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(54) FIBER SHEETS AND STRUCTURES COMPRISING FIBER SHEETS

FASERBOGEN UND STRUKTUREN MIT FASERBOGEN

FEUILLES DE FIBRES ET STRUCTURES COMPRENANT DES FEUILLES DE FIBRES

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EP 3 224 411 B1

Description

FIELD OF THE INVENTION

[0001] The invention relates to fiber sheets, to structures comprising said fiber sheets, to the use of said fiber sheets and to a method for the manufacture of said fiber sheets. The invention further relates to biodegradable and/or recyclable products comprising said fiber sheets, useful in replacing non-biodegradable products.

BACKGROUND

[0002] Polymeric products, such as plastic packaging materials, plastic bags, and other plastic applications have become a serious environmental problem. It is estimated that each EU citizen uses an average of 200 plastic bags every year. Said plastic bags are kept for an average of 20 minutes and it takes about 1000 years to degrade the plastic bags. About 4 Mtn on yearly basis of plastic material, particularly plastic bags, can be found in the seas and oceans, where it cause serious damage to the sea ecosystem. The new amendment to the EU waste directive and implementation of the directive on individual country level is targeting to reduce the usage of plastic bags to level of 90 bags per citizen by 2019 and further to 40 bags by 2025. Currently only about 6.6 % of plastic bags are recycled and more than 8% ends up as litter. Thus environmentally acceptable, consumer preferred, recyclable and biodegradable substitute materials for plastic bags are needed.

[0003] Corresponding products traditionally made of paper, such as paper bags are also used. However, they have poor water resistance, they are relatively high in weight (e.g. in comparison to plastics), they are inflexible, their converting process is slow, they have poor user experience and preference, and they generally have limited strength properties, especially related to tear.

[0004] Further, plastic bags made of biodegradable plastic, such as polylactic acids or polymeric starch are available, but they have limited water resistance as well as user acceptance and strength properties. Starch products further compete with food production, which is a serious concern for the sustainability and land use.

[0005] CN101302319 describes biodegradable shopping bags made of a slurry comprising refined grass, wheat straw, bagasse, annual herb leaves and stems, polyvinyl alcohol, optional gypsum, salt, defoamer and water-proofing agent, where said slurry is poured in a mold, dewatered and dried to obtain a sheet, which is formed to a shopping bag. Technique relating to methods for producing foam-laid fiber webs is known technology particularly in the field of manufacture of non-woven and tissue products. Fiber web is formed from a dispersion of fibers in a foamed liquid. A pulp or fiber furnish is first prepared in a pulper, followed by dewatering, mixing with a foam or foamable liquid containing a surfactant and water. The fibers are dispersed in the foam and the formed fiber-foam is deposited on a wire and the main portion of the liquid, which is essentially in the form of foam, is removed by a suction. This technique is disclosed in EP 481746. Surfactants may be of any suitable type, such as anionic, cationic, non-ionic and amphoteric surfactants. Additionally, wet-strengtheners, binders, creping chemicals etc. may be used. Surfactants used in the foaming process are generally regarded as having a negative influence on both the dry and wet tensile strength of a paper web.

[0006] Based on the above it can be seen that there exists a need to provide environmentally acceptable and biodegradable substitute materials for non-degradable plastics presently used in various applications, such as packaging, plastic bags, etc.

SUMMARY

[0007] An object of the present invention is to overcome or substantially reduce the above described problems relating to the use of non-biodegradable plastic materials, such as packaging materials, by way of finding a new material, which is biodegradable and/or recyclable using the currently available recycling systems, flexible, easy to manufacture, user friendly (both consumer and retailer), cost effective, particularly related to water, energy, chemical and material costs, and has sufficient strength properties.

[0008] A further object of the invention is to provide fiber sheets, which can be used for replacing plastic materials.

[0009] A still further object of the invention is to provide structures comprising said fiber sheets.

[0010] A still further object of the invention is to provide uses of said fiber sheets in packaging, in carrier bags and sacks, covering, construction, clothing and fabrics, graphics and interior design applications.

[0011] A still further object of the invention is to provide a method for the manufacture of said fiber sheets.

[0012] The present invention generally concerns a fiber sheet, which it is obtainable by foam based production technology, it comprises fibers, a binder and a foaming polymer, and where 50-99 wt% of said fibers are natural fibers and 1-50 wt% of said fibers are reinforcement fibers selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, and where said sheet has properties typically characterizing plastic materials, flexibility, heat sealability, hydrophobicity, water repellency, elongation and strength, and where said sheet is biodegradable and/or recyclable.

[0013] The present invention relates to a fiber sheet, which it is obtainable by foam based production technology, a binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof, and a

foaming agent, and where 50-99 wt% of said fibers are natural fibers having average fiber length of 0.5 - 5mm and 1-50 wt%of said fibers are reinforcement fibers having average fiber length of 5 - 30 mm, selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, and where said fiber sheet has stretch in the range of 3-50 %. The fiber sheet is biodegradable and/or recyclable.

[0014] The present invention further relates to structures comprising said fiber sheets.

[0015] The present invention further relates to a method for the manufacture of a fiber sheet, where said method comprises the steps of

- forming at least one foamed dispersion by dispersing fibers comprising natural fibers having average fiber length of 0.5 - 5mm and reinforcement fibers having average fiber length of 5 - 30 mm, where the reinforcement fibers are selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof in a foam or foamable liquid comprising water and at least one foaming agent to obtain fiber-foam comprising 50 - 99% by weight of natural fibers, 1 to 50% by weight of reinforcement fibers, 0.5 - 10% by weight of at least one foaming agent,
- conveying the formed fiber-foam to a foraminous support and draining liquid trough the foraminous support to form a sheet,
- finalizing the formed sheet by treating the sheet with at least one binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof, and
- drying and calandering the sheet to obtain the fiber sheet, where the finalizing is carried out before or after the drying.

[0016] The invention provides a simple, environmentally acceptable solution for replacing non-biodegradable/non-recyclable/non-renewable materials as described above, at least partly, and it provides even further advantages to the products and structure made from the fiber sheets. The currently available recycling systems can be utilized for recycling the products of the present invention.

[0017] In particular, it has surprisingly been found that flexible, light, biodegradable and/or recyclable fiber sheets with high strength, burst and elongation properties can be obtained. Said fiber sheets may be used in a wide range of applications, such as packaging, covering, construction, interior design, graphics, clothing and fabrics, bags and sacks, and the like.

[0018] A method utilizing foam based production technology refers here particularly to a method where a fiber web is formed using a foam-laid method. Preferably said foam-laid method is followed by finalizing. Preferably the finalizing is carried out by applying binder to the fibrous web with a method selected from surface treatment methods.

[0019] The invention is also directed to the use of the fiber sheet in applications in the field of packaging, carrier bags and sacks, covering, construction, interior design, graphics, clothing and fabrics, and the like.

[0020] The characteristic features of the invention are presented in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Figure 1 (1A-1D) illustrates pulling force as a function of elongation for paper, plastic and products of the invention.

Figure 2 (2A-2B) illustrates strength and TEA of paper, plastic and products of the invention, calculated from the total areas of the curves.

Figure 3 illustrates strength properties of the product according to the invention.

Figure 4 (4A-4E) illustrates properties of the samples according to the invention, when contacted with water.

Figure 5 (5A- 5D) illustrates the stretch and strength properties of the wet sample according to the invention, using paper as reference.

Figure 6 illustrates beneficial bursting behavior of products according to the invention.

Figure 7 illustrates tear strength of products according to the invention.

Figure 8 (8A-8E) illustrates laboratory scale process used in development of the invention.

Figure 9 (9A-9B) illustrates bags made from the fiber sheets of the invention.

DEFINITIONS

[0022] Unless otherwise specified, the terms, which are used in the specification and claims, have the meanings commonly used in the field of pulp and paper industry, as well as in packaging industry. Specifically, the following terms have the meanings indicated below.

[0023] The term "bio-degradable" refers here to material being capable of being broken down or destroyed to innocuous products or very small parts by natural processes, i.e. by the action of living things such as microor-

ganisms.

[0024] The term "recyclable" refers here to material being capable of reusing for providing new products.

[0025] The term "biodegradable and/or recyclable products" refers here to biodegradable products, or recyclable products, or biodegradable and recyclable products.

[0026] The term "foam-laying method", also known as "foam-forming method" refers here to any conventional mono-layer and multi-layer foam-laid method used in the manufacture of non-woven products, paper products, tissue products and the like.

[0027] The term "foraminous support", also known as "foraminated support" refers here to a wire or the like.

[0028] The term "fiber sheet" refers here to flat, continuous or discontinuous mass or piece of fibrous material or fibrous web.

DETAILED DESCRIPTION OF THE INVENTION

[0029] It was surprisingly found that burst resistant, flexible, but yet sufficiently strong, elastic and water resistant fiber sheets can be obtained from biodegradable and/or recyclable materials with a simple and cost effective process. Said fiber sheets find numerous uses in the field of packaging, in carrier bags and sacks, covering, construction, interior design, graphics, clothing and fabrics, and the like.

[0030] The fiber sheet has an ideal combination of the advantageous properties of paper and plastics and thus it finds numerous applications in the fields where earlier plastic or paper has been the most popular choice.

[0031] The fiber sheet is obtainable by foam based production technology, it comprises fibers having average fiber length of 0.5-100 mm, a binder and a foaming agent, and where 50-99 wt% of said fibers are natural fibers and 1-50 wt% of said fibers are reinforcement fibers selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, and where said fiber sheet has stretch in the range of 3-50 %.

[0032] The present invention relates to a fiber sheet, which is obtainable by foam based production technology,

- it comprises 50 - 99 wt% of natural fibers having average fiber length of 0.5 - 5mm and 1-50 wt% of reinforcement fibers having average fiber length of 5 - 30 mm,
- a binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof,
- foaming agent,
- 50-99 wt% of said fibers are natural fibers and 1-50 wt% of said fibers are reinforcement fibers selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, and

said fiber sheet has stretch in the range of 3-50%.

[0033] The fiber sheet is biodegradable and/or recyclable.

[0034] Preferably the fiber sheet has stretch in the range of 5-45 %, particularly preferably 10-40 %. Stretch is measured using the method ISO 1924-2:2008.

[0035] Obtainable by foam based technology refers to a method utilizing foam based production technology. It particularly refers to a method where a fiber web is formed using a foam-laid method, followed by finalizing. The finalizing is carried out with a method selected from surface treatment methods. Preferably a binder is applied to the fibrous web with a method selected from surface treatment methods. The binder may alternatively be applied during the foam laid method, or with the surface treatment method and the foam laid method.

[0036] The surface treatment methods are selected from spray coating and foam assisted methods carried out at the press section of a paper machine, where the foam laid method is carried out, from external sizing methods carried out at a paper machine, where the foam laid method is carried out, methods utilizing size press, and from conventional surface treatment methods carried out with online or offline coating machines, and foam assisted coating methods.

[0037] According to a preferable embodiment the fiber sheet has elongation at break of 5-50%, preferably 10-40%, particularly preferably 25-40%. Elongation at break is measured using the method ISO 1924-2:2008.

[0038] The fibrous web may have grammage of 2 g/m^2 - 500 g/m^2, preferably 10 g/m^2 - 500 g/m^2, which may be adjusted according to the end product or structure.

Natural fibers

[0039] The natural fibers are selected from wood pulp, non-wood plant materials, and combinations thereof.

[0040] The natural fibers may be selected from chemical pulp, such as sulphate and sulphite pulp, organosolv pulp; recycled fibers; and/or mechanical pulp including e.g. refiner mechanical pulp (RMP), pressurized refiner mechanical pulp (PRMP), pretreatment refiner chemical alkaline peroxide mechanical pulp (P-RC APMP), thermomechanical pulp (TMP), thermomechanical chemical pulp (TMCP), high-temperature TMP (HT-TMP) RTS-TMP, alkaline peroxide pulp (APP), alkaline peroxide mechanical pulp (APMP), alkaline peroxide thermomechanical pulp (APTMP), Thermopulp, groundwood pulp (GW), stone groundwood pulp (SGW), pressure groundwood pulp (PGW), super pressure groundwood pulp (PGW-S), thermo groundwood pulp (TGW), thermo stone groundwood pulp (TSGW), chemimechanical pulp (CMP), chemirefinermechanical pulp (CRMP), chemithermomechanical pulp (CTMP), high-temperature CTMP (HT-

CTMP), sulphite-modified thermomechanical pulp (SMTMP), reject CTMP (CTMPR), groundwood CTMP (G-CTMP), semichemical pulp (SC), neutral sulphite semi chemical pulp (NSSC), high-yield sulphite pulp (HYS), biomechanical pulp (BRMP), pulps produced according to the OPCO process, explosion pulping process, Bi-Vis process, dilution water sulfonation process (DWS), sulfonated long fibres process (SLF), chemically treated long fibres process (CTLF), long fibre CMP process (LFCMP), Kraft wood pulp, and modifications and combinations thereof. The pulp may be a bleached or non-bleached pulp.

[0041] The wood pulp may originate from hardwood or softwood, including birch, beech, aspen such as European aspen, alder, eucalyptus, maple, acacia, mixed tropical hardwood, pine such as loblolly pine, fir, hemlock, larch, spruce such as Black spruce or Norway spruce, and mixtures thereof. Suitably pulp originating from pine is used.

