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(54) **A PROCESS OF FORMING AN OPEN CONTAINER FOR DAIRY, PLANT-BASED FOOD AND/OR FROZEN FOOD**

(57) The invention relates to a converting-process of forming an open container from laminated raw materials and/or from treated laminated raw materials, particularly from a packaging material comprising at least a fiber based substrate layer [K] having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; and one or more cross-linked polysiloxane layers [N] which have a total area weight, deter-

mined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻². Preferably, the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, relative to the total weight of the packaging material. Preferably, the packaging material has a Cobb 600 value determined according to EN ISO 535 of below 0.2 g·m⁻², preferably at most 0.1 g·m⁻².

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a converting-process of forming an open container from laminated raw materials and/or from treated laminated raw materials, particularly from a packaging material comprising at least a fiber based substrate layer **[K]** having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; and one or more cross-linked polysiloxane layers **[N]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻². Preferably, the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, relative to the total weight of the packaging material. Preferably, the packaging material has a Cobb 600 value determined according to EN ISO 535 of below 0.2 g·m⁻², preferably at most 0.1 g·m⁻².

[0002] Paperboard used in containers for dairy or frozen food is usually provided with barrier coatings both on the inside (facing the packed item) and on the outside (print-side). The barrier coating applied on the inside makes the material resistant against e.g. liquids, grease and/or aroma and enables it to withstand the influence of the packed item on the packaging material. The barrier coating should also be sealable, preferably heat-sealable. The barrier coating applied on the outside protects the packed item from the surrounding, especially from water vapor and condensation that is formed on the surface due to temperature fluctuations or temperature differences between cup outside vs cup inside (when filled).

[0003] Barriers are normally created by coating the fiber based substrate with a composition which gives the substrate barrier properties. The most commonly used materials when forming a barrier on a fiber based product, are polyolefins, such as polyethylene (PE) or polypropylene (PP). Bio-based versions thereof have also been proposed. Paperboard intended for cups is frequently provided with a polyolefin coating to provide a barrier both on the inside towards the liquid content and on the outer/print side to provide a barrier against moisture arising from condensation. The polymers can for example be laminated or extrusion coated to the fiber based product.

[0004] Currently, most of the barrier coatings are manufactured with extrusion coating techniques and hence made off-line in a separate coating unit. This increases the flexibility of the paper or board machine since different operation schedules can be used on the paper or board machine and the extrusion coating unit.

[0005] However, one disadvantage is that this is not cost efficient since it requires extra handling of the reels and an extra converting step. In addition, such coatings might not be biodegradable or recyclable. The extrusion coated polymers are hard to disintegrate and re-use as part of a broke handling in paper and paperboard making. Polyolefin coatings further put limitations on the printability of the surface and are not compatible with all kind of inks. Environmental concerns and increasing oil prices has further created a renewed interest in barriers from non-fossil-based materials.

[0006] Other commonly used barrier materials comprise pigments such as clay and calcium carbonate in combinations with binders. Typical binders include synthetic organic polymers such as styrene-acrylate (SA), styrene-butadiene-rubber (SBR), ethylene acrylic acid (EAA), polyvinyl acetate (PVAC), polyvinyl acrylic polyester dispersions, and the like. Barrier materials of this type are typically applied in considerably high amounts in order to provide satisfactory barrier properties, e.g. 15 to 30 g·m⁻², thereby introducing considerably high amounts of synthetic organic polymers.

[0007] Another disadvantage of conventional barrier materials is that they are often not transparent. Thus, print images and the like which are located underneath these materials would not be visible through said barrier materials with the naked eye. In consequences, print images are conventionally applied onto the layers of the barrier materials and then overcoated with suitable transparent materials in order to maintain visibility of the print images and to provide protection against outer mechanical impact.

[0008] Such arrangements are disadvantageous not only because they require an additional overcoating step; an additional disadvantage is that the barrier material does not form the outer surface of the fiber based substrates. Thus, when the coated and overcoated fiber based substrates are exposed to water or humidity, the barrier layer can evolve its barrier function as an intermediate layer only, but not as an outer layer. In consequence, the overcoated layer is fully exposed to the water and humidity, respectively. The barrier function merely comes into play when the water or humidity has penetrated the overcoated layer thus reaching the barrier layer.

[0009] This problem is even more critical when the fiber based substrates are used for the manufacture of containers that need to be transparent on their inside, e.g. because they carry a print image on their inside, i.e. on the surface that faces the holding space of the container. Such print images have become popular not only for indicating a certain fill height corresponding to a certain volume of packaged goods, but also for other purposes such as esthetics, commercials or other information.

[0010] Under these circumstances, the layer that comes into direct contact with the packaged goods must have sufficient barrier property. Thus, in these cases, the outer layer of the coated fiber based substrate needs to be based upon a barrier material. When such barrier material is not transparent, however, a print image underneath said barrier material would not be visible. Applying instead the print image onto the barrier material and overcoating said barrier

material with an overcoat (which in turn has no barrier properties itself) would hardly be possible in view of the massive contact with water when the container is filled - the overcoat would not withstand the liquid.

[0011] EP 0 811 508 A1 relates to moisture resistant packaging, usable notably for frozen-food, using highly-sized paperboard and press applied moisture resistant over-print varnishes.

[0012] EP 1 059 383 A1 relates to a coated material comprising a paper substrate or a fiber substrate and a polymer membrane having a polysiloxane structure as the main structure provided on the surface of at least one side of the substrate, by a film or sheet for packing foods and a food container made of the coated material.

[0013] EP 3 456 528 A2 relates to a method of making a cup for containing a food beverage, comprising a step of cutting at least one coated cardboard sheet to form the sidewall and the bottom, and an assembly step by heat-sealing the thus cut sheets to form the cup.

[0014] KR 2021 0157981 A relates to a coating material replacing conventional paper materials, and at the same time, provides a film or sheet for food packaging that has oxygen barrier properties and is free from concerns regarding endocrine disruptors as well as a transparent food container that has the oxygen barrier properties and can be used as a container for food cooked in a microwave oven at a high temperature exceeding 200°C. The coating material comprises: a paper material or a fiber material; and a polymer film provided on at least one side of the paper material or fiber material and having an alkoxy silane structure as a main structure, a film or sheet for food packaging made of the coating material, and a food container.

[0015] US 2013 0225744 A1 relates to a method for preparing an aqueous based coating system, and coating systems made thereby, for coating onto paper and/or paperboard for providing barrier to liquid, moisture vapor, oil and grease including a pigment and a polymer emulsion system or natural based binding system.

[0016] US 2018 0058010 A1 relates to a coated paper-based substrate for manufacturing a container and a method for preparing the same. The coated paper-based substrate comprises a cellulosic fiber-based substrate coated on a first surface with a coating A and coated on a second surface with a coating B. The coating A and the coating B are heat sealable to each other.

[0017] WO 1998 054410 A1 relates to coated board, a process for its manufacture, and containers and packaging formed therefrom. The board comprises at least one polymer-based coat preventing the transmission of liquids and gases, which coat is according to the invention made from a polymer dispersion to which talc particles are added so that talc will constitute 30-80 % of the dry weight of the dried coat.

[0018] WO 2002 053838 A1 relates generally to materials and methods suitable for use as packaging materials whereby the appearance of grease, fat or oil staining on the packaging material is reduced or eliminated.

[0019] WO 2006 007239 A2 relates to a multi-layer, high barrier packaging lid material that is adapted for releasably sealing to a plurality of containers including a first container comprised of one polymer and a second container comprised of another polymer. The packaging lid material comprises a paper base with internal wet strength agent and an anti-wicking agent.

[0020] WO 2007 037680 A1 relates to a pigment coated paper base that comprises a paper base, which paper base comprises one or more wet strength agents, and a pigment coating on at least the topside of said paper base, which pigment coating comprises a binder and a pigment in a specific binder/pigment weight ratio, which is preferably from 40/100 to 150/100.

[0021] WO 2010 052571 A2 discloses a paperboard coated with a first and a second barrier coating layers consisting of an aqueous polymer dispersion comprising from about 70-90 wt.-% of a polymer emulsion and 10-30 wt.-% of a pigment.

[0022] WO 2013 053997 A1 relates to a packaging board comprising a fibrous base and one or more polymer coating layers on one or both sides of the fibrous base. The fibrous base contains the combination of an alkyl ketene dimer size, stearic acid anhydride, a wet-strength size and an aluminum compound, which give the board resistance to aggressive liquids as well as thermal treatment, particularly an improved resistance to raw edge penetration in such circumstances.

[0023] WO 2013 019833 A1 relates to coated substrates comprising a substrate and a barrier coating on at least one surface of the substrate. The barrier coating comprises (i) vermiculite, (ii) polymer capable of forming a film, (iii) chemical stabilizing agent, and (iv) cross-linking agent.

[0024] WO 2014 005697 A2 relates to a recyclable sheet material and a container, preferably cup, formed of such recyclable sheet material comprising 1a) a paper board coated with a water barrier coating on at least one of its uncoated surfaces having a smoothness of equal or less than 500 ml/min according to Bendtsen ISO 8791-2 or 1b) a paper board which is coated on at least one of its uncoated surfaces with a first surface coating comprising at least one mineral pigment and at least one polymeric binder, preferably with polar groups, said coated surface having a smoothness of 100 ml/min or less according to Bendtsen ISO 8791-2 and on top of said first surface coating a water barrier coating.

[0025] WO 2015 155413 A1 discloses a coated food cardboard, with a dispersion barrier coating applied between the board layer and a pigment coating layer.

[0026] WO 2016 170229 A1 relates to a method for manufacturing coated paperboard suitable for packaging paperboard applications. The method comprises coating a first surface of the paperboard web by applying a) a first coating composition in a precoating unit for forming a precoating layer comprising inorganic mineral pigment particles and least

one binder for sealing the first surface of the paperboard web; and b) a second coating composition in a curtain coating unit for forming at least one barrier coating layer on the first surface of the paperboard web; and c) a third coating composition comprising a polymer dispersion in the curtain coating unit for forming at least one heat sealable coating layer on the first surface of the paperboard web.

[0027] WO 2017 073537 A1 relates to a laminate for a heat insulating container, which is a material for a heat insulating container having a printed layer on the surface, which is excellent in smoothness of the surface of the printed layer even after foaming and can realize a desired design.

[0028] WO 2017 186586 A1 relates to an aqueous coating composition, a greaseproof article and a process of forming a coating on a substrate. The aqueous coating composition comprises at least the following components: an organopolysiloxane (A) which is a polysiloxane compound having at least two alkenyl groups per molecule, an organohydrogenpolysiloxane (B) which is a polysiloxane compound comprising at least two Si H groups per molecule, an hydrosilylation catalyst (C) able to catalyze an hydrosilylation reaction between the organopolysiloxane compound (A) and the organohydrogenpolysiloxane compound (B), an organic copolymer (D) comprising at least two types of repeating units (i) and (ii): unit (i) which is an alkyl group comprising from 2 to 2 carbon atoms, unit (ii) which is an alkyl group comprising from 2 to 12 carbon atoms and having at least one pendant alcohol substituent, water, and the composition is able to form upon curing by hydrosilylation a coating on a substrate.

[0029] WO 2019 025962 A1 relates to an environment-friendly polymeric composite prepared using biodegradable, compostable and recyclable materials, yet having good mechanical properties. The polymeric composite comprises a biodegradable and compostable multilayer first substrate comprising an inner layer, an outer layer and a core layer; and a second substrate comprising at least one layer selected from metal layer, metallized layer, paper layer and pretreated paper layer, such that the second substrate is disposed on the outer layer of the multilayer first substrate.

[0030] WO 2019 130179 A1 relates to a paperboard for packaging of liquid and frozen food, comprising a dispersion coating as the only barrier layer on its outside/print side. The dispersion coating comprising latex and pigment applied on the outside/print side of a paperboard for liquid and/or frozen food serves as the only barrier against moisture arising from condensation.

[0031] WO 2021 004818 A1 relates to a barrier paper comprising a carrier which comprises a paper and which has a respective coating on a first face and on a second face opposite the first face at least in some sections, wherein the coatings on the two opposing faces differ, wherein the barrier paper has an oxygen transport rate of $\leq 10 \text{ cm}^3/\text{m}^2\cdot\text{d}\cdot\text{bar}$ and a water vapor permeability of $\leq 15 \text{ g}/\text{m}^2\cdot\text{d}$, at least the first coating on the first face comprises a semicrystalline polyurethane coating, and at least the second coating arranged on the second face comprises a thermally activatable sealing layer.

[0032] It is further known from the prior art to provide fiber-based substrates with silane layers, e.g. by means of a sol-gel process. The sol-gel process is a known method for producing layers of solid materials from small molecules. The process involves conversion of monomers into a colloidal solution (sol) that acts as the precursor for an integrated network (or gel) of network polymers. In particular, the colloidal solution is formed that then gradually evolves towards the formation of a gel-like diphasic system containing both a liquid phase and solid phase. Removal of the solvent typically requires a drying process. Afterwards, a thermal treatment, or firing process, is often necessary in order to favor further polycondensation and enhance mechanical properties and structural stability. The precursor sol can be deposited on a substrate to form a film, e.g. by dip-coating or spin coating (see e.g. https://en.wikipedia.org/wiki/Sol-gel_process).

[0033] A typical process involves the hydrolysis of alkoxysilanes to produce hydroxyl groups, followed by polycondensation among these groups and residual alkoxy groups to form a three-dimensional polymeric network (or gel). Coatings with a longer chain are found to decrease the wettability and absorption of base paper more efficiently than coatings with a shorter alkyl chain (see e.g. S. Yujun, Inorganic and Organic Thin Films: Fundamentals, Fabrication, and Applications, 1st ed., Wiley 2021, page 500).

[0034] Substituted silanes may serve as feedstocks for numerous industrial sol-gel processes, which yield coatings that are very thin, yet extremely durable. Several silanes that are suitable for preparing such coatings are commercially available (e.g. the products of the series Geniosil[®], Silan M1, M2, M3, IO and P series, all of Wacker Chemie AG, Munich).

[0035] US 5,510,147 relates to a relaxed sol-gel composition and a coated substrate article which is produced therefrom. A tetrafunctional alkoxide silicate is hydrolyzed in an aqueous solution together with a Lewis acid or metal chelate catalyst with optional protic acid until a viscosity of 2600-3200 cps is obtained to form a crosslinked sol-gel polymer composition. The polymer is relaxed by diluting it with water or water plus alcohol optionally containing a Lewis acid or metal chelate until a viscosity of about 1 cps is obtained while not depolymerizing the polymer. The relaxed polymer has substantially no visible polymer particles. The relaxed polymer composition is uniformly coating a substrate and dried without requiring an in-situ curing.

[0036] US 5,776,565 relates to hybrid sol-gel barrier coatings that are produced by hydrolyzing a tetrafunctional alkoxide silicate and a silane having one or two pendant crosslinkable groups in water or water plus a water miscible organic solvent and a catalytic amount a protic acid, Lewis acid, or metal chelate, until a viscosity of from about 2,600 to about 3,200 cps is obtained. The product is then diluted water or water plus a water miscible organic solvent, optionally

containing a protic acid, Lewis acid, or metal chelate, until a viscosity of about 0.5 to about 10 cps is obtained. The diluted product is blended with a photoinitiator, coated onto a substrate, dried and irradiated to obtain oxygen barrier films having a very low oxygen transmission rate.

[0037] US 6,307,192 relates to an ovenable food tray and its manufacturing method. The paperboard or cardboard tray is provided with at least one layer of polymeric coating which is lying at least on the side of the tray coming into contact with the food and contains a polymerized crosslink structure which consists of an inorganic, chain or crosslinked polymeric backbone which contains alternating silicon and oxygen atoms and which comprises side chains and/or crosslinks formed by organic groups or chains.

[0038] US 2009 0022898 A1 provides a sol-gel composition which is dilutable with water in any proportion and is based on the reaction of at least the following components: (i) a glycidyoxypropylalkoxysilane, (ii) an aqueous silica sol having a solids content of > 1% by weight, (iii) an organic acid as hydrolysis catalyst, and (iv) n-propyl zirconate, butyl titanate or titanium acetylacetonate as crosslinker, starting from a mass ratio of the solids mass of component (ii) to component (i) 0.75.

[0039] US 2011 0114276 A1 relates to a method of improving a strength property of a sheet-formed fibrous material formed from an aqueous slurry of cellulose fiber, including coating at least one face of the material with a coating formulation including a polysaccharide containing at least two carboxylic groups and low molecular weight organic mono-, di- or poly-carboxylic acid in an aqueous carrier, keeping the coated face at a temperature of 50° C or more for a time sufficient to obtain the desired improvement including drying of the material.

[0040] US 2014 0342098 A1 relates to a process of fabricating the waterproof coating that may include selecting a substrate, utilizing a sol-gel comprising a silane or silane derivative and metal oxide precursor to coat the substrate, and optionally coating the substrate with a hydrophobic chemical agent and/or other chemical agents to create a surface with nanoscopic or microscopic features.

[0041] WO 2020 261198 A1 relates to the techniques for producing stirring spoons or sticks made of paper or cardboard and coated with a layer of material. The layer of material is adapted to make the stirring spoons or sticks waterproof, to make them usable with all types of beverages, including hot beverages.

[0042] WO 2021 019220 A1 relates to colloidal solutions (known as sols), the use of sols to impart desirable properties to products, products made using sols, and methods of using such sols.

[0043] M.-Ch. Brochier Salon et al., Colloids and Surfaces A: Physicochem. Eng. Aspects 366 (2010) 147-154 relates to the competition between hydrolysis and condensation reactions of trialkoxysilanes, as a function of the amount of water and the nature of the organic group.

[0044] T.-A. Nguyen et al., Journal of Sol-Gel Science and Technology volume 69, 237-249 (2014), report about effects of hydrophobic polyhedral oligomeric silsesquioxane coating on water vapor barrier and water resistance properties of paperboard.

[0045] V.M. Dias et al., World Journal of Nano Science and Engineering, 2015, 5, 126-139, relates to silica-based nanocoating doped by layered double hydroxides to enhance the paperboard barrier properties.

[0046] The coated paperboards of the prior art are not satisfactory in every respect and there is a demand for improved coated paperboards. There remains a need for a coated paperboard for dairy, plant-based food and/or frozen food, which provides a barrier towards moisture arising from condensation and yet good optical and mechanical properties.

[0047] It is an object of the invention to reduce the content of polyolefins, preferably of any synthetic organic polymers in containers for food and beverages, preferably dairy, plant-based food and/or frozen food, without compromising the other properties of the containers, such as mechanical strength and deep-temperature properties. The containers should have good recyclability with little rejection and should facilitate repulping. Further, the containers should be easy to manufacture on large scale in a timely and cost-efficient manner.

SUMMARY OF THE INVENTION

[0048] This object has been achieved by the process of the patent claims.

[0049] The process according to the invention is a process for the manufacture of a container comprising a sidewall with an opening and optionally a bottom (in the following also referred to as "*container according to the invention*"). A starting material of the process according to the invention, from which the container according to the invention is made, is a first element which has a first edge as well as a second edge (in the following also referred to as "*first element according to the invention*"). The first element according to the invention may be combined with additional elements, e.g. a second element, to form the container according to the invention.

[0050] The process according to the invention comprises the steps of

- (a) providing a first element which has a first edge as well as a second edge and which is made of a certain packaging material according to the invention; and

(b) joining at least the first edge and the second edge of the first element with one another thereby forming at least the sidewall of the container.

[0051] The first element according to the invention is made of a certain packaging material, which comprises at least

- a fiber based substrate layer **[K]** having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; and
- one or more cross-linked polysiloxane layers **[N]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻² (in the following also referred to as "*packaging material according to the invention*").

[0052] It has been found that in the packaging material according to the invention the total content of polyolefins, preferably of any synthetic organic polymers, can be minimized without compromising performance. Preferably, the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, relative to the total weight of the packaging material.

[0053] Further, it has been found that cross-linked polysiloxane layer **[N]** can sufficiently protect the optional barrier layer **[M]** against humidity. This is particularly relevant because the optional barrier layer **[M]** is preferably based upon water soluble polymers such as EVOH which in the absence of crosslinked polysiloxane layer **[N]** would at least partially dissolve upon contact with water and humidity, respectively, and thus would be at risk of losing its barrier function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054]

Figures 1 to 17 schematically illustrate preferred embodiments of the packaging material according to the invention. The thickness of the layers shown in the Figures does not represent the preferred thickness of the layers in reality.

Figures 18 and 19 schematically illustrate a preferred container according to the invention made from the packaging material according to the invention.

Figures 20 to 23 schematically illustrate preferred modes of joining two edges of the packaging material according to the invention with one another in order to form a sidewall of a container according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0055] The invention relates to a converting-process of forming an open container from laminated raw materials and/or from treated laminated raw materials, particularly from a packaging material. The packaging material that is processed by the process according to the invention is preferably useful for packaging food or beverages, preferably dairy, plant-based food and/or frozen food.

[0056] The packaging material according to the invention comprises

- optionally, a sealing layer **[A]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, one or more cross-linked polysiloxane layers **[B]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, a printing layer **[C]**;
- optionally, a mineral layer **[D]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;
- a fiber based substrate layer **[K]** having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²;
- optionally, a mineral layer **[L]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;

- optionally, a barrier layer **[M]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- one or more cross-linked polysiloxane layers **[N]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and
- optionally, a sealing layer **[O]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻².

[0057] Preferably, the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, relative to the total weight of the packaging material.

[0058] The packaging material according to the invention comprises layers that can be prepared by means of products that are known to the skilled person and that are commercially available. Technologies for applying such layers are also known to the skilled person. In this regard reference is made e.g. to A.A. Tracton, Coatings Technology Handbook, 3rd ed., Taylor Francis, 2005; J.R. Wagner Jr., Multilayer Flexible Packaging: Technology and Applications, Elsevier, 2010; M.J. Kirwan, Handbook Of Paper And Paperboard Packaging Technology, 2nd ed., Wiley-Blackwell, 2013; G. Cirillo et al., Functional Polymers In Food Science, Volume 1, Food Packaging, Wiley, 2015; P. Bajpai, Biermann's Handbook Of Pulp And Paper: Paper And Board Making, 3rd ed., Elsevier, 2018; S. Farris et al., Functional Coatings For Food Packaging Applications, MDPI, 2020; A. Athanassiou, Sustainable Food Packaging Technology, Wiley, 2021; which are incorporated by reference.

