

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
24 December 2008 (24.12.2008)

PCT

(10) International Publication Number  
**WO 2008/157144 A1**

(51) International Patent Classification:  
D21H 25/00 (2006.01)

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(21) International Application Number:  
PCT/US2008/066471

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date: 11 June 2008 (11.06.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
11/763,278 14 June 2007 (14.06.2007) US

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(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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Published:

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments



WO 2008/157144 A1

(54) Title: PROCESS FOR INCREASING THE BASIS WEIGHT OF SHEET MATERIALS

(57) Abstract: Sheet-like products are disclosed containing an additive composition. In accordance with the present disclosure, the additive composition is applied to a creping surface. The additive composition includes at least an aqueous dispersion containing a thermoplastic polymer. A base sheet is then pressed against the creping surface for contact with the additive composition. The base sheet is then creped from the creping surface causing the additive composition to transfer to the base sheet. In particular, the additive composition is transferred to the base sheet in amounts greater than about 1 percent by weight, such as from 2 percent to 50 percent by weight. The additive composition may further include a lotion, a debonder, a softener, or mixtures thereof.

**PROCESS FOR INCREASING THE BASIS WEIGHT OF SHEET MATERIALS**

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**Field of Invention**

The instant invention relates to a process for increasing the basis weight of sheet materials.

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**RELATED APPLICATIONS**

The present application claims priority to United States Serial No. 11/763,278 filed on June 14, 2007, which claims priority to and is a continuation-in-part application of United States Serial No. 11/303,002 filed on December 15, 2005, United States Serial No. 11/304,490 filed on December 15, 2005, United States Serial No. 11/303,036 filed on December 15, 2005, United States Serial No. 11/304,998 filed on December 15, 2005, United States Serial No. 11/304,063 filed on December 15, 2005 and United States Serial No. 11/635,385 filed on December 7, 2006.

**BACKGROUND**

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Absorbent tissue products such as paper towels, facial tissues, bath tissues and other similar products are designed to include several important properties. For example, the products should have good bulk, a soft feel and should be highly absorbent. In addition, the products should also have sufficient strength for the particular application and environment in which they are to be used.

25

In the past, those skilled in the art have developed various processes for enhancing and improving various properties of tissue products. For example, in order to increase bulk and improve softness, tissue products have been subjected to creping processes. For example, in one embodiment, a creping adhesive is sprayed onto a rotating drum, such as a Yankee dryer. A base web is then adhered to the outside surface as the drum is rotating. A creping blade is then used to remove the base web from the surface of the drum. Creping the web from the drum compacts the web and can break fiber to fiber bonds which both increases the bulk and softness of the product.

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The present disclosure is directed to further improvements in web creping processes. In particular, the present disclosure is directed to process that can not only be used to crepe base sheets but can also be used to incorporate useful additives into the base sheets in amounts sufficient to improve the properties of the sheets.

### **SUMMARY**

In general, the present disclosure is directed to a method for applying an additive composition to a base sheet. In addition, as will be described in greater detail below, the base sheet may also be subjected to a creping process while the additive composition is being applied to the base sheet. Of particular advantage, the additive composition can be applied to the base sheet according to the present disclosure in an amount sufficient so as to increase the basis weight of the base sheet and improve various properties of the sheet.

For instance, in one embodiment, the present disclosure is directed to a process for producing a sheet product. The process includes the steps of applying an additive composition to a moving creping surface. The creping surface, for instance, may comprise the surface of a rotating drum. The drum may be at ambient temperature or may be heated.

Once the additive composition is applied to the creping surface, a base sheet is pressed against the creping surface. The additive composition adheres the base sheet to the creping surface. The base sheet is then removed from the creping surface. For instance, in one embodiment, a creping blade can be used to crepe the base sheet from the creping surface. During removal of the base sheet from the creping surface, in accordance with the present disclosure, the additive composition transfers to the base sheet such that the basis weight of the base sheet increases by at least about 1 percent by weight. Thus, the additive composition not only adheres the base sheet to the creping surface, but also transfers to the base sheet in an amount sufficient to influence the basis weight.

For example, through the process of the present disclosure, the basis weight of the base sheet may increase in an amount from 2 percent to 50 percent by weight, such as from 3 percent to 40 percent by weight, such as from 3 percent to 25 percent by weight, such as from 3 percent to 15 percent by weight. In one

embodiment, for instance, the basis weight of the base sheet may increase in an amount from 5 percent to 10 percent by weight.

In accordance with the present disclosure, the additive composition includes a thermoplastic polymer, such as a dispersion containing a thermoplastic polymer.

5 The additive composition may further comprise any suitable composition capable of adhering the base sheet to the creping surface while also being capable of transferring to the base sheet after the base sheet is removed from the creping surface. In other embodiments, the additive composition may further comprise a lotion, a softener, a debonder for cellulosic fibers, or any combination thereof. For  
10 example, in one embodiment, the additive composition may comprise a thermoplastic polymer combined with a lotion, a thermoplastic polymer combined with a debonder, or a thermoplastic polymer combined with a softener.

Any of the above described additive compositions can also be combined with various other ingredients. For instance, in one embodiment, the additive  
15 composition may contain in minor amounts of aloe and/or vitamin E that are intended to transfer to the base sheet from the creping surface.

As described above, in one embodiment, the additive composition may comprise a thermoplastic resin. The thermoplastic resin may be contained, for instance, in an aqueous dispersion prior to application to the creping surface.  
20 In one particular embodiment, the additive composition may comprise a non-fibrous olefin polymer. The additive composition, for instance, may comprise a film-forming composition and the olefin polymer may comprise an interpolymer of ethylene and at least one comonomer comprising an alkene, such as 1-octene. The additive composition may also contain a dispersing agent, such as a  
25 carboxylic acid. Examples of particular dispersing agents, for instance, include fatty acids, such as oleic acid or stearic acid.

In one particular embodiment, the additive composition may contain an ethylene and octene copolymer in combination with an ethylene-acrylic acid copolymer. The ethylene-acrylic acid copolymer is not only a thermoplastic resin,  
30 but may also serve as a dispersing agent. The ethylene and octene copolymer may be present in combination with the ethylene-acrylic acid copolymer in a weight ratio of from 1:10 to 10:1, such as from 2:3 to 3:2.

The olefin polymer composition may exhibit a crystallinity of less than about 50 percent, such as less than about 20 percent. The olefin polymer may also have a melt index of less than about 1000 g/10 min, such as less than about 700 g/10 min. The olefin polymer may also have a relatively small particle size, such as  
5 from 0.1 micron to 5 microns when contained in an aqueous dispersion.

In an alternative embodiment, the additive composition may contain an ethylene-acrylic acid copolymer. The ethylene-acrylic acid copolymer may be present in the above additive composition in combination with a dispersing agent, such as a fatty acid.

10 Once applied to a base web, it has been discovered that the additive composition may form a discontinuous but interconnected film depending upon the amount applied to the web. In other embodiments, the additive composition may be applied to a web such that the additive composition forms discrete treated areas on the surface of the web.

15 When containing a thermoplastic resin as described above, the additive composition may improve various properties of the base sheet. For instance, the additive composition provides the base sheet with a lotiony and soft feel. One test that measures one aspect of softness is called the Stick-Slip Test. During the Stick-Slip Test, a sled is pulled over a surface of the base sheet while the resistive  
20 force is measured. A higher stick-slip number indicates a more lotiony surface with lower drag forces. Base webs treated in accordance with the present disclosure, for instance, can have a stick-slip on one side of greater than about -0.01, such as from -0.006 to 0.7, such as from 0 to 0.7.

In addition, the additive composition when containing the thermoplastic  
25 resin may also increase the strength of the product while also enhancing softness.

The base sheets treated in accordance with the present disclosure can be made entirely from cellulosic fibers, such as pulp fibers, can be made from other natural fibers, can be made from synthetic fibers, or can be made from a mixture of different fibers. For instance, the base sheets can comprise cellulosic fibers in  
30 combination with synthetic fibers. The base sheet may, for example, comprise less than 50 percent by weight of cellulosic fibers based on the weight of the base sheet; for example, the base sheet may comprise 0 to 49 percent by weight of cellulosic fibers based on the weight of the sheet. In the alternative, a portion of

the fibers, such as greater than 50 percent by dry weight, or from 55 to 99 percent by dry weight, can be synthetic fibers such as rayon, polyolefin fibers, polyester fibers, bicomponent sheath-core fibers, multi-component binder fibers, and the like. In the alternative, the base sheet can be made entirely from synthetic fibers such as rayon, polyolefin fibers, polyester fibers, bicomponent sheath-core fibers, multi-  
5 component binder fibers, and the like.

Base sheets that may be treated in accordance with the present disclosure include wet-laid base webs. The sheet products made in accordance with the present disclosure, for instance, may comprise bath tissue, facial tissue, paper  
10 towels, industrial wipers, premoistened wipers, and the like. The product may contain one-ply or may contain multiple plies.

In other embodiments, however, the base sheet may comprise an airlaid web, a hydroentangled web, a coform web, a spunbond web, a meltblown web, and the like. In still other embodiments, the base sheet may comprise a woven  
15 material or a knitted material.

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

### **BRIEF DESCRIPTION OF THE DRAWINGS**

20 For the purpose of illustrating the instant invention, there is shown in the drawings a form that is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

Figure 1 is a schematic diagram of a tissue web forming machine, illustrating the formation of a stratified base web having multiple layers in  
25 accordance with the present disclosure;

Figure 2 is a schematic diagram of one embodiment of a process for forming wet pressed, creped base webs for use in the present disclosure;

Figures 3-12 and 14-19 are the results obtained in the Examples as described below;

30 Figure 13 is a diagram illustrating the equipment used to perform a Stick-Slip Test;

Figure 20 is a schematic diagram of another embodiment of a process for forming creped tissue webs in accordance with the present disclosure; and

Figure 21 is a schematic diagram of still another embodiment of a process for applying an additive composition to one side of a base web and creping one  
5 side of the web in accordance with the present disclosure.

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

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### **DETAILED DESCRIPTION**

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.

In general, the present disclosure is directed to the incorporation of an  
15 additive composition into a sheet product, such as a tissue web. More particularly, the present disclosure is directed to applying an additive composition to a creping surface. The additive composition adheres a base sheet to the creping surface for creping the base sheet from the surface. In addition to adhering the base sheet to the creping surface, the additive composition also transfers to the base sheet in  
20 amounts sufficient to increase the basis weight, such as more than 1 percent by weight. In this manner, sufficient amounts of the additive composition can be transferred to a sheet in order to improve one or more properties of the base sheet. In addition, during the process, the base sheet can be creped which may also increase the softness and bulk of the base sheet.

25 The additive composition comprises a thermoplastic polymer, such as an aqueous dispersion containing a thermoplastic resin. Once transferred to the base sheet, the thermoplastic resin may be configured to increase the strength of the base sheet, to improve the feel of the base sheet, and/or to enhance various other properties of the base sheet.

30 The additive composition may further include various ingredients and components. For example, in one embodiment, the additive composition may further comprise a lotion that improves the feel of the base sheet and/or may be available for transfer to a user's skin for moisturizing the skin and providing other

benefits. In general, any suitable lotion composition may be used in accordance with the present disclosure as long as the lotion is capable of adhering the base sheet to a creping surface.

In addition, the additive composition may contain various other ingredients.

5 For instance, other ingredients that may be contained within the additive composition include a debonder, a softener, and/or various other beneficial agents, such as aloe or vitamin E. For instance, in one embodiment, the additive composition may comprise a lotion and a thermoplastic polymer dispersion that  
10 either to the product or to the user of the product. In still another embodiment, a lotion may be combined with a thermoplastic polymer dispersion to form the additive composition of the present disclosure.

The base sheet that may be processed according to the present disclosure can vary depending upon the particular application and the desired result. The  
15 base sheet may comprise, for instance, a base web containing cellulosic fibers. In alternative embodiments, the base sheet may comprise nonwoven webs containing cellulosic fibers and synthetic fibers such as hydroentangled webs and coform webs. In other embodiments, nonwoven webs, such as meltblown webs and spunbond webs may still be used. In still other embodiments, woven materials  
20 and knitted materials may also be used in the process as long as the materials are capable of being adhered to a creping surface and removed.

In one particular embodiment, for instance, the process of the present disclosure is directed to forming wet pressed base webs. In this embodiment, an  
25 aqueous suspension of paper making fibers is formed into a base web which is then adhered to a creping surface while wet. For example, referring to **Fig. 2** one embodiment of a process for forming wet pressed creped base webs is shown. In this embodiment, a headbox **60** emits an aqueous suspension of fibers onto a forming fabric **62** which is supported and driven by a plurality of guide rolls **64**. A vacuum box **66** is disposed beneath forming fabric **62** and is adapted to remove  
30 water from the fiber furnish to assist in forming a web. From forming fabric **62**, a formed web **68** is transferred to a second fabric **70**, which may be either a wire or a felt. Fabric **70** is supported for movement around a continuous path by a plurality



of guide rolls **72**. Also included is a pick up roll **74** designed to facilitate transfer of web **68** from fabric **62** to fabric **70**.

From fabric **70**, web **68**, in this embodiment, is transferred to the surface of a rotatable heated dryer drum **76**, such as a Yankee dryer.

5 In accordance with the present disclosure, the additive composition can be incorporated into the base web **68** by being applied to the surface of the dryer drum **76** for transfer onto one side of the base web **68**. In this manner, the additive composition is used to adhere the base web **68** to the dryer drum **76**. In this  
10 embodiment, as web **68** is carried through a portion of the rotational path of the dryer surface, heat is imparted to the web causing most of the moisture contained within the web to be evaporated. Web **68** is then removed from dryer drum **76** by a creping blade **78**. Creping web **78** as it is formed further reduces internal bonding within the web and increases softness. Applying the additive composition to the web during creping, on the other hand, may improve other properties of the  
15 web.

In accordance with the present disclosure, substantial amounts of the additive composition are transferred to the base web during the creping process. For instance, the basis weight of the web may increase by more than 1 percent by weight due to the amount of additive composition that is transferred. More  
20 particularly, the additive composition may be transferred to the web in an amount from 2 percent to 50 percent by weight, such as from 2 percent to 40 percent by weight, such as from 2 percent to 30 percent by weight. In various embodiments, for instance, the additive composition may transfer to the base web in an amount from 5 percent to 25 percent by weight, such as from an amount of 5 percent to 15  
25 percent by weight.

