

	Upper light diffusion layer thickness (μm)	Lower light diffusion layer thickness (μm)	Tt (%)	Hz (%)	Ra (μm)	Rz (μm)	Rq (μm)
Right terminal point	299	296	96	86	2.6(upper) 1.8(lower)	15.5(upper) 12(lower)	3.4(upper) 2.5(lower)
Central point	442	407	97	77	2.8(upper) 2.1(lower)	16.1(upper) 12.5(lower)	3.7(upper) 2.7(lower)
Left terminal point	340	301	96	83	2.8(upper) 2.3(lower)	15.6(upper) 14.3(lower)	3.62(upper) 2.9(lower)

[0082] As indicated in above embodiments and comparison examples, the plates formed in comparison examples 1-2 contain the first light diffusion

particles and the second light diffusion particles but without the transparent substrate, and therefore have poor full luminance transmittance and are susceptible by water. The plate formed in comparison example 3 contains the transparent substrate but without the light diffusion layer, and therefore has poor performance in terms of shielding effect and cannot be used as a building material plate. The first light diffusion particles are present in an amount of more than 30% or the second light diffusion particles are present in an amount of more than 5% of the plates formed in embodiments 8-9, therefore the shielding effect will deteriorate. However, the overall performance of embodiments 8-9 is still better than that of comparison examples 1-3.

[0083] As indicated in above embodiments and comparison examples, only the building material plate containing the transparent substrate and the light diffusion layer whose light diffusion particles are suitably adjusted can produce suitable optical properties including light transmittance and haze, as well as practical performance including privacy protection and anti-water-caused-penetration.

[0084] While the invention has been described by way of example and in terms of the preferred embodiment (s), it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and

procedures.

WHAT IS CLAIMED IS:

1. A building material plate, comprising:
 - a transparent substrate, wherein the transparent substrate has a total light transmittance of 85-99%; and
 - a light diffusion layer located on at least one surface of the transparent substrate, wherein a ratio of a thickness of the light diffusion layer to a thickness of the transparent substrate is 0.05-0.7, the light diffusion layer has the thickness of 100-3000 μ m, the light diffusion layer comprises:
 - an optical material;
 - a plurality of first light diffusion particles having an average particle size of 6-100 micrometers (μ m); and
 - a plurality of second light diffusion particles having an average particle size of 0.5-5 micrometers (μ m),
 - wherein a ten-point mean roughness (Rz) of the light diffusion layer is 11-28 μ m, the first light diffusion particles are present in an amount of 10-30 weight parts based on 100 weight parts of the optical material, the second light diffusion particles are present in an amount of larger than 0 weight part and less than or equal to 5 weight parts based on 100 weight parts of the optical material, the building material plate has a transmittance of 77-86%.
2. The building material plate according to claim 1, wherein the first light diffusion particles and the second light diffusion particles are formed of different materials.
3. The building material plate according to claim 1, wherein the second light diffusion particles comprise a crosslinked siloxane group silicone resin.
4. The building material plate according to claim 1, wherein at least one of the first light diffusion particles and the second light diffusion particles comprise a crosslinked polymer.
5. The building material plate according to claim 4, wherein the crosslinked polymer comprises at least one of polysiloxane, polymethylmethacrylate (PMMA), methyl methacrylate-styrene copolymer (MS) and polystyrene (PS).
6. The building material plate according to claim 1, wherein the first light diffusion particles comprise a crosslinked polymer selected from a group consisting of polystyrene, polymethylmethacrylate and methylmethacrylate-styrene copolymer.
7. The building material plate according to claim 1, wherein the transparent substrate and the optical material are separately and independently

formed of a material selected from a group consisting of methyl methacrylate-styrene copolymer (MS), polymethylmethacrylate (PMMA), polystyrene (PS), acrylonitrile-styrene (AS), cyclo-olefin copolymer, polyolefin copolymers, polyester, polyethylene, polypropylene, polyvinyl chloride, ionomer and polycarbonate (PC).

8. The building material plate according to claim 7, wherein the transparent substrate is formed of a material selected from a group consisting of polycarbonate (PC), polystyrene (PS), polymethylmethacrylate (PMMA) and methyl methacrylate-styrene copolymer (MS).

9. The building material plate according to any one of claims 1-8, wherein an interface between the light diffusion layer and the transparent substrate is a planar surface or a curved surface.

