

COMPOSITE SHEET FOR PACKAGE, METHOD OF PREPARING THE SAME, SLEEVE,
AND PACKAGE CONTAINER

TECHNICAL FIELD

[0001] Embodiments of the present disclosure relate to the field of package, in particular to a composite sheet for package, a method for preparing the same, a sleeve, and a package container.

BACKGROUND

[0002] Food industry is not only the life industry of human beings, but it is also an important part of modern industry. In modern food industry, a shelf life of industrial food is usually extended by putting food (e.g., solid, paste, or liquid food) into a container, which is then sterilized and sealed. In recent years, heat-sealable composite sheets for package are increasingly used in industry to produce oxygen-impermeable, water-impermeable, and leak-free containers for food packages. The containers made from such composite sheet for package can store food safely for a relatively long time, and has many advantages, such as, they can be light-weighted, have a regular shape, be not easily damaged, be self-sealable, be easy to open, and can be directly printed with product information, etc. The composite sheet for packages may typically comprise at least an outer layer, an intermediate layer, and an inner layer. In use, the composite sheet for packages is typically folded many times according to predetermined folding line positions to form a predetermined shape (such, a brick-like shape, pillow-like shape or in the shape of a gable-top package box), and overlapped each other at some edges thereof, then treated (e.g., by

heating and/or pressure treatment) at the overlapped position to form a sealing there, and finally folded to form a closed container for food storage, for example.

SUMMARY

[0003] At least an embodiment of the present invention discloses a composite sheet for package comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in a first direction, in which the inner layer comprises a first Low-Density Polyethylene (LDPE) with Melt Flow Index (MFI) of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg, and the first direction is a direction from an external atmosphere contact surface of the composite sheet toward a package content contact surface of the composite sheet.

[0004] For example, in the composite sheet for package described in the embodiments of the present disclosure, the inner layer comprises one or more sublayers, wherein at least one sublayer is a first sublayer comprising the first LDPE with MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

[0005] For example, in the composite sheet for package described in the embodiments of the present disclosure, the first sublayer comprises the first LDPE, and the first LDPE is a combination of a tubular LDPE and a first autoclave LDPE, wherein the tubular LDPE and/or the first autoclave LDPE have an MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

[0006] For example, in the composite sheet for package described in the embodiments of the present disclosure, the tubular LDPE comprises 0-70 wt% of the combination, and the first autoclave LDPE comprises 30-100 wt% of the combination, based on the total weight of the combination.

[0007] For example, in the composite sheet for package described in the embodiments of the present disclosure, the inner layer further comprising at least one second sublayer, the second sublayer comprises a second autoclave LDPE, and the second autoclave LDPE have an MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

[0008] For example, in the composite sheet for package described in the embodiments of

the present disclosure, the inner layer comprises: a first sublayer comprising the first LDPE, and optionally a second sublayer, the second sublayer comprising a blend of the first LDPE and a metallocene polyethylene (mPE), wherein the first LDPE have an MFI of 6.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

[0009] For example, in the composite sheet for package described in the embodiments of the present disclosure, the outer layer comprises a second LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

[0010] For example, in the composite sheet for package described in the embodiments of the present disclosure, the second LDPE in the outer layer is identical to the first LDPE in the inner layer in chemical composition. In another example, in the composite sheet for package described in the embodiments of the present disclosure, the second LDPE in the outer layer is different from the first LDPE in the inner layer in chemical composition.

[0011] For example, in the composite sheet for package described in the embodiments of the present disclosure, the second LDPE is a combination of a second tubular LDPE and a third autoclave LDPE, wherein the second tubular LDPE and/or the third autoclave LDPE have an MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

[0012] For example, the composite sheet for package described in the embodiments of the present disclosure further comprises an odor barrier layer, wherein a material of the odor barrier layer is selected from the group consisting of high-density polyethylene (HDPE), polyamide (PA), or any combination thereof. In another example, the material of the odor barrier layer is selected from the group consisting of the HDPE, the PA, a third LDPE, or any combination thereof.

[0013] For example, in the composite sheet for package described in the embodiments of the present disclosure, the odor barrier layer is disposed between the intermediate layer and the inner layer.

[0014] For example, in the composite sheet for package described in the embodiments of the present disclosure, the odor barrier layer comprises 65 wt% - 100 wt% of HDPE and 0 -35 wt% of the third LDPE.

[0015] For example, the composite sheet for package described in the embodiments of the

present disclosure, the third LDPE has an MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

[0016] For example, in the composite sheet for package described in the embodiments of the present disclosure, the third LDPE is identical to the first LDPE in the inner layer in chemical composition. In another example, in the composite sheet for package described in the embodiments of the present disclosure, the third LDPE is different from the first LDPE in the inner layer in chemical composition.

[0017] For example, the composite sheet for package described in the embodiments of the present disclosure further comprises a further barrier layer disposed between the intermediate layer and the inner layer, preferably between the odor barrier layer and the inner layer.

[0018] For example, in the composite sheet for package described in the embodiments of the present disclosure, the further barrier layer comprises a polymer compound, wherein preferably the polymer compound is selected from a group consisting of a polyvinylidene chloride (PVDC), PE, PP, PET, PA, PVOH, an ethylene vinyl alcohol (EVOH), PVC, polyvinyl alcohol (PVA), PLA, PHA, styrene acrylate and styrene butadiene, nanocellulose, cellulose nanocrystals, cellulose nanofibrils or any combination thereof, more preferably the polymer compound is selected from a group consisting of the EVOH, the PVA, or any combination thereof.

[0019] For example, the composite sheet for package described in the embodiments of the present disclosure further comprises a further adhesive layer between the intermediate layer and the inner layer, preferably between the intermediate layer and the odor barrier layer.

[0020] For example, in the composite sheet for package described in the embodiments of the present disclosure, the further adhesive layer comprises a fourth LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 k.

[0021] For example, in the composite sheet for package described in the embodiments of the present disclosure, the fourth LDPE is identical to the second LDPE in the outer layer in chemical composition. In another example, in the composite sheet for package described in the embodiments of the present disclosure, the second LDPE is different from the fourth

LDPE in the outer layer in chemical composition.

[0022] For example, in the composite sheet for package described in the embodiments of the present disclosure, the first LDPE has an MFI of 4.0 g/10 min as measured at 190°C and 2.16 kg, a density of 0.91-0.95 g/cm³, and a melting point of 110-115°C.

[0023] For example, in the composite sheet for package described in the embodiments of the present disclosure, the odor barrier layer is a liquid package board (LPB).

[0024] For example, in the composite sheet for package described in the embodiments of the present disclosure, the LPB comprises, sequentially stacked in the first direction, (1) a surface layer comprising 45% to 55% of long-fiber bleached chemical pulp and 45% to 55% of short-fiber bleached chemical pulp, based on the total weight of the surface layer; (2) a core layer comprising 40 wt% to 60 wt% of mechanical pulp, 30 wt% to 40 wt% of long-fiber bleached chemical pulp, and 10 wt% to 20 wt% of short-fiber bleached chemical pulp, based on the total weight of the core layer, wherein the mechanical pulp is selected from the group consisting of a broad-leaved wood mechanical pulp, a coniferous wood mechanical pulp or any mixture thereof; and (3) a bottom layer comprising 50% to 70% of long-fiber bleached chemical pulp and 30% to 50% of short-fiber bleached chemical pulp, based on the total weight of the bottom layer, wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer.

[0025] For example, in the composite sheet for package described in the embodiments of the present disclosure, the LPB comprises, sequentially stacked in the first direction: (1) a surface layer comprising 20 wt% to 30 wt% of long-fiber bleached chemical pulp and 50 wt% to 80 wt% of short-fiber bleached chemical pulp, based on the total weight of the surface layer; (2) a core layer comprising more than 45 wt% of broad-leaved wood mechanical pulp, based on the total weight of the core layer; and (3) a bottom layer comprising more than 20 wt% of long-fiber bleached chemical pulp, based on the total weight of the bottom layer, wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer.

[0026] For example, the composite sheet for package described in the embodiments of the present disclosure is free of a metal foil barrier layer.

[0027] At least an embodiment of the present disclosure further discloses a method for producing a composite sheet for package, the composite sheet comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in the first direction, wherein the inner layer comprises a first LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg, and the first direction is a direction from an external atmosphere contact surface of the composite sheet toward a package content contact surface of the composite sheet, and the method comprising: adhering the outer layer the intermediate layer, and the inner layer by sequential stacking.

[0028] For example, in the method for producing the composite sheet for package described in the embodiments of the present disclosure, the adhering the outer layer, the intermediate layer, and the inner layer by sequential stacking comprises: forming the outer layer on a first surface of the intermediate layer; and forming the inner layer on a second surface of the intermediate layer opposite to the first surface.

[0029] For example, the method for producing the composite sheet for package described in the embodiments of the present disclosure further comprises: forming an odor barrier layer on the second surface before forming the inner layer on the second surface, and then forming the inner layer on the odor barrier layer.

[0030] For example, the method for producing the composite sheet for package described in the embodiments of the present disclosure further comprises: forming an odor barrier layer on the second surface of the intermediate layer; forming a further barrier layer on the odor barrier layer; and forming the inner layer on the further barrier layer.

[0031] For example, the method for producing the composite sheet for package described in the embodiments of the present disclosure further comprises: forming a further adhesive layer on the second surface of the intermediate layer; forming an odor barrier layer on the further adhesive layer; forming a further barrier layer on the odor barrier layer; and forming the inner layer on the further barrier layer.

[0032] At least an embodiment of the present disclosure further discloses a sleeve obtained by longitudinal sealing of any composite sheet for package disclosed in the embodiments of the present disclosure. The sleeve has two ends which are open in a top region and a bottom region.

[0033] At least an embodiment of the present disclosure further discloses a package container obtained by folding and sealing of both of the ends of the sleeve described above.

BRIEF DESCRIPTION OF DRAWINGS

[0034] In order to clearly illustrate the technical solution of the embodiments of the invention, the drawings of the embodiments will be briefly described in the following. It is obvious that the described drawings are only related to some embodiments of the invention and thus are not limitative of the invention.

[0035] FIG. 1 is a schematic diagram of a composite sheet provided in an embodiment of the present disclosure.

[0036] FIG. 2 is a schematic diagram of a composite sheet provided in a further embodiment of the present disclosure, wherein the inner layer comprises one or more sublayers.

[0037] FIG. 3 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer.

[0038] FIG. 4 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises a layer structure of liquid packaging board.

[0039] FIG. 5 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure.

[0040] FIG. 6 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an adhesive layer.

[0041] FIG. 7 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and an adhesive layer.

[0042] FIG. 8 is a schematic diagram of a composite sheet provided in an another

embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and two adhesive layers, and wherein the inner layer comprises one or more sublayers.

[0043] FIG. 9 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and an adhesive layer.

[0044] FIG. 10 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and two adhesive layers.

[0045] FIG. 11 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and two adhesive layers as well as a further adhesive layer.

[0046] FIG. 12 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and a further barrier layer.

[0047] FIG. 13 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and a further barrier layer as well as three adhesive layers.