As described, in one embodiment, the additive composition may comprise a thermoplastic polymer resin. The thermoplastic polymer resin may be applied to the creping surface in a form of an aqueous dispersion. Once transferred to the base web in accordance with the present disclosure, the polymer dispersion may  
30 improve various properties of the web. For instance, the polymer may improve the geometric means tensile strength and the geometric mean tensile energy absorbed of the web. Further, the strength of the web may be improved without

adversely impacting the stiffness of the web. In fact, the thermoplastic polymer may improve the perceived softness of the web.

When comprising a thermoplastic resin, the additive composition generally contains an aqueous dispersion comprising at least one thermoplastic resin, water, and, optionally, at least one dispersing agent. The thermoplastic resin is present within the dispersion at a relatively small particle size. For example, the average volumetric particle size of the polymer may be less than about 5 microns. The actual particle size may depend upon various factors including the thermoplastic polymer that is present in the dispersion. Thus, the average volumetric particle size may be from 0.05 microns to 5 microns, such as less than about 4 microns, such as less than about 3 microns, such as less than about 2 microns, such as less than about 1 micron. Particle sizes can be measured on a Coulter LS230 light-scattering particle size analyzer or other suitable device. When present in the aqueous dispersion and when present in the base web, the thermoplastic resin is typically found in a non-fibrous form.

The particle size distribution of the polymer particles in the dispersion may be less than or equal to about 2.0, such as less than 1.9, 1.7 or 1.5.

Examples of aqueous dispersions that may be incorporated into the additive composition of the present disclosure are disclosed, for instance, in U.S. Patent Application Publication No. 2005/0100754, U.S. Patent Application Publication No. 2005/0192365, PCT Publication No. WO 2005/021638, and PCT Publication No. WO 2005/021622, which are all incorporated herein by reference.

In one embodiment, the additive composition may comprise a film forming composition capable of forming a film on the surface of a base web. For instance, when applied to a base web, the additive composition can form a discontinuous but interconnected film. In other words, the additive composition forms an interconnected polymer network over the surface of the base web. The film or polymer network, however, is discontinuous in that various openings are contained within the film. The size of the openings can vary depending upon the amount of additive composition that is applied to the web and the manner in which the additive composition is applied. Of particular advantage, the openings allow liquids to be absorbed through the discontinuous film and into the interior of the

base web. In this regard, the wicking properties of the base web are not substantially affected by the presence of the additive composition.

In other embodiments, the additive composition does not form an interconnected network but, instead, appears on the base sheet as treated discrete  
5 areas.

In this embodiment, the additive composition can remain primarily on the surface of the base web. In this manner, not only does the discontinuous film allow the base web to absorb fluids that contact the surface but also does not significantly interfere with the ability of the base web to absorb relatively large  
10 amounts of fluid. Thus, the additive composition does not significantly interfere with the liquid absorption properties of the web while increasing the strength of the web without substantially impacting adversely on the stiffness of the web.

The thickness of the additive composition when present on the surface of a base sheet can vary depending upon the ingredients of the additive composition  
15 and the amount applied. In general, for instance, the thickness can vary from 0.01 microns to 10 microns. At higher add-on levels, for instance, the thickness may be from 3 microns to 8 microns. At lower add-on levels, however, the thickness may be from 0.1 microns to 1 micron, such as from 0.3 microns to 0.7 microns.

At relatively low add-on levels, the additive composition may also deposit  
20 differently on the base sheet than when at relatively high add-on levels. For example, at relatively low add-on levels, not only do discrete treated areas form on the base sheet, but the additive composition may better follow the topography of the base sheet. For instance, in one embodiment, it has been discovered that the additive composition follows the crepe pattern of a base sheet when the base  
25 sheet is creped.

The thermoplastic resin contained within the additive composition may vary depending upon the particular application and the desired result. In one embodiment, for instance, thermoplastic resin is an olefin polymer. As used herein, an olefin polymer refers to a class of unsaturated open-chain hydrocarbons  
30 having the general formula  $C_nH_{2n}$ . The olefin polymer may be present as a copolymer, such as an interpolymers. As used herein, a substantially olefin polymer refers to a polymer that contains less than about 1 percent substitution.

In one particular embodiment, for instance, the olefin polymer may comprise an alpha-olefin interpolpolymer of ethylene with at least one comonomer selected from the group consisting of a C<sub>4</sub>-C<sub>20</sub> linear, branched or cyclic diene, or an ethylene vinyl compound, such as vinyl acetate, and a compound represented by the formula H<sub>2</sub>C=CHR wherein R is a C<sub>1</sub>-C<sub>20</sub> linear, branched or cyclic alkyl group or a C<sub>6</sub>-C<sub>20</sub> aryl group. Examples of comonomers include propylene, 1-butene, 3-methyl-1-butene, 4-methyl-1-pentene, 3-methyl-1-pentene, 1-heptene, 1-hexene, 1-octene, 1-decene, and 1-dodecene. In some embodiments, the interpolpolymer of ethylene has a density of less than about 0.92 g/cc.

In other embodiments, the thermoplastic resin comprises an alpha-olefin interpolpolymer of propylene with at least one comonomer selected from the group consisting of ethylene, a C<sub>4</sub>-C<sub>20</sub> linear, branched or cyclic diene, and a compound represented by the formula H<sub>2</sub>C=CHR wherein R is a C<sub>1</sub>-C<sub>20</sub> linear, branched or cyclic alkyl group or a C<sub>6</sub>-C<sub>20</sub> aryl group. Examples of comonomers include ethylene, 1-butene, 3-methyl-1-butene, 4-methyl-1-pentene, 3-methyl-1-pentene, 1-heptene, 1-hexene, 1-octene, 1-decene, and 1-dodecene. In some embodiments, the comonomer is present at 5 percent by weight to 25 percent by weight of the interpolpolymer. In one embodiment, a propylene-ethylene interpolpolymer is used.

Other examples of thermoplastic resins which may be used in the present disclosure include homopolymers and copolymers (including elastomers) of an olefin such as ethylene, propylene, 1-butene, 3-methyl-1-butene, 4-methyl-1-pentene, 3-methyl-1-pentene, 1-heptene, 1-hexene, 1-octene, 1-decene, and 1-dodecene as typically represented by polyethylene, polypropylene, poly-1-butene, poly-3-methyl-1-butene, poly-3-methyl-1-pentene, poly-4-methyl-1-pentene, ethylene-propylene copolymer, ethylene-1-butene copolymer, and propylene-1-butene copolymer; copolymers (including elastomers) of an alpha-olefin with a conjugated or non-conjugated diene as typically represented by ethylene-butadiene copolymer and ethylene-ethylidene norbornene copolymer; and polyolefins (including elastomers) such as copolymers of two or more alpha-olefins with a conjugated or non-conjugated diene as typically represented by ethylene-propylene-butadiene copolymer, ethylene-propylene-dicyclopentadiene copolymer, ethylene-propylene-1,5-hexadiene copolymer, and ethylene-propylene-

ethylidene norbornene copolymer; ethylene-vinyl compound copolymers such as ethylene-vinyl acetate copolymers with N-methylol functional comonomers, ethylene-vinyl alcohol copolymers with N-methylol functional comonomers, ethylene-vinyl chloride copolymer, ethylene acrylic acid or ethylene-(meth)acrylic acid copolymers, and ethylene-(meth)acrylate copolymer; styrenic copolymers (including elastomers) such as polystyrene, ABS, acrylonitrile-styrene copolymer, methylstyrene-styrene copolymer; and styrene block copolymers (including elastomers) such as styrene-butadiene copolymer and hydrate thereof, and styrene-isoprene-styrene triblock copolymer; polyvinyl compounds such as polyvinyl chloride, polyvinylidene chloride, vinyl chloride-vinylidene chloride copolymer, polymethyl acrylate, and polymethyl methacrylate; polyamides such as nylon 6, nylon 6,6, and nylon 12; thermoplastic polyesters such as polyethylene terephthalate and polybutylene terephthalate; polycarbonate, polyphenylene oxide, and the like. These resins may be used either alone or in combinations of two or more.

In particular embodiments, polyolefins such as polypropylene, polyethylene, and copolymers thereof and blends thereof, as well as ethylene-propylene-diene terpolymers are used. In some embodiments, the olefinic polymers include homogeneous polymers described in U.S. Pat. No. 3,645,992 by Elston; high density polyethylene (HDPE) as described in U.S. Pat. No. 4,076,698 to Anderson; heterogeneously branched linear low density polyethylene (LLDPE); heterogeneously branched ultra low linear density (ULDPE); homogeneously branched, linear ethylene/alpha-olefin copolymers; homogeneously branched, substantially linear ethylene/alpha-olefin polymers which can be prepared, for example, by a process disclosed in U.S. Pat. Nos. 5,272,236 and 5,278,272, the disclosure of which process is incorporated herein by reference; and high pressure, free radical polymerized ethylene polymers and copolymers such as low density polyethylene (LDPE). In still another embodiment of the present invention, the thermoplastic resin comprises an ethylene-carboxylic acid copolymer, such as ethylene-acrylic acid (EAA) and ethylene-methacrylic acid copolymers such as for example those available under the tradenames PRIMACOR<sup>TM</sup> from The Dow Chemical Company, NUCREL<sup>TM</sup> from DuPont, and ESCOR<sup>TM</sup> from ExxonMobil, and described in U.S. Pat. Nos. 4,599,392, 4,988,781, and 5,384,373, each of

which is incorporated herein by reference in its entirety, and ethylene-vinyl acetate (EVA) copolymers. Polymer compositions described in U.S. Pat. Nos. 6,538,070, 6,566,446, 5,869,575, 6,448,341, 5,677,383, 6,316,549, 6,111,023, or 5,844,045, each of which is incorporated herein by reference in its entirety, are also suitable in  
5 some embodiments. Of course, blends of polymers can be used as well. In some embodiments, the blends include two different Ziegler-Natta polymers. In other embodiments, the blends can include blends of a Ziegler-Natta and a metallocene polymer. In still other embodiments, the thermoplastic resin used herein is a blend of two different metallocene polymers.

10 In one particular embodiment, the thermoplastic resin comprises an alpha-olefin interpolymer of ethylene with a comonomer comprising an alkene, such as 1-octene. The ethylene and octene copolymer may be present alone in the additive composition or in combination with another thermoplastic resin, such as ethylene-acrylic acid copolymer. Of particular advantage, the ethylene-acrylic acid  
15 copolymer not only is a thermoplastic resin, but also serves as a dispersing agent. For some embodiments, the additive composition should comprise a film-forming composition. It has been found that the ethylene-acrylic acid copolymer may assist in forming films, while the ethylene and octene copolymer lowers the stiffness. When present together, the weight ratio between the ethylene and  
20 octene copolymer and the ethylene-acrylic acid copolymer may be from 1:10 to 10:1, such as from 3:2 to 2:3.

The thermoplastic resin, such as the ethylene and octene copolymer, may have a crystallinity of less than about 50 percent, such as less than about 25 percent. The polymer may have been produced using a single site catalyst and  
25 may have a weight average molecular weight of from 15,000 to 5 million, such as from 20,000 to 1 million. The molecular weight distribution of the polymer may be from 1.01 to 40, such as from 1.5 to 20, such as from 1.8 to 10.

Depending upon the thermoplastic polymer, the melt index of the polymer may range from 0.001 g/10 min to 1,000 g/10 min, such as from  
30 0.5 g/10 min to 800 g/10 min. For example, in one embodiment, the melt index of the thermoplastic resin may be from 100 g/10 min to 700 g/10 min.

The thermoplastic resin may also have a relatively low melting point. For instance, the melting point of the thermoplastic resin may be less than about

140 °C, such as less than 130 °C, such as less than 120 °C. For instance, in one embodiment, the melting point may be less than about 90 °C. The glass transition temperature of the thermoplastic resin may also be relatively low. For instance, the glass transition temperature may be less than about 50 °C, such as less than  
5 about 40 °C.

The one or more thermoplastic resins may be contained within the additive composition in an amount from 1 percent by weight to 96 percent by weight. For instance, the thermoplastic resin may be present in the aqueous dispersion in an amount from 10 percent by weight to 70 percent by weight, such as from 20  
10 percent to 50 percent by weight.

In addition to at least one thermoplastic resin, the aqueous dispersion may also contain a dispersing agent. A dispersing agent is an agent that aids in the formation and/or the stabilization of the dispersion. One or more dispersing agents may be incorporated into the additive composition.

15 In general, any suitable dispersing agent can be used. In one embodiment, for instance, the dispersing agent comprises at least one carboxylic acid, a salt of at least one carboxylic acid, or carboxylic acid ester or salt of the carboxylic acid ester. Examples of carboxylic acids useful as a dispersant comprise fatty acids such as montanic acid, stearic acid, oleic acid, and the like. In some  
20 embodiments, the carboxylic acid, the salt of the carboxylic acid, or at least one carboxylic acid fragment of the carboxylic acid ester or at least one carboxylic acid fragment of the salt of the carboxylic acid ester has fewer than 25 carbon atoms. In other embodiments, the carboxylic acid, the salt of the carboxylic acid, or at least one carboxylic acid fragment of the carboxylic acid ester or at least one  
25 carboxylic acid fragment of the salt of the carboxylic acid ester has 12 to 25 carbon atoms. In some embodiments, carboxylic acids, salts of the carboxylic acid, at least one carboxylic acid fragment of the carboxylic acid ester or its salt has 15 to 25 carbon atoms are preferred. In other embodiments, the number of carbon atoms is 25 to 60. Some examples of salts comprise a cation selected from the  
30 group consisting of an alkali metal cation, alkaline earth metal cation, or ammonium or alkyl ammonium cation.

In still other embodiments, the dispersing agent is selected from the group consisting of ethylene-carboxylic acid polymers, and their salts, such as ethylene-

acrylic acid copolymers or ethylene-methacrylic acid copolymers.

In other embodiments, the dispersing agent is selected from alkyl ether carboxylates, petroleum sulfonates, sulfonated polyoxyethylenated alcohol, sulfated or phosphated polyoxyethylenated alcohols, polymeric ethylene  
5 oxide/propylene oxide/ethylene oxide dispersing agents, primary and secondary alcohol ethoxylates, alkyl glycosides and alkyl glycerides.

When ethylene-acrylic acid copolymer is used as a dispersing agent, the copolymer may also serve as a thermoplastic resin.

In one particular embodiment, the aqueous dispersion contains an ethylene  
10 and octene copolymer, ethylene-acrylic acid copolymer, and a fatty acid, such as stearic acid or oleic acid. The dispersing agent, such as the carboxylic acid, may be present in the aqueous dispersion in an amount from 0.1 percent to 10 percent by weight.

