ENVIRONMENTALLY FRIENDLY MATERIAL FOR OUTDOOR SEATS AND PRODUCTION PROCESS THEREOF

TECHNICAL FIELD

The present invention relates to the technical field of composite materials, and specifically to an environmentally friendly material for outdoor seats and a production process thereof.

BACKGROUND

Outdoor seats provide people with places to rest and relax outdoors, meeting their various needs in outdoor work, study, rest, and event holding. Outdoor seats made mainly of plastic materials have advantages including light weight and diverse designs, and may meet the usage requirements of various outdoor environments. Common plastic materials used for manufacturing outdoor seats include polyethylene (PE), polypropylene (PP), polycarbonate (PC), acrylonitrile-butadiene-styrene copolymer (ABS), etc. These materials have advantages like light texture, durability, easy of cleaning, resistance to deformation, and strong impact resistance. However, these plastic materials belong to traditional petroleum-based materials, which consume natural resources and do not have environmental friendliness and degradability. Moreover, outdoor seats usually have a long service life. During use, petroleum-based materials will continuously interact with the environment, generating harmful substances that pollute the soil and air, and their waste will burden the environment. Therefore, the research and improvement of environmentally friendly materials for making outdoor seats are of great practical significance.

Polylactic acid (PLA), as a bio-based environmentally friendly and degradable material, may be completely degraded into carbon dioxide and water. It has excellent properties including non-toxicity, low density, easy processing, wear resistance, and water resistance, and may be used to make outdoor seats. However, the performance of PLA materials still has shortcomings, which limit their application. PLA materials have poor ultraviolet resistance. Under long-term ultraviolet irradiation, their molecular chains are prone to breakage, leading to material aging and performance degradation. In addition, PLA has poor toughness and is easily damaged when subjected to external impact. Furthermore, the antibacterial and antifungal properties of PLA are related to users' health and the service life of outdoor seats. Improving the antibacterial and antifungal properties of PLA materials may effectively reduce the erosion of materials by microorganisms including bacteria and molds, reduce the frequency of cleaning and maintenance, and improve the service life of materials. Therefore, the present invention provides an environmentally friendly material, which takes PLA as the matrix, has excellent performance and a long service life, and may be used to make outdoor seats.

SUMMARY

To address the problems mentioned in the background, an objective of the present invention is to provide an environmentally friendly material for outdoor seats and a production process thereof.

The objective of the present invention may be achieved through the following technical solutions.

An environmentally friendly material for outdoor seats includes the following raw materials in parts by weight: 70-90 parts of PLA, 20-50 parts of PC, 2-5 parts of compatibilizer, 1-4 parts of lubricant, 1-3 parts of antioxidant, 3-6 parts of functional fiber filler, and 2-5 parts of antibacterial and antifungal component.

Further, the compatibilizer is ethylene-methyl acrylate-glycidyl methacrylate; the lubricant is PE wax; and the antioxidant is an antioxidant 1010 or an antioxidant 168.

Further, a preparation method of the functional fiber filler includes the following steps:

S1: mixing quartz fibers with N,N-dimethylformamide, raising a temperature to 60-80°C, adding chloroethyl isocyanate and a catalyst A, reacting for 2-4 hours, and performing suction filtration, washing and drying to obtain modified quartz fibers; and

S2: adding the modified quartz fibers into toluene, followed by mixing uniformly, introducing nitrogen, raising the temperature to 70-80°C, adding 2,2,6,6-tetramethyl-4-piperidinol and an alkaline catalyst, reacting for 3-5 hours, and performing suction filtration, washing and drying to obtain the functional fiber filler.

By adopting the above technical solution, under the action of the catalyst, hydroxyl groups on surfaces of the quartz fibers may react with isocyanate groups in a structure of the chloroethyl isocyanate, introducing chloro substituents on the surfaces of quartz fibers to obtain modified quartz fibers. Under the action of an acid-binding agent, the chloro substituents on the surfaces of modified quartz fibers may undergo a substitution reaction with hydroxyl groups in a structure of the 2,2,6,6-tetramethyl-4-piperidinol to obtain the functional fiber filler.

Further, in S1, the catalyst A is dibutyltin dilaurate or stannous octoate.

Further, in S2, the alkaline catalyst is sodium carbonate solution or potassium carbonate solution.

Further, a preparation method of the antibacterial and antifungal component is as follows:

adding polyamidoamine into toluene and stirring a mixture uniformly, adding an acid anhydride modifier, reacting at a room temperature for 1-3 hours, raising the temperature to 80-100°C, adding diniconazole and catalyst B, maintaining the temperature for reaction for 3-5 hours, followed by cooling to the room temperature, and discharging a material to obtain the antibacterial and antifungal component.

