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(54) **FEUILLE BIODEGRADABLE ET COMPOSTABLE A ETIREMENT MONOAXIAL ET A PROPRIETES AMELIOREES**

(54) **MONOAXIALLY STRETCHED, BIODEGRADABLE AND COMPOSTABLE FOIL WITH IMPROVED PROPERTIES**

(57) La feuille décrite est orientée selon un seul axe et sensiblement constituée d'un ou plusieurs polymères qui sont tous biodégradables et compostables, ainsi que d'au maximum 5 % en poids d'agents nucléants, d'au maximum 5 % en poids de stabilisants et neutralisants usuels, d'au maximum 5 % en poids de lubrifiants et d'agents de démoulage usuels et d'au maximum 5 % en poids d'agents antigrippants usuels.

(57) A foil with a monoaxial orientation substantially consists of one or several polymers which are biologically degradable and compostable, as well as maximum 5 % by weight nucleating agents, maximum 5 % by weight common stabilisers and neutralisers, maximum 5 % by weight common internal lubricants and parting agents and maximum 5 % by weight common antigriping agents.

WW 5468-Foreign

Abstract

Monoaxially stretched, biodegradable and compostable film having improved properties

The present invention relates to a film which has a monoaxial orientation and consists substantially of one or more, all without exception biodegradable and compostable, polymers and in addition contains at most 5 wt.% of nucleating agents and at most 5 wt.% of the conventional stabilisers and neutralising agents and at ost 5 wt.% of the conventional lubricants and release agents and at most 5 wt.% of the conventional antiblocking agents.

WW 5468-Foreign

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Monoaxially stretched, biodegradable and compostable film having improved properties

This invention relates to a monoaxially stretched, biodegradable and compostable film.

It is known that certain polymeric materials may be subject to biodegradation. Materials to be mentioned here are mainly those obtained directly or after modification from naturally occurring polymers, for example, polyhydroxyalkanoates such as polyhydroxybutyrate, plastic celluloses, cellulose esters, plastic starches, chitosan and pullulan. Owing to the natural process of synthesis, a deliberate variation of the polymeric composition or of the structures which may be desirable from the aspect of polymer use is possible only with difficulty and often only to a very limited extent.

On the other hand, many of the synthetic polymers are attacked not at all or only extremely slowly by microorganisms. In the main, synthetic polymers which contain hetero atoms in the main chain are regarded as being potentially biodegradable. Among these materials, the polyesters are an important class. Synthetic raw materials which contain only aliphatic monomers have a relatively good biodegradability, but owing to their material properties they can be used only to an extremely limited extent; cf. Witt et al. in Macrom. Chem. Phys., 195 (1994) pp. 793 - 802. In comparison, aromatic polyesters display distinctly impaired biodegradability and good material properties.

Recently various biodegradable polymers have become known (see DE 44 32 161). These possess the property of being readily thermoplastically processable and, on the other hand, of being biodegradable, that is, their entire polymer chain is split by microorganisms (bacteria and fungi) by means of enzymes and is completely decomposed into carbon dioxide, water and biomass. A corresponding test in a

natural environment with exposure to the action of microorganisms, such as prevails in a compost and in other places, is given inter alia in DIN 54 900. Because of their thermoplastic behaviour, these biodegradable materials can be processed to form semi-finished products, such as cast films or blown films. The use of these semi-finished products is nevertheless greatly limited. Firstly, these films are known to have poor mechanical properties and secondly, the barrier properties with regard to water vapour and gases are very poor in comparison with films made of typical, but not biodegradable, synthetic materials such as polyethylene, polypropylene or polyamide.

The object of the present invention is to produce a biodegradable and compostable film having improved mechanical and optical properties as well as improved splicing properties. This objective is achieved by subjecting a biodegradable and compostable polymer or a mixture of several polymers, in each case biodegradable and compostable, to a monoaxial orientation. For the purpose of this invention, the terms "biodegradable and compostable polymers and films respectively" means items which receive the certification "biodegradable" in conformity with the test in accordance with DIN 54 900 in the version dated 1996.

It came as a surprise to the inventor that these biodegradable polymers, in addition to the thermoplastic processability, can also be oriented monoaxially and that the physical properties of the film can be distinctly improved through this orientation process. These properties include a distinct increase in strength, an improvement in the optical properties and an improved splicing quality of the film.