[0048] FIG. 14 is a schematic diagram of a composite sheet provided in an another embodiment of the present disclosure, wherein the composite sheet further comprises an odor barrier layer and a further barrier layer, and three adhesive layers and a further adhesive layer.

DETAILED DESCRIPTION

[0049] In order to make objects, technical details and advantages of the embodiments of the invention apparent, the embodiments will be described in connection with the drawings related to the embodiments of the invention. The described embodiments are just a part but not all of the embodiments of the invention. The shapes and sizes of various parts in the

drawings do not reflect the true proportions of the parts, but only schematically illustrate the disclosure.

[0050] Unless otherwise defined, all the technical and scientific terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which the present invention belongs. The terms “first,” “second,” etc., which are used in the description and the claims of the present application for invention, are not intended to indicate any sequence, amount or importance, but distinguish various components. , The terms “comprise,” “comprising,” “include,” “including,” etc., are intended to specify that the elements or the objects stated before these terms encompass the elements or the objects and equivalents thereof listed after these terms, but do not preclude the other elements or objects.

[0051] For the purposes of the following detailed description, it should be understood that the present disclosure can adopt various alternative variations and step sequences, unless explicitly stated to the contrary. In addition, all numbers, e.g., expressing the quantities of components used in the specification and claims are to be understood as being modified in all instances by the term “about”, unless in any operation examples, or otherwise set forth. Accordingly, the numerical parameters set forth in the follow description and claims are approximations that may vary depending upon the desired properties to be obtained by the present invention, unless otherwise indicated to the contrary. At the very least, it is not an attempt to limit the doctrine of equivalents to the scope of the claims, and each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0052] Although the numerical ranges and parameters describing the broad scope of the present invention are approximations, the numerical values listed in the particular examples should be reported as precisely as possible. However, any numerical values would inherently contain an error that necessarily results from the standard deviation found in their respective testing measurements.

[0053] In addition, it should be understood that any numerical range described herein is intended to encompass all the sub-ranges subsumed therein. For example, a range of “1 to 10” is intended to include all the sub-ranges between the minimum value of 1 and the

maximum value of 10 (inclusive), namely, it has a minimum value equal to or great than 1 and a maximum value equal to or less than 10.

[0054] In the present disclosure, unless expressly stated otherwise, the use of singular comprises a plural and the use of a plural comprises a singular. Moreover, in the present application, unless expressly stated otherwise, the use of “or” means “and/or”, even though “and/or” can be expressly used in some cases. In addition, in the present application, unless expressly stated otherwise, the use of “a/an” means “at least one”. For example, “a” polymer, “a” combination, “a component”, or the like refers to any one or more of those objects or components.

[0055] An embodiment of the present embodiment provides a composite sheet for package comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in the first direction, wherein the first direction is a direction from an external atmosphere contact surface of the composite sheet toward a package content contact surface of the composite sheet.

[0056] For example, the inner layer can comprise a first LDPE with MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg). In some examples, the first LDPE can have preferably an MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg).

[0057] For example, the outer layer can primarily play a role of waterproofing and participating in the sealing of package. The outer layer can comprise or be formed from polyethylene (PE). In some examples, the PE used in the outer layer can be LDPE, e.g., a tubular LDPE, an autoclave LDPE, or a combination thereof, in particular a blend thereof. In some examples, the combination of the tubular LDPE and the autoclave LDPE can have an MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg). The outer layer can also be free of PE, but use other polymer(s) instead of PE to achieve the waterproofing or sealing function, e.g., using waterborne resin (e.g., waterborne polyacrylics, waterborne polyurethane, etc.) or solvent-based resin (nitrocellulose, polyvinyl chloride, polyvinyl butyral, solvent-based polyacrylics, aldehyde ketone resin, etc.)

[0058] For example, the intermediate layer can primarily play a role of providing stiffness in the package forming, and can also have a function of protecting the content at the same time. The intermediate layer can be a paperboard, e.g., a liquid packaging board (LPB). In

some examples, such paperboard can comprise a surface layer, a core layer, and a bottom layer. The terms “paperboard” and “paper” are used herein according to the definitions in the standard DIN 6735:2010.

[0059] As used herein, the term “for package” means that the relevant products are used for package purposes, such as, for the package of food, drugs, health care products, daily chemical products, or the like, e.g., for the package of fruit juice, milk, powdered/particulate solid beverages, protein powder, pharmaceutical powder/granules, detergents, etc. In some aspect, the package of the present disclosure can be food package. As used herein, the term “composite sheet” refers to a sheet-like material which is composed of two or more materials with different physical/chemical properties, and has distinct interface between materials. For example, the composite sheet can comprise an outer layer, one or more intermediate paperboard layers, and an inner layer sequentially stacked, and optionally one or more additional layers, such as, odor barrier layer and/or adhesive layer. Basically, “composite sheet” is used herein as a generic term that includes both semi-endless roll material and a blank of such roll material. The blank is preferably designed to produce a single container. The composite sheet can be a flat or three-dimensional object. The latter is, in particular the case, if the sheet-like composite has been folded or rolled up.

[0060] In the composite sheet, the layers of the layer sequence have been joined to one another in a planar manner, preferably over their entire surfaces. Here, the area of the through-hole or part of this area may make an exception. Two layers are joined together when their adhesion to each other exceeds Van der Waals forces of attraction. Preferably, layers joined with one another are one selected from the group consisting of joined with one another by coating, laminated together, sealed together, glued together, and pressed together, or a combination of at least two thereof. Layers joined with one another by coating are preferably joined with one another by melt coating or by vapour deposition. A preferred melt coating is a melt extrusion coating.

[0061] Unless stated otherwise, in a layer sequence, the layers may follow one another indirectly, i.e. with one or at least two intermediate layers, or directly, i.e. with no intermediate layer. This is the case especially in the form of words in which one layer is superimposed to another layer. A form of words in which a layer sequence comprises

enumerated layers means that at least the layers specified are present in the sequence specified by the enumeration. This form of words does not necessarily mean that these layers follow on directly from one another. A form of words in which two layers adjoin one another or are adjacent to one another means that these two layers follow on from one another directly and hence with no intermediate layer. However, this form of words does not specify whether or not the two layers have been joined to one another. Instead, these two layers may be in contact with one another. Preferably, however, these two layers are joined to one another, preferably in a planar manner

[0062] In general, such composite sheet is typically produced by (co)extruding the organic/inorganic materials for forming the layers to form coatings or films, and then laminating the coatings or films onto the intermediate paperboard layer. During production, the composition of the organic materials and the process parameters such as extrusion rate, melting temperature, and lamination temperature will influence the production rate and mechanical properties of the final composite sheet. Moreover, in use, the composite sheet for package of the present disclosure is typically folded many times according to predetermined folding line positions to form a first shape (such, a sleeve), and overlapped each other at some edges thereof, then subjected to treatment (e.g., by heating and/or pressure treatment) at the overlapped position to form a sealing there, and finally formed to a second final shape, e.g., a closed container for food storage. Here, the treatment at the overlapped position is typically performed by introducing heat and/or pressure (e.g., by hot air or hot plate) into the composite sheet. During the treatment, the overlapped edge of the composite sheet and the surrounding areas are subjected to zone heating so that the polymer material in the inner layer is softened and bonded to each other. Such zone heating needs to be performed within a certain temperature window, and it is required to observe whether the sealing is successful in the temperature window. Too high zone heating temperature may cause damage to the composite sheet, e.g., damage of the inner layer or outer layer (e.g., by generation of holes or channels), and/or foaming of the inner layer of the composite sheet due to excessive softening or melting. These damages can cause leakage in a final package. Too low zone heating temperature cannot produce sufficient sealing so that leakage will also occur. Some existing composite sheets for package tend to have narrow working temperature window for sealing, so that they have poor operability in

production, often causing phenomenon of unstable or unsuccessful bonding. Therefore, there is a need for composite sheets for package that have good sealing properties, can be produced at high speed, and have a larger operating temperature window.

[0063] To address at least one of the above problems, at least an embodiment of the present disclosure provides a composite sheet for package comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in the first direction, wherein the inner layer comprises a first LDPE with MFI of 3.5-7.5 g/10 (190°C, 2.16 kg); and wherein the first direction is a direction from an external atmosphere contact surface of the composite sheet toward the package content contact surface of the composite sheet. In some aspects, the composite sheet for package of at least an embodiment of the present disclosure is free of a metal foil barrier layer, e.g., free of an aluminum foil layer.

[0064] As used herein, the term “inner layer” refers to a structural layer of the composite sheet that comes into contact with the package content after the final formation of the package container. The structural layer can be a polymeric layer stacked on the intermediate layer, e.g., by means of lamination, adhesion, etc., and can be softened/melted by heat and/or pressure to bond to the intermediate layer and/or the inner layer of the composite sheet to form a seal.

[0065] The inner layer of the composite sheet for package used in at least an embodiment of the present disclosure can comprise a first LDPE with MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg), preferably, 3.5-4.5 g/10 min (190°C, 2.16 kg), for example. For example, the first LDPE can have an MFI of 4.0 g/10 min (190°C, 2.16 kg), a density of 0.91-0.95 g/cm³, and a melting point of 110-115°C.

[0066] In some aspects of the disclosure, the first LDPE can be a tubular LDPE, an autoclave LDPE, or a combination thereof, in particular a blend thereof, wherein the tubular LDPE and/or the autoclave LDPE can have an MFI of 3.5-4.5 g/10 min (190°C/2.16 kg). As used herein, the term “tubular LDPE” refers to an LDPE produced by a tubular reactor; and the term “autoclave LDPE” refers to an LDPE produced by pressure kettle processing. In some examples, the tubular LDPE can comprise 0 wt% to 70 wt% of the combination; and the autoclave LDPE can comprise 30 wt% to 100 wt% of the combination, based on the total weight of the combination.

[0067] In other aspects of the disclosure, the inner layer can comprise one or more sublayers, such as a first sublayer. Among them, each of the sublayers can comprise or be formed from the same or different materials, but at least one sublayer therein comprises or is formed from the first LDPE with MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg). For example, the inner layer can comprise a plurality of sublayers, in which a first sublayer can comprise or be formed from the first LDPE with MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg). For example, the first LDPE can be a tubular LDPE, an autoclave LDPE, or a combination thereof, in particular a blend thereof, wherein the tubular LDPE and/or the autoclave LDPE can have an MFI of 3.5-4.5 g/10 min. In some examples, the tubular LDPE can comprise 0 wt% to 70 wt% of the combination; and the autoclave LDPE can comprise 30 wt% to 100 wt% of the combination, based on the total weight of the combination.

[0068] Alternatively, in addition to the first sublayer of the combination comprising the combination of the tubular LDPE and the autoclave LDPE, the inner layer can further comprise at least one additional sublayer, e.g., a second sublayer, wherein the second sublayer can comprise or be formed from LDPE, wherein the LDPE can have an MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg). In some examples, the LDPE in the second sublayer can comprise or be formed from a second autoclave LDPE with MFI of 3.5-4.5 g/10 min.