[0059] The packaging material according to the invention comprises at least one cross-linked polysiloxane layer, namely the one or more cross-linked polysiloxane layers **[N]**. It has been found that by employing the packaging material with the one or more cross-linked polysiloxane layers **[N]**, excellent properties can be achieved for the purposes of packaging beverages and/or food, especially dairy, plant-based food and/or frozen food at very low polymer content. Thus, the packaging material according to the invention is environmentally friendly and has improved recyclability.

[0060] Compositions for preparing cross-linked polysiloxane layers are provided as liquid solutions, for example at 70% solids dissolved in ethanol. Since such a silane solution can be absorbed by untreated cardboard, a large amount of such a silane solution would be needed in order to provide a uniform, thin cross-linked polysiloxane layer that covers the whole surface of the cardboard and thus provides the desired properties. It has been found and is contemplated that these problems can be overcome by applying more than a single layer of silane material, i.e. by applying a first sublayer, followed by a second sublayer, e.g. of the same material. However, given that the commercial compositions for preparing cross-linked polysiloxane layers are expensive, it is desirable to reduce the quantity that is needed in order to achieve the desired properties. It has been found that when another coating is first applied to the cardboard, preferably a mineral layer (e.g. a bio-coating, for instance), the consumption of the composition for preparing cross-linked polysiloxane layers can be significantly reduced.

[0061] The one or more cross-linked polysiloxane layers can also be applied over printing layer **[C]**. Besides providing a water repellency barrier, the one or more cross-linked polysiloxane layers increase the surface strength of the packaging material.

[0062] The one or more cross-linked polysiloxane layers provide the packaging material with excellent water repellency. Water repellency can be expressed in terms of e.g. Cobb 600 values. While conventional untreated cardboards have Cobb 600 values of about 2 g·m⁻², the packaging material according to the invention may have Cobb 600 values of 0.5 g·m⁻² or 0.2 g·m⁻² or even below without requiring significant amounts of synthetic polymers. Preferably, the packaging material has a Cobb 600 value determined according to EN ISO 535 of below 0.2 g·m⁻², preferably at most 0.1 g·m⁻².

[0063] The one or more cross-linked polysiloxane layers of the multilayer cardboard according to the invention may also contribute to the visual appearance of the packaging material. It has been found that the packaging material coated with the one or more cross-linked polysiloxane layers has a glassy and glossy appearance.

[0064] It is also contemplated to provide the packaging material according to the invention with one or more additional cross-linked polysiloxane layers, namely with optional one or more cross-linked polysiloxane layers **[H]**. This embodiment is particularly relevant when the packaging material according to the invention is a duplex comprising fiber based substrate layer **[E]** and fiber based substrate layer **[K]**.

[0065] While it is contemplated that the optional one or more cross-linked polysiloxane layers **[B]** and the one or more cross-linked polysiloxane layers **[N]** may form the two outer surfaces of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and the one or more cross-linked polysiloxane layers **[N]** independently of one another are preferably overcoated with sealing layer **[A]** and sealing layer **[O]**, respectively. According to these embodiments, sealing layer **[A]** and sealing layer **[O]** preferably form the two outer surfaces of the packaging material according to the invention, i.e. are in turn not overcoated by additional layers. The sealing layer **[A]** and the sealing layer **[O]** not only close remaining pores of the optional one or more cross-linked polysiloxane layers **[B]** and the one or more cross-linked polysiloxane layers **[N]**, if any, but additionally provide the packaging material with a

good bonding surface. The optional sealing layer [A] and the optional sealing layer [O] independently of one another may be applied to the full surface area of the packaging material according to the invention, or only to a portion of the full surface area of the packaging material according to the invention. In the latter case, the optional sealing layer [A] and the optional sealing layer [O] independently of one another may be applied as a pattern.

[0066] Unless expressly stated otherwise, all percentages are expressed in wt.-% and are related to the total weight of the packaging material or the specified layer thereof, respectively.

[0067] For the purpose of the specification, "based on" preferably indicates that the stated ingredient or mixture of ingredients is that having the greatest content of all ingredients. However, this does not necessarily mean that the content must exceed 50 wt.-%.

[0068] A packaging material according to the invention can be any comparatively thick paper-based material, for the purposes of the specification referred to as "fiber based substrate". The packaging material typically is foldable and rigid. The packaging material may be single-ply or multi-ply.

[0069] The packaging material according to the invention is fiber-based, preferably a cardboard. Besides the fiber-based substrate (paper-based material), the packaging material comprises one or more coatings, preferably on both of its sides.

[0070] The packaging material according to the invention is preferably suitable for packaging of food or beverages, preferably dairy, plant-based food and/or frozen food. Packaging materials for dairy, plant-based food and/or frozen food preferably have certain advantageous properties. Firstly, the packaging (container) should not contain any harmful ingredients so that they may be brought into direct contact with dairy, plant-based food and/or frozen food, at least on one of their outer sides, during the whole shelf-life of the packaged dairy, plant-based food and/or frozen food. Secondly, the packaging (container) should be compatible with dairy, plant-based food and/or frozen food and provide a barrier for a sufficient period of time such that a packaging made of the packaging material maintains its desired properties during the whole shelf-life of the packaged dairy, plant-based food and/or frozen food. Thirdly, especially with respect to packaged dairy, the packaging (container) should be chemically resistant e.g. against lactic acid and other ingredients of dairy that are known to interact with uncoated cardboard over time. Fourthly, especially with respect to packaged frozen food, the packaging (container) should provide mechanical strength also at lower temperatures, e.g. in deep freezers, and should be tolerable to moisture that condenses at the outer side of the packaging (container) when it is removed from the deep freezer and exposed to ambient conditions. The condensed moisture should not penetrate into the coated cardboard because this would negatively influence the mechanical properties of the packaging (container) during the defrosting.

[0071] Preferably, the packaging material according to the invention has a total area weight (grammage), determined according to EN ISO 536, within the range of from 100 to 500 g·m⁻². The total area weight of the packaging material includes the area weight of all coatings and layers that may be present.

[0072] In preferred embodiments, the packaging material has a total area weight, determined according to EN ISO 536, within the range of from 150 to 450 g·m⁻². In preferred embodiments, the packaging material has a total area weight, determined according to EN ISO 536, within the range of 200±50 g·m⁻², or 225±50 g·m⁻², or 250±50 g·m⁻², or 275±50 g·m⁻², or 300±50 g·m⁻², or 325±50 g·m⁻², or 350±50 g·m⁻², or 375±50 g·m⁻², or 400±50 g·m⁻².

[0073] In preferred embodiments, the packaging material has a total thickness, determined according to EN ISO 534, within the range of from 100 to 750 µm. In preferred embodiments, the packaging material has a total thickness, determined according to EN ISO 534, within the range of 200±50 µm, or 225±50 µm, or 250±50 µm, or 275±50 µm, or 300±50 µm, or 325±50 µm, or 350±50 µm, or 375±50 µm, or 400±50 µm, or 425±50 µm, or 450±50 µm, or 475±50 µm, or 500±50 µm, or 525±50 µm, or 550±50 µm, or 575±50 µm, or 600±50 µm, or 625±50 µm, or 650±50 µm, or 675±50 µm, or 700±50 µm.

[0074] In preferred embodiments of the packaging material according to the invention, the layers are arranged in alphabetical order.

[0075] The packaging material according to the invention comprises at least two layers, namely [K] and [N].

[0076] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least one additional layer selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0077] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least two additional layers selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0078] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least three additional layers selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0079] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least four additional layers selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0080] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least five additional layers selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0081] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises at least six additional layers selected from layers [A], [B], [C], [D], [L], [M], and [O].

[0082] In preferred embodiments, the packaging material according to the invention comprises at least three layers, namely **[A]**, **[K]** and **[N]**; **[B]**, **[K]** and **[N]**; **[C]**, **[K]** and **[N]**; **[D]**, **[K]** and **[N]**; **[K]**, **[L]**, and **[N]**; **[K]**, **[M]**, and **[N]**; or **[K]**, **[N]**, and **[O]**;

[0083] In preferred embodiments, the packaging material according to the invention comprises at least four layers, namely **[A]**, **[B]**, **[K]** and **[N]**; **[A]**, **[C]**, **[K]** and **[N]**; **[A]**, **[D]**, **[K]** and **[N]**; **[A]**, **[K]**, **[L]** and **[N]**; **[A]**, **[K]**, **[M]**, and **[N]**; **[A]**, **[K]**, **[N]**, and **[O]**; **[B]**, **[C]**, **[K]** and **[N]**; **[B]**, **[D]**, **[K]** and **[N]**; **[B]**, **[K]**, **[L]** and **[N]**; **[B]**, **[K]**, **[M]** and **[N]**; **[B]**, **[K]**, **[N]** and **[O]**; **[C]**, **[D]**, **[K]** and **[N]**; **[C]**, **[K]**, **[L]**, and **[N]**; **[C]**, **[K]**, **[M]**, and **[N]**; **[C]**, **[K]**, **[N]**, and **[O]**; **[D]**, **[K]**, **[L]**, and **[N]**; **[D]**, **[K]**, **[M]**, and **[N]**; **[D]**, **[K]**, **[N]**, and **[O]**; **[K]**, **[L]**, **[M]**, and **[N]**; **[K]**, **[L]**, **[N]**, and **[O]**; or **[K]**, **[M]**, **[N]**, and **[O]**.

[0084] In preferred embodiments, the packaging material according to the invention comprises at least layers

- **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or
- **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or
- **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or
- **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**.

[0085] In preferred embodiments, the packaging material according to the invention comprises a sealing layer **[A]**.

[0086] Preferably, the optional sealing layer **[A]** forms an outer surface of the packaging material.

[0087] Preferably, the optional sealing layer **[A]** is in direct contact with the optional one or more crosslinked polysiloxane layers **[B]**.

[0088] The packaging material according to the invention optionally comprises one or more crosslinked polysiloxane layers **[B]**.

[0089] In preferred embodiments, the optional one or more cross-linked polysiloxane layers **[B]** form an outer surface of the packaging material.

[0090] In other preferred embodiments, the optional one or more cross-linked polysiloxane layers **[B]** are located between

- the optional sealing layer **[A]** and
- the optional printing layer **[C]**, or the optional mineral layer **[D]**.

[0091] Preferably, the optional one or more cross-linked polysiloxane layers **[B]** are in direct contact with the optional sealing layer **[A]**.

[0092] Preferably, the optional one or more cross-linked polysiloxane layers **[B]** are in direct contact with the optional printing layer **[C]**, or the optional mineral layer **[D]**.

[0093] In preferred embodiments, the packaging material according to the invention comprises a printing layer **[C]**.

[0094] Preferably, the optional printing layer **[C]** is located between

- the optional one or more cross-linked polysiloxane layers **[B]**, and
- the optional mineral layer **[D]**.

[0095] Preferably, the optional printing layer **[C]** is in direct contact with the optional one or more cross-linked polysiloxane layers **[B]**.

[0096] Preferably, the optional printing layer **[C]** is in direct contact with the optional mineral layer **[D]**.

[0097] The packaging material according to the invention comprises optionally, a mineral layer **[D]**.

[0098] Preferably, the optional mineral layer **[D]** is located between

- the optional printing layer **[C]**, or the optional one or more cross-linked polysiloxane layers **[B]** and
- the optional barrier layer **[G]**, or the fiber based substrate layer **[K]**.

[0099] Preferably, the optional mineral layer **[D]** is in direct contact with the optional printing layer **[C]**, or the optional

one or more cross-linked polysiloxane layers [B].

[0100] Preferably, the optional mineral layer [D] is in direct contact with the fiber based substrate layer [K].

[0101] In preferred embodiments, the packaging material according to the invention additionally comprises

- 5 - a fiber based substrate layer [E] having an area weight, determined according to EN ISO 536, within the range of from 10 to 475 g·m⁻²; preferably 10 to 150 g·m⁻² or 25 to 475 g·m⁻²;
- optionally, a mineral layer [F] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;
- 10 - optionally, a barrier layer [G] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, one or more cross-linked polysiloxane layers [H] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- 15 - optionally, a barrier layer [I] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and
- 20 - optionally, a mineral layer [J] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻².

[0102] According to these preferred embodiments, the packaging material according to the invention is a duplex comprising fiber based substrate layer [E] and fiber based substrate layer [K]. The duplex has several advantages.

25 **[0103]** In preferred embodiments, fiber based substrate layer [E] is a comparatively thin paper layer that is applied in addition to the main cardboard, i.e. fiber based substrate layer [K]. This combination provides the stiffness and thickness that is required for the packaging, whereas the thin paper layer, i.e. fiber based substrate layer [E], acts as an (additional) lactic acid barrier and Oz barrier. Moreover, the thin paper layer, i.e. fiber based substrate layer [E], is easier to coat than the main cardboard, i.e. fiber based substrate layer [K], due to its greater smoothness.

30 **[0104]** In other preferred embodiments, fiber based substrate layer [K] is a comparatively thin paper layer that is applied in addition to the main cardboard, i.e. fiber based substrate layer [E].

[0105] According to these preferred embodiments, the packaging material according to the invention comprises

- 35 - a sealing layer [A] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 0.1 to 3.0 g·m⁻²; preferably wherein the sealing layer [A] is based upon an anti moisture varnish;
- optionally, one or more cross-linked polysiloxane layers [B] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- 40 - a printing layer [C]; preferably having an area weight, determined according to EN ISO 536, within the range of from 1.0 to 5.0 g·m⁻²;
- a mineral layer [D] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 3.0 to 15 g·m⁻²; preferably wherein mineral layer [D] is based upon clay;
- 45 - a fiber based substrate layer [E] having an area weight, determined according to EN ISO 536, within the range of from 10 to 475 g·m⁻²; preferably 10 to 150 g·m⁻² or 25 to 475 g·m⁻²; more preferably 50 to 80 g·m⁻² or 150 to 300 g·m⁻²;
- optionally, a mineral layer [F] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 3.0 to 10 g·m⁻²; preferably wherein mineral layer [F] is based upon clay;
- 50 - a barrier layer [G] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 3.0 g·m⁻²; preferably wherein barrier layer [G] is based upon PVOH;
- 55 - one or more cross-linked polysiloxane layers [H] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²;
- a barrier layer [I] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10

g·m⁻²; preferably 0.5 to 3.0 g·m⁻²; preferably wherein barrier layer [I] is based upon PVOH;

- optionally, a mineral layer [J] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²; preferably wherein mineral layer [J] is based upon clay;
- a fiber based substrate layer [K] having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; preferably 100 to 300 g·m⁻² or 30 to 80 g·m⁻²;
- a mineral layer [L] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 5.0 to 15 g·m⁻²; preferably wherein mineral layer [L] is based upon clay;
- optionally, a barrier layer [M] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- one or more cross-linked polysiloxane layers [N] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²; and
- a sealing layer [O] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻².

[0106] Preferably, the packaging material according to the invention comprises at least layers [A], [C], [D], [E], [F], [H], [I], [J], [K], [L], [N], and [O].

[0107] Preferably, the packaging material according to the invention comprises at least layers [A], [C], [D], [E], [F], [G], [H], [I], [K], [L], [N], and [O].

[0108] Preferably, the packaging material according to the invention comprises at least layers [A], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [N], and [O].

[0109] In preferred embodiments, the packaging material according to the invention comprises a fiber based substrate layer [A].

[0110] Preferably, the fiber based substrate [E] is located between

- the optional mineral layer [D] and
- the optional miner layer [F], the optional barrier layer [G], the optional one or more cross-linked polysiloxane layers [H], the optional barrier layer [I], the optional mineral layer [J], or the fiber based substrate layer [K].

[0111] Preferably, the fiber based substrate layer [E] is in direct contact with the optional mineral layer [D].

[0112] Preferably, the fiber based substrate layer [E] is in direct contact with the optional miner layer [F], the optional barrier layer [G], the optional one or more cross-linked polysiloxane layers [H], the optional barrier layer [I], the optional mineral layer [J], or the fiber based substrate layer [K].

[0113] In preferred embodiments, the packaging material according to the invention comprises a mineral layer [F].

[0114] Preferably, the optional mineral layer [F] is located between

- the optional mineral layer [D] or the fiber based substrate layer [E] and
- the optional barrier layer [G], the optional one or more cross-linked polysiloxane layers [H], the optional barrier layer [I], the optional mineral layer [J], or the fiber based substrate layer [K].

[0115] Preferably, the optional mineral layer [F] is in direct contact with the optional mineral layer [D] or the fiber based substrate layer [E].

[0116] Preferably, the optional mineral layer [F] is in direct contact with the optional one or more crosslinked polysiloxane layers [H], the optional barrier layer [I], the optional mineral layer [J], or the fiber based substrate layer [K].

[0117] In preferred embodiments, the packaging material according to the invention comprises one or more cross-linked polysiloxane layers [H].

[0118] Preferably, the optional one or more cross-linked polysiloxane layers [H] is located between

- the optional mineral layer [D], the fiber based substrate layer [E], or the optional mineral layer [F] and
- the optional barrier layer [I], the optional mineral layer [J], or the fiber based substrate layer [K].

[0119] Preferably, the optional one or more cross-linked polysiloxane layers **[H]** is in direct contact with the fiber based substrate layer **[E]**, or the optional mineral layer **[F]**.

[0120] Preferably, the optional one or more cross-linked polysiloxane layers **[H]** is in direct contact with the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

[0121] In preferred embodiments, the packaging material according to the invention comprises a barrier layer **[I]**.

[0122] Preferably, the optional barrier layer **[I]** is located between

- the optional mineral layer **[D]**, the fiber based substrate layer **[E]**, the optional mineral layer **[F]**, or the optional one or more cross-linked polysiloxane layers **[H]** and

- the optional barrier layer **[G]**, or the fiber based substrate layer **[K]**.

[0123] Preferably, the optional barrier layer **[I]** is in direct contact with the optional mineral layer **[D]**, the fiber based substrate layer **[E]**, the optional mineral layer **[F]**, or the optional one or more crosslinked polysiloxane layers **[H]**.

[0124] Preferably, the optional barrier layer **[I]** is in direct contact with the fiber based substrate layer **[K]**.

[0125] In preferred embodiments, the packaging material according to the invention comprises at least layers

- **[A]**, **[B]**, **[D]**, **[E]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[E]**, **[K]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**.

[0126] In preferred embodiments, the packaging material according to the invention comprises at least layers

- **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**.

[0127] In preferred embodiments, the packaging material according to the invention comprises at least layers

- **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[A]**, **[B]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[E]**, **[F]**, **[G]**, **[H]**, **[I]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or

- [A], [B], [C], [D], [E], [F], [G], [H], [I], [K], [L], [M], [N], and [O].

[0128] In preferred embodiments, the packaging material according to the invention comprises at least layers

- 5 - [A], [B], [D], [E], [F], [H], [I], [J], [K], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [J], [K], [M], and [N]; or [B], [C], [D], [E], [F], [H], [I], [J], [K], [M], and [N]; or [B], [D], [E], [F], [H], [I], [J], [K], [L], [M], and [N]; or [B], [D], [E], [F], [H], [I], [J], [K], [M], [N], and [O]; or
- 10 - [A], [B], [C], [D], [E], [F], [H], [I], [J], [K], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [J], [K], [L], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [J], [K], [M], [N], and [O]; or [B], [C], [D], [E], [F], [H], [I], [J], [K], [M], [N], and [O]; or [B], [C], [D], [E], [F], [H], [I], [J], [K], [L], [M], and [N]; or [B], [C], [D], [E], [F], [H], [I], [J], [K], [M], [N], and [O]; or [B], [D], [E], [F], [H], [I], [J], [K], [L], [M], [N], and [O]; or
- 15 - [A], [B], [C], [D], [E], [F], [H], [I], [J], [K], [L], [M], and [N]; or [A], [B], [C], [D], [E], [F], [H], [I], [J], [K], [M], [N], and [O]; or [A], [B], [D], [E], [F], [H], [I], [J], [K], [L], [M], [N], and [O]; or [B], [C], [D], [E], [F], [H], [I], [J], [K], [L], [M], [N], and [O]; or
- [A], [B], [C], [D], [E], [F], [H], [I], [J], [K], [L], [M], [N], and [O].

20 **[0129]** In preferred embodiments, the packaging material according to the invention comprises at least layers

- [A], [B], [D], [E], [F], [G], [H], [I], [J], [K], [M], and [N]; or [A], [B], [D], [E], [F], [G], [H], [I], [J], [K], [M], and [N]; or [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [M], and [N]; or [B], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], and [N]; or [B], [D], [E], [F], [G], [H], [I], [J], [K], [M], [N], and [O]; or
- 25 - [A], [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [M], and [N]; or [A], [B], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], and [N]; or [A], [B], [D], [E], [F], [G], [H], [I], [J], [K], [M], [N], and [O]; or [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [M], [N], and [O]; or [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], and [N]; or [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [M], [N], and [O]; or [B], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], [N], and [O]; or
- 30 - [A], [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], and [N]; or [A], [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [M], [N], and [O]; or [A], [B], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], [N], and [O]; or [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], [N], and [O]; or
- 35 - [A], [B], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [M], [N], and [O].

[0130] The packaging material according to the invention comprises a fiber based substrate layer [K].

[0131] Preferably, the fiber based substrate layer [K] is located between

- 40 - the optional mineral layer [D] and
- the optional mineral layer [L], or the optional barrier layer [M].

45 **[0132]** Preferably the fiber based substrate layer [K] is in direct contact with the optional mineral layer [L], or the optional barrier layer [M].

[0133] In preferred embodiments, the packaging material according to the invention comprises a mineral layer [L].

[0134] Preferably, the optional mineral layer [L] is located between

- 50 - the fiber based substrate layer [K] and
- the optional barrier layer [M].

[0135] Preferably, the optional mineral layer [L] is in direct contact with the fiber based substrate layer [K].

[0136] Preferably, the optional mineral layer [L] is in direct contact with the optional barrier layer [M].

55 **[0137]** The packaging material according to the invention comprises optionally, a barrier layer [M].