10. The building material plate according to any one of claims 1-8, wherein the transparent substrate has a surface, the surface is opposite to an interface between the transparent substrate and the light diffusion layer, and the surface of the transparent substrate has a surface roughness of 0.002-0.5 μ m.

11. The building material plate according to any one of claims 1-8, wherein the light diffusion layer is located on two opposite surfaces of the transparent substrate.

12. The building material plate according to any one of claims 1-8, wherein the building material plate has a haze of 70-99%.

13. The building material plate according to any one of claims 1-8, wherein the building material plate has a thickness between 1-20 millimeters (mm).

14. The building material plate according to any one of claims 1-8, wherein the light diffusion layer has a surface average roughness of 1.5-5.5 μ m.

15. A building material plate, comprising:

a transparent substrate, wherein the transparent substrate has a total light transmittance of 85-99%; and

a light diffusion layer located on at least one surface of the transparent substrate, wherein a ratio of a thickness of the light diffusion layer to a thickness of the transparent substrate is 0.05-0.7, the light diffusion layer has the thickness of 100-3000 μ m, the light diffusion layer comprises:

an optical material;

a plurality of first light diffusion particles having an average particle size of 6-100 micrometers (μ m); and

a plurality of second light diffusion particles having an average particle size of 0.5-5 micrometers (μ m), wherein a surface average roughness of the light diffusion layer is 1.5-5.5 μ m, the first light diffusion particles are present in an

amount of 10-30 weight parts based on 100 weight parts of the optical material, the second light diffusion particles are present in an amount of larger than 0 weight part and less than or equal to 5 weight parts based on 100 weight parts of the optical material, the building material plate has a transmittance of 77-86%.

16. A bathroom door-plate, comprising a building material plate as claimed in any one of claims 1-15.

17. A door sheet structure, comprising:

a frame; and

a sheet plate disposed inside the frame, the sheet plate comprises a building material plate as claimed in any one of claims 1-15.

18. A kitchen door-plate, comprising a door sheet structure according to claim 17.

19. A bedroom door-plate, comprising a door sheet structure according to claim 17.

20. A conference room door-plate, comprising a door sheet structure according to claim 17.

21. A office partition, comprising a door sheet structure according to claim 17.

22. A manufacturing method of a building material plate, comprising:

providing a first transparent thermoplastic resin;

providing a light diffusion layer material, the light diffusion layer material comprising:

a second transparent thermoplastic resin;

a plurality of first light diffusion particles having an average particle size of 6-100 micrometers (μm) ; and

a plurality of second light diffusion particles having an average particle size of 0.5-5 micrometers (μm); and

performing a co-extrusion process to co-extrude the first the thermoplastic resin and the light diffusion layer material for forming a transparent substrate and a light diffusion layer of a building material plate respectively, wherein a ratio of a thickness of the light diffusion layer to a thickness of the transparent substrate is 0.05-0.7, the light diffusion layer has the thickness of 100-3000 μm , a ten-point mean roughness (R_z) of the light diffusion layer is 11-28 μm , the transparent substrate has a total light transmittance of 85-99%, the light diffusion layer comprises an optical material, the first light diffusion particles are present in an amount of 10-30 weight parts based on 100 weight parts of the optical material, the second light diffusion particles are present in an amount of

larger than 0 weight part and less than or equal to 5 weight parts based on 100 weight parts of the optical material, the building material plate has a transmittance of 77-86%.

23. The manufacturing method of the building material plate according to claim 22, wherein the light diffusion layer of the building material plate formed of the light diffusion layer material is located on two opposite surfaces of the transparent substrate.

24. The manufacturing method of the building material plate according to claim 22, further comprising providing two of the light diffusion layer materials, wherein the two light diffusion layer materials and the first transparent thermoplastic resin are co-extruded by performing the co-extrusion process for forming the transparent substrate of the building material plate and the light diffusion layer located on two opposite surfaces of the transparent substrate.

25. The manufacturing method of the building material plate according to any one of claims 22-24, wherein the first transparent thermoplastic resin and the second transparent thermoplastic resin are formed of the same material.

26. The manufacturing method of the building material plate according to any one of claims 22-24, wherein the first transparent thermoplastic resin and the second transparent thermoplastic resin are formed of different materials.