[0069] In some examples, the first sublayer, and the second sublayer can have the same or different thicknesses. They can be stacked in any order, and laminated together. In a preferred aspect, the first sublayer can be disposed between the second sublayer, and the intermediate layer, wherein the first sublayer can comprise or be formed from a combination of a tubular LDPE and an autoclave LDPE, and the second sublayer can comprise or be formed from autoclave LDPE.

[0070] Alternatively, the inner layer can also comprise a first sublayer and an optional second sublayer, wherein the first sublayer can comprise or be formed from the first LDPE, and the optional second sublayer can comprise or be formed from a blend of the first LDPE and a metallocene polyethylene, wherein the first LDPE has an MFI of 7.0 g/10 min. As used herein, the term “metallocene polyethylene (mPE)” refers to polyethylene produced using metallocene as polymerization catalysts.

[0071] In other aspects of embodiments of the present disclosure, the inner layer can have a coating weight of 23-37 g/m², e.g., 25 g/m².

[0072] As used herein, the term “outer layer” refers to a structural layer of the composite sheet that comes into contact with external atmosphere after the final formation of the package container, which can be a polymeric layer stacked on the intermediate layer by means of lamination, adhesion, etc. In some aspects of the disclosure, the outer layer can comprise polyethylene (PE), such as, low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), and metallocene polyethylene (mPE). In general, the outer layer of the composite sheet can serve as a protective layer for the entire structure of the composite sheet. In some aspects of the disclosure, the outer layer can comprise or be formed from a second LDPE with MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg), for example. Further, the second LDPE can comprise or be formed from a tubular LDPE, an autoclave LDPE, or a combination thereof, in particular a blend thereof, wherein the tubular LDPE and/or the autoclave LDPE have an MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg). In some aspects, the outer layer can comprise greater than 75 wt% of polyethylene, preferably greater than 80 wt%, greater than 90 wt%, greater than 95 wt%, or even 100 wt% polyethylene, based on the total weight of the outer layer. In other aspects, the outer layer can have a coating dry weight of 14-22 g/m², e.g., 18 g/m². The second LDPE in the outer layer can be identical to or different from the first LDPE in the inner layer in chemical composition.

[0073] As used herein, the term “melt flow index (MFI)” means a melt flow index as measured in accordance with the ASTM D1238 method at 190°C and 2.16 kg.

[0074] As used herein, the term “intermediate layer” refers to a structural layer of the composite sheet that is not in contact with external atmosphere or the package content (e.g., food, beverages, etc.) after the final formation of the package container. In some aspects, the intermediate layer can be a material layer made from a material such as plastic sheet, paperboard, or paper. For example, a suitable intermediate layer for at least an embodiment of the present disclosure can be a paperboard layer, e.g., a liquid packaging paperboard (LPB).

[0075] In some aspects of the disclosure, the LPB can comprise, sequentially stacked in the first direction: (1) a surface layer comprising 45% to 55% of long-fiber bleached chemical pulp and 45% to 55% of short-fiber bleached chemical pulp, e.g., a surface layer comprising 50% of long-fiber bleached chemical pulp and 50% of short-fiber bleached chemical pulp, based on the total weight of the surface layer; (2) a core layer comprising 40 wt% to 60 wt% of mechanical pulp, 30 wt% to 40 wt% of long-fiber bleached chemical pulp, and 10 wt% to 20 wt% of short-fiber bleached chemical pulp, e.g., a core layer comprising 50% of mechanical pulp, 40 wt% of long-fiber bleached chemical pulp, and 10 wt% of short-fiber bleached chemical pulp, based on the total weight of the core layer, wherein the mechanical pulp is selected from the group consisting of a broad leaved wood mechanical pulp, a coniferous wood mechanical pulp or any mixture thereof; and (3) a bottom layer comprising 50% to 70% of long-fiber bleached chemical pulp and 30% to 50% of short-fiber bleached chemical pulp, e.g., a bottom layer comprising 60 wt% of long-fiber bleached chemical pulp and 40 wt% short-fiber bleached chemical pulp, based on the total weight of the bottom layer, wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer, and wherein the first direction is the same as the first direction described above for the composite sheet.

[0076] Alternatively, the LPB can comprise, sequentially stacked in the first direction: (1) a surface layer comprising 20-30 wt% of long-fiber bleached chemical pulp and 50-80 wt% of short-fiber bleached chemical pulp, e.g., a surface layer comprising 30 wt% of long-fiber bleached chemical pulp and 70 wt% of short-fiber bleached chemical pulp, based on the total weight of the surface layer; (2) a core layer comprising more than 45 wt% of broad-leaved wood mechanical pulp, e.g., a core layer comprising 45-60 wt% of broad-leaved wood mechanical pulp, based on the total weight of the core layer; and (3) a bottom layer comprising more than 20 wt% of long-fiber bleached chemical pulp, e.g., a bottom layer comprising 30 wt% of long-fiber bleached chemical pulp and 70 wt% short-fiber bleached chemical pulp, based on the total weight of the bottom layer, wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer, and wherein the first direction is the same as the first direction described above for the composite sheet.

[0077] Additionally or alternatively, in addition to the outer layer, the intermediate layer, and the inner layer described above, the composite sheet for package of the present

disclosure can further comprise an odor barrier layer disposed between the intermediate layer and the inner layer to prevent any unwanted odor in the external environment from penetrating the composite sheet to influence the quality of the package content. In some aspects, the odor barrier layer can be composed of material selected from high-density polyethylene (HDPE), polyamide (PA), or any combination thereof. For example, the odor barrier layer can be a HDPE layer. With a barrier polymer as the odor barrier layer, it is possible to not only achieve a low water vapor permeation but also a low oxygen permeation (oxygen transmission rate, OTR) and a high odor barrier. There is no objective measure for the odor barrier, so that the effect as an odor barrier is determined subjectively by odor tests.

[0078] In another example, the odor barrier layer can be composed of material selected from HDPE, PA, a third LDPE, or any combination thereof. In one example, the odor barrier layer comprises 65 wt%-100 wt% of HDPE and 0 -35 wt% of the third LDPE. In one example, the third LDPE has a MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

[0079] Additionally or alternatively, the composite sheet for package of the present disclosure can further comprise a further barrier layer disposed between the intermediate layer and the inner layer, preferably between the odor barrier layer and the inner layer, to prevent oxygen and/or water from penetrating the composite sheet to influence the quality of the package content. In the context of a food package, by blocking out these elements, the barrier layer helps to maintain the food's freshness, flavor, and nutritional value for a longer period. The further barrier layer can also enhance the function of the odor barrier layer of preventing the unwanted odor in the external environment from penetrating the composite sheet.

[0080] The barrier compound in the further barrier layer may be any one compound, in particular an organic compound, that is able to improve the barrier properties such as for example oxygen transmission rate (OTR) or water vapor transmission rate (WVTR) of the pulp-based substrate layer when formed into a layer on the pulp-based substrate layer. Suitable barrier compounds may be chosen from polymers barrier compounds that may be man-made or natural such as for example polyesters, polyolefins or polyamides. In particular, the man-made polymer barrier compounds may be chosen among

polyvinylidene chloride (PVDC), PE, PP, PET, PA, PVOH, ethylene vinyl alcohol (EVOH), PVC, polyvinyl alcohol (PVA), PLA, PHA, styrene acrylate and styrene butadiene, nanocellulose, cellulose nanocrystals or cellulose nanofibrils. In one example, the further barrier layer can comprise a polymer compound. Preferably, a material of the further barrier layer can be selected from a group consisting of the EVOH, the PVA, or any combination thereof.

[0081] EVOH that can be used is any of the EVOHs that appear to the person skilled in the art to be suitable for the inventive use. Examples here are obtainable commercially inter alia with the trademark EVALTM from EVAL Europe NV, Belgium in a plurality of different embodiments, examples being the grades EVALTM F104B and EVALTM LR171B. Preferred EVOHs have at least one, two, a plurality of, or all of, the following properties:

- ethylene content in a range from 20 to 60 mol%, preferably from 25 to 45 mol%;
- density in the range from 1.0 to 1.4 g/cm³, preferably from 1.1 to 1.3 g/cm³;
- melting point in the range from above 155 to 235°C, preferably from 165 to 225°C;
- MFI (210°C/2.16 kg if $T_{M(EVOH)} < 210^{\circ}\text{C}$; 230°C/2.16 kg, if $210^{\circ}\text{C} \leq T_{M(EVOH)} < 230^{\circ}\text{C}$) in the range from 1 to 25 g/10 min, preferably from 2 to 20 g/10 min;
- oxygen transmission rate in the range from 0.05 to 3.2 cm³·20 μm/m²·day·atm, preferably in the range from 0.1 to 1 cm³·20 μm/m²·day·atm.

[0082] Additionally or alternatively, the composite sheet for package of the present disclosure can or cannot be each independently provided with an adhesive layer between any two adjacent layers. The adhesive layer can be, e.g., but not limited to, hot melt adhesives and/or pressure sensitive adhesives, etc. The adhesive can help adjacent layers bond together better.

[0083] More particularly, an adhesive layer may be present between the barrier layer and the inner layer, or between the barrier layer and the intermediate layer, or between barrier layers. Useful adhesive in an adhesive layer includes all polymers which are suitable for producing a firm bond through functionalization by means of suitable functional groups, through the forming of ionic bonds or covalent bonds with a surface of a respective adjacent layer. Preferably, these comprise functionalized polyolefins which have been obtained by copolymerization of ethylene with acrylic acids such as acrylic acid, methacrylic acid,

crotonic acid, acrylates, acrylate derivatives or carboxylic anhydrides that bear double bonds, for example maleic anhydride, or at least two of these. Among these, preference is given to polyethylene-maleic anhydride graft polymers (EMAH), ethylene-acrylic acid copolymers (EAA) or ethylene-methacrylic acid copolymers (EMAA), which are sold, for example, under the Bynel and Nucrel0609HSA trade names by DuPont or Escor6000ExCo by ExxonMobil Chemicals.

[0084] Additionally or alternatively, the composite sheet for package of the present disclosure can further comprise a further adhesive layer between the intermediate layer and the inner layer, preferably between the intermediate layer and the odor barrier layer. The further adhesive layer can enhance bonding performance of the odor barrier layer to the intermediate layer. In one example, the further adhesive layer can comprise a fourth LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 k. The fourth LDPE can be identical to or different from the second LDPE in the outer layer in chemical composition. In a further example, an adhesive layer as described above is provided between the further adhesive layer and the odor barrier layer, to achieve a better adhesion performance. In addition, the further adhesive layer can enhance barrier performance for odor or oxygen.

[0085] At least an embodiment of the present disclosure further provides a method for producing a composite sheet for package comprising adhering the outer layer, the intermediate layer, and the inner layer by sequential stacking to obtain a composite sheet for package. Among them, the outer layer, the intermediate layer, and the inner layer are the same as those described above for the composite sheet for package.

[0086] In an aspect of the method for producing the composite sheet for package described above, the adhering the outer layer, the intermediate layer, and the inner layer by sequential stacking comprises: forming the outer layer on a first surface of the intermediate layer; and forming the inner layer on a surface of the intermediate layer opposite to the first surface. For example, the first surface of the intermediate layer can be the surface of the surface layer of the paperboard layer, and the second surface of the intermediate layer can be the surface of the bottom layer of the paperboard layer. For example, the outer layer and/or the inner layer can be formed on the surface of the intermediate layer by (co)extrusion.

