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(72) Inventors:
• **Niederhuber, Armin**
83052 Bruckmühl (DE)
• **Cherkas, Oxana**
29393 Quimperle (FR)
• **Hervé, Raoul**
29393 Quimperle (FR)
• **Raverdy-Lambert, Diane**
29393 Quimperle (FR)

(71) Applicants:
• **Neenah Gessner GmbH**
83052 Bruckmühl (DE)
• **Mativ Luxembourg**
5326 Contern (LU)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) **POROUS, LOW OPACITY PAPER**

(57) A low opacity paper is disclosed. The low opacity paper is made from a fibrous web containing unrefined cellulose fibers. The fibrous web is coated with a bio-based wax, such as a coconut-based, palm-based

and soy-based wax. The resulting product can have a relatively low opacity. Thus, the product can have excellent transparent or translucent characteristics.

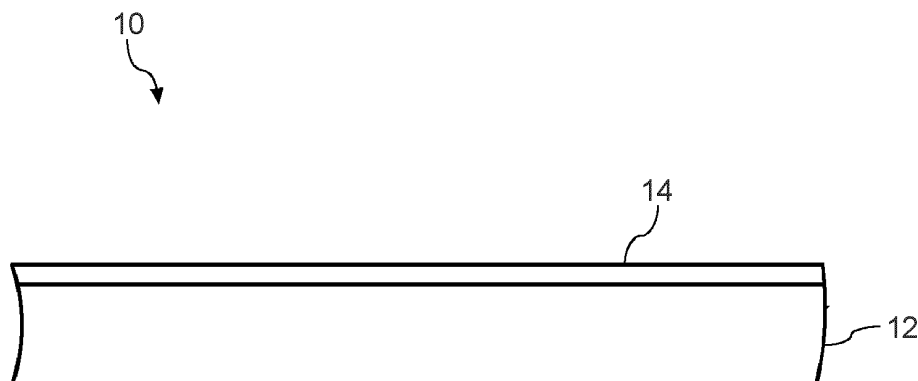


FIG. 1

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Description**BACKGROUND**

[0001] Transparent or translucent materials are used in all different types of applications. Transparency, for instance, is a highly desirable quality in packaging materials. For example, although packaging materials are necessary to protect products during shipping and sales, consumers prefer to be able to view the product through the packaging.

[0002] In the past, most transparent or translucent materials, including packaging materials, were formed from plastic materials, such as polyester polymers and polyolefin polymers. These plastic materials, however, are derived from non-renewable, fossil resources, including petroleum-based resources. These resources are not sustainable, are not renewable, and produce polymer products that do not readily degrade. Thus, efforts have been made in the past in an attempt to produce transparent or translucent materials from renewable resources, such as cellulose materials.

[0003] For example, low opacity or transparent papers have been developed and produced in the past. Transparent paper products, for instance, have been used in the form of tracing paper, clear windows for envelopes, and more recently packaging paper for cereals, pasta, or bakery products.

[0004] In many instances, in order to produce a transparent or translucent paper, non-renewable resources or components that do not readily biodegrade were combined with the paper. For example, one type of paper produced in the past was manufactured from wood pulp fibers that may have been combined with an enzyme, such as xylanase. These substrates typically had a relatively high basis weight in order to provide sufficient strength or other mechanical properties. In order to reduce the thickness of the cellulose paper, densify the paper, and produce transparent properties, the paper was combined with petroleum-based chemicals or synthesized resins and then fed through a supercalendering process. As used herein, during supercalendering, a paper is first calendered by pressing it between metal cylinders or rollers. Afterwards, the paper is sent through an additional set of calenders to produce an even smoother and glossier paper, referred to as a supercalendered paper. The supercalender includes several cylinders alternating between polished metal and soft resilient surfaces. The supercalender applies pressure, heat, and friction to glaze both surfaces of the paper to make the paper smooth and/or glossy.

[0005] Transparent or translucent papers made in the past as described above have various drawbacks and deficiencies. For instance, as stated above, even though the fibers used to produce the paper are obtained from renewable resources and are biodegradable and compostable, the papers are typically combined with petroleum-based chemicals or other synthetic resins that can frustrate the goal of producing bio-sourced materials. In addition, although supercalendering can be very effective at changing the properties of the paper, the process is very energy intensive. Further, due to the manner in which the papers described above are formed, the papers have a very low porosity and the process provides little to no control over increasing the porosity.

[0006] In view of the above, a need currently exists for a low opacity paper that can be greater than 90% bio-sourced and can be biodegradable and compostable. A need also exists for a low opacity paper that can be produced without supercalendering. A need also exists for a low opacity paper that, in one aspect, can be formed with a relatively high porosity or permeability.

SUMMARY

[0007] It is an object of the present invention to provide an alternative to plastic films currently on the market. More particularly, the present disclosure is directed to a low opacity paper that can be constructed without containing any petroleum-based resources, and without having to supercalender the paper, thus reducing the energy requirements needed to make the product. The low opacity paper of the present disclosure can also be formulated to be completely biodegradable and compostable. In addition, the low opacity paper can have an excellent balance of properties including high transparency and good mechanical properties for converting and handling. Further, the porosity of the low opacity paper can be controlled. Thus, low air permeability papers can be formed or papers having a relatively high air permeability or porosity can be formed depending upon the particular application and the desired result.

