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(54) Title: FIBER FORMULATION, ITS USE AND METHOD FOR MAKING IT

(57) Abstract: The various embodiments of the present invention generally relate to the use of earth-tone high-yield fiber formulation, where the fibers are selectively derived from hardwood or softwood or a combination thereof to advantageously manufacture towel, and tissue paper products and other sustainable hygienic products with much improved softness, water absorbency capacity, and tensile strength, as compared to bleached fibers. Further disclosed are specific preferred embodiments using earth-tone high-yield fibers selectively derived from eucalyptus and/or acacia pulp, in accordance with the principles of the present invention for production of the aforementioned products with the advantages set forth above. Additional advantages of the embodiments of the present invention will be readily apparent to the reader from this disclosure.



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FIBER FORMULATION, ITS USE AND METHOD FOR MAKING IT

Field of the Invention

This invention generally relates to earth-tone high-yield fiber formulation to advantageously manufacture towel, tissue paper products and other sustainable
5 hygienic products and to a method for making it according to preambles of the enclosed claims.

Background of the Invention

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The pulp and paper industry in North America produce an extensive volume of bleached softwood kraft pulp that is used in consumer products. Examples of uses of bleached pulp include, for example, the manufacturing of disposable tissue products and towels (e.g. facial and bath tissue, paper towels, etc.), and disposable
15 absorbent products (e.g. baby diapers, adult incontinence products, etc.), with about eight million tons per year of such pulp being used.

Commercially available towel and tissue products are usually composed of bleached kraft pulp fibers. Bleaching process increases the brightness of fibers by using
20 chemicals, such as for example, chlorine dioxide, for removing and/or oxidizing residual lignin from pulp fibers, that are typically obtained from kraft pulping or related chemical pulping processes. However, bleaching may lead to low fiber yields, high chemical usage, and significant effluent discharges (AOX, BOD) from the bleaching process.

25

Bleaching may also have a significant effect on the final fiber and tissue properties. In this regard, this may for example result in bulk, strength and water absorption properties being diminished, virtually due to the collapsing of fibers, when bleached, during the drying phase of tissue paper, primarily because the fibers are inherently
30 more flexible, and as such, a larger number of hydroxyl groups are thereby exposed on the cellulose molecules.

Often times, these properties exist in a trade-off, in which an increase in one property results in a decrease in another. In addition, the pulp material must be able to withstand the processes used to form the products. Tissue and towel products are generally manufactured by either i) conventional wet or light dry creped (LDC) processes or ii) structured tissue processes, such as through-air drying ("TAD")-creped and uncreped processes, Advanced Tissue Molding System (ATMOS), New Tissue Technology (NTT), double re-crepe process, etc. In the conventional wet or light dry creped process, a low consistency suspension (single layer, or multilayer) or the above-mentioned mixture of softwood and hardwood pulp fibers is wet laid, dewatered, and then pressed in its wet state, followed by drying and creping on a Yankee dryer, and finally finished by forming the sheets into rolls. In the TAD process, a wet formed sheet is first molded into a structured fabric (TAD fabric) and then through-air dried, with or without creping, resulting in a structured light-weight tissue product. Typically, TAD process uses minimal refining and wet web consolidation while delivering higher bulk, softness, and absorption properties at a lower basis weight. However, it uses a higher amount of creping chemistries and drying energy. Further, tissue converting processes may include slitting, cutting, printing, calendering, embossing, ply-bonding, gluing folding, etc.

Bleached baled eucalyptus hardwood has generally been the standard pulp for premium tissue and towel manufacturing, due to the fact that it provides optimum softness. Approximately 15 million tons of bleached eucalyptus is sold globally with the majority going to the tissue market. Kraft bleached hardwood eucalyptus fibers are commonly used in hygienic grades, such as facial, toilet and towel products at levels ranging from 50% to 90% of the total fiber formulation, because of the preferable sheet properties that it provides, such as, flexible fibers and further the propensity of providing free fiber ends that lends itself to a great overall sheet softness over other bleached hardwood fibers.

In the global manufacturing of tissue and towel products, the majority of grades are thus using bleached virgin fibers and/or bleached recycled fibers. A smaller market uses unbleached recycled Old Corrugated Containers (OCC) and Double Lined

Kraft (DLK), in order to produce away from home (commercial) earth-tone towel and napkins. For premium grades, the sheer majority uses bleached virgin fibers including at least a blend and mixture of hardwood fibers with softwood fibers, typically in a 70/30 ratio, so as to achieve desirable properties such as enhanced
5 softness, stiffness, and durability (e.g., tear strength, tensile strength, etc.).

Various prior art exists that solely deals with bleached fiber pulps. For example, US Patent No. 6,582,560 specifically pertains to a method for preparing fully bleached chemically-treated pulp fiber US Patent No. 8,257,551 discloses soft, layered,
10 single-ply wet-pressed tissue, which can be made with improved softness, by providing one or both outer layers of the tissue with bleached and poly-siloxane-treated pulp fibers.

When taking the above prior art into consideration, according to the inventors' expertise and general knowledge, that is additionally extending extensively beyond
15 the prior art presented above in the area of tissue, towel paper product development, there is generally a lack of use of earth-tone high-yield fiber formulation from hardwood, e.g., from eucalyptus or from acacia, for making tissue towel products and other sustainable hygienic products for that matter.

20 Consequently, as it stands now, there is an acute and an unmet need for manufacturing of earth-tone high-yield fiber formulation from hardwood or softwood, and particularly, the production of unbleached fibers from eucalyptus, and/or acacia pulp, that specifically take the aforementioned problems, limitations and
25 disadvantages into full consideration and thereby, in whole, eliminating them.

Therefore, it should be apparent by now that the general trend and future movement should be geared and focused away from the use of bleached grades, and instead directed towards the use of more high-yield light earth-tone or natural grades.

30 With the above in mind, this disclosure now provides surprising and novel solutions over the prior art and the previously mentioned problems, limitations, obstacles and

disadvantages, and particularly, deals with issues faced thus far, during the manufacturing process of tissue towel products and other hygienic products.

This, in turn, holds great promise and provides more environmentally friendly natural grades, that are manifold lower in cost to produce, than using bleached pulp, ultimately offering the advantage of also providing higher fiber yield in the end of the overall pulp processing phase, and in turn, exhibiting much improved inherent physical and chemical properties compared to bleached pulp fibers.

10 Summary of the Invention

According to a first aspect of the present invention, an earth-tone high-yield fiber formulation used for manufacturing of towel and tissue paper products and other sustainable hygienic products is contemplated, the formulation having earth-tone high-yield lignocellulosic fibers in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total wt-% of the fiber formulation, where the fiber formulation preferably has a brightness of less than 65% as compared to a bleached fiber formulation control and where fiber formulation has a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5 wt% of the total wt-% of the fiber formulation.

According to some particular preferred embodiments, the fibers are selectively derived from hardwood or softwood fibers. According to some particular preferred embodiments, the fibers are selectively derived from eucalyptus or acacia fibres as examples of hardwood pulp fibers. According to preferred embodiment the fibers have a freeness number higher than 300, and more preferably between 500-700. According to some particular embodiments, the fiber formulation has a brightness of less than 40% as compared to a bleached fiber formulation control. According to some particular embodiments, at least 50% of the fibers have an average length ranging from at least approximately 0.5 mm to at least approximately 3.0 mm. According to some particular embodiments, the fibers have a length less than approximately 5.0 mm. According to some particular embodiments, the fiber

formulation additionally includes additional fibers that are selectively derived from other hardwood species, such as poplar fibers or from softwood species, such as pine fibers or from mixed hardwood fibers, or from any such combination thereof. According to some particular preferred embodiments, the eucalyptus pulp fibers are prepared using a chemical pulping process such as carbonate-based pulping system, or a high kappa kraft pulping process in combination with a mechanical refining process. According to some advantageous embodiments, the fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared to a bleached fiber formulation control. According to some particular embodiments, the fiber formulation further includes additional chemicals selected from the group consisting of plasticizers, surfactants, and strength agents, flocculants, retention aids, drainage aids, biocides, defoamers, brightening agents, colorants, dyes, sizing agents, fixatives, and coagulants.

According to a second aspect of the present invention, a method for preparing an unbleached fiber formulation as described hereinabove is contemplated, used for manufacturing of towel and tissue paper products and other sustainable hygienic products, the method including selectively deriving earth-tone high-yield lignocellulosic fibers from a hardwood pulp or a softwood pulp or combination thereof; forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, the pulp slurry including at least approximately 1 wt-% fibers and at least approximately 99 wt-% water, where at least 80% of the fibers are unbleached; optionally adding into the slurry additional fibers, the additional fibers being different from the the earth-tone high-yield lignocellulosic fibers; optionally refining the slurry; sequentially passing the slurry through a screen, thereby filtering away debris having an unwanted size from the fiber formulation; and obtaining the earth-tone high-yield fiber formulation, where the earth-tone high-yield lignocellulosic fibers are in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total weight of the fiber formulation, and where the fiber formulation preferably has a brightness of less than 65% as compared to a bleached fiber formulation control, and the fiber formulation has a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3

wt%, and more preferably a lignin content greater than 5 wt% of the total weight of the fiber formulation.