[0087] Additionally or alternatively, the preparation method can further comprise: forming an odor barrier layer on the second surface before forming the inner layer on the second surface, and then forming the inner layer on the odor barrier layer. Additionally or alternatively, the preparation method can further comprise: forming an odor barrier layer on the second surface of the intermediate layer; forming a further barrier layer on the odor barrier layer; and forming the inner layer on the further barrier layer. Additionally or alternatively, the preparation method can further comprise: forming a further adhesive layer on the second surface of the intermediate layer; forming an odor barrier layer on the further adhesive layer; forming a further barrier layer on the odor barrier layer; and forming the inner layer on the further barrier layer. Additionally or alternatively, the preparation method can further comprise, optionally, disposing an adhesive layer between any two adjacent layers, and adhering the two adjacent layers together by the adhesive layer.

[0088] At least an embodiment of the present disclosure further provides a sleeve obtained by longitudinal sealing of any composite sheet for package described in the present disclosure. The sleeve has two ends which are open in a top region and a bottom region. In some aspects, the composite sheet for package can be cut into a rectangular sheet with four edges which are parallel to each other in pairs. A set of predetermined creased lines are formed on the rectangular sheet, which are parallel to a set of parallel edges of the rectangular sheet. One or more or all of the set of predetermined creased lines can extend between another set of parallel edges of the rectangular sheet. The set of predetermined crease lines can comprise two or more predetermined crease lines, preferably three lines. The composite sheet for package can be folded in the same direction along each of the set of (e.g., three) predetermined crease lines. After being folded along the last predetermined creased line, two edges of the rectangular sheet parallel to the creased line are overlapped each other to form a longitudinal overlap joint. By heat/pressure activation method (e.g., hot air activation method), the area where the longitudinal overlap joint is located is heated so that the inner layer within this area is softened or melted, thereby adhering to each other to form a longitudinal joint. In other embodiments of the present disclosure, the longitudinal joint can also be formed by other means, which are not limited herein.

[0089] At least an embodiment of the present disclosure further provides a package container obtained by folding and sealing both ends of any sleeve described in the present

disclosure. The sleeve has two ends which are open in a top region and a bottom region. The outer surface of the package container is formed by the outer layer of the composite sheet, and the inner surface thereof is formed by the inner layer of the composite sheet. In some aspects, the package container can be used to package refrigerated food or beverages. For example, the package container could be a gable-top box or a flat-top box for pourable food or beverages.

[0090] The present application will be further explained in detail below with reference to the accompanying drawings. However, those skilled in the art will understand that these drawings only schematically illustrate some examples of the embodiments of the present disclosure, and are not intended to limit the application thereto.

[0091] As shown in FIG. 1, the composite sheet for package 100 can comprise an outer layer 101, an intermediate layer 102, and an inner layer 103.

[0092] Among them, the outer layer 101 is an LDPE layer with MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg), preferably 3.5-4.5 g/10 min. The LDPE layer of the LDPE outer layer 101 can be a layer of tubular LDPE and autoclave LDPE in combination. In particular, the LDPE layer of the LDPE outer layer 101 can be a layer comprising a blend of tubular LDPE and autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg), preferably 3.5-4.5 g/10 min (190°C, 2.16 kg).

[0093] The intermediate layer 102 is a paperboard layer, specifically, it can be LPB. The specific structure is shown in FIG. 4.

[0094] The inner layer 103 comprises an LDPE layer. In an embodiment, the LDPE layer in the inner layer 103 can be LDPE with MFI of 4.5-7.5 g/10 min. In another embodiment, the LDPE layer in the inner layer 103 can be LDPE with MFI of 3.5-4.5 g/10 min. In another embodiment, the inner layer can also be an LDPE layer with MFI of 6.5-7.5 g/10 min or a layer of LDPE with MFI of 6.5-7.5 g/10 min admixed with mPE.

[0095] The LDPE layer in the inner layer 103 can be a layer of a tubular LDPE admixed with an autoclave LDPE, wherein the tubular LDPE and the autoclave LDPE in the inner

layer have an MFI of 3.5-7.5 g/10 min (190°C, 2.16 kg), preferably 3.5-4.5 g/10 min (190°C, 2.16 kg).

[0096] Further, the inner layer 103 can comprise one or more sublayers, as shown in FIG.

2. The inner layer 103 can comprise a first sublayer 1031 and a second sublayer 1032. In an embodiment, both the first sublayer 1031 and the second sublayer 1032 are LDPE layers which can be different types and have different properties. For example, according to an aspect of the present application, the first sublayer 1031 can be a layer of tubular LDPE and autoclave LDPE in combination. In particular, the first sublayer 1031 can be a layer comprising a blend of tubular LDPE and autoclave LDPE. The tubular LDPE and the autoclave LDPE have an MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg), and wherein the tubular LDPE comprises 30-70 wt% of the combination, and the autoclave LDPE comprises 30-70 wt% of the combination, based on the combined weight of the tubular LDPE and the autoclave LDPE. The second sublayer is a layer of autoclave LDPE with MFI of 3.5-4.5 g/10 min (190°C, 2.16 kg).

[0097] An odor barrier layer 104 is further provided between the inner layer 103 and the intermediate layer 102, as shown in FIG. 3. According to some aspects of the present application, the composite sheet for package of at least an embodiment of the present disclosure is free of metal foil barrier layer, e.g., free of aluminum foil layer. As used herein, the term “metal foil barrier layer” refers to a material layer which is made from metal and has a thickness of more than 1 μm . Due to the absence of metal foil barrier layer, the odor of the intermediate layer 102 is easily transferred to the inner layer. Therefore, it is necessary to add an odor barrier layer to protect the content from any odor of the intermediate layer 102. The material of the odor barrier layer 104 can be selected from the group consisting of HDPE, PA, or any combination thereof. Preferably, the odor barrier layer 104 is a HDPE layer or a PA layer. More preferably, the odor barrier layer 104 is a HDPE layer.

[0098] Finally, referring to FIG. 4, the intermediate layer 102 is an LPB layer, specially comprising the surface layer 1021, the core layer 1022, and the bottom layer 1023 described above.

[0099] As shown in FIG. 5, the composite sheet for package 100 can comprise an outer layer 101, an intermediate layer 102, and an inner layer 103.

[0100] Among them, the outer layer 101 is an LDPE layer with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The LDPE layer of the LDPE outer layer 101 can be a layer of tubular LDPE or a layer of the autoclave LDPE. The LDPE layer of the LDPE outer layer 101 can also be a layer of tubular LDPE and the autoclave LDPE in combination. In particular, the LDPE layer of the LDPE outer layer 101 can also be a layer comprising a blend of tubular LDPE and the autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min (190°C, 2.16 kg), more preferably 3.5-4.5 g/10 min (190°C, 2.16 kg). The outer layer is overlaid at a basis weight in a range from 10 to 30 g/m², preferably from 12 to 20 g/m², more preferably from 13 to 18 g/m², most preferably from 14 to 16 g/m².

[0101] The intermediate layer 102 is a paperboard layer. The intermediate layer is overlaid at a basis weight in a range from 150 to 400 g/m², preferably from 180 to 350 g/m², more preferably from 200 to 300 g/m², most preferably from 230 to 260 g/m².

[0102] The inner layer 103 comprises an LDPE layer. In an embodiment, the LDPE layer in the inner layer 103 can be LDPE with MFI of MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The inner layer is overlaid at a basis weight in a range from 15 to 55 g/m², preferably from 15 to 40 g/m², more preferably from 20 to 35 g/m², most preferably from 22 to 30 g/m².

[0103] As shown in FIG. 6, compared with the embodiment shown in FIG. 5, the composite sheet for package 100 further comprises an adhesive layer 106 between the intermediate layer 102 and the inner layer 103. The adhesive layer is overlaid at a basis weight in a range from 2 to 6 g/m², preferably from 3 to 5 g/m². The adhesive layer can be EAA or EMAA in this embodiment.

[0104] An odor barrier layer 104 is further provided between the inner layer 103 and the intermediate layer 102, particularly between the adhesive layer 106 and the inner layer 103, as shown in FIG. 7. The odor barrier layer is overlaid at a basis weight in a range from 3 to 10 g/m², preferably from 4 to 8 g/m², more preferably from 5 to 7 g/m². The material of

the odor barrier layer 104 can be selected from the group consisting of HDPE, PA, LDPE, or any combination thereof.

[0105] In one embodiment, the odor barrier layer 104 comprises a blend of HDPE and LDPE. In one example, the odor barrier layer 104 comprises 65 wt%-100 wt% of HDPE with MFI of 5-10 g/10 min (190°C, 2.16 kg) and 0 -35 wt% of LDPE with MFI of 3-9 g/10 min, preferably 3.5-7.5 g/10 min (190°C, 2.16 kg). In the embodiment shown in FIG. 7, the inner layer 103 can be a layer of 20 wt%-80 wt% of LDPE with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 6.5-7.5 g/10 min admixed with 20 wt%-80 wt% of mPE with MFI of 6-15 g/10 min. The inner layer 103 is overlaid at a basis weight in a range from 10 to 55 g/m², preferably from 15 to 40 g/m², more preferably from 20 to 35 g/m², most preferably from 22 to 30 g/m².

[0106] In an alternative embodiment, the odor barrier layer 104 is a layer of PA, as shown in FIG. 8. Adhesive layers 1061 and 1062 are provided between the intermediate layer 102 and the odor barrier layer 104, and between the odor barrier layer 104 and the inner layer 103, respectively. The adhesive layers 1061 and 1062 can be MAH-PE in this embodiment. The adhesive layers 1061 and 1062 are overlaid at a basis weight in a range from 2 to 6 g/m², preferably from 3 to 5 g/m². In the embodiment shown in FIG. 8, the inner layer 103 can comprise a first sublayer 1031 and a second sublayer 1032. The first sublayer 1031 can be a layer of tubular LDPE and autoclave LDPE in combination. In particular, the first sublayer 1031 can be a layer comprising a blend of tubular LDPE and autoclave LDPE. The tubular LDPE and the autoclave LDPE have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The first sublayer 1031 is overlaid at a basis weight in a range from 5 to 25 g/m², preferably from 5 to 20 g/m², more preferably from 8 to 15 g/m². The second sublayer 1032 can be a layer of 20 wt%-80 wt% of LDPE with MFI of preferably 3.5-7.5 g/10 min, more preferably 6.5-7.5 g/10 min admixed with 20 wt%-80 wt% of mPE with MFI of 6-15 g/10 min. The second sublayer 1032 is overlaid at a basis weight in a from 5 to 25 g/m², preferably from 5 to 20 g/m², more preferably from 8 to 15 g/m².

[0107] In the embodiment shown in FIG. 9, the composite sheet for package 100 can comprise an outer layer 101, an intermediate layer 102, an inner layer 103, and an odor

barrier layer 104 as well as an adhesive layer 106 between the odor barrier layer 104 and the inner layer 103.