[0008] In one aspect, the present disclosure is directed to a paper product with low opacity characteristics. The paper product comprises a fibrous web containing cellulose fibers. At least part of the cellulose fibers contained in the web is unrefined as may be measured according to a freeness value. The freeness value ($^{\circ}$ SR) measures generally the rate at which a dilute suspension of refined fibers may be drained. The freeness is measured by the Schopper Riegler Method for drainability. As used herein, freeness can be measured according to DIN EN ISO 5267-1 :2000. The cellulose fibers contained in the web, for example, can have a degree of refining of less than about 25° SR, such as less than about 20° SR, such as less than about 15° SR. The fibers generally have a freeness value of greater than about 5° SR.

[0009] The basis weight of the fibrous web can be, in one aspect, from about 13 g/m^2 to about 60 g/m^2 , including all increments of 1 g/m^2 therebetween. In one aspect, the fibrous web can have a relatively low basis weight. For instance, the basis weight of the web can be less than about 55 g/m^2 , such as less than about 37 g/m^2 , and generally greater

than about 13 g/m². The fibrous web defines a first surface and a second surface. As will be readily understood by the skilled person, the first surface and the second surface are the main surfaces of the fibrous web, which may also be referred to as "upper" and lower" surface and are located opposite to each other. In accordance with the present invention, the paper product comprises a coating on a least one, preferably one, of the first surface and/or the second surface of the fibrous web. The coating comprises a transparency agent. The transparency agent comprises a bio-based wax or oil. Paper products made in accordance with the present disclosure can display an opacity of less than about 45% when tested according to ISO 2471:2008. For example, the opacity can be less than about 40%, such as less than about 38%, such as less than about 36%.

[0010] In one aspect, the transparency agent included in the coating is a plant or animal derived wax or oil. For example, in one aspect, the transparency agent is a plant derived wax or oil. In particular embodiments, the transparency agent can be a coconut-based wax, a palm-based wax, and/or a soy-based wax.

[0011] In one aspect, the fibrous web can comprise a wetlaid web. The fibrous web can contain wood pulp fibers alone or in combination with bast fibers. The wood pulp fibers, for instance, can be softwood fibers, hardwood fibers, or combinations thereof. In one aspect, greater than about 90% by weight of the fibrous web comprises unrefined cellulose fibers. In addition to wood pulp fibers and/or bast fibers, the fibrous web may contain leaf fibers, such as abaca fibers, sisal fibers, or mixtures thereof. The fibrous web can also contain regenerated cellulose fibers. Such fibers include rayon fibers, viscose fibers, lyocell fibers, and the like. Bast fibers that can be incorporated into the fibrous web include hemp fibers, flax fibers, or mixtures thereof.

[0012] The paper product can be produced without containing any paraffins, mineral oils, or hydrocarbon oils. Thus, in one aspect, the paper product can be repulpable and compostable.

[0013] The basis weight of the paper product can generally be from about 13 g/m² to about 60 g/m², including all increments of 1 g/m² therebetween. In various embodiments, the basis weight of the paper product can be less than about 55 g/m², such as less than about 50 g/m², such as less than about 40 g/m², and greater than about 13 g/m². The paper product can contain cellulose fibers generally in an amount greater than about 50% by weight, such as in an amount greater than about 60% by weight, such as in an amount greater than about 65% by weight, such as in an amount greater than about 70% by weight, such as in an amount greater than about 75% by weight, such as in an amount greater than about 80% by weight. Cellulose fibers are generally present in the paper product in an amount less than about 95% by weight, such as in an amount less than about 90% by weight, such as in an amount less than about 85% by weight, such as in an amount less than about 80% by weight.

[0014] The transparency agent can be present in the paper product generally in an amount greater than about 3 g/m², such as in an amount greater than about 5 g/m², such as in an amount greater than about 8 g/m², such as in an amount greater than about 10 g/m². The transparency agent can be present in the paper product in an amount less than about 30 g/m², such as in an amount less than about 20 g/m², such as in an amount less than about 15 g/m².

[0015] As described above, the paper product of the present disclosure can be formed with a relatively high permeability. Permeability as used herein refers to air permeability and is measured as volumetric flow rate of air (cm³ min⁻¹) passing through a 1 cm² sample of substrate at an applied pressure difference of 1kPa (in short: cm³/min/cm²). For instance, the paper product can display permeability of greater than about 350 cm³/min/cm², such as greater than about 500 cm³/min/cm², such as greater than about 1,000 cm³/min/cm², such as greater than about 2,000 cm³/min/cm², such as greater than about 3,000 cm³/min/cm², such as greater than about 4,000 cm³/min/cm². The porosity or permeability is generally less than about 30,000 cm³/min/cm². The air permeability is measured according to ISO 2965:2009.

[0016] Although having a high porosity or permeability, the paper product also displays barrier properties. For instance, the paper product can display a water drop resistance of greater than 10 min according to TAPPI T 432 cm-09 (2μL of water drop is used).

[0017] The paper product of the present disclosure can be used in numerous and diverse applications. In one aspect, the present disclosure is directed to a packaging paper made from the paper product.

[0018] The present disclosure, in another aspect, is also directed to a method for producing a low opacity paper product as described above. The method includes coating a fibrous web with an aqueous composition containing a transparency agent. The fibrous web can contain unrefined cellulose fibers. The transparency agent can comprise a bio-based wax or oil, such as a coconut-based wax, a palm-based wax and/or a soy-based wax. In one aspect, the fibrous web is impregnated with the aqueous composition containing the transparency agent using a size press. In other embodiments, however, the transparency agent can be applied to the fibrous web by using an applicator roll, by a size-press, by a film-press, by spraying, or by using any suitable coating technique.