By adopting the above technical solution, amino groups in a structure of the polyamidoamine may react with the acid anhydride modifier, introducing carboxyl groups into the structure. Under the action of the catalyst B, the carboxyl groups may undergo an esterification reaction with hydroxyl groups in a structure of the diniconazole to obtain the antibacterial and antifungal component.

Further, the acid anhydride modifier is succinic anhydride or glutaric anhydride.

Further, the catalyst B is p-toluenesulfonic acid.

A production process of the environmentally friendly material for outdoor seats includes the following steps:

step 1: adding PLA, PC, compatibilizer, lubricant, antioxidant, functional fiber filler and antibacterial and antifungal component into a high-speed mixer, raising a temperature to 60-90°C, followed by mixing for 1-2 hours to obtain a premix; and

step 2: placing the premix in a twin-screw extruder, and performing melt extrusion and granulation to obtain the environmentally friendly material.

Further, in step 2, an extrusion temperature of the twin-screw extruder is 180-220°C, and a screw rotation speed is 100-400 r/min.

The present invention has the following advantages.

(1) The functional fiber filler prepared in the present invention uses quartz fibers as the matrix. After organic modification of the quartz fibers, the compatibility problem between the quartz fibers and the PLA matrix is improved. The functional fiber filler may be uniformly dispersed in the PLA matrix, and the interface bonding effect with the PLA matrix is further strengthened, which plays a reinforcing role in the PLA matrix and improves the mechanical properties of the PLA matrix. In addition, small molecules containing hindered amine groups are grafted on the surface of the functional fiber filler, which may prevent the migration and precipitation of small molecule ultraviolet stabilizers, may act in the PLA matrix for a long time,

enhance the ultraviolet resistance of the environmentally friendly material, and prevent the environmentally friendly material from aging due to long-term ultraviolet irradiation in outdoor environments, which would lead to the degradation of the performance of the environmentally friendly material and affect the service life of outdoor seats.

(2) The antibacterial and antifungal component prepared in the present invention contains polyamidoamine with a branched structure. The branched structure has a large number of amide bonds, which may interact with the molecular chain groups of the PLA matrix, increase the entanglement with the PLA molecular chains, promote system crystallization nucleation, improve the crystallization rate of the system, and at the same time enhance the compactness of the PLA matrix, which may effectively disperse and transfer stress, enhance the impact toughness of the PLA matrix, prevent the material from being damaged when subjected to external impact, and improve the impact toughness of the environmentally friendly material. The small molecule antibacterial and antifungal substance diniconazole has efficient and broad-spectrum antibacterial and antifungal effects. After chemical bonding with polyamidoamine, it may act in the PLA matrix for a long time, effectively enhance the antibacterial and antifungal properties of the environmentally friendly material, and also prevent the migration and precipitation of small molecule antibacterial and antifungal substances, avoid the erosion of the environmentally friendly material by microorganisms including bacteria and molds, and thus prolong the service life of outdoor seats.

It is to be understood that any product implementing the present invention does not necessarily need to achieve all the above-mentioned advantages at the same time.

BRIEF DESCRIPTION OF THE DRAWINGS

To more clearly illustrate the technical solutions of the examples of the present invention, the accompanying drawings required for describing the examples will be briefly introduced below. Obviously, the drawings in the following description are only some examples of the present invention. For those ordinary in the art, other drawings may also be obtained based on these drawings without creative efforts.

FIG. 1 is an infrared spectrogram of a functional fiber filler prepared by the present invention; and

FIG. 2 is an infrared spectrogram of an antibacterial and antifungal component prepared by the present invention.

DETAILED DESCRIPTION

The technical solutions in the examples of the present invention will be clearly and completely described in conjunction with the accompanying drawings in the examples of the present invention, and it is obvious that the described examples are only some of, rather than all of the examples. Based on the examples in the present invention, all other examples obtained by those ordinary in the art without creative efforts fall within the scope of protection of the present invention.

Preparation methods of a functional fiber filler and an antibacterial and antifungal component in the following examples and comparative examples are as follows.

I. Preparation of the functional fiber filler

In S1, 3.2 g of quartz fibers were mixed with N,N-dimethylformamide, a temperature was raised to 70°C, 2.6 g of chloroethyl isocyanate and 0.2 g of dibutyltin dilaurate were added, and after reaction for 3 hours, suction filtration, washing and drying were performed to obtain modified quartz fibers.