[0108] Among them, the outer layer 101 is an LDPE layer with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The LDPE layer of the LDPE outer layer 101 can be a layer of tubular LDPE or a layer of the autoclave LDPE. The LDPE layer of the LDPE outer layer 101 can also be a layer of tubular LDPE and the autoclave LDPE in combination. In particular, the LDPE layer of the LDPE outer layer 101 can also be a layer comprising a blend of tubular LDPE and the autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min (190°C, 2.16 kg), more preferably 3.5-4.5 g/10 min (190°C, 2.16 kg). The outer layer is overlaid at a basis weight in a range from 4 to 20 g/m², preferably from 10 to 20 g/m², more preferably from 15 to 20 g/m².

[0109] The intermediate layer 102 is disposed between the outer layer 101 and the inner layer 103. The intermediate layer 102 can be a paperboard layer. The intermediate layer 102 is overlaid at a basis weight in a range from 150 to 400 g/m², preferably from 200 to 400 g/m², more preferably from 300 to 350 g/m².

[0110] The inner layer 103 can be a layer of 0-70 wt% of LDPE with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 6.5-7.5 g/10 min admixed with 0 - 30 wt% of mPE with MFI of 6-15 g/10 min. The inner layer 103 is overlaid at a basis weight in a range from 27 to 36 g/m², preferably from 28 to 32 g/m², more preferably from 28 to 30 g/m².

[0111] The odor barrier layer 104 is disposed between the intermediate layer 102 and the inner layer 103. The odor barrier layer 104 can be a layer of Nylon PA. The odor barrier layer 104 is overlaid at a basis weight in a range from 6 to 15 g/m², preferably from 8 to 12 g/m², more preferably from 9 to 11 g/m².

[0112] The adhesive layer 106 is provided between the odor barrier layer 104 and the inner layer 103. The adhesive layer 106 is overlaid at a basis weight in a range from 3 to 5 g/m², preferably from 3 to 4 g/m². The adhesive layer can be PE-g-MAH in this embodiment.

[0113] As shown in FIG. 10, compared with the embodiment shown in FIG. 9, the composite sheet for package 100 comprises two adhesive layers 1061 and 1062 between the intermediate layer 102 and the odor barrier layer 104, and between the odor barrier layer 104 and the inner layer 103, respectively. Each adhesive layer is overlaid at a basis weight in a range from 3 to 5 g/m², preferably from 3 to 4 g/m². The adhesive layers 1061 and 1062 can be PE-g-MAH in this embodiment.

[0114] Further to embodiment shown in FIG. 10, in the embodiment shown in FIG. 11, a further adhesive layer 107 is provided between the intermediate layer 102 and the second adhesive layer 1062. The further adhesive layer 107 is overlaid at a basis weight in a range from 10 to 15 g/m², preferably from 12 to 14 g/m². The further adhesive layer 107 is an LDPE layer with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The LDPE layer of the further adhesive layer 107 can be a layer of tubular LDPE or a layer of the autoclave LDPE. The LDPE layer of the further adhesive layer 107 can also be a layer of tubular LDPE and the autoclave LDPE in combination. In particular, the LDPE layer of the further adhesive layer 107 can also be a layer comprising a blend of tubular LDPE and the autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min (190°C, 2.16 kg), more preferably 3.5-4.5 g/10 min (190°C, 2.16 kg).

[0115] In the embodiment shown in FIG. 12, the composite sheet for package 100 can comprise an outer layer 101, an intermediate layer 102, an inner layer 103, an odor barrier layer 104, two adhesive layers 1061 and 1062, and a further barrier layer 108.

[0116] Among them, the outer layer 101 is an LDPE layer with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The LDPE layer of the LDPE outer layer 101 can be a layer of tubular LDPE or a layer of the autoclave LDPE. The LDPE layer of the LDPE outer layer 101 can also be a layer of tubular LDPE and the autoclave LDPE in combination. In particular, the LDPE layer of the LDPE outer layer 101 can also be a layer comprising a blend of tubular LDPE and autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min (190°C, 2.16 kg), more

preferably 3.5-4.5 g/10 min (190°C, 2.16 kg). The outer layer is overlaid at a basis weight in a range from 4 to 20 g/m², preferably from 10 to 20 g/m², more preferably from 15 to 20 g/m².

[0117] The intermediate layer 102 is disposed between the outer layer 101 and the inner layer 103. The intermediate layer 102 can be a paperboard layer. The intermediate layer is overlaid at a basis weight in a range from 150 to 400 g/m², preferably from 200 to 400 g/m², more preferably from 300 to 350 g/m².

[0118] The inner layer 103 can be a layer of 0-70 wt% of LDPE with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 6.5-7.5 g/10 min admixed with 0 - 30 wt% of mPE with MFI of 6-15 g/10 min. The inner layer 103 is overlaid at a basis weight in a range from 27 to 36 g/m², preferably from 28 to 32 g/m², more preferably from 28 to 30 g/m².

[0119] The odor barrier layer 104 is disposed between the intermediate layer 102 and the inner layer 103. The odor barrier layer 104 can be a layer of Nylon PA. The odor barrier layer 104 is overlaid at a basis weight in a range from 6 to 12 g/m², preferably from 8 to 12 g/m², more preferably from 9 to 11 g/m².

[0120] The further barrier layer 108 is provided in the embodiment shown in FIG. 12. The further barrier layer can comprise a polymer compound selected from a group consisting of an ethylene vinyl alcohol (EVOH), polyvinyl alcohol (PVA), or any combination thereof. Preferably, the further barrier layer 108 is a layer of EVOH. The further barrier layer 108 is overlaid at a basis weight in a range from 3 to 7 g/m², preferably from 3 to 6 g/m², more preferably from 3 to 5 g/m².

[0121] The first adhesive layer 1061 is disposed between the further barrier layer 108 and the inner layer 103. The first adhesive layer 1061 is overlaid at a basis weight in a range from 3 to 10 g/m², preferably from 5 to 8 g/m², more preferably from 6 to 8 g/m². The second adhesive layer 1062 is provided between the further barrier layer 108 and the odor barrier layer 104. In another example, adhesive layer between the further barrier layer 108 and the odor barrier layer 104 can be omitted. The second adhesive layer 1062 is overlaid at a basis weight in a range from 3 to 5 g/m², preferably from 3 to 4 g/m². The adhesive layers 1061 and 1062 can be PE-g-MAH in this embodiment.

[0122] As shown in FIG. 13, compared with the embodiment shown in FIG. 12, the composite sheet for package 100 further comprises a third adhesive layer 1063 between the odor barrier layer 104 and the intermediate layer 102. The third adhesive layer 1063 is overlaid at a basis weight in a range from 3 to 5 g/m², preferably from 3 to 4 g/m². The third adhesive layer 1063 can be PE-g-MAH in this embodiment.

[0123] Further to embodiment shown in FIG. 13, in the embodiment shown in FIG. 14, a further adhesive layer 107 is provided between the intermediate layer 102 and the third adhesive layer 1063. The further adhesive layer 107 is overlaid at a basis weight in a range from 10 to 15 g/m², preferably from 12 to 14 g/m². The further adhesive layer 107 is an LDPE layer with MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min, more preferably 3.5-4.5 g/10 min. The LDPE layer of the further adhesive layer 107 can be a layer of tubular LDPE or a layer of the autoclave LDPE. The LDPE layer of the further adhesive layer 107 can also be a layer of tubular LDPE and the autoclave LDPE in combination. In particular, the LDPE layer of the further adhesive layer 107 can also be a layer comprising a blend of tubular LDPE and autoclave LDPE. Among them, the tubular LDPE and the autoclave LDPE in the outer layer have an MFI of 3-9 g/10 min (190°C, 2.16 kg), preferably 3.5-7.5 g/10 min (190°C, 2.16 kg), more preferably 3.5-4.5 g/10 min (190°C, 2.16 kg). In one example of this embodiment, the further barrier layer 108 and the odor barrier layer 104 can be stacked directly to each other without an adhesive layer being provided therebetween. That is, the second adhesive layer 1062 shown in FIG. 14 can be omitted.

EXAMPLES

[0124] Hereinafter the embodiments of the present application will be described in detail with reference to the examples, but those skilled in the art will understand that the following examples are only used to illustrate the present application and should not be regarded as limiting the scope of the present application. Unless otherwise specified, all amounts listed are expressed in parts by weight based on total weight. This application should not be construed as limited to the specific embodiments described.

Preparation Example 1: Preparation of Composite Sheet for Package

[0125] Several composite sheets for package were prepared using the materials shown in Table 1 below, wherein the composite sheets comprised a lamination structure with “outer layer → intermediate layer → odor barrier layer (if present) → inner layer” sequentially stacked. Composite sheets numbered E1 to E4 were obtained.

Table 1. Materials for Forming Composite Sheets for Package

No.	Outer layer	Intermediate layer	Odor barrier layer	Inner layer
E1	Tubular LDPE + autoclave LDPE (MFI = 4)	LPB	Absent	Tubular LDPE + autoclave LDPE (MFI = 4)
E2	Tubular LDPE + autoclave LDPE (MFI = 4)	LPB	Absent	LDPE (MFI=7)
E3	Tubular LDPE + autoclave LDPE (MFI = 4)	LPB	HDPE	Tubular LDPE + autoclave LDPE (MFI = 4)
E4	Tubular LDPE + autoclave LDPE (MFI = 4)	LPB	PA	Tubular LDPE + autoclave LDPE (MFI = 4)

Performance Tests

1. Odor barrier experiment

[0126] The composite sheets of the examples were formed into package containers which were tested for their odor barrier property. The results are shown below:

Table 2. Odor Barrier Experiment

No.	Odor barrier layer	Odor Level
E1	Absent	2
E2	Absent	2
E3	HDPE	1
E4	PA	0

[0127] Among them, odor level 0 means no detectable odor, odor level 1 means slightly detectable odor, and odor level 2 means moderately detectable odor. It can be seen from the above results that the package containers formed from the composite sheet of the present disclosure can effectively prevent odors from penetrating into the interior of the package, thereby ensuring that the package contents are not affected by adverse environmental odors and maintain better quality during the shelf life.

2. Working temperature test:

[0128] The composite sheets for package prepared in the examples were formed to a closed container which was filled with colored water as the content, wherein the bottom area was heated at different working temperature so that the inner layer within the bottom area bonded each other to seal the bottom area. The test results are shown below.

Table 3. Working Temperature Test Experiment:

Temperature [°C]	Top sealing	Bottom sealing	Top sealing	Bottom sealing
400	Acceptable	Acceptable	Unacceptable	Unacceptable
420	Acceptable	Acceptable	Unacceptable	Acceptable
440	Good	Good	Unacceptable	Acceptable
460	Good	Good	Acceptable	Acceptable

480	Good	Good	Acceptable	Unacceptable
500	Good	Good	Unacceptable	Unacceptable
EXAMPLES	E1		E2	

[0129] The bottom area was checked for the seal, and the closed container was left for 3 hours and observed for its leakage. The results show that thermally activating the bottom area in the temperature range of 420-460°C can seal the bottom area well. At the same time, using LDPE with MFI of 4 in the inner layer will provide a wider operating window (400-500°C, span 100°C). It can be seen from the results that the composite sheet for package of the present disclosure can be subjected to bottom sealing within a wide operating temperature window, improving the processing performance of the composite sheet for package.