[0042] Also non-wood plant raw material, such as seed hair fibers, leaf fibers, bast fibers, plant fibers can be provided from e.g. straws of grain crops, wheat straw, reed canary grass, reeds, flax, hemp, kenaf, jute, ramie, seed, sisal, abaca, coir, bamboo, bagasse, cotton kapok, milkweed, pineapple, cotton, rice, reed, esparto grass, *Phalaris arundinacea,* or combinations thereof.

[0043] Also any combinations of wood pulp and non-wood plant material may be used.

[0044] According to a preferable embodiment the fiber sheet comprises 50-99 wt%, particularly preferably 70-99 wt% of the natural fibers.

[0045] According to a preferable embodiment the fiber sheet comprises 50-99 wt% of natural fibers having average fiber length 0.5-5 mm.

[0046] According to a preferable embodiment the natural fibers have average fiber length of 0.5-5 mm, preferably 1-3 mm.

Reinforcement fibers

[0047] The reinforcement fibers are long fibers selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof. The polymer fibers have thermoplastic properties or they are mixed with thermoplastic materials.

[0048] The non-wood natural fibers originate from non-wood plant materials as described above.

[0049] According to a preferable embodiment the polymer fibers are thermoplastic polymer fibers selected from polylactides (PLA), glycolic acid polymers (PGA), polyolefins (PO), polyethyleneterephthalates (PET), polyester (PES), polyvinyl alcohols (PVA) and bicomponent fibers comprising thermoplastic polymers.

[0050] Preferably the bicomponent fibers are selected from fibers having a thermoplastic polymer as the sheat polymer (bicomponent fiber with thermoplastic surface), such as polyester (PES) core and polyethylene (PE) sheat. Suitably PES/PE bicomponent fibers are used.

[0051] Bicomponent fibers are comprised of two polymers of different chemical and/or physical properties, extruded from the same spinneret with both polymers in the same filament.

[0052] The long reinforcement fibers add flexibility, stretch, strength and functional properties, to the fiber sheet.

[0053] Thermoplastic fibers add functional properties such as heat sealability to the fiber sheet, as well as latex binders applied as surface treatment.

[0054] According to a preferable embodiment the fiber sheet of the present invention comprises 1-50 wt% of reinforcement fibers having average fiber length of 3-100 mm.

[0055] According to a preferable embodiment the fiber sheet of the present invention comprises 1-30 wt%, particularly preferably 1-20 wt% of the reinforcement fibers.

[0056] According to a preferable embodiment the fiber sheet of the present invention comprises at least 5 wt% of thermoplastic polymer fibers, whereby the obtained fiber sheet is heat sealable.

[0057] According to a preferable embodiment the reinforcement fibers have average fiber length of 5-30 mm, particularly preferably 6-15 mm.

Binder

[0058] According to a preferable embodiment the fiber sheet of the present invention comprises a binder in an amount of 0.005 - 10% by weight, preferably 0.05 - 5% by weight, particularly preferably 1 - 5% by weight.

[0059] Suitably the binder is selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, such as biopolymers based on starch derivatives, natural gum latexes, alginates, guar gum, hemicellulose derivatives, chitin, chitosan, pectin, agar, xanthan, amylose, amylopectin, alternan, gellan, mutan, dextran, pullulan, fructan, locust bean gum, carrageenan, glycogen, glycosaminoglycans, murein, bacterial capsular polysaccharides, and the like and combinations thereof.

[0060] The binder is preferably selected from acrylic latexes (polyacrylate latexes or polyacrylic acid latexes) and combinations thereof, optionally in combination with polyvinylalcohol. The binder may originate from the foam laid method, or from the finalizing method or from both.

Foaming agent

[0061] According to a preferable embodiment the fiber sheet of the present invention comprises 0.1 -10 wt% of the foaming agent.

[0062] The foaming agent acts as a surface active agent, which enables the formation of the foam and additionally it provides the formed fibrous web the desired

strength.

[0063] The foaming agent is selected from water-soluble foaming polymeric agent and water dispersible foaming polymeric agents and combinations thereof.

[0064] Preferably the foaming agent is selected from water soluble glycans, water dispersible glycans, water soluble hydrophilic polymers and water dispersible hydrophilic polymers and combinations thereof.

[0065] Preferably the water soluble glycans and water dispersible glycans are selected from polysaccharides and derivatives thereof.

[0066] Preferably the water soluble hydrophilic polymers and water dispersible hydrophilic polymers are selected from poly(vinyl alcohol)s and poly(vinyl acetate)s and copolymers thereof.

Optional additives

[0067] Optionally additives modifying the functional properties of the sheet, such as heat resistance, heat sealability, opacity, printability, formability, flame resistance, etc. or providing more flexibility and/or strength can be used, and/or additives modifying the appearance of the web.

[0068] Suitably the additives are selected from nanofibrillated cellulose, microfibrillated cellulose, starch, resins etc., as well as colorants etc.

Use and applications of the fiber sheet

[0069] It was surprisingly found that the highly durable and flexible fiber sheet can be used in numerous applications in the field of packaging, covering, construction, interior design, graphics, clothing and fabrics, in carrier bags and sacks, and the like. Examples of such applications are industrial packaging, carrier bags and sacks, covers, medical packaging, envelopes, coverts, medical fabrics, protective apparel, etc.

[0070] The fiber sheet can be made heat sealable by selecting the reinforcement fibers from thermoplastic polymers. Suitably combinations of thermoplastic polymers and latexes are used. Thus products like bags, sacks, flexible packaging and clothing etc. can be easily produced without the usage of glues and adhesives, with efficient heat sealing converting machinery and providing seams having suitable durability.

[0071] The fiber sheet has very good wet strength and water repellency, and thus the structures like bags and sacks maintain their form even when being in contact with moisture.

[0072] The fiber sheet can be printed if desired using printing methods used for fibrous and paper and plastic substrates, such as offset, gravure, flexo, digital printing and the like.

[0073] The fiber sheet and structures, such as products made therefrom can be sterilized using suitable sterilization methods.

[0074] The fiber sheet and structures made therefrom can be pressed, squeezed or compressed to a small volume whereby surprisingly the products maintain the small volume and do not expand like a plastic bag etc. However, it can be reopened repeatable to its original shape and the origial condition can be maintained.

[0075] The fiber sheet may be recyclable and/or at least partly or even completely biodegradable, depending on the selected materials used in the manufacture. Completely biodegradable fiber sheets are obtained from completely biodegradable materials.

[0076] The fiber sheet and structures, such as products, may be designed and manufactured according to varying needs and specifications, with respect to the composition, thickness and field of use of the desired product.

[0077] Products in the field of packaging, such as carrier bags and sacks, light and medium weight shopping bags, bags of various size for replacing conventional plastic bags in grocery shops etc, refuse sacks, wrappings of goods, industrial packages, medical packages, coverts, envelopes etc packaging structures may be obtained from the fiber sheet.

[0078] Products in the field of construction, such as wind shield panels, protective and construction sheets, earth/ground frost insulation sheets, geotextiles and sheets in excavation may be obtained from the fiber sheet. Said products provide improved protection against water and moisture intrusion.

[0079] Water resistant covers are particularly suitable for boats, cars, campers etc.

[0080] Products for use in various graphic applications, such as maps, posters, banners, flags may be obtained from the fiber sheet.

[0081] Products in the field of interior design, such as decorative sheets, may be obtained from the fiber sheet.

[0082] Products in the field of clothing and fabrics, such as protective apparel, disposable clothing, disposable cloths and sheets, medical fabrics, cloths for diapers and disposable incontinence products, and the like may be obtained from the fiber sheet.

[0083] The products and fiber sheets of the present invention may be disposed of by degrading them biologically, recycling them in paper and/or carton recycling systems, or by combustion.

Manufacture of the fiber sheet

[0084] The fiber sheet may be obtained by a method utilizing foam based production technology. Preferably the fiber sheet may be obtained by a method utilizing foam based production technology, followed by finalizing by a method utilizing surface treating technology.

[0085] Particularly, the present invention relates to a method for the manufacture of a fiber sheet, where said method comprises the steps of

- forming at least one foamed dispersion by dispersing fibers comprising natural fibers having average fiber

length of 0.5 - 5mm and reinforcement fibers having average fiber length of 5 - 30 mm, where the reinforcement fibers are selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, in a foam or foamable liquid comprising water and at least one foaming agent to obtain fiber-foam comprising 50 - 99% by weight of natural fibers, 1 to 50% by weight of reinforcement fibers, 0.5 - 10% by weight of at least one foaming agent,

- conveying the formed fiber-foam to a foraminous support and draining liquid trough the foraminous support to form a sheet,
- finalizing the formed sheet by treating the sheet with at least one binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof, and
- drying and calandering the sheet to obtain the fiber sheet, where the finalizing is carried out before or after the drying.

[0086] According to one embodiment the foam or foamable liquid comprises at least one binder.

[0087] According to one embodiment the foam or foamable liquid comprises at least one binder and the fiber-foam comprises 0.5 - 10% by weight of at least one binder.

[0088] The method utilizing foam based production technology is a foam-laid method generally known in the art.

[0089] Preferably, a fiber web is formed using a foam-laid method, followed by finalizing with a method selected from surface treatment methods, particularly preferably by applying binder to the fibrous web or sheet with a method selected from surface treatment methods.

[0090] In the surface treatment method an aqueous dispersion or foam comprising 10- 70 wt%, preferably 20-50 wt% of the binder is applied on the surface of the sheet. Preferably foam is used. Preferably 2-50 g/m^2, particularly preferably 2-10 g/m^2 of the binder is applied on the surface.

[0091] A method utilizing surface treating technology, i.e. surface treatment method is selected from conventional coating methods and external sizing methods used in paper and board manufacture and from spray coating and foam assisted coating methods carried out at the press section of a paper machine, and foam assisted coating methods.

[0092] The surface treatment methods are preferably selected from spray coating and foam assisted methods carried out at the press section of a paper machine, where the foam laid method is carried out, from external sizing methods carried out at a paper machine, where the foam laid method is carried out, methods utilizing size press, and from conventional surface treatment methods carried out with online or offline coating machines, and from foam assisted coating methods.

[0093] The method of the invention provides effective, continuous and economic means for producing the fiber sheets of the invention.

Foam-laid method

[0094] The foam-laid method may be any foam-laid method known in the art. Typically a fiber web is formed from a dispersion of fibers in a foamed liquid. A pulp or fiber furnish is first prepared in a pulper, followed by dewatering, mixing with a foam or foamable liqued comprising a surfactant and water. The fibers are dispersed in the foam and the formed fiber-foam is deposited on a wire and the main portion of the liquid, which is essentially in the form of foam, is removed. This technique is disclosed in EP 481746.

[0095] The foam-laid method makes it possible to produce flexible, plastic like fiber webs. The foam-formation technology provides several benefits, such as even formation, controllable fiber orientation and makes it possible to use polymers and long reinforcement fibers, which are generally not suitable for water forming methods.

[0096] In the foam-laid method a binder may be used, selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, such as biopolymers based on starch derivatives, natural gum latexes, acrylic latexes, alginates, guar gum, hemicellulose derivatives, chitin, chitosan, pectin, agar, xanthan, amylose, amylopectin, alternan, gellan, mutan, dextran, pullulan, fructan, locust bean gum, carrageenan, glycogen, glycosaminoglycans, murein, bacterial capsular polysaccharides, and the like and combinations thereof.

[0097] The foaming agent, also known as foaming polymer, is selected from water-soluble foaming polymeric agent and water dispersible foaming polymeric agents and combinations thereof.

[0098] Preferably the foaming agent is selected from water soluble glycans, water dispersible glycans, water soluble hydrophilic polymers and water dispersible hydrophilic polymers and combinations thereof.

[0099] Preferably the water soluble glycans and water dispersible glycans are selected from polysaccharides and derivatives thereof.

[0100] Preferably the water soluble hydrophilic polymers and water dispersible hydrophilic polymers are selected from poly(vinyl alcohol)s and poly(vinyl acetate)s and copolymers thereof.

[0101] Optionally the foam or foamable liquid may comprise at least one binder, preferably the amount of the binder is 0.5 - 10% by weight.

[0102] The fiber-foam refers here to foamed dispersion.

[0103] Optionally at least one additional foamed dispersion is formed of fibers comprising natural fibers and reinforcement fibers by dispersing said fibers in a foamable liquid comprising water and at least one foaming polymer.

[0104] Optionally said foamed dispersions are conveyed to the foraminous support as individual layers.

[0105] The foraminous support is suitable a wire.

[0106] The draining is suitably carried out with the aid of vacuum, using vacuum pumps, or by gravitational filtration.

[0107] Drying of the formed web or sheet is suitably carried out for example by heating with means conventionally used in the manufacture of non-woven, paper and tissue products.

[0108] In the method the foamed dispersion (or dispersions) is formed of 50 - 99% by weight, preferably 70 - 99% by weight, particularly preferably 85 - 99% by weight of natural fibers, 1 to 50% by weight, preferably 1 - 30% by weight, particularly preferably 1 - 20% by weight of reinforcement fibers, 0.5 - 10% by weight, preferably 0.5 - 5% by weight, particularly preferably 0.5 - 2% by weight of at least one foaming polymer, 0.5 - 10% by weight, preferably 0.5 - 5% by weight, particularly preferably 0.5 - 2% by weight of at least one binder, water and optional additives.