[0019] In one aspect, the fibrous web can be a wetlaid web. The method of making the product can include combining the unrefined, cellulose fibers with water to form an aqueous suspension of fibers; depositing the aqueous suspension of fibers onto a porous forming surface to form a fibrous web; and coating the fibrous web with an aqueous composition containing the transparency agent. In one embodiment, the porous forming surface can be an inclined surface.

[0020] Other features and aspects of the present disclosure are discussed in greater detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] A full and enabling disclosure of the present disclosure is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

Figure 1 is a cross-sectional schematic view of one embodiment of a low opacity paper made in accordance with the present disclosure.

[0022] Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the present invention.

DEFINITIONS

[0023] As understood herein, a "coating" on the surface(s) of the fibrous web can be obtained by applying a generally liquid coating agent on the surface(s) of the fibrous web by means of any suitable coating, impregnation or saturation technique, such as for example air knife coating, roll-to-roll coating, blade coating, spray coating, Mayer rod coating, direct gravure printing, offset gravure printing, reverse gravure printing, smooth roll coating, curtain coating, bead coating, slot coating, fill press coating or impregnation via a size press. The coating can be a continuous coating or a discontinuous coating. Accordingly, along the lateral dimension of the fibrous web, the coating can be present in a part of or the complete fibrous web. When applying the coating composition to the fibrous web, it will penetrate into some of the internal spaces and pores between the fibers of the fibrous web resulting in saturation and/or impregnation of the fibrous web with the coating (composition). That is, in the present invention the coating will permeate into the fibrous web, in particular internal spaces and pores therein, and apart from this it can cover and preferably does cover at least part of the first and/or the second surface of the fibrous web in the form of a surface coating. In other words, a "coating" as understood herein covers the saturation and impregnation of the fibrous web.

[0024] As used herein, the term "low opacity" means transparent or translucent. A product is considered to have low opacity when the product displays an opacity of, e.g., less than about 45% when tested according to ISO 2471:2008. Low opacity characteristics refer to the characteristics which provide a paper product with transparency or translucency, such as the presence of a transparency agent.

[0025] As used herein, the term "transparency agent" refers to an agent which decreases the opacity of fibrous web when applied inside or on the fibrous web. Examples include plant or animal derived waxes or oils, such as a coconut-based wax, a palm-based wax, and/or a soy-based wax. Plant or animal derived components as understood herein can be obtained from biomass. The transparency agent can be a bio-based wax or oil.

[0026] As used herein, the term "biomass" is broadly understood as encompassing all kinds of plant and animal material and material derived from the same. Biomass does not include petroleum or petroleum-derived products.

[0027] The biomass for use in the present invention may comprise macromolecular compounds, examples of which are lignin and polysaccharides, such as starch, cellulose, hemicellulose commonly also referred to as polyose, glycogen and alginate.

[0028] As will be appreciated, certain kinds of biomass may include both plant and animal-derived material. As examples, manure (dung), night soil and sewage sludge can be mentioned. While the biomass for use in the present invention is preferably plant biomass, i.e. biomass of or derived from plants, certain contents of animal biomass (i.e. biomass of or derived from animals) may be present therein. For instance, the biomass may contain up to 30 % of animal biomass. According to a preferred embodiment, the biomass for use in the present disclosure, which is preferably plant biomass, contains more than 70 wt%, most preferably more than 90 wt%, of polysaccharides and lignines in terms of the solid contents of the biomass.

[0029] For instance, the plant biomass may be agricultural plant material (e.g. agricultural wastes) or all kinds of wood material. Biomass may be in the form of waxes and oils, including coconut, palm, and soy waxes and oil.

[0030] As used herein, a "biodegradable" component is a component that is capable of being decomposed by living organisms, such as bacteria or fungi. A biodegradable component can thus be decomposed by the action of microorganisms such as bacteria or fungi with or without oxygen. In one aspect, a biodegradable component fulfills the requirements of at least one of the international industrial standards ISO 14855:2018, ISO 14853:2017, and ASTM D5338:2015.

[0031] As used herein, the term "compostable" refers to components that can disintegrate into non-toxic, natural elements. Compostable components, for instance, can degrade at a rate consistent with similar organic materials. Compostable components degrade when exposed to microorganisms, humidity, and/or heat to yield a finished compost product. Coated papers made according to the present disclosure can be formulated to meet international industrial standards ISO 17088:2021, DIN EN 13432:2007, DIN EN 14995:2007, and/or ASTM 6400:2021 defines the requirements for industrially compostable components.

[0032] The term "pulp" as used herein refers to fibers from natural sources such as woody and non-woody plants. Woody plants include, for example, deciduous and coniferous trees. Non-woody plants include, for example, cotton, flax, esparto grass, milkweed, straw, jute, hemp, sisal, abaca and bagasse. Pulp fibers can include hardwood fibers,

softwood fibers, and mixtures thereof.

[0033] As used herein, the term "fibrous web" refers to a sheet made from the pulp by a wetlaid process without coating.

[0034] As used herein, the term "unrefined cellulose fibers" refers to a fiber pulp which was used without any refining steps in the paper making.

[0035] As used herein, the term "bio-based wax or oil" refers to wax or oil which have a bio-based content more than 90% by weight. The "bio-based wax or oil" is preferably derived from plant biomass. Examples include coconut-based wax, a palm-based wax and/or a soy-based wax.

[0036] As used herein, the term "regenerated cellulose fibers" refers to fibers manufactured by the conversion of natural cellulose to a soluble cellulosic derivative and subsequent regeneration. Examples include rayon fibers, viscose fibers, lyocell fibers, and the like.

DETAILED DESCRIPTION

[0037] It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only and is not intended as limiting the broader aspects of the present disclosure.