This invention provides a film which has a monoaxial orientation and consists of one or more, all without exception biodegradable and compostable, polymers and in addition contains at most 5 wt.% of nucleating agents and at most 5 wt.% of the conventional stabilisers and neutralising agents and at most 5 wt.% of the conventional lubricants and release agents and at most 5 wt.% of the conventional antiblocking agents.

In a particular embodiment, the surface of the film can in addition be treated using a corona pretreatment and/or flame pretreatment and/or plasma pretreatment and/or with an oxidising substance and/or with an attachable/precipitable substance and/or a mixture of substances composed of oxidising and/or attachable substances, for example, gases containing radical components such as ozone or a plasma-excited gas mixture composed, for example, of hexamethyldisiloxane with nitrogen (N_2) and/or oxygen (O_2). Here the above-mentioned surface pretreatments are carried out preferably after the biaxial orientation.

The monoaxial orientation is carried out within temperature ranges above the glass transition point in the case of amorphous thermoplastics and below the crystallite melting point in the case of partially crystalline thermoplastics.

The invention also provides the use of certain biodegradable and compostable polymers or a mixture of these polymers for the production of the film.

The following are suitable polymers:-

Aliphatic and partially aromatic polyesters comprising

A) linear bifunctional alcohols, for example, ethylene glycol, hexanediol or preferably butanediol, and/or optionally cycloaliphatic bifunctional alcohols, for example, cyclohexanedimethanol, and in addition optionally small quantities of higher-functional alcohols, for example, 1,2,3-propanetriol or neopentyl glycol, and of linear bifunctional acids, for example, succinic acid or adipic acid, and/or optionally cycloaliphatic bifunctional acids, for example, cyclohexanedicarboxylic acid, and/or optionally aromatic bifunctional acids, for example, terephthalic acid or isophthalic acid or naphthalenedicarboxylic acid, and in addition optionally small quantities of higher-functional acids, for example, trimellitic acid,

or

B) of acid- and alcohol-functionalised structural units, for example, hydroxybutyric acid or hydroxyvaleric acid, or derivatives thereof, for example, ε-caprolactone,

or of a mixture or a copolymer of A) and B),

the aromatic acids amounting to a proportion of not more than 50 wt.%, based on all acids.

The acids can also be used in the form of derivatives, for example, acid chlorides or esters.

Aliphatic polyester urethanes comprising

C) an ester component composed of linear bifunctional alcohols, for example, ethylene glycol, butanediol, hexanediol, preferably butanediol, and/or optionally cycloaliphatic bifunctional alcohols, for example, cyclohexanedimethanol, and in addition optionally small quantities of higher-functional alcohols, for example, 1,2,3-propanetriol or neopentyl glycol, and of linear bifunctional acids, for example, succinic acid or adipic acid, and/or optionally cycloaliphatic and/or aromatic bifunctional acids, for example, cyclohexanedicarboxylic acid and terephthalic acid, and in addition optionally small quantities of higher-functional acids, for example, trimellitic acid, or

D) of an ester component composed of acid- and alcohol-functionalised structural units, for example, hydroxybutyric acid or hydroxyvaleric acid, or derivatives thereof, for example, ε-caprolactone,

or of a mixture or a copolymer of C) and D) and

E) of the reaction product of C) and/or D) with aliphatic and/or cycloaliphatic bifunctional isocyanates and in addition optionally higher-functional isocyanates, for example, tetramethylene diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, and optionally in addition with linear and/or cycloaliphatic bifunctional and/or higher-functional alcohols, for example, ethylene glycol, butanediol, hexanediol, neopentyl glycol, cyclohexanedimethanol,

the ester component C) and/or D) amounting to at least 75 wt.%, based on the sum of C), D) and E).

Aliphatic-aromatic polyester carbonates comprising

F) an ester component composed of linear bifunctional alcohols, for example, ethylene glycol, butanediol, hexanediol, preferably butanediol, and/or cycloaliphatic bifunctional alcohols, for example, cyclohexanedimethanol, and in addition optionally small quantities of higher-functional alcohols, for example, 1,2,3-propanetriol or neopentyl glycol, and of linear bifunctional acids, for example, succinic acid or adipic acid, and/or optionally cycloaliphatic bifunctional acids, for example, cyclohexanedicarboxylic acid, and in addition optionally small quantities of higher-functional acids, for example, trimellitic acid, or

G) of an ester component composed of acid- and alcohol-functionalised structural units, for example, hydroxybutyric acid or hydroxyvaleric acid, or derivatives thereof, for example, ε-caprolactone,

or of a mixture or a copolymer of F) and G) and

H) of a carbonate component, which is prepared from aromatic bifunctional phenols, preferably bisphenol A and carbonate donors, for example, phosgene,

the ester component F) and/or G) amounting to at least 70 wt.%, based on the sum of F), G) and H).