In S2, 2.8 g of the modified quartz fibers were added into toluene, after uniform mixing, nitrogen was introduced, the temperature was raised to 75°C, 2 g of 2,2,6,6-tetramethyl-4-piperidinol and 0.3 g of potassium carbonate solution were added, and after reaction for 4 hours, suction filtration, washing and drying were performed to obtain the functional fiber filler.

Samples were prepared by the potassium bromide pellet method, and the functional fiber filler was subjected to infrared testing using an AVATAR-370FT infrared spectrometer, as shown in FIG. 1. Analysis shows that in an infrared spectrum of the functional fiber filler, an absorption peak of C=O in carbamate appears at 1709 cm-1, an absorption peak of N-H in carbamate appears at 1540 cm-1, absorption peaks of piperidine ring appear at 1465 cm-1, 1383 cm-1 and 1366 cm-1, an absorption peak of ether bond C-O appears at 1132 cm-1, and an absorption peak of Si-O-Si appears at 1086 cm-1.

II. Preparation of the antibacterial and antifungal component

6 g of polyamidoamine was added into toluene and stirred uniformly, 2.2 g of succinic anhydride was added, after reaction at room temperature for 2 hours, a temperature was raised to 95°C, 1.6 g of diniconazole and 0.5 g of p-toluenesulfonic acid were added, after heat preservation and reaction for 5 hours, a mixture was cooled to a room temperature, and

discharged to obtain the antibacterial and antifungal component.

Samples were prepared by the potassium bromide pellet method, and the antibacterial and antifungal component was subjected to infrared testing using an AVATAR-370FT infrared spectrometer, as shown in FIGS. 2. Analysis shows that in an infrared spectrum of the antibacterial and antifungal component, an absorption peak of C-H in alkene appears at 3054 cm-1, an absorption peak of C-H in benzene ring appears at 3029 cm-1, an absorption peak of C=O in ester group appears at 1733 cm-1, an absorption peak of C=O in amide appears at 1649 cm-1, and an absorption peak of C=N appears at 1560 cm-1.

Example 1

Preparation of an environmentally friendly material

In step 1, 70 g of PLA, 20 g of PC, 2 g of ethylene-methyl acrylate-glycidyl methacrylate, 1 g of PE wax, 1 g of antioxidant 1010, 3 g of functional fiber filler and 2 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 60°C, and after mixing for 1 hour, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 180°C, a screw rotation speed was set to 100 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Example 2

Preparation of an environmentally friendly material

In step 1, 80 g of PLA, 30 g of PC, 3 g of ethylene-methyl acrylate-glycidyl methacrylate, 2 g of PE wax, 2 g of antioxidant 1010, 4 g of functional fiber filler and 3 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 70°C, and after mixing for 1.5 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 190°C, a screw rotation speed was set to 200 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Example 3

Preparation of an environmentally friendly material

In step 1, 85 g of PLA, 40 g of PC, 4 g of ethylene-methyl acrylate-glycidyl methacrylate, 3 g of PE wax, 2.5 g of antioxidant 1010, 5 g of functional fiber filler and 4 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 80°C, and after mixing for 2 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 200°C, a screw rotation speed was set to 300 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Example 4

Preparation of an environmentally friendly material

In step 1, 90 g of PLA, 50 g of PC, 5 g of ethylene-methyl acrylate-glycidyl methacrylate, 4 g of PE wax, 3 g of antioxidant 1010, 6g of functional fiber filler and 5 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 90°C, and after mixing for 2 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 220°C, a screw rotation speed was set to 400 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Comparative Example 1

Preparation of an environmentally friendly material

In step 1, 80 g of PLA, 30 g of PC, 3 g of ethylene-methyl acrylate-glycidyl methacrylate, 2 g of PE wax, 2 g of antioxidant 1010 and 4 g of functional fiber filler were added into a high-speed mixer, a temperature was raised to 70°C, and after mixing for 1.5 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 190°C, a screw rotation speed was set to 200 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Comparative Example 2

Preparation of an environmentally friendly material

In step 1, 80 g of PLA, 30 g of PC, 3 g of ethylene-methyl acrylate-glycidyl methacrylate, 2 g of PE wax, 2 g of antioxidant 1010 and 3 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 70°C, and after mixing for 1.5 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 190°C, a screw rotation speed was set to 200 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Comparative Example 3

Preparation of an environmentally friendly material

In step 1, 80 g of PLA, 30 g of PC, 3 g of ethylene-methyl acrylate-glycidyl methacrylate, 2 g of PE wax, 2 g of antioxidant 1010, 4 g of 2,2,6,6-tetramethyl-4-piperidinol and 3 g of antibacterial and antifungal component were added into a high-speed mixer, a temperature was raised to 70°C, and after mixing for 1.5 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 190°C, a screw rotation speed was set to 200 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Comparative Example 4

Preparation of an environmentally friendly material

In step 1, 80 g of PLA, 30 g of PC, 3 g of ethylene-methyl acrylate-glycidyl methacrylate, 2 g of PE wax, 2 g of antioxidant 1010, 4 g of functional fiber filler and 3 g of diniconazole were added into a high-speed mixer, a temperature was raised to 70°C, and after mixing for 1.5 hours, a premix was obtained.