According to a third aspect of the present invention, a method for preparing an unbleached fiber formulation as described hereinabove is contemplated, used for manufacturing of towel and tissue paper products and other sustainable hygienic products, the method including selectively deriving earth-tone high-yield lignocellulosic fibers from a hardwood or a softwood or their combinations by cooking the hardwood or softwood chips in a closed vessel at a temperature of approximately 160° C for about 3 hours under conditions characterized by having approximately 12% of an active alkali, 25% sulfidity and a ratio of 4/1 of liquor/wood, washing with water, and disintegrating the hardwood and/or softwood cooked chips; and optionally delignifying the earth-tone high-yield fibers under conditions characterized by having approximately 2.5% alkali, at a pressure of 100 psig oxygen and at a temperature of approximately 100° C for about one hour; and obtaining the earth-tone high-yield fiber formulation and washing the earth-tone high-yield fibers; and obtaining the earth-tone high-yield lignocellulosic fibers; and forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, the pulp slurry including at least approximately 1 wt-% fibers and at least approximately 99 wt-% water, where at least 80% of the fibers are unbleached, where the earth-tone high-yield lignocellulosic fibers are in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total wt-% of the fiber formulation, and where the fiber formulation preferably has a brightness of less than 65% as compared to a bleached fiber formulation control, and wherein fiber formulation has a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5 wt% of the total weight of the fiber formulation.

According to some particular preferred embodiments, the lignocellulosic fibers are selectively derived from hardwood or softwood fibers or any combinations thereof. According to some particular preferred embodiments, the lignocellulosic fibers are selectively derived from eucalyptus or acacia pulp fibers and the fibers preferably

have a freeness number higher than 300, and more preferably between 500-700. According to some particular embodiments, the fiber formulation has a brightness of less than 40% as compared to a bleached fiber formulation control. According to some particular embodiments, at least 50% of the fibers have an average length
5 ranging from at least approximately 0.5 mm to at least approximately 3.0 mm. According to some particular embodiments, the fibers have a length less than approximately 5.0 mm. According to some particular embodiments, the fiber formulation additionally includes additional fibers that are selectively derived from poplar fibers, pine fibers or mixed hardwood fibers, or from any such combination
10 thereof. According to some particular preferred embodiments, the eucalyptus pulp fibers are prepared using a carbonate-based pulping process, or a high kappa kraft pulping process in combination with a mechanical refining process. According to some advantageous embodiments, the fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared to
15 a bleached fiber formulation control. According to some particular embodiments, the fiber formulation further includes additional chemicals selected from the group consisting of plasticizers, surfactants, and strength agents, flocculants, retention aids, drainage aids, biocides, defoamers, brightening agents, colorants, dyes, sizing agents, fixatives, and coagulants.

20

According to a fourth aspect of the present invention, an earth-tone high-yield fiber formulation is contemplated according to previously set forth hereinbefore and prepared according to the methods previously presented hereinabove, which is used for manufacturing of towel and tissue paper products and other sustainable
25 hygienic products.

According to a fifth aspect of the present invention, a tissue paper product is contemplated having one or more plies and including approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of earth-tone high-yield
30 lignocellulosic fibers of the total wt-% of the tissue paper, where the tissue paper product exhibits at least a tensile index to Emtec TSA Softness (dB peak 620 Hz)

ratio of 0.50, and more preferably a tensile index to Emtec TSA Softness (dB peak 620 Hz) ratio of greater than 0.70.

Brief Description of the Drawings

- 5 The following drawings form part of the present specification and are included to further demonstrate certain aspects of the present invention. The invention may be better understood by reference to one or more of these drawings, in combination, with the detailed description of the specification embodiments presented herein.
- 10 FIG. 1 shows a schematic diagram of an exemplary embodiment of a generic tissue making process, which is suitable for use for various purposes of this invention.
- FIG. 2 shows a comparison of the characteristics of tissue handsheet tensile strength and stretchability properties.
- FIG. 3 shows a comparison of the characteristics of tissue handsheet water
- 15 absorption and bulk properties.
- FIG. 4A shows the softness of tissue paper as relayed by the Emtec TSA analyzer at dB peak 6200 Hz representing TS7. Lower peak values for TS7 correlate with higher intrinsic fiber flexibility and compliance.
- FIG. 4B shows the softness of tissue paper as relayed by the Emtec TSA method.
- 20 Lower peak values for both TS7 and TS750 correlate with higher hand feel values.
- FIG. 5 shows the tensile index and TSA softness (dB peak 6200 Hz) ratio.
- FIG. 6A shows a visual picture of unrefined unbleached eucalyptus pulp (UEK) creped sheet.
- FIG. 6B shows a visual picture of unrefined, unbleached and oxygenated eucalyptus
- 25 pulp (UEK-O) creped sheet.
- FIG. 6C shows a visual picture of refined unbleached eucalyptus pulp (UEK) creped sheet.
- FIG. 6D shows a visual picture of refined, unbleached and oxygenated eucalyptus pulp (UEK-O) creped sheet.
- 30 FIG. 7 shows different embodiments of the final sheets and how the earth-tone unbleached fibers can be composed as i) separate layers from the bleached white fibers or may be composed as ii) intermingled and intermixed with one another either

homogenously or heterogeneously, in accordance with different aspects of the invention.

Detailed Description of the Invention

5 The various embodiments of the present invention are generally directed to primarily the use of earth-tone high-yield fibers, in order to advantageously manufacture towel products and other sustainable hygienic products, with for example, much improved physical properties and other characteristics, such as but not limited to, softness, water absorbency capacity, tensile strength, stretchability and tensile index-softness
10 ratio. Additional advantages of the embodiments of the present invention will be readily apparent from this disclosure.

This disclosure now provides surprising and novel solutions over the prior art and the previously mentioned problems, limitations, obstacles and disadvantages, and
15 particularly, deals with issues faced thus far, during the manufacturing process of tissue towel products and other hygienic products. The present invention provides more environmentally friendly natural grades, that are manifold lower in cost to produce, than using bleached pulp, ultimately offering the advantage of also providing higher fiber yield in the end of the overall pulp processing phase, and in
20 turn, exhibiting much improved inherent physical and chemical properties compared to bleached pulp fibers.

Here, a significant innovation in tissue and related hygiene products is demonstrated through a novel formulation and a novel process technology. The sustainable
25 method exhibits a high yield, low chemical usage, low effluent discharge, while at the same time delivering a desirable improved bulk, water absorption, tensile strength, stretchability and softness properties. Additional advantages of the embodiments of the present invention will be readily apparent from this disclosure.

30 More specifically, what is disclosed in the preferred embodiments are earth-tone high-yield fibers specifically obtained from eucalyptus, and/or acacia pulp, in accordance with the principles of the present invention, for the production of the

forementioned products, or products, similar or akin to those mentioned hereinabove.

During a typical pulping process, a cellulosic fiber suspension having relatively high consistency, the so-called thick stock, is diluted with water, into what, is subsequently termed as thin stock.

The methods of the present disclosure are thus suitable for the manufacture of fiber webs of single ply, as well as, fiber webs comprising multiple plies. Depending on the application, the number of fibrous plies or layers in a given towel or tissue paper product can vary. The towel or tissue paper product may have one fibrous ply or layer or may advantageously have two or more fibrous plies or layers, e.g., a two-ply or multi-ply tissue product. Each of the plies or layers of a two- or multi-ply product may have different properties and may be formed from fiber suspensions having different types and amounts of fiber. For example, towel or tissue paper product may have a three ply configuration, but can equally be composed of a four ply, a five ply, and so forth, and however many layers a skilled artisan can advantageously envisage.

In a first aspect of the invention, an earth-tone high-yield fiber formulation used for manufacturing of towel and tissue products and other sustainable hygienic products is contemplated, the formulation having earth-tone high-yield lignocellulosic fibers in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total weight of the fiber formulation, and where the fiber formulation preferably has a brightness of less than 65% as compared to a bleached fiber formulation control, and where the fiber formulation has a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5 wt% of the total weight of the fiber formulation.

30

In a particular embodiment, towel or tissue product comprising an unbleached fiber formulation may include a layer of earth-tone high-yield lignocellulosic fibers with

two opposed surfaces obtained from, for example, hardwood, softwood fibers or a combination of the mentioned sources.

5 In one preferable embodiment, the earth-tone high-yield fibers are selectively derived from eucalyptus or acacia pulp fibers, or any mixtures thereof. Preferably the earth-tone high yield fibers are derived from eucalyptus pulp fibers. At least 50% of the eucalyptus or acacia fibers may have an average length ranging from at least approximately 0.5 mm to approximately 3.0 mm.

10 In a particular embodiment, the hardwood or softwood fibers are present in an amount ranging from approximately at least 50 wt-% to approximately at least 80 wt-% of a total weight of a tissue layer.

15 In a particular embodiment, the hardwood or softwood fibers may be present in an amount ranging from approximately at least 10 wt-% to approximately at least 50 wt-% of a total weight of a matrix. These fibers may be a different type of fiber, but should preferably have a length less than 5 mm.

20 In a particular embodiment, acceptable additional fibers that can be used within the scope of the invention, that at the same time provide desirable physical and chemical properties of the final manufactured product may selectively be derived from for example poplar fibers, pine fibers, or mixed hardwood fibers or softwood fibers.

25 In a particular embodiment, eucalyptus fibers may be prepared using a carbonate-based pulping process (1 to 4%) or high kappa kraft pulping process (i.e. Kappa number of approximately at least 53.5), in combination with mechanical refining processes, such as, for example disk refining.