Aliphatic polyester amides comprising

I) an ester component composed of linear and/or cycloaliphatic bifunctional alcohols, for example, ethylene glycol, hexanediol or butanediol, preferably butanediol or cyclohexanedimethanol, and in addition optionally small quantities of higher-functional alcohols, for example, 1,2,3-propanetriol or neopentyl glycol, and of linear and/or cycloaliphatic bifunctional acids, for example, succinic acid, adipic acid, cyclohexanedicarboxylic acid, preferably adipic acid and in addition optionally small quantities of higher-functional acids, for example, trimellitic acid, or

K) of an ester component composed of acid- or alcohol-functionalised structural units, for example, hydroxybutyric acid or hydroxyvaleric acid, or derivatives thereof, for example, ε-caprolactone,

or of a mixture or a copolymer of I) and K) and

L) of an amide component composed of linear and/or cycloaliphatic bifunctional and in addition optionally small quantities of higher-functional amines, for example, tetramethylenediamine, hexamethylene diamine, isophorone diamine, and of linear and/or cycloaliphatic bifunctional acids and in addition optionally small quantities of higher-functional acids, for example, succinic acid or adipic acid, or

M) of an amide component composed of acid- and amine-functionalised structural units, preferably ω-laurolactam and particularly preferably ε-caprolactam,

or of a mixture of L) and M) as amide component,

the ester component I) and/or K) amounting to at least 30 wt.%, based on the sum of I), K), L) and M).

The biodegradable and compostable raw materials according to the invention can be supplied with at most 5 wt.% of nucleating agents typically used for polyesters (for example, 1,5-naphthalenedisodium sulfonate or sheet silicates, for example, talc, or nucleating agents of nanoparticle size, i.e. having average particle sizes < 1 µm, consisting for example of titanium nitride, aluminium hydroxide hydrate, barium sulfate or zirconium compounds) and with at most 5 wt.% of the conventional stabilisers and neutralising agents and with at most 5 wt.% of the conventional lubricants and release agents and at most 5 wt.% of the conventional antiblocking agents, and possibly treated on the surface using a corona pretreatment and/or flame pretreatment and/or plasma pretreatment or with an oxidising substance or mixture of substances, for example, gases containing radical components such as ozone or a plasma-excited gas mixture composed, for example, of hexamethyldisiloxane with nitrogen (N_2) and/or oxygen (O_2).

The stabilisers and neutralising agents employed can be the stabilising compounds conventionally used for polyester compounds. The quantity of these added is at most 5 wt.%.

Particularly suitable stabilisers are phenolic stabilisers, alkali metal/alkaline-earth stearates and/or alkali metal/alkaline-earth carbonates. Phenolic stabilisers in a quantity of from 0 to 3 wt.%, in particular from 0.15 to 0.3 wt.%, and having a molar mass of more than 500 g/mol. are preferred. Pentaerythritol tetrakis-3(3,5-

ditertiary butyl-4-hydroxyphenyl)propionate or 1,3,5-trimethyl-2,4,6-tris(3,5-ditertiary butyl-4-hydroxybenzyl)benzene are particularly advantageous.

Preferred neutralising agents are dihydrotalcit, calcium stearate, calcium carbonate and/or calcium montanate having an average particle size of at most 0.7 µm, an absolute particle size of less than 10 µm and a specific surface of at least 40 m^2/g.

In a particularly preferred embodiment of the film, the latter contains from 0.0001 to 2 wt.% of a nucleating component and from 0.0001 to 2 wt.% of stabilising and neutralising components.

Lubricants and release agents are higher aliphatic amides, tertiary amines, aliphatic acid amides, higher aliphatic acid esters, low-molecular polar-modified waxes, montan waxes, cyclic waxes, phthalates, metal soaps and silicone oils. The addition of higher aliphatic acid amides and silicone oils is particularly suitable.