[0138] Preferably, the optional barrier layer [M] is located between

- the optional mineral layer [L] or the fiber based substrate layer [K] and

- the one or more cross-linked polysiloxane layers [N].

[0139] Preferably, the optional barrier layer [M] is in direct contact with the optional mineral layer [L] or the fiber based substrate layer [K].

[0140] Preferably, the optional barrier layer [M] is in direct contact with the one or more cross-linked polysiloxane layers [N].

[0141] The packaging material according to the invention comprises one or more cross-linked polysiloxane layers [N].

[0142] In preferred embodiments, the one or more cross-linked polysiloxane layers [N] form an outer surface of the packaging material.

[0143] In other preferred embodiments, the one or more cross-linked polysiloxane layers [N] are located between

- the optional barrier layer [M] and

- the optional sealing layer [O].

[0144] Preferably, the one or more cross-linked polysiloxane layers [N] are in direct contact with the optional sealing layer [O].

[0145] In preferred embodiments, the packaging material according to the invention comprises a sealing layer [O].

[0146] Preferably, the optional sealing layer [O] forms an outer surface of the packaging material.

[0147] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises one or more cross-linked polysiloxane layers [B].

[0148] In preferred embodiments, besides layers [K] and [N], the packaging material according to the invention comprises one or more cross-linked polysiloxane layers [H].

[0149] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers [B] and/or the optional one or more cross-linked polysiloxane layers [H] and/or the one or more cross-linked polysiloxane layers [N] independently of one another are based upon a cross-linked polysiloxane.

[0150] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers [B] and/or the optional one or more cross-linked polysiloxane layers [H] and/or the one or more cross-linked polysiloxane layers [N] independently of one are based on a hybrid material comprising an inorganic polysiloxane backbone and pendant organic substituents.

[0151] The inorganic polysiloxane backbone can be a polymer chain or a polymer network.

[0152] The pendant organic substituents are preferably linked to silicon atoms of the inorganic polysiloxane backbone through oxygen atoms. The pendant organic substituents can be organic radicals (i.e. residues, moieties), macromolecular chains or networks thereof. Preferably, the pendant organic substituents connect or otherwise cross-link the inorganic polysiloxane backbone.

[0153] The pendant organic substituents can comprise synthetic organic moieties and/or optionally modified natural moieties such as optionally modified biomaterials. Said synthetic organic moieties preferably connect or otherwise cross-link the inorganic polysiloxane backbone. Said optionally modified natural moieties or optionally modified biomaterials preferably connect or otherwise cross-link the inorganic polysiloxane backbone. Said optionally modified natural moieties or optionally modified biomaterials may additionally or alternatively connect or otherwise cross-link said synthetic moieties.

[0154] The synthetic organic moieties may be comprised of groups present in the precursor or further groups, linear, branched and/or cross-linked, comprised in further precursors typically free of silicon atoms. Such precursors or moieties can comprise reactive groups promoting linkage to inorganic moieties and/or to the moieties of biomaterials.

[0155] The biomaterial can be a biopolymer such as a starch-based polymer, a hemi-cellulose-based polymer, a cellulose-based polymer, a lignin-based polymer, a chitosan-based polymer, or mixtures or combinations thereof. The biomaterial can be in the form of a flour, for example an oat flour, a barley flour, a rye flour, a wheat flour, a rice flour, a bamboo flour, a lentil flour, a chickpea flour, a pea flour, a corn flour, or a mixture or combination thereof. The biopolymers or flours can be functionalized with reactive groups promoting linkage to inorganic moieties and/or to the synthetic organic moieties.

[0156] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers [B] and/or the optional one or more cross-linked polysiloxane layers [H] and/or the one or more cross-linked polysiloxane layers [N] independently of one another are based upon a polysiloxane selected from the group consisting of polydialkylsiloxanes, preferably polydimethylsiloxanes, and polyalkylarylsiloxanes, preferably polymethylphenylsiloxanes.

[0157] In preferred embodiments, the optional one or more cross-linked polysiloxane layers [B] and/or the optional one or more cross-linked polysiloxane layers [H] and/or the one or more cross-linked polysiloxane layers [N] independently of one another are derived from silicon-based sol-gel layers. Preferably, the one or more cross-linked polysiloxane layers result from (i) the application of a sol-gel composition, typically in a fluid form, and (ii) treatment to obtain a sol-

gel layer, typically is a solid form. Such sol-gel compositions and layers are known to the skilled person.

[0158] Examples of sol-gel compositions, sol-gel sols, materials or layers derived therefrom include technologies referred to as or similar to organically modified ceramics or ormocers (e.g.Ormocer®, BioOrmocer®, Fraunhofer Institute).

[0159] For the purpose of the specification, "*sol-gel composition*" preferably refers to a stable colloidal suspension of particles in a liquid. The liquid of the sol-gel composition is also referred to as "*solvent*".

[0160] The solvents preferably comprises one or more alcohols, typically of formula HO-R. The solvent preferably comprises water. In a preferred embodiment, the solvent comprises water and one or more alcohols, typically of formula HO-R. Examples of alcohols include methanol, ethanol, butanol, ethylene glycol, isopropanol, or mixtures thereof, and optionally further mixed with water.

[0161] In a preferred embodiment, the sol-gel composition comprises water and a least one solvent different from water, preferably an alcohol such as methanol or ethanol. In this embodiment, the ratio by weight between water of the solvent can be for example of from 75/25 to 50/50, or from 90/10 to 75/25. Higher ratios improve ecological footprint and industrial efficacy and safety, especially for application on fiber-based materials.

[0162] The sol-gel composition comprises precursors forming the sol-gel layer, which in turn, typically after further treatment, yields the cross-linked polysiloxane layer.

[0163] Precursors for example comprise:

a) silicon precursors, such as molecules of formula $(R_B)_nSi(OR_A)_{4-n}$, wherein

- R_A is an identical or different hydrogen or hydrocarbon group, for example an alkyl group such a methyl or ethyl group, optionally comprising further reactive groups;
- R_B is an identical or different hydrogen or hydrocarbon group, for example an alkyl group such a methyl or ethyl group, optionally comprising further reactive groups;
- n is an average number of from 0 to 2, preferably from 0 to 1; or

b) organic precursors, for example synthetic and/or natural precursors, preferably free from silicon atoms.

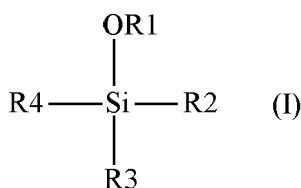
[0164] Examples of preferred silicon precursors include but are not limited to alkoxysilanes, such as tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), tetrapropyl silane, n-propyl triethoxy silane, methyl trimethoxy silane, triethyl methoxy silane, methyl triethoxy silane, octyl triethoxy silane, phenyl triethoxy silane, cyclopentyl triethoxy silane, (3-glycidyloxypropyl) trimethoxy silane (GLYMO), 3-amino-propyl triethoxy silane (APTES), triethoxy-3-(2-imidazolin-1-yl) propylsilane, tetrapropyl orthosilicate triethyloxysilane, (3-methacryloxypropyl)triethoxy silane (MEMO), vinyl trimethoxy silane, and their mixtures or associations.

[0165] The sol-gel composition may further contain one or more catalysts. Catalysts can be any catalyst promoting or accelerating the sol gel layer formation. Catalysts include acid catalysts, such as hydrochloric acid, citric acid, nitric or acetic acid; and base catalysts, such as sodium hydroxide, potassium hydroxide and ammonia.

[0166] Preferably, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another do not contain a pigment selected from kaolin, feldspar, mica, calcined kaolin, clay, natural clay, delaminated clay, calcined clay, calcium carbonate, chalk, ground calcium carbonate, precipitated calcium carbonate, prespite calcium carbonate, talc, gypsum, aluminum trihydrates, titanium dioxide, zinc sulfide, zinc oxide, calcium sulfite, barium sulfate, magnesium hydroxide, amorphous silica, silicates, plastic pigments, and mixtures thereof; preferably do not contain any pigment or mineral filler.

[0167] Preferably, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are derived from a sol-gel composition.

[0168] In preferred embodiments, the sol-gel composition comprises a non-functionalized silane of general formula (I)



wherein

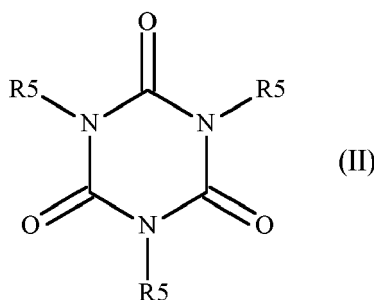
R1 means $-C_{1-18}$ -alkyl, $-C(=O)-C_{1-18}$ -alkyl, or $-C_{6-12}$ -aryl; preferably $-CH_3$, $-CH_2CH_3$, $-CH_2CH_2CH_3$, $-CH(CH_3)_2$, or $-C_6H_5$; and

R2, R3 and R4 independently of one another mean $-C_{1-18}$ -alkyl, $-C_{3-8}$ -cycloalkyl, $-O-C_{1-18}$ -alkyl, $-O-C_{3-8}$ -cycloalkyl, $-O-C(=O)-C_{1-18}$ -alkyl, $-C_{6-12}$ -aryl, or $-O-C_{6-12}$ -aryl; preferably $-CH_3$, $-CH_2CH_3$, $-CH_2CH_2CH_3$, $-CH(CH_3)_2$, $-C_6H_5$, $-O-CH_3$, or $-O-CH_2CH_3$.

[0169] Preferably, the non-functionalized silane of general formula (I) is selected from the group consisting of

- tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof;
- alkyl trialkoxy silanes; preferably methyl trimethoxy silane, methyl triethoxy silane, ethyl trimethoxy silane, ethyl triethoxy silane, octyl trimethoxy silane, octyl triethoxy silane (OTES), hexadecyl trimethoxy silane, or mixtures thereof;
- aryl trialkoxy silanes; preferably phenyl trimethoxy silane, phenyl triethoxy silane, or mixtures thereof;
- dialkyl dialkoxo silanes; preferably dimethyl dimethoxy silane, dimethyl diethoxy silane (DEDMS), cyclohexyl methyl dimethoxy silane, dicyclopentyl dimethoxy silane, or mixtures thereof;
- trialkyl alkoxy silanes; preferably trimethyl methoxy silane, trimethyl ethoxy silane, triethyl methoxy silane, and mixtures thereof; and
- mixtures of any of the foregoing.

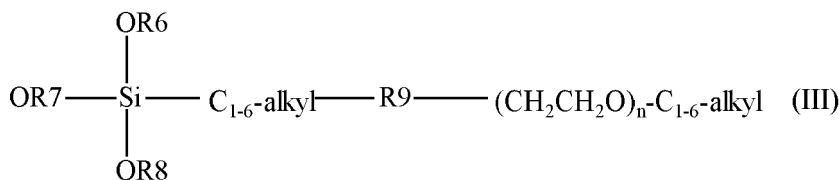
[0170] In preferred embodiments, the sol-gel composition comprises a non-functionalized silane of general formula (II)



wherein R5 means $-C_{1-18}$ -alkyl-Si($O-C_{1-6}$ -alkyl)₃;

preferably wherein the non-functionalized silane of general formula (II) is tris-[3-(trimethoxysilyl) propyl] -isocyanurate.

[0171] In preferred embodiments, the sol-gel composition comprises a non-functionalized alkyl trialkoxy silane oligomer of general formula (III)



wherein

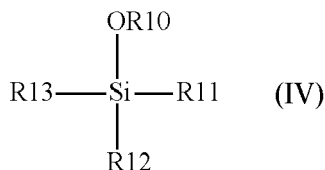
R6, R7 and R8 independently of one another mean $-C_{1-6}$ -alkyl; preferably $-CH_3$ or $-CH_2CH_3$; and

R9 means $-C(=O)-O-$ or $-NH-C(=O)-O-$;

preferably wherein the non-functionalized alkyl trialkoxy silane oligomer of general formula (III) is the reaction product of poly(ethylene glycol) monomethyl ether (preferably Mw 350-750 g/mol) with isocyanate-functionalized alkyl tri-

alkoxy silane (preferably 3-isocyanatopropyl-triethoxy silane).

[0172] In preferred embodiments, the sol-gel composition comprises a functionalized silane of general formula (IV)



wherein

R10 means -C₁₋₁₈-alkyl, -C(=O)-C₁₋₁₈-alkyl, or -C₆₋₁₂-aryl; preferably -CH₃, -CH₂CH₃, -CH₂CH₂CH₃, -CH(CH₃)₂, or -C₆H₅;

R11 means -CH=CH₂, -C₁₋₁₈-alkyl-NH₂, -C₁₋₁₈-alkyl-NH-C₁₋₆-alkyl, -C₁₋₁₈-alkyl-NH-C₁₋₆-alkyl-NH₂, -C₁₋₈-alkyl-NH-C₁₋₆-alkyl-NH-C₁₋₆-alkyl-NH₂, -C₁₋₁₈-alkyl-NH-C₃₋₈-cycloalkyl, -C₁₋₁₈-alkyl-C₆₋₁₀-aryl-NH₂, -C₁₋₁₈-alkyl-imidazoliny, -C₁₋₁₈-alkyl-NH-C(=O)-NH₂, -C₁₋₁₈-alkyl-glycidoxy, -C₁₋₁₈-alkyl-acryloxy, -C₁₋₁₈-alkyl-methacryloxy, -C₁₋₁₈-alkyl-NCO, -C₁₋₁₈-alkyl-NH-C(=O)-O-C₁₋₆-alkyl, -C₁₋₁₈-alkyl-O-C(=O)-NH-C₁₋₆-alkyl;

R12 and R13 independently of one another mean -C₁₋₁₈-alkyl, -C₃₋₈-cycloalkyl, -O-C₁₋₁₈-alkyl, -O-C₃₋₈-cycloalkyl, -O-C(=O)-C₁₋₁₈-alkyl, -C₆₋₁₂-aryl, or -O-C₆₋₁₂-aryl; preferably -CH₃, -CH₂CH₃, -CH₂CH₂CH₃, -CH(CH₃)₂, -C₆H₅, -O-CH₃, or -O-CH₂CH₃.

[0173] Preferably, the functionalized silane of general formula (IV) is selected from the group consisting of

- vinyl trialkoxy silanes; preferably trimethoxy vinyl silane, triethoxy vinyl silane (VES), N-2-(vinylbenzylamino)-ethyl-3-amino-propyl trimethoxy silane; or mixtures thereof;
- vinyl alkyl dialkoxy silanes; preferably vinyl methyl dimethoxy silane;
- vinyl triacetoxysilanes;
- aminoalkyl trialkoxy silanes; preferably 3-aminopropyl trimethoxy silane (APMS), 3-aminopropyl triethoxy silane (APTES, APES), 3-(2-aminoethylamino)propyl trimethoxy silane (DAMS), 3-(2-aminomethylamino)propyl triethoxy silane, 3-[2-(2-aminoethylamino)ethylamino]propyl trimethoxy silane (TAMS), trimethoxy [3-(phenylamino)propyl] silane (PAPMS), triethoxy-3-(2-imidazolin-1-yl)propyl silane (IZPES), N-cyclohexyl-3-aminopropyl trimethoxy silane, N-cyclohexyl aminomethyl triethoxy silane, 3-ureidopropyl trimethoxy silane, or mixtures thereof;
- aminoalkyl alkyl dialkoxy silanes; preferably N-(2-aminoethyl)-3-aminopropylmethyl dimethoxy silane;
- glycidoxyalkyl trialkoxy silanes; preferably 3-glycidoxypropyl trimethoxy silane (GLYMO), 3-glycidoxypropyl triethoxy silane, or mixtures thereof;
- acryloxyalkyl trialkoxy silanes; preferably methacryloxymethyl trimethoxy silane, 3-methacryloxypropyl trimethoxy silane (MPMS), 3-methacryloxypropyl triethoxy silane (MEMO), or mixtures thereof;
- acryloxyalkyl alkyl dialkoxy silanes; preferably methacryloxymethyl methyl dimethoxy silane;
- isocyanatoalkyl trialkoxy silanes; preferably 3-isocyanatopropyl triethoxy silane;
- carbamatoalkyl trialkoxy silanes; preferably N-methyl[3-(trimethoxysilyl)propyl] carbamate, N-tri-methoxysilylmethyl-O-methyl carbamate, or mixtures thereof;
- carbamatoalkyl alkyl dialkoxy silanes; preferably N-dimethoxy(methyl) silyl-methyl-O-methyl carbamate;
- fluoroalkyl trialkoxy silanes;

- phenyl trialkoxy silanes; preferably phenyl trimethoxy silane;
- mixtures of any of the foregoing.

5 **[0174]** In preferred embodiments, the sol-gel composition comprises a metal alcoholate; preferably selected from the group consisting of $\text{Al}(\text{OC}_{1-6}\text{-alkyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-alkyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-alkyl})_4$, or mixtures thereof.

[0175] In preferred embodiments, the sol-gel composition comprises a combination of

- 10 - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof;
- one or more glycidoxymethyl trialkoxy silanes; preferably 3-glycidoxymethyl trimethoxy silane (GLYMO), 3-glycidoxymethyl triethoxy silane, or mixtures thereof;
- 15 - optionally, one or more polyols; preferably triethanol amine; and
- optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-alkyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-alkyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-alkyl})_4$, or mixtures thereof.

20 **[0176]** In preferred embodiments, the sol-gel composition comprises a combination of

- optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof;
- 25 - one or more glycidoxymethyl trialkoxy silanes; preferably 3-glycidoxymethyl trimethoxy silane (GLYMO), 3-glycidoxymethyl triethoxy silane, or mixtures thereof;
- one or more aminoalkyl trialkoxy silanes; preferably 3-aminopropyl trimethoxy silane (APMS), 3-aminopropyl triethoxy silane (APTES, APES, AMEO), 3-(2-aminoethylamino)propyl trimethoxy silane (DAMS), 3-(2-aminomethylamino) propyl triethoxy silane, 3-[2-(2-aminoethylamino) ethylamino]propyl trimethoxy silane (TAMS), trimethoxy
- 30 [3-(phenylamino)propyl] silane (PAPMS), triethoxy-3-(2-imidazolyl-1-yl) propyl silane (IZPES), N-cyclohexyl-3-aminopropyl trimethoxy silane, N-cyclohexyl aminomethyl triethoxy silane, 3-ureidopropyl trimethoxy silane, or mixtures thereof; and
- 35 - optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-alkyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-alkyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-alkyl})_4$, or mixtures thereof.

[0177] In preferred embodiments, the sol-gel composition comprises a combination of

- 40 - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof;
- one or more glycidoxymethyl trialkoxy silanes; preferably 3-glycidoxymethyl trimethoxy silane (GLYMO), 3-glycidoxymethyl triethoxy silane, or mixtures thereof;
- 45 - one or more fluoroalkyl trialkoxy silanes; and
- optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-alkyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-alkyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-alkyl})_4$, or mixtures thereof.

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[0178] In preferred embodiments, the sol-gel composition comprises a combination of

- one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; and
- 55 - one or more vinyl trialkoxy silanes; preferably trimethoxy vinyl silane, triethoxy vinyl silane (VES), N-2-(vinylbenzylamino)-ethyl-3-amino-propyl trimethoxy silane, or mixtures thereof.

[0179] In preferred embodiments, the sol-gel composition comprises a combination of

- optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof;
- acryloxyalkyl trialkoxy silanes; preferably methacryloxymethyl trimethoxy silane, 3-methacryloxypropyl trimethoxy silane (MPMS), 3-methacryloxypropyl triethoxy silane (MEMO), or mixtures thereof;
- optionally, a reactive diluent; preferably (meth)acrylic acid; and
- optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

[0180] In preferred embodiments, the sol-gel composition comprises a solvent; preferably water; more preferably does not comprise an organic solvent.

[0181] Preferably, the content of crosslinked polysiloxane the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another is at least 35 wt.-%, preferably at least 40 wt.-%, more preferably at least 45 wt.-%, still more preferably at least 50 wt.-%, yet more preferably at least 55 wt.-%, even more preferably at least 60 wt.-%, most preferably at least 65 wt.-%, and in particular at least 70 wt.-%; relative to the total weight of the optional one or more crosslinked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]**, respectively.

[0182] In preferred embodiments of the multilayer cardboard according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, of not more than $25 \text{ g}\cdot\text{m}^{-2}$, preferably not more than $22.5 \text{ g}\cdot\text{m}^{-2}$, more preferably not more than $20 \text{ g}\cdot\text{m}^{-2}$, still more preferably not more than $17.5 \text{ g}\cdot\text{m}^{-2}$, yet more preferably not more than $15 \text{ g}\cdot\text{m}^{-2}$, even more preferably not more than $12.5 \text{ g}\cdot\text{m}^{-2}$, most preferably not more than $10 \text{ g}\cdot\text{m}^{-2}$, and in particular not more than $7.5 \text{ g}\cdot\text{m}^{-2}$.

[0183] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to $20 \text{ g}\cdot\text{m}^{-2}$, preferably in the range of from 0.1 to $10 \text{ g}\cdot\text{m}^{-2}$, preferably of from 2.0 to $7.0 \text{ g}\cdot\text{m}^{-2}$.

[0184] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g}\cdot\text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g}\cdot\text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g}\cdot\text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g}\cdot\text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g}\cdot\text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g}\cdot\text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g}\cdot\text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g}\cdot\text{m}^{-2}$.

[0185] Preferably, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a variance of area weight (determined according to EN ISO 536) of at most $\pm 50\%$ of $\emptyset$, preferably at most $\pm 40\%$ of $\emptyset$, more preferably at most $\pm 30\%$ of $\emptyset$, still more preferably at most $\pm 20\%$ of $\emptyset$, and yet more preferably at most $\pm 10\%$ of $\emptyset$. Variance is calculated according to formula $\sum [x_i - \emptyset]^2 / n$, wherein x_i are the individual measured values from $i = 1$ to n , wherein n is the total number of measured values, and wherein $\emptyset$ is the arithmetic mean of all measured values (i.e. $\sum x_i / n$). Preferably, n is 10.

[0186] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are transparent. Transparence of optional the optional one or more cross-linked polysiloxane layers **[B]** is preferred in order to allow visibility of optional printing layer **[C]**.

[0187] In preferred embodiments of the packaging material according to the invention, the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another each consist of two or more sublayers of the same or different material.