[0038] In general, the present disclosure is directed to a low opacity paper. In one aspect, the paper can be transparent. Alternatively, the paper can be formulated to be translucent. The low opacity paper of the present disclosure can be formed exclusively from sustainable resources that meets all of the requirements for entering the paper recycle stream after use. In the past, for instance, transparent papers typically contained components derived from fossil-based resources, such as petroleum-derived products. The low opacity paper of the present disclosure, however, can be produced having over 90% bio-based content. In addition, in one aspect, the low opacity paper can be formulated to be paraffin-free. The low opacity paper can be constructed in order to meet all of the requirements for food contact and food handling.

[0039] In one aspect, the low opacity paper of the present disclosure is formed from a fibrous web containing unrefined cellulose fibers. By using unrefined cellulose fibers, less energy is needed in order to produce the web, thus providing further environmental benefits, especially compared to existing solutions. By using unrefined fibers, the air permeability of the product can also be controlled. In one aspect, for instance, a highly porous but low opacity paper product can be produced, which can provide various benefits. For example, higher air permeability products are particularly well suited for applications where breathability is important, such as when packaging bread, fruits or vegetables. According to a preferred embodiment of the invention, the cellulose fibers comprised in the fibrous web of the paper product are unrefined cellulose fibers.

[0040] Overall, the low opacity paper product of the present disclosure can have relatively high transparency (less than 45% of opacity) and can be manufactured without refining the cellulose fibers and without using a supercalender. In addition, products can be formed having a relatively high air permeability (higher than 350 cm³/min/cm²) while still having excellent water resistance. In addition, the paper product displays excellent mechanical properties necessary for converting and handling.

[0041] All of the benefits above can be obtained while still producing a paper product having an opacity of less than about 45% when tested according to ISO 2471:2008. For instance, the opacity of the paper products can be less than about 40%, such as less than about 38%, such as less than about 36%, such as less than about 32%, such as less than about 28%, such as less than about 25%. The actual opacity can depend upon various factors and is generally greater than 1%, such as greater than about 5%. The above opacity levels make it possible to see printed matter through the paper product. For instance, bar codes, QR codes, and other machine-readable codes can be scanned through the paper product of the present disclosure.

[0042] Referring to **FIG. 1**, one embodiment of a low opacity paper or paper product **10** made in accordance with the present disclosure is shown. **FIG. 1** represents a cross-sectional schematic view of the product **10**. As shown, in this embodiment, the low opacity paper **10** includes a paper base sheet **12** which is a fibrous web comprising cellulose fibers, wherein the cellulose fibers contain or are unrefined cellulose fibers. The fibrous web **12**, for instance, can be a wetlaid paper web. In other embodiments, however, the fibrous web **12** can be made using any suitable papermaking technique. The fibrous web **12** includes a first surface opposite a second surface. Applied to the first surface of the fibrous web **12** is a coating **14**. The coating **14** contains a transparency agent that lowers the opacity of the paper product **10**. The coating **14** is shown as a separate layer in **FIG. 1** but it will also become impregnated into the fibrous web **12** as explained above. As will be described in greater detail below, the coating **14** can be made from a bio-based oil or wax. In one particular aspect, for instance, the coating **14** is formed from a coconut-based, palm-based and/or soy-based wax.

[0043] As shown in **FIG. 1**, the low opacity paper **10** can be made exclusively from a single layer of a fibrous web in combination with the coating **14**. Alternatively, the low opacity paper **10** can include a second coating (not shown) applied to the opposite surface of the fibrous web, such as a heat-sealable coating.

[0044] As described above, in one embodiment, the fibrous web **12** can be a wetlaid paper web containing unrefined cellulose fibers. For example, the fibrous web can be formed from an aqueous suspension of fibers. The cellulose fibers contained in the fibrous web can be pulp fibers including wood pulp fibers, plant waste fibers, regenerated cellulose

fibers, or other plant fibers. In forming the fibrous web, the aqueous suspension of fibers can be deposited onto a porous forming surface that allows water to drain thereby forming the fibrous web. In one embodiment, the porous forming surface may be inclined, especially when the fiber furnish contains a significant amount of unrefined fibers.

[0045] In one aspect, the fibrous web is made primarily from plant derived or natural fibers. Natural (plant derived) fibers may be selected from chemical pulp, such as sulphate and sulphite pulp, organosolv pulp, recycled fibers, and/or mechanical pulp, nanocellulose, and modifications and combinations thereof. The pulp may be a bleached or non-bleached pulp. The 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.

[0046] Non-wood plant fibers can also be used, such as seed hair fibers, leaf fibers, and 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.

[0047] In one aspect, the fibrous web can contain regenerated cellulose fibers. Such fibers can include rayon fibers, lyocell fibers, viscose fibers, and mixtures thereof. When present, the regenerated cellulose fibers can be present in the fibrous web in an amount from about 3% to about 50% by weight, such as from about 5% to about 15% by weight.

[0048] The fibrous web can be primarily formed from the cellulose fibers without being combined with other components, such as fillers. For instance, the fibrous web (prior to coating) can contain cellulose fibers in an amount greater than about 90% by weight, such as in an amount greater than about 95% by weight. Particular cellulose fibers well suited to producing the fibrous web include softwood fibers, hardwood fibers, birch fibers, hemp fibers, flax fibers, or mixtures thereof. For example, in one embodiment, the fibrous web can be made exclusively from softwood fibers alone or in combination with hardwood fibers. Alternatively, the fibrous web can be made from a blend of wood pulp fibers, such as softwood fibers, with bast fibers, such as hemp fibers or flax fibers. In still another aspect, the fiber furnish can include softwood fibers and/or hardwood fibers combined with leaf fibers, such as abaca fibers, sisal fibers, or mixtures thereof. Alternatively, the entire fibrous web can be made from the leaf fibers described above. The cellulose fibers can be selected, for instance, in order to produce a web that can be efficiently drained from aqueous fluids during formation and that can produce a relatively low opacity paper while still retaining mechanical properties needed for processing and handling.