Among the aliphatic amides, the commercially supplied forms of acetamide to stearamide are particularly suitable. Aliphatic acid amides are amides of a water-insoluble monocarboxylic acid (so-called fatty acids) containing 8 to 24 carbon atoms, preferably 10 to 18 carbon atoms. Of these, erucamide, stearamide and oleylamide are preferred.

Compounds containing both ester groups and amide groups such as, for example, stearamide-ethyl stearate or 2-stear-amido-ethyl stearate, are also suitable for use as release agents and lubricants.

The term "montan waxes" covers a number of different compounds. Regarding these, see: Neumüller et al. in Römpps Chemie-Lexikon, Franckh'sche Verlagshandlung, Stuttgart, 1974.

Examples of suitable cyclic waxes are components such as cyclic tetramethylene adipate or 1,6-dioxa-2,7-dioxocyclododecane, or the homologous hexamethylene derivative. These compounds are known as proprietary products by the name of Glycolube VL.

Suitable silicone oils are polydialkylsiloxanes, preferably polydimethylsiloxane, polymethylphenylsiloxane, olefinically modified silicone, silicone modified with polyethers such as, for example, polyethylene glycol and polypropylene glycol, as well as epoxyamino-modified and alcohol-modified silicone. The viscosity of suitable silicone oils is in the range of 5,000 to 1,000,000 mm^2/s. Polydimethylsiloxane having a viscosity of from 10,000 to 100,000 mm^2/s is preferred.

The quantity of lubricant added is 5 wt.% at most. In a particularly preferred embodiment of the film, the latter contains from 0.005 to 4 wt.% of a lubricating component. In a most preferred embodiment of the film, the latter contains from 0.05 to 1 wt.% of a lubricating component.

Suitable antiblocking agents may be inorganic as well as organic additives which, after the monoaxial stretching, protrude in the form of an elevation from the surface of the film and thus create a spacer effect.

In a preferred embodiment, the following substances are used as inorganic antiblocking agents:

aluminium hydroxide

aluminium silicates, for example, kaolin or china clay

aluminium oxides, for example, Θ-aluminium oxide

aluminium sulfate

ceramics composed of silica-aluminium oxides

barium sulfate

natural and synthetic silicas

sheet silicates, for example, asbestos

silicon dioxide

calcium carbonate of the calcite type

calcium phosphate

magnesium silicates

magnesium carbonate

magnesium oxide

titanium dioxide

zinc oxide

glass microbeads

and the following substances are used as organic antiblocking agents:

organic polymers which are incompatible with the biodegradable polymer, such as

starch

polystyrenes

polyamides

polycarbonates

cross-linked and uncross-linked polymethyl methacrylate

cross-linked polysiloxane (e.g. Tospearl)

polar-modified polyethylene (e.g. maleic anhydride-grafted polyethylene)

polar-modified polypropylene (e.g. maleic anhydride-grafted polypropylene)

statistical copolymers based on ethylene or propylene together with vinyl alcohol or vinyl acetate or acrylic acid or acrylic ester or methacrylic acid or methacrylic ester or metal salts of methacrylic acid or metal salts of methacrylic esters

benzoguanamine-formaldehyde polymers

aliphatic and partially aromatic polyesters having melting points different from those of the raw material of the film

aliphatic polyester amides having melting points different from those of the raw material of the film

aliphatic polyester urethanes having melting points different from those of the raw material of the film

aliphatic-aromatic polyester carbonates having melting points different from those of the raw material of the film.

The effective quantity of antiblocking agent is within the range of up to 5 wt.% at most. In a particularly preferred embodiment, the film contains from 0.005 to 4 wt.% of antiblocking agent. In a most preferred embodiment, the film contains from 0.05 to 1 wt.% of antiblocking agent. The average particle size is between 1 and 6 µm, in particular 2 and 5 µm, with particles having a spherical shape, as described in EP-A-0 236 945 and in DE-A-38 01 535, being particularly suitable. Combinations of different spacer systems are also particularly suitable.