[0109] An additional foamed dispersion (s) may be conveyed individually on the support, whereby a product comprising at least two individual fiber layers is obtained.

[0110] The foamed dispersion comprises from 40 to 80% by volume, preferably from 55 to 75% by volume of air. Air refers here to all gases having more than 50% by volume of nitrogen content, which includes atmospheric air or gases derived from atmospheric air.

[0111] In the foam-laid method any equipment and apparatus used in foam-formation processes in the tissue paper and non-woven manufacture can be utilized here, such as suggested for example in GB 1397378, EP 481746 and US 3716449. Products comprising one or more foam-deposited layers may be obtained.

[0112] Optionally the dried product (such as sheet, felt, etc) is coated or laminated on one side or on both sides with at least one layer comprising at least one polymer.

[0113] The applying of the polymer may be carried out by coating using spray coating, extrusion coating, curtain coating or foam coating.

Finalizing of the sheet

[0114] The sheet may be finalized utilizing surface treatment methods. The surface treatment methods are preferably selected from spray coating and foam assisted methods carried out at the press section of a paper machine, where the foam laid method is carried out, from external sizing methods carried out at a paper machine, where the foam laid method is carried out, methods utilizing size press, and from conventional surface treatment methods carried out with online or offline coating machines, and from foam assisted coating methods.

[0115] Surface treatment methods with foamed compositions include external sizing of fibrous web using a foamed composition and coating with a foamed composition. Any surface treatment methods with foamed compositions known in the art may be utilized, such as those described in US 4,597,831 and in EP 0195458.

[0116] In the method a substrate is treated by applying to the surface of the substrate a foamed composition comprising a liquid vehicle, a binder and a foaming agent, through at least one foam applicator, followed by breaking down mechanically at least part of the applied foam.

[0117] The substrate is a sheet or web obtained from the natural fibers and reinforcement fibers using foam laid technology, as described above

[0118] The liquid vehicle is preferably an aqueous solution, suitably water.

[0119] In the surface treatment method an aqueous dispersion or foam comprising 10- 70 wt%, preferably 20-50 wt% of the binder is applied on the surface of the sheet. Preferably foam is used. Preferably 2-50 g/m^2, particularly preferably 2-10 g/m^2 of the binder is applied on the surface.

[0120] Suitably the binder is selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, such as biopolymers based on starch derivatives, natural gum latexes, alginates, guar gum, hemicellulose derivatives, chitin, chitosan, pectin, agar, xanthan, amylose, amylopectin, alternan, gellan, mutan, dextran, pullulan, fructan, locust bean gum, carrageenan, glycogen, glycosaminoglycans, murein, bacterial capsular polysaccharides, and the like and combinations thereof.

[0121] The foaming agent is selected from water-soluble foaming polymeric agent and water dispersible foaming polymeric agents and combinations thereof. Preferably the foaming agent is selected from water soluble glycans, water dispersible glycans, water soluble hydrophilic polymers and water dispersible hydrophilic polymers and combinations thereof.

[0122] Preferably the water soluble glycans and water dispersible glycans are selected from polysaccharides and derivatives thereof.

[0123] Preferably the water soluble hydrophilic polymers and water dispersible hydrophilic polymers are selected from poly(vinyl alcohol)s and poly(vinyl acetate)s and copolymers thereof.

[0124] The mechanical breaking down of the foam may preferably be effected after drying with drying felts, using any suitable method, such as by suction if the foam is applied to a sheet or web still on a wire or foraminous former, or if the foam is applied to a sheet the mechanical breakdown may be effected using an a knife edge or blade, roll-nip press, or by means of rolls, rods or air knife.

[0125] After breaking down of the foam the sheet or

web, which is dried and calendared, followed by optional coating as described above.

[0126] Alternatively conventional surface treatment methods carried out with online or offline coating machines may be used for finalizing the fiber sheet obtained by foam laid methods as described above. Said conventional methods utilize aqueous non-foamed coating compositions comprising the binder. The coating is effected on/in the sheet or web suitably using a roll-nip press, blade-coater, spray coating device, curtain coating device, extrusion coating device.

[0127] Binders and foaming agents as described in connection with surface treatment with foamed compositions can be used, in the same amounts.

[0128] In a preferable embodiment acrylic latexes are used in the present invention.

[0129] In another preferable embodiment acrylic latex (polyacrylic acid) and polyvinylalcohols are used.

[0130] In further preferable embodiment acrylic acids are used and the manufacturing method is selected from surface treatment methods with foamed composition.

[0131] Particularly, on an industrial scale it is preferable to use a foam laid method followed by finalizing, where the binder is added in the finalizing step.

[0132] The present invention has several advantages. It provides a continuous, effective and economic method for the manufacture of flexible fibrous webs, thus providing economic and environmental benefits. Completely bio-degradable products can be achieved if desired. The properties of the products can be tailored by adjusting the starting materials and process.

[0133] The fiber sheets of the invention can be heat-sealable in contrast to the paper.

[0134] Further, the fiber sheets of the invention are water resistant in contrast to the paper.

[0135] The fiber sheets of the invention have several properties, which are more typical to plastics than paper. Particularly, when compared with plastics, the fiber sheet of the invention comprises mainly or even completely renewable raw material, it is recyclable and can be biodegradable.

[0136] One severe drawbacks of paper is the sensitivity for the moisture. If paper gets wet it loses its strength values very rapidly. In case of the fiber sheets of the invention the wetness reduces strength values only slightly.

[0137] Particularly biodegradable products can be obtained having excellent properties. Tailored products can be manufactured according to end user's need, the amounts of components, foaming polymers and binders may be varied resulting in different properties in the products.

EXAMPLES

[0138] The following examples are illustrative of embodiments of the present invention, as described above, and they are not meant to limit the invention in any way.

EXAMPLE 1

Manufacture of fibrous sheets

[0139] The fibrous sheets were manufactured on laboratory scale as follows. Soft wood fibers were mixed with bicomponent synthetic fibers (PES/PE) in the ratio of 70:30 to the prefabricated foam made from water and polyvinyl alcohol containing soft latex (poly acrylic acid). Foam laid hand sheets were made using a method and an equipment setup adopted in the glassfiber industry. The fiber foam was decanted into a hand sheet mold and filtrated through a wire using a vacuum chamber. Then the filtrated sheet was detached with the wire from the mold and pre-dried on the suction table. The suction table has a slit with 5 mm width, which sucks air through the sheets with ~0.2 bar vacuum. The picture series presented in Figure 8 shows the working procedure used in the laboratory scale development work.

[0140] After drying under constant atmosphere the sheets were calandered using a Gradek laboratory calander, under nip pressure 80 bar and at roll temperature of 60°C.

[0141] The properties of the obtained fiber sheets were tested and paper and plastic were used as reference. The benefit of the fibre sheet of invention is that its properties combine the advantages of paper and plastic. The fiber sheets of the invention have smaller tensile strength than paper but similar to the plastic used in plastic bags. Paper sheet breaks down immediately, when local disruption of the fiber network occurs. Similar to plastic films, the sheet of the invention has an area of elongation with constant force. It means that even when there starts to be breakings in the structure, the material can still carry load. It also gives material flexibility to withstand large force peaks, which is exemplified in Figure 1. Figure 1 shows pulling force as a function of the elongation for paper (1A), plastic (1B) and invention samples 60 and 20 g/m^2 (1C and 1D).

[0142] Figure 2 presents strength (2A) and TEA (2B) of paper, plastic and products of the invention, calculated from the total areas of the curves, giving the toughness of the material. The sheets of the invention have this value higher than paper but smaller than plastic.

[0143] Figure 3 illustrates the stretch and strength properties and mechanism of failure of the samples according to the invention, as pictures of the test strips used in the measurements. Samples 1-5 are parallel samples made according to the invention. In this test the samples according to the invention after strength measurements were used. The complete breaking from one point, using paper as reference, was observed. The samples of the invention stretched significantly before breaking, finally breaking occurred at one or more points.

[0144] Figure 4 illustrates the properties of the samples according to the invention, when contacted with water. One severe drawback of conventional paper is the sensitivity for the moisture. If a paper sheet absorbs moisture

it loses its strength properties very rapidly. In case of the sheets of the invention the wetness of the sample reduces strength values only slightly.

[0145] In Figure 4, in 4A and in 4B the behaviour of the water droplet on the surface of a conventional paper bag (left and middle samples, both sides of the bag) and of the material according to the invention (samples on the right, after time period 15 seconds and after 30 seconds. The paper bag had absorbed the water droplets, whereas the water droplet on the surface of the sample according to the invention was remained unchanged. After 40 minutes (4C) the water droplet still can be seen on the surface according to the invention.

[0146] Figure 4, 4D and 4E illustrates samples of paper, of conventional paper bag (brown, resin sized) and of the material according to the invention, where the samples were set in water (4D). After 3 minutes the samples were removed from the water and drawn (4E). The paper materials broke similar way, but the material according to the invention stretched before a breakdown.

[0147] Figure 5 illustrates the stretch and strength properties of the wet sample according to the invention, using paper as reference. A water droplet of the size of 200 μl was put on the samples and allowed to absorb in the structure: in paper 40 seconds, sample according to the invention 40 minutes and rest of the water was dried away using a paper towel. Elongation was measured from the samples. Elongation of dry paper sample is presented in Figure 5A, and of wet paper sample in Figure 5B. Elongation of dry sample of the invention is presented in Figure 5C and of wet paper sample in Figure 5D. The water droplet was absorbed in the conventional paper and also in brown paper bag in 30 seconds, whereas the fiber sheet of the invention repelled water. The elongation of paper decreased from 2 % to less than 0.7 % in the wet sample. The fiber sheet absorbed 2/3 of the water droplet after 40 minutes. The elongation decreased from 37% to 9 % in the moist sample of the invention.

[0148] Figure 6 illustrates the bursting strength of the sample according to the invention (left) and paper (right).In case of paper after initial burst the whole section under pressure rips open, where as in case of the sheet of the invention only the cap of the pressed area is damaged. This indicates much better resistance to withstand puncture, which is a highly critical property particularly in packaging applications.

[0149] Figure 7 illustrates the tear strength of the sample according to the invention.The tear strength of the sheet made according to the invention is over 70 5 higher than that for typical paper bag material (kraft paper), over 200 % higher than that for conventional paper, and over 50 % higher than that of biodegradable plastic film. The plastic shopping bag measured had a tear strength of 6200 mN.

EXAMPLE 2

Manufacture of bags from fiber sheets

[0150] Bags were made from fiber sheets manufactured as follows. Fiber sheets were obtained with the foam-laid method as described in example 1. Soft wood (pine) fibers were mixed with bicomponent synthetic fibers (PES/PE) in the ratio of 70:30 to the prefabricated foam made from water and polyvinyl alcohol (PVA) containing soft latex (poly acrylic acid). After drying under constant atmosphere the sheets were calandered. Fiber sheets containing 10 wt% of PVA and latex (total) and having grammage of 30 g/m^2 and 80 g/m^2 were obtained. Heat sealed bags were made of the fiber sheets. The bags were repeatably compressed to small balls and reopened to the original shape without any alterations in the appearance and no breakage was observed. The bags can be turned around like socks. A photo of the bags is presented in Figure 9A and tearing strength of plastic bags, paper bags, paper and the bags made in this example is presented in Figure 9B.

Claims

1. A fiber sheet, **characterized in that** the fiber sheet it is obtainable by foam based production technology,

   - it comprises 50 - 99 wt% of natural fibers having average fiber length of 0.5 - 5mm and 1-50 wt% of reinforcement fibers having average fiber length of 5 - 30 mm,
   - a binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof,
   - foaming agent,
   - 50-99 wt% of said fibers are natural fibers and 1-50 wt% of said fibers are reinforcement fibers selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, and
   - said fiber sheet has stretch in the range of 3-50%.

2. The fiber sheet according to claim 1, **characterized in that** the fiber sheet fiber sheet is biodegradable and/or recyclable.

3. The fiber sheet according to claim 1 or 2, **characterized in that** the polymer fibers are thermoplastic polymer fibers selected from polylactides (PLA), gly-

colic acid polymers (PGA), polyolefins (PO), polyethyleneterephthalates (PET), polyester (PES), polyvinyl alcohols (PVA) and bicomponent fibers comprising thermoplastic polymers.

4. The fiber sheet according to claim 3, **characterized in that** the bicomponent fibers are selected from fibers having a thermoplastic polymer as sheat polymer.

5. The fiber sheet according to any one claims 1-4, **characterized in that** the foaming agents is selected from water-soluble and dispersible foaming agents, preferably from water-soluble glycans, water-dispersible glycans, water-soluble hydrophilic polymers and copolymers, and water-dispersible hydrophilic polymers and copolymers, particularly preferably from polysaccharides and derivatives thereof, poly(vinyl alcohols), poly(vinyl acetates) and copolymers thereof.

6. The fiber sheet according to any one of claims 1-5, **characterized in that** the fiber sheet has stretch in the range of 5-45%, preferably 10-40%.

7. The fiber sheet according to any one of claims 1-6, **characterized in that** the foam based production technology comprises foam-laid method followed by finalizing by treating the surface of the fiber sheet with a binder.