30 In a second aspect of the invention, a method for preparing an unbleached fiber formulation is disclosed, for manufacturing of towel products and other sustainable hygienic products, the method including selectively deriving earth-tone high-yield

lignocellulosic fibers from a hardwood or a softwood; forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, the pulp slurry including at least approximately 1 wt-% fibers and at least approximately 99 wt-% water, where at least 80% of the fibers are unbleached; optionally adding into the slurry additional
5 fibers, the additional fibers being different from the lignocellulosic fibers; optionally refining the slurry; sequentially passing the slurry through a screen, thereby filtering away debris having an unwanted size from the fiber formulation; and obtaining the earth-tone high-yield fiber formulation, where the earth-tone high-yield lignocellulosic fibers are in an amount ranging from approximately at least 10
10 weight-% (wt-%) to approximately at least 90 wt-% of the total wt-% of the fiber formulation, where the fiber formulation has preferably a brightness of less than 65% as compared to a bleached fiber formulation control, and a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5% of the total wt-% of the fiber formulation, and where
15 the unbleached fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared to a bleached fiber formulation control.

In other words, according to the above method, the tissue pulp stock may be made
20 by incorporating preferably at least unbleached earth-tone high-yield lignocellulose eucalyptus fibers into an appropriate amount of water, in order to form a pulp slurry. The slurry may contain at least approximately 1% fibers and at least approximately 99% water, where at least approximately 80% of the fibers are unbleached. In other particular embodiments, the unbleached earth-tone high-yield lignocellulose fibers
25 may be selectively derived from acacia pulp fibers.

If other fibers are included, they may be added into the slurry or may alternatively be added as a separate layer deposited through a multi-layered headbox or twin wire former. The slurry may typically be mechanically refined in a beater, refiner, or
30 a similar such device, which would generally be known by a skilled artisan. It should be understood that a refiner applies mechanical and hydraulic forces in order to alter the fiber contexture within the water slurry. Without being bound by theory, for

example, the refining procedure may cause one or more of the following physical changes to the pulp material: fiber shortening, fibrillation (internal and external), removal of the primary walls, and the formation of fiber debris or fines. Refining may be accomplished to achieve the desired tensile strength for machine runnability and ease of consumer handling. The refining intensity can be measured using a freeness tester (e.g., targeting a certain freeness number according to the Canadian Standard Method (CSF) test).

In a particular embodiment, refining of the pulp slurry, i.e. solid phase matrix stock, is targeted to provide a freeness number higher than about 300 for eucalyptus, and more preferably, refining of the solid phase matrix stock is targeted to provide a freeness number ranging from about 500 to about 700 for eucalyptus. After beating or refining, the slurry may also be passed through a screen, which removes larger debris, but allows the desired size fibers to pass through the screen.

In some particular embodiments, tissue paper may be made using any suitable papermaking process, for example, as directed and set forth by the steps particularly accomplished by the equipment of FIG. 1.

In a particular embodiment, tissue paper is formed using a British handsheet mold as per T 205 Tappi Method with the following modifications: a light weight (~ 0.15 kg) foam roller was used for couching instead of a standard heavy (13 kg) brass roller and did not include the pressing. Tissue handsheets were conditioned at 23 °C and 50% RH before testing.

In a particular embodiment, tissue paper is formed using a continuous process on a Crescent or a Fourdrinier paper machine. The paper machine may have a single or multilayer headbox that delivers a stream of diluted fibers onto a continuously moving wire belt. The water drains through the wire, thereby forming a wet mat of fibers. The wet fiber mat is then pressed and dried on Yankee dryer or through an air-drying process. Subsequent operations may add softening additives or subject the fiber-mat to drying, creping, stretching, and/or embossing patterns, so as to

control tissue strength, softness, absorption, and other physical properties of the fiber formulation.

5 Tissue paper made by a continuous process, such as a crescent former paper machine, can advantageously impart directionality. The Machine Direction (MD) of the tissue paper corresponds to the direction the wire travels. The Cross Direction (CD) of the tissue paper refers to the direction perpendicular to the direction the wire travels. Some physical properties of the tissue paper, such as the tensile, will have different values in the MD versus CD.

10

In a certain particular embodiment, still further papermaking additives, i.e. additional chemicals, may be added to the aqueous fiber stock, at any time before the headbox, such as, but not limited to plasticisers, surfactants, strength agents and/or flocculants, as well as retention aids, drainage aids, biocides, defoamers, 15 brightening agents, colorants, dyes, sizing agents, fixatives, coagulants, or any combinations thereof.

According to a third aspect of the present invention, a method for preparing an unbleached fiber formulation as described hereinabove is contemplated, used for 20 manufacturing of towel and tissue paper products and other sustainable hygienic products, the method including selectively deriving earth-tone high-yield lignocellulosic fibers from a hardwood or a softwood by cooking the hardwood or softwood chips in a closed vessel at a temperature of approximately 160° C for about 3 hours under conditions characterized by having approximately 12% of an active 25 alkali, 25% sulfidity and a ratio of 4/1 of liquor/wood, washing with water, and disintegrating the hardwood or softwood cooked chips; optionally delignifying the earth-tone high-yield fibers under conditions characterized by having approximately 2.5% alkali, at a pressure of 100 psig oxygen and at a temperature of approximately 100° C for about one hour; obtaining the earth-tone high-yield fiber formulation and 30 washing the earth-tone high-yield fibers; obtaining the earth-tone high-yield lignocellulosic fibers; and forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, the pulp slurry including at least approximately 1 wt-

% fibers and at least approximately 99 wt-% water, where at least 80% of the fibers are unbleached, where the earth-tone high-yield lignocellulosic fibers are in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total wt-% of the fiber formulation, where the fiber formulation
5 has a brightness of less than 65% as compared to a bleached fiber formulation control and a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5% of the total wt-% of the fiber formulation, and where the unbleached fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared
10 to a bleached fiber formulation control.

According to a fourth aspect of the present invention, an earth-tone high-yield fiber formulation is contemplated, according to previously set forth hereinbefore and prepared by the methods presented hereinabove, which is used for manufacturing
15 of towel and tissue paper products and other sustainable hygienic products.

According to a fifth aspect of the present invention, a tissue paper product is contemplated having one or more plies and including approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of earth-tone high-yield
20 lignocellulosic fibers of the total wt-% of the tissue paper, where the tissue paper product exhibits at least a tensile index to Emtec TSA Softness (dB peak 620 Hz) ratio of 0.50, and more preferably a tensile index to Emtec TSA Softness (dB peak 620 Hz) ratio of greater than 0.70.

25 Some embodiments of the invention are described with the help of the following schematical and non-limiting drawings.

Figure 1 shows a schematic diagram of an exemplary embodiment of a generic tissue making process suitable for various purposes of this invention. Below are set
30 forth the individual structural components that are used in processing of fibrous pulp, in order to produce various sorts of tissues, as would be apparent to one having ordinary skill in the art. A fiber suspension may have a consistency of at least above

20 g/l, which is called a thick stock, before it is eventually diluted with white water into, what is characterized by being a thin stock. Thin stock is then delivered from the wet-end supply to a headbox 10 in the wet-end of the tissue-making machine. It is common practice to add various chemicals to the thin or thick stock, prior to the stock being expelled from the headbox 10, in order to achieve much better processing properties and end-use properties. Once jetted from the headbox 10, the fiber-water suspension is dewatered on a continuously moving screen 20, e.g. a machine wire, forming a fiber mat or web, which may also be referred to as a "ply" in a multi-layer (multi-ply) sheet. Optionally, the individual ply is combined with other plies, being formed simultaneously by other forming equipment, typically headboxes 10 or vat formers.

The wet-web is then released from the moving screen 20 of the forming section by going over a release roll, generally referred to as the couch roll, and is then guided into the wet-press section 30, where additional water is removed from the sheet via mechanical action and pressing, while still being processed in the wet web, and is then subsequently, dried and creped in the dryer section 40, for example by a Yankee dryer or simply by hot air, in order to finally form the dry sheet. The dry sheet is then finally rolled up on a spool, into what is called a reel 90. Some systems may have additional equipment 80 that apply one or more pigmented coatings to one or both sides of the sheet, before the dry sheet is rolled up into the reel 90.

Now all or some of the possible end-configurations and constitutions of the fibers, and how they coexist in the final sheets will be clarified, outlined and described with the help of Figure 7. As specifically visually illustrated in FIG. 7, in accordance with the different embodiments of the present invention, the bleached and earth-tone unbleached fibers can either exist in towel and tissue paper products as separate layers, or can equally be intermingled and intermixed with one another. As can be seen, for example, embodiment 1 shows pure earth-tone unbleached fibers, while embodiments 2 and 3, respectively, illustrate a two-ply configuration, in which the two layers of the white fibers and earth-tone unbleached fibers are physically separated from each other in separate layers. In embodiment 2, the earth-tone

unbleached fibers make up the top layer, while in embodiment 3, it is the white fibers, which make up the top layer. According to embodiments 4 and 5, the invention further contemplates, for example, a three-ply configuration, where the earth-tone unbleached fibers and white fibers are separated from each other in separate layers, and consequently, compose and thereby make up a three-layered end-product of towel or tissue. According to embodiment 4, the earth-tone unbleached fibers make up the first and third layers, having sandwiched in between therein white fibers, while in embodiment 5, in contrast, white fibers make up the first and third layers sandwiching the earth-tone unbleached fibers in the middle layer instead.

Embodiment 6 denotes a homogenous mixture of the earth-tone unbleached fibers within the white fibers, where the both fibers are intermingled and intermixed with each other. Finally, embodiment 7 illustrates a heterogenous mixture of the earth-tone unbleached fibers within the white fibers. In both embodiments 6 and 7, the reverse can easily and advantageously be envisioned, that is, in for example embodiment 6, denoting a homogenous mixture of the white fibers within the earth-tone unbleached fibers, where the fibers are intermingled and intermixed with each other. This equally holds true for embodiment 7, where the reverse would be a heterogenous mixture made up by white fibers laid-down within the earth-tone unbleached fibers.