In the processes used hitherto, the polymers used for the film provided with additives are supplied with the desired quantities by weight of organic or inorganic fillers during the production of the raw material. This is effected by granulating the raw material, for example, in twin-screw extruders, where the additives are introduced into the raw material. Besides this method of addition, it is also possible to add a portion or all of the required additives to a raw material in the form of a master batch, which has been supplied partially or not at all with the additives. For the purpose of the present invention, the term "master batch" means a stock mixture, in particular a granular dust-free concentrate of a synthetic raw material containing high quantities of additives, which is used as an intermediate in the preparation of the composition (as material addition to a granular material which is not, or only partially, or incompletely supplied with additives), in order to produce from this films containing a given quantity of additives. Before the polymer granules are packed into the extruder, the master batch is mixed with the raw materials, which are not, or only partially, or incompletely supplied with additives, in quantities such that the desired percentages by weight of fillers are obtained in the films.

The materials from which, besides the additives, the master batches are produced are preferably substances which are compatible with the biodegradable raw materials described in this invention. In a particularly preferred embodiment, the materials

from which, besides the additives, the master batches are produced are likewise biodegradable materials.

In the corona treatment, a useful procedure is to pass the film between two conductor elements serving as electrodes, while between the electrodes a voltage - in most cases an alternating voltage (about 5 to 20 kV and 5 to 30 kHz) - is applied which is of such a strength that spray discharges or corona discharges can take place. The air above the surface of the film is ionised by the spray discharge or corona discharge and reacts with the molecules of the surface of the film, so that in addition polar inclusions are formed in the polymer matrix.

For a flame treatment using a polarised flame (cf. US-A-4,622,237) an electric direct current is applied between a burner (negative pole) and a cooling roller. The strength of the applied voltage is between 400 and 3,000 V; it is preferably in the range of 500 to 2,000 V. As a result of the applied voltage, the ionised atoms acquire an increased acceleration and strike the surface of the polymer with greater kinetic energy. The chemical bonds within the polymer molecule are broken more easily and radical formation takes place more rapidly. The thermal loading of the polymer is here far less than is the case with the standard flame treatment, and it is possible to obtain films in which the sealing properties of the treated side are even better than those of the untreated side.

In the plasma pretreatment, gases, for example, oxygen or nitrogen or carbon dioxide or methane or halogenated hydrocarbons or silane compounds or high-molecular compounds or mixtures of these, in a low pressure chamber are exposed to a high-energy-rich field, for example, microwave radiation. Electrons rich in high energy are formed, which strike the molecules and transfer their energies. This gives rise to local radical structures, whose excited states correspond to temperatures of several tens of thousands of degrees Celsius, although the actual plasma is virtually at room temperature. Because of this it is possible to break chemical bonds and to initiate reactions which normally can proceed only at elevated temperatures.

Monomeric radicals and ions are formed. From the monomeric radicals are formed - to some extent even in the plasma - short-chain oligomers, which then condense and polymerise on the surface being coated. A homogeneous film is thereby deposited on the coating material.

Before the monomeric radicals or ions are deposited on the substrate, however, it is moreover additionally possible to add a further flow of material to the excited molecules in the so-called afterglow zone. Through this it is possible to produce a substance or a mixture of substances which, on encountering the polymer film surface, produces an oxidising attacking reaction in the substrate polymers. A glass-like and mostly highly cross-linked layer is formed, which is firmly bonded with the surface of the film. If the substance is of a suitable composition, the surface tension of the film is thereby increased.

The invention also provides the use of a particular class of materials from the biodegradable and compostable polymers for the production of the film, the said class of materials being polyester amide. The film according to the invention can be produced from a polyester amide or from a mixture of different polyester amides.

The invention also provides a process for the production of the film according to the invention. This process is characterised in that the biodegradable and compostable material or materials is or are first of all digested by heat action and shearing action, this melt is discharged into a mould, cooled until it solidifies, then tempered at temperatures below the crystallite melting point in the case of partially crystalline materials and above the glass transition point in the case of amorphous materials and is then monoxially stretched one or more times. After the single stretching step or after each stretching step, the film may optionally be fixed. After the stretching processes and after the fixing steps possibly carried out, the resulting finished film may possibly be subjected to an in-line surface pretreatment. The pretreatment can be carried out using a corona, a flame, a plasma or an oxidising substance or mixture of substances, for example, gases containing radical components such as

ozone or a plasma-excited gas mixture composed, for example, of hexamethyldisiloxane with nitrogen (N_2) and/or oxygen (O_2), in such a way that there is an increase in the surface tension of the film.