8. Use of the fiber sheet of any one of claims 1-7 in packaging, covering, construction, interior design, graphics, carrier bags and sacks, and clothing and fabrics applications.

9. Use according to claim 8, **characterized in that** the packaging applications are selected from carrier bags and sacks, shopping bags, refuse sacks, wrappings of goods, industrial packages, medical packages, coverts, envelopes and bags for replacing plastic bags.

10. Use according to claim 8, **characterized in that** the construction applications are selected from wind shield panels, protective and construction sheets, earth/ground frost insulation sheets, geotextiles and sheets in excavation.

11. Use according to claim 8, **characterized in that** the clothing and fabrics applications are selected from protective apparel, disposable clothing, disposable cloths and sheets, covers, medical fabrics.

12. Use according to claim 8, **characterized in that** the graphic applications are selected from maps, posters, decorative sheets, banners and flags.

13. Structures comprising the fiber sheet of any one of claims 1-7, **characterized in that** the structures are selected from packages, carrier bags, sacks, shopping bags, refuse sacks, wrappings of goods, industrial packages, medical packages, coverts, envelopes and bags for replacing plastic bags.

14. Structures comprising the fiber sheet of any one of claims 1-7, **characterized in that** the structures are selected from wind shield panels, protective and construction sheets, earth/ground frost insulation sheets, geotextiles and sheets in excavation.

15. Structures comprising the fiber sheet of any one of claims 1-7, **characterized in that** the structures are selected from clothing, fabrics, protective apparel, disposable clothing, disposable cloths and sheets, covers and medical fabrics.

16. Structures comprising the fiber sheet of any one of claims 1-7, **characterized in that** the structures are selected from maps, posters, banners, flags and decorative sheets.

17. A method for the manufacture of the fiber sheets of any one of claims 1-7, **characterized in that** the method comprises the steps

- forming at least one foamed dispersion by dispersing fibers comprising natural fibers having average fiber length of 0.5 - 5mm and reinforcement fibers having average fiber length of 5 - 30 mm, where the reinforcement fibers are selected from polymer fibers, mineral fibers, non-wood natural fibers and glass-fibers and combinations thereof, in a foam or foamable liquid comprising water and at least one foaming agent to obtain fiber-foam comprising 50 - 99% by weight of natural fibers, 1 to 50% by weight of reinforcement fibers, 0.5 - 10% by weight of at least one foaming agent,
- conveying the formed fiber-foam to a foraminous support and draining liquid trough the foraminous support to form a sheet,
- finalizing the formed sheet by treating the sheet with at least one binder selected from a group consisting of polyvinyl alcohols, polyvinyl acetate dispersions, ethyl vinyl alcohol dispersions, polyurethane dispersions, acrylic latexes, styrene butadiene dispersions, binders based on finely divided cellulose, binders based on cellulose derivatives, biopolymers, and combinations thereof, and
- drying and calandering the sheet to obtain the fiber sheet, where the finalizing is carried out before or after the drying.

18. The method according to claim 17, **characterized**

in that the foam or foamable liquid comprises at least one binder.

19. The method according to claim 17 or 18, **characterized in that** the polymer fibers are thermoplastic polymer fibers selected from polylactides (PLA), glycolic acid polymers (PGA), polyolefins (PO), polyethyleneterephthalates (PET), polyester (PES), polyvinyl alcohols (PVA) and bicomponent fibers comprising thermoplastic polymers.

20. The method according to claim 19, **characterized in that** the bicomponent fibers are selected from fibers having a thermoplastic polymer as sheat polymer.

21. The method according to any one claims 17 - 20, **characterized in that** the foaming agents is selected from water-soluble and dispersible foaming agents, preferably from water-soluble glycans, water-dispersible glycans, water-soluble hydrophilic polymers and copolymers, and water-dispersible hydrophilic polymers and copolymers, particularly preferably from polysaccharides and derivatives thereof, poly(vinyl alcohols), poly(vinyl acetates) and copolymers thereof.

22. The method according to any one of claims 17 - 21, **characterized in that** the finalizing is carried out with a method selected from surface treatment methods, preferably by applying the binder to the sheet with a surface treatment method selected from spray coating methods and foam assisted methods carried out at the press section of a paper machine, where the foam laid method is carried out, from external sizing methods carried out at a paper machine, where the foam laid method is carried out, methods utilizing size press, and from conventional surface treatment methods carried out with online or offline coating machine, and foam assisted coating methods.

Patentansprüche

1. Faserbahn, **dadurch gekennzeichnet, dass** die Faserbahn durch eine schaumbasierte Produktionstechnologie erzeugbar ist,

- umfassend: 50 bis 99 Gew.-% Naturfasern mit einer mittleren Faserlänge von 0,5 bis 5 mm und 1 bis 50 Gew.-% Verstärkungsfasern mit einer mittleren Faserlänge von 5 bis 30 mm,
- ein Bindemittel, das gewählt ist aus einer Gruppe bestehend aus Polyvinylalkoholen, Polyvinylacetat-Dispersionen, Ethylvinylalkohol-Dispersionen, Polyurethan-Dispersionen, Acrylatexen, Styrolbutadien-Dispersionen, auf fein geteilter Cellulose basierenden Bindemitteln, auf Cellulosederivaten basierenden Bindemitteln, Biopolymeren und deren Kombinationen,
- ein Schäumungsmittel,
- wobei 50 bis 99 Gew.-% der Fasern Naturfasern sind und 1 bis 50 Gew.-% der Fasern Verstärkungsfasern sind, die gewählt sind aus Polymerfasern, Mineralfasern, nichtholzigen Naturfasern und Glasfasern und deren Kombinationen sind, und
- die Faserbahn eine Dehnung im Bereich von 3 bis 50 % aufweist.

2. Faserbahn nach Anspruch 1, **dadurch gekennzeichnet, dass** die Faserbahn biologisch abbaubar und/oder rezyklierbar ist.

3. Faserbahn nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Polymerfasern thermoplastische Polymerfasern sind, die gewählt sind aus Polylaktiden (PLA), Glycolsäurepolymeren (PGA), Polyolefinen (PO), Polyethylenterephthalaten (PET), Polyestern (PES), Polyvinylalkoholen (PVA) und Zweikomponentenfasern, die thermoplastische Polymere umfassen.

4. Faserbahn nach Anspruch 3, **dadurch gekennzeichnet, dass** die Zweikomponentenfasern aus Fasern gewählt sind, die ein thermoplastisches Polymer als Mantelpolymer aufweisen.

5. Faserbahn nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** das Schäumungsmittel gewählt ist aus wasserlöslichen und -dispergierbaren Schäumungsmitteln, bevorzugt aus wasserlöslichen Glykanen, wasserdispergierbaren Glykanen, wasserlöslichen hydrophilen Polymeren und Copolymeren sowie wasserdispergierbaren hydrophilen Polymeren und Copolymeren, besonders bevorzugt aus Polysacchariden und deren Derivaten, Poly(vinylalkoholen), Poly(vinylacetaten) und deren Copolymeren.

6. Faserbahn nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die Faserbahn eine Dehnung im Bereich von 5 bis 45 %, bevorzugt 10 bis 40 %, aufweist.

7. Faserbahn nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die schaumbasierte Produktionstechnologie ein Schaumlegeverfahren, gefolgt von der Fertigbearbeitung durch Behandeln der Oberfläche der Faserbahn mit einem Bindemittel, umfasst.

8. Verwendung der Faserbahn nach einem der Ansprüche 1 bis 7 in Verpackung, Verkleidung, Bau, Innengestaltung, Grafik, Tragetaschen und Säcke sowie Bekleidungs- und Stoffanwendungen.

9. Verwendung nach Anspruch 8, **dadurch gekennzeichnet, dass** die Verpackungsanwendungen gewählt sind aus Tragetaschen und Säcken, Einkaufsbeuteln, Müllsäcken, Warenumhüllungen, Industrieverpackungen, medizinischen Verpackungen, Bedeckungen, Umschlägen und Beuteln als Ersatz von Plastikbeuteln.

10. Verwendung nach Anspruch 8, **dadurch gekennzeichnet, dass** die Bauanwendungen ausgewählt sind aus Windschutzelementen, Schutz- und Baubahnen, Bodenfrostisolierbahnen, Geotextilien und Verkleidungen in Baugruben.

11. Verwendung nach Anspruch 8, **dadurch gekennzeichnet, dass** die Bekleidungs- und Stoffanwendungen ausgewählt sind aus Schutzbekleidung, Einwegbekleidung, wegwerfbaren Tüchern und Laken, Bezügen, medizinischen Geweben.

12. Verwendung nach Anspruch 8, **dadurch gekennzeichnet, dass** die Grafikanwendungen ausgewählt sind aus Landkarten, Plakaten, Dekorbahnen, Bannern und Flaggen.

13. Strukturen, die die Faserbahn nach einem der Ansprüche 1 bis 7 umfassen, **dadurch gekennzeichnet, dass** die Strukturen ausgewählt sind aus Verpackungen, Tragetaschen, Säcken, Einkaufsbeuteln, Müllsäcken, Warenumhüllungen, Industrieverpackungen, medizinischen Verpackungen, Bedeckungen, Umschlägen und Beuteln als Ersatz von Plastikbeuteln.

14. Strukturen, die die Faserbahn nach einem der Ansprüche 1 bis 7 umfassen, **dadurch gekennzeichnet, dass** die Strukturen ausgewählt sind aus Windschutzelementen, Schutz- und Baubahnen, Bodenfrostisolierbahnen, Geotextilien und Verkleidungen in Baugruben.

15. Strukturen, die die Faserbahn nach einem der Ansprüche 1 bis 7 umfassen, **dadurch gekennzeichnet, dass** die Strukturen ausgewählt sind aus Bekleidung, Flächengebilden, Schutzkleidung, Einwegbekleidung, wegwerfbaren Tüchern und Laken, Bezügen und medizinischen Geweben.

16. Strukturen, die die Faserbahn nach einem der Ansprüche 1 bis 7 umfassen, **dadurch gekennzeichnet, dass** die Strukturen ausgewählt sind aus Landkarten, Plakaten, Bannern, Flaggen und Dekorbahnen.

17. Verfahren zur Herstellung der Faserbahnen nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** das Verfahren die Schritte umfasst:

- Ausbilden mindestens einer geschäumten Dispersion durch Dispergieren von Fasern, die Naturfasern mit einer mittleren Faserlänge von 0,5 bis 5 mm und Verstärkungsfasern mit einer mittleren Faserlänge von 5 bis 30 mm umfassen, wobei die Verstärkungsfasern ausgewählt sind aus Polymerfasern, Mineralfasern, nichtholzigen Naturfasern und Glasfasern und deren Kombinationen, in einem Schaum oder einer schäumbaren Flüssigkeit, die Wasser und mindestens ein Schäumungsmittel umfasst, um einen Faserschaum zu erzeugen, der 50 bis 99 Gew.-% Naturfasern, 1 bis 50 Gew.-% Verstärkungsfasern, 0,5 bis 10 Gew.-% mindestens eines Schäumungsmittels umfasst,
- Fördern des ausgebildeten Faserschaums zu einer foraminösen Unterlage und Abführen von Flüssigkeit durch die foraminöse Unterlage zur Ausbildung einer Bahn,
- Fertigbearbeitung der ausgebildeten Bahn durch Behandeln der Bahn mit mindestens einem Bindemittel, das ausgewählt ist aus einer Gruppe bestehend aus Polyvinylalkoholen, Polyvinylacetat-Dispersionen, Ethylvinylalkohol-Dispersionen, Polyurethan-Dispersionen, Acryllatexen, Styrolbutadien-Dispersionen, auf fein geteilter Cellulose basierenden Bindemitteln, auf Cellulosederivaten basierenden Bindemitteln, Biopolymeren und deren Kombinationen, und
- Trocknen und Kalandern der Bahn zur Erzeugung der Faserbahn, wobei die Fertigbearbeitung vor oder nach dem Trocknen ausgeführt wird.

18. Verfahren nach Anspruch 17, **dadurch gekennzeichnet, dass** der Schaum oder die schäumbare Flüssigkeit mindestens ein Bindemittel umfasst.

19. Verfahren nach Anspruch 17 oder 18, **dadurch gekennzeichnet, dass** die Polymerfasern thermoplastische Polymerfasern sind, die gewählt sind aus Polylaktiden (PLA), Glycolsäurepolymeren (PGA), Polyolefinen (PO), Polyethylenterephthalaten (PET), Polyester (PES), Polyvinylalkoholen (PVA) und Zweikomponentenfasern, die thermoplastische Polymere umfassen.

20. Verfahren nach Anspruch 19, **dadurch gekennzeichnet, dass** die Zweikomponentenfasern aus Fasern ausgewählt sind, die ein thermoplastisches Polymer als Mantelpolymer aufweisen.

21. Verfahren nach einem der Ansprüche 17 bis 20, **dadurch gekennzeichnet, dass** das Schäumungsmittel gewählt ist aus wasserlöslichen und -dispergierbaren Schäumungsmitteln, bevorzugt aus wasserlöslichen Glykanen, wasserdispergierbaren Glyka-

nen, wasserlöslichen hydrophilen Polymeren und Copolymeren sowie wasserdispergierbaren hydrophilen Polymeren und Copolymeren, besonders bevorzugt aus Polysacchariden und deren Derivaten, Poly(vinylalkoholen), Poly(vinylacetaten) und deren Copolymeren.