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The specific direction and particular configuration, whereby the heterogeneously laid down earth-tone unbleached fibers are intermixed and intermingled within the white fibers, for example in embodiment 7, may vary. Thus, they do not necessarily need to be laid down and situated exclusively horizontally, but they may equally be situated vertically, or in any other possible angular position intermingled and intermixed within the white fibers.

25

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any materials similar or equivalent to those described herein can also be used in the practice of the present invention, exemplary materials are described for illustrative purposes.

30

As used herein this disclosure, "*Tensile Index (TI)*" is the tensile strength (TS) in N/m divided by basis weight (BW) in g/m². As used herein this disclosure, "*Tensile Strength*" is a measure, of how likely a given product or component is to break, when the product is undergoing stress, and is thereby being pulled at opposite ends. Tensile strength of an object is thus a physical characteristic that is inversely correlated to the phenomenon of undergoing breakage. Hence, the higher an object possesses tensile strength, the less likely the object will break. Tensile strength can be described by stress-strain graphs and may preferably be measured by TAPPI tests T-404 and T-494. Stress-strain curves provide a fundamental engineering description of the mechanical and physical behavior of a given product, when the product is subjected to considerable tensile stress exposure.

As used herein this disclosure, "*tensile stiffness*" describes the characteristics and the extent, to which, an object can resist a strain and a deformation, in response to an externally applied stress, force and load, and can be measured by any known method known to a person having ordinary skill in the art, but preferably, by the TAPPI T 494 Tensile properties of paper and paperboard (using constant rate of elongation apparatus) method. Hence the term, "*tensile stiffness*," the ratio of tensile force per unit width to tensile strain within the elastic region of the tensile-strain relationship. The elastic region of the tensile-strain relationship is the linear portion of the load-elongation relationship up to the elastic limit. The elastic limit is the maximum tensile force above which the load-elongation relationship departs from linearity. Tensile stiffness is numerically equivalent to $E \cdot t$, where E is the modulus of elasticity and t is sample thickness. Tensile stiffness relates to stiffness of the sheet and often gives a better indication of the mechanical response of the paper sheet to converting forces experienced during converting operations.

As used herein this disclosure "*unbleached*", unless stated otherwise, specifically refers to an earth-tone high-yield fiber formulation, while bleached fibers are meant to be characterized solely as white fibers in the context of the embodiments of the present invention. Particularly, in the context relating to the present disclosure,

earth-tone high-yield fiber formulation, may be subsequently treated by subjecting it to oxygen exposure at a given pressure, in order to further delignify the fibers in the final fiber formulation. However, a person having ordinary skill in the art would understand that this process of delignifying the fiber components undertaken via oxygen treatment is not equivalent to, and is therefore not identical to bleaching the fibers in the final fiber formulation. Thus, throughout this disclosure, and especially when viewed in the context of the provided Examples, a bleached fiber formulation is used as a negative control, as opposed to either oxygenated, or non-oxygenated unbleached and/or refined earth-tone high-yield fiber formulation. Especially, in the context of the present disclosure, what is specifically meant by "*high-yield*" describes a range of a weight-percent of the lignocellulosic fibers of the total fiber formulation, the lignocellulosic fibers being in an amount of from approximately at least 50% to approximately at least 60% of the total fiber formulation, and more preferably from approximately at least 55% to approximately at least 65% of the total fiber formulation.

As used herein this disclosure, in all disclosed embodiments, the term "*weight-percent*" and "*wt-%*" specifically refers to the individual weight of a component or constituent, taken in relation to the entire total weight of a formulation, unless stated and specified otherwise, in which case, it would be intended to mean the individual weight of the component relative to the total volume of the formulation.

As used herein, the terms "*about*" and "*approximately*" are used interchangeably, and are meant to designate any value, which lies preferably within a range of $\pm 5\%$, more preferably within a range of $\pm 2\%$, still more preferably, within a range of $\pm 1\%$ of the claimed value.

As used herein this disclosure, the term "*wet-pressing*" refers to a manner, in which, the newly formed wet tissue web is mechanically dewatered prior to undergoing drying. More specifically, the wet-web, while in contact with a papermaking felt, is pressed against and transferred to a hot drying cylinder, for example a Yankee dryer. During the pressing step, free water within the wet-web is expressed and

absorbed and carried away by the felt. The tissue is then finally dried on the Yankee dryer and subsequently creped, in order to soften the resulting tissue sheet.

As used herein this disclosure, the terms, "*wet end stock*" refers to thick stock or
5 thin stock or both. Thick stock or thin stock may contain other chemical additives other than merely fiber and water.

In the specific context of the invention, tissue and towel products generally refer to various paper products, such as, but not limited to facial tissue, bath tissue, paper
10 towels, napkins and so on, and absorbent products generally pertain to baby diapers and other products adapted to retain body exudates, such as bandages, feminine hygiene products, adult incontinence products, and so forth.

As used herein this disclosure, the term "*pulp*" refers to any pulp, which may be used
15 for the production of the towel and tissue paper products with the principles of the embodiments of the present invention. For example, the pulp may be selectively supplied preferably as a wood pulp, which may be made from softwood, such as, but not limited to, for example, pine, redwood, fir, spruce, cedar and hemlock, or from hardwood, such as, but not limited to, for example, eucalyptus, acacia, maple,
20 alder, birch, hickory, beech, aspen. In a particular preferred embodiment, the pulp may equally advantageously include a combination of both hardwood pulp and softwood pulp.

In a particular preferred embodiment, the suitable fibers used in accordance with
25 the main principles of the invention, include primarily earth-tone high-yield hardwood fibers and/or conventional eucalyptus pulp fibers and/or fibers originating from acacia such as disclosed in U.S. Pat. No. 6,582,560 B2, which is hereby incorporated by reference. A skilled artisan would understand that all depending on the desirable end-product, the mentioned fibers in the pulp, can be used either
30 separately or in any combination that would be applicable to the skilled artisan, for that matter.

In some particular embodiments, the amount or weight of the pulp fibers may independently be from greater than 0 wt-% to about 100 wt-%, more preferably from about 10 wt-% to about 100 dry wt-%, or even more preferably from about 10 wt-% to about 90 wt-% of the total weight of the fiber formulation.

5

It can be advantageous to provide an "*air side*", which is the outer layer (the outer layer of the tissue web not in contact with the Yankee dryer surface during the creping procedure), with a greater amount of pulp fibers than the "*dryer side*" outer layer (the outer layer of the tissue web that is indeed in contact with the Yankee
10 dryer surface during the creping procedure).

Suitable fibers may include any fibers, which provide sufficient tensile strength to the product for its intended purpose. Such fibers may preferably include conventional lignocellulosic fibers, such as hardwood and softwood fibers, and
15 especially in the context of the invention unbleached earth-tone high-yield fibers, as particularly and unequivocally set forth hereinbefore in this disclosure.

The fibers may advantageously be mechanically pulped (e.g., groundwood), chemically pulped (including but not limited to the kraft and sulfite pulp processes
20 performed by alkaline cooking, where most of the lignin and hemicellulose components are removed), organo-solvently pulped, semi-chemically-pulped, thermo-mechanically pulped, chemi-thermo-mechanically pulped, or may advantageously, undergo any such single or combinatory refining treatments, or may be subjected to any other pulping means, that would readily and generally be
25 known by a skilled artisan in the area of fiber pulping.

As would be understood by a skilled artisan, mechanical pulping is understood to be manufactured by the grinding and refining methods, where the raw material is primarily subjected to periodical pressure treatments that physically alter the overall
30 length and three-dimensional structure of the fibers in the pulp.

Again, to reiterate mixtures of any subset of the above-mentioned fiber types or related fiber classes combined with any refining method(s) can be undertaken, in order to provide a desirable final basis weight, strength and bulk.

- 5 In a particular preferred embodiment, the pulp to be used in the process of the invention may be a suspension of i) mechanical or ii) chemical pulp or iii) a combination thereof. For example, the final pulp to be used in the process of the invention may include 0%, 10-20%, 20-30%, 30-40%, 40-50%, 50-60%, 60-70%, 70-80%, 80-90%, or 90-100% of chemical pulp. In a particular embodiment, a
10 chemical pulp may form a part of the pulp being used for manufacturing the material in accordance with the embodiments of the present invention, such as, but not limited to towel products and other sustainable hygienic products. In the present context, the expression "*forms part of*" means that in the pulp to be used in the process of the invention, the percent of chemical pulp lies within the range of 1-99%,
15 while the remaining percent of the pulp is composed of preferably mechanically processed pulp or yet a differently processed pulp, as previously set forth hereinbefore. In particular embodiments, the percent of chemical pulp may lie within a range of 2-98%, 3-97%, 4-96%, 5-95%, 6-94%, 7-93%, 8-92%, 9-91%, 10-90%, 15-85%, 20-80%, 25-75%, 30-70%, 40-60%, or 45-55%, while the rest is made up
20 mechanically processed pulp or a yet differently processed pulp.

As used herein this disclosure, by cellulosic fibers are meant any cellulosic or ligno-cellulosic fibers that may be separated from hardwood or softwood or any combination thereof.

25

- In certain preferred embodiments, the cellulosic fiber suspension includes earth-tone high-yield fiber. In addition to cellulosic fibers, the cellulosic fiber suspension may equally also include other non-cellulosic polymeric fibers, such as, but not limited to fibers of cotton linters, rags, polyethylene, polypropylene, or polyester, in
30 the form of, e.g., single component or bi-component fibers.