In an even more preferred embodiment of the film according to the invention, the monoaxial stretching is characterised in that the total stretch ratio in the longitudinal direction is from 1 : 1.5 to 1 : 15.

In an even more preferred embodiment of the film according to the invention, the monoaxial stretching is characterised in that the total stretch ratio in the longitudinal direction is from 1 : 2.8 to 1 : 8.

In an even more preferred embodiment of the film according to the invention, the said film has a thickness of less than 500 µm.

In an even more preferred embodiment of the film according to the invention, the said film has a thickness of less than 80 µm.

The invention also provides the use of the film according to the invention. Suitable applications are the use of this film as a solo film in pretreated or unpretreated and in printed or unprinted form for packaging in the food and non-food sectors or as a solo film in pretreated or unpretreated form for coverings in hothouses or mulch films in the horticultural and agricultural sectors or processed to form bags for the storage and transport of goods, for example, organic waste, or as a solo film in pretreated or unpretreated form for protective and separatory functions in connection with cosmetics and articles of hygiene, for example, for nappies or sanitary towels, or as a solo film in pretreated or unpretreated form for the protection of surfaces or the refining of surfaces in the field of cardboard lining, paper lining and letter window lining or as a refined film, which, in pretreated or unpretreated and in printed or unprinted form and provided with adhesive, can be used as labels or as adhesive tape. To improve the pressure adhesion or adhesiveness, during production

and/or subsequently during further processing, the surface of the film can be pretreated using a corona, a flame, a plasma or another oxidising substance or mixture of substances, for example, gases containing radical components such as ozone or a plasma-excited gas mixture composed, for example, of hexamethyldisiloxane with nitrogen (N_2) and/or oxygen (O_2), in such a way that there is an increase in the surface tension.

The invention furthermore provides the use of the film according to the invention as a coated film or in a composite film. Here the other films of the composite can be non-degradable films or else likewise biodegradable and compostable films. Moreover, the coating materials or adhesives used may belong to the usual non-biodegradable systems or to the biodegradable and compostable raw materials.

In a particularly preferred form of the use of this film according to the invention, only materials which are biodegradable and compostable are used for the production of the coated film or of a composite film, so that the entire composite is likewise biodegradable and compostable.

The invention furthermore provides the use of the film according to the invention or of the coated film or of the composite as starting material for the production of tapes or detachable strips, by cutting up the film or the coated film or the composite in a further operating step.

The invention furthermore provides the use of the tape according to the invention for the production of woven fabrics or netting or knitted fabrics or nonwoven fabrics.

Example 1

A biodegradable polyester amide having a melting viscosity of 250 Pas at 190°C (measured in accordance with DIN 54 811 - B) and a melting point of 125°C (measured in accordance with ISO 3146 / C2) and containing 1 wt.% of a lubricant component and 0.1 wt.% of an antiblocking component was monoaxially stretched under the following processing conditions. The maximal extrusion temperature was 205°C. Accordingly the extruder tempering zones were tempered to a maximum temperature of 182°C and the mould to a maximum temperature of 205°C. The melt was cooled in the form of a flat film on a cooling roller stand at roller temperatures of 20°C. A solid, thick film was formed, which in the next processing step was heated to the stretching temperature by means of tempering rollers at temperatures of 65°C. The actual stretching rollers were operated at a temperature of 70°C. The flat film was stretched longitudinally in two steps, once by the ratio 1 : 1.5 and then by the ratio of 1 : 3.25. The total stretch ratio longitudinally was therefore 1 : 4.875. The aftercuring rollers, over which the film then passed, were at a temperature of 85°C. The production rate after the stretching was 30.0 m/min. It was possible to produce a film having a thickness of 30 µm.

Comparison Example 1

The same biodegradable polyester amide from Examples 1 and 2 was processed in a film-blowing unit. The melting temperature measured at the nozzle outlet was 152°C. Here the cylinder temperature of the extruder was controlled at a maximum of 145°C and that of the nozzle at 145°C. The diameter of the nozzle used was 400 mm. The horizontal width of the finished film was 950 mm. It was produced at a withdrawal rate of 6.3 m/min. The thickness of the blown film was 30 µm.

On the finished samples, the following physical properties and compostability were measured in the following way.

Mechanical properties:

On the samples, the mechanical quantities of tear strength and elongation at tear were measured both longitudinally and transversely in accordance with DIN 53 455. The elastic moduli were determined longitudinally and transversely in accordance with DIN 53 457.