[0188] In the formation of the one or more cross-linked polysiloxane layers, the silicon precursor in the sol-gel composition is typically hydrolyzed and condensed, thus forming a three-dimensional molecular network optionally with the synthetic organic moieties and/or the biomaterial. The one or more crosslinked polysiloxane layers can be comprised of a single layer or of two or more sublayers. To this end, the sol-gel composition can be applied in two or more coating

steps. Where several layers are present, the layers can be the identical or different. Where sublayers are present, the sublayers may be identical or different.

[0189] The "one or more cross-linked polysiloxane layers" can also be referred to as "sol-gel coating" or "silicon-based coating". The one or more cross-linked polysiloxane layers can be obtained by applying the sol-gel composition onto a laminar substrate, by any generally known coating technique, such as rod coating, blade coating, spraying, curtain coating, roll coating, dip coating, gravure coating, reverse gravure coating, or brushing. The laminar substrate can be fiber-based substrate layer, optionally comprising or precoated with mineral layers and optionally further layers.

[0190] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises mineral layer **[D]**.

[0191] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises mineral layer **[F]**.

[0192] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises mineral layer **[L]**.

[0193] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises mineral layer **[J]**.

[0194] In preferred embodiments, the packaging material according to the invention comprises the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]**. These layers (sometimes also referred to as "pigment coatings") typically comprise binders and mineral pigments such as calcium carbonate, clay, talc etc. The mineral pigments provide brightness and smoothness to the surface.

[0195] In preferred embodiments of the packaging material according to the invention, the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently of one another contain a mineral selected from the group consisting of clay, calcined clay, non-calcined (hydrous) clay, talc, calcium carbonate, magnesium carbonate, dolomite, gypsum, halloysite, metakaolin, fully calcined kaolin, silicate, mica, perlite, diatomaceous earth, magnesium hydroxide, barium sulphate, titanium dioxide, aluminum trihydrate, bentonite, quartz, or combinations thereof; preferably clay.

[0196] Preferably, the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently of one another comprise a binder, preferably a latex.

[0197] Preferably, the latex is selected from isoprene-latexes, styrene-isoprene-latexes, styrene-butadiene-latexes, styrene-ethylene-butadiene-latexes, styrene-ethylene-propylene-latexes, acrylate latexes, vinylacetate latexes, styrene-(meth)acrylate latexes, vinylacetate-(meth)acrylate latexes, styrene-butadiene-acrylonitrile latexes, styrene-(meth)acrylate-acrylonitrile latexes, styrene-butadiene-(meth)acrylate-acrylonitrile latexes, styrene-maleic anhydride latexes, styrene-(meth)acrylate-maleic anhydride latexes, styrene-butylacrylate latexes, styrene-2-ethylhexyl acrylate latexes, and styrene-methacrylate-2-ethylhexyl acrylate latexes.

[0198] Preferably, the content of the binder is within the range of from 5.0 to 20 wt.-%, and wherein the content of the pigment is within the range of from 80 to 95 wt.-%, in each case relative to the total weight of the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]**, respectively.

[0199] In preferred embodiments of the packaging material according to the invention, the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently of one another have an area weight, determined according to EN ISO 536, within the range of from $10 \pm 9.0 \text{ g} \cdot \text{m}^{-2}$, preferably $10 \pm 8.0 \text{ g} \cdot \text{m}^{-2}$, more preferably $10 \pm 7.0 \text{ g} \cdot \text{m}^{-2}$, still more preferably $10 \pm 6.0 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $10 \pm 5.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $10 \pm 4.0 \text{ g} \cdot \text{m}^{-2}$, most preferably $10 \pm 3.0 \text{ g} \cdot \text{m}^{-2}$, and in particular $10 \pm 2.0 \text{ g} \cdot \text{m}^{-2}$.

[0200] The optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** can be obtained by applying a suitable composition onto a laminar substrate, by any generally known coating technique, such as rod coating, blade coating, spraying, curtain coating, roll coating, dip coating, gravure coating, reverse gravure coating, or brushing. The laminar substrate can be fiber-based substrate layer, optionally comprising or precoated with mineral layers and optionally further layers.

[0201] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises fiber based substrate layer **[E]**.

[0202] In preferred embodiments of the packaging material according to the invention, the optional fiber based substrate layer **[E]** and/or the fiber based substrate layer **[K]** independently of one another are based on paper, paperboard or cardboard.

[0203] The fiber based substrate is preferably a cellulosic material conventionally used in the manufacture of paper or packaging material. The cellulosic material may be made from virgin pulp, recycle pulp or mixtures thereof. The fiber based substrate may be essentially a single layer or may comprise two or more layers.

[0204] In preferred embodiments, the fiber based substrate comprises one or more layers.

[0205] In preferred embodiments, the fiber based substrate comprises a top layer, a middle layer and a back layer.

[0206] In preferred embodiments, the middle layer (a) is located between the top layer and the back layer.

[0207] In preferred embodiments, the thickness of the middle layer is greater than the thickness of the top layer.

[0208] In preferred embodiments, the top layer, the middle layer and/or the back layer is based upon sulphate pulp; preferably bleached sulphate pulp.

5 **[0209]** In preferred embodiments, the middle layer is based upon chemi-thermo-mechanical pulp; preferably in admixture with sulphate pulp, preferably bleached sulphate pulp.

[0210] In preferred embodiments of the packaging material according to the invention, the optional fiber based substrate layer **[E]** and/or the fiber based substrate layer **[K]** independently of one another are based on cellulose fibers.

10 **[0211]** In preferred embodiments of the packaging material according to the invention, the optional fiber based substrate layer **[E]** has an area weight, determined according to EN ISO 536, within the range of from $70 \pm 60 \text{ g} \cdot \text{m}^{-2}$, preferably $70 \pm 50 \text{ g} \cdot \text{m}^{-2}$, more preferably $70 \pm 40 \text{ g} \cdot \text{m}^{-2}$, still more preferably $70 \pm 30 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $70 \pm 20 \text{ g} \cdot \text{m}^{-2}$, even more preferably $70 \pm 15 \text{ g} \cdot \text{m}^{-2}$, most preferably $70 \pm 10 \text{ g} \cdot \text{m}^{-2}$, and in particular $70 \pm 5 \text{ g} \cdot \text{m}^{-2}$.

15 **[0212]** In preferred embodiments of the packaging material according to the invention, the fiber based substrate layer **[K]** has an area weight, determined according to EN ISO 536, within the range of from $225 \pm 200 \text{ g} \cdot \text{m}^{-2}$, preferably $225 \pm 175 \text{ g} \cdot \text{m}^{-2}$, more preferably $225 \pm 150 \text{ g} \cdot \text{m}^{-2}$, still more preferably $225 \pm 125 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $225 \pm 100 \text{ g} \cdot \text{m}^{-2}$, even more preferably $225 \pm 75 \text{ g} \cdot \text{m}^{-2}$, most preferably $225 \pm 50 \text{ g} \cdot \text{m}^{-2}$, and in particular $225 \pm 25 \text{ g} \cdot \text{m}^{-2}$.

[0213] In preferred embodiments, the fiber based substrate layer **[K]** has an area weight, determined according to EN ISO 536, within the range of from 150 to $370 \text{ g} \cdot \text{m}^{-2}$. In preferred embodiments, the fiber based substrate has an area weight, determined according to EN ISO 536, within the range of $200 \pm 50 \text{ g} \cdot \text{m}^{-2}$, or $225 \pm 50 \text{ g} \cdot \text{m}^{-2}$, or $250 \pm 50 \text{ g} \cdot \text{m}^{-2}$, or $275 \pm 50 \text{ g} \cdot \text{m}^{-2}$, or $300 \pm 50 \text{ g} \cdot \text{m}^{-2}$, or $325 \pm 50 \text{ g} \cdot \text{m}^{-2}$.

20 **[0214]** In preferred embodiments, the fiber based substrate layer **[K]** has a total thickness, determined according to EN ISO 534, within the range of from 150 to $750 \mu\text{m}$. In preferred embodiments, the fiber based substrate has a total thickness, determined according to EN ISO 534, within the range of $200 \pm 50 \mu\text{m}$, or $225 \pm 50 \mu\text{m}$, or $250 \pm 50 \mu\text{m}$, or $275 \pm 50 \mu\text{m}$, or $300 \pm 50 \mu\text{m}$, or $325 \pm 50 \mu\text{m}$, or $350 \pm 50 \mu\text{m}$, or $375 \pm 50 \mu\text{m}$, or $400 \pm 50 \mu\text{m}$, or $425 \pm 50 \mu\text{m}$, or $450 \pm 50 \mu\text{m}$, or $475 \pm 50 \mu\text{m}$, or $500 \pm 50 \mu\text{m}$, or $525 \pm 50 \mu\text{m}$, or $550 \pm 50 \mu\text{m}$, or $575 \pm 50 \mu\text{m}$, or $600 \pm 50 \mu\text{m}$, or $625 \pm 50 \mu\text{m}$, or $650 \pm 50 \mu\text{m}$, or $675 \pm 50 \mu\text{m}$, or $700 \pm 50 \mu\text{m}$.

[0215] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises barrier layer **[G]**.

[0216] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises barrier layer **[I]**.

30 **[0217]** In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises barrier layer **[M]**.

[0218] In preferred embodiments of the packaging material according to the invention, the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another are based on a material selected from the group consisting of metal (e.g. aluminum), metal oxide (e.g. Al_2O_3 , SiO_2 , CaO , MgO), polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), polyamide, and combinations thereof; preferably ethylene vinyl alcohol (EVOH).

35 **[0219]** Preferably, the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another comprise a water-soluble polymer, preferably selected from the group consisting of polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), starch, carboxymethylcellulose (CMC), polysaccharides, and combinations thereof. Preferably, the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another comprise the water-soluble polymer in an amount of from 50 to 100 wt.-%, preferably 70 to 95 wt.-%, more preferably 80 to 90 wt.-%, relative to the total weight of the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]**, respectively. The optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** comprising water soluble polymer is preferably both
40 protected by the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** and also makes the laminate easier to recycle.

[0220] As these barrier materials (i.e. polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), starch, carboxymethylcellulose (CMC), polysaccharides, and combinations thereof) are water soluble, the optional barrier layer **[M]** should
50 not come into direct contact with water and humidity, respectively. It has been found that cross-linked polysiloxane layer **[N]** can sufficiently protect the optional barrier layer **[M]** against humidity.

[0221] It is contemplated that the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another may consist of two or more sublayers of essentially the same material. This can be advantageous in order to avoid pinholes. According to these embodiments, the area weight of the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another
55 is expressed as the total area weight of all sublayers of the optional barrier layer **[G]** and all sublayers of the optional barrier layer **[I]** and all sublayers of the optional barrier layer **[M]**, respectively.

[0222] In preferred embodiments of the packaging material according to the invention, the optional barrier layer **[G]**

and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another have an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.

[0223] The optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** can be obtained by applying a suitable composition onto a laminar substrate, by any generally known coating technique, such as rod coating, blade coating, spraying, curtain coating, roll coating, dip coating, gravure coating, reverse gravure coating, or brushing. The laminar substrate can be fiber-based substrate layer, optionally comprising or precoated with mineral layers and optionally further layers.

[0224] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises sealing layer **[A]**.

[0225] In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises sealing layer **[O]**.

[0226] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are heat-sealable.

[0227] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are transparent. Transparency of optional sealing layer **[A]** is preferred in order to allow visibility of optional printing layer **[C]**.

[0228] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are an anti-moisture varnish, i.e. a varnish having barrier properties against water vapor.

[0229] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are an anti-moisture anti-grease varnish.

[0230] For the purpose of the specification, a "varnish" preferably is a clear transparent solid protective finish or film. It may be pigmented as desired. The term "varnish" according to the invention encompasses spirit-drying materials (e.g. "lacquers") and chemical-cure materials (i.e. thermosets). The anti-moisture anti-grease varnish layer is typically based upon one or more synthetic polymers.

[0231] The anti-moisture anti-grease varnish functions as a barrier to moisture and grease. Thus, the anti-moisture anti-grease varnish is preferably soluble neither in water nor in oil. However, the barrier function to moisture and grease does not need to be absolute. It is contemplated that the anti-moisture anti-grease varnish according to the invention exhibits at least some barrier property for at least some time compared to a packaging material not containing the anti-moisture anti-grease varnish. The same analogously applies to an anti-moisture varnish with respect to the barrier properties against water vapor.

[0232] The varnish may comprise both, thermoset as well as thermoplastic materials. For example, a "heat-sealable varnish" according to the invention may be based upon a thermoset material, e.g. a thermoset polyurethane, in combination with a thermoplastic material, e.g. a thermoplastic polyolefin, whereas the thermoset material contributes to the film-forming protective properties and the thermoplastic material contributes to the heat-sealability.

[0233] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are based upon a crosslinked thermoset material.

[0234] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another comprises a crosslinker.

[0235] In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are based on a polymer selected from the group consisting of

(i) polyolefins or olefin copolymers; preferably selected from the group consisting of polyethylenes, low density polyethylenes, linear low density polyethylenes, very low density polyethylenes, ultra-low density polyethylenes, medium density polyethylenes, high density polyethylenes, ultra-high molecular weight polyethylenes, polypropylenes, isotactic polypropylenes, syndiotactic polypropylenes, atactic polypropylenes, ethylene-propylene copolymers, heterophasic polypropylenes, and polystyrenes;

(ii) halogenated polyolefins; preferably selected from the group consisting of polyvinyl chloride, polyvinylidene chloride, polytetrafluoroethylene, ethylene-tetrafluoroethylene copolymers, propylene-tetrafluoroethylene copolymers, polyvinylfluoride;

(iii) cyclopolyolefins or cycloolefin copolymers; preferably selected from norbornene copolymers, and norbornene-ethylene-copolymers;

(iv) ethylene copolymers; preferably selected from the group consisting of ethylene-vinylacetate copolymers, ethylene-vinyl laurate alcohol copolymers, and ethylene-vinyl alcohol copolymers;

(v) synthetic latices; preferably selected from isoprene-latices, styrene-isoprene-latices, styrene-butadiene-latices, styrene-ethylene-butadiene-latices, styrene-ethylene-propylene-latices, acrylate latices, vinylacetate latices, styrene-(meth)acrylate latices, vinylacetate-(meth)acrylate latices, styrene-butadiene-acrylonitrile latices, styrene-(meth)acrylate-acrylonitrile latices, styrene-butadiene-(meth)acrylate-acrylonitrile latices, styrene-maleic anhydride latices, styrene-(meth)acrylate-maleic anhydride latices, styrene-butylacrylate latices, styrene-2-ethylhexyl acrylate latices, and styrene-methacrylate-2-ethylhexyl acrylate latices;

(vi) polyvinyl alcohols or vinylalcohol copolymers;

(vii) polyvinyl acetate and vinylacetate copolymers;

(viii) polyurethanes or urethane copolymers;

(ix) (meth)acrylic acid homopolymers, (meth)acrylic acid copolymers, (meth)acrylic acid ester homopolymers or (meth)acrylic acid ester copolymers; preferably selected from the group consisting of poly(meth)acrylates, (meth)acrylate copolymers, polyalkyl(meth)acrylates, alkyl(meth)acrylate copolymers, polyaryl(meth)acrylates, aryl(meth)acrylate copolymers, styrene-alkyl(meth)acrylate copolymers, and styrene-aryl(meth)acrylate copolymers;

(x) epoxy resins; preferably selected from the group consisting of aliphatic epoxy resins, aromatic epoxy resins, phenoxy resins, copolymers of aliphatic epoxides and alkyl(meth)acrylates, and copolymers of aliphatic epoxides and aryl(meth)acrylates;

(xi) polyvinylpyrrolidones or vinylpyrrolidone copolymers;

(xii) polyamides or polyamide copolymers;

(xiii) polyimides or imide copolymers;

(xiv) polyesters or polyester copolymers; preferably selected from the group consisting of polylactic acid, polyhydroxy alkanoates, polyhydroxy butyrates, polyhydroxy valerates, polyethylene terephthalates, glycolized polyesters, polybutylene succinates, copolyesters of butanediol and adipic acid and terephthalic acid;

(xv) polycarbonates or polycarbonate copolymers;

(xvi) polyethers or ether copolymers; preferably selected from the group consisting of polyethylene glycols, polypropylene glycols, poloxamers, and polyethylene oxides;

(xvii) cellulose ethers or cellulose esters; preferably selected from the group consisting of methyl cellulose, ethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methyl cellulose, carboxymethylated cellulose, cellulose acetate, cellulose acetate butyrate, cellulose stearyl ester;

(xviii) starches or modified starches; preferably selected from hydrophobic starches;

(xix) polysaccharides; preferably selected from chitosan, alginates, and carrageenans;

(xx) proteins; preferably selected from wheat-gluten, casein, caseinates, whey, collagen, soya, and corn zein;

(xxi) lipids; preferably selected from bees wax, carnauba wax, candilla wax, wool wax, hydrated jojoba wax, paraffin, polyethylene wax, polyethylene glycol wax, and ceresin;

(xxii) core shell copolymers;

and any mixture of the foregoing;

preferably a combination of at least two polymers selected from polymers (i) and (iv); (i) and (vi); (i) and (viii); (i) and

(x); (i) and (xii); (i) and (xiv); (i) and (xvi); (iv) and (vi); (iv) and (viii); (iv) and (x); (iv) and (xii); (iv) and (xiv); (iv) and (xvi); (vi) and (viii); (vi) and (x); (vi) and (xii); (vi) and (xiv); (vi) and (xvi); (viii) and (x); (viii) and (xii); (viii) and (xiv); (viii) and (xvi); (x) and (xii); (x) and (xiv); (x) and (xvi); (xii) and (xiv); (xii) and (xvi); or (xiv) and (xvi).

- 5 **[0236]** In preferred embodiments of the packaging material according to the invention, the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another have an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.
- 10 **[0237]** The optional sealing layer **[A]** and/or the optional sealing layer **[O]** can be obtained by applying a suitable composition onto a laminar substrate, by any generally known coating technique, such as rod coating, blade coating, spraying, curtain coating, roll coating, dip coating, gravure coating, reverse gravure coating, or brushing. The laminar substrate can be fiber-based substrate layer, optionally comprising or precoated with mineral layers and optionally further layers.
- 15 **[0238]** The optional sealing layer **[A]** and the optional sealing layer **[O]** independently of one another may be applied to the full surface area of the packaging material according to the invention, or only to a portion of the full surface area of the packaging material according to the invention. In the latter case, the optional sealing layer **[A]** and the optional sealing layer **[O]** independently of one another may be applied as a pattern.
- 20 **[0239]** In preferred embodiments, besides layers **[K]** and **[N]**, the packaging material according to the invention comprises printing layer **[C]**.
- [0240]** In preferred embodiments of the packaging material according to the invention, the optional printing layer **[C]** comprises a latex, optionally together with a pigment.
- 25 **[0241]** In preferred embodiments, the latex is selected from isoprene-latexes, styrene-isoprene-latexes, styrene-butadiene-latexes, styrene-ethylene-butadiene-latexes, styrene-ethylene-propylene-latexes, acrylate latexes, vinylacetate latexes, styrene-(meth)acrylate latexes, vinylacetate-(meth)acrylate latexes, styrene-butadiene-acrylonitrile latexes, styrene-(meth)acrylate-acrylonitrile latexes, styrene-butadiene-(meth)acrylate-acrylonitrile latexes, styrene-maleic anhydride latexes, styrene-(meth)acrylate-maleic anhydride latexes, styrene-butylacrylate latexes, styrene-2-ethylhexyl acrylate latexes, and styrene-methacrylate-2-ethylhexyl acrylate latexes.
- 30 **[0242]** In preferred embodiments, the pigment is selected from kaolin, feldspar, mica, calcined kaolin, clay, natural clay, delaminated clay, calcined clay, calcium carbonate, chalk, ground calcium carbonate, precipitated calcium carbonate, prespice calcium carbonate, talc, gypsum, aluminum trihydrates, titanium dioxide, zinc sulfide, zinc oxide, calcium sulfite, barium sulfate, magnesium hydroxide, amorphous silica, silicates, plastic pigments, and mixtures thereof.
- [0243]** In preferred embodiments, the content of the latex is within the range of from 30 to 50 wt.-%, and wherein the content of the pigment is within the range of from 50 to 70 wt.-%, in each case relative to the total weight of the printing layer.
- 35 **[0244]** In preferred embodiments, the printing layer comprises a cross-linker.
- [0245]** In preferred embodiments, the cross-linker is selected from the group consisting of ammonium zirconium carbonate (AZC), potassium zirconium carbonate, potassium zirconium acetate, (methylated) melamine formaldehyde resin, (methylated) urea formaldehyde resin, glyoxal, imidazoline, imidazoline derivatives, di-aldehyde polysaccharides, and combinations thereof.
- 40 **[0246]** In preferred embodiments, the optional printing layer **[C]** has an area weight, determined according to EN ISO 536, within the range of from 5.0 to $50 \text{ g} \cdot \text{m}^{-2}$; preferably 10 to $30 \text{ g} \cdot \text{m}^{-2}$.
- [0247]** In preferred embodiments, the printing layer comprises an upper sublayer and a lower sublayer.
- [0248]** In preferred embodiments, the upper sublayer and the lower sublayer independently of one another each have an area weight, determined according to EN ISO 536, within the range of from 2.5 to $25 \text{ g} \cdot \text{m}^{-2}$; preferably 5.0 to $15 \text{ g} \cdot \text{m}^{-2}$.
- 45 **[0249]** The optional printing layer **[C]** typically comprises a printed image and/or decoration.
- [0250]** In preferred embodiments, the printed image and/or decoration covers at least 40% of the area of the optional printing layer **[C]**; preferably at least 50%, more preferably at least 60%, still more preferably at least 70%, yet more preferably at least 80%, even more preferably at least 90%, most preferably at least 95%, and in particular about 100%.
- [0251]** Preferably, the printed image and/or decoration is made from at least two different colors.
- 50 **[0252]** The printed image and/or decoration can be applied by means of printing inks that are commercially available and known to the skilled person. Preferably, the printing inks comprise vehicle, coloring ingredients, and additives. The vehicle can be e.g. a vegetable base or a solvent base. The coloring ingredients can be pigments, agents made from chemicals but soluble both in water and in solvents; and lacquers. The additives stabilize the mixture and give the ink additional desirable characteristics.
- 55 **[0253]** Preferably, the printed image and/or decoration has been applied by flexography, rotogravure or offset printing.
- [0254]** In preferred embodiments of the packaging material according to the invention, the optional printing layer **[C]** has an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more

preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.