TEST METHODS

[0130] The following test methods were used within the context of the invention. Unless stated otherwise, the measurements were conducted at an ambient temperature of 23 °C, an ambient air pressure of 100 kPa (0.986 atm) and a relative air humidity of 50 %.

[0131] Bending stiffness

The following devices are used to determine the bending stiffness of a sheet-like material, in particular a sheet-like composite or carrier layer:

- bending stiffness tester L&W Bending Tester Code 160, type 977682 from Lorentzen & Wettre, Sweden,
- punching machine for bending stiffness samples.

[0132] The material to be tested is climatised for 24 h in a standard climate (23 °C, 50 % relative humidity). The measurement is also carried out in a standard climate. Specimens with a width of 38.1 mm and a length of 69.85 mm are punched out of the material to be tested. In the case of roll material, the specimens are taken at 5 positions distributed over the width of the web. In any case, for each bending direction of the material to be tested, 2

specimens with their length in the corresponding bending direction of the material are punched out of the material at each specimen-taking position. Specimens may only be taken from areas of the material to be tested which neither have grooves nor folds.

[0133] Per bending direction to be considered, the bending stiffness (in mN) of the outer side and the opposite inner side is determined. For this purpose, the specimen is placed in the bending stiffness tester with the side to be measured facing forwards and the measurement is started by pressing the green button. For each combination of bending direction and material side (outer side or inner side), the same number of specimens is measured. A 2-point bending test is carried out by the bending stiffness measuring device. In this test, the specimen clamped at one end is deflected at its other end by a measuring edge through a bending angle of 15° . Here, a direction in which the material has the bending stiffness, i.e., the bending direction, is the direction of a straight line connecting the two points at which bending forces are exerted to the specimen in the 2-point bending test. In the case of the bending stiffness tester, this direction is the direction of the shortest straight line from the clamp to the measuring edge. In this direction, the specimen forms a curve during bending. Perpendicular to this direction, a straight fold line would form if the specimen were bent far enough for this. The free clamping length of the specimen is 50 mm. Each specimen may only be used for one measurement. Measurements of the outer side and the inner side on the same specimen are not permitted. The individual measured values are read from the display.

[0134] If multiple specimens were measured for each of the combinations of bending direction and material side, the arithmetic mean over the specimens is calculated for each of the combinations individually. The arithmetic mean values are then used as values for each of the combinations of bending direction and material side. The bending stiffness in a specific bending direction is the geometric mean over the values for the combinations of this bending direction/outer side and this bending direction/inner side.

[0135] Oxygen transmission rate (OTR)

Oxygen transmission rate of a sheet-like composite or of a barrier layer or a combination of layers, including a barrier layer, is determined according to standard ASTM D3985-05

(2010). The sample to be tested, unless stated otherwise, is taken from an ungrooved and unfolded region of the laminate. In addition, the sample is tested with the side facing outward in the laminate facing the test gas. The area of the sample is 50 cm². The measurements are conducted at an ambient temperature of 23°C, an ambient air pressure of 100 kPa (0.986 atm) and a relative air humidity of 50%. The test instrument is an Ox-Tran 2/22 from Mocon, Neuwied, Germany. The measurement is conducted without compressed air compensation. For the measurements, samples at ambient temperature are used. Further, 0 % oxygen at the outer side of the sample and 100 % oxygen at the inner side are used for the measurement. Further settings and factors that affect the measurement – especially the rest of those listed under point 16 of the standard ASTM D3985-05 (2010) – are defined by the instrument used and the proper use and maintenance thereof according to the manufacturer's handbook.

[0136] In order to determine the oxygen transmission rate of a container, a hole is cut into a side panel of the filled closed container. The dimensions of the hole are 10 mm × 40 mm. The container is emptied through the hole. Afterwards, a metal plate having tubes as gas inlet and gas outlet is put on the hole of the container such that the hole is fully covered by the plate. The gas inlet and the gas outlet extend through the hole into the interior of the container. In order to obtain a gas tight connection between plate and container, an epoxy resin, Devcon 5 Minute® Epoxy by company ITW Engineered Polymers, is used as sealing compound. Further, the container is connected to the measurement device Ox-Tran Model 2/21, Mocon, Neuwied, Germany via the tubes. The device is operated according to the software which comes along with the device. Measurement of the OTR is conducted with the Ox-Tran Model 2/21 device (Mocon, Neuwied, Germany) and the according software. Therein, the measurement is in accordance with the standards ASTM D3985 (2010), DIN 53380-3 (1998-07), ASTM F-2622, ISO 14663-2 Annex C or ISO 15105-2 (2003-02). Measurement is conducted at 23 °C and 50 % relative air humidity for a duration of 24 h. Five containers which are identical in construction and which have been produced identically are prepared and studied as described above and the arithmetic mean is calculated and presented in volume of O₂ in ml / (package year).

[0137] Water vapour transmission rate (WVTR)

Water vapour transmission rate of a sheet-like composite or a barrier layer or a combination of layers, including a barrier layer, is determined according to standard ASTM F1249-13. The sample to be tested, unless stated otherwise, is taken from an ungrooved and unfolded region of the laminate. In addition, the sample is tested with its side facing inward in the laminate (the side facing the contents of the container) facing the elevated humidity. The measurement area of the sample is 50 cm². The measurements are conducted at an ambient temperature of 23°C, an ambient air pressure of 100 kPa (0.986 atm) and a relative air humidity of 50 % on the outer side of the sample and of 0 % on the inner side of the sample. The test instrument is a Permatran – W Model 3/33 from Mocon, Neuwied, Germany. For the measurements, samples at ambient temperature are used. Further settings and factors that affect the measurement – especially the rest of those listed under point 12 of the standard ASTM F1249-13 – are defined by the instrument used and the proper use and maintenance thereof according to the manufacturer's handbook.

[0138] In order to determine the water vapour transmission rate of a container, a hole is cut into a side panel of the filled closed container. The dimensions of the hole are 10 mm × 40 mm. The container is emptied through the hole and the container is left for drying. After the container interior has dried, a metal plate having a tube as gas inlet and gas outlet is put on the hole of the container such that the hole is fully covered by the plate. The gas inlet and the gas outlet extend through the hole into the interior of the container. In order to obtain a gas tight connection between plate and container, an epoxy resin, Devcon 5 Minute® Epoxy by company ITW Engineered Polymers, is used as sealing compound. Further, the container is connected to the measurement device Permatran – W Model 3/33 from Mocon, Neuwied, Germany via the tubes. The device is operated according to the software which comes along with the device. The WVTR is determined according to the ASTM F1249-13 standard. The measuring surface of the sample corresponds to the inner surface of the sample. The measurements are performed at an ambient temperature of 23 °C, an ambient air pressure of 100 kPa (0.986 atm) and an ambient (outside the container) relative humidity of 50 %. At the beginning of the measurement, the relative humidity in the container is 0 %. The tester is a Permatran – W Model 3/33 from Mocon, Neuwied, Germany. For the measurements, samples with the ambient temperature are used. Further settings and influencing factors for the measurement – in particular the other factors listed

under point 12 of ASTM F1249-13 – are predetermined by the measuring instrument used and its proper use and maintenance according to the manufacturer's manual. The obtained value of the WVTR is converted to cm² of the container wall (inner side) and year.

[0139] MFI value

The MFI value (mass-based melt flow index in g/10 min) is measured in accordance with the standard DIN EN ISO 1133-1:2012-03 (unless otherwise stated at 190°C with 2.16 kg). There-in, method A as defined in the standard is used applying the standardised extrusion tool. The sample is conditioned in accordance with DIN EN ISO 1872-1. Sample mass and time interval for cutting off the extrudate are selected in accordance with table 4 on page 16 of DIN EN ISO 1133-1:2012-03. In accordance with the comment under the index c below the table 4, the mass is to be determined at an accuracy of 0.1 g.

[0140] Density

Density is measured in accordance with the standard DIN EN ISO 1183-1:2012-04. Therein, method B (section 5.2 of the standard), applying a liquid pycnometer, is used. The sample to be studied is conditioned in accordance with DIN EN ISO 1872-1:199-10. Distilled water is used as the immersion liquid. The test temperature is 23 °C. No buoyancy correction is applied.

[0141] Scott Bond value

The Scott Bond value is determined in accordance with Tappi T 569.

[0142] Melting temperature

Sample preparation for differential scanning calorimetry (DSC):

In case of a layer of a laminate, the material to be studied is separated from the other layers of the laminate as described above. A sample of at least 1.0 mg is weighed with a Kern 770 precision balance from Kern & Sohn GmbH, Balingen, Germany. For this purpose, the empty DSC pan is tared on the balance. Then the sample is weighed. Subsequently, the pan is closed with a lid on a press. The lid should have a small hole, so that the pan will not be

deformed during DSC measurement. The sample and the crucible must not be deformed during the DSC measurement. Care must be taken not to touch the sample or the crucible by bare hand during sample preparation.

[0143] Differential scanning calorimetry (DSC):

The melting temperature is determined in accordance with standard DIN EN ISO 11357-3:2011(E). As described therein by reference, the differential scanning calorimetry is conducted according to standard DIN EN ISO 11357-1, here version 11357-1:2010-03. The following details apply in addition to what is given in the standard or deviating from the standard. The calorimeter is a DSC 8000 from PerkinElmer Inc. In the DSC-method, the heat flow is measured as a function of the temperature. The graph of the measurement therefore shows the heat flow (dQ/dt) on the ordinate axis as a function of the temperature (T) on the abscissa axis. The endothermic direction is always upwards, as in note 2 to section 3.1 of DIN EN ISO 11357-1:2010-03. According to section 4.2 of standard DIN EN ISO 11357-1:2010-03, a heat flow differential calorimetry is carried out. In this case, the reference crucible is always empty and, according to section 3.10 of DIN EN ISO 11357-1:2010-03, the reference position is always used for the temperature. Nevertheless, a reference crucible must always be used. The flushing gas used (sections 5.5 and 9.1.2 of DIN EN ISO 11357-1:2010-03) is nitrogen. Prior to each measurement, the DSC instrument is calibrated according to sections 8.2 to 8.4 of DIN EN ISO 11357-1:2010-03 using the calibrating substances (section 3.2 and 5.4 of DIN EN ISO 11357-1:2010-03) indium and zinc (as per annex C of DIN EN ISO 11357-1:2010-03). As recommended in 8.4.2 of DIN EN ISO 11357-1:2010-03, the heat calibration is carried out using indium as calibrating substance. The crucible is fed to the calorimeter via the auto-sampler. Details about the sample are entered via the editor (name, weight, method of measurement, position on the auto sampler, memory location). The measurements are carried out in dynamic mode (3.9.5 of DIN EN ISO 11357-1:2010-03). In this case the sample is pre-treated by first heating from 35 °C to 160 °C at 20 °C/min and maintaining the temperature for 1 minute. Thereafter, the sample is cooled to 35 °C at 2 °C/min. After that, the measurement process is carried out with a heating rate of 20°C/min up to 160°C.