The thickness of the individual samples was determined in accordance with DIN 53 370. To determine the perforating force and the perforated distance, the samples were analysed by means of the biaxial perforation test in accordance with DIN 53 373.

Splicing quality:

The splicing quality of the finished film was evaluated by means of an incision, of approx. 5 mm in length, in the longitudinal direction of the film and a qualitative assessment by a manual tear-growth test. A film which can be torn apart "straight" without difficulty in the longitudinal direction over a length of 100 mm is defined as having "good" splicing behaviour. The term "straight" has the following meaning: over a length of 100 mm, the tear must not deviate by more than 5 mm from an idealised straight line.

Optics:

To assess the optical properties, the surface gloss of the films was determined in accordance with DIN 67 530 at a test angle of 20° and the turbidity was determined in accordance with ASTM D 1003. The gloss was measured on both sides of the film. From the values thus determined an averaging was then carried out and reported as the result.

Compostability:

The compostability was tested in accordance with the testing instructions of DIN Standard DIN 54 900 Part 3 in the version dated 1996. The sample films were classified into the appropriate classes in accordance with the DIN directions on the basis of the experimental results.

The results of the investigations into the samples from Example 1 and from Comparison Example 1 are listed in Table 1.

Table 1

	Example 1	Comparison example 1
Mechanical properties		
Thickness [µm]	30	30
Elastic modulus, longitudinal [MPa]	470	296
Elastic modulus, transverse [MPa]	610	392
Tear strength, longitudinal [MPa]	165	61
Tear strength, transverse [MPa]	22	50
Elongation at tear, longitudinal [%]	50	388
Elongation at tear, transverse [%]	750	639
Perforating force [N]	102	47
Perforated distance [mm]	13.6	38
Splicing behaviour		
quality of splicing	good	poor
Optics		
Gloss [GE]	94	3.1
Turbidity [%]	5.8	38.9
Compostability		
Biodegradable	yes	yes

Claims

1. A film, characterised in that it has a monoaxial orientation and in that it consists substantially of one or more, all without exception biodegradable and compostable, polymers and in addition contains at most 5 wt.% of nucleating agents and at most 5 wt.% of the conventional stabilisers and neutralising agents and at most 5 wt.% of the conventional lubricants and release agents and at most 5 wt.% of the conventional antiblocking agents.

2. A film according to claim 1, characterised in that the surface thereof is treated using a corona pretreatment and/or flame pretreatment and/or plasma pretreatment and/or with an oxidising substance and/or with an attachable/precipitable substance and/or with a mixture of substances composed of oxidising and/or attachable substances.

3. A film according to claims 1 or 2, characterised in that the biodegradable polymer or polymers are aliphatic and partially aromatic polyesters composed of

aliphatic and partially aromatic polyesters comprising

A) linear bifunctional alcohols and/or optionally cycloaliphatic bifunctional alcohols and in addition optionally small quantities of higher-functional alcohols and of linear bifunctional acids and/or optionally cycloaliphatic bifunctional acids and/or optionally aromatic bifunctional acids and in addition optionally small quantities of higher-functional acids or

B) of acid- and alcohol-functionalised structural units or derivatives thereof

or of a mixture or a copolymer of A) and B),

the aromatic acids amounting to a proportion of not more than 50 wt.%, based on all acids, or of

aliphatic polyester urethanes comprising;

C) an ester component composed of linear bifunctional alcohols and/or optionally cycloaliphatic bifunctional alcohols and in addition optionally small quantities of higher-functional alcohols and of linear bifunctional acids and/or optionally cycloaliphatic and/or aromatic bifunctional acids and in addition optionally small quantities of higher-functional acids or

D) of an ester component composed of acid- and alcohol-functionalised structural units or derivatives thereof

or of a mixture or a copolymer of C) and D) and

E) of the reaction product of C) and/or D) with aliphatic and/or cycloaliphatic bifunctional isocyanates and in addition optionally higher-functional isocyanates and optionally in addition with linear and/or cycloaliphatic bifunctional and/or higher-functional alcohols,

the ester component C) and/or D) amounting to at least 75 wt.%, based on the sum of C), D) and E), or of

aliphatic-aromatic polyester carbonates comprising

F) an ester component composed of linear bifunctional alcohols and/or cycloaliphatic bifunctional alcohols and in addition optionally small

quantities of higher-functional alcohols and of linear bifunctional acids and/or optionally cycloaliphatic bifunctional acids and in addition optionally small quantities of higher-functional acids or