[0255] The optional printing layer **[C]** can be obtained by applying a suitable composition onto a laminar substrate, by any generally known coating technique, such as rod coating, blade coating, spraying, curtain coating, roll coating, dip coating, gravure coating, reverse gravure coating, or brushing. The laminar substrate can be fiber-based substrate layer, optionally comprising or precoated with mineral layers and optionally further layers.

[0256] Preferably, the packaging material according to the invention has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, relative to the total weight of the packaging material.

[0257] Preferably, relative to the total weight of the packaging material, the packaging material has a total content of polyolefins, preferably of synthetic organic polymers, of at most 4.0 wt.-%, preferably at most 3.0 wt.-%, more preferably at most 2.0 wt.-%, still more preferably at most 1.0 wt.-%, yet more preferably at most 0.5 wt.-%, even more preferably at most 0.3 wt.-%, most preferably at most 0.2 wt.-%, and in particular at most 0.1 wt.-%.

[0258] For the purpose of the specification, the total content of "*synthetic organic polymers*" includes all synthetic organic polymers that may be contained in any coating or layer of the packaging material but does not include the non-synthetic (i.e. natural) polymers that are contained in the fiber based substrate, e.g. the cellulosic materials of the packaging material such as cellulose, hemicellulose, lignin, and the like. For the purpose of the specification, crosslinked polysiloxanes are no "*synthetic organic polymers*" in the meaning of the invention, but are "*synthetic inorganic polymers*", even if they carry organic functional groups and/or side chains such as methoxy groups, ethoxy groups, and the like. In case that in the course of the manufacture of the packaging material the cellulosic material has been treated with chemicals thereby converting the non-synthetic (natural) polymer fibers into chemically modified polymer fibers, such chemically modified polymer fibers are nonetheless no "*synthetic organic polymers*" in the meaning of the invention.

[0259] For the purpose of the specification, the distinction of "*synthetic organic polymers*" on the one hand and the other constituents of the packaging material including e.g. the fiber-based substrate on the other hand shall serve the purpose of quantifying the recyclability of the overall material forming the packaging material according to the invention. The lower the total content of synthetic organic polymers, the better the recyclability and sustainability of the packaging material according to the invention. Minor chemical modifications of cellulosic fibers that are conventionally performed in the course of manufacture of packaging material are not considered to alter the recyclability and therefore do not render the non-synthetic (natural) polymers to become "*synthetic organic polymers*" according to the invention.

[0260] Preferably, all "*synthetic organic polymers*" according to the invention were synthesized from monomers or comonomers but were not obtained by polymer analogous reactions of natural polymers with other substances reacting with functional groups and/or side chains of the polymer backbone of the natural polymers.

[0261] Preferably, "*synthetic organic polymers*" according to the invention are those that are rejected according to the regulations related to circular economy and sustainability. In this regard, reference is made to the most current version of European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste; and the most current version Directive (EU) 2018/851 of the European Parliament and Council of 30 May 2018 amending Directive 2008/98/EC on waste.

[0262] In preferred embodiments, the packaging material according to the invention has a Cobb 600 value determined according to EN ISO 535 of at most $0.8 \text{ g} \cdot \text{m}^{-2}$, preferably at most $0.7 \text{ g} \cdot \text{m}^{-2}$, more preferably at most $0.5 \text{ g} \cdot \text{m}^{-2}$, still more preferably at most $0.5 \text{ g} \cdot \text{m}^{-2}$, yet more preferably at most $0.4 \text{ g} \cdot \text{m}^{-2}$, even more preferably at most $0.3 \text{ g} \cdot \text{m}^{-2}$, most preferably at most $0.2 \text{ g} \cdot \text{m}^{-2}$, and in particular at most $0.1 \text{ g} \cdot \text{m}^{-2}$. Preferably, the packaging material has a Cobb 600 value determined according to EN ISO 535 of below $0.2 \text{ g} \cdot \text{m}^{-2}$, preferably at most $0.1 \text{ g} \cdot \text{m}^{-2}$.

[0263] In preferred embodiments, after exposing the container for 120 seconds to water containing ice cubes, the container provides a Cobb value, determined according to EN ISO 535, of at most $20 \text{ g} \cdot \text{m}^{-2}$, preferably at most $17.5 \text{ g} \cdot \text{m}^{-2}$, more preferably at most $15 \text{ g} \cdot \text{m}^{-2}$, still more preferably at most $12.5 \text{ g} \cdot \text{m}^{-2}$, yet more preferably at most $10 \text{ g} \cdot \text{m}^{-2}$, even more preferably at most $7.5 \text{ g} \cdot \text{m}^{-2}$, most preferably at most $5.0 \text{ g} \cdot \text{m}^{-2}$, and in particular at most $2.5 \text{ g} \cdot \text{m}^{-2}$.

[0264] In preferred embodiments, the packaging material according to the invention has a water vapor transmission rate, determined according to ASTM F-1249, in either direction of at most $8.0 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, preferably at most $7.5 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, more preferably at most $7.0 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, still more preferably at most $6.5 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, yet more preferably at most $6.0 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, even more preferably at most $5.5 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, most preferably at most $5.0 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$, and in particular at most $4.5 \text{ g} \cdot \text{h}^{-1} \cdot \text{m}^{-2}$.

[0265] The process according to the invention is drawn to the manufacture of a container, preferably for packaging food or beverages, preferably dairy, plant-based food and/or frozen food, comprising the packaging material according to the invention as described above.

[0266] The container according to the invention is preferably for packaging of food or beverages, preferably dairy, plant-based food and/or frozen food.

[0267] Preferably, the packaging material according to the invention forms the at least one wall of the container, preferably all walls of the container. When the container additionally comprises a lid, the lid may also be formed from the packaging material according to the invention or by a different material.

[0268] Preferably, the container has an interior and an exterior, wherein the layers of the packaging material are arranged in alphabetical order from the exterior of the container towards the interior of the container. Thus, fiber based

substrate layer **[K]** and e.g. optional sealing layer **[A]** preferably face (are relatively oriented towards) the exterior of the container, whereas the one or more cross-linked polysiloxane layers **[N]** and e.g. optional sealing layer **[O]** preferably face (are relatively oriented towards) the interior of the container. Optional printing layer **[C]** is preferably visible from the exterior through the optional sealing layer **[A]** and the optional one or more cross-linked polysiloxane layers **[B]**.

[0269] Figure 18 schematically illustrates a perspective view of a preferred container (1) according to the invention for packaging dairy, plant-based food and/or frozen food made from the packaging material according to the invention. The container (1) comprises an interior (2) for receiving the dairy, plant-based food and/or frozen food, which is formed by a sidewall (3) having rim (4) and bottom (5). The sidewall (3) has a first edge (6) and a second edge (7) which are arranged in an overlapping manner at side seam area (8). The sidewall is formed from the packaging material according to the invention. The bottom (5) may also be formed from the packaging material according to the invention or from a different material.

[0270] Figure 19 schematically illustrates a cross-sectional view of a preferred container (1) according to the invention for packaging dairy, plant-based food and/or frozen food made from the packaging material according to the invention. The container (1) comprises an interior (2) for receiving the dairy, plant-based food and/or frozen food, which is formed by a sidewall (3) having rim (4) and bottom (5). The rim is joined with sidewall (3) by means of seal (9). The bottom (5) comprises annular section (10) about which sidewall (3) is folded thereby forming annular collar (11).

[0271] Figure 20 schematically illustrates a top view of a preferred embodiment of the side seam area (8) where the first edge (6) of the sidewall (3) is joined to the second edge (7) of the sidewall (3) which are arranged in an overlapping manner. The sidewall (3) is formed from the packaging material according to the invention comprising at least layers **[A]**, **[K]** and **[N]** as shown, and optionally additional layers (not shown). Along the side seam area (8), the sealing layer **[A]** at first edge (6) is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at second edge (7).

[0272] Figure 21 schematically illustrates a top view of another preferred embodiment of the side seam area (8) where the first edge (6) of the sidewall (3) is joined to the second edge (7) of the sidewall (3) which are arranged in an overlapping manner. The sidewall (3) is formed from the packaging material according to the invention comprising at least layers **[K]**, **[N]** and **[O]** as shown, and optionally additional layers (not shown). Along the side seam area (8), the fiber based substrate layer **[K]** at first edge (6) is joined, preferably sealed to the sealing layer **[O]** at second edge (7).

[0273] Figure 22 schematically illustrates a top view of a further preferred embodiment of the side seam area (8) where the first edge (6) of the sidewall (3) is joined to the second edge (7) of the sidewall (3) which are arranged in an overlapping manner. The sidewall (3) is formed from the packaging material according to the invention comprising at least layers **[A]**, **[K]**, **[N]** and **[O]** as shown, and optionally additional layers (not shown). Along the side seam area (8), the sealing layer **[A]** at first edge (6) is joined, preferably sealed to the sealing layer **[O]** at second edge (7).

[0274] Figure 23 schematically illustrates a top view of still another preferred embodiment of the side seam area (8) where the first edge (6) of the sidewall (3) is joined to the second edge (7) of the sidewall (3) which are arranged in an overlapping manner. The sidewall (3) is formed from the packaging material according to the invention comprising at least layers **[A]**, **[K]** and **[N]** as shown, and optionally additional layers (not shown). Along the side seam area (8), the one or more cross-linked polysiloxane layers **[N]** is missing at first edge (6) so that it only covers the fiber based substrate layer **[K]** apart from side seam area (8). In consequence, the sealing layer **[A]** at first edge (6) is joined, preferably sealed to the fiber based substrate layer **[K]** at second edge (7).

[0275] Dairy according to the invention includes but is not limited to milk, fermented milk, yoghurt, cheese, cream, quark, fromage frais, cream cheese, kefir, butter, and the like but also margarine.

[0276] Plant-based food according to the invention means any food but animal products. Plant-based food according to the invention includes but is not limited to vegetables, fruits, grains, legumes, nuts, seeds, herbs, and spices.

[0277] Frozen food according to the invention includes but is not limited to ice cream and convenience food.

[0278] The container typically defines a holding space, preferably configured for receiving the food or beverages, preferably dairy, plant-based food and/or frozen food, wherein the holding space is at least partially surrounded by the packaging material.

[0279] In preferred embodiments, the container according to the invention is a cup or a tube.

[0280] In preferred embodiments, the container contains dairy, plant-based food and/or frozen food.

[0281] The container may be closed with a lid. Materials for producing a lid are not particularly limited and include metal foil, polymer film, packaging material, other laminates, and the like. Preferably, the lid is sealed to a rim of the container.

[0282] The process according to the invention is for the preparation of a container which comprises a sidewall with an opening and optionally a bottom. The process according to the invention comprises the steps of

- (a) providing a first element which has a first edge as well as a second edge and which is made of a multilayer material comprising a fiber-based substrate layer and a cross-linked polysiloxane layer, wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**;

(b) joining at least the first edge and the second edge of the first element with one another thereby forming at least the sidewall of the container.

[0283] Preferably, the first element is prepared by cutting a roll or a board made of the packaging material, preferably of the packaging material according to the invention as described above.

[0284] Preferably, the container has an interior and an exterior, wherein upon forming at least the sidewall of the container in step (b), the cross-linked polysiloxane layer faces the interior of the container, whereas the fiber-based substrate layer faces the exterior of the container.

[0285] Preferably, the first element is made of the packaging material according to the invention as described above, i.e. comprises at least the fiber based substrate layer **[K]** and the one or more crosslinked polysiloxane layers **[N]**. In preferred embodiments, the first element is made of the packaging material that additionally comprises one or more of the optional sealing layer **[A]**, the optional one or more cross-linked polysiloxane layers **[B]**, the optional printing layer **[C]**, the optional mineral layer **[D]**, the optional mineral layer **[L]**, the optional barrier layer **[M]**, and/or the optional sealing layer **[O]**. In preferred embodiments, the first element is made of the packaging material that additionally comprises one or more of the optional fiber based substrate layer **[E]**, the optional mineral layer **[F]**, the optional barrier layer **[G]**, the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]** and/or the optional mineral layer **[J]**.

[0286] Preferably, the container has an interior and an exterior, wherein upon forming at least the sidewall of the container in step (b), the layers of the packaging material are arranged in alphabetical order from the exterior of the container towards the interior of the container.

[0287] Preferably, joining at least the two edges of the first element with one another in step (b) is performed by sealing, preferably under the application of heat.

[0288] In preferred embodiments,

- the fiber based substrate layer **[K]** at a first edge is joined, preferably sealed to the sealing layer **[O]** at a second edge (see e.g. Figure 21);
- the mineral layer **[D]** at a first edge is joined, preferably sealed to the sealing layer **[O]** at a second edge;
- the printing layer **[C]** at a first edge is joined, preferably sealed to the sealing layer **[O]** at a second edge;
- the one or more cross-linked polysiloxane layers **[B]** at a first edge are joined, preferably sealed to the sealing layer **[O]** at a second edge;
- the sealing layer **[A]** at a first edge is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge (see e.g. Figure 20); or
- the sealing layer **[A]** at a first edge is joined, preferably sealed to the sealing layer **[O]** at a second edge (see e.g. Figure 22).

[0289] In other preferred embodiments,

- the one or more cross-linked polysiloxane layers **[B]** at a first edge are joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge;
- the printing layer **[C]** at a first edge is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge; or
- the mineral layer **[D]** at a first edge is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge.

[0290] Preferably, the process according to the invention comprises the additional steps of

(c) providing a second element having a circumferential edge which is preferably also made of a multilayer material comprising a fiber-based substrate layer and a cross-linked polysiloxane layer, wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**; and

(d) joining the circumferential edge of the second element with another edge of the first element thereby forming the bottom of the container.

[0291] Preferably, the second element is also prepared by cutting a roll or a board made of the packaging material, preferably of the packaging material according to the invention as described above.

[0292] Preferably, the container has an interior and an exterior, wherein upon forming the bottom of the container in step (d), the cross-linked polysiloxane layer faces the interior of the container, whereas the fiber-based substrate layer faces the exterior of the container.

[0293] Preferably, the second element is made of the packaging material according to the invention as described above, i.e. comprises at least the fiber based substrate layer **[K]** and the one or more crosslinked polysiloxane layers **[N]**. In preferred embodiments, the second element is made of the packaging material that additionally comprises one or more of the optional sealing layer **[A]**, the optional one or more cross-linked polysiloxane layers **[B]**, the optional printing layer **[C]**, the optional mineral layer **[D]**, the optional mineral layer **[L]**, the optional barrier layer **[M]**, and/or the optional sealing layer **[O]**. In preferred embodiments, the second element is made of the packaging material that additionally comprises one or more of the optional fiber based substrate layer **[E]**, the optional mineral layer **[F]**, the optional barrier layer **[G]**, the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]** and/or the optional mineral layer **[J]**.

[0294] Preferably, the container has an interior and an exterior, wherein upon forming the bottom of the container in step (d), the layers of the packaging material are arranged in alphabetical order from the exterior of the container towards the interior of the container.

[0295] Preferably, joining in step (d) is performed by sealing, preferably under the application of heat.

[0296] Particularly preferred embodiments of the invention are summarized as clauses 1 to 131 hereinafter:

Clause 1: A process for the preparation of a container (1) comprising a sidewall (3) with an opening and optionally a bottom (5), the process comprising the steps of (a) providing a first element which has a first edge (6) as well as a second edge (7) and which is made of a packaging material comprising - optionally, a sealing layer **[A]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; - optionally, one or more cross-linked polysiloxane layers **[B]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; - optionally, a printing layer **[C]**; - optionally, a mineral layer **[D]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; - a fiber based substrate layer **[K]** having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; - optionally, a mineral layer **[L]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; - optionally, a barrier layer **[M]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; - one or more cross-linked polysiloxane layers **[N]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and - optionally, a sealing layer **[O]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**; and (b) joining at least the first edge (6) and the second edge (7) of the first element with one another thereby forming at least the sidewall (3) of the container (1).

Clause 2: The process according to clause 1, wherein the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, preferably at most 4.0 wt.-%, preferably at most 3.0 wt.-%, more preferably at most 2.0 wt.-%, still more preferably at most 1.0 wt.-%, yet more preferably at most 0.5 wt.-%, even more preferably at most 0.3 wt.-%, most preferably at most 0.2 wt.-%, and in particular at most 0.1 wt.-%; relative to the total weight of the packaging material.

Clause 3: The process according to clause 1 or 2, wherein the layers are arranged in alphabetical order.

Clause 4: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises at least one additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 5: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises at least two additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 6: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises at least three additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 7: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises at least four additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 8: The process according to any of the preceding clauses, wherein the packaging material besides layers

[K] and **[N]** comprises at least five additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 9: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises at least six additional layer selected from layers **[A]**, **[B]**, **[C]**, **[D]**, **[L]**, **[M]**, and **[O]**.

Clause 10: The process according to any of the preceding clauses, wherein the packaging material comprises at least four layers; preferably selected from **[A]**, **[B]**, **[K]** and **[N]**; **[A]**, **[C]**, **[K]** and **[N]**; **[A]**, **[D]**, **[K]** and **[N]**; **[A]**, **[K]**, **[L]** and **[N]**; **[A]**, **[K]**, **[M]**, and **[N]**; **[A]**, **[K]**, **[N]**, and **[O]**; **[B]**, **[C]**, **[K]** and **[N]**; **[B]**, **[D]**, **[K]** and **[N]**; **[B]**, **[K]**, **[L]** and **[N]**; **[B]**, **[K]**, **[M]** and **[N]**; **[B]**, **[K]**, **[N]** and **[O]**; **[C]**, **[D]**, **[K]** and **[N]**; **[C]**, **[K]**, **[L]**, and **[N]**; **[C]**, **[K]**, **[M]**, and **[N]**; **[C]**, **[K]**, **[N]**, and **[O]**; **[D]**, **[K]**, **[L]**, and **[N]**; **[D]**, **[K]**, **[M]**, and **[N]**; **[D]**, **[K]**, **[N]**, and **[O]**; **[K]**, **[L]**, **[M]**, and **[N]**; **[K]**, **[L]**, **[N]**, and **[O]**; or **[K]**, **[M]**, **[N]**, and **[O]**.

Clause 11: The process according to any of the preceding clauses, wherein the packaging material comprises at least layers - **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or - **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or - **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, and **[N]**; or **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[M]**, **[N]**, and **[O]**; or **[A]**, **[B]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**; or - **[A]**, **[B]**, **[C]**, **[D]**, **[K]**, **[L]**, **[M]**, **[N]**, and **[O]**.

Clause 12: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the sealing layer **[A]**.

Clause 13: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the one or more cross-linked polysiloxane layers **[B]**.

Clause 14: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the printing layer **[C]**.

Clause 15: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the mineral layer **[D]**.

Clause 16: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the mineral layer **[L]**.

Clause 17: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the barrier layer **[M]**.

Clause 18: The process according to any of the preceding clauses, wherein the packaging material besides layers **[K]** and **[N]** comprises the sealing layer **[O]**.

Clause 19: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** forms an outer surface of the packaging material.

Clause 20: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** is in direct contact with the optional one or more cross-linked polysiloxane layers **[B]**.

Clause 21: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** form an outer surface of the packaging material.

Clause 22: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** are located between - the optional sealing layer **[A]** and - the optional printing layer **[C]**, or the optional mineral layer **[D]**.

Clause 23: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** are in direct contact with the optional sealing layer **[A]**.

Clause 24: The process according to any of the preceding clauses, wherein the optional one or more cross-linked

polysiloxane layers **[B]** are in direct contact with the optional printing layer **[C]**, or the optional mineral layer **[D]**.

Clause 25: The process according to any of the preceding clauses, wherein the optional printing layer **[C]** is located between - the optional one or more cross-linked polysiloxane layers **[B]** and - the optional mineral layer **[D]**.

Clause 26: The process according to any of the preceding clauses, wherein the optional printing layer **[C]** is in direct contact with the optional one or more cross-linked polysiloxane layers **[B]**.

Clause 27: The process according to any of the preceding clauses, wherein the optional printing layer **[C]** is in direct contact with the optional mineral layer **[D]**.

Clause 28: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** is located between - the optional printing layer **[C]**, or the optional one or more cross-linked polysiloxane layers **[B]** and - the fiber based substrate layer **[K]**.

Clause 29: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** is in direct contact with the optional printing layer **[C]**, or the optional one or more cross-linked polysiloxane layers **[B]**.

Clause 30: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** is in direct contact with the fiber based substrate layer **[K]**.

Clause 31: The process according to any of the preceding clauses, wherein the fiber based substrate layer **[K]** is located between - the optional mineral layer **[D]** and - the optional mineral layer **[L]**, or the optional barrier layer **[M]**.

Clause 32: The process according to any of the preceding clauses, wherein the fiber based substrate layer **[K]** is in direct contact with the optional mineral layer **[L]**, or the optional barrier layer **[M]**.

Clause 33: The process according to any of the preceding clauses, wherein the optional mineral layer **[L]** is located between - the fiber based substrate layer **[K]** and - the optional barrier layer **[M]**.

Clause 34: The process according to any of the preceding clauses, wherein the optional mineral layer **[L]** is in direct contact with the fiber based substrate layer **[K]**.

Clause 35: The process according to any of the preceding clauses, wherein the optional mineral layer **[L]** is in direct contact with the optional barrier layer **[M]**.

Clause 36: The process according to any of the preceding clauses, wherein the optional barrier layer **[M]** is located between - the optional mineral layer **[L]** or the fiber based substrate layer **[K]** and - the one or more cross-linked polysiloxane layers **[N]**.

Clause 37: The process according to any of the preceding clauses, wherein the optional barrier layer **[M]** is in direct contact with the optional mineral layer **[L]** or the fiber based substrate layer **[K]**.

Clause 38: The process according to any of the preceding clauses, wherein the optional barrier layer **[M]** is in direct contact with the one or more cross-linked polysiloxane layers **[N]**.