[0144] Evaluation:

For the evaluation of the measurement, only the second heating curve described above is used. The curve can be selected in the menu under “curves” and there “heat flow”. The selected curve is coloured in blue, the rest of the data is red and can be removed via “remove curve”. Then, the melting temperature can be determined from the data via selecting “peak area” in the menu “calc”. The peak is marked and then evaluated automatically. The sample has exactly as many melting temperatures as its second heating curve has endothermic peaks. If a sample has more than one peak, i.e., more than one melting temperature, the one of these at the lowest temperature is meant in case of any reference herein to a single melting temperature.

[0145] Tensile strength, elongation at break and modulus of elasticity

If the barrier layer is present as part of a laminate structure, the barrier layer is separated from laminate as described above. If the partial sheet-like composite is to be examined, the layers on the side of the barrier layer, which faces the outer surface of the sheet-like composite are separated off of the partial sheet-like composite as described above. The tensile strength, elongation at break and modulus of elasticity of the barrier layer are determined according to the standard DIN 53504:2017-03. The following test conditions are to be used:

- ambient temperature: 23 °C
- relative humidity: 50 %
- sample width: 15 mm
- clamp distance: 40 mm
- test speed: 100 mm/min

[0146] Adhesion

The adhesion of two adjacent layers is determined by fixing them in a 90° peel test instrument, for example the Instron “German rotating wheel fixture”, on a rotatable roller which rotates at 40 mm/min during the measurement. The samples had been cut beforehand

into strips 15 mm wide. On one side of the sample, the laminas are detached from one another and the detached end is clamped in a tensile device directed vertically upward. A measuring instrument to determine the tensile force is attached to the tensile device. As the roller rotates, the force needed to separate the laminas from one another is measured. This force corresponds to the adhesion of the layers to one another and is reported in N/15 mm. The separation of the individual layers can be effected mechanically, for example, or by means of a controlled pre-treatment, for example by soaking the sample in 30 % acetic acid at 60 °C for 3 min.

[0147] Layer thickness

The layer thickness of a sample having an area of 0.5 cm² is determined by means of a scanning electron microscope (SEM). For this purpose, a cross section through the layer structure to be determined is prepared manually with a blade (Leica Microtome Blades 819). The cross section is sputtered with gold (Cressington 108auto from Cressington Scientific Instruments Ltd., Watford (UK)) and then analysed by SEM (Quanta 450, FEI Deutschland GmbH, Frankfurt) under high vacuum (pressure < 7.0·10⁻⁵ Pa). The layer thicknesses of the individual layers are ascertained with the "xT Microscope Control" software, version 6.2.11.3381, FEI Company, Frankfurt, Germany. To determine the average thickness, three samples are taken, the layer thickness in each sample is determined as described above, and the arithmetic mean is formed.

[0148] Leak tightness of top seals

The test medium used for the leak tightness test is Kristalloel 60 from Shell Chemicals with methylene blue. For this test, 250 containers were produced from the test laminate as described below for the inventive and comparative examples, and were filled with water and closed. The closed containers are subsequently cut along their periphery in each case in such a way as to obtain two cup-like container parts, one of which includes the top region of the container, the other one the bottom region. The parts including the top regions with the top seals are filled with approximately 20 ml of the test medium each and stored for 24 hours. After intervals of one, three and 24 hours, the container parts are inspected with the

naked eye on the external side of the top and the bottom region to ascertain whether the test medium there has generated – in the case of leakage of the top seal – blue colourations.

[0149] Compression test

For this test, 5 containers are manufactured according to the corresponding example or comparative example. The purpose of the test is to determine the compressive strength along the longitudinal axis of the container, i.e. the compressive strength in the direction of the longitudinal folds. It may also be used to assess the resilience of filled containers in the static case of storage and in the dynamic case of transportation. The compression test is carried out on the individual containers in accordance with DIN EN ISO12048. The preceding storage of the containers is carried out in accordance with DIN EN ISO 2233:2000. The measuring device used is TIRAtest 28025 (Tira GmbH, Eisfelder Strasse 23/25; 96528 Schalkau, Germany). The mean value of the maximum breaking load (load value) is determined. This describes the value that leads to the failure of the containers.

[0150] The invention is described in more detail hereinafter by examples, although the examples do not imply any restriction of the invention. Also, unless otherwise indicated, the drawings are not to scale.

[0151] All the examples presented in the present invention have passed the leak tightness test.

[0152] Example 2

[0153] Table 2. Construction of the composite sheet for package according to Example 2

Layer designation	Material	Basis weight [g/m ²]
Outer layer	LDPE 2420K from PTT Public Company Limited, Thailand	15
Intermediate layer	Aseptic Board from Stora Enso, Finland	240

First adhesive layer	MAH-PE from Dow Chemical, US	4
Odor barrier layer	PA6 from BASF, Germany	4
Further adhesive layer	MAH-PE from Dow Chemical, US	4
First inner sublayer	LDPE 450E from Dow Chemical, US	10
Second inner sublayer	Blend of (1) 80wt% of LDPE 450E from Dow Chemical, US and (2) 20wt% of mPE from Affinity 1845G from Dow Chemical, US	15

[0154] Example 3

[0155] Table 3. Construction of the composite sheet for package according to Example 3

Layer designation	Material	Basis weight [g/m ²]
Outer layer	LDPE 2420K from PTT Public Company Limited, Thailand	15
Intermediate layer	Aseptic Board from Stora Enso, Finland	240
Adhesive layer	EAA or EMAA from Dow Chemical, US	4
Odor barrier layer	Blend of (1) 65wt% of HDPE Rigidex	6

	HD6070FA from Ineos Group of Switzerland and (2) 35wt% of LDPE 2420K from PTT Public Company Limited of Thailand	
Inner layer	Blend of (1) 40wt% of LDPE 450E from Dow Chemical, US and (2) 60wt% of mPE from Affinity 1845G from Dow Chemical, US	25

[0156] Example 4

[0157] Table 4. Construction of the composite sheet for package according to Example 4

Layer designation	Material	Basis weight [g/m ²]
Outer layer	LDPE 2420K from PTT Public Company Limited, Thailand	15
Intermediate layer	Aseptic Board from Stora Enso, Finland	240
Adhesive layer	EAA or EMAA from Dow Chemical, US	4
Inner layer	LDPE 450E from Dow Chemical, US	25

[0158] Example 5

[0159] Table 5. Construction of the composite sheet for package according to Example 5

Layer designation	Material	Basis weight [g/m ²]
Outer layer	LDPE 2420K from PTT Public Company Limited, Thailand	15
Intermediate layer	Aseptic Board from Stora Enso, Finland	240
Inner layer	LDPE 450E from Dow Chemical, US	25

[0160] The results of the studies conducted in the context of Examples 2 to 5 are summarized in Tables 6-1 and 6-2.

[0161] Table 6-1. Evaluation of the measurements of seam sealing strength, box compression test and odor level by comparison of Examples 2 to 5

	Seam Sealing strength [N/15mm]	Box compression test [N]	Odor Level
Example 2	27	640	0.5
Example 3	23	590	1
Example 4	19	290	2
Example 5	19	270	1

Table 6-2. Evaluation of the measurements of OTR, WVTR, stiffness and tensile strength by comparison of Examples 2 to 5

	OTR	WVT	Stiffness	Tensile strength
--	-----	-----	-----------	------------------

Example 2	++++	+++	+++	+++
Example 3	++	+++	++	+++
Example 4	++	+++	++	+++
Example 5	++	+++	++	+++

[0162] The following scale was used for the assessment of OTR of the above examples:

“++” = lower oxygen transmission rate

“++++” = very high oxygen transmission rate

[0163] The following scale was used for the assessment of WVT of the above examples:

“+++” = high water vapour transmission rate

[0164] The following scale was used for the assessment of stiffness of the above examples:

“++” = lower bending stiffness

“+++” = higher bending stiffness

[0165] The following scale was used for the assessment of tensile strength of the above examples:

“+++” = high tensile strength

[0166] As shown by the study results summarized in Table 6-1, compared to Examples 3 and 4, Examples 2 and 3 show better performance in odor test, seam sealing and compression test by having an odor barrier layer. An odor barrier layer of PA in Example 2 is even more optimal in terms of odor barrier. An odor barrier layer of PA in Example 2 can also have a higher bending stiffness.

[0167] Example 6

[0168] Table 7. Construction of the composite sheet for package according to Example 6

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20
Intermediate layer	HT Board from Stora Enso, Finland	340
First adhesive layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	13
Second adhesive layer	PE-g-MAH from Dow Chemical of US	4
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Third adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0169] Example 7

[0170] Table 8. Construction of the composite sheet for package according to Example 7

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20
Intermediate layer	HT Board from Stora Enso, Finland	340
First adhesive layer	PE-g-MAH from Dow Chemical of US	4
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Further adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0171] Example 8

[0172] Table 9. Construction of the composite sheet for package according to Example 8

Layer designation	Material	Basis weight [g/m ²]
-------------------	----------	----------------------------------

Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20
Intermediate layer	HT Board from Stora Enso, Finland	340
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0173] Example 9

[0174] Table 10. Construction of the composite sheet for package according to Example 9

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20

Intermediate layer	HT Board from Stora Enso, Finland	340
First adhesive layer	PE-g-MAH from Dow Chemical of US	4
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Second adhesive layer	PE-g-MAH from Dow Chemical of US	4
Further barrier layer	EVOH from BASF, Germany with melting temperature of 183 °C and density of 1.19×10^3 kg/m ³	4
Third adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0175] Example 10

[0176] Table 11. Construction of the composite sheet for package according to Example 10

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2)	20

	60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	
Intermediate layer	HT Board from Stora Enso, Finland	340
First adhesive layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	13
Second adhesive layer	PE-g-MAH from Dow Chemical of US	4
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Further barrier layer	EVOH from BASF, Germany with melting temperature of 183 °C and density of 1.19×10^3 kg/m ³	4
Fourth adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0177] Example 11

[0178] Table 12. Construction of the composite sheet for package according to Example 11

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20
Intermediate layer	HT Board from Stora Enso, Finland	340
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
First adhesive layer	PE-g-MAH from Dow Chemical of US	4
Further barrier layer	EVOH from BASF, Germany with melting temperature of 183 °C and density of 1.19×10^3 kg/m ³	4
Second adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0179] Example 12

[0180] Table 13. Construction of the composite sheet for package according to Example 12

Layer designation	Material	Basis weight [g/m ²]
Outer layer	Blend of (1) 40wt% of tubular LDPE and (2) 60wt% of autoclave LDPE (MFI = 4) from PTT Public Company Limited, Thailand	20
Intermediate layer	HT Board from Stora Enso, Finland	340
Odor barrier layer	Nylon PA from BASF, Germany (melting temperature of 222 °C; density of 1.14×10^3 kg/m ³)	10
Further barrier layer	EVOH from BASF, Germany with melting temperature of 183 °C and density of 1.19×10^3 kg/m ³	4
First adhesive layer	PE-g-MAH from Dow Chemical of US	4
Inner layer	LDPE 450E from Dow Chemical of US (MFI = 7)	30

[0181] Test shows that the composite sheets for package according to Examples 6 to 8 have OTR of about 5.2-5.3 $\text{cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$, stiffness of 458-490 mN, tensile strength of 12-15 KN/m in cross direction (CD) and 22-26 KN/m in machine direction (MD), and Scott-bond of 210-250 J/m^2 . Test shows that the composite sheets for package according to Examples 9 to 12 have OTR of 0.36-0.9 $\text{cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$, stiffness of 480-500 mN, tensile strength of 14-16 KN/m in CD and 24-26 KN/m in MD, and Scott-bond of 210-250 J/m^2 . Tables 14-1, 14-2 and 14-3 illustrate comparison between the examples.