[0049] As described above, the non-fibrous web contains unrefined fibers. The unrefined fibers can be defined by a freeness value as measured by the Schopper Riegler Method for drainability (ISO 5267-1:2000) that is expressed in the unit of "°SR". As a rule of thumb, the lower the value of °SR, the more unrefined the fibers are. As used herein, unrefined cellulose fibers include fibers that may have been subjected to some mechanical action or refining but still have a freeness value of less than about 25 °SR, such as less than about 22 °SR, such as less than about 20 °SR, such as less than about 18 °SR, such as less than about 15 °SR, such as less than about 13 °SR. The freeness value of the fibers can be greater than 5 °SR, such as greater than 8 °SR.

[0050] The fibrous web can contain unrefined cellulose fibers in an amount greater than about 50% by weight, such as in an amount greater than about 60% by weight, such as in an amount greater than about 70% by weight, such as in an amount greater than about 80% by weight, such as in an amount greater than about 90% by weight, such as in an amount greater than about 95% by weight. In one embodiment, the fibrous web is made entirely from unrefined cellulose fibers, such as softwood fibers, bast fibers, leaf fibers, or mixtures thereof.

[0051] Using unrefined cellulose fibers not only reduces the energy requirements for producing the paper product of the present disclosure but can also offer various advantages. For instance, controlling the amount of unrefined fibers in the fibrous web can allow for control over the air permeability of the resulting paper product. For example, the paper products of the present disclosure can have low opacity characteristics while still having a air permeability of greater than about 500 cm³/min/cm², such as greater than about 750 cm³/min/cm², such as greater than about 1,000 cm³/min/cm², such as greater than about 1,250 cm³/min/cm², such as greater than about 1,500 cm³/min/cm², such as greater than about 1,750 cm³/min/cm², such as greater than about 2,000 cm³/min/cm², such as greater than about 2,250 cm³/min/cm², such as greater than about 2,500 cm³/min/cm², such as greater than about 2,750 cm³/min/cm², such as greater than about 3,000 cm³/min/cm², such as greater than about 3,225 cm³/min/cm², such as greater than about 3,500 cm³/min/cm², such as greater than about 3,750 cm³/min/cm², such as greater than about 4,000 cm³/min/cm². The air permeability of the paper product is generally less than about 30,000 cm³/min/cm², such as less than about 20,000 cm³/min/cm², such as less than about 10,000 cm³/min/cm², such as less than about 7,000 cm³/min/cm². For higher basis weight products, the air permeability can be less than about 3,000 cm³/min/cm², such as less than about 2,000 cm³/min/cm², such as less than about 1,000 cm³/min/cm².

[0052] The low opacity paper product can have the above air permeability characteristics while still having excellent barrier properties. For instance, the paper product can display a water drop resistance of greater than 10 minutes.

[0053] The basis weight of the fibrous web used to form the paper product of the present disclosure can vary depending upon the particular application and the desired result. In general, the basis weight of the fibrous web can be from about

13 g/m² to about 60 g/m², including all increments of 1 g/m² therebetween. In one embodiment, the fibrous web can have a relatively high basis weight that is greater than about 30 g/m², such as greater than about 34 g/m², and less than about 55 g/m², such as less than about 53 g/m². In one embodiment, the basis weight of the fibrous web can be from about 40 g/m² to about 60 g/m². In still another embodiment, the basis weight of the fibrous web can be from about 30 g/m² to about 40 g/m².

[0054] In an alternative embodiment, the basis weight of the fibrous web can be relatively low. For instance, the basis weight can be less than about 35 g/m², such as less than about 30 g/m², such as less than about 28 g/m², such as less than about 26 g/m², such as less than about 24 g/m². The basis weight of the fibrous web is generally greater than about 13 g/m², such as greater than about 15 g/m², such as greater than about 18 g/m².

[0055] In accordance with the present disclosure, a coating is applied to the fibrous web.

[0056] In accordance with the present disclosure, the coating comprises a transparency agent that is applied to the fibrous web. The transparency agent can comprise a bio-based wax or oil. The bio-based wax or oil, for instance, can be derived from animal or plant biomass. In one aspect, the transparency agent can be a bio-based wax or oil derived from at least 80% by weight vegetable oils, such as at least about 90% by weight vegetable oils, such as up to 100% by weight vegetable oils. The bio-based wax or oil can be paraffin-free and can be free of mineral oil saturated hydrocarbons and mineral oil aromatic hydrocarbons. Of particular advantage, the transparency agent can meet all government requirements for food contact and food handling. For instance, the low opacity paper of the present disclosure can meet all of the requirements of FDA 21 CFR § 176.180 which is directed to components of paper and paperboard that is in contact with dry food. Similarly, the transparency agent and the low opacity paper can also meet all of the requirements of European Commission Regulation No. 1935/2004 regarding materials and articles intended to come in contact with food.