Clause 39: The process according to any of the preceding clauses, wherein the one or more cross-linked polysiloxane layers **[N]** form an outer surface of the packaging material.

Clause 40: The process according to any of the preceding clauses, wherein the one or more cross-linked polysiloxane layers **[N]** are located between - the optional barrier layer **[M]** and - the optional sealing layer **[O]**.

Clause 41: The process according to any of the preceding clauses, wherein the one or more cross-linked polysiloxane layers **[N]** are in direct contact with the optional sealing layer **[O]**.

Clause 42: The process according to any of the preceding clauses, wherein the optional sealing layer **[O]** forms an outer surface of the packaging material.

Clause 43: The process according to any of the preceding clauses, wherein the packaging material additionally comprises - a fiber based substrate layer **[E]** having an area weight, determined according to EN ISO 536, within the range of from 10 to 475 g·m⁻²; preferably 10 to 150 g·m⁻² or 25 to 475 g·m⁻²; - optionally, a mineral layer **[F]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; - optionally, a barrier layer **[G]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; - optionally, one or more cross-linked polysiloxane layers **[H]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; - optionally, a barrier layer **[I]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and - optionally, a mineral layer **[J]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻².

Clause 44: The process according to clause 43, wherein the fiber based substrate **[E]** is located between - the optional mineral layer **[D]** and - the optional miner layer **[F]**, the optional barrier layer **[G]**, the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 45: The process according to clause 43 or 44, wherein the fiber based substrate layer **[E]** is in direct contact with the optional mineral layer **[D]**.

Clause 46: The process according to any of clauses 43 to 45, wherein the fiber based substrate layer **[E]** is in direct contact with the optional miner layer **[F]**, the optional barrier layer **[G]**, the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 47: The process according to any of clauses 43 to 46, wherein the optional mineral layer **[F]** is located between - the optional mineral layer **[D]** or the fiber based substrate layer **[E]** and - the optional barrier layer **[G]**, the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 48: The process according to any of clauses 43 to 47, wherein the optional mineral layer **[F]** is in direct contact with the optional mineral layer **[D]** or the fiber based substrate layer **[E]**.

Clause 49: The process according to any of clauses 43 to 48, wherein the optional mineral layer **[F]** is in direct contact with the optional one or more cross-linked polysiloxane layers **[H]**, the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 50: The process according to any of clauses 43 to 49, wherein the optional one or more crosslinked polysiloxane layers **[H]** is located between - the optional mineral layer **[D]**, the fiber based substrate layer **[E]**, or the optional mineral layer **[F]** and - the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 51: The process according to any of clauses 43 to 50, wherein the optional one or more crosslinked polysiloxane layers **[H]** is in direct contact with the fiber based substrate layer **[E]**, or the optional mineral layer **[F]**.

Clause 52: The process according to any of clauses 43 to 51, wherein the optional one or more crosslinked polysiloxane layers **[H]** is in direct contact with the optional barrier layer **[I]**, the optional mineral layer **[J]**, or the fiber based substrate layer **[K]**.

Clause 53: The process according to any of clauses 43 to 52, wherein the optional barrier layer **[I]** is located between - the optional mineral layer **[D]**, the fiber based substrate layer **[E]**, the optional mineral layer **[F]**, or the optional one or more cross-linked polysiloxane layers **[H]** and - the optional barrier layer **[G]**, or the fiber based substrate layer **[K]**.

Clause 54: The process according to any of clauses 43 to 53, wherein the optional barrier layer **[I]** is in direct contact with the optional mineral layer **[D]**, the fiber based substrate layer **[E]**, the optional mineral layer **[F]**, or the optional one or more cross-linked polysiloxane layers **[H]**.

Clause 55: The process according to any of clauses 43 to 54, wherein the optional barrier layer **[I]** is in direct contact with the fiber based substrate layer **[K]**.

Clause 56: The process according to any of clauses 43 to 55, wherein the packaging material comprises at least layers - [A], [B], [D], [E], [K], [M], and [N]; or [A], [B], [D], [E], [K], [M], and [N]; or [B], [C], [D], [E], [K], [M], and [N]; or [B], [D], [E], [K], [L], [M], and [N]; or [B], [D], [E], [K], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [K], [M], and [N]; or [A], [B], [D], [E], [K], [L], [M], and [N]; or [A], [B], [D], [E], [K], [M], [N], and [O]; or [B], [C], [D], [E], [K], [M], [N], and [O]; or [B], [C], [D], [E], [K], [L], [M], and [N]; or [B], [C], [D], [E], [K], [M], [N], and [O]; or [B], [D], [E], [K], [L], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [K], [L], [M], and [N]; or [A], [B], [C], [D], [E], [K], [M], [N], and [O]; or [A], [B], [D], [E], [K], [L], [M], [N], and [O]; or [B], [C], [D], [E], [K], [L], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [K], [L], [M], [N], and [O].

Clause 57: The process according to any of clauses 43 to 56, wherein the packaging material comprises at least layers - [A], [B], [D], [E], [F], [H], [I], [K], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [K], [M], and [N]; or [B], [C], [D], [E], [F], [H], [I], [K], [M], and [N]; or [B], [D], [E], [F], [H], [I], [K], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [F], [H], [I], [K], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [K], [L], [M], and [N]; or [A], [B], [D], [E], [F], [H], [I], [K], [M], [N], and [O]; or [B], [C], [D], [E], [F], [H], [I], [K], [L], [M], and [N]; or [B], [C], [D], [E], [F], [H], [I], [K], [M], [N], and [O]; or [B], [D], [E], [F], [H], [I], [K], [L], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [F], [H], [I], [K], [L], [M], and [N]; or [A], [B], [C], [D], [E], [F], [H], [I], [K], [M], [N], and [O]; or [A], [B], [D], [E], [F], [H], [I], [K], [L], [M], [N], and [O]; or [B], [C], [D], [E], [F], [H], [I], [K], [L], [M], [N], and [O]; or - [A], [B], [C], [D], [E], [F], [H], [I], [K], [L], [M], [N], and [O].

Clause 58: The process according to any of the preceding clauses, wherein the packaging material comprises a sealing layer [A] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 0.1 to 3.0 g·m⁻²; preferably wherein the sealing layer [A] is based upon an anti moisture varnish; optionally, one or more cross-linked polysiloxane layers [B] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; a printing layer [C]; preferably having an area weight, determined according to EN ISO 536, within the range of from 1.0 to 5.0 g·m⁻²; a mineral layer [D] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 3.0 to 15 g·m⁻²; preferably wherein mineral layer [D] is based upon clay; - a fiber based substrate layer [E] having an area weight, determined according to EN ISO 536, within the range of from 10 to 475 g·m⁻²; preferably 10 to 150 g·m⁻² or 25 to 475 g·m⁻²; more preferably 50 to 80 g·m⁻² or 150 to 300 g·m⁻²; - optionally, a mineral layer [F] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 3.0 to 10 g·m⁻²; preferably wherein mineral layer [F] is based upon clay; - a barrier layer [G] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 3.0 g·m⁻²; preferably wherein barrier layer [G] is based upon PVOH; - one or more cross-linked polysiloxane layers [H] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²; - a barrier layer [I] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 0.5 to 3.0 g·m⁻²; preferably wherein barrier layer [I] is based upon PVOH; - optionally, a mineral layer [J] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²; preferably wherein mineral layer [J] is based upon clay; a fiber based substrate layer [K] having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²; preferably 100 to 300 g·m⁻² or 30 to 80 g·m⁻²; a mineral layer [L] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²; preferably 5.0 to 15 g·m⁻²; preferably wherein mineral layer [L] is based upon clay; optionally, a barrier layer [M] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; one or more cross-linked polysiloxane layers [N] which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻²; and a sealing layer [O] having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; preferably 1.0 to 5.0 g·m⁻².

Clause 59: The process according to any of the preceding clauses, wherein the packaging material comprises at least layers [A], [C], [D], [E], [F], [H], [I], [J], [K], [L], [N], and [O].

Clause 60: The process according to any of the preceding clauses, wherein the packaging material comprises at least layers [A], [C], [D], [E], [F], [G], [H], [I], [K], [L], [N], and [O].

Clause 61: The process according to any of the preceding clauses, wherein the packaging material comprises at least layers [A], [C], [D], [E], [F], [G], [H], [I], [J], [K], [L], [N], and [O].

Clause 62: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers [B] and/or the optional one or more cross-linked polysiloxane layers [H] and/or the one or more

cross-linked polysiloxane layers **[N]** independently of one another are based on a hybrid material comprising an inorganic polysiloxane backbone and pendant organic substituents.

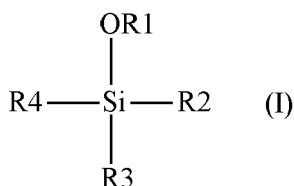
Clause 63: The process according to clause 62, wherein (i) the inorganic polysiloxane backbone is a polymer chain or a polymer network; and/or (ii) the pendant organic substituents are linked to silicon atoms of the inorganic polysiloxane backbone through oxygen atoms; preferably wherein the pendant organic substituents are organic radicals, macromolecular chains or networks thereof.

Clause 64: The process according to clause 62 or 63, wherein the pendant organic substituents comprise synthetic organic moieties and/or optionally modified natural moieties, preferably optionally modified biomaterials; preferably biopolymers; more preferably biopolymers selected from starch-based polymers, hemi-cellulose-based polymers, cellulose-based polymers, lignin-based polymers, chitosan-based polymers, or mixtures or combinations thereof.

Clause 65: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another do not contain a pigment selected from kaolin, feldspar, mica, calcined kaolin, clay, natural clay, delaminated clay, calcined clay, calcium carbonate, chalk, ground calcium carbonate, precipitated calcium carbonate, prespate calcium carbonate, talc, gypsum, aluminum trihydrates, titanium dioxide, zinc sulfide, zinc oxide, calcium sulfite, barium sulfate, magnesium hydroxide, amorphous silica, silicates, plastic pigments, and mixtures thereof; preferably do not contain any pigment or mineral filler.

Clause 66: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are derived from a sol-gel composition.

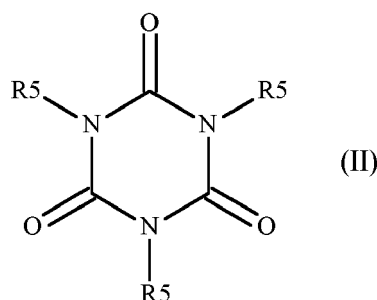
Clause 67: The process according to clause 66, wherein the sol-gel composition comprises a non-functionalized silane of general formula (I)



wherein R1 means -C₁₋₁₈-alkyl, -C(=O)-C₁₋₁₈-alkyl, or -C₆₋₁₂-aryl; preferably -CH₃, -CH₂CH₃, -CH₂CH₂CH₃, -CH(CH₃)₂, or -C₆H₅; and R2, R3 and R4 independently of one another mean -C₁₋₁₈-alkyl, -C₃₋₈-cycloalkyl, -O-C₁₋₁₈-alkyl, -O-C₃₋₈-cycloalkyl, -O-C(=O)-C₁₋₁₈-alkyl, -C₆₋₁₂-aryl, or -O-C₆₋₁₂-aryl; preferably -CH₃, -CH₂CH₃, -CH₂CH₂CH₃, -CH(CH₃)₂, -C₆H₅, -O-CH₃, or -O-CH₂CH₃.

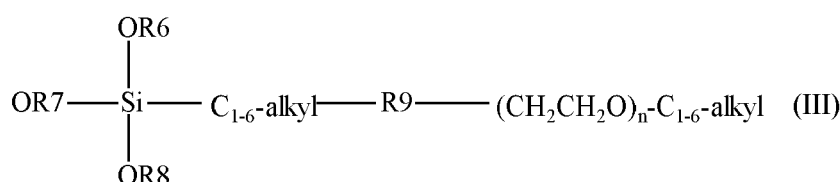
Clause 68: The process according to clause 67, wherein the non-functionalized silane of general formula (I) is selected from the group consisting of - tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; - alkyl trialkoxy silanes; preferably methyl trimethoxy silane, methyl triethoxy silane, ethyl trimethoxy silane, ethyl triethoxy silane, octyl trimethoxy silane, octyl triethoxy silane (OTES), hexadecyl trimethoxy silane, or mixtures thereof; - aryl trialkoxy silanes; preferably phenyl trimethoxy silane, phenyl triethoxy silane, or mixtures thereof; - dialkyl dialkoxo silanes; preferably dimethyl dimethoxy silane, dimethyl diethoxy silane (DEDMS), cyclohexyl methyl dimethoxy silane, dicyclopentyl dimethoxy silane, or mixtures thereof; - trialkyl alkoxy silanes; preferably trimethyl methoxy silane, trimethyl ethoxy silane, triethyl methoxy silane, and mixtures thereof; and - mixtures of any of the foregoing.

Clause 69: The process according to any of clauses 66 to 68, wherein the sol-gel composition comprises a non-functionalized silane of general formula (II)



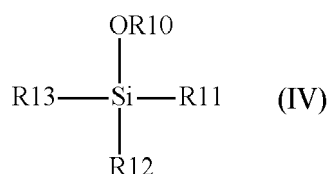
wherein R5 means $\text{-C}_{1-18}\text{-alkyl-Si(O-C}_{1-6}\text{-alkyl)}_3$; preferably wherein the non-functionalized silane of general formula (II) is tris-[3-(trimethoxysilyl) propyl]-isocyanurate.

Clause 70: The process according to any of clauses 66 to 69, wherein the sol-gel composition comprises a non-functionalized alkyl trialkoxy silane oligomer of general formula (III)



wherein R6, R7 and R8 independently of one another mean $\text{-C}_{1-6}\text{-alkyl}$; preferably -CH_3 or $\text{-CH}_2\text{CH}_3$; and R9 means -C(=O)-O- or -NH-C(=O)-O- ; preferably wherein the non-functionalized alkyl trialkoxy silane oligomer of general formula (III) is the reaction product of polyethylene glycol monomethyl ether (preferably Mw 350-750 g/mol) with isocyanate-functionalized alkyl trialkoxy silane (preferably 3-isocyanatopropyl-triethoxy silane).

Clause 71: The process according to any of clauses 66 to 70, wherein the sol-gel composition comprises a functionalized silane of general formula (IV)



wherein R10 means $\text{-C}_{1-18}\text{-alkyl}$, $\text{-C(=O)-C}_{1-18}\text{-alkyl}$, or $\text{-C}_{6-12}\text{-aryl}$; preferably -CH_3 , $\text{-CH}_2\text{CH}_3$, $\text{-CH}_2\text{CH}_2\text{CH}_3$, $\text{-CH(CH}_3)_2$, or $\text{-C}_6\text{H}_5$; R11 means -CH=CH_2 , $\text{-C}_{1-18}\text{-alkyl-NH}_2$, $\text{-C}_{1-18}\text{-alkyl-NH-C}_{1-6}\text{-alkyl}$, $\text{-C}_{1-18}\text{-alkyl-NH-C}_{1-6}\text{-alkyl-NH}_2$, $\text{-C}_{1-18}\text{-alkyl-NH-C}_{1-6}\text{-alkyl-NH-C}_{1-6}\text{-alkyl-NH}_2$, $\text{-C}_{1-18}\text{-alkyl-NH-C}_{3-8}\text{-cycloalkyl}$, $\text{-C}_{1-18}\text{-alkyl-C}_{6-10}\text{-aryl-NH}_2$, $\text{-C}_{1-18}\text{-alkyl-imidazolyl}$, $\text{-C}_{1-18}\text{-alkyl-NH-C(=O)-NH}_2$, $\text{-C}_{1-18}\text{-alkyl-glycidoxy}$, $\text{-C}_{1-18}\text{-alkyl-acryloxy}$, $\text{-C}_{1-18}\text{-alkyl-methacryloxy}$, $\text{-C}_{1-18}\text{-alkyl-NCO}$, $\text{-C}_{1-18}\text{-alkyl-NH-C(=O)-O-C}_{1-6}\text{-alkyl}$, $\text{-C}_{1-18}\text{-alkyl-O-C(=O)-NH-C}_{1-6}\text{-alkyl}$; R12 and R13 independently of one another mean $\text{-C}_{1-18}\text{-alkyl}$, $\text{-C}_{3-8}\text{-cycloalkyl}$, $\text{-O-C}_{1-18}\text{-alkyl}$, $\text{-O-C}_{3-8}\text{-cycloalkyl}$, $\text{-O-C(=O)-C}_{1-18}\text{-alkyl}$, $\text{-C}_{6-12}\text{-aryl}$, or $\text{-O-C}_{6-12}\text{-aryl}$; preferably -CH_3 , $\text{-CH}_2\text{CH}_3$, $\text{-CH}_2\text{CH}_2\text{CH}_3$, $\text{-CH(CH}_3)_2$, $\text{-C}_6\text{H}_5$, -O-CH_3 , or $\text{-O-CH}_2\text{CH}_3$.

Clause 72: The process according to clause 71, wherein the functionalized silane of general formula (IV) is selected from the group consisting of - vinyl trialkoxy silanes; preferably trimethoxy vinyl silane, triethoxy vinyl silane (VES), N-2-(vinylbenzylamino)-ethyl-3-amino-propyl trimethoxy silane; or mixtures thereof; - vinyl alkyl dialkoxy silanes; preferably vinyl methyl dimethoxy silane; - vinyl triacetoxysilanes; - aminoalkyl trialkoxy silanes; preferably 3-aminopropyl trimethoxy silane (APMS), 3-aminopropyl triethoxy silane (APTES, APES), 3-(2-aminoethylamino)propyl trimethoxy silane (DAMS), 3-(2-aminomethylamino) propyl triethoxy silane, 3-[2-(2-aminoethylamino)ethylamino]propyl trimethoxy silane (TAMS), trimethoxy [3-(phenylamino)propyl] silane (PAPMS), triethoxy-3-(2-imidazolyl) propyl silane (IZPES), N-cyclohexyl-3-aminopropyl trimethoxy silane, N-cyclohexyl aminomethyl triethoxy silane, 3-ureidopropyl trimethoxy silane, or mixtures thereof; - aminoalkyl alkyl dialkoxy silanes; preferably N-(2-aminoethyl)-3-aminopropylmethyl dimethoxy silane; - glycidoxyalkyl trialkoxy silanes; preferably 3-glycidoxypropyl

trimethoxy silane (GLYMO), 3-glycidoxypentyl triethoxy silane, or mixtures thereof; - acryloxyalkyl trialkoxy silanes; preferably methacryloxymethyl trimethoxy silane, 3-methacryloxypropyl trimethoxy silane (MPMS), 3-methacryloxypropyl triethoxy silane (MEMO), or mixtures thereof; - acryloxyalkyl alkyl dialkoxysilanes; preferably methacryloxymethyl methyl dimethoxy silane; - isocyanatoalkyl trialkoxy silanes; preferably 3-isocyanatopropyl triethoxy silane; - carbamatoalkyl trialkoxy silanes; preferably N-methyl[3-(trimethoxysilyl)propyl] carbamate, N-trimethoxysilylmethyl-O-methyl carbamate, or mixtures thereof; - carbamatoalkyl alkyl dialkoxysilanes; preferably N-dimethoxy(methyl) silyl-methyl-O-methyl carbamate; - fluoroalkyl trialkoxy silanes; - phenyl trialkoxy silanes; preferably phenyl trimethoxy silane; and - mixtures of any of the foregoing.

Clause 73: The process according to any of clauses 66 to 72, wherein the sol-gel composition comprises a metal alcoholate; preferably selected from the group consisting of $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

Clause 74: The process according to any of clauses 66 to 73, wherein the sol-gel composition comprises a combination of - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; - one or more glycidoxylalkyl trialkoxy silanes; preferably 3-glycidoxypentyl trimethoxy silane (GLYMO), 3-glycidoxypentyl triethoxy silane, or mixtures thereof; - optionally, one or more polyols; preferably triethanol amine; and - optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

Clause 75: The process according to any of clauses 66 to 74, wherein the sol-gel composition comprises a combination of - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; - one or more glycidoxylalkyl trialkoxy silanes; preferably 3-glycidoxypentyl trimethoxy silane (GLYMO), 3-glycidoxypentyl triethoxy silane, or mixtures thereof; - one or more aminoalkyl trialkoxy silanes; preferably 3-aminopentyl trimethoxy silane (APMS), 3-aminopentyl triethoxy silane (APTES, APES, AMEO), 3-(2-aminoethylamino)propyl trimethoxy silane (DAMS), 3-(2-aminomethylamino) propyl triethoxy silane, 3-[2-(2-aminoethylamino)ethylamino]propyl trimethoxy silane (TAMS), trimethoxy [3-(phenylamino)propyl] silane (PAPMS), triethoxy-3-(2-imidazolin-1-yl) propyl silane (IZPES), N-cyclohexyl-3-aminopentyl trimethoxy silane, N-cyclohexyl aminomethyl triethoxy silane, 3-ureidopentyl trimethoxy silane, or mixtures thereof; and - optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

Clause 76: The process according to any of clauses 66 to 74, wherein the sol-gel composition comprises a combination of - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; - one or more glycidoxylalkyl trialkoxy silanes; preferably 3-glycidoxypentyl trimethoxy silane (GLYMO), 3-glycidoxypentyl triethoxy silane, or mixtures thereof; - one or more fluoroalkyl trialkoxy silanes; and - optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

Clause 77: The process according to any of clauses 66 to 74, wherein the sol-gel composition comprises a combination of - one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; and - one or more vinyl trialkoxy silanes; preferably trimethoxy vinyl silane, triethoxy vinyl silane (VES), N-2-(vinylbenzylamino)-ethyl-3-amino-propyl trimethoxy silane, or mixtures thereof.

Clause 78: The process according to any of clauses 66 to 74, wherein the sol-gel composition comprises a combination of - optionally, one or more tetraalkoxy silanes; preferably tetramethoxy silane (TMOS), tetraethoxy silane (TEOS), or mixtures thereof; - acryloxyalkyl trialkoxy silanes; preferably methacryloxymethyl trimethoxy silane, 3-methacryloxypropyl trimethoxy silane (MPMS), 3-methacryloxy-propyl triethoxy silane (MEMO), or mixtures thereof; - optionally, a reactive diluent; preferably (meth)acrylic acid; and - optionally, one or more metal alcoholates; preferably $\text{Al}(\text{OC}_{1-6}\text{-akyl})_3$, $\text{Zr}(\text{OC}_{1-6}\text{-akyl})_4$, $\text{Ti}(\text{OC}_{1-6}\text{-akyl})_4$, or mixtures thereof.