In some particular preferred embodiments, the lignocellulosic fiber suspension may include at least about 10 wt-%, to at least about 90 wt-% of the total wt-% of the tissue paper.

- 5 As used herein this disclosure and in the appended claims, the singular form "a," "and," "the" include plural referents unless the context clearly dictates otherwise.

As used herein this disclosure, the terms "*comprises*," "*comprising*," "*includes*," "*including*," "*having*" and their conjugates mean "*including but not limited to*." Terms
10 and phrases used in this application, and variations thereof, unless otherwise expressly stated, should be construed as open ended as opposed to limiting. As examples of the foregoing, the term "*including*" should be read as meaning "*including, without limitation*" or the like. The term "*example*" is used to provide exemplary instances of the item in discussion, not an exhaustive or limiting list
15 thereof. Adjectives such as, e.g., "*conventional*," "*traditional*," "*known*" and terms of similar meaning should not be construed as limiting the item described to a given time period, or to an item available as of a given time. But instead these terms should be read to encompass conventional, traditional, normal, or standard technologies that may be available, known now, or at any time in the future.

20

Likewise, a group of items linked with the conjunction "*and*" should not be read as requiring that each and every one of those items be present in the grouping, but rather should be read as "*and/or*" unless expressly stated otherwise. Similarly, a group of items linked with the conjunction "*or*" should not be read as requiring mutual
25 exclusivity among that group, but rather should also be read as "*and/or*" unless expressly stated otherwise.

The presence of broadening words and phrases such as, "*one or more*," "*at least*," "*but not limited to*," or other like phrases in some instances shall not be read to mean
30 that the narrower case is intended or required in instances, where such broadening phrases may be absent.

It will be readily understood by one of ordinary skill in the relevant art that the present invention has broad utility and application. Although the present invention has been described and illustrated herein with referred to certain embodiments, it will be apparent to those of ordinary skill in the art that other embodiments may perform
5 similar functions and/or achieve like results, and that the described embodiments are for illustrative purposes only. Thus, it should be understood that various features and aspects of the disclosed embodiments can be combined with, or substituted for one another in order to form varying modes of the disclosed invention. Many different embodiments such as, variations, adaptations, modifications, and
10 equivalent arrangements are will be implicitly and explicitly disclosed by the embodiments described herein, and thus fall within the scope and spirit of the present invention.

Any embodiment discussed with respect to one aspect of the invention applies to
15 other aspects of the invention as well and vice versa. Each embodiment described herein is understood to be embodiments of the invention that are applicable to all aspects of the invention. It is contemplated that any embodiment discussed herein can be implemented with respect to any method, product or use of the invention, and vice versa.

20

Further, the discussed prior art is not an admission by the inventors and should not be construed that the current invention does not antecede and is not patentable over the discussed prior art, but has merely been presented to better define the knowledge in the field to a skilled artisan.

25

Finally, the scope of the embodiments should be determined by the appended claims and their legal equivalents, rather than by the Examples provided herein this disclosure.

30 **Examples**

The following non-limiting examples as well as the figures are included to demonstrate preferred embodiments of the invention. It should be appreciated by

those skilled in the art that the techniques disclosed in the Examples and Figures represent techniques discovered by the inventors to function well in the practice of the invention, and thus can be considered to constitute preferred modes for its practice. However, those of skill in the art should, in light of the present disclosure, appreciate that many changes can be made in the specific embodiments, which are disclosed and still obtain a like or similar result without departing from the spirit and scope of the invention.

Example 1: Comparison of tissue handsheet properties – Unbleached earth-tone high-yield fiber pulp exhibits improved physical and chemical characteristics as compared to a bleached control fiber pulp

In order to test the tissue handsheet properties, bleached eucalyptus pulp was used as a control and obtained from commercial sources, hereby denoted as BEK.

Unbleached eucalyptus kraft, UEK, pulp was produced using a mild kraft pulping process, where the conditions were as follows: 12% active alkali, 25% sulfidity, and 4/1 liquor/wood in a stainless-steel closed vessel under a controlled temperature (160° C) for 3 hours. The pulp yield was 61.3% with a Kappa number of 53.5 with a Klason lignin content of 8.8%.

The UEK pulp was further delignified using 2.5% alkali at 100°C, 100 psig oxygen and 10% consistency, hereby denoted as UEK-O.

All pulps, BEK, UEK, UEK-O, were subsequently refined, i.e. mechanically treated, using a PFI mill at 2.5K (2500) revolution at 10% consistency.

Tissue handsheets at a target basis weight of 40 g/m² were prepared according to standard TAPPI T205 with the following modifications: a light weight (~ 0.15 kg) foam roller was used for couching instead of a standard heavy (13 kg) brass roller with no pressing. All handsheets were conditioned at 23°C and 50% relative humidity RH before testing.

The tissue handsheets were tested for basic tissue properties such as water absorption applying the ISO 12625-8 Method, Density (T258), Air resistance/Porosity using TAPPI T460 method, tensile strength properties employing TAPPI T494 method, and softness using the Emtec TSA softness tester.

5 Table 1 show the different obtained results and properties of the experiment.

Table 1. Comparison of different tissue handsheet properties.

Sample ID		Unrefined			Refined		
		BEK (Control)	UEK (Invention)	UEK-O (Invention)	BEK (Control)	UEK (Invention)	UEK-O (Invention)
Basis Weight, g/m ²	Avg.	40.38	41.85	47.30	42.48	41.80	42.24
	St.Dev.	0.51	0.51	0.56	0.75	0.44	0.43
Caliper, mil	Avg.	6.68	9.31	9.28	5.20	5.28	4.94
Density, g/cc	Avg.	0.24	0.18	0.201	0.32	0.312	0.337
Bulk, cm ³ /g	Avg.	4.20	5.65	5.0	3.11	3.2	3.0
Tensile strength KN/m	Avg.	0.71	0.64	0.77	1.64	2.68	3.11
	St.Dev.	0.05	0.13	0.12	0.07	0.16	0.17
Stretch (%)	Avg.	2.83	0.91	0.91	2.89	2.99	4.12
	St.Dev.	0.57	0.16	0.10	0.27	0.28	0.48
Tensile Index (N.m/g)		17.47	15.39	16.26	38.49	64.19	73.53
Emtec TSA Softness (dB peak 6200 Hz)		42.20	17.17	23.03	103.50	90.76	73.54
Tensile Index and TSA Softness Ratio		0.41	0.90	0.71	0.37	0.71	1.00
Tensile Stiffness, KN/m	Avg.	103.32	126.00	145.00	183.28	240.40	244.80
	St.Dev.	7.80	21.40	10.20	10.58	15.50	16.85
Brightness, ISO	Avg.	83.20	23.18	34.20	84.10	21.73	29.45
	St.Dev.	0.42	0.46	0.65	0.37	0.21	0.23
Porosity, Secs/100 ml	Avg.	0.18	0.07	0.13	2.11	0.85	1.21
	St.Dev.	0.02	0.01	0.03	0.02	0.02	0.03
Water absorption g/g	Avg.	7.25	9.00	8.19	5.27	5.21	5.21
	St.Dev.	0.30	0.60	0.81	0.50	0.51	0.52
		Avg.	719	607	715	554	359
							307

PFI Refined at 2.5K Rev Freeness, CSF	St.Dev.	2.30	5.50	7.0	6.50	2.0	4.0
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A significant increase in fiber yield was obtained, which was 61.3% for the UEK invention when compared to BEK control, which is approximately 45-50% according to current practice. Further, reductions in chemical effluent discharge were observed, and a higher bulk and water absorption were achieved with unrefined UEK and UEK-O relative to the BEK control (FIG. 3). The unbleached tissue sample showed a surprising and an unanticipated, but yet an advantageous improvement in softness and smoothness (FIGs. 4A-4B and FIG 5), when compared to the BEK control.

Overall, refined UEK and UEK-O exhibited a higher tensile strength and softness, while at the same time, displaying similar water absorption and bulk profiles as the BEK control (FIGs. 2-3 and 4A-4B).

Tensile strength depends on factors such as fiber strength, fiber length, and bonding, among other things. Tensile strength exhibited similar behavior for both BEK and UEK unrefined fibers, as specifically seen in FIG. 2. However, unrefined UEK showed lower stretchability %. The UEK and UEK-O refined tissue handsheets showed higher tensile strengths compared to refined BEK tissue handsheets. Further, stretchability (%) also increased significantly with refining in these pulps.

Water absorption is one of the key characteristics of tissue paper. Water can be absorbed through the porous structure of paper or can be taken up by capillary action through the cell cavity and fiber walls of the cellulosic fibers. The capacity of water absorption depends on several factors such as paper density, pulp freeness, fiber types, fiber surface and chemicals used in the paper making process, and types of creping process.

FIG. 3 depicts the water absorption of tissue handsheets made from BEK and UEK hardwood pulps, and as can be seen, UEK pulps showed equal to or better water absorption relative to BEK pulp.

5 FIGs. 4A-4B show the softness of tissue paper as relayed by the Emtec TSA method. The softness of tissue paper is a combination of bulk and surface smoothness. Generally, softness correlates inversely with mechanical strength, as softness decreases with increasing mechanical strength properties. For instance, to increase the strength properties of tissue handsheets, inter-fiber bonding must be
10 increased, which reduces the flexibility of the paper structure. However, this also results in lower softness. The balance between softness and paper strength is delicate, and often can be solved by adding chemicals to the pulp or spraying on the surface of the paper. A higher ratio of tensile index and TSA softness was achieved with UEK and UEK-O relative to BEK control without any additives (FIG. 5).