[0057] The bio-based wax, in one embodiment, can have a melting point of from about 25°C to about 75°C, including all increments of 1°C therebetween. The melting point of the bio-based wax can be less than about 70°C, such as less than about 65°C, such as less than about 60°C, such as less than about 55°C, such as less than about 50°C, such as less than about 45°C, such as less than about 40°C. The melting point of the bio-based wax can be greater than about 25°C, such as greater than about 30°C, such as greater than about 35°C, such as greater than about 40°C, such as greater than about 45°C, such as greater than about 50°C. A bio-based wax can be selected having a particular melting point that is well suited for a particular application.

[0058] In one particular embodiment, the transparency agent comprises a bio-based wax that is a coconut-based wax, a palm-based wax, a soy-based wax or mixtures thereof.

[0059] In one aspect, for instance, the transparency agent is a coconut-based wax or oil. The coconut-based wax can have a melting point of from about 25 degrees C to about 45 degrees C, such as from about 30 degrees C to about 40 degrees C. The coconut-based wax can be applied to the fibrous web as an anionic, aqueous dispersion.

[0060] In another aspect, the transparency agent can be a palm-based wax or oil. The palm-based wax can have a melting point of from about 50 degrees C to about 70 degrees C, such as from about 55 degrees C to about 65 degrees C. The palm-based wax can be applied to the fibrous web as an anionic, aqueous dispersion.

[0061] Alternatively, the transparency agent can be a soy-based wax that may be applied to the fibrous web as an aqueous cationic emulsion having a melting point of from about 55 degrees C to about 80 degrees C, such as from about 63 degrees C to about 72 degrees C.

[0062] In one aspect, the bio-based wax can be water dispersible or water miscible. Thus, the transparency agent can be incorporated into an aqueous composition for application to the fibrous web in producing the low opacity paper.

[0063] The transparency agent can be applied to the fibrous web using any suitable method or technique. For example, in one embodiment, an aqueous composition containing the transparency agent can be applied to the fibrous web using a size press either at the wet end of the papermaking machine or after the web has been dried. By using a size press, the low opacity paper can be produced in a single process. Alternatively, however, the fibrous web can be formed and then later coated with a composition containing the transparency agent. Coating can be performed using any suitable method including air knife coating, roll-to-roll coating, blade coating, spray coating, Mayer rod coating, direct gravure printing, offset gravure printing, reverse gravure printing, smooth roll coating, curtain coating, bead coating, slot coating, fill press coating, and the like.

[0064] Once the transparency agent has been applied to the fibrous web and dried, the fibrous web can be calendered without being supercalendered. In one aspect, a plain filigree press may be used for a glazing effect on the surface of the product. The calender rolls, for instance, can include a hard roll opposite a soft roll. The pressure applied to the coated paper can be greater than about 200 kPa (2 bar), such as greater than about 400 kPa (4 bar), such as greater than about 500 kPa (5 bar), and generally less than about 1200 kPa (12 bar), such as less than about 1000 kPa (10 bar), such as less than about 800 kPa (8 bar), such as less than about 700 kPa (7 bar). Calendering can occur at ambient temperature or, alternatively, one or both of the calender rolls can be heated.

[0065] The amount of transparency agent incorporated into the low opacity paper can depend upon various factors including the basis weight of the paper and the desired opacity that is to be reached. The transparency agent, for instance,

can be applied to the fibrous web in an amount greater than about 3 g/m², such as in an amount greater than about 4 g/m², such as in an amount greater than about 5 g/m², such as in an amount greater than about 6 g/m², such as in an amount greater than about 7 g/m², such as in an amount greater than about 8 g/m², such as in an amount greater than about 9 g/m², such as in an amount greater than about 10 g/m². The transparency agent can be applied to the fibrous web in an amount less than about 30 g/m², such as in an amount less than about 20 g/m², such as in an amount less than about 15 g/m², such as in an amount less than about 10 g/m².

[0066] The amount of transparency agent incorporated into the low opacity paper can also be described on a weight percentage basis, based on the weight of the product. In general, the transparency agent, such as a bio-based wax, can be present in the coated paper in an amount of from about 5% by weight to about 50% by weight, including all increments of 1% by weight therebetween. For instance, the transparency agent can be incorporated into the coated paper in an amount greater than about 5% by weight, such as in an amount greater than about 7% by weight, such as in an amount greater than about 10% by weight, such as in an amount greater than about 13% by weight, such as in an amount greater than about 16% by weight. The transparency agent can be present in the coated paper, in one aspect, in an amount less than about 50% by weight, such as in an amount less than about 40% by weight, such as in an amount less than about 30% by weight, such as in an amount less than about 25% by weight, such as in an amount less than about 22% by weight, such as in an amount less than about 20% by weight such as in an amount less than about 18% by weight such as in an amount less than about 15% by weight.

[0067] In one embodiment, the coating composition applied to the fibrous web can contain at least one coloring agent. The coloring agent can be a dye, a pigment, or mixtures thereof. In this manner, the final product can display a color and remain translucent.

[0068] The transparency agent can improve various properties and characteristics of the coated paper. For instance, the transparency agent can increase the transparency and/or decrease the opacity of the final product. The transparency agent can also reduce the air permeability of the low opacity paper and increase the barrier properties of the paper.

[0069] Low opacity papers made according to the present disclosure not only display low opacity but also display a beneficial blend of other properties. For example, the paper product of the present disclosure can display a tensile strength in at least one direction of greater than about 2,000 cN/30mm, such as greater than about 2,500 cN/30mm, such as greater than about 3,000 cN/30mm, such as greater than about 3,500 cN/30 mm, and less than about 10,000 cN/30mm. The elongation in at least one direction can be greater than about 1.2 %, such as greater than about 1.4 %, and less than about 3 %, such as less than about 2.5 %, such as less than about 2 %. The tensile strength and elongation are measured according to ISO 1924-2:2008. The measurements are made on a paper band that is 30 mm wide at a speed 10 mm/min.