Clause 79: The process according to any of clauses 66 to 78, wherein the sol-gel composition comprises a solvent; preferably water; more preferably does not comprise an organic solvent.

Clause 80: The process according to any of the preceding clauses, wherein the content of crosslinked polysiloxane in the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another is at least 35 wt.-%, preferably at least 40 wt.-%, more preferably at least 45 wt.-%, still more preferably at least 50 wt.-%, yet more preferably at least 55 wt.-%, even more preferably at least 60 wt.-%, most preferably at least 65 wt.-%.

%, and in particular at least 70 wt.-%; relative to the total weight of the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]**, respectively.

Clause 81: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, of not more than 25 g·m⁻², preferably not more than 22.5 g·m⁻², more preferably not more than 20 g·m⁻², still more preferably not more than 17.5 g·m⁻², yet more preferably not more than 15 g·m⁻², even more preferably not more than 12.5 g·m⁻², most preferably not more than 10 g·m⁻², and in particular not more than 7.5 g·m⁻².

Clause 82: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, within the range of from 2.0±1.8 g·m⁻², preferably 2.0±1.6 g·m⁻², more preferably 2.0±1.4 g·m⁻², still more preferably 2.0±1.2 g·m⁻², yet more preferably 2.0±1.0 g·m⁻², even more preferably 2.0±0.8 g·m⁻², most preferably 2.0±0.6 g·m⁻², and in particular 2.0±0.4 g·m⁻².

Clause 83: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are transparent.

Clause 84: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another consist of two or more sublayers of the same or different material.

Clause 85: The process according to any of the preceding clauses, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a variance of area weight (determined according to EN ISO 536) of at most ±50% of Ø, preferably at most ±40% of Ø, more preferably at most ±30% of Ø, still more preferably at most ±20% of Ø, and yet more preferably at most ±10% of Ø.

Clause 86: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently of one another contain a mineral selected from the group consisting of clay, calcined clay, non-calcined (hydrous) clay, talc, calcium carbonate, magnesium carbonate, dolomite, gypsum, halloysite, metakaolin, fully calcined kaolin, silicate, mica, perlite, diatomaceous earth, magnesium hydroxide, barium sulphate, titanium dioxide, aluminum trihydrate, bentonite, quartz, or combinations thereof; preferably clay.

Clause 87: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently of one another comprise a binder, preferably a latex.

Clause 88: The process according to clause 87, wherein the latex is selected from isoprene-latexes, styrene-isoprene-latexes, styrene-butadiene-latexes, styrene-ethylene-butadiene-latexes, styrene-ethylene-propylene-latexes, acrylate latexes, vinylacetate latexes, styrene-(meth)acrylate latexes, vinylacetate-(meth)acrylate latexes, styrene-butadiene-acrylonitrile latexes, styrene-(meth)acrylate-acrylonitrile latexes, styrene-butadiene-(meth)acrylate-acrylonitrile latexes, styrene-maleic anhydride latexes, styrene-(meth)acrylate-maleic anhydride latexes, styrene-butylacrylate latexes, styrene-2-ethylhexyl acrylate latexes, and styrene-methacrylate-2-ethylhexyl acrylate latexes.

Clause 89: The process according to clause 87 or 88, wherein the content of the binder is within the range of from 5.0 to 20 wt.-%, and wherein the content of the pigment is within the range of from 80 to 95 wt.-%, in each case relative to the total weight of the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]**, respectively.

Clause 90: The process according to any of the preceding clauses, wherein the optional mineral layer **[D]** and/or the optional mineral layer **[F]** and/or the optional mineral layer **[J]** and/or the optional mineral layer **[L]** independently

of one another have an area weight, determined according to EN ISO 536, within the range of from $10 \pm 9.0 \text{ g} \cdot \text{m}^{-2}$, preferably $10 \pm 8.0 \text{ g} \cdot \text{m}^{-2}$, more preferably $10 \pm 7.0 \text{ g} \cdot \text{m}^{-2}$, still more preferably $10 \pm 6.0 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $10 \pm 5.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $10 \pm 4.0 \text{ g} \cdot \text{m}^{-2}$, most preferably $10 \pm 3.0 \text{ g} \cdot \text{m}^{-2}$, and in particular $10 \pm 2.0 \text{ g} \cdot \text{m}^{-2}$.

Clause 91: The process according to any of the preceding clauses, wherein the optional fiber based substrate layer **[E]** and/or the fiber based substrate layer **[K]** independently of one another are based on paper, paperboard or cardboard.

Clause 92: The process according to any of the preceding clauses, wherein the optional fiber based substrate layer **[E]** and/or the fiber based substrate layer **[K]** independently of one another are based on cellulose fibers.

Clause 93: The process according to any of the preceding clauses, wherein the optional fiber based substrate layer **[E]** has an area weight, determined according to EN ISO 536, within the range of from $70 \pm 60 \text{ g} \cdot \text{m}^{-2}$, preferably $70 \pm 50 \text{ g} \cdot \text{m}^{-2}$, more preferably $70 \pm 40 \text{ g} \cdot \text{m}^{-2}$, still more preferably $70 \pm 30 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $70 \pm 20 \text{ g} \cdot \text{m}^{-2}$, even more preferably $70 \pm 15 \text{ g} \cdot \text{m}^{-2}$, most preferably $70 \pm 10 \text{ g} \cdot \text{m}^{-2}$, and in particular $70 \pm 5 \text{ g} \cdot \text{m}^{-2}$.

Clause 94: The process according to any of the preceding clauses, wherein the fiber based substrate layer **[K]** has an area weight, determined according to EN ISO 536, within the range of from $225 \pm 200 \text{ g} \cdot \text{m}^{-2}$, preferably $225 \pm 175 \text{ g} \cdot \text{m}^{-2}$, more preferably $225 \pm 150 \text{ g} \cdot \text{m}^{-2}$, still more preferably $225 \pm 125 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $225 \pm 100 \text{ g} \cdot \text{m}^{-2}$, even more preferably $225 \pm 75 \text{ g} \cdot \text{m}^{-2}$, most preferably $225 \pm 50 \text{ g} \cdot \text{m}^{-2}$, and in particular $225 \pm 25 \text{ g} \cdot \text{m}^{-2}$.

Clause 95: The process according to any of the preceding clauses, wherein the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another are based (i) on a material selected from the group consisting of metal (e.g. aluminum), metal oxide (e.g. Al_2O_3 , SiO_2 , CaO , MgO), polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), polyamide, and combinations thereof; preferably ethylene vinyl alcohol (EVOH); or (ii) on a water soluble polymer; preferably selected from the group consisting of polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), starch, carboxymethylcellulose (CMC), polysaccharides, and combinations thereof.

Clause 96: The process according to any of the preceding clauses, wherein the optional barrier layer **[G]** and/or the optional barrier layer **[I]** and/or the optional barrier layer **[M]** independently of one another have an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.

Clause 97: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are heat-sealable.

Clause 98: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are an anti-moisture anti-grease varnish.

Clause 99: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are based upon a crosslinked thermoset material.

Clause 100: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another comprises a cross-linker.

Clause 101: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are based on a polymer selected from the group consisting of (i) polyolefins or olefin copolymers; preferably selected from the group consisting of polyethylenes, low density polyethylenes, linear low density polyethylenes, very low density polyethylenes, ultra-low density polyethylenes, medium density polyethylenes, high density polyethylenes, ultra-high molecular weight polyethylenes, polypropylenes, isotactic polypropylenes, syndiotactic polypropylenes, atactic polypropylenes, ethylene-propylene copolymers, heterophasic polypropylenes, and polystyrenes; (ii) halogenated polyolefins; preferably selected from the group consisting of polyvinyl chloride, polyvinylidene chloride, polytetrafluoroethylene, ethylene-tetrafluoroethylene copolymers, propylene-tetrafluoroethylene copolymers, polyvinylfluoride; (iii) cyclopolyolefins or cycloolefin copolymers; preferably selected from norbornene copolymers, and norbornene-ethylene-copolymers; (iv) ethylene copolymers; preferably selected from the group consisting of ethylene-vinylacetate copolymers, ethylene-vinyl laurate

alcohol copolymers, and ethylene-vinylalcohol copolymers; (v) synthetic latices; preferably selected from isoprene-latices, styrene-isoprene-latices, styrene-butadiene-latices, styrene-ethylene-butadiene-latices, styrene-ethylene-propylene-latices, acrylate latices, vinylacetate latices, styrene-(meth)acrylate latices, vinylacetate-(meth)acrylate latices, styrene-butadiene-acrylonitrile latices, styrene-(meth)acrylate-acrylonitrile latices, styrene-butadiene-(meth)acrylate-acrylonitrile latices, styrene-maleic anhydride latices, styrene-(meth)acrylate-maleic anhydride latices, styrene-butylacrylate latices, styrene-2-ethylhexyl acrylate latices, and styrene-methacrylate-2-ethylhexyl acrylate latices; (vi) polyvinyl alcohols or vinylalcohol copolymers; (vii) polyvinyl acetate and vinylacetate copolymers; (viii) polyurethanes or urethane copolymers; (ix) (meth)acrylic acid homopolymers, (meth)acrylic acid copolymers, (meth)acrylic acid ester homopolymers or (meth)acrylic acid ester copolymers; preferably selected from the group consisting of poly(meth)acrylates, (meth)acrylate copolymers, polyalkyl(meth)acrylates, alkyl(meth)acrylate copolymers, polyaryl(meth)acrylates, aryl(meth)acrylate copolymers, styrene-alkyl(meth)acrylate copolymers, and styrene-aryl(meth)acrylate copolymers; (x) epoxy resins; preferably selected from the group consisting of aliphatic epoxy resins, aromatic epoxy resins, phenoxy resins, copolymers of aliphatic epoxides and alkyl(meth)acrylates, and copolymers of aliphatic epoxides and aryl(meth)acrylates; (xi) polyvinylpyrrolidones or vinylpyrrolidone copolymers; (xii) polyamides or polyamide copolymers; (xiii) polyimides or imide copolymers; (xiv) polyesters or polyester copolymers; preferably selected from the group consisting of polylactic acid, polyhydroxy alkanoates, polyhydroxy butyrates, polyhydroxy valerates, polyethylene terephthalates, glycolized polyesters, polybutylene succinates, copolyesters of butanediol and adipic acid and terephthalic acid; (xv) polycarbonates or polycarbonate copolymers; (xvi) polyethers or ether copolymers; preferably selected from the group consisting of polyethylene glycols, polypropylene glycols, poloxamers, and polyethylene oxides; (xvii) cellulose ethers or cellulose esters; preferably selected from the group consisting of methyl cellulose, ethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methyl cellulose, carboxymethylated cellulose, cellulose acetate, cellulose acetate butyrate, cellulose stearyl ester; (xviii) starches or modified starches; preferably selected from hydrophobic starches; (xix) polysaccharides; preferably selected from chitosan, alginates, and carrageenans; (xx) proteins; preferably selected from wheat-gluten, casein, caseinates, whey, collagen, soya, and corn zein; (xxi) lipids; preferably selected from bees wax, carnauba wax, candilla wax, wool wax, hydrated jojoba wax, paraffin, polyethylene wax, polyethylene glycol wax, and ceresin; (xxii) core shell copolymers; and any mixture of the foregoing; preferably a combination of at least two polymers selected from polymers (i) and (iv); (i) and (vi); (i) and (viii); (i) and (x); (i) and (xii); (i) and (xiv); (i) and (xvi); (iv) and (vi); (iv) and (viii); (iv) and (x); (iv) and (xii); (iv) and (xiv); (iv) and (xvi); (vi) and (viii); (vi) and (x); (vi) and (xii); (vi) and (xiv); (vi) and (xvi); (viii) and (x); (viii) and (xii); (viii) and (xiv); (viii) and (xvi); (x) and (xii); (x) and (xiv); (x) and (xvi); (xii) and (xiv); (xii) and (xvi); or (xiv) and (xvi).

Clause 102: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another have an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.

Clause 103: The process according to any of the preceding clauses, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are transparent.

Clause 104: The process according to any of the preceding clauses, wherein the optional printing layer **[C]** comprises or is based on a latex; preferably selected from isoprene-latices, styrene-isoprene-latices, styrene-butadiene-latices, styrene-ethylene-butadiene-latices, styrene-ethylene-propylene-latices, acrylate latices, vinylacetate latices, styrene-(meth)acrylate latices, vinylacetate-(meth)acrylate latices, styrene-butadiene-acrylonitrile latices, styrene-(meth)acrylate-acrylonitrile latices, styrene-butadiene-(meth)acrylate-acrylonitrile latices, styrene-maleic anhydride latices, styrene-(meth)acrylate-maleic anhydride latices, styrene-butylacrylate latices, styrene-2-ethylhexyl acrylate latices, and styrene-methacrylate-2-ethylhexyl acrylate latices.

Clause 105: The process according to any of the preceding clauses, wherein the optional printing layer **[C]** comprises a pigment; preferably selected from kaolin, feldspar, mica, calcined kaolin, clay, natural clay, delaminated clay, calcined clay, calcium carbonate, chalk, ground calcium carbonate, precipitated calcium carbonate, prespice calcium carbonate, talc, gypsum, aluminum trihydrates, titanium dioxide, zinc sulfide, zinc oxide, calcium sulfite, barium sulfate, magnesium hydroxide, amorphous silica, silicates, plastic pigments, and mixtures thereof.

Clause 106: The process according to clause 104 or 105, wherein the content of the latex is within the range of from 30 to 50 wt.-%, and wherein the content of the pigment is within the range of from 50 to 70 wt.-%, in each case relative to the total weight of the printing layer.

Clause 107: The process according to any of the preceding clauses, wherein the optional printing layer [C] has an area weight, determined according to EN ISO 536, within the range of from $2.0 \pm 1.8 \text{ g} \cdot \text{m}^{-2}$, preferably $2.0 \pm 1.6 \text{ g} \cdot \text{m}^{-2}$, more preferably $2.0 \pm 1.4 \text{ g} \cdot \text{m}^{-2}$, still more preferably $2.0 \pm 1.2 \text{ g} \cdot \text{m}^{-2}$, yet more preferably $2.0 \pm 1.0 \text{ g} \cdot \text{m}^{-2}$, even more preferably $2.0 \pm 0.8 \text{ g} \cdot \text{m}^{-2}$, most preferably $2.0 \pm 0.6 \text{ g} \cdot \text{m}^{-2}$, and in particular $2.0 \pm 0.4 \text{ g} \cdot \text{m}^{-2}$.

Clause 108: The process according to any of the preceding clauses, wherein the optional printing layer [C] comprises a printed image and/or decoration.

Clause 109: The process according to any of the preceding clauses, wherein relative to the total weight of the packaging material, the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers of at most 4.0 wt.-%, preferably at most 3.0 wt.-%, more preferably at most 2.0 wt.-%, still more preferably at most 1.0 wt.-%, yet more preferably at most 0.5 wt.-%, even more preferably at most 0.3 wt.-%, most preferably at most 0.2 wt.-%, and in particular at most 0.1 wt.-%.

Clause 110: The process according to any of the preceding clauses, which has a Cobb 600 value determined according to EN ISO 535 of at most $0.8 \text{ g} \cdot \text{m}^{-2}$, preferably at most $0.7 \text{ g} \cdot \text{m}^{-2}$, more preferably at most $0.5 \text{ g} \cdot \text{m}^{-2}$, still more preferably at most $0.5 \text{ g} \cdot \text{m}^{-2}$, yet more preferably at most $0.4 \text{ g} \cdot \text{m}^{-2}$, even more preferably at most $0.3 \text{ g} \cdot \text{m}^{-2}$, most preferably at most $0.2 \text{ g} \cdot \text{m}^{-2}$, and in particular at most $0.1 \text{ g} \cdot \text{m}^{-2}$; preferably, wherein the packaging material has a Cobb 600 value determined according to EN ISO 535 of below $0.2 \text{ g} \cdot \text{m}^{-2}$, preferably at most $0.1 \text{ g} \cdot \text{m}^{-2}$.

Clause 111: The process according to any of the preceding clauses, wherein the packaging material and/or the container is for packaging food or beverages, preferably dairy, plant-based food and/or frozen food.

Clause 112: The process according to any of the preceding clauses, wherein the packaging material forms the at least one wall of the container (1), preferably all walls of the container (1).

Clause 113: The process according to any of the preceding clauses, wherein the container (1) has an interior (2) and an exterior, wherein the layers of the packaging material are arranged in alphabetical order from the exterior of the container (1) towards the interior (2) of the container (1).

Clause 114: The process according to any of the preceding clauses, wherein the container (1) comprises an interior (2) for receiving the dairy, plant-based food and/or frozen food, which is formed by a sidewall (3) having rim (4) and bottom (5); wherein the sidewall (3) has a first edge (6) and a second edge (7) which are arranged in an overlapping manner at side seam area (8); wherein the sidewall (3) is formed from the packaging material; and wherein the bottom (5) is formed from the packaging material or from a different material.

Clause 115: The process according to any of the preceding clauses, wherein the container (1) comprises an interior (2) for receiving the dairy, plant-based food and/or frozen food, which is formed by a sidewall (3) having rim (4) and bottom (5); wherein the rim (4) is joined with sidewall (3) by means of seal (9); and wherein the bottom (5) comprises annular section (10) about which sidewall (3) is folded thereby forming annular collar (11).

Clause 116: The process according to any of the preceding clauses, wherein the container (1) has an interior (2) and an exterior, wherein upon forming at least the sidewall (3) of the container (1) in step (b), the cross-linked polysiloxane layer faces the interior (2) of the container (1), whereas the fiber-based substrate layer faces the exterior of the container (1).

Clause 117: The process according to any of the preceding clauses, wherein joining at least the two edges of the first element with one another in step (b) is performed by sealing.

Clause 118: The process according to any of the preceding clauses, wherein in step (b) the fiber based substrate layer [K] at a first edge (6) is joined, preferably sealed to the sealing layer [O] at a second edge (7).

Clause 119: The process according to any of the preceding clauses, wherein in step (b) the mineral layer [D] at a first edge (6) is joined, preferably sealed to the sealing layer [O] at a second edge (7).

Clause 120: The process according to any of the preceding clauses, wherein in step (b) the printing layer [C] at a first edge (6) is joined, preferably sealed to the sealing layer [O] at a second edge (7).

Clause 121: The process according to any of the preceding clauses, wherein in step (b) the one or more cross-linked polysiloxane layers **[B]** at a first edge (6) are joined, preferably sealed to the sealing layer **[O]** at a second edge (7).

Clause 122: The process according to any of the preceding clauses, wherein in step (b) the sealing layer **[A]** at a first edge (6) is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge (7).

Clause 123: The process according to any of the preceding clauses, wherein in step (b) the sealing layer **[A]** at a first edge (6) is joined, preferably sealed to the sealing layer **[O]** at a second edge (7).

Clause 124: The process according to any of the preceding clauses, wherein in step (b) the one or more cross-linked polysiloxane layers **[B]** at a first edge (6) are joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge (7).

Clause 125: The process according to any of the preceding clauses, wherein in step (b) the printing layer **[C]** at a first edge (6) is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge (7).

Clause 126: The process according to any of the preceding clauses, wherein in step (b) the mineral layer **[D]** at a first edge (6) is joined, preferably sealed to the one or more cross-linked polysiloxane layers **[N]** at a second edge (7).

Clause 127: The process according to any of the preceding clauses, which comprises the additional steps of (c) providing a second element having a circumferential edge which is preferably also made of a multilayer material comprising a fiber-based substrate layer and a cross-linked polysiloxane layer, wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**; and (d) joining the circumferential edge of the second element with another edge of the first element thereby forming the bottom (5) of the container (1).

Clause 128: The process according to clause 127, wherein the second element is independently made of the packaging material as defined in any of the preceding clauses and comprises at least the fiber based substrate layer **[K]** and the one or more cross-linked polysiloxane layers **[N]**.

Clause 129: The process according to clause 128, wherein the second element additionally comprises one or more of the optional sealing layer **[A]**, the optional one or more cross-linked polysiloxane layers **[B]**, the optional printing layer **[C]**, the optional mineral layer **[D]**, the optional mineral layer **[L]**, the optional barrier layer **[M]**, and/or the optional sealing layer **[O]**.

Clause 130: The process according to any of clauses 127 to 129, wherein the container (1) has an interior (2) and an exterior, wherein upon forming the bottom (5) of the container (1) in step (d), the layers of the packaging material are arranged in alphabetical order from the exterior of the container (1) towards the interior (2) of the container (1).

Clause 131: The process according to any of clauses 127 to 130, wherein joining in step (d) is performed by sealing.

Reference numerals:

[0297]

1 - container;	5 - bottom;	9 - seal;
2 - interior;	6 - first edge;	10 - annular section;
3 - sidewall;	7 - second edge;	11 - annular collar.
4 - rim;	8 - side seam area;	

[0298] The following examples illustrate the invention but are not to be construed as limiting its scope.

Examples 1A - 10F:

[0299] 10 different laminated cardboards comprising the following layers at the following area weights determined according to EN ISO 536 are provided as starting materials:

area weight [g·m ⁻²]	1	2	3	4	5	6	7	8	9	10
printing layer [C]	-	-	10	-	10	-	10	-	10	10
mineral layer [D]	-	15	-	15	-	15	-	15	-	15
fiber-based substrate layer [K]	125	150	175	200	225	250	275	300	325	350
mineral layer [L]	-	-	-	15	15	-	-	15	15	15
barrier layer [M]	-	-	-	-	-	10	10	10	10	10

[0300] Printing layer **[C]** in each case where it is present comprises a print image and is based on 30 wt.-% of a vinylacetate latex and 70 wt.-% calcium carbonate. Mineral layer **[D]** in each case where it is present is based on 10 wt.-% of a styrene-maleic anhydride latex and 90 wt.-% clay. Fiber-based substrate layer **[K]** in each case where it is present is based on cellulosic cardboard. Mineral layer **[L]** in each case where it is present is based on 10 wt.-% of a styrene-maleic anhydride latex and 90 wt.-% clay. Barrier layer **[M]** in each case where it is present is based on polyvinyl alcohol (PVOH).