In step 2, the premix was placed in a twin-screw extruder, an extrusion temperature was set to 190°C, a screw rotation speed was set to 200 r/min, and melt extrusion and granulation were performed to obtain the environmentally friendly material.

Performance testing

The environmentally friendly materials prepared in Examples 1-4 and Comparative Examples 1-4 were processed into samples meeting testing conditions. According to GB/T 1040.1-2018, the tensile strength of the samples was tested to determine mechanical properties of the samples; and according to GB/T 1043.2-2018, the impact strength of the samples was tested to judge the impact toughness of the samples. The ultraviolet resistance of the samples was tested by the following method: according to GB/T 16422.2-2022, using an FLB40T12E/90D ultraviolet fluorescent lamp, after 500 hours of aging, a △E value of color difference was calculated by the formula △E=[(△L)2+(△a)2+(△b)2]1/2, and the larger the △E value, the more serious the aging of the sample. The antibacterial and antifungal properties of the samples were tested by the following method: after the samples were placed for 60 days, 1 mL of Staphylococcus aureus was placed in a nutrient agar medium at 36°C for 8 hours, then a bacterial solution concentration was diluted to 1×10-5 CFU/mL, 1 mL of the bacterial solution was dropped on a surface of a sterilized sample, cultured at 36°C for 6 hours, 20 μL of the cultured bacterial solution was taken and evenly spread on a solid medium, after culturing at 36°C for 24 hours, the number of colonies in the medium was counted as W, and a blank test was done at the same time, the number of colonies in the blank test was counted as X, and an antibacterial rate was calculated by the formula [(W-X)/W]×100%. The test results are as follows.

	Tensile strength (MPa)	Impact strength (KJ/m^2)	Color difference△E	Antibacterial rate (%)
Example 1	98.2	31.2	2.4	99.6
Example 2	99.3	32.1	1.9	99.9
Example 3	98.5	31.5	2.3	99.7
Example 4	98.8	31.8	2.2	99.8
Comparative Example 1	97.1	14.3	2.8	40.3
Comparative Example 2	50.3	30.4	5.1	99.1
Comparative Example 3	56.2	30.7	4.2	99.3
Comparative Example 4	97.3	16.8	2.7	63.4

It can be seen from the above table that the environmentally friendly material prepared by the present invention exhibits excellent mechanical properties, impact toughness, ultraviolet resistance and antibacterial and antifungal properties, among which Example 2 demonstrates the best test effect. In Comparative Example 1, the functional fiber filler is added, with excellent mechanical properties and ultraviolet resistance, and the antibacterial and antifungal component is not added, with poor impact toughness and antibacterial and antifungal properties; in Comparative Example 2, the antibacterial and antifungal component is added, with excellent impact toughness and antibacterial and antifungal properties, and the functional fiber filler is not added, with poor ultraviolet resistance and mechanical properties; in Comparative Example 3, 2,2,6,6-tetramethyl-4-piperidinol and the antibacterial and antifungal component are added, and the small molecule hindered amine 2,2,6,6-tetramethyl-4-piperidinol may migrate and precipitate, resulting in poor ultraviolet resistance, but with excellent impact toughness and antibacterial and antifungal properties; and quartz fibers are not added, which may not reinforce the mechanical properties of the PLA matrix, so the poor mechanical properties are poor; and in Comparative Example 4, functional fiber filler and diniconazole are added, with excellent ultraviolet resistance and mechanical properties, as well as poor antibacterial and antifungal properties due to the migration and precipitation of the small molecule antibacterial and antifungal diniconazole. It is impossible to utilize the branched structure of polyamidoamine to interact with the PLA matrix, and entangle with the PLA molecular chains, enhance the compactness of the PLA matrix molecular chains, and improve the impact toughness, so the impact toughness is poor.

The above content is only an illustrative explanation of the concept of the present invention. Those skilled in the art may make various modifications or supplements to the specific examples described or adopt similar methods for substitution. As long as modifications, supplements or substitutions do not deviate from the concept of the present invention or go beyond the scope defined by the claims of the present invention, the modifications, supplements or substitutions fall within the protection scope of the present invention.