15

As can be clearly seen in FIG. 4A, refined UEK and UEK-O exhibited a consistently improved smoothness compared to unrefined UEK and UEK-O around a peak at 6200 Hz.

20 In FIG. 4B, the first dominant peak around approximately 750 Hz frequency, also called the TS750 peak, indicates that the overall sheet structure can be defined as the roughness/smoothness of the paper. The higher the peak (sound intensity), the rougher the paper and vice versa. Consequently, the reverse is characterized by the lower the peak (sound intensity), the softer the product. In FIG. 4B, the second
25 dominant peak between approximately 6000-6500 Hz frequency, also known as the TS7 peak, on the other hand, specifically depicts the softness of tissue paper. Like smoothness, the higher the intensity of the second peak, the less soft the paper. And again, the lower the peak (sound intensity), the softer the product. Further as can be seen in FIG. 4B, refined UEK-O showed around 6000 f[Hz] the highest
30 softness (between 70-75 db V2 rms), as it consistently exhibited a lower peak (sound intensity) than what was contrasted by a lower softness and a higher peak (sound intensity) (between 100-105 db V2 rms) displayed by the refined BEK

control. UEK refined similarly exhibited a higher softness than by the refined BEK control, due to a peak (sound intensity) about 90 db V2 rms around 6000 f[Hz]. The unrefined BEK control showed lower softness, and thereby a higher peak (around 40 db V2 rms) compared to unrefined UEK and UEK-O, both of which, exhibited
5 peaks (sound intensities) slightly above 20 db V2 rms.

Finally, FIGs. 6A-6D show visually as pictures unrefined unbleached eucalyptus pulp UEK, oxygenated unrefined unbleached eucalyptus pulp UEK-O, refined unbleached eucalyptus pulp UEK and oxygenated refined unbleached eucalyptus
10 pulp UEK-O, respectively. It can be observed that the oxygenated unbleached eucalyptus (FIGs. 6B and 6D) exhibits a much more smoothly organized vertical fiber surface pattern, than their unbleached eucalyptus counterparts that possess no oxygenation in the pulp (FIGs 6A and 6C).

Claims

1. An earth-tone high-yield fiber formulation for manufacturing of towel and tissue paper products and other sustainable hygienic products, said fiber formulation
5 comprising:
earth-tone high-yield lignocellulosic fibers in an amount ranging from approximately at least 10 weight-% to approximately at least 90 weight-% of the total weight-% of the fiber formulation, wherein the fiber formulation has a lignin content greater than 1.5 weight-%, preferably a lignin content greater than 3 weight-%, and
10 more preferably a lignin content greater than 5 weight-% of the total weight of the fiber formulation.
2. The earth-tone high-yield fiber formulation according to claim 1, wherein the fibers are selectively derived from hardwood or softwood fibers or any combination
15 thereof.
3. The earth-tone high-yield fiber formulation according to claim 1 or 2, wherein the fibers are selectively derived from eucalyptus or acacia pulp fibres.
- 20 4. The earth-tone high-yield fiber formulation according to claim 1, 2 or 3, wherein the fibers have a freeness number of greater than 300, and more preferably between 500-700.
5. The earth-tone high-yield fiber formulation according to any one of claims 1
25 to 4, wherein the fiber formulation has a brightness of less than 65%, preferably less than 40%, as compared to a bleached fiber formulation control.
6. The earth-tone high-yield fiber formulation according to any one of the previous claims, wherein at least 50% of the fibers have an average length ranging
30 from at least approximately 0.5 mm to at least approximately 3.0 mm.

7. The earth-tone high-yield fiber formulation according to any one of the previous claims, wherein the fibers have a length less than approximately 5.0 mm.

8. The earth-tone high-yield fiber formulation according to any one of the previous claims, wherein the fiber formulation additionally comprises additional fibers that are selectively derived from poplar fibers, pine fibers or mixed hardwood fibers, or from any combination thereof.

9. The earth-tone high-yield fiber formulation according to any one of claims 3 to 8, wherein the fibers are eucalyptus pulp fibers and are prepared using a carbonate-based pulping process, or a high kappa kraft pulping process in combination with a mechanical refining process.

10. The earth-tone high-yield fiber formulation according to any one of the previous claims, wherein the fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared to a bleached fiber formulation control.

11. The earth-tone high-yield fiber formulation according to any one of the previous claims, further comprising additional chemicals selected from the group consisting of plasticizers, surfactants, and strength agents, flocculants, retention aids, drainage aids, biocides, defoamers, brightening agents, colorants, dyes, sizing agents, fixatives, and coagulants.

12. A method for preparing an earth-tone high-yield fiber formulation according to any of claims 1 – 11 for manufacturing of towel and tissue paper products and other sustainable hygienic products, said method comprising:

selectively deriving earth-tone high-yield lignocellulosic fibers from a hardwood or a softwood fibers or a combination thereof;

forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, said pulp slurry comprising at least approximately 1 wt-% fibers and at

least approximately 99 wt-% water, wherein at least 80% of the fibers are unbleached;

optionally adding into the slurry additional fibers, said additional fibers being different from the earth-tone high-yield lignocellulosic fibers;

5 optionally refining the slurry;

sequentially passing the slurry through a screen, thereby filtering away debris having an unwanted size from the fiber formulation; and

obtaining the earth-tone high-yield fiber formulation,

wherein said earth-tone high-yield lignocellulosic fibers are in an amount
10 ranging from approximately at least 10 weight-% to approximately at least 90 weight-% of the total weight of the fiber formulation, and

wherein the fiber formulation has a lignin content greater than 1.5 weight-%, preferably a lignin content greater than 3 weight-%, and more preferably a lignin content greater than 5 weight-% of the total weight of the fiber formulation.

15

13. A method for preparing an earth-tone high-yield fiber formulation according to any of claims 1 – 11 for manufacturing of towel and tissue paper products and other sustainable hygienic products, said method comprising:

selectively deriving earth-tone high-yield lignocellulosic fibers from a
20 hardwood or a softwood fibers or a combination thereof;

cooking hardwood or softwood chips in a closed vessel at a temperature of approximately 160° C for about 3 hours under conditions characterized by having approximately 12% of an active alkali, 25% sulfidity and a ratio of 4/1 of liquor/wood, washing with water and disintegrating the hardwood or softwood cooked chips;

25 optionally delignifying the earth-tone high-yield fibers under conditions characterized by having approximately 2.5% alkali, at a pressure of 100 psig oxygen and at a temperature of approximately 100° C for about 1.0 hour, and washing the earth-tone high-yield pulp fibers;

obtaining the earth-tone high-yield lignocellulosic fibers; and

30 forming a pulp slurry by mixing the earth-tone high-yield lignocellulosic fibers into water, said pulp slurry comprising at least approximately 1 wt-% fibers and at

least approximately 99 wt-% water, wherein at least 80% of the fibers are unbleached,

wherein said earth-tone high-yield lignocellulosic fibers are in an amount ranging from approximately at least 10 weight-% (wt-%) to approximately at least 90 wt-% of the total wt-% of the fiber formulation, and

wherein the fiber formulation has a brightness of less than 65% as compared to a bleached fiber formulation control and a lignin content greater than 1.5 wt%, preferably a lignin content greater than 3 wt%, and more preferably a lignin content greater than 5% of the total wt-% of the fiber formulation.

10

14. The method according to claim 12 or 13, wherein the fibers are selectively derived from eucalyptus or acacia pulp fibers.

15. The method according to claim 12, 13 or 14, wherein the fibers have a freeness number of greater than 300, and more preferably between 500 and 700.

20

16. The method according to claim 12 – 15, wherein the fiber formulation has a brightness of less than 65%, preferably less than 40% as compared to a bleached fiber formulation control.

17. The method according to any one of claims 12 – 16, wherein at least 50% of the fibers have an average length ranging from at least approximately 0.5 mm to at least approximately 3.0 mm.

25 18. The method according to any one of claims 12 – 17, wherein the fibers have a length less than approximately 5.0 mm.

19. The method according to any one of claims 12 – 18, wherein the fiber formulation additionally comprises additional fibers that are selectively derived from poplar fibers, pine fibers or mixed hardwood fibers, or from any combination thereof.

30

20. The method according to claim 14 – 19, wherein the eucalyptus pulp fibers are prepared using a carbonate-based pulping process, or a high kappa kraft pulping process in combination with a mechanical refining process.

5 21. The method according to any one of claims 12 – 20, wherein the fiber formulation exhibits at least an improved softness, water absorbency capacity and tensile strength, as compared to a bleached fiber formulation control.

22. The method according to any one of claims 12 – 21, further comprising
10 additional chemicals selected from the group consisting of plasticizers, surfactants, and strength agents, flocculants, retention aids, drainage aids, biocides, defoamers, brightening agents, colorants, dyes, sizing agents, fixatives, and coagulants.

23. Use of an earth-tone high-yield fiber formulation according to any one of
15 claims 1 – 11 and prepared by the method according to anyone of claims 12 – 22 for manufacturing of towel and tissue paper products and other sustainable hygienic products.

24. A tissue paper product having one or more plies and comprising
20 approximately at least 10 weight-% to approximately at least 90 wt-% of earth-tone high-yield lignocellulosic fibers of the total weight of the tissue paper product, wherein the tissue paper product exhibits a tensile index to Emtec TSA Softness (dB peak 620 Hz) ratio of at least 0.50, more preferably a tensile index to Emtec TSA Softness (dB peak 620 Hz) ratio of greater than 0.70.