[0301] 6 different sol-gel compositions A through F are provided comprising the following ingredients at the following content:

[mole.-%]	A	B	C	D	E	F
tetramethoxy silane	30	30		20		
(3-glycidyoxypropyl)trimethoxy silane	45	35	67			
(3-aminopropyl)triethoxysilane						
N-2-(vinylbenzyl-amino)-ethyl-3- amino-propyl trimethoxy silane (40% MeOH)				80		
3-methacryloxy-propyl trimethoxy silane					67	
3-aminopropyl trimethoxy silane	5					9
aluminum tri-sec-butoxide	10	7.5	16.5			
zirconium n-propoxide (70% in PrOH)	10	7.5			16.5	
ethyl acetoacetate			16.5			
methacrylic acid					16.5	
triethanolamine		20				
MeOH				+		
EtOH						91
PrOH	+				+	
H ₂ O		+				
curing mode	heat	heat	heat	UV ¹	UV ¹	heat
¹ 1-hydroxycyclohexyl phenyl ketone is used as UV catalyst						

[0302] All ingredients are mixed under stirring and cooling keeping the temperature below 15°C. After 15 minutes, water is added (1.5 mole eq. relative to silane(s)).

[0303] In separate samples, each of the thus obtained sol-gel compositions A through F is applied to each of laminated cardboards, namely to

- fiber-based substrate layer **[K]** (samples 1A-1F, samples 2A-2F, and samples 3A-3F);
- mineral layer **[L]** (samples 4A-4F, and samples 5A-5F);

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- barrier layer **[M]** (samples 6A-6F, samples 7A-7F, samples 8A-8F, samples 9A-9F, and samples 10A-10F).

[0304] The wet layer of the thus applied sol-gel composition is cured at elevated temperature and under exposure to UV light, respectively. Solvent is evaporated under reduced pressure and at elevated temperature thereby obtaining one cross-linked polysiloxane layer **[N]**:

area weight [g·m ⁻²]	1 A-F	2 A-F	3 A-F	4 A-F	5 A-F	6 A-F	7 A-F	8 A-F	9 A-F	10 A-F
printing layer [C]	-	-	10	-	10	-	10	-	10	10
mineral layer [D]	-	15	-	15	-	15	-	15	-	15
fiber-based substrate layer [K]	125	150	175	200	225	250	275	300	325	350
mineral layer [L]	-	-	-	15	15	-	-	15	15	15
barrier layer [M]	-	-	-	-	-	10	10	10	10	10
cross-linked polysiloxane layer [N] ²	5	5	5	5	5	5	5	5	5	5
² In each case 6 samples having different compositions of cross-linked polysiloxane layer [N] based upon sol-gel compositions A through E										

[0305] The application of the sol-gel composition is repeated, the thus obtained wet layer is cured again and solvent is evaporated thereby obtaining two cross-linked polysiloxane layers **[N]** having a doubled total area weight:

area weight [g·m ⁻²]	1 A-F	2 A-F	3 A-F	4 A-F	5 A-F	6 A-F	7 A-F	8 A-F	9 A-F	10 A-F
printing layer [C]	-	-	10	-	10	-	10	-	10	10
mineral layer [D]	-	15	-	15	-	15	-	15	-	15
fiber-based substrate layer [K]	125	150	175	200	225	250	275	300	325	350
mineral layer [L]	-	-	-	15	15	-	-	15	15	15
barrier layer [M]	-	-	-	-	-	10	10	10	10	10
cross-linked polysiloxane layer [N]	10	10	10	10	10	10	10	10	10	10

[0306] To the two cross-linked polysiloxane layers **[N]** of each sample, a sealing layer **[O]** is applied based upon a heat-sealable ethylene vinylacetate (EVA):

area weight [g·m ⁻²]	1 A-F	2 A-F	3 A-F	4 A-F	5 A-F	6 A-F	7 A-F	8 A-F	9 A-F	10 A-F
printing layer [C]	-	-	10	-	10	-	10	-	10	10
mineral layer [D]	-	15	-	15	-	15	-	15	-	15
fiber-based substrate layer [K]	125	150	175	200	225	250	275	300	325	350
mineral layer [L]	-	-	-	15	15	-	-	15	15	15
barrier layer [M]	-	-	-	-	-	10	10	10	10	10
cross-linked polysiloxane layer [N]	10	10	10	10	10	10	10	10	10	10
sealing layer [O]	5	5	5	5	5	5	5	5	5	5

[0307] Elements of suitable size and shape are prepared by cutting the thus obtained packaging material. Two edges of said elements are joined to one another and to a bottom element by means of sealing layer **[O]** under the application of heat thereby obtaining a container as shown in Figures 18 and 19.

Examples 11 and 12

[0308] Two laminated cardboards comprising the following layers at the following area weights determined according to EN ISO 536 were provided:

[g·m ⁻²]	11	12
sealing layer [A] based upon anti moisture varnish	3.0	3.0
printing layer [C]		
mineral layer [D] based upon clay	5.0	10
fiber based substrate layer [E]	60	200
mineral layer [F] based upon clay	5.0	-
barrier layer [G] based upon PVOH	1.5	1.0
one or more cross-linked polysiloxane layers [H]	3.0	3.0
barrier layer [I] based upon PVOH	1.5	1.0
mineral layer [J] based upon clay	-	2.0
fiber based substrate layer [K]	185	43
mineral layer [L] based upon clay	10	7.0
one or more cross-linked polysiloxane layers [N]	3.0	3.0
sealing layer [O] (pattern or full surface)	1.5	1.5
taping (PE/PET/PE)		
total area weight [g·m ⁻²]	278.5	274.5
content of paper [wt.-%]	95.15	95.45
content of synthetic polymer	2.69	2.37
content of plant-based ingredients	87.97	88.52

[0309] The laminated cardboard according to Example 11 has the advantages that fiber based substrate **[K]** is composed of cardboard (not paper) which as such exhibits a certain degree of water repellency compared to thinner paper. Thus, less moisture barrier needs to be applied on the inside of the cardboard (layers **[L]**, **[N]**, and **[O]**). Applying printing layer **[C]** in turn can be more cost-efficient. Under these circumstances, it is preferred to apply sealing layer **[O]** as full surface sealant (no pattern). Oxygen barrier can be placed near the outside and thus less influences the product which is protected by the cardboard and the lamination.

[0310] The laminated cardboard according to Example 12 has the advantages that water-repellency can be put in the lamination-layer between fiber based substrate **[K]** (paper) and fiber based substrate **[E]** (cardboard). In consequence, the barrier layers are closer to the product and there is less influence of humidity on the card board, which is thus more protected and more rigid.

Claims

1. A process for the preparation of a container (1) comprising a sidewall (3) with an opening and optionally a bottom (5), the process comprising the steps of

(a) providing a first element which has a first edge (6) as well as a second edge (7) and which is made of a packaging material comprising

- optionally, a sealing layer **[A]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, one or more cross-linked polysiloxane layers **[B]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;

- optionally, a printing layer **[C]**;
- optionally, a mineral layer **[D]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;
- a fiber based substrate layer **[K]** having an area weight, determined according to EN ISO 536, within the range of from 25 to 475 g·m⁻²;
- optionally, a mineral layer **[L]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;
- optionally, a barrier layer **[M]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- one or more cross-linked polysiloxane layers **[N]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and
- optionally, a sealing layer **[O]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;

wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**; and
 (b) joining at least the first edge (6) and the second edge (7) of the first element with one another thereby forming at least the sidewall (3) of the container (1).

2. The process according to claim 1, wherein the packaging material has a total content of polyolefins, preferably of any synthetic organic polymers, of at most 5.0 wt.-%, preferably at most 4.0 wt.-%, preferably at most 3.0 wt.-%, more preferably at most 2.0 wt.-%, still more preferably at most 1.0 wt.-%, yet more preferably at most 0.5 wt.-%, even more preferably at most 0.3 wt.-%, most preferably at most 0.2 wt.-%, and in particular at most 0.1 wt.-%; relative to the total weight of the packaging material.

3. The process according to claim 1 or 2, wherein the layers are arranged in alphabetical order.

4. The process according to any of the preceding claims, wherein the packaging material besides layers **[K]** and **[N]** comprises the one or more cross-linked polysiloxane layers **[B]**.

5. The process according to any of the preceding claims, wherein the optional sealing layer **[A]** forms an outer surface of the packaging material.

6. The process according to any of the preceding claims, wherein the optional sealing layer **[O]** forms an outer surface of the packaging material.

7. The process according to any of the preceding claims, wherein the packaging material additionally comprises

- a fiber based substrate layer **[E]** having an area weight, determined according to EN ISO 536, within the range of from 10 to 475 g·m⁻²; preferably 10 to 150 g·m⁻² or 25 to 475 g·m⁻²;
- optionally, a mineral layer **[F]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻²;
- optionally, a barrier layer **[G]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, one or more cross-linked polysiloxane layers **[H]** which have a total area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²;
- optionally, a barrier layer **[I]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 10 g·m⁻²; and
- optionally, a mineral layer **[J]** having an area weight, determined according to EN ISO 536, within the range of from 0.1 to 20 g·m⁻².

8. The process according to any of the preceding claims, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are based on a hybrid material comprising an inorganic polysiloxane backbone and pendant organic substituents.

9. The process according to any of the preceding claims, wherein the content of crosslinked polysiloxane in the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers

[H] and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another is at least 35 wt.-%, preferably at least 40 wt.-%, more preferably at least 45 wt.-%, still more preferably at least 50 wt.-%, yet more preferably at least 55 wt.-%, even more preferably at least 60 wt.-%, most preferably at least 65 wt.-%, and in particular at least 70 wt.-%; relative to the total weight of the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]**, respectively.

10. The process according to any of the preceding claims, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another have a total area weight, determined according to EN ISO 536, of not more than 25 g·m⁻², preferably not more than 22.5 g·m⁻², more preferably not more than 20 g·m⁻², still more preferably not more than 17.5 g·m⁻², yet more preferably not more than 15 g·m⁻², even more preferably not more than 12.5 g·m⁻², most preferably not more than 10 g·m⁻², and in particular not more than 7.5 g·m⁻²

11. The process according to any of the preceding claims, wherein the optional one or more cross-linked polysiloxane layers **[B]** and/or the optional one or more cross-linked polysiloxane layers **[H]** and/or the one or more cross-linked polysiloxane layers **[N]** independently of one another are transparent.

12. The process according to any of the preceding claims, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are heat-sealable.

13. The process according to any of the preceding claims, wherein the optional sealing layer **[A]** and/or the optional sealing layer **[O]** independently of one another are transparent.

14. The process according to any of the preceding claims, wherein the packaging material has a Cobb 600 value determined according to EN ISO 535 of below 0.2 g·m⁻², preferably at most 0.1 g·m⁻²

15. The process according to any of the preceding claims, which comprises the additional steps of

(c) providing a second element having a circumferential edge which is preferably also made of a multilayer material comprising a fiber-based substrate layer and a cross-linked polysiloxane layer, wherein the one or more cross-linked polysiloxane layers **[N]** directly or indirectly cover at least a part of the fiber-based substrate layer **[K]**; and

(d) joining the circumferential edge of the second element with another edge of the first element thereby forming the bottom (5) of the container (1).

Figure 1

[B]	
[D]	
[K]	
[M]	
[N]	

Figure 2

[B]	
[D]	
[K]	
[L]	
[M]	
[N]	

Figure 3

[B]	
[C]	
[D]	
[K]	
[L]	
[M]	
[N]	

Figure 4

[A]	
[B]	
[D]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 5

[A]	
[B]	
[C]	
[D]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 6

[B]	
[D]	
[E]	
[K]	
[L]	
[M]	
[N]	

Figure 7

[B]	
[C]	
[D]	
[E]	
[K]	
[L]	
[M]	
[N]	

Figure 8

[A]	
[B]	
[D]	
[E]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 9

[A]	
[B]	
[C]	
[D]	
[E]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 10

[B]	
[D]	
[E]	
[F]	
[H]	
[I]	
[K]	
[L]	
[M]	
[N]	

Figure 11

[B]	
[C]	
[D]	
[E]	
[F]	
[H]	
[I]	
[K]	
[L]	
[M]	
[N]	

Figure 12

[A]	
[B]	
[D]	
[E]	
[F]	
[H]	
[I]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 13

[A]	
[B]	
[C]	
[D]	
[E]	
[F]	
[H]	
[I]	
[K]	
[L]	
[M]	
[N]	
[O]	

Figure 14

[A]	
[C]	
[D]	
[E]	
[F]	
[H]	
[I]	
[K]	
[L]	
[N]	
[O]	

Figure 15

[A]	
[C]	
[D]	
[E]	
[F]	
[H]	
[I]	
[J]	
[K]	
[L]	
[N]	
[O]	

Figure 16

[A]	
[C]	
[D]	
[E]	
[F]	
[G]	
[H]	
[I]	
[K]	
[L]	
[N]	
[O]	

Figure 17

[A]	
[C]	
[D]	
[E]	
[F]	
[G]	
[H]	
[I]	
[J]	
[K]	
[L]	
[N]	
[O]	

Figure 18

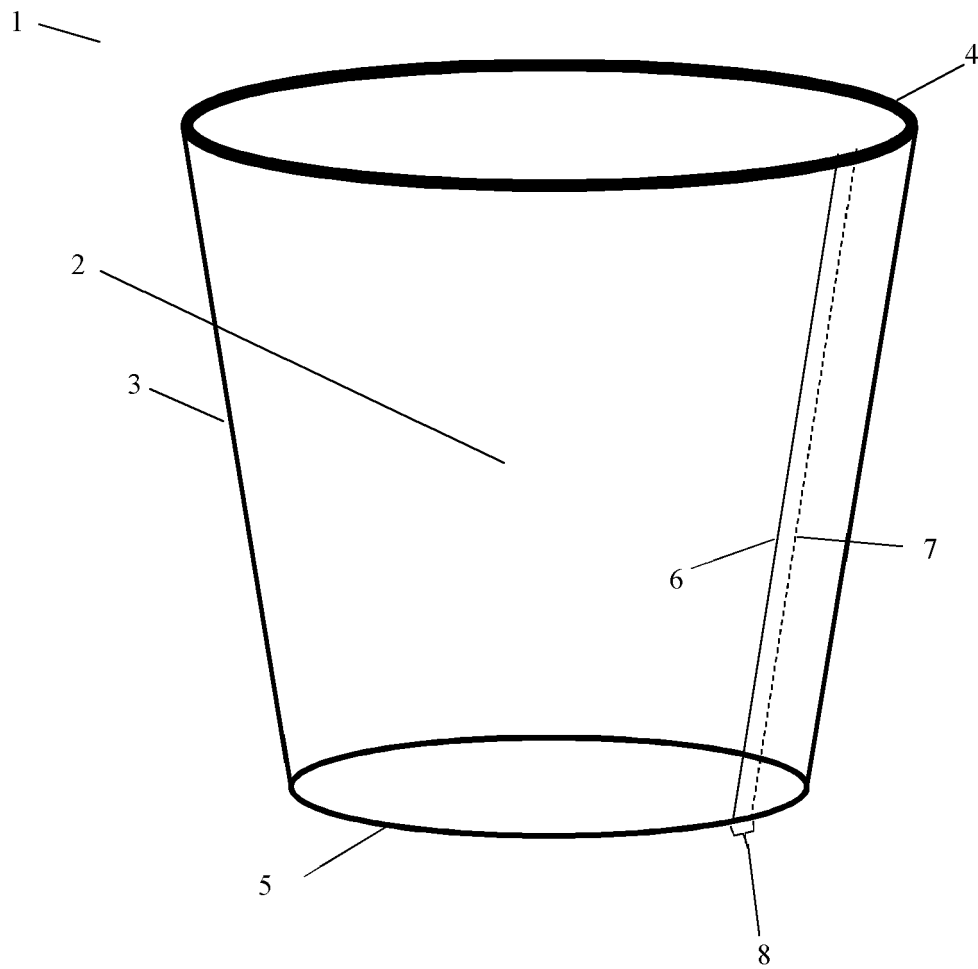


Figure 19

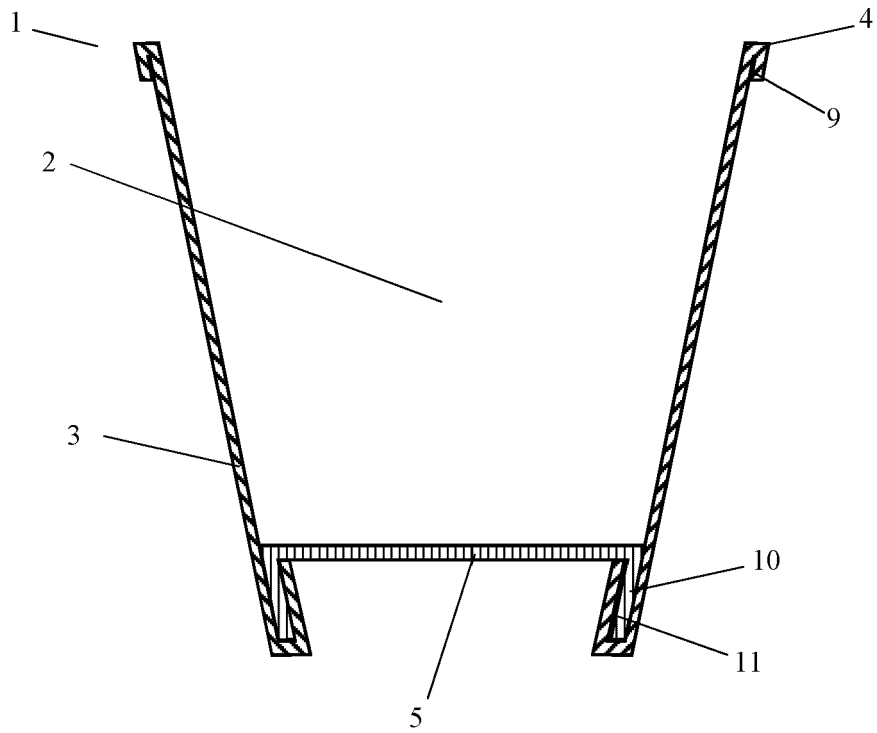


Figure 20

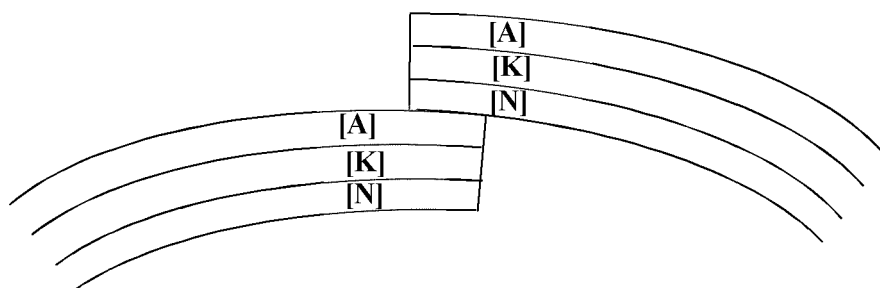


Figure 21

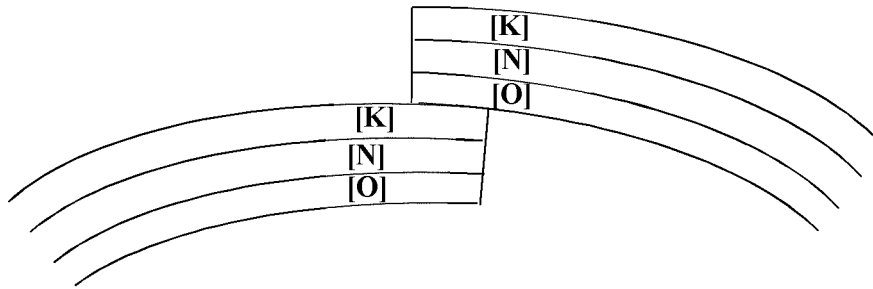


Figure 22

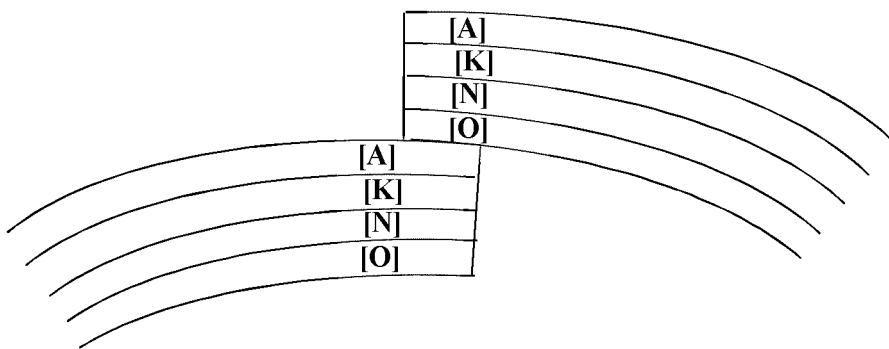
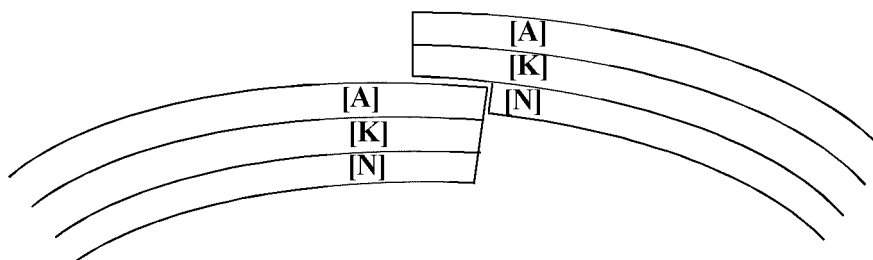


Figure 23





EUROPEAN SEARCH REPORT

Application Number

EP 23 15 5061

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D21H
B65D

The present search report has been drawn up for all claims

1

Place of search

Munich

Date of completion of the search

30 June 2023

Examiner

Ponsaud, Philippe

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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30-06-2023

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