[0070] The low opacity paper can also have a water drop resistance greater than 10 min according to TAPPI T 432 cm-09.

[0071] The low opacity paper of the present disclosure has numerous uses and applications. For instance, the low opacity paper can be used as a packaging material for fruits, vegetables, breads, flowers, plants and the like. The low opacity paper, for instance, can be made to be flexible or semi-rigid making the product well suited for constructing packages.

[0072] Alternatively, the low opacity paper can be laminated to a paper or a paperboard and formed into a container, such as a box or a bag.

[0073] In still another embodiment, the low opacity paper can be used as a tracing paper.

[0074] In addition to being directed to a low opacity paper and to products made from the paper, the present disclosure is also directed to a method for producing a low opacity paper. The method includes forming a fibrous web from a fiber furnish. The fibrous web, for instance, can be a wetlaid web. The fibrous web is then coated with an aqueous composition containing the transparency agent as described above. Any suitable technique can be used to coat the fibrous web. For instance, in one aspect, the fibrous web can be coated using a size press, air knife or bar coating.

[0075] According to a preferred embodiment, a paper product (10) comprises: a paper base sheet (12) comprising a fibrous web comprising unrefined cellulose fibers, the fibrous web having a basis weight of from 20 to 25 g/m², wherein the unrefined cellulose are softwood fibers; and a coating (14) comprising a transparency agent, wherein the transparency agent is a coconut-based wax, a palm-based wax or a soy-based wax; and wherein the paper product displays an opacity of less than 30%, preferably less than 25%, when tested according to ISO 2471:2008, and wherein the paper product has a basis weight less than 40 g/m² and an air permeability of greater than 3000 cm³/min/cm² and less than 6000 cm³/min/cm².

[0076] According to another preferred embodiment, a paper product (10) comprises: a paper base sheet (12) comprising a fibrous web containing unrefined cellulose fibers, the fibrous web having a basis weight of from 30 to 55 g/m², preferably 35 to 50 g/m², wherein the unrefined cellulose are softwood fibers; and a coating (14) comprising a transparency agent, wherein the transparency agent is a coconut-based wax; and wherein the paper product displays an opacity of less than 40%, when tested according to ISO 2471:2008, and wherein the paper product has a basis weight less than 72 g/m² and an air permeability of greater than 500 cm³/min/cm² and less than 2000 cm³/min/cm².

[0077] The present disclosure may be better understood with reference to the following examples.

Examples

[0078] Low opacity papers were made in accordance with the present disclosure and tested for various properties. Uncoated basesheets (fibrous webs) were also tested for purposes of comparison.

[0079] In a first set of examples, a fibrous web was constructed having a basis weight of 22 g/m². The fibrous web was formed from 100% unrefined softwood fibers using an inclined wire paper machine. Various transparency agents were applied to the fibrous web using a bar coating as follows:

Sample No. 1 and Sample No. 2: the transparency agent was a coconut-based wax having a melting point of from 30°C to 40°C;

Sample No. 3: the transparency agent was a palm-based wax having a melting point of about 60°C; and

Sample No. 4: the transparency agent was a soy-based wax having a melting point of about 68°C.

[0080] The coconut-based wax and the palm-based wax were both applied to the fibrous web as anionic aqueous dispersions. The soy-based wax, however, was applied to the fibrous web as a cationic emulsion. The samples were tested for opacity, mechanical properties, permeability, and water drop resistance. The following results were obtained:

	Base paper 22 g/m ²	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Grammage (g/m ²)	22	27	33	32	34
Add-on (g/m ²)	-	5	10.6	9.9	11.7
Opacity (%)	39.5	23.8	20.3	24.1	21.65
Tensile strength (cN/30mm)	3562	not measured	3691	4057	3778
Elongation (%)	1.55	1.46	1.95	1.92	1.8
Air permeability (cm ³ /min/cm ²)	7000	5578	4953	4070	4224
Water drop resistance (min)	0,15	>10	>10	>10	>10

[0081] As shown above, the opacity of the samples made in accordance with the present disclosure decreased by more than about 20%, such as by more than about 30%, such as by more than about 35% in comparison to the base paper. Water drop resistance dramatically increased while the product still had high air permeability characteristics.

[0082] Further low opacity papers were made in accordance with the present disclosure. In Sample No. 5, the coconut-based wax was applied using a bar coating to a fibrous web having a basis weight of 36 g/m². In Sample No. 6, the coconut-based wax was applied using a bar coating to a base paper having a basis weight of 50 g/m². The fibrous webs were formed from 100% unrefined softwood fibers using an inclined wire paper machine. The following results were obtained:

	Base paper 36 g/m ²	Sample No. 5	Base paper 50 g/m ²	Sample No. 6
Grammage (g/m ²)	36	52	50	72
Add-on (g/m ²)	-	17	-	21
Opacity (%)	52	28	62	36
Air permeability (cm ³ /min/cm ²)	2600	1596	1590	573
Water drop resistance (min)	0	10	0	10

[0083] These and other modifications and variations to the present invention may be practiced by those of ordinary skill in the art. Embodiments of the present invention are more particularly set forth in the appended claims.