G) of an ester component composed of acid- and alcohol-functionalised structural units or derivatives thereof

or of a mixture or a copolymer of F) and G) and

H) of a carbonate component, which is prepared from aromatic bifunctional phenols and carbonate donors,

the ester component F) and/or G) amounting to at least 70 wt.%, based on the sum of F), G) and H), or of

aliphatic polyester amides comprising

I) an ester component composed of linear and/or cycloaliphatic bifunctional alcohols and in addition optionally small quantities of higher-functional alcohols and of linear and/or cycloaliphatic bifunctional acids and in addition optionally small quantities of higher-functional acids or

K) of an ester component composed of acid- or alcohol-functionalised structural units or derivatives thereof

or of a mixture or a copolymer of I) and K) and

L) of an amide component composed of linear and/or cycloaliphatic bifunctional and in addition optionally small quantities of higher-functional amines and of linear and/or cycloaliphatic bifunctional

acids and in addition optionally small quantities of higher-functional acids or

M) of an amide component composed of acid- and amine-functionalised structural units

or of a mixture of L) and M) as amide component,

the ester component I) and/or K) amounting to at least 30 wt.%, based on the sum of I), K), L) and M).

4. A film according to claims 1 to 3, characterised in that the biodegradable and compostable polymer or polymers are polyester amides.

5. A film according to claims 1 to 4, characterised in that the content of lubricants is within the range of 0.005 to 4 wt.% and the content of antiblocking particles is within the range of 0.005 to 4 wt.%.

6. A film according to claims 1 to 5, characterised in that the content of lubricants is within the range of 0.05 to 1 wt.% and the content of antiblocking particles is within the range of 0.05 to 1 wt.%.

7. A film according to claims 1 to 6, characterised in that the biodegradable and compostable material or materials is or are first of all digested by heat action and shearing action, this melt is discharged into a mould, cooled until it solidifies, then tempered at temperatures below the crystallite melting point in the case of partially crystalline materials and above the glass transition point in the case of amorphous materials and is then monoxially stretched one or more times and after the individual stretching step or stretching steps is possibly fixed and after these stretching and fixing processes is possibly surface-treated.

8. A film according to claims 1 to 7, characterised in that the total stretch ratio in the longitudinal direction is from 1 : 1.5 to 1 : 15.

9. A film according to claims 1 to 8, characterised in that the total stretch ratio in the longitudinal direction is from 1 : 2.8 to 1 : 8.

10. A film according to claims 1 to 9, characterised in that the film thickness is less than 500 µm.

11. A film according to claims 1 to 10, characterised in that the film thickness is less than 80 µm.

12. Use of the film according to claims 1 to 11 as a solo film in pretreated or unpretreated and in printed or unprinted form for packaging in the food and non-food sectors or as a solo film in pretreated or unpretreated form for coverings in hothouses or mulch films in the horticultural and agricultural sectors or processed to form bags for the storage and transport of goods or as a solo film in pretreated or unpretreated form and in printed or unprinted form for protective and separatory functions in connection with cosmetics and articles of hygiene or as a solo film in pretreated or unpretreated form for the protection of surfaces or the refining of surfaces in the field of cardboard lining, paper lining and letter window lining or as refined film in pretreated or unpretreated and in printed or unprinted form and provided with adhesive as labels or as adhesive tape.

13. Use of the film according to claims 1 to 11 for the production of coated films or composites or laminates composed of the identical or different biodegradable and compostable films or with other non-biodegradable types of films, the coating materials or adhesives used not necessarily having to be biodegradable and compostable.

14. Use of the film according to claims 1 to 11 or 13, characterised in that all films and coating materials and adhesives used in the composite or laminate or in the coated film are biodegradable and compostable and consequently the composite or the laminate is itself also biodegradable and compostable.

15. Use of the film according to claims 1 to 11, 13 or 14, characterised in that the film according to the invention or the coated film or the composite or the laminate is cut up in a further operating step in order to produce tapes or detachable strips.

16. Use of the film according to claims 1 to 15, characterised in that the tapes according to the invention are used for the production of woven fabrics or netting or knitted fabrics or nonwoven fabrics.

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