In addition to the above components, the aqueous dispersion also contains  
15 water. Water may be added as deionized water, if desired. The pH of the aqueous dispersion is generally less than about 12, such as from 5 to 11.5, such as from 7 to 11. The aqueous dispersion may have a solids content of less than about 75 percent, such as less than about 70 percent. For instance, the solids content of the aqueous dispersion may range from 5 percent to 60 percent.

20 While any method may be used to produce the aqueous dispersion, in one embodiment, the dispersion may be formed through a melt-kneading process. For example, the kneader may comprise a Banbury mixer, single-screw extruder or a multi-screw extruder. The melt-kneading may be conducted under the conditions which are typically used for melt-kneading the one or more thermoplastic resins.

25 In one particular embodiment, the process includes melt-kneading the components that make up the dispersion. The melt-kneading machine may include multiple inlets for the various components. For example, the extruder may include four inlets placed in series. Further, if desired, a vacuum vent may be added at an optional position of the extruder.

30 In some embodiments, the dispersion is first diluted to contain 1 to 3 percent by weight water and then, subsequently, further diluted to comprise greater than about 25 percent by weight water.



In an alternative embodiment, the additive composition may further comprise a lotion. The lotion, for instance, can be formulated to not only adhere the base web to the creping surface but may also be designed to transfer to the surface of the web in amounts sufficient to later provide benefits to the user. For instance, in one embodiment, the lotion can be transferred to the base web in an amount sufficient such that the lotion then later transfers to a user's skin when wiped across the skin by a user.

In general, any suitable lotion composition may be used that is capable of adhering the base sheet to the creping surface and thereafter transferring to the base sheet such that the base sheet increases in basis weight by greater than about 2 percent by weight. Examples of lotions that may be used in accordance with the present disclosure, for instance, are disclosed in U.S. Patent No. 5,885,697, U.S. Patent Publication No. 2005/0058693, and/or U.S. Patent Publication No. 2005/0058833, which are all incorporated herein by reference.

In one embodiment, for instance, the lotion composition may comprise an oil, a wax, a fatty alcohol, and one or more other additional ingredients.

For instance, the amount of oil in the lotion composition can be from 30 to 90 weight percent, more specifically from 40 to 70 weight percent, and still more specifically from 45 to 60 weight percent. Suitable oils include, but are not limited to, the following classes of oils: petroleum or mineral oils, such as mineral oil and petrolatum; animal oils, such as mink oil and lanolin oil; plant oils, such as aloe extract, sunflower oil and avocado oil; and silicone oils, such as dimethicone and alkyl methyl silicones.

The amount of wax in the lotion composition can be from 10 to 40 weight percent, more specifically from 10 to 30 weight percent, and still more specifically from 15 to 25 weight percent. Suitable waxes include, but are not limited to the following classes: natural waxes, such as beeswax and carnauba wax; petroleum waxes, such as paraffin and ceresin wax; silicone waxes, such as alkyl methyl siloxanes; or synthetic waxes, such as synthetic beeswax and synthetic sperm wax.

The amount of fatty alcohol in the lotion composition, if present, can be from 5 to 40 weight percent, more specifically from 10 to 30 weight percent, and still more specifically from 15 to 25 weight percent. Suitable fatty alcohols include

alcohols having a carbon chain length of C.sub.14 -C.sub.30, including cetyl alcohol, stearyl alcohol, behenyl alcohol, and dodecyl alcohol.

In order to better enhance the benefits to consumers, additional ingredients can be used. The classes of ingredients and their corresponding benefits include, without limitation, C<sub>10</sub> or greater fatty alcohols (lubricity, body, opacity); fatty esters (lubricity, feel modification); vitamins (topical medicinal benefits); dimethicone (skin protection); powders (lubricity, oil absorption, skin protection); preservatives and antioxidants (product integrity); ethoxylated fatty alcohols; (wetability, process aids); fragrance (consumer appeal); lanolin derivatives (skin moisturization), colorants, optical brighteners, sunscreens, alpha hydroxy acids, natural herbal extracts, and the like.

In one embodiment, the lotion composition can further contain a humectant. Humectants are typically cosmetic ingredients used to increase the water content of the top layers of the skin or mucous membrane, by helping control the moisture exchange between the product, the skin, and the atmosphere. Humectants may include primarily hydroscopic materials. Suitable humectants for inclusion in the moisturizing and lubrication compositions of the present disclosure include urocanic acid, N-Acetyl ethanolamine, aloe vera gel, arginine PCA, chitosan PCA, copper PCA, Corn glycerides, dimethyl imidazolidinone, fructose, glucamine, glucose, glucose glutamate, glucuronic acid, glutamic acid, glycereth-7, glycereth-12, glycereth-20, glycereth-26, glycerin, honey, hydrogenated honey, hydrogenated starch hydrolysates, hydrolyzed corn starch, lactamide MEA, lactic acid, lactose lysine PCA, mannitol, methyl gluceth-10, methyl gluceth-20, PCA, PEG-2 lactamide, PEG-10 propylene glycol, polyamino acids, polysaccharides, polyamino sugar condensate, potassium PCA, propylene glycol, propylene glycol citrate, saccharide hydrolysate, saccharide isomerate, sodium aspartate, sodium lactate, sodium PCA, sorbitol, TEA-lactate, TEA-PCA, Urea, Xylitol, and the like and mixtures thereof. Preferred humectants include polyols, glycerine, ethoxylated glycerine, polyethylene glycols, hydrogenated starch hydrolysates, propylene glycol, silicone glycol and pyrrolidone carboxylic acid.

In one embodiment, a lotion or one of the above ingredients contained in a lotion can be combined with a polymer dispersion as described above to produce

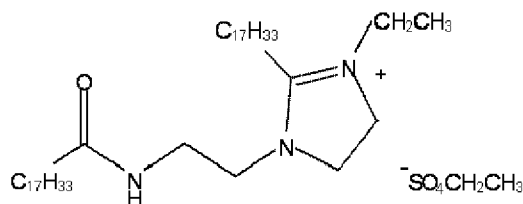
an additive composition in accordance with the present disclosure having desired properties.

In addition, a polymer dispersion may be combined with a lotion and/or various other additives or ingredients. For instance, in one embodiment, a debonder may be present within the additive composition. A debonder is a chemical species that softens or weakens a tissue sheet by preventing the formation of hydrogen bonds.

Suitable debonding agents that may be used in the present disclosure include cationic debonding agents such as fatty dialkyl quaternary amine salts, mono fatty alkyl tertiary amine salts, primary amine salts, imidazoline quaternary salts, silicone quaternary salt and unsaturated fatty alkyl amine salts. Other suitable debonding agents are disclosed in U.S. Patent No. 5,529,665 to Kaun which is incorporated herein by reference. In particular, Kaun discloses the use of cationic silicone compositions as debonding agents.

In one embodiment, the debonding agent used in the process of the present disclosure is an organic quaternary ammonium chloride and, particularly, a silicone-based amine salt of a quaternary ammonium chloride.

In one embodiment, the debonding agent can be PROSOFT® TQ1003, marketed by the Hercules Corporation. For example, one debonding agent that can be used is 1-Ethyl-2-Noroleyl-3-Oleyl Amidoethyl Imidazolinium Ethosulfate, having the following formula.



In another embodiment, the additive composition may further comprise a softener, such as a polysiloxane softener. Silicones, such as polysiloxanes, however, may interfere with the ability of the additive composition to adhere a base sheet to a creping surface. Thus, when present, the polysiloxane can be added to the additive composition in an amount of less than about 5 percent by weight.

Still in another embodiment, various beneficial agents can be incorporated into the additive composition in any amount as desired. For instance, in one

embodiment, aloe, vitamin E, or mixtures thereof can be combined into the additive composition in amounts less than about 5 percent by weight, such as from 0.1 percent to 3 percent by weight. Such ingredients can be combined into a lotion, into a polymer dispersion as described above, or into a mixture of both.

5           Once formulated, the additive composition can be applied to the creping surface, such as the surface of the Yankee dryer 76 as shown in **Fig. 2** using any suitable method or technique. For instance, the additive composition can be sprayed onto the creping surface, extruded onto the creping surface, or printed onto the creping surface. When printed onto the creping surface using, for  
10 instance, a flexographic printer, the additive composition can be applied in a pattern. In other embodiments, a flooded nip may be used to apply the additive composition to the creping surface. In still other embodiments, the additive composition can be applied as a foam or can be applied according to a plasma coating process.

15           In one embodiment, the additive composition can be preheated prior to being applied to the creping surface. For example, in some embodiments, heating the additive composition may decrease the viscosity. In particular, in some embodiments, the additive composition may have a melting point of, for instance, from 30° C to 70° C. If desired, the additive composition can be heated above the  
20 melting point and then applied to the creping surface.

As shown in **Fig. 2** the creping surface comprises the surface of a Yankee dryer. In the embodiment illustrated in **Fig. 2** the creping surface is heated in order to dry the base web as it is creped. For example, the creping surface can be heated to a temperature of from 30° C to 150° C, such as from 100° C to 130° C.

25           In the embodiment illustrated in **Fig. 2** the base web is pressed against the creping surface while wet. For instance, the base web, in one embodiment, may have a consistency of from 10 percent to 30 percent solids, such as from 10 percent to 15 percent solids. In an alternative embodiment, however, the base web may be partially dried prior to being pressed against the creping surface. In this  
30 embodiment, for instance, the base web may have a consistency from 30 percent to 70 percent solids.

The amount of time that the base sheet stays in contact with the creping surface can depend upon numerous factors. For instance, the base sheet can

stay in contact with the creping surface in an amount of time from as little as about 100 milliseconds to 10 seconds or even greater. A particular advantage, however, the additive composition is capable of both adhering to the base sheet and transferring to the base sheet in a very short amount of time. For instance, in one  
5 embodiment, the base sheet stays in contact with the creping surface in an amount of time from 120 milliseconds to 5 seconds, such as from 120 milliseconds to 2,000 milliseconds. In this embodiment, the base sheet can be moving at a speed of greater than about 1,000 feet per minute, such as from 1,500 feet per minute to 3,000 feet per minute.

10 Referring to **Fig. 20** another alternative embodiment of a process for forming creped base webs is shown. Like reference numerals have been used to indicate similar elements with respect to the process illustrated in **Fig. 2**.

As shown in **Fig. 20**, the formed web **68** is transferred to the surface of the rotatable heated dryer drum **76**, which may be a Yankee dryer. The press roll **72**  
15 may, in one embodiment, comprise a suction breast roll. In order to adhere the web **68** to the surface of the dryer drum **76**, a creping adhesive may be applied to the surface of the dryer drum by a spraying device **69**. The spraying device **69** may emit an additive composition made in accordance with the present disclosure or may emit a conventional creping adhesive.

20 As shown in **Fig. 20**, the web is adhered to the surface of the dryer drum **76** and then creped from the drum using the creping blade **78**. If desired, the dryer drum **76** may be associated with a hood **71**. The hood **71** may be used to force air against or through the web **68**.

Once creped from the dryer drum **76**, the web **68** is then adhered to a  
25 second dryer drum **73**. The second dryer drum **73** may comprise, for instance, a heated drum surrounded by a hood **77**. The drum may be heated to a temperature of from 25°C to 200°C, such as from 100°C to 150°C.

In order to adhere the web **68** to the second dryer drum **73**, a second spray device **75** may emit an adhesive onto the surface of the dryer drum. In  
30 accordance with the present disclosure, for instance, the second spray device **75** may emit an additive composition as described above. The additive composition not only assists in adhering the base web **68** to the dryer drum **73**, but also is

transferred to the surface of the web as the web is creped from the dryer drum **73** by the creping blade **79**.

Once creped from the second dryer drum **73**, the web **68** may, optionally, be fed around a cooling reel drum **81** and cooled prior to being wound on a reel **83**.

5 In the embodiment shown in **Fig. 2** and in **Fig. 20**, the creping process is directly incorporated into the process for forming the web. These embodiments may be considered "in-line" processes. In an alternative embodiment, however, the base sheet may be formed and then subjected to the creping process.

10 For instance, referring to **Fig. 21**, still another embodiment of a process for applying the additive composition to one side of a base sheet in accordance with the present disclosure is illustrated. As shown, in this embodiment, a formed base sheet **80** is unwound from a roll **85** and fed into the process. This process may be considered an off-line process, although the application method may also be installed in-line.

15 As illustrated in **Fig. 21**, the base sheet **80** is pressed against a dryer drum **108** by a press roll **110**. A spray device **109** applies the additive composition of the present disclosure to the surface of the dryer drum. The additive composition thus not only adheres the base sheet **80** to the surface of the dryer drum **108**, but also transfers to the base sheet as the sheet is creped from the drum using a creping  
20 blade **112**. Once creped from the dryer drum **108**, the base sheet **80** is wound into a roll **116**.

In the embodiment illustrated in **Fig. 21**, a preformed base sheet is creped from the rotating cylinder **108** when processing base webs, for instance, the base web is generally dry when adhered to the creping surface. For instance, the base  
25 web can have a consistency of greater than about 95 percent.

In the embodiment illustrated in **Fig. 21**, the creping surface may be at ambient temperature or may be heated. It should be understood, however, that it may not be necessary to heat the creping surface in the embodiment illustrated in  
30 **Fig. 21** depending upon the additive composition that is used. In one embodiment, for instance, the additive composition itself may be preheated prior to being applied to the creping surface.

The amount of surface area that the additive composition covers on the base sheet when applied to the base sheet can vary. In general, for instance, the

additive composition covers greater than about 40 percent of the surface are of one side of the base sheet. For instance, the additive composition may cover from 40 percent to 100 percent of the surface are of the base sheet, such as from 40 percent to 90 percent, such as from 40 percent to 75 percent.

5           In the embodiments illustrated in the figures, only one side of the base sheet is treated with the additive composition. It should be understood, however, that both sides of the base sheet may be treated in accordance with the present disclosure. For instance, once one side of the base sheet is creped from a creping surface, the opposite side can be similarly adhered to a creping surface by the  
10           additive composition.

Numerous different types of base sheets may be processed according to the present disclosure. For instance, as particularly shown in **Figs. 2** and **20**, in one embodiment, the base sheet comprises a base web containing cellulosic fibers.

15           Tissue products made according to the present disclosure may include single-ply tissue products or multiple-ply tissue products. For instance, in one embodiment, the product may include two plies or three plies.

In general, any suitable base web may be treated in accordance with the present disclosure. For example, in one embodiment, the sheet product can be a  
20           wiping product, such as a bath tissue, a facial tissue, a paper towel, an industrial wiper, and the like. The wiping product may have any bulk; for example, the wiping product may have a bulk of less than 3 cc/g; or in the alternative, the wiping product may have a bulk in the range of equal or greater than 3 cc/g; such as 3 cc/g to 20 cc/g, such as from 5 cc/g to 15 cc/g. The wiping products can contain  
25           one or more plies and can be made from any suitable types of fiber.

Fibers suitable for making base webs comprise any natural or synthetic cellulosic fibers including, but not limited to nonwoody fibers, such as cotton, abaca, kenaf, sabai grass, flax, esparto grass, straw, jute hemp, bagasse, milkweed floss fibers, and pineapple leaf fibers; and woody or pulp fibers such as  
30           those obtained from deciduous and coniferous trees, including softwood fibers, such as northern and southern softwood kraft fibers; hardwood fibers, such as eucalyptus, maple, birch, and aspen. Pulp fibers can be prepared in high-yield or low-yield forms and can be pulped in any known method, including kraft, sulfite,

high-yield pulping methods and other known pulping methods. Fibers prepared from organosolv pulping methods can also be used, including the fibers and methods disclosed in U.S. Patent No. 4,793,898, issued Dec. 27, 1988 to Laamanen et al.; U.S. Patent No. 4,594,130, issued June 10, 1986 to Chang et al.;  
5 and U.S. Patent No. 3,585,104. Useful fibers can also be produced by anthraquinone pulping, exemplified by U.S. Patent No. 5,595,628 issued Jan. 21, 1997, to Gordon et al.

The base sheet may, for example, comprise less than 50 percent by weight of cellulosic fibers based on the weight of the base sheet; for example, the base  
10 sheet may comprise 0 to 49 percent by weight of cellulosic fibers based on the weight of the sheet. In the alternative, a portion of the fibers, such as greater than 50 percent by dry weight, or from 55 to 99 percent by dry weight, can be synthetic fibers such as rayon, polyolefin fibers, polyester fibers, bicomponent sheath-core fibers, multi-component binder fibers, and the like. In the alternative, the base  
15 sheet may entirely comprise of a non-cellulosic material. For example, the base sheet can be made entirely from synthetic fibers such as rayon, polyolefin fibers, polyester fibers, bicomponent sheath-core fibers, multi-component binder fibers, and the like. An exemplary polyethylene fiber is Fybrel®, available from Minifibers, Inc. (Jackson City, TN). Any known bleaching method can be used. Synthetic  
20 cellulose fiber types include rayon in all its varieties and other fibers derived from viscose or chemically-modified cellulose. Chemically treated natural cellulosic fibers can be used such as mercerized pulps, chemically stiffened or crosslinked fibers, or sulfonated fibers. For good mechanical properties in using papermaking fibers, it can be desirable that the fibers be relatively undamaged and largely  
25 unrefined or only lightly refined. While recycled fibers can be used, virgin fibers are generally useful for their mechanical properties and lack of contaminants. Mercerized fibers, regenerated cellulosic fibers, cellulose produced by microbes, rayon, and other cellulosic material or cellulosic derivatives can be used. Suitable papermaking fibers can also include recycled fibers, virgin fibers, or mixes thereof.  
30 In certain embodiments capable of high bulk and good compressive properties, the fibers can have a Canadian Standard Freeness of at least 200, more specifically at least 300, more specifically still at least 400, and most specifically at least 500.



Other papermaking fibers that can be used in the present disclosure include paper broke or recycled fibers and high yield fibers. High yield pulp fibers are those papermaking fibers produced by pulping processes providing a yield of about 65 percent or greater, more specifically about 75 percent or greater, and still  
5 more specifically 75 percent to 95 percent. Yield is the resulting amount of processed fibers expressed as a percentage of the initial wood mass. Such pulping processes include bleached chemithermomechanical pulp (BCTMP), chemithermomechanical pulp (CTMP), pressure/pressure thermomechanical pulp (PTMP), thermomechanical pulp (TMP), thermomechanical chemical pulp (TMCP),  
10 high yield sulfite pulps, and high yield Kraft pulps, all of which leave the resulting fibers with high levels of lignin. High yield fibers are well known for their stiffness in both dry and wet states relative to typical chemically pulped fibers.

In general, any process capable of forming a base sheet can also be utilized in the present disclosure especially for webs processed according to **Fig. 21**. For  
15 example, a papermaking process of the present disclosure can utilize creping, wet creping, double creping, embossing, wet pressing, air pressing, through-air drying, creped through-air drying, uncreped through-air drying, hydroentangling, air laying, coform methods, as well as other steps known in the art.

Also suitable for products of the present disclosure are tissue sheets that  
20 are pattern densified or imprinted, such as the tissue sheets disclosed in any of the following U.S. Patent Nos.: 4,514,345 issued on April 30, 1985, to Johnson et al.; 4,528,239 issued on July 9, 1985, to Trokhan; 5,098,522 issued on March 24, 1992; 5,260,171 issued on November 9, 1993, to Smurkoski et al.; 5,275,700 issued on January 4, 1994, to Trokhan; 5,328,565 issued on July 12, 1994, to  
25 Rasch et al.; 5,334,289 issued on August 2, 1994, to Trokhan et al.; 5,431,786 issued on July 11, 1995, to Rasch et al.; 5,496,624 issued on March 5, 1996, to Steltjes, Jr. et al.; 5,500,277 issued on March 19, 1996, to Trokhan et al.; 5,514,523 issued on May 7, 1996, to Trokhan et al.; 5,554,467 issued on September 10, 1996, to Trokhan et al.; 5,566,724 issued on October 22, 1996, to  
30 Trokhan et al.; 5,624,790 issued on April 29, 1997, to Trokhan et al.; and, 5,628,876 issued on May 13, 1997, to Ayers et al., the disclosures of which are incorporated herein by reference to the extent that they are non-contradictory herewith. Such imprinted base sheets may have a network of densified regions

that have been imprinted against a drum dryer by an imprinting fabric, and regions that are relatively less densified (for example, "domes" in the tissue sheet) corresponding to deflection conduits in the imprinting fabric, wherein the base sheet superposed over the deflection conduits was deflected by an air pressure differential across the deflection conduit to form a lower-density pillow-like region or dome in the base sheet.

If desired, various chemicals and ingredients may be incorporated into base webs that are processed according to the present disclosure. The following materials are included as examples of additional chemicals that may be applied to the web. The chemicals are included as examples and are not intended to limit the scope of the invention. Such chemicals may be added at any point in the papermaking process.

In general, the products of the present invention can be used in conjunction with any known materials and chemicals that are not antagonistic to its intended use. Examples of such materials include but are not limited to odor control agents, such as odor absorbents, activated carbon fibers and particles, baby powder, baking soda, chelating agents, zeolites, perfumes or other odor-masking agents, cyclodextrin compounds, oxidizers, and the like. Superabsorbent particles, synthetic fibers, or films may also be employed. Additional options include cationic dyes, optical brighteners, emollients, and the like.

The different chemicals and ingredients that may be incorporated into the base sheet may depend upon the end use of the product. For instance, various wet strength agents may be incorporated into the product. For bath tissue products, for example, temporary wet strength agents may be used. As used herein, wet strength agents are materials used to immobilize the bonds between fibers in the wet state. Typically, the means by which fibers are held together in paper and tissue products involve hydrogen bonds and sometimes combinations of hydrogen bonds and covalent and/or ionic bonds. In some applications, it may be useful to provide a material that will allow bonding to the fibers in such a way as to immobilize the fiber-to-fiber bond points and make them resistant to disruption in the wet state. The wet state typically means when the product is largely saturated with water or other aqueous solutions.

Any material that when added to a paper or tissue web results in providing the sheet with a mean wet geometric tensile strength:dry geometric tensile strength ratio in excess of 0.1 may be termed a wet strength agent.

Temporary wet strength agents, which are typically incorporated into bath tissues, are defined as those resins which, when incorporated into paper or tissue products, will provide a product which retains less than 50 percent of its original wet strength after exposure to water for a period of at least 5 minutes. Temporary wet strength agents are well known in the art. Examples of temporary wet strength agents include polymeric aldehyde-functional compounds such as glyoxylated polyacrylamide, such as a cationic glyoxylated polyacrylamide.

Such compounds include PAREZ 631 NC wet strength resin available from Cytec Industries of West Patterson, N.J., chloroxylated polyacrylamides, and HERCOBOND 1366, manufactured by Hercules, Inc. of Wilmington, Del. Another example of a glyoxylated polyacrylamide is PAREZ 745, which is a glyoxylated poly (acrylamide-co-diallyl dimethyl ammonium chloride).

For facial tissues and other tissue products, on the other hand, permanent wet strength agents may be incorporated into the base sheet. Permanent wet strength agents are also well known in the art and provide a product that will retain more than 50 percent of its original wet strength after exposure to water for a period of at least 5 minutes.

Once formed, the products may be packaged in different ways. For instance, in one embodiment, the sheet product may be cut into individual sheets and stacked prior to being placed into a package. Alternatively, the sheet product may be spirally wound. When spirally wound together, each individual sheet may be separated from an adjacent sheet by a line of weakness, such as a perforation line. Bath tissues and paper towels, for instance, are typically supplied to a consumer in a spirally wound configuration.

Base webs that may be treated in accordance with the present disclosure may include a single homogenous layer of fibers or may include a stratified or layered construction. For instance, the base web ply may include two or three layers of fibers. Each layer may have a different fiber composition. For example, referring to **Fig. 1**, one embodiment of a device for forming a multi-layered stratified pulp furnish is illustrated. As shown, a three-layered headbox **10**

generally includes an upper head box wall **12** and a lower head box wall **14**. Headbox **10** further includes a first divider **16** and a second divider **18**, which separate three fiber stock layers.

Each of the fiber layers comprise a dilute aqueous suspension of  
5 papermaking fibers. The particular fibers contained in each layer generally depends upon the product being formed and the desired results. For instance, the fiber composition of each layer may vary depending upon whether a bath tissue product, facial tissue product or paper towel is being produced. In one  
10 embodiment, for instance, middle layer **20** contains southern softwood kraft fibers either alone or in combination with other fibers such as high yield fibers. Outer layers **22** and **24**, on the other hand, contain softwood fibers, such as northern softwood kraft.

In an alternative embodiment, the middle layer may contain softwood fibers for strength, while the outer layers may comprise hardwood fibers, such as  
15 eucalyptus fibers, for a perceived softness.

An endless traveling forming fabric **26**, suitably supported and driven by rolls **28** and **30**, receives the layered papermaking stock issuing from headbox **10**. Once retained on fabric **26**, the layered fiber suspension passes water through the fabric as shown by the arrows **32**. Water removal is achieved by combinations of  
20 gravity, centrifugal force and vacuum suction depending on the forming configuration.

Forming multi-layered paper webs is also described and disclosed in U.S. Patent No. 5,129,988 to Farrington, Jr., which is incorporated herein by reference.

The basis weight of base webs made in accordance with the present  
25 disclosure can vary depending upon the final product. For example, the process may be used to produce bath tissues, facial tissues, paper towels, industrial wipers, and the like. In general, the basis weight of the tissue products may vary from 10 gsm to 110 gsm, such as from 20 gsm to 90 gsm. For bath tissue and facial tissues, for instance, the basis weight may range from 10 gsm to 40 gsm.  
30 For paper towels, on the other hand, the basis weight may range from 25 gsm to 80 gsm.

The sheet product may have any bulk; for example, the sheet product may have a bulk of less than 3 cc/g; or in the alternative, the sheet product may have a

bulk in the range of equal or greater than 3 cc/g; such as 3 cc/g to 20 cc/g, such as from 5 cc/g to 15 cc/g. The sheet "bulk" is calculated as the quotient of the caliper of a dry tissue sheet, expressed in microns, divided by the dry basis weight, expressed in grams per square meter. The resulting sheet bulk is expressed in  
5 cubic centimeters per gram. More specifically, the caliper is measured as the total thickness of a stack of ten representative sheets and dividing the total thickness of the stack by ten, where each sheet within the stack is placed with the same side up. Caliper is measured in accordance with TAPPI test method T411 om-89 "Thickness (caliper) of Paper, Paperboard, and Combined Board" with Note 3 for  
10 stacked sheets. The micrometer used for carrying out T411 om-89 is an Emveco 200-A Tissue Caliper Tester available from Emveco, Inc., Newberg, Oregon. The micrometer has a load of 2.00 kilo-Pascals (132 grams per square inch), a pressure foot area of 2500 square millimeters, a pressure foot diameter of 56.42 millimeters, a dwell time of 3 seconds and a lowering rate of 0.8 millimeters per  
15 second.

In multiple ply products, the basis weight of each base web present in the product can also vary. In general, the total basis weight of a multiple ply product will generally be the same as indicated above, such as from 20 gsm to 110 gsm. Thus, the basis weight of each ply can be from 10 gsm to 60 gsm, such as from 20  
20 gsm to 40 gsm.

In one embodiment, base webs made according to the present disclosure can be incorporated into multiple-ply products. For instance, in one embodiment, a base web made according to the present disclosure can be attached to one or more other base webs for forming a wiping product having desired characteristics.  
25 The other webs laminated to the base web of the present disclosure can be, for instance, a wet-creped web, a calendered web, an embossed web, a through-air dried web, a creped through-air dried web, an uncreped through-air dried web, a hydroentangled web, a coform web, an airlaid web, and the like.

In one embodiment, when incorporating a base web made according to the present disclosure into a multiple-ply product, it may be desirable to only apply the additive composition to one side of the base web and to crepe the treated side of  
30 the web. The creped side of the web is then used to form an exterior surface of a

multiple ply product. The untreated and uncreped side of the web, on the other hand, is attached by any suitable means to one or more plies.

In addition to wet lay processes as shown in **Fig. 2**, it should be understood that various other base sheets may be treated in accordance with the present disclosure. For instance, other base sheets that may be treated in accordance with the present disclosure include airlaid webs, coform webs, hydroentangled webs, meltblown webs, spunbond webs, woven materials, knitted materials, and the like. For instance, any of the above materials can be treated according to the process illustrated in **Fig. 21**.

Airlaid webs are formed in an air forming process in which a fibrous nonwoven layer is created. In the airlaying process, bundles of small fibers having typical lengths ranging from 3 to 52 millimeters (mm) are separated and entrained in an air supply and then deposited onto a forming screen, usually with the assistance of a vacuum supply. The randomly deposited fibers then are bonded to one another using, for example, hot air or a spray adhesive. The production of airlaid nonwoven composites is well defined in the literature and documented in the art. Examples include the DanWeb process as described in US patent 4,640,810 to Laursen et al. and assigned to Scan Web of North America Inc, the Kroyer process as described in US patent 4,494,278 to Kroyer et al. and US patent 5,527,171 to Soerensen assigned to Niro Separation a/s, the method of US patent 4,375,448 to Appel et al assigned to Kimberly-Clark Corporation, or other similar methods.

Other materials containing cellulosic fibers include coform webs and hydroentangled webs. In the coform process, at least one meltblown diehead is arranged near a chute through which other materials are added to a meltblown web while it is forming. Such other materials may be natural fibers, superabsorbent particles, natural polymer fibers (for example, rayon) and/or synthetic polymer fibers (for example, polypropylene or polyester), for example, where the fibers may be of staple length.

Coform processes are shown in commonly assigned US Patents 4,818,464 to Lau and 4,100,324 to Anderson et al., which are incorporated herein by reference. Webs produced by the coform process are generally referred to as coform materials. More particularly, one process for producing coform nonwoven webs involves

extruding a molten polymeric material through a die head into fine streams and attenuating the streams by converging flows of high velocity, heated gas (usually air) supplied from nozzles to break the polymer streams into discontinuous microfibers of small diameter. The die head, for instance, can include at least one straight row  
5 of extrusion apertures. In general, the microfibers may have an average fiber diameter of up to about 10 microns. The average diameter of the microfibers can be generally greater than about 1 micron, such as from 2 microns to 5 microns. While the microfibers are predominantly discontinuous, they generally have a length exceeding that normally associated with staple fibers.

10 In order to combine the molten polymer fibers with another material, such as pulp fibers, a primary gas stream is merged with a secondary gas stream containing the individualized wood pulp fibers. Thus, the pulp fibers become integrated with the polymer fibers in a single step. The wood pulp fibers can have a length of from 0.5 millimeters to 10 millimeters. The integrated air stream is then directed onto a  
15 forming surface to air form the nonwoven fabric. The nonwoven fabric, if desired, may be passed into the nip of a pair of vacuum rolls in order to further integrate the two different materials.

Natural fibers that may be combined with the meltblown fibers include wool, cotton, flax, hemp and wood pulp. Wood pulps include standard softwood  
20 fluffing grade such as CR-1654 (US Alliance Pulp Mills, Coosa, Alabama). Pulp may be modified in order to enhance the inherent characteristics of the fibers and their processability. Curl may be imparted to the fibers by methods including chemical treatment or mechanical twisting. Curl is typically imparted before crosslinking or stiffening. Pulps may be stiffened by the use of crosslinking agents  
25 such as formaldehyde or its derivatives, glutaraldehyde, epichlorohydrin, methylolated compounds such as urea or urea derivatives, dialdehydes such as maleic anhydride, non-methylolated urea derivatives, citric acid or other polycarboxylic acids. Pulp may also be stiffened by the use of heat or caustic treatments such as mercerization. Examples of these types of fibers include  
30 NHB416 which is a chemically crosslinked southern softwood pulp fibers which enhances wet modulus, available from the Weyerhaeuser Corporation of Tacoma, WA. Other useful pulps are debonded pulp (NF405) and non-debonded pulp (NB416) also from Weyerhaeuser. HPZ3 from Buckeye Technologies, Inc of

Memphis, TN, has a chemical treatment that sets in a curl and twist, in addition to imparting added dry and wet stiffness and resilience to the fiber. Another suitable pulp is Buckeye HP2 pulp and still another is IP Supersoft from International Paper Corporation. Suitable rayon fibers are 1.5 denier Merge 18453 fibers from Acordis  
5 Cellulose Fibers Incorporated of Axis, Alabama.

When containing cellulosic materials such as pulp fibers, a coform material may contain the cellulosic material in an amount from 10 percent by weight to 80 percent by weight, such as from 10 percent by weight to 49 percent by weight. For example, in one embodiment, a coform material may be produced containing pulp  
10 fibers in an amount from 10 percent by weight to 45 percent by weight.

In addition to coform webs, hydroentangled webs can also contain synthetic and pulp fibers. Hydroentangled webs refer to webs that have been subjected to columnar jets of a fluid that cause the fibers in the web to entangle. Hydroentangling a web typically increases the strength of the web. In one  
15 embodiment, pulp fibers can be hydroentangled into a continuous filament material, such as a spunbond web. The hydroentangled resulting nonwoven composite may contain pulp fibers in an amount from 10 percent to 80 percent by weight, such as in an amount in the range of 10 percent by weight to 45 percent by weight. Commercially available hydroentangled composite webs as described  
20 above are commercially available from the Kimberly-Clark Corporation under the name HYDROKNIT. Hydraulic entangling is described in, for example, U.S. Patent No. 5,389,202 to Everhart, which is incorporated herein by reference.

In addition to base sheets containing cellulosic fibers, the present disclosure is also directed to applying additive compositions to base sheets made entirely  
25 from synthetic fibers. For instance, in one embodiment, the base sheet may comprise a nonwoven meltblown web.

Meltblown fibers are formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten fibers into converging high velocity gas (for example, air) streams that attenuate the fibers of  
30 molten thermoplastic material to reduce their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly disbursed meltblown fibers. Such a process is disclosed, for example, in U.S. Pat.



No. 3,849,241 to Butin, et al. Generally speaking, meltblown fibers may be microfibers that may be continuous or discontinuous, are generally smaller than 10 microns in diameter, and are generally tacky when deposited onto a collecting surface.

5 In still another embodiment, the base sheet may comprise a nonwoven spunbond web. Spunbonded fibers are small diameter substantially continuous fibers that are formed by extruding a molten thermoplastic material from a plurality of fine, usually circular, capillaries of a spinnerette with the diameter of the extruded fibers then being rapidly reduced as by, for example, eductive drawing  
10 and/or other well-known spunbonding mechanisms. The production of spunbonded nonwoven webs is described and illustrated, for example, in U.S. Pat. Nos. 4,340,563 to Appel, et al. 3,692,618 to Dorschner, et al., 3,802,817 to Matsuki et al., 3,338,992 to Kinney, 3,341,394 to Kinney, 3,502,763 to Hartman, 3,502,538 to Levy, 3,542,615 to Dobo, et al., and 5,382,400 to Pike, et al. Spunbond fibers are  
15 generally not tacky when they are deposited onto a collecting surface. Spunbond fibers can sometimes have diameters less than about 40 microns, and are often between 5 to 20 microns.

In still another embodiment, the base sheet might comprise a laminate. For instance, the base sheet may comprise a spunbond/meltblown/spunbond laminate.

20 In addition to nonwoven materials, the base sheet may also comprise a woven fabric or a knitted fabric. In general, any suitable base sheet may be treated in accordance with the present disclosure that is capable of adhering to a creping surface and being removed from the creping surface.

The present disclosure may be better understood with reference to the  
25 following examples.

#### EXAMPLE 1

In this example, tissue webs were made generally according to the process illustrated in **Fig. 2** and formed into two-ply products. In order to adhere the base web to a creping surface, which in this embodiment comprised a Yankee dryer,  
30 additive compositions made according to the present disclosure were sprayed onto the dryer prior to contacting the dryer with the web. The samples were then subjected to various standardized tests.

For purposes of comparison, samples were also produced using a standard PVOH/KYMENE crepe package.

The following process was used to produce the samples.

Initially, 80 pounds of air-dried softwood kraft (NSWK) pulp was placed into  
5 a pulper and disintegrated for 15 minutes at 4 percent consistency at 120 degrees  
F. Then, the NSWK pulp was refined for 15 minutes, transferred to a dump chest  
and subsequently diluted to approximately 3 percent consistency. (Note: Refining  
fibrillates fibers to increase their bonding potential.) Then, the NSWK pulp was  
diluted to about 2 percent consistency and pumped to a machine chest, such that  
10 the machine chest contained 20 air-dried pounds of NSWK at 0.2-0.3 percent  
consistency. The above softwood fibers were utilized as the inner strength layer in  
a 3-layer tissue structure.

Two kilograms KYMENE® 6500, available from Hercules, Incorporated,  
located in Wilmington, Delaware, U.S.A., per metric ton of wood fiber and two  
15 kilograms per metric ton of wood fiber PAREZ® 631 NC, available from LANXESS  
Corporation., located in Trenton, New Jersey, U.S.A., was added and allowed to  
mix with the pulp fibers for at least 10 minutes before pumping the pulp slurry  
through the headbox.

Forty pounds of air-dried Aracruz ECF, a eucalyptus hardwood Kraft  
20 (EHWK) pulp available from Aracruz, located in Rio de Janeiro, RJ, Brazil, was  
placed into a pulper and disintegrated for 30 minutes at about 4 percent  
consistency at 120 degrees Fahrenheit. The EHWK pulp was then transferred to a  
dump chest and subsequently diluted to about 2 percent consistency.

Next, the EHWK pulp slurry was diluted, divided into two equal amounts,  
25 and pumped at about 1 percent consistency into two separate machine chests,  
such that each machine chest contained 20 pounds of air-dried EHWK. This pulp  
slurry was subsequently diluted to about 0.1 percent consistency. The two EHWK  
pulp fibers represent the two outer layers of the 3-layered tissue structure.

Two kilograms KYMENE® 6500 per metric ton of wood fiber was added and  
30 allowed to mix with the hardwood pulp fibers for at least 10 minutes before  
pumping the pulp slurry through the headbox.

The pulp fibers from all three machine chests were pumped to the headbox  
at a consistency of about 0.1 percent. Pulp fibers from each machine chest were

sent through separate manifolds in the headbox to create a 3-layered tissue structure. The fibers were deposited on a forming fabric. Water was subsequently removed by vacuum.

5 The wet sheet, 10-20 percent consistency, was transferred to a press felt or press fabric where it was further dewatered. The sheet was then transferred to a Yankee dryer through a nip via a pressure roll. The consistency of the wet sheet after the pressure roll nip (post-pressure roll consistency or PPRC) was approximately 40 percent. The wet sheet adhered to the Yankee dryer due to an adhesive that is applied to the dryer surface. Spray booms situated underneath  
10 the Yankee dryer sprayed either an adhesive package, which is a mixture of polyvinyl alcohol/KYMENE®/Rezosol 2008M, or an additive composition according to the present disclosure onto the dryer surface. Rezosol 2008M is available from Hercules, Incorporated, located in Wilmington, Delaware, U.S.A.

15 One batch of the typical adhesive package on the continuous handsheet former (CHF) typically consisted of 25 gallons of water, 5000mL of a 6 percent solids polyvinyl alcohol solution, 75mL of a 12.5 percent solids KYMENE® solution, and 20mL of a 7.5 percent solids Rezosol 2008M solution.

The additive compositions according to the present disclosure varied in solids content from 2.5 percent to 10 percent.

20 The sheet was dried to about 95 percent consistency as it traveled on the Yankee dryer and to the creping blade. The creping blade subsequently scraped the tissue sheet and small amounts of dryer coating off the Yankee dryer. The creped tissue base sheet was then wound onto a 3" core into soft rolls for converting. Two rolls of the creped tissue were then rewound and plied together  
25 so that both creped sides were on the outside of the 2-ply structure. Mechanical crimping on the edges of the structure held the plies together. The plied sheet was then slit on the edges to a standard width of approximately 8.5 inches and folded. Tissue samples were conditioned and tested.

In particular, the following tests were performed on the samples:  
30 Tensile Strength, Geometric Mean Tensile Strength (GMT), and Geometric Mean Tensile Energy Absorbed (GMTEA):

The tensile test that was performed used tissue samples that were conditioned at 23° C +/- 1°C and 50 percent +/- 2 percent relative humidity for a

minimum of 4 hours. The 2-ply samples were cut into 3 inch wide strips in the machine direction (MD) and cross-machine direction (CD) using a precision sample cutter model JDC 15M-10, available from Thwing-Albert Instruments, a business having offices located in Philadelphia, Pennsylvania, U.S.A.

5           The gauge length of the tensile frame was set to four inches. The tensile frame was an Alliance RT/1 frame run with TestWorks 4 software. The tensile frame and the software are available from MTS Systems Corporation, a business having offices located in Minneapolis, Minnesota, U.S.A.

10           A 3" strip was then placed in the jaws of the tensile frame and subjected to a strain applied at a rate of 25.4 cm per minute until the point of sample failure. The stress on the tissue strip is monitored as a function of the strain. The calculated outputs included the peak load (grams-force/3", measured in grams-force), the peak stretch (percent, calculated by dividing the elongation of the sample by the original length of the sample and multiplying by 100 percent), the  
15           percent stretch @ 500 grams-force, the tensile energy absorption (TEA) at break (grams-force\*cm/cm<sup>2</sup>, calculated by integrating or taking the area under the stress-strain curve up the point of failure where the load falls to 30 percent of its peak value), and the slope A (kilograms-force, measured as the slope of the stress-strain curve from 57-150 grams-force).

20           Each tissue code (minimum of five replicates) was tested in the machine direction (MD) and cross-machine direction (CD). Geometric means of the tensile strength and tensile energy absorption (TEA) were calculated as the square root of the product of the machine direction (MD) and the cross-machine direction (CD). This yielded an average value that is independent of testing direction. The  
25           samples that were used are shown below.

Elastic Modulus (Maximum Slope) and Geometric Mean Modulus (GMM) as Measures of Sheet Stiffness:

30           Elastic Modulus (Maximum Slope) E(kg<sub>f</sub>) is the elastic modulus determined in the dry state and is expressed in units of kilograms of force. Tappi conditioned samples with a width of 3 inches are placed in tensile tester jaws with a gauge length (span between jaws) of 4 inches. The jaws move apart at a crosshead speed of 25.4 cm/min and the slope is taken as the least squares fit of the data between stress values of 57 grams of force and 150 grams of force. If the sample

is too weak to sustain a stress of at least 200 grams of force without failure, an additional ply is repeatedly added until the multi-ply sample can withstand at least 200 grams of force without failure. The geometric mean modulus or geometric mean slope was calculated as the square root of the product of the machine  
5 direction (MD) and the cross direction (CD) elastic moduli (maximum slopes), yielding an average value that is independent of testing direction.

Wet/Dry Tensile Test (percent in the cross machine direction)

The dry tensile test is described in Example 1, with the gauge length (span between jaws) being 2 inches.. Wet tensile strength was measured in the same  
10 manner as dry strength except that the samples were wetted prior to testing. Specifically, in order to wet the sample, a 3"x 5" tray was filled with distilled or deionized water at a temperature of  $23 \pm 2^\circ\text{C}$ . The water is added to the tray to an approximate one cm depth.

A 3M "Scotch-Brite" general purpose scrubbing pad is then cut to  
15 dimensions of 2.5"x 4". A piece of masking tape approximately 5" long is placed along one of the 4" edges of the pad. The masking tape is used to hold the scrubbing pad.

The scrubbing pad is then placed into the water with the taped end facing up. The pad remains in the water at all times until testing is completed. The  
20 sample to be tested is placed on blotter paper that conforms to TAPPI T205. The scrubbing pad is removed from the water bath and tapped lightly three times on a screen associated with the wetting pan. The scrubbing pad is then gently placed on the sample parallel to the width of the sample in the approximate center. The scrubbing pad is held in place for approximately one second. The sample is then  
25 immediately put into the tensile tester and tested.

To calculate the wet/dry tensile strength ratio, the wet tensile strength value was divided by the dry tensile strength value.

The additive compositions of the present disclosure that were applied to the samples and tested in this example are as follows.

30 In the table below, AFFINITY<sup>TM</sup> EG8200 plastomer is an alpha-olefin interpolymer comprising an ethylene and octene copolymer that was obtained from The Dow Chemical Company of Midland, Michigan, U.S.A. PRIMACOR<sup>TM</sup> 5980i copolymer is an ethylene-acrylic acid copolymer also obtained from The Dow

Chemical Company. The ethylene-acrylic acid copolymer can serve not only as a thermoplastic polymer but also as a dispersing agent. INDUSTRENE® 106 comprises oleic acid, which is marketed by Chemtura Corporation, Middlebury, Connecticut. PRIMACOR™ 5980i copolymer contains 20.5 percent by weight acrylic acid and has a melt flow rate of 13.75 g/10 min at 125°C and 2.16 kg as measured by ASTM D1238. AFFINITY™ EG8200G plastomer has a density of 0.87 g/cc as measured by ASTM D792 and has a melt flow rate of 5 g/10 min at 190°C and 2.16 kg as measured by ASTM D1238.

10

Sample No.	Polymer (wt. ratios in parentheses)	Dispersing Agent	Dispersing Agent conc. (wt.%)	% Solids
1	AFFINITY™ EG8200/PRIMACOR™ 5980i (60/40)	PRIMACOR™ 5980i / Industrene® 106	40.0 / 6.0	2.5
2	AFFINITY™ EG8200/PRIMACOR™ 5980i (60/40)	PRIMACOR™ 5980i	40.0	2.5
3	AFFINITY™ EG8200/PRIMACOR™ 5980i (60/40)	PRIMACOR™ 5980i / Industrene® 106	40.0 / 6.0	5
4	AFFINITY™ EG8200/PRIMACOR™ 5980i (60/40)	PRIMACOR™ 5980i	40.0	5
5	AFFINITY™ EG8200/PRIMACOR™ 5980i (60/40)	PRIMACOR™ 5980i / Industrene® 106	40.0 / 6.0	10

Sample No	Polymer							
	Particle size (um)	Poly-dispersity	Solids (wt.%)	pH	Viscosity (cp)	Temp (oC)	RPM	Spindle
1	1.01	1.57	32.1	10.3	572	21.7	50	RV3
2	0.71	2.12	40.0	11.3	448	22.1	50	RV3
3	1.01	1.57	32.1	10.3	572	21.7	50	RV3
4	0.71	2.12	40.0	11.3	448	22.1	50	RV3
5	1.01	1.57	32.1	10.3	572	21.7	50	RV3

DOWICIL™ 200 antimicrobial, which is a preservative with the active composition of 96 percent cis 1-(3-chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride(also known as Quaternium-15) obtained from The Dow Chemical Company, was also present in each of the additive compositions.

As shown above, the percent solids in solution for the different additive compositions was varied. Varying the solids content in solution also varies the

amount of solids incorporated into the base web. For instance, at 2.5 percent solution solids, it is estimated that from 35 kg/MT to 60 kg/MT solids is incorporated into the tissue web. At 5 percent solution solids, it is estimated that from 70 kg/MT to 130 kg/MT solids is incorporated into the tissue web. At 10 percent solution solids, it is estimated that from 140 kg/MT to 260 kg/MT solids is incorporated into the tissue web.

The results of this example are illustrated in **Figs. 3-7**. As shown in **Fig. 3**, for instance, the geometric mean tensile strength of the samples made according to the present disclosure were greater than the non-inventive sample treated with the conventional bonding material. Similar results were also obtained for the geometric mean total energy absorbed.

In addition to testing the properties of the samples, some of the samples were also photographed. For instance, referring to **Figs. 8, 9, 10** and 11, four of the samples are shown at 500 times magnification. In particular, **Fig. 8** represents a photograph of the non-inventive sample, **Fig. 9** is a photograph of Sample No. 1, **Fig. 10** is a photograph of Sample No. 3, and **Fig. 11** is a photograph of Sample No. 5. As shown, the additive composition of the present disclosure tends to form a discontinuous film over the surface of the tissue web. Further, the greater the solution solids, the greater the amount of film formation. These figures indicate that the additive composition generally remains on the surface of the tissue web.

Referring to **Fig. 12**, a photograph of the cross section of the same sample illustrated in **Fig. 11** is shown. As can be seen in the photograph, even at 10 percent solution solids, most of the additive composition remains on the surface of the tissue web. In this regard, the additive composition penetrates the web in an amount less than about 25 percent of the thickness of the web, such as less than about 15 percent of the thickness of the web, such as less than about 5 percent of the thickness of the web.

In this manner, it is believed that the additive composition provides a significant amount of strength to the tissue web. Further, because the film is discontinuous, the wicking properties of the web are not substantially adversely affected. Of particular advantage, these results are obtained without also a substantial increase in stiffness of the tissue web and without a substantial decrease in the perceived softness.

## EXAMPLE 2

In this example, tissue webs made according to the present disclosure were compared to commercially available products. The samples were subjected to various tests. In particular, the samples were subjected to a “Stick-Slip Parameter  
5 Test” which measures the perceived softness of the product by measuring the spacial and temporal variation of a drag force as skin simulant is dragged over the surface of the sample.

More particularly, the following tests were performed in this example.

### Stick-Slip Test

10 Stick-slip occurs when the static coefficient of friction (“COF”) is significantly higher than the kinetic COF. A sled pulled over a surface by a string will not move until the force in the string is high enough to overcome the static COF times the normal load. However, as soon as the sled starts to move the static COF gives way to the lower kinetic COF, so the pulling force in the string is unbalanced and  
15 the sled accelerates until the tension in the string is released and the sled stops (sticks). The tension then builds again until it is high enough to overcome the static COF, and so on. The frequency and amplitude of the oscillations depend upon the difference between the static COF and the kinetic COF, but also upon the length and stiffness of the string (a stiff, short string will let the force drop down  
20 almost immediately when the static COF is overcome so that the sled jerks forward only a small distance), and upon the speed of travel. Higher speeds tend to reduce stick-slip behavior.

Static COF is higher than kinetic COF because two surfaces in contact under a load tend to creep and comply with each other and increase the contact  
25 area between them. COF is proportional to contact area so more time in contact gives a higher COF. This helps explain why higher speeds give less stick-slip: there is less time after each slip event for the surfaces to comply and for the static COF to rise. For many materials the COF decreases with higher speed sliding because of this reduced time for compliance. However, some materials (typically  
30 soft or lubricated surfaces) actually show an increase in COF with increasing speed because the surfaces in contact tend to flow either plastically or viscoelastically and dissipate energy at a rate proportional to the rate at which they are sheared. Materials which have increasing COF with velocity do not show stick-



slip because it would take more force to make the sled jerk forward than to continue at a constant slower rate. Such materials also have a static COF equal to their kinetic COF. Therefore, measuring the slope of the COF versus velocity curve is a good means of predicting whether a material is likely to show stick-slip:

5 more negative slopes will stick-slip easily, while more positive slopes will not stick-slip even at very low velocities of sliding.

According to the Stick-Slip test, the variation in COF with velocity of sliding is measured using an Alliance RT/1 tensile frame equipped with MTS TestWorks 4 software. A diagram of part of the testing apparatus is shown in **Fig. 13**. As

10 illustrated, a plate is fixed to the lower part of the frame, and a tissue sheet (the sample) is clamped to this plate. An aluminum sled with a 1.5" by 1.5" flat surface with a 1/2" radius on the leading and trailing edges is attached to the upper (moving part) of the frame by means of a slender fishing line (30 lb, Stren clear monofilament from Remington Arms Inc, Madison, NC) lead through a nearly

15 frictionless pulley up to a 50 N load cell. A 50.8 mm wide sheet of collagen film is clamped flat to the underside of the sled by means of 32 mm binder clips on the front and back of the sled. The total mass of the sled, film and clips is 81.1 g. The film is larger than the sled so that it fully covers the contacting surfaces. The collagen film may be obtained from NATURIN GmbH, Weinheim, Germany, under

20 the designation of COFFI (Collagen Food Film), having a basis weight of 28 gsm. Another suitable film may be obtained from Viscofan USA Inc, 50 County Court, Montgomery AL 36105. The films are embossed with a small dot pattern. The flatter side of the film (with the dots dimpled down) should be facing down toward the tissue on the sled to maximize contact area between the tissue and collagen.

25 The samples and the collagen film should be conditioned at 72 F and 50 percent RH for at least 6 hours prior to testing.

The tensile frame is programmed to drag the sled at a constant velocity (V) for a distance of 1 cm while the drag force is measured at a frequency of 100 hz. The average drag force measured between 0.2 cm and 0.9 cm is calculated, and

30 kinetic COF is calculated as:

$$COF_v = \frac{f}{81.1} \quad (1)$$

Where  $f$  is the average drag force in grams, and 81.1 g is the mass of the sled, clips and film.

For each sample the COF is measured at 5, 10, 25, 50 and 100 cm/min. A new piece of collagen film is used for each sample.

- 5           The COF varies logarithmically with velocity, so that the data is described by the expression:

$$COF = a + SSP \ln(V)$$

- Where  $a$  is the best fit COF at 1cm/min and SSP is the Stick-Slip Parameter, showing how the COF varies with velocity. A higher value of SSP indicates a more  
10 lotiony, less prone to stick-slip sheet. SSP is measured for four tissue sheet samples for each code and the average is reported.

#### Hercules Size Test (HST)

- The "Hercules Size Test" (HST) is a test that generally measures how long it takes for a liquid to travel through a tissue sheet. Hercules size testing was done  
15 in general accordance with TAPPI method T 530 PM-89, Size Test for Paper with Ink Resistance. Hercules Size Test data was collected on a Model HST tester using white and green calibration tiles and the black disk provided by the manufacturer. A 2 percent Naphthol Green N dye diluted with distilled water to 1 percent was used as the dye. All materials are available from Hercules, Inc.,  
20 Wilmington, Delaware.

All specimens were conditioned for at least 4 hours at 23+/-1 C and 50 +/-2 percent relative humidity prior to testing. The test is sensitive to dye solution temperature so the dye solution should also be equilibrated to the controlled condition temperature for a minimum of 4 hours before testing.

- 25           Six (6) tissue sheets as commercially sold (18 plies for a 3-ply tissue product, 12 plies for a two-ply product, 6 plies for a single ply product, etc.) form the specimen for testing. Specimens are cut to an approximate dimension of 2.5 X 2.5 inches. The instrument is standardized with white and green calibration tiles per the manufacturer's directions. The specimen (12 plies for a 2-ply tissue  
30 product) is placed in the sample holder with the outer surface of the plies facing outward. The specimen is then clamped into the specimen holder. The specimen holder is then positioned in the retaining ring on top of the optical housing. Using the black disk, the instrument zero is calibrated. The black disk is removed and 10

+/-0.5 milliliters of dye solution is dispensed into the retaining ring and the timer started while placing the black disk back over the specimen. The test time in seconds (sec.) is recorded from the instrument.

#### Extraction Method for Determining Additive Content in Tissue

5 One method for measuring the amount of additive composition in a tissue sample is removal of the additive composition in a suitable solvent. Any suitable solvent may be selected, provided that it can dissolve at least a majority of the additive present in the tissue. One suitable solvent is Xylene.

10 To begin, a tissue sample containing the additive composition (3 grams of tissue minimum per test) was placed in an oven set at 105 °C overnight to remove all water. The dried tissue was then sealed in a metal can with a lid and allowed to cool in a dessicator containing calcium sulfate dessicant to prevent absorption of water from the air. After allowing the sample to cool for 10 minutes, the weight of the tissue was measured on a balance with an accuracy of  $\pm 0.0001$  g. and the  
15 weight recorded ( $W_1$ ).

The extraction was performed using a soxhlet extraction apparatus. The soxhlet extraction apparatus consisted of a 250 ml glass round bottom flask connected to a soxhlet extraction tube (Corning® no. 3740-M, with a capacity to top of siphon of 85 ml) and an Allihn condenser (Corning® no. 3840-MCO). The  
20 condenser was connected to a fresh cold water supply. The round bottom flask was heated from below using an electrically heated mantle (Glas Col, Terre Haute, IN USA) controlled by a variable auto transformer (Superior Electric Co., Bristol, CT USA).

To conduct an extraction, the pre-weighed tissue containing the additive  
25 composition was placed into a 33 mm x 80 mm cellulose extraction thimble (Whatman International Ltd, Maidstone, England). The thimble was then put into the soxhlet extraction tube and the tube connected to the round bottom flask and the condenser. Inside the round bottom flask was 150 ml of xylene solvent. The heating mantle was energized and water flow through the condenser was initiated.  
30 The variable auto transformer heat control was adjusted such that the soxhlet tube filled with xylene and cycled back into the round bottom flask every 15 minutes. The extraction was conducted for a total of 5 hours (approximately 20 cycles of xylene through the soxhlet tube). Upon completion the thimble containing the

tissue was removed from the soxhlet tube and allowed to dry in a hood. The tissue was then transported to an oven set at 150°C and dried for 1 hour to remove excess xylene solvent. This oven was vented to a hood. The dry tissue was then placed in an oven set at 105°C overnight. The next day the tissue was removed,  
5 placed in a metal can with a lid, and allowed to cool in a desiccator containing calcium sulfate desiccant for 10 minutes. The dry, cooled extracted tissue weight was then measured on a balance with an accuracy of  $\pm 0.0001$  g. and the weight recorded ( $W_2$ ).

The percent xylene extractives was calculated using the equation below:

10

$$\text{percent xylene extractives} = 100 \times (W_1 - W_2) \div W_1$$

Because not all of the additive composition may extract in the selected solvent, it was necessary to construct a calibration curve to determine the amount  
15 of additive composition in an unknown sample. A calibration curve was developed by first applying a known amount of additive to the surface of a pre-weighed tissue ( $T_1$ ) using an air brush. The additive composition was applied evenly over the tissue and allowed to dry in an oven at 105°C overnight. The weight of the treated tissue was then measured ( $T_2$ ) and the weight percent of additive was calculated  
20 using the equation below:

$$\text{percent additive} = 100 \times (T_2 - T_1) \div T_1$$

Treated tissues over a range of additive composition levels from 0 percent  
25 to 13 percent were produced and tested using the soxhlet extraction procedure previously described. The linear regression of percent xylene extractives (Y variable) vs. percent additive (X variable) was used as the calibration curve.

Calibration curve: percent xylene extractives =  $m(\text{percent additive}) + b$

30

or: percent additive =  $(\text{percent xylene extractives} - b) / m$

where:  $m$  = slope of linear regression equation

b = y-intercept of linear regression equation

After a calibration curve has been established, the additive composition of a tissue sample can be determined. The xylene extractives content of a tissue sample was measured using the soxhlet extraction procedure previously described. The percent additive in the tissue was then calculated using the linear regression equation:

$$\text{percent additive} = (\text{percent xylene extractives} - b) / m$$

where: m = slope of linear regression equation  
 b = y-intercept of linear regression equation

A minimum of two measurements were made on each tissue sample and the arithmetic average was reported as the percent additive content.

Dispersibility-Slosh Box Measurements

The slosh box used for the dynamic break-up of the samples consists of a 14"Wx18"Dx12"H plastic box constructed from 0.5" thick Plexiglas with a tightly fitting lid. The box rests on a platform, with one end attached to a hinge and the other end attached to a reciprocating cam. The amplitude of the rocking motion of the slosh box is ± 2" (4" range). The speed of the sloshing action is variable but was set to a constant speed of 20 revolutions per minute of the cam, or 40 sloshes per minute. A volume of 2000 mL of either the "tap water" or "soft water" soak solution was added to the slosh box before testing. The tap water solution can contain about 112 ppm HCO<sub>3</sub><sup>-</sup>, 66 ppm Ca<sup>2+</sup>, 20 ppm Mg<sup>2+</sup>, 65 ppm Na<sup>+</sup>, 137 ppm Cl<sup>-</sup>, 100 ppm SO<sub>4</sub><sup>2-</sup> with a total dissolved solids of 500 ppm and a calculated water hardness of about 248 ppm equivalents CaCO<sub>3</sub>. The soft water solution, on the other hand, contains about 6.7 ppm Ca<sup>2+</sup>, 3.3 ppm Mg<sup>2+</sup>, and 21.5 ppm Cl<sup>-</sup> with a total dissolved solids of 31.5 ppm and a calculated water hardness of about 30 ppm equivalents CaCO<sub>3</sub>. A sample was unfolded and placed in the slosh box. The slosh box was started and timing was started once the sample was added to the soak solution. The break-up of the sample in the slosh box was visually observed and the time required for break-up into pieces less than about 1" square

in area was recorded. At least three replicates of the samples were recorded and averaged to achieve the recorded values. Sample which do not break-up into pieces less than about 1" square in area within 24 h in a particular soak solution are considered non-dispersible in that soak solution by this test method.

5           In this example, 14 tissue samples were made and subjected to at least one of the above tests and compared to various commercially available tissue products.

          The first three samples made according to the present disclosure (Sample Nos. 1, 2 and 3 in the table below) were made generally according to the process  
10 described in Example 1 above.

          Tissue web samples 4 through 7, on the other hand, were made generally according to the process illustrated in **Fig. 2**. In order to adhere the tissue web to a creping surface, which in this embodiment comprised a Yankee dryer, additive compositions made according to the present disclosure were sprayed onto the  
15 dryer prior to contacting the dryer with the web. Two-ply or three-ply tissue products were produced. The samples were then subjected to various standardized tests.

          Initially, softwood kraft (NSWK) pulp was dispersed in a pulper for 30 minutes at 4 percent consistency at about 100 degrees F. Then, the NSWK pulp  
20 was transferred to a dump chest and subsequently diluted to approximately 3 percent consistency. Then, the NSWK pulp was refined at 4.5 hp-days/metric ton. The above softwood fibers were utilized as the inner strength layer in a 3-layer tissue structure. The NSWK layer contributed approximately 34 percent of the final sheet weight.

25           Two kilograms KYMENE® 6500, available from Hercules, Incorporated, located in Wilmington, Delaware, U.S.A., per metric ton of wood fiber was added to the furnish prior to the headbox.

          Aracruz ECF, a eucalyptus hardwood Kraft (EHWK) pulp available from Aracruz, located in Rio de Janeiro, RJ, Brazil, was dispersed in a pulper for 30  
30 minutes at about 4 percent consistency at about 100 degrees Fahrenheit. The EHWK pulp was then transferred to a dump chest and subsequently diluted to about 3 percent consistency. The EHWK pulp fibers represent the two outer layers

of the 3-layered tissue structure. The EHWK layers contributed approximately 66 percent of the final sheet weight.

Two kilograms KYMENE® 6500 per metric ton of wood fiber was added to the furnish prior to the headbox.

5           The pulp fibers from the machine chests were pumped to the headbox at a consistency of about 0.1 percent. Pulp fibers from each machine chest were sent through separate manifolds in the headbox to create a 3-layered tissue structure. The fibers were deposited onto a felt in a Crescent Former, similar to the process illustrated in **Fig. 2**.

10           The wet sheet, 10-20 percent consistency, was adhered to a Yankee dryer, traveling at about 2500 fpm, (750 mpm) through a nip via a pressure roll. The consistency of the wet sheet after the pressure roll nip (post-pressure roll consistency or PPRC) was approximately 40 percent. The wet sheet adhered to the Yankee dryer due to the additive composition that is applied to the dryer  
15 surface. Spray booms situated underneath the Yankee dryer sprayed the additive composition, described in the present disclosure, onto the dryer surface at an addition level of 100 to 600 mg/m<sup>2</sup>.

To prevent the felt from becoming contaminated by the additive composition, and to maintain desired sheet properties, a shield was positioned  
20 between the spray boom and the pressure roll.

The sheet was dried to 95 percent – 98 percent consistency as it traveled on the Yankee dryer and to the creping blade. The creping blade subsequently scraped the tissue sheet and a portion of the additive composition off the Yankee dryer. The creped tissue base sheet was then wound onto a core traveling at  
25 about 1970 fpm (600 mpm) into soft rolls for converting. The resulting tissue base sheet had an air-dried basis weight of 14.2 g/m<sup>2</sup>. Two or three soft rolls of the creped tissue were then rewound and plied together so that both creped sides were on the outside of the 2- or 3-ply structure. Mechanical crimping on the edges of the  
30 structure held the plies together. The plied sheet was then slit on the edges to a standard width of approximately 8.5 inches and folded. Tissue samples were conditioned and tested.

The additive composition that was applied to Samples 4 through 7 and tested is as follows:



Polymer (wt. ratios in parentheses)	Dispersing Agent	Dispersing Agent conc. (wt.%)
AFFINITY™ EG8200/PRIMACOR™ 5986 (60/40)	PRIMACOR™ 5986	40.0

Polymer							
Particle size (um)	Poly- dispersity	Solids (wt.%)	pH	Viscosity (cp)	Temp (oC)	RPM	Spindle
0.71	2.12	40.0	11.3	448	22.1	50	RV3

5 DOWICIL™ 75 antimicrobial, which is a preservative with the active composition of 96 percent cis 1-(3-chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride(also known as Quaternium-15) obtained from The Dow Chemical Company, was also present in each of the additive compositions.

The percent solids in solution for the different additive compositions was varied to deliver 100 to 600 mg/m<sup>2</sup> spray coverage on the Yankee Dryer. Varying  
10 the solids content in solution also varies the amount of solids incorporated into the base web. For instance, at 100 mg/m<sup>2</sup> spray coverage on the Yankee Dryer, it is estimated that about 1 percent additive composition solids is incorporated into the tissue web. At 200 mg/m<sup>2</sup> spray coverage on the Yankee Dryer, it is estimated that about 2 percent additive composition solids is incorporated into the tissue  
15 web. At 400 mg/m<sup>2</sup> spray coverage on the Yankee Dryer, it is estimated that about 4 percent additive composition solids is incorporated into the tissue web.

Tissue Sample No. 8, on the other hand, comprised a 2-ply product. Tissue Sample No. 8 was made similar to the process described in Example 1. The  
20 tissue web, however, was substantially dry prior to being attached to the dryer drum using the additive composition.

Prior to testing, all of the samples were conditioned according to TAPPI standards. In particular, the samples were placed in an atmosphere at 50 percent relative humidity and 72°F for at least four hours.

25 The following results were obtained:

Sample No.	Identification of Control Samples	# plies	Basis Weight - Bone Dry (gsm)	Basis Weight (gsm)	Additive Composition Coverage (mg/m <sup>2</sup> )	GMI (g/3')	GMT/PLY	HST (seconds)	Xylene extraction add-on (%)	Dispersibility Siosh Box (min)	Stick-Slip Result
Control 1	PUFF's Plus (Procter & Gamble)	2			0						-0.020
Control 2	CELEB Glycerin Treated Tissue(Nepia)	2			0						-0.019
Control 3	KLEENEX Ultra (Kimberly-Clark)	3	39.21		0	880	293	65.8			-0.018
Control 4	PUFFS (Procter & Gamble)	2			0	672	336				-0.018
Control 5	KLEENEX Lotion (Kimberly-Clark)	3			0						-0.017
Control 6	KLEENEX (Kimberly-Clark)	2	26.53		0	622	311	1.2			-0.012
Control 7	COTTONELLE Ultra (Kimberly-Clark)	2			0					1.1	-0.013
Control 8	ANDREX (Kimberly-Clark)	2			0					0.1	-0.017
Control 9	CHARMIN Ultra (Procter & Gamble)	2			0					1.9	-0.018
Control 10	CHARMIN Plus (Procter & Gamble)	2			0						-0.018
Control 11	CHARMIN Giant (Procter & Gamble)	1			0						-0.021
1		2			2804			1.5	23.8		0.058
2		2			701	927	464		6.8		0.054
3		2			1402	1170	585		13.3		0.070
4		2	27.32		200	792	396	4.1	1.2		0.000
5		2	26.89		400	775	388	7	4.1		0.016
6		3	39.93		400	1067	356	9.8	3.3		0.018
7		2			431	874	437		3.2*		0.023
8		2		28	411	1457		1.2	1.4	0.5	-0.006

As shown above, the samples made according to the present disclosure had good water absorbency rates as shown by the Hercules Size Test. In particular, samples made according to the present disclosure had an HST of well below 60 seconds, such as below 30 seconds, such as below 20 seconds, such as  
5 below 10 seconds. In fact, two of the samples had an HST of less than about 2 seconds.

In addition to being very water absorbent, bath tissue samples made according to the present disclosure even containing the additive composition had good dispersibility characteristics. For instance, as shown, the sample tested had  
10 a dispersibility of less than about 2 minutes, such as less than about 1-1/2 minutes, such as less than about 1 minute.

As also shown by the above table, samples made according to the present disclosure had superior stick-slip characteristics. As shown, samples made according to the present disclosure had a stick-slip of from -0.007 to 0.1. More  
15 particularly, samples made according to the present disclosure had a stick-slip of greater than about -0.006, such as greater than about 0. All of the comparative examples, on the other hand, had lower stick-slip numbers.

### Example 3

Tissue samples made according to the present disclosure were prepared  
20 similar to the process described in Example No. 2 above. In this example, the additive composition was applied to the first sample in a relatively heavy amount and to a second sample in a relatively light amount. In particular, Sample 1 contained the additive composition in an amount of 23.8 percent by weight. Sample 1 was made similar to the manner in which Sample 1 was produced in  
25 Example No. 4 above. Sample 2, on the other hand, contained the additive composition in an amount of about 1.2 percent by weight. Sample 2 was made generally in the same manner as Sample 4 was made in Example No. 2 above.

After the samples were prepared, one surface of each sample was photographed using a scanning electron microscope.

30 The first sample containing the additive composition in an amount of 23.8 percent by weight is illustrated in **Figs. 14 and 15**. As shown, in this sample, the additive composition forms a discontinuous film over the surface of the product.

**Figs. 16-19**, on the other hand, are photographs of the sample containing the additive composition in an amount of about 1.2 percent by weight. As shown, at relatively low amounts, the additive composition does not form an interconnected network. Instead, the additive composition is present on the surface of the product in discrete and separate areas. Even at the relatively low amounts, however, the tissue product still has a lotiony and soft feel

These and other modifications and variations to the present disclosure may be practiced by those of ordinary skill in the art, without departing from the spirit and scope of the present disclosure, which is more particularly set forth in the appended claims. In addition, it should be understood that aspects of the various embodiments may be interchanged either in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the disclosure so further described in such appended claims.

15

**WHAT IS CLAIMED:**

1. A process for producing a sheet product comprising:  
applying an additive composition to a moving creping surface, wherein said  
additive composition comprising an aqueous dispersion containing a thermoplastic  
5 polymer;  
pressing a base sheet having an initial basis weight against the creping  
surface after the additive composition has been applied, the additive composition  
adhering the base sheet to the creping surface, wherein said base sheet  
comprising less than 50 percent by weight of cellulosic materials; and  
10 removing the base sheet from the creping surface, wherein the additive  
composition transfers to the base sheet such that the basis weight of the base  
sheet increases by at least about 1 percent by weight.
2. A process for producing a sheet product comprising:  
applying an additive composition to a moving creping surface, wherein said  
15 additive composition comprising an aqueous dispersion containing a thermoplastic  
polymer;  
pressing a base sheet having an initial basis weight against the creping  
surface after the additive composition has been applied, the additive composition  
adhering the base sheet to the creping surface, wherein said sheet comprising less  
20 than 50 percent by weight of cellulosic materials; and  
removing the base sheet from the creping surface, wherein the additive  
composition transfers to the base sheet such that the basis weight of the base  
sheet increases by at least about 1 percent by weight, and wherein the product  
has a bulk of less than 3 cc/g.
- 25 3. A process for producing a sheet product comprising:  
applying an additive composition to a moving creping surface, wherein said  
additive composition comprising an aqueous dispersion containing a thermoplastic  
polymer;  
pressing a base sheet having an initial basis weight against the creping  
30 surface after the additive composition has been applied, the additive composition  
adhering the base sheet to the creping surface, and wherein said sheet being a  
non-cellulosic material; and

removing the base sheet from the creping surface, wherein the additive composition transfers to the base sheet such that the basis weight of the base sheet increases by at least about 1 percent by weight.

4. A process as defined in claim, 2, wherein the base sheet comprises less  
5 than 50 percent by weight of cellulosic fibers.
5. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet comprises a wet laid base web.
6. A process as defined in claim 1, wherein the base sheet comprises an air formed web.
- 10 7. A process as defined in any of the claims 1, 2, or 3, wherein the base web comprises a spunbond web or a meltblown web.
8. A process as defined in any of the claims 1 or 2, wherein the base sheet comprises a hydroentangled web, the base sheet containing synthetic fibers and cellulosic fibers.
- 15 9. A process as defined in any of the claims 1 or 2, wherein the base sheet comprise a co-formed web, the web containing synthetic fibers and cellulosic fibers.
10. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet has a consistency of from 10 percent to 30 percent when pressed against the  
20 creping surface.
11. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet has a consistency of from 30 percent to 70 percent when pressed against the creping surface.
12. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet  
25 contains moisture in an amount less than about 5 percent by weight when pressed against the creping surface.

13. A process as defined in any of the claims 1, 2, or 3, wherein the creping surface is heated to a temperature from 70° C to 350° C.
14. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet is on the creping surface for a period of time from 120 milliseconds to 2,000  
5 milliseconds prior to being removed from the creping surface.
15. A process as defined in any of the claims 1, 2, or 3, wherein the creping surface comprises a surface of a rotating cylinder.
16. A process as defined in any of the claims 1, 2, or 3, wherein the additive composition further comprises a lotion.
- 10 17. A process as defined in claim 16, wherein the lotion comprises a wax and an oil.
18. A process as defined in any of the claims 1, 2, or 3, wherein the the aqueous dispersion further includes a dispersing agent.
19. A process as defined in any of the claims 1, 2, or 3, wherein the  
15 thermoplastic polymer comprises a non-fibrous olefin polymer, an ethylene-carboxylic acid copolymer, or mixtures thereof
20. A process as defined in claim 19, wherein the non-fibrous olefin polymer comprises an alpha-olefin interpolpolymer of ethylene and at least one comonomer selected from the group consisting of a C<sub>4</sub> to C<sub>20</sub> linear, branched or cyclic diene,  
20 vinyl acetate, and a compound represented by the formula H<sub>2</sub>C=CHR, wherein R is a C<sub>1</sub> to C<sub>20</sub> linear, branched or cyclic alkyl group or a C<sub>6</sub> to C<sub>20</sub> aryl group, or the alpha-olefin polymer comprises a copolymer of propylene with at least one comonomer selected from the group consisting of ethylene, a C<sub>4</sub> to C<sub>20</sub> linear, branched or cyclic diene, and a compound represented by the formula H<sub>2</sub>C=CHR,  
25 wherein R is a C<sub>1</sub> to C<sub>20</sub> linear, branched or cyclic alkyl group or a C<sub>6</sub> to C<sub>20</sub> aryl group.
21. A process as defined in claim 19, wherein the aqueous dispersion comprises a mixture of the non-fibrous olefin polymer and the ethylene-carboxylic

acid copolymer, and wherein the non-fibrous olefin polymer comprises an interpolymer of ethylene and an alkene, and wherein the aqueous dispersion further comprises a carboxylic acid.

22. A process as defined in claim 20, wherein the additive composition further  
5 contains a lotion.

23. A process as defined in claim 19, wherein the additive composition further comprises a softener.

24. A process as defined in claim 19, wherein the additive composition further comprises a debonder.

10 25. A process as defined in claim 19, wherein the additive composition further comprise aloe, vitamin E, or mixtures thereof.

26. A process as defined in any of the claims 1, 2, or 3, wherein the basis weight of the base sheet increases by from 2 percent to 30 percent by weight.

15 27. A process as defined in any of the claims 1, 2, or 3, wherein the basis weight of the base sheet increases by from 2 percent to 15 percent by weight.

28. A sheet product produced via the process according to any of the claims 1, 2, or 3.

29. A process as defined in any of the claims 1, 2, or 3, wherein the basis weight of the base sheet increases by from 2 percent to 50 percent by weight.

20 30. A process as defined in any of the claims 1, 2, or 3, wherein the base sheet is creped from the creping surface.



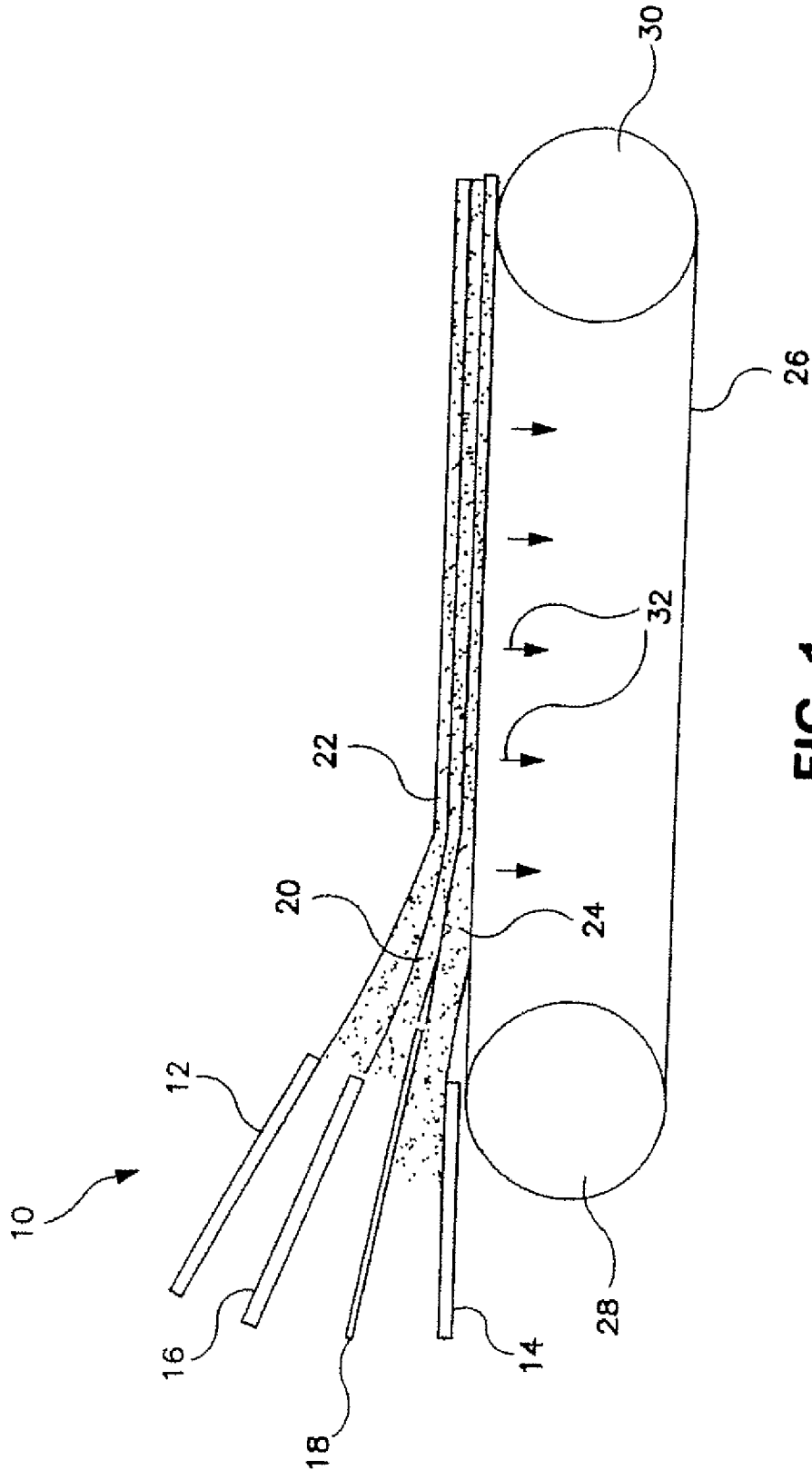


FIG. 1

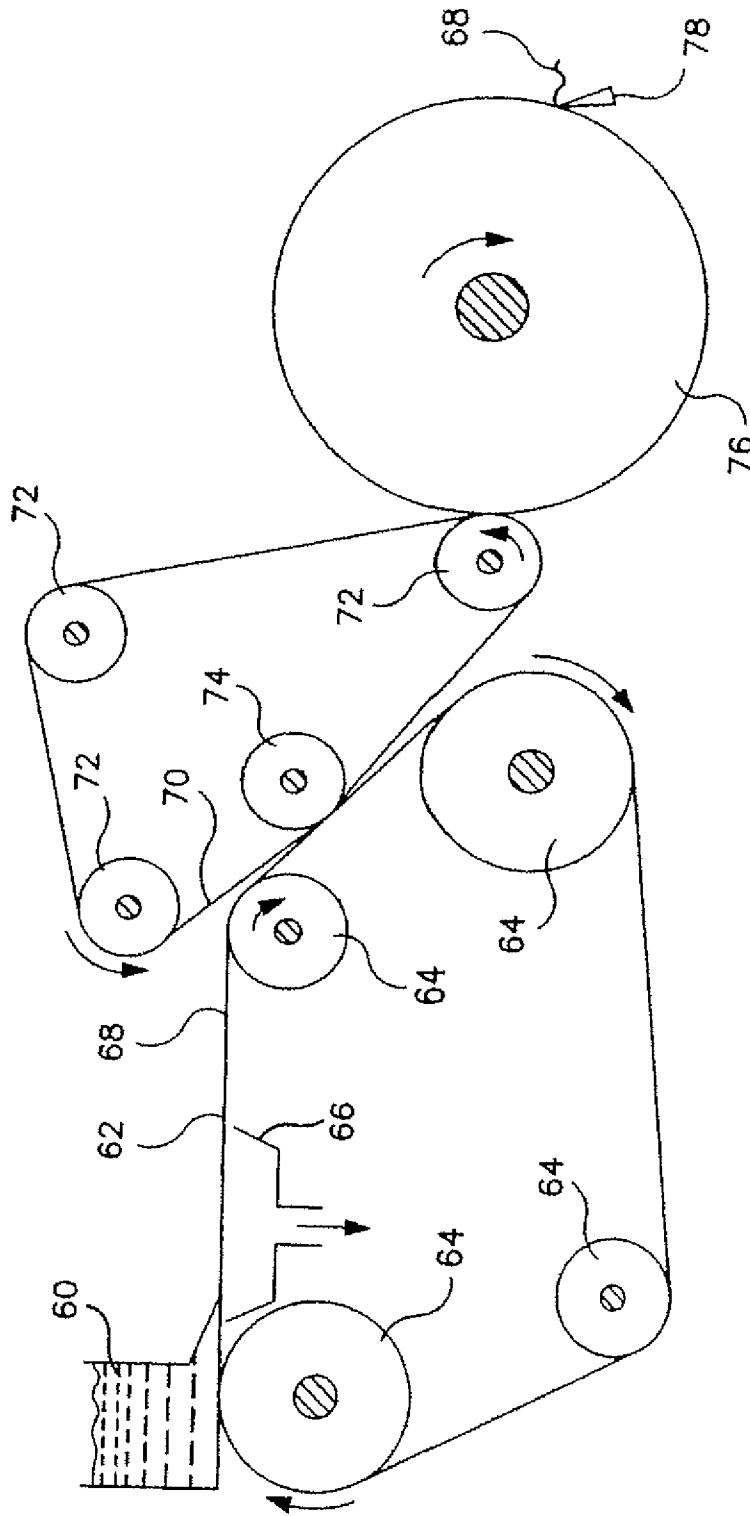
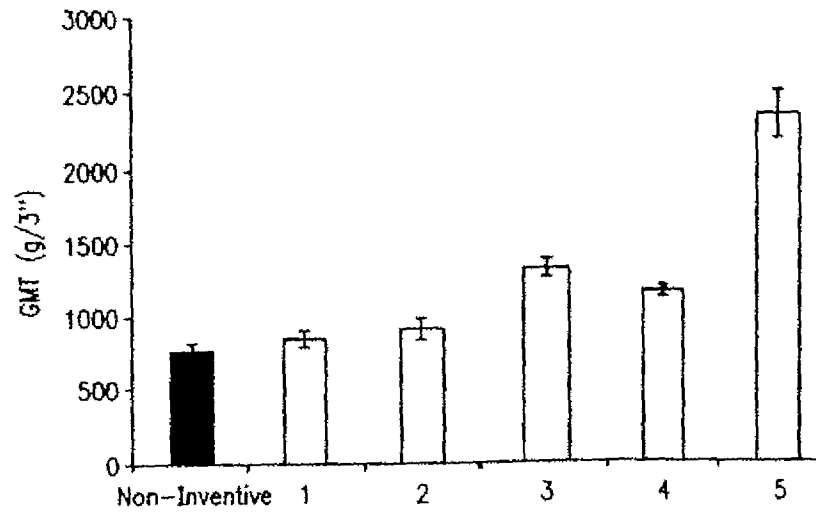
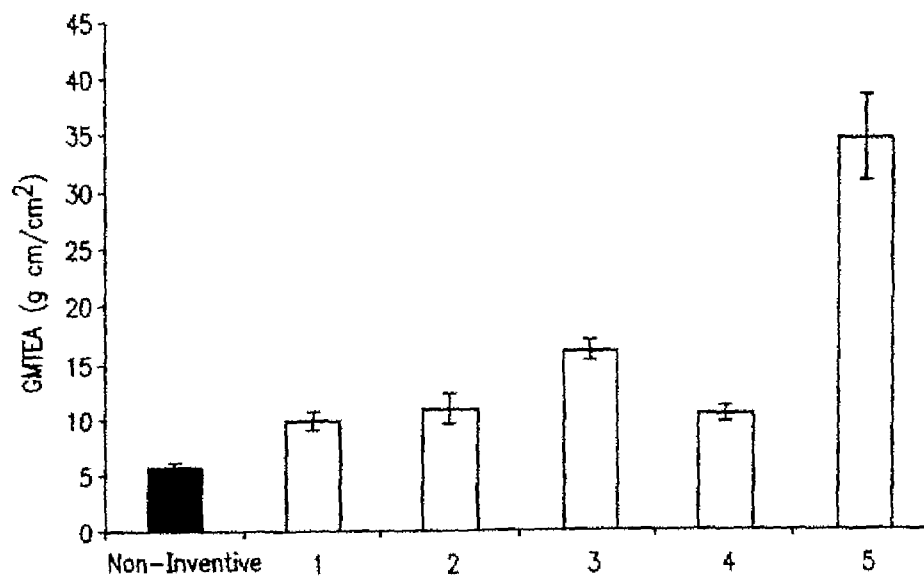