Claims

1. A paper product comprising:

a fibrous web comprising cellulose fibers, the fibrous web having a basis weight of from 13 g/m² to 60 g/m² and defining a first surface and a second surface, wherein the cellulose fibers contain unrefined cellulose fibers; and a coating on the first surface and/or the second surface of the fibrous web, preferably on one of the first surface and the second surface, the coating comprising a transparency agent, the transparency agent comprising at least 95% by weight of a bio-based wax or oil, and wherein the paper product displays an opacity of less than 45% when tested according to ISO 2471:2008, and wherein the paper product also has an air permeability of greater than 350 cm³/min/cm².

2. A paper product as defined in claim 1, wherein the unrefined cellulose fibers have a Schopper-Riegler freeness value of greater than 5° SR and less than 25° SR, preferably greater than 7° SR and less than 20° SR.

3. A paper product as defined in claim 1 or 2, wherein the fibrous web comprises greater than 90% by weight of the unrefined cellulose fibers.

4. A paper product as defined in any of the preceding claims, wherein the unrefined cellulose fibers comprise wood fibers, preferably softwood fibers, hardwood fibers, or mixtures thereof.

5. A paper product as defined in any of claims 1 through 3, wherein the unrefined cellulose fibers comprise leaf fibers, preferably abaca fibers, sisal fibers, or mixtures thereof.

6. A paper product as defined in any of the preceding claims, wherein the fibrous web comprises regenerated cellulose fibers.

7. A paper product as defined in any of the preceding claims, wherein the fibrous web comprises bast fibers, preferably hemp fibers, flax fibers, or mixtures thereof.

8. A paper product as defined in any of the preceding claims, wherein the paper product has an air permeability of greater than 500 cm³/min/cm², preferably greater than 1000 cm³/min/cm², more preferably greater than 2000 cm³/min/cm², even more preferably greater than 3000 cm³/min/cm², most preferably greater than 4000 cm³/min/cm², and less than 30,000 cm³/min/cm².

9. A paper product as defined in any of the preceding claims, wherein the paper product displays a water drop resistance of greater than 10 minutes TAPPI T 432 cm-09.

10. A paper product as defined in any of the preceding claims, wherein the fibrous web has a basis weight of less than 55 g/m², preferably less than 40 g/m², more preferably less than 30 g/m², even more preferably less than 25 g/m².

11. A paper product as defined in any of the preceding claims, wherein the paper product has a basis weight of less than 75 g/m², preferably less than 60 g/m², more preferably less than 40 g/m², and greater than 18 g/m².

12. A paper product as defined in any of the preceding claims, wherein the paper product has not been supercalendered.

13. A paper product as defined in any of the preceding claims, wherein the bio-based wax or oil is a plant derived wax or oil, which preferably has a melting point of from 25°C to 75°C.

14. A paper product as defined in any of the preceding claims, wherein the bio-based wax or oil is a coconut-based wax, a soy-based wax, a palm-based wax, a rice-based wax or mixtures thereof.

15. A paper product as defined in any of the preceding claims, wherein the transparency agent comprises a wax having a melting point of from 25°C to 75°C, preferably from 30°C to 45°C.

16. A paper product as defined in any of the preceding claims, wherein the paper product has an opacity of less than 40%, preferably less than 38%, more preferably less than 36%, most preferably less than 32% when tested according to ISO 2471:2008.

17. A paper product as defined in any of the preceding claims, wherein the fibrous web comprises a wetlaid web.
18. A paper product as defined in any of the preceding claims, wherein the paper product is free of paraffins, mineral oil, or hydrocarbon oils.
19. A paper product as defined in any of the preceding claims, wherein the fibrous web comprises wood pulp fibers alone or in combination with bast fibers or leaf fibers.
20. A paper product as defined in any of the preceding claims, wherein the transparency agent is present in the paper product in an amount greater than 3 g/m², preferably in an amount greater than 5 g/m², more preferably in an amount greater than 8 g/m², even more preferably in an amount greater than 10 g/m², and in an amount less than 30 g/m², preferably in an amount less than 25 g/m², more preferably in an amount less than 15 g/m².
21. A method for producing the paper product as defined in any of the preceding claims, comprising:
- creating an aqueous suspension of the cellulose fibers
 - depositing the aqueous suspension of fibers onto a porous forming surface to form a fibrous web; and
 - coating at least one, preferably one, side of the fibrous web with an aqueous composition containing the transparency agent.
22. A use of the paper product as defined in any of claims 1 to 20 as a packaging material for fruits, vegetables, bread, flowers and/or plants.

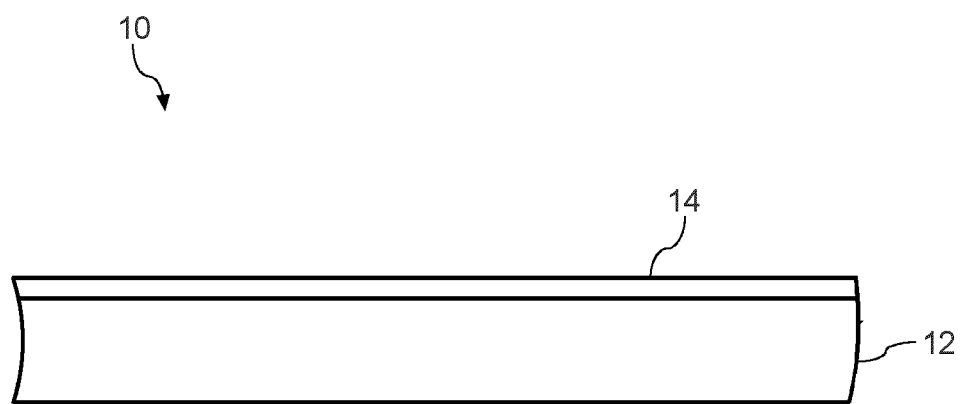


FIG. 1



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