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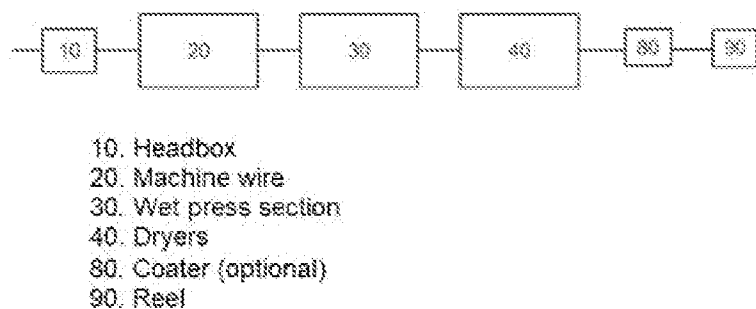


FIG. 1

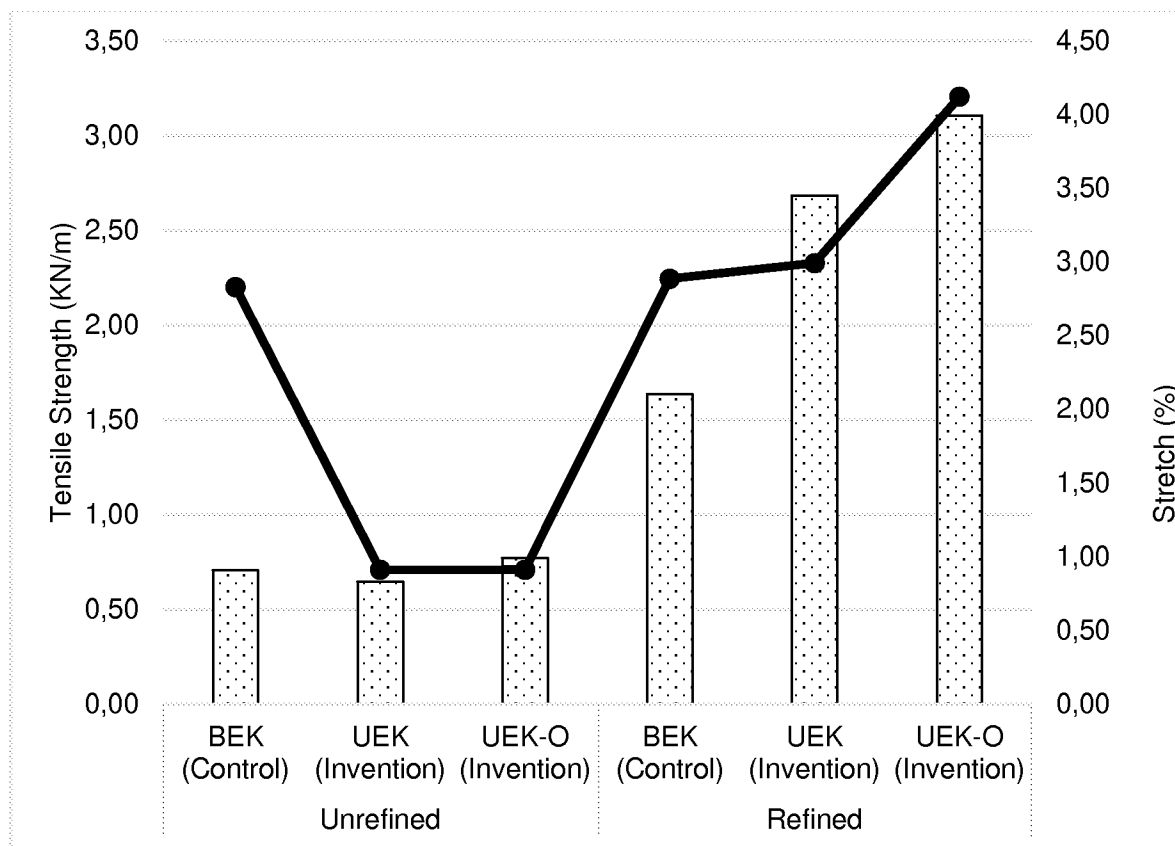


FIG. 2

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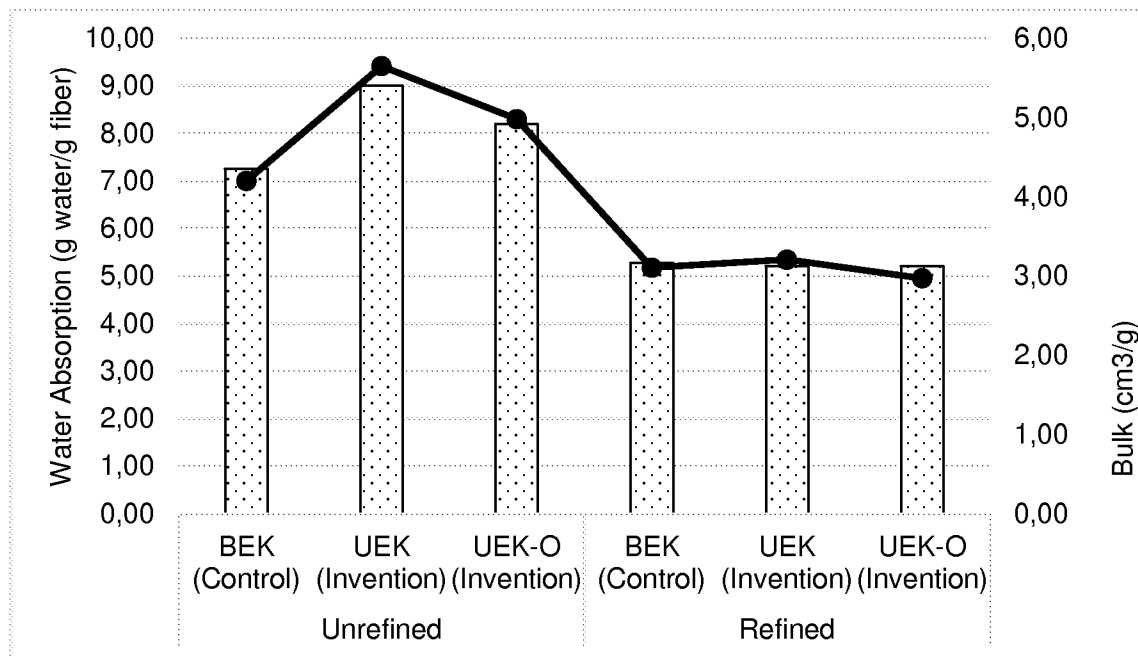