[0182] Table 14-1. Evaluation of the measurements of OTR, WVTR and stiffness by comparison of Examples 6 to 12

	OTR [$\text{cm}^3/(\text{m}^2 \cdot \text{d} \cdot \text{bar})$]	WVTR [$\text{cm}^3/(\text{m}^2 \cdot \text{d})$]	Stiffness [mN]
Example 6	5.2	1.5	490
Example 7	5.3	1.2	460
Example 8	5.2	2.2	458
Example 9	0.52	1.3	488
Example 10	0.45	1.1	499
Example 11	0.56	1.0	500
Example 12	0.49	1.4	495

[0183] Table 14-2. Evaluation of the measurements of tensile strength, Seam Sealing strength and odor level by comparison of Examples 6 to 12

	Tensile strength [KN/M]	Seam Sealing strength [N/15mm]	Odor Level
Example 6	CD 12	159	1.5

	MD 23		
Example 7	CD 13 MD 22	160	1.5
Example 8	CD 15 MD 22	179	1.5
Example 9	CD 15 MD 26	178	1.5
Example 10	CD 14 MD 26	213	1.5
Example 11	CD 13 MD 24	207	1.5
Example 10	CD 13 MD 23	208	1.5

[0184] Table 14-3. Evaluation of the measurements of processing difficulty, work window (temperature/ speed) , adhesion of Examples 6 to 12

	Processing difficulty	Work window (temperature/ speed)	Adhesion
Example 6	+++	+++	+++
Example 7	++	++	++
Example 8	+	+	+
Example 9	+	+	+
Example 10	+++	+	+++

Example 11	++	++	++
Example 12	+	+++	+

[0185] The following scale was used for the assessment of processing difficulty of the above examples, in particular in terms of number of processes and complexity of process:

“+” = less difficult for processing

“++” = difficult for processing

“+++” = more difficult for processing

[0186] The following scale was used for the assessment of work window of the above examples, in particular in terms of temperature window for sealing and speed window for transporting in work station:

“+” = smaller work window

“++” = larger work window

“+++” = very large work window

[0187] The following scale was used for the assessment of adhesion of the above examples:

“+” = less adhesive

“++” = more adhesive

“+++” = very adhesive

[0188] As shown by the study results summarized in Table 14-1, compared to Examples 6-8, oxygen transmission rate and water vapour transmission rate have been greatly reduced in Examples 9-12 of the present invention by having a further barrier layer of EVOH. The further barrier layer of EVOH reduces oxygen and/or water from penetrating the composite sheet to a minimum degree. In the meanwhile, addition of a further barrier layer improves the stiffness of the composite sheet. As shown by the study results summarized in Table 14-2, compared to Examples 6-8, an increase in tensile strength and seam sealing strength has been observed in Examples 9-12. As shown by the study

results summarized in Table 14-3, Examples 6 and 10 feature better adhesion property by having a further adhesive layer. Accordingly, an increase in the processing difficulty can be seen from Table 14-3.

[0189] As for the present disclosure, it is also noted that the embodiments and the features in embodiments of the present disclosure can be combined with each other to obtain new embodiments, in case of no conflict. The foregoing is only exemplary embodiments of the present disclosure, and are not used to limit the scope of the present disclosure, which is determined by the appended claims.

CLAIMS

1. A composite sheet for package, comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in a first direction, wherein the inner layer comprises a first low-density polyethylene (LDPE) with melt flow index (MFI) of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg, and the first direction is a direction from an external atmosphere contact surface of the composite sheet toward a package content contact surface of the composite sheet.

2. The composite sheet for package according to claim 1, wherein the inner layer comprises one or more sublayers.

3. The composite sheet for package according to claim 2, wherein at least one sublayer is a first sublayer comprising the first LDPE with MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

4. The composite sheet for package according to claim 3, wherein the first sublayer comprises the first LDPE, and the first LDPE is a combination of a tubular LDPE and a first autoclave LDPE, wherein the tubular LDPE and/or the first autoclave LDPE have an MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

5. The composite sheet for package according to claim 4, wherein the tubular LDPE comprises 0-70 wt% of the combination, and the first autoclave LDPE comprises 30-100 wt% of the combination, based on a total weight of the combination.

6. The composite sheet for package according to claim 4, wherein the inner layer further comprises at least one second sublayer, the second sublayer comprises a second autoclave LDPE, and the second autoclave LDPE has an MFI of 3.5-4.5 g/10 min as measured at 190°C and 2.16 kg.

7. The composite sheet for package according to claim 2, wherein the inner layer comprises:
a first sublayer comprising the first LDPE, and
optionally a second sublayer comprising a blend of the first LDPE and a metallocene polyethylene,
wherein the first LDPE have an MFI of 6.5-7.5 g/10 min as measured at 190°C and 2.16 kg.
8. The composite sheet for package according to claim 1, wherein the outer layer comprises a second LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.
9. The composite sheet for package according to claim 8, wherein the second LDPE is a combination of a second tubular LDPE and a third autoclave LDPE, wherein the second tubular LDPE and/or the third autoclave LDPE have an MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.
10. The composite sheet for package according to any one of previous claims, further comprising an odor barrier layer disposed between the intermediate layer and the inner layer, wherein a material of the odor barrier layer is selected from the group consisting of a high-density polyethylene (HDPE), a polyamide polymer, or any combination thereof.
11. The composite sheet for package according to claim 10, wherein the group further comprises a third LDPE, wherein preferably, the odor barrier layer comprises 65 wt% - 100 wt% of HDPE and 0 - 35 wt% of the third LDPE.
12. The composite sheet for package according to claim 11, wherein the third LDPE has an MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg.

13. The composite sheet for package according to any one of claims 10-12, further comprising a further barrier layer disposed between the intermediate layer and the inner layer, preferably between the odor barrier layer and the inner layer.

14. The composite sheet for package according to claim 13, wherein the further barrier layer comprises a polymer compound, wherein preferably the polymer compound is selected from a group consisting of a polyvinylidene chloride (PVDC), PE, PP, PET, PA, PVOH, an ethylene vinyl alcohol (EVOH), PVC, polyvinyl alcohol (PVA), PLA, PHA, styrene acrylate and styrene butadiene, nanocellulose, cellulose nanocrystals, cellulose nanofibrils or any combination thereof, more preferably the polymer compound is selected from a group consisting of the EVOH, the PVA, or any combination thereof.

15. The composite sheet for package according to any one of claims 10-14, further comprising a further adhesive layer disposed between the intermediate layer and the inner layer, preferably between the intermediate layer and the odor barrier layer,

16. The composite sheet for package according to claim 15, wherein the further adhesive layer comprises a fourth LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 k.

17. The composite sheet for package according to any one of claims 1-6 and 8-9, wherein the first LDPE has an MFI of 4.0 g/10 min as measured at 190°C and 2.16 kg, a density of 0.91-0.95 g/cm³, and a melting point of 110-115°C.

18. The composite sheet for package according to any one of claims 1-17, wherein the intermediate layer is a liquid packaging board (LPB).

19. The composite sheet for package according to claim 18, wherein the LPB comprises, sequentially stacked in the first direction,

(1) a surface layer comprising 45% to 55% of long-fiber bleached chemical pulp and 45% to 55% of short-fiber bleached chemical pulp, based on a total weight of the surface layer;

(2) a core layer comprising 40 wt% to 60 wt% of mechanical pulp, 30 wt% to 40 wt% of long-fiber bleached chemical pulp, and 10 wt% to 20 wt% of short-fiber bleached chemical pulp, based on a total weight of the core layer, wherein the mechanical pulp is selected from the group consisting of a broad-leaved wood mechanical pulp, a coniferous wood mechanical pulp or any mixture thereof; and

(3) a bottom layer comprising 50% to 70% of long-fiber bleached chemical pulp and 30% to 50% of short-fiber bleached chemical pulp, based on a total weight of the bottom layer,

wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer.

20. The composite sheet for package according to claim 18, wherein the LPB comprises, sequentially stacked in the first direction:

(1) a surface layer comprising 20 wt% to 30 wt% of long-fiber bleached chemical pulp and 50 wt% to 80 wt% of short-fiber bleached chemical pulp, based on a total weight of the surface layer;

(2) a core layer comprising more than 45 wt% of broad-leaved wood mechanical pulp, based on a total weight of the core layer; and

(3) a bottom layer comprising more than 20 wt% of long-fiber bleached chemical pulp, based on a total weight of the bottom layer,

wherein the surface layer, the core layer, and the bottom layer are sized by an alkyl ketene dimer.

21. The composite sheet for package according to any one of claims 1-16, wherein the composite sheet for package is free of a metal foil barrier layer.

22. A method for producing a composite sheet for package, the composite sheet comprising an outer layer, an intermediate layer, and an inner layer sequentially stacked in a first direction, wherein the inner layer comprises a first LDPE with MFI of 3.5-7.5 g/10 min as measured at 190°C and 2.16 kg, and the first direction is a direction from an external atmosphere contact surface of the composite sheet toward a package content contact surface of the composite sheet, and the method comprising:

adhering the outer layer, the intermediate layer, and the inner layer by sequential stacking.

23. The method according to claim 22, wherein the adhering the outer layer, the intermediate layer, and the inner layer by sequential stacking comprises:

forming the outer layer on a first surface of the intermediate layer; and

forming the inner layer on a second surface of the intermediate layer opposite to the first surface.

24. The method according to claim 23, further comprising:

forming an odor barrier layer on the second surface before forming the inner layer on the second surface, and then forming the inner layer on the odor barrier layer.

25. The method according to claim 23, further comprising:

forming an odor barrier layer on the second surface of the intermediate layer;

forming a further barrier layer on the odor barrier layer; and

forming the inner layer on the further barrier layer.

26. The method according to claim 23, further comprising:

forming a further adhesive layer on the second surface of the intermediate layer;

forming an odor barrier layer on the further adhesive layer;

forming a further barrier layer on the odor barrier layer; and

forming the inner layer on the further barrier layer.

27. A sleeve, obtained by longitudinal sealing of the composite sheet for package according to any one of claims 1-21, wherein the sleeve has two ends which are open in a top region and a bottom region.

28. A package container, obtained by folding and sealing of both of the ends of the sleeve according to claim 27.