22. Verfahren nach einem der Ansprüche 17 bis 21, **dadurch gekennzeichnet, dass** die Fertigbearbeitung mit einem Verfahren ausgeführt wird, das aus Oberflächenbehandlungsverfahren ausgewählt ist, bevorzugt durch Auftragen des Bindemittels auf die Bahn mit einem Oberflächenbehandlungsverfahren, das ausgewählt ist aus Aufsprühstreichverfahren und Schaum-unterstützten Verfahren, die an der Pressenpartie einer Papiermaschine ausgeführt werden, an der das Schaumlegeverfahren ausgeführt wird, aus externen Leimungsverfahren, die an einer Papiermaschine ausgeführt werden, an der das Schaumlegeverfahren ausgeführt wird, Verfahren, die eine Leimpresse nutzen, und aus herkömmlichen Oberflächenbehandlungsverfahren, die mit einer Online- oder Offline-Streichmaschine ausgeführt werden, und Schaum-unterstützten Beschichtungsverfahren.

Revendications

1. Feuille fibreuse, **caractérisée en ce que** la feuille fibreuse est obtenable par une technologie de fabrication à base de mousse,

- comprenant : 50 à 99 % en poids de fibres naturelles ayant une longueur de fibre moyenne de 0,5 à 5 mm et 1 à 50 % en poids de fibres de renforcement ayant une longueur de fibre moyenne de 5 à 30 mm,
- un liant choisi dans un groupe constitué par les alcools polyvinyliques, les dispersions d'acétate de polyvinyle, les dispersions d'éthylène alcool vinylique, les dispersions de polyuréthane, les latex acryliques, les dispersions de butadiène de styrène, les liants à base de cellulose finement divisée, les liants à base de dérivés de cellulose, les biopolymères et leurs combinaisons,
- un agent moussant,
- 50 à 99 % en poids desdites fibres étant des fibres naturelles et 1 à 50 % en poids desdites fibres étant des fibres de renforcement choisies parmi les fibres polymériques, les fibres minérales, les fibres naturelles non ligneuses et les fibres de verre et leurs combinaisons, et
- ladite feuille fibreuse a un allongement compris entre 3 et 50 %.

2. Feuille fibreuse selon la revendication 1, **caractérisée en ce que** la feuille fibreuse est biodégradable et/ou recyclable.

3. Feuille fibreuse selon la revendication 1 ou 2, **caractérisée en ce que** les fibres polymériques sont des fibres polymériques thermoplastiques choisies parmi les polylactides (PLA), les polyglycolides (PGA), les polyoléfines (PO), les polytéréphthalates d'éthylène (PET), les polyesters (PES), les alcools polyvinyliques (PVA) et les fibres bicomposantes comprenant des polymères thermoplastiques.

4. Feuille fibreuse selon la revendication 3, **caractérisée en ce que** les fibres bicomposantes sont choisies parmi les fibres ayant comme polymère d'enveloppe un polymère thermoplastique.

5. Feuille fibreuse selon l'une des revendications 1 à 4, **caractérisée en ce que** l'agent moussant est choisi parmi les agents moussants solubles et dispersibles dans l'eau, préférablement parmi les glycanes solubles dans l'eau, les glycanes dispersibles dans l'eau, les polymères et copolymères hydrophiles solubles dans l'eau, et les polymères et copolymères hydrophiles dispersibles dans l'eau, de manière particulièrement préférée parmi les polysaccharides et leurs dérivés, les poly(alcools vinyliques), les poly(acétates vinyliques) et leurs copolymères.

6. Feuille fibreuse selon l'une des revendications 1 à 5, **caractérisée en ce que** la feuille fibreuse a un allongement compris entre 5 et 45 %, préférablement entre 10 et 40 %.

7. Feuille fibreuse selon l'une des revendications 1 à 6, **caractérisée en ce que** la technologie de production à base de mousse comprend un procédé de formation par mousse suivi par une finalisation par traitement de la surface de la feuille fibreuse avec un liant.

8. Utilisation de la feuille fibreuse selon l'une des revendications 1 à 7 dans le conditionnement, le revêtement, la construction, la décoration intérieure, le graphique, les sacs à poignées et de transport, et dans les applications d'habillement et de tissu.

9. Utilisation selon la revendication 8, **caractérisée en ce que** les applications de conditionnement sont choisies parmi les sacs à poignées et de transport, les sacs à provision, les sacs à ordures, les emballages de marchandises, les emballages industriels, les emballages médicaux, les housses, les enveloppes et les sacoches pour remplacer les sacs en plastique.

10. Utilisation selon la revendication 8, **caractérisée en**

ce que les applications de construction sont choisies parmi les panneaux anti-vent, les membranes de construction et de protection, les membranes isolantes contre la gelée au sol, les géotextiles et les membranes en excavation.

11. Utilisation selon la revendication 8, **caractérisée en ce que** les applications d'habillement et de tissu sont choisies parmi les vêtements de protection, les vêtements à usage unique, les chiffons et draps jetables, les housses, les tissus médicaux.

12. Utilisation selon la revendication 8, **caractérisée en ce que** les applications graphiques sont choisies parmi les cartes géographiques, les affiches, les feuilles décoratives, les bannières et les drapeaux.

13. Structures comprenant la feuille fibreuse selon l'une des revendications 1 à 7, **caractérisées en ce que** les structures sont choisies parmi les emballages, les sacs à poignées, les sacs de transport, les sacs à provision, les sacs à ordures, les emballages de marchandises, les emballages industriels, les emballages médicaux, les housses, les enveloppes et les sacoches pour remplacer les sacs en plastique.

14. Structures comprenant la feuille fibreuse selon l'une des revendications 1 à 7, **caractérisées en ce que** les structures sont choisies parmi les panneaux anti-vent, les membranes de construction et de protection, les membranes isolantes contre la gelée au sol, les géotextiles et les membranes en excavation.

15. Structures comprenant la feuille fibreuse selon l'une des revendications 1 à 7, **caractérisées en ce que** les structures sont choisies parmi les habillements, les tissus, les vêtements de protection, les vêtements à usage unique, les chiffons et draps jetables, les housses et les tissus médicaux.

16. Structures comprenant la feuille fibreuse selon l'une des revendications 1 à 7, **caractérisées en ce que** les structures sont choisies parmi les cartes géographiques, les affiches, les bannières, les drapeaux et les feuilles décoratives.

17. Procédé de fabrication des feuilles fibreuses selon l'une des revendications 1 à 7, **caractérisé en ce que** le procédé comprend les étapes consistant à

- former au moins une dispersion de mousse en dispersant des fibres comprenant des fibres naturelles ayant une longueur de fibre moyenne de 0,5 à 5 mm et des fibres de renforcement ayant une longueur de fibre moyenne de 5 à 30 mm, lesdites fibres de renforcement étant choisies parmi les fibres polymériques, les fibres minérales, les fibres naturelles non ligneuses et les fibres de verre et leurs combinaisons, dans une mousse ou un liquide moussable comprenant de l'eau et au moins un agent moussant pour obtenir une mousse fibreuse comprenant 50 à 99 % en poids de fibres naturelles, 1 à 50 % en poids de fibres de renforcement, 0,5 à 10 % en poids d'au moins un agent moussant,
- acheminer la mousse fibreuse formée vers un support foramineux et évacuer du liquide à travers le support foramineux pour former une feuille,
- finaliser la feuille formée en traitant la feuille avec au moins un liant choisi dans un groupe constitué par les alcools polyvinyliques, les dispersions d'acétate de polyvinyle, les dispersions d'éthylène alcool vinylique, les dispersions de polyuréthane, les latex acryliques, les dispersions de butadiène de styrène, les liants à base de cellulose finement divisée, les liants à base de dérivés de cellulose, les biopolymères et leurs combinaisons, et
- sécher et calandrer la feuille pour obtenir la feuille fibreuse, ladite finalisation étant réalisée avant ou après le séchage.

18. Procédé selon la revendication 17, **caractérisé en ce que** la mousse ou le liquide moussable comprend au moins un liant.

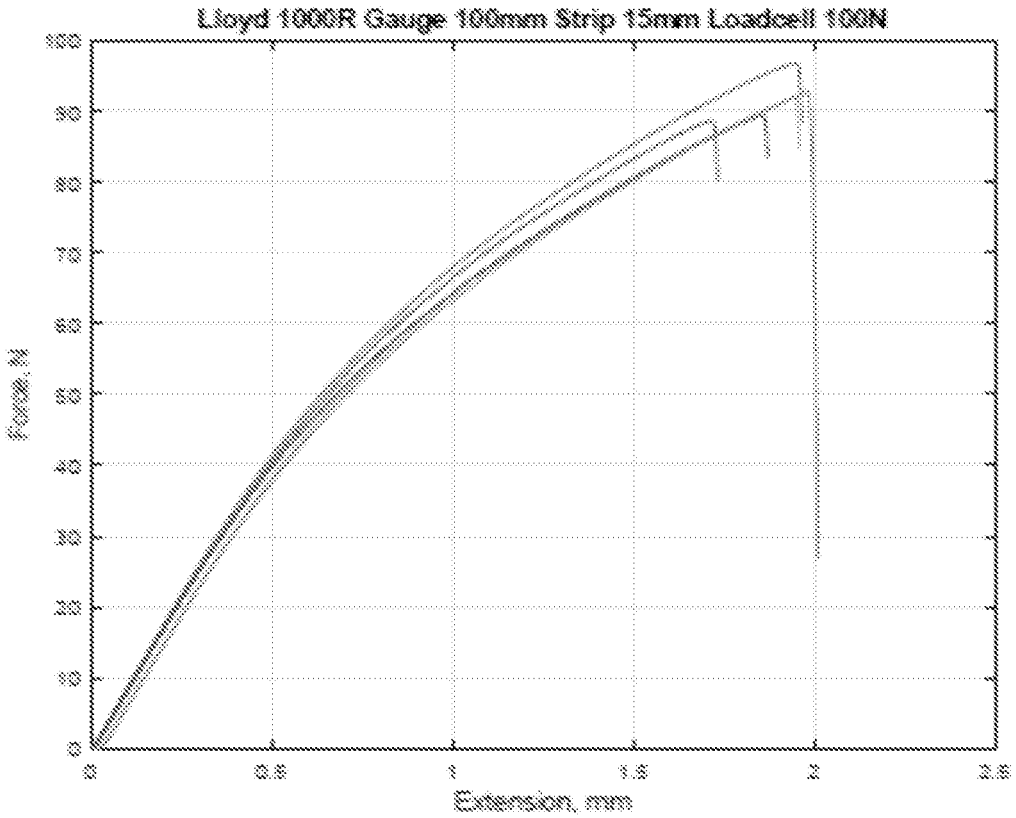
19. Procédé selon la revendication 17 ou 18, **caractérisé en ce que** les fibres polymériques sont des fibres polymériques thermoplastiques choisies parmi les polylactides (PLA), les polyglycolides (PGA), les polyoléfines (PO), les polytéréphthalates d'éthylène (PET), les polyesters (PES), les alcools polyvinyliques (PVA) et les fibres bicomposantes comprenant des polymères thermoplastiques.

20. Procédé selon la revendication 19, **caractérisé en ce que** les fibres bicomposantes sont choisies parmi les fibres ayant comme polymère d'enveloppe un polymère thermoplastique.

21. Procédé selon l'une des revendications 17 à 20, **caractérisé en ce que** l'agent moussant est choisis parmi les agents moussants solubles et dispersibles dans l'eau, préférablement parmi les glycanes solubles dans l'eau, les glycanes dispersibles dans l'eau, les polymères et copolymères hydrophiles solubles dans l'eau, et les polymères et copolymères hydrophiles dispersibles dans l'eau, de manière particulièrement préférée parmi les polysaccharides et leurs dérivés, les poly(alcools vinyliques), les poly (acétates vinyliques) et leurs copolymères.

22. Procédé selon l'une des revendications 17 à 21, **caractérisé en ce que** la finalisation est réalisée avec un procédé choisi parmi les procédés de traitement

de surface, préférablement par l'application du liant sur la feuille avec un procédé de traitement de surface choisi parmi les procédés de couchage par pulvérisation et les procédés assistés par mousse réalisés dans la section des presses d'une machine à papier, où le procédé de formation par mousse est exécuté, parmi les procédés de collage externe réalisés sur la machine à papier, où le procédé de formation par mousse est réalisé, les procédés utilisant une size-press, et parmi les procédés de traitement de surface classiques réalisés avec une coucheuse en ligne ou hors ligne, et les procédés de couchage assistés par mousse.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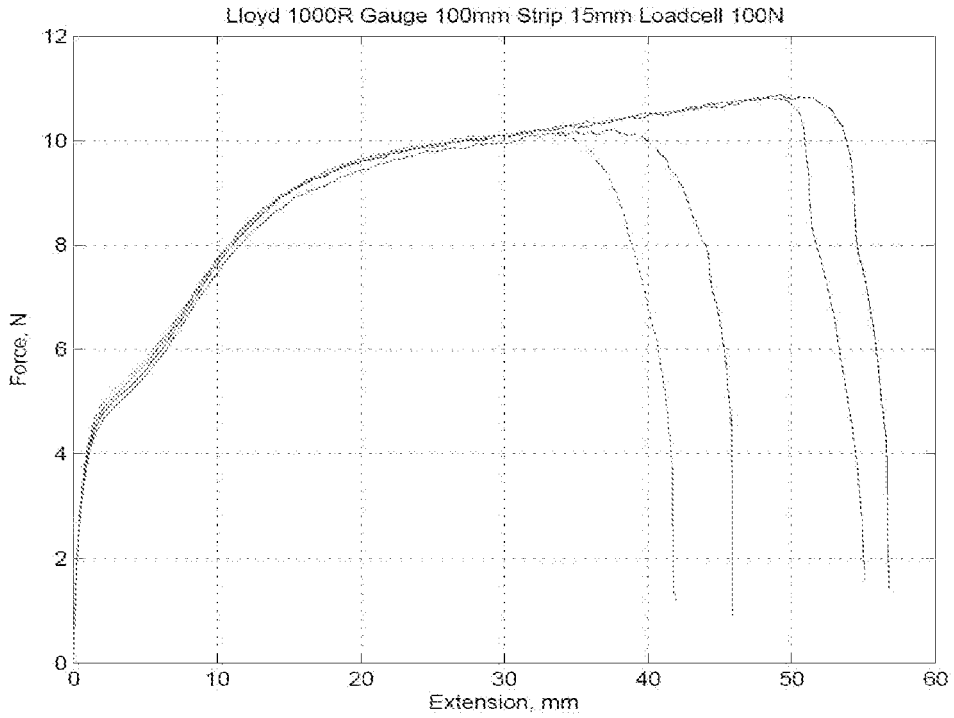
Extension, mm

Fig. 1A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20
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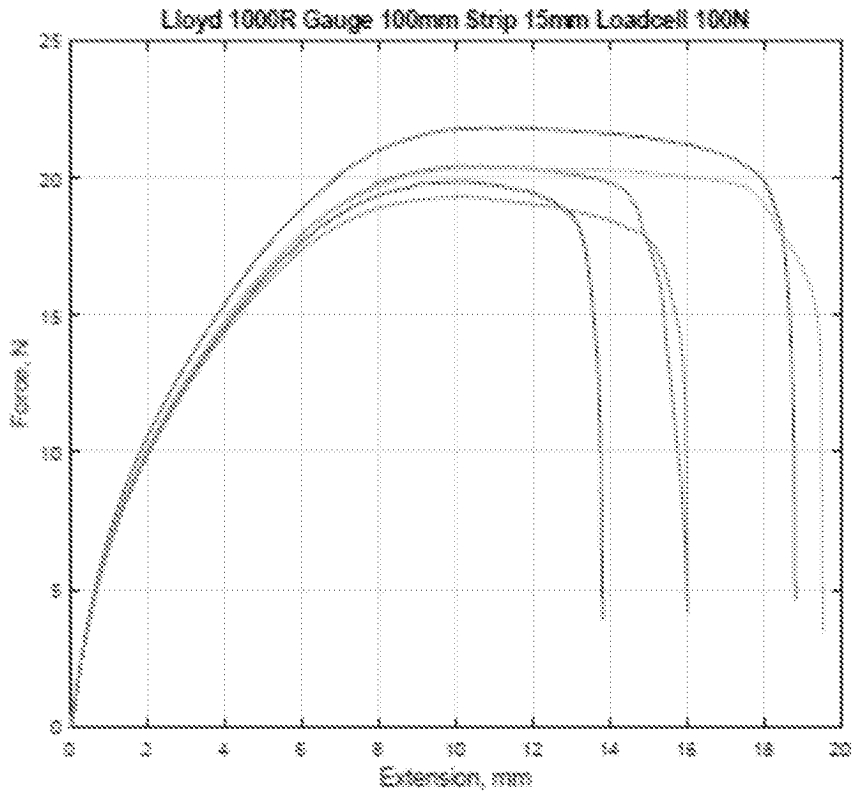
60
Extension, mm

Fig. 1B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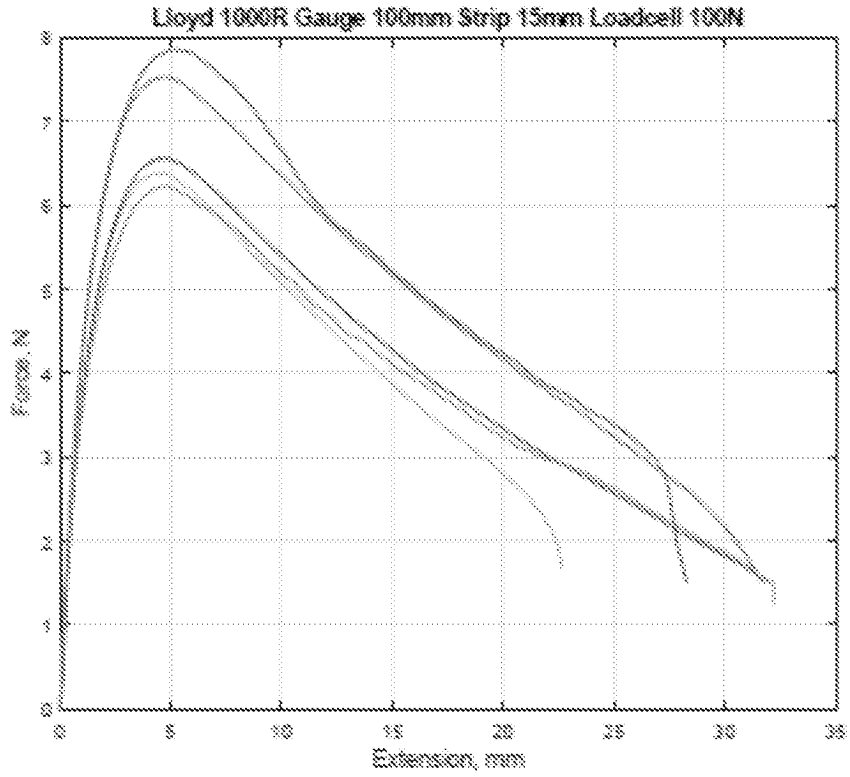
Force, N
Extension, mm

Fig. 1C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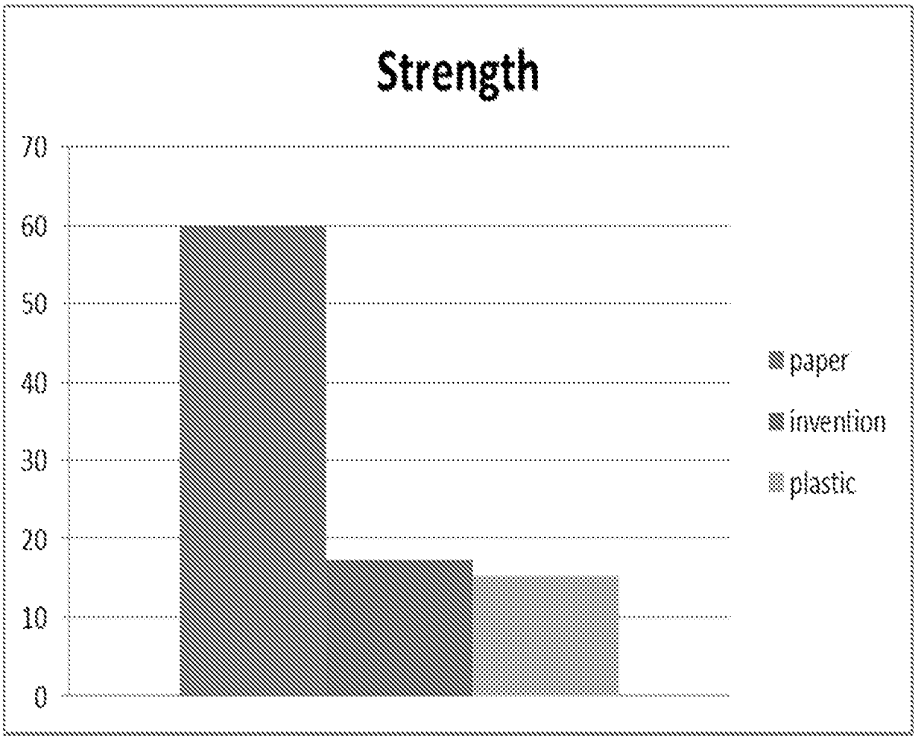
Force, N
Extension, mm

Fig. 1D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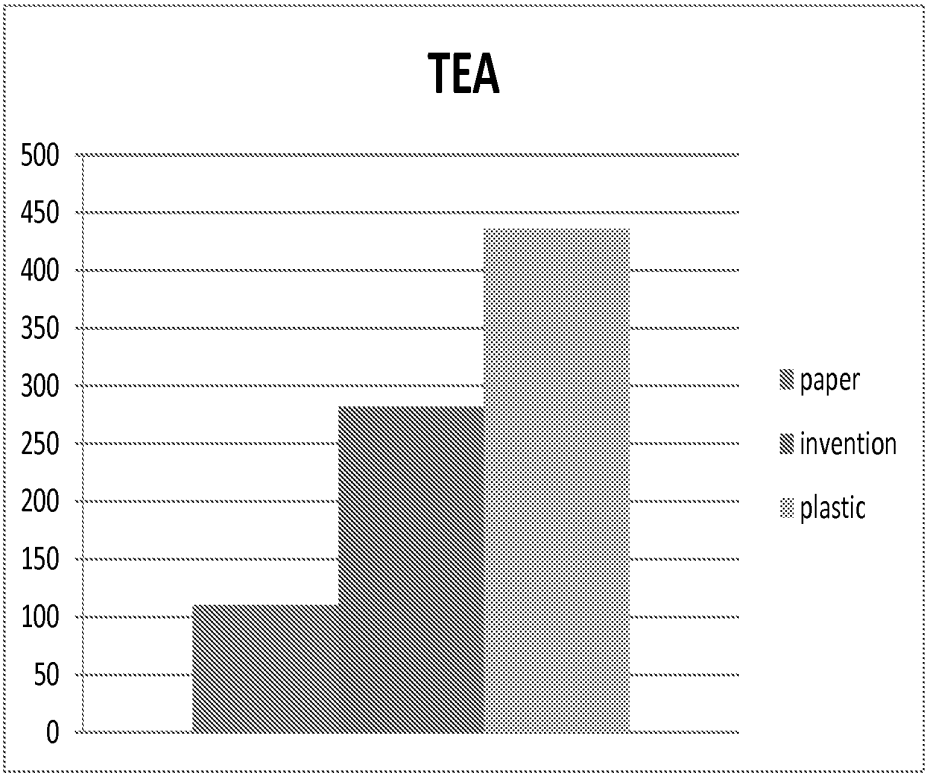
40
30
20
10
0
paper
invention
plastic

Fig. 2A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plastic

Fig. 2B

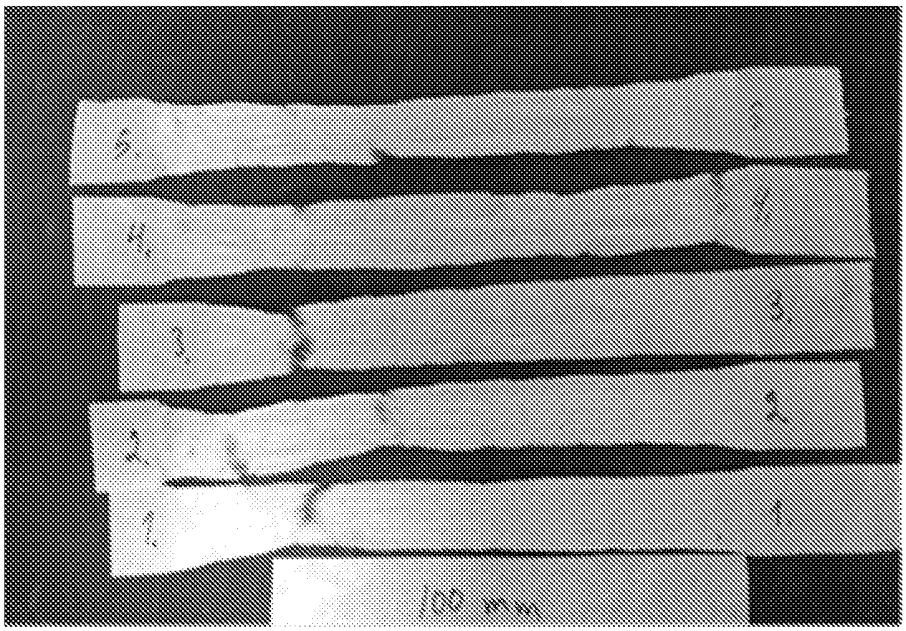


Fig. 3

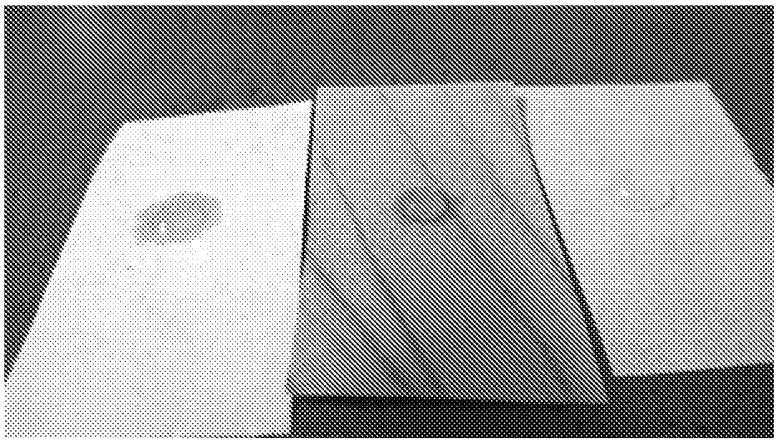


Fig. 4A

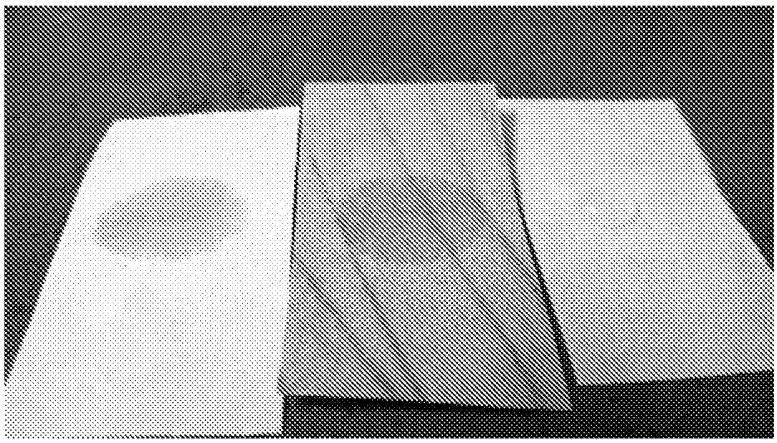


Fig. 4B

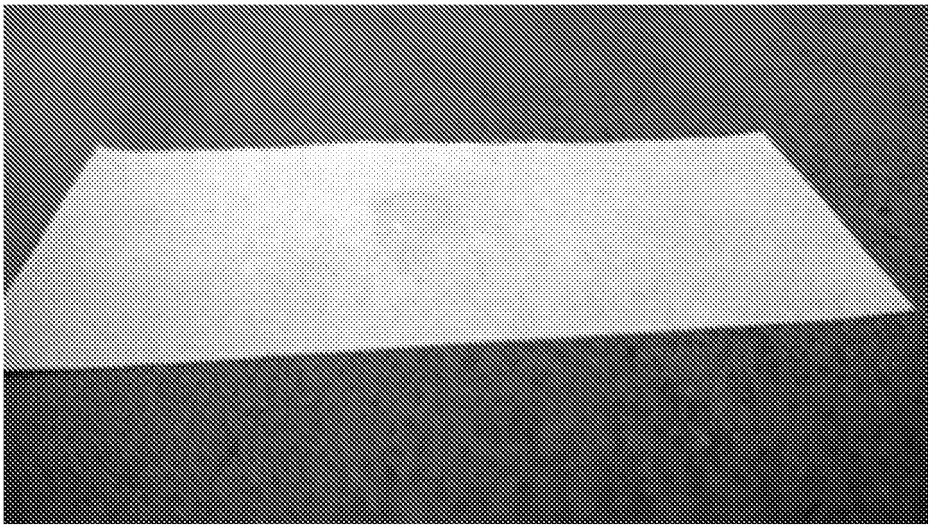


Fig. 4C

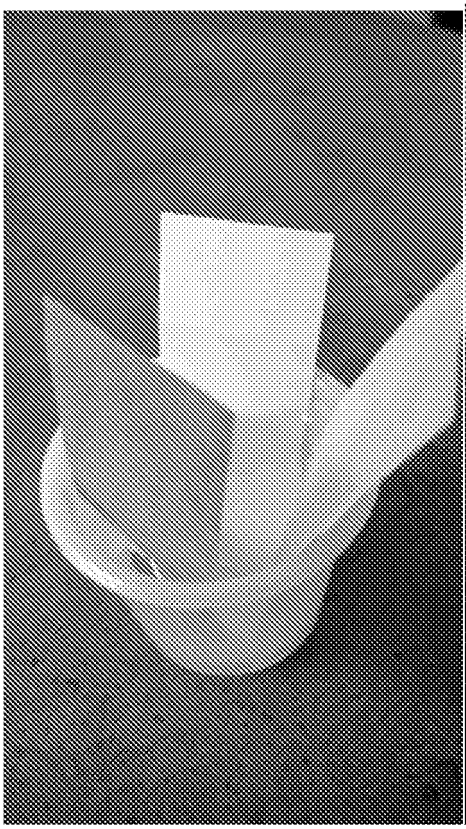


Fig. 4D

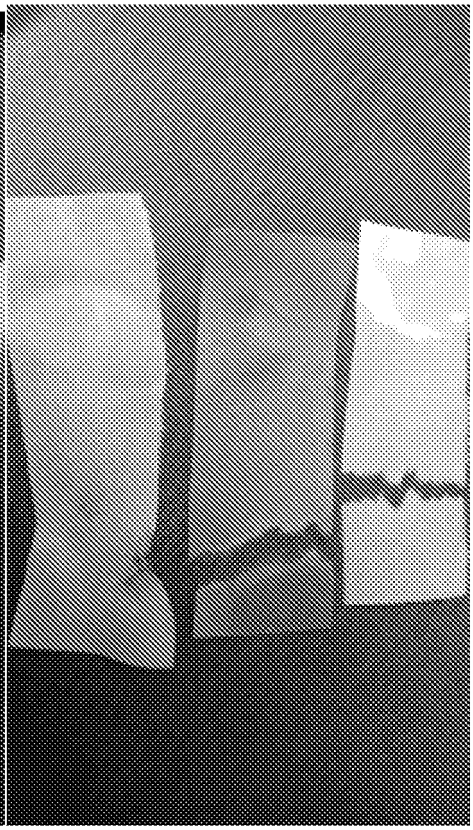
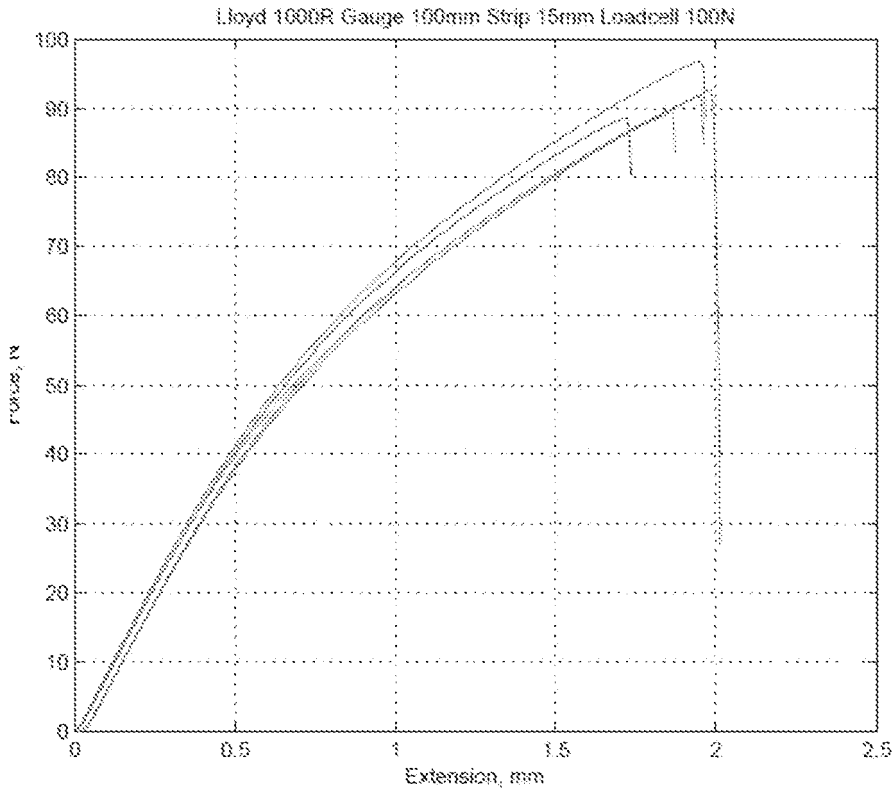


Fig. 4E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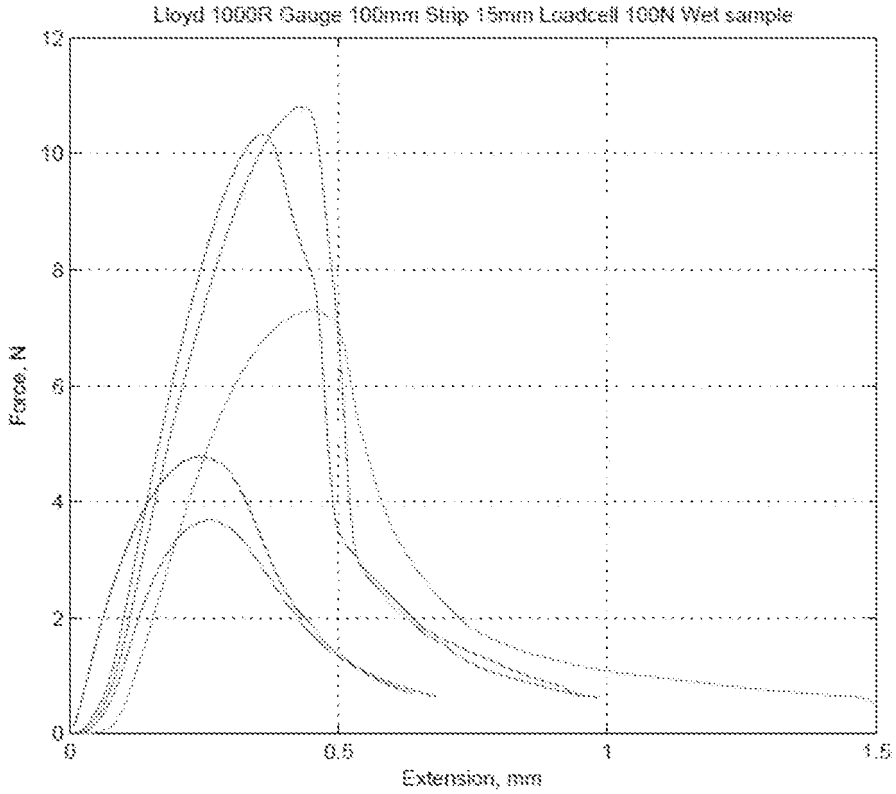
2
2.5

Fig. 5A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Extension, mm
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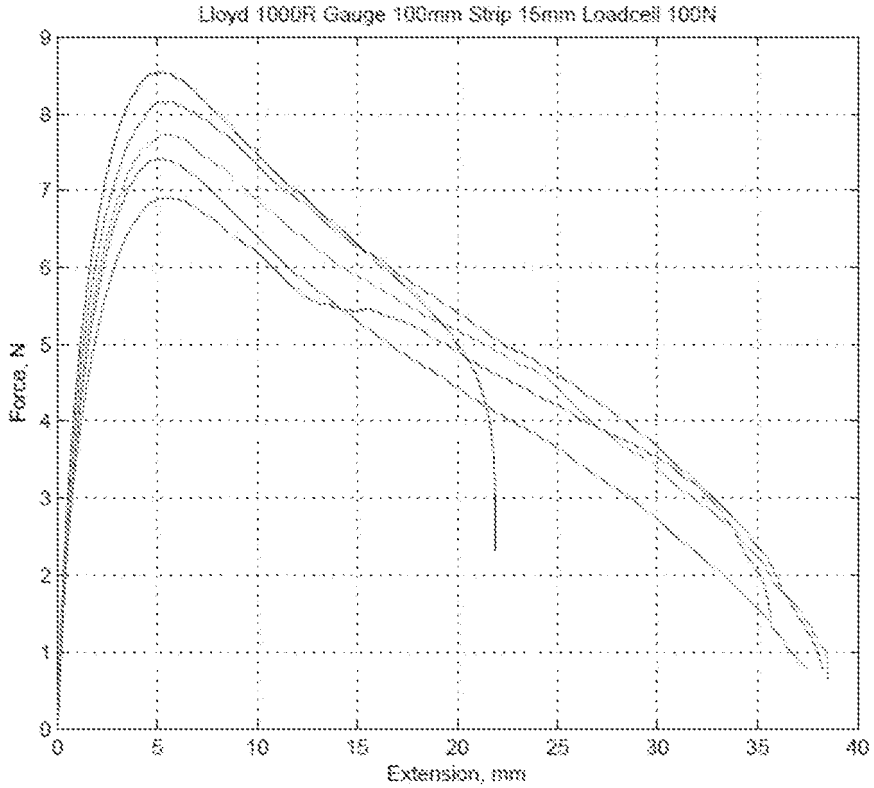
0.5
1
1.5

Fig. 5B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Force, N
Extension, mm
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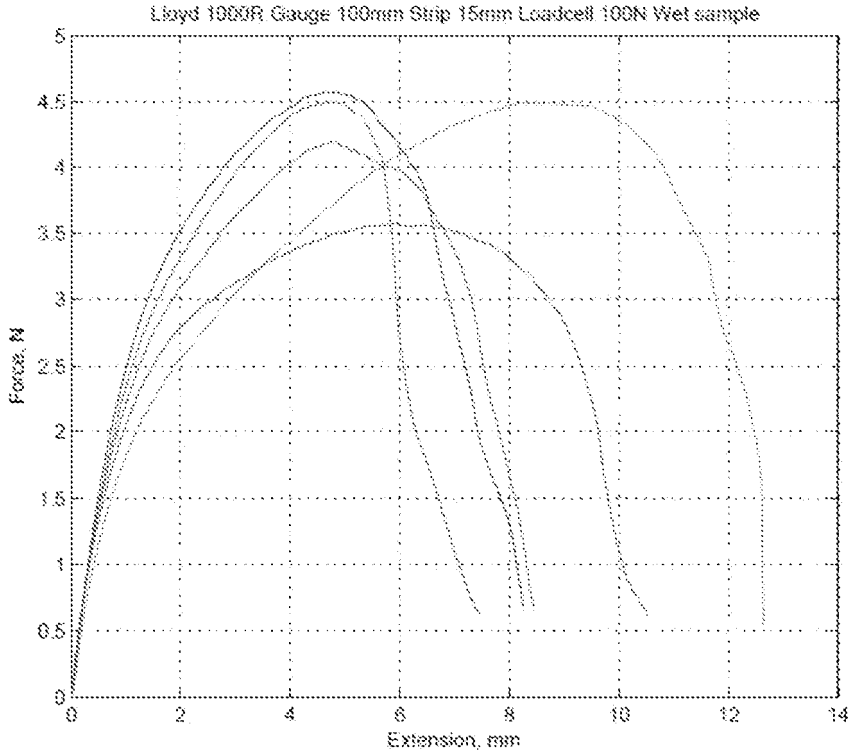
25
30
35
40

Fig. 5C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Extension, mm
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0.5
1
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2.5
3
3.5
4
4.5
5
0
2
4
6
8
10
12
14

Fig. 5D

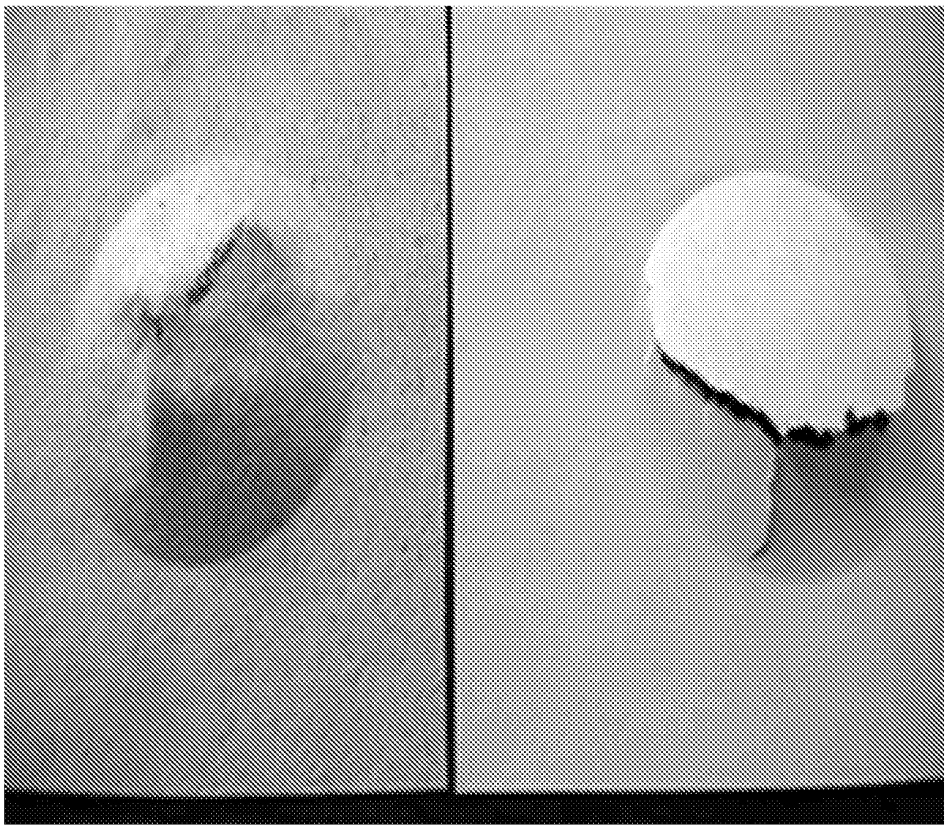
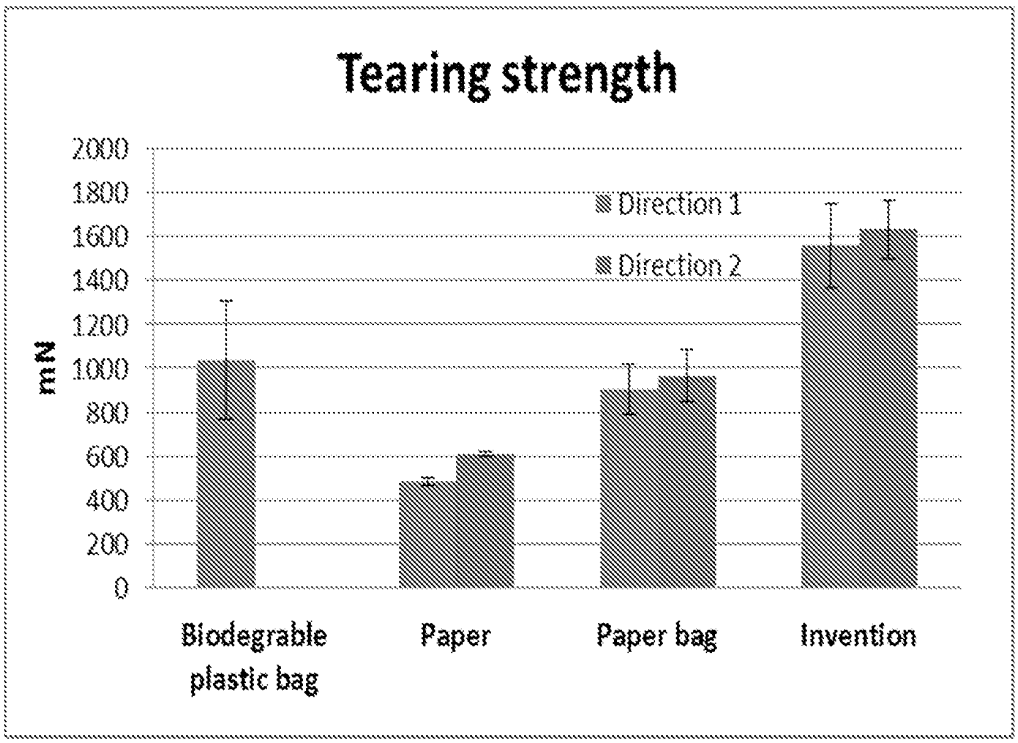


Fig. 6


Tearing strength
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1600
1400
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400
200
0
mN
Direction 1
Direction 2
Biodegrable plastic bag
Paper
Paper bag
Invention

Fig. 7

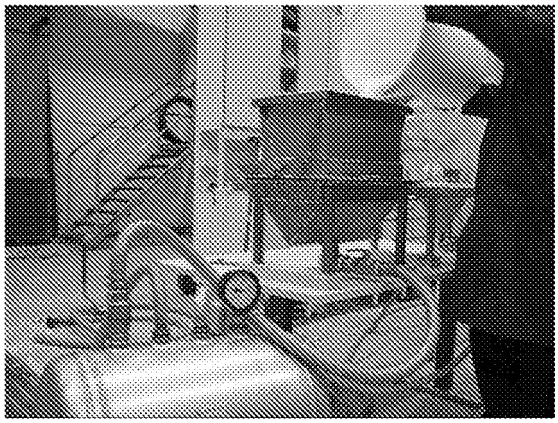


Fig 8A

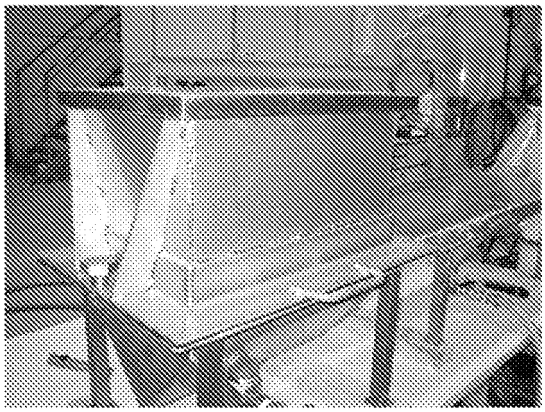


Fig 8B

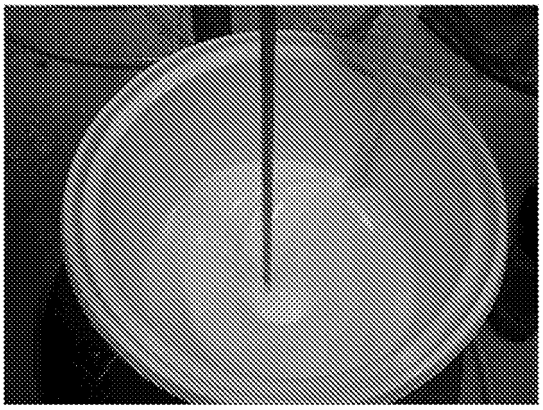


Fig 8C

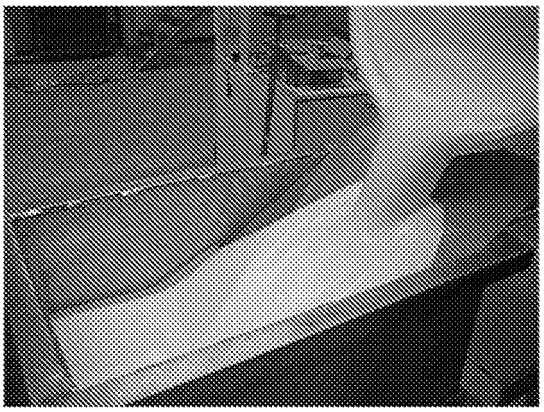


Fig 8D

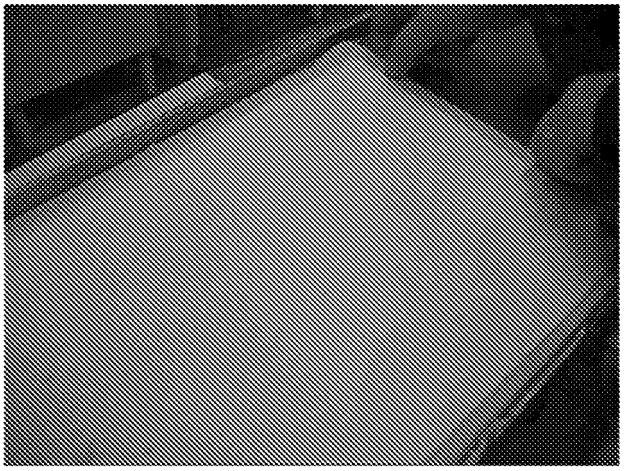
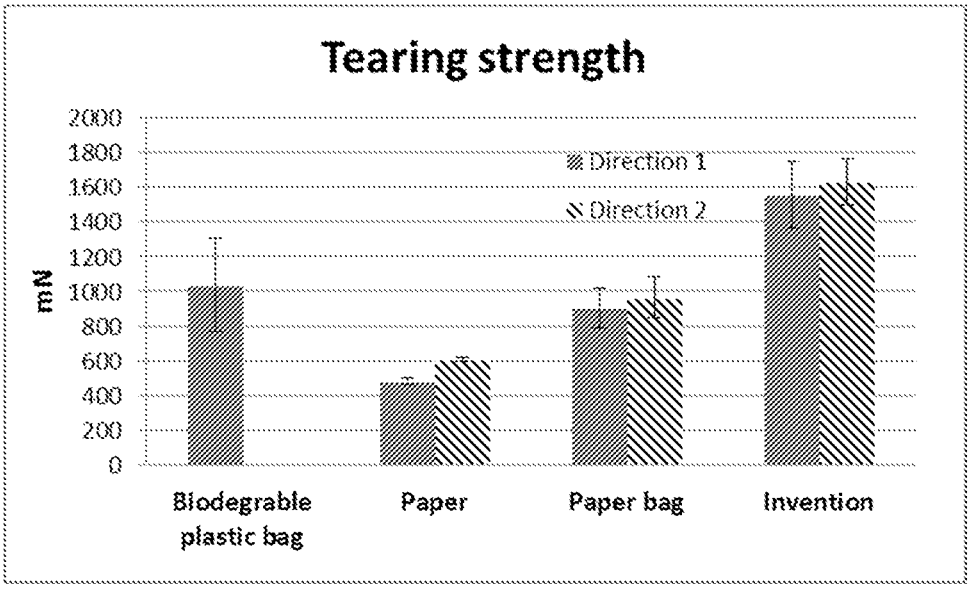


Fig. 8E

Fig. 8

Fig. 9A


Tearing strength
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800
600
400
200
0
mN
Direction 1
Direction 2
Biodegrable plastic bag
Paper
Paper bag
Invention

Fig. 9B

REFERENCES CITED IN THE DESCRIPTION

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