FIG. 3

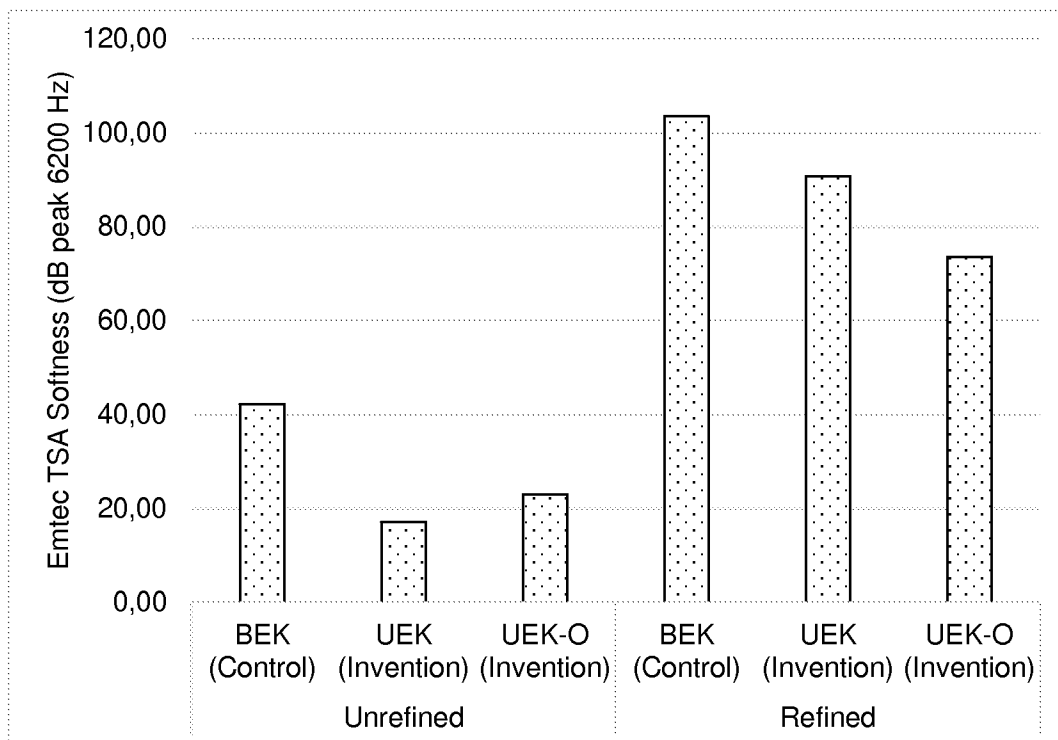


FIG. 4A

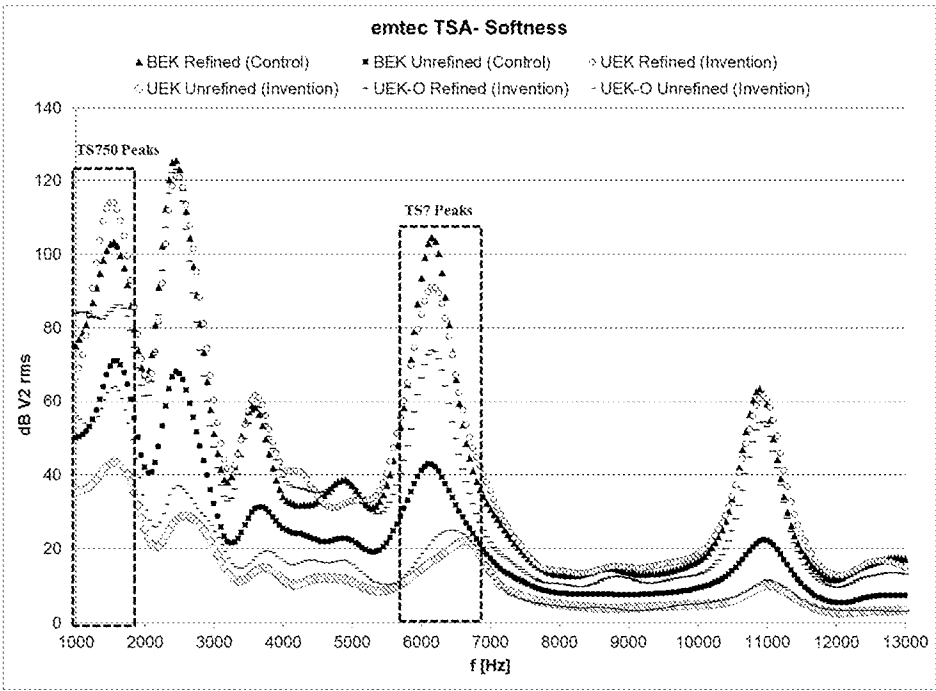


FIG. 4B

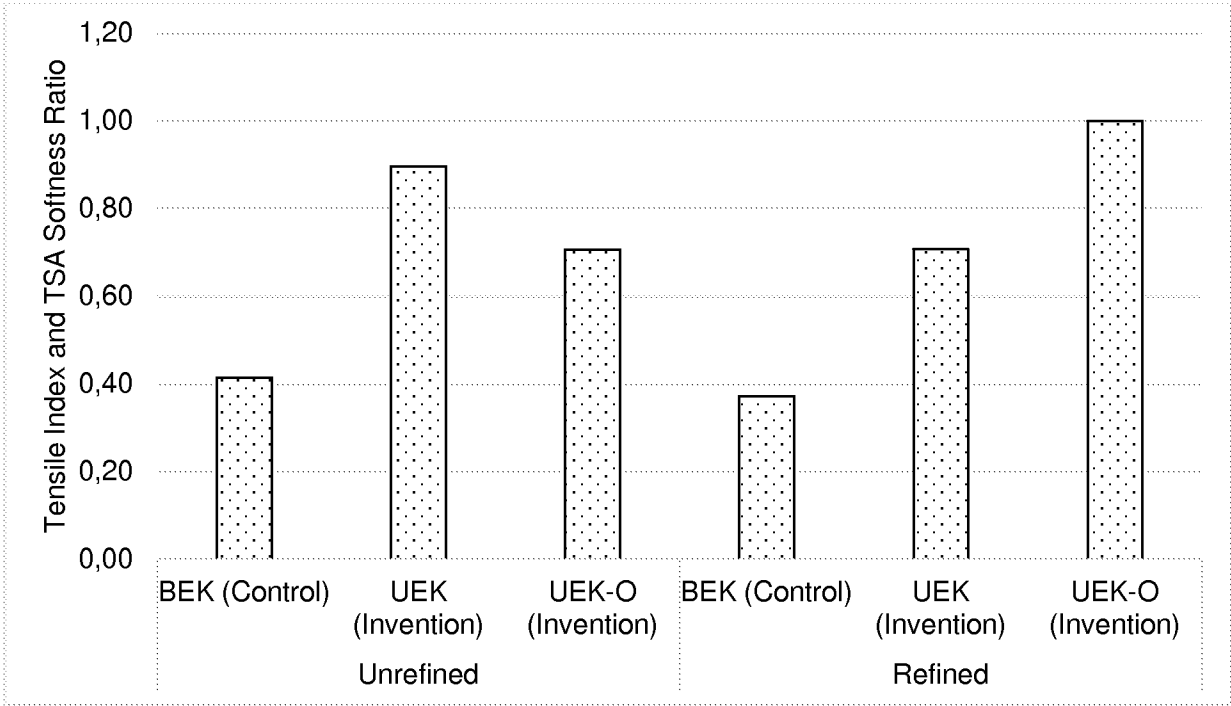


FIG. 5

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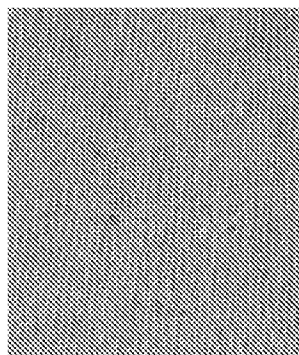


FIG. 6A

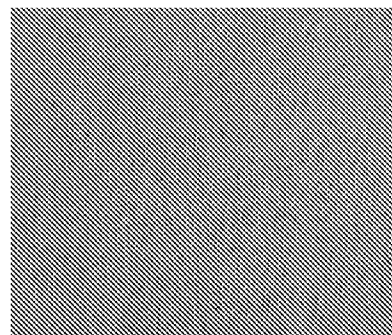


FIG. 6D

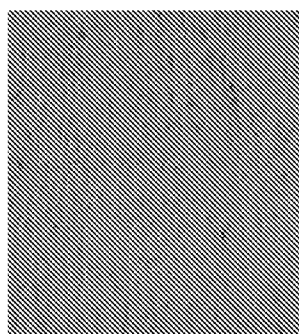


FIG. 6B

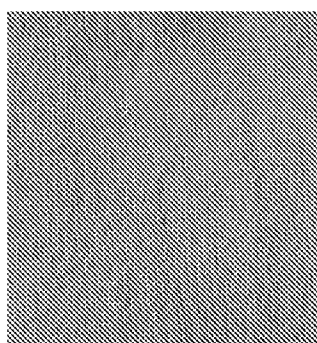
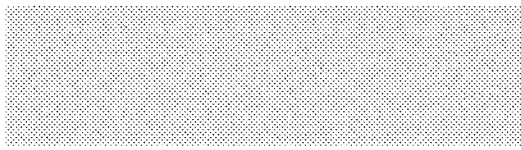
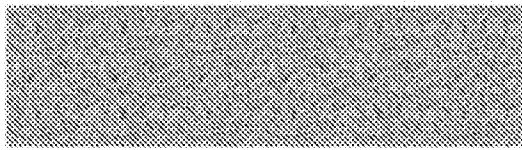


FIG. 6C

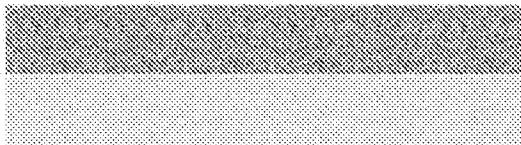
5/5



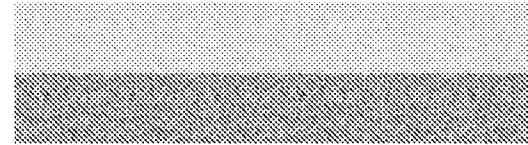
Control: White fibers



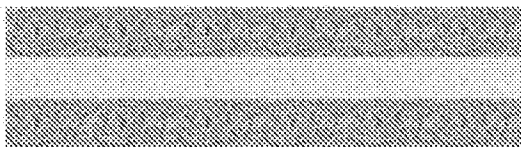
Invention Embodiment 1: Earth-tone Fibers



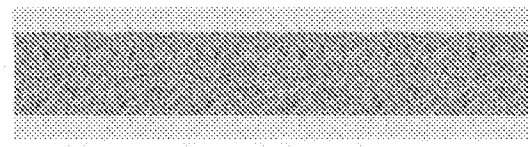
Invention Embodiment 2: Two Ply



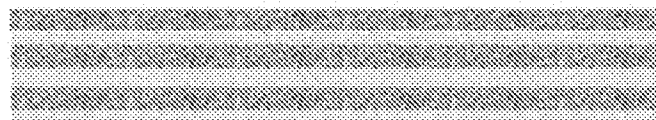
Invention Embodiment 3: Two Ply



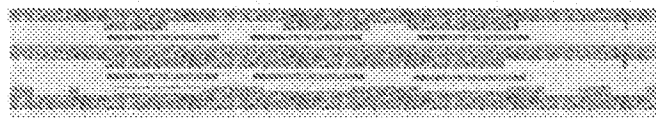
Invention Embodiment 4: Three Ply



Invention Embodiment 5: Three Ply



Invention Embodiment 6: Homogenous mixture



Invention Embodiment 7: Heterogenous mixture

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2020/050328

A. CLASSIFICATION OF SUBJECT MATTER INV. D21H27/00 D21H11/08 D21H11/10 D21H15/02 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) D21H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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X	US 2013/029106 A1 (LEE JEFFREY A [US] ET AL) 31 January 2013 (2013-01-31) claims 1-81; examples 1-2 -----	1-24
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X	WO 2016/195625 A1 (KIMBERLY CLARK CO [US]) 8 December 2016 (2016-12-08) claims 1-20 ----- -/-	1,12,23,24
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 11 August 2020		Date of mailing of the international search report 21/08/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Karlsson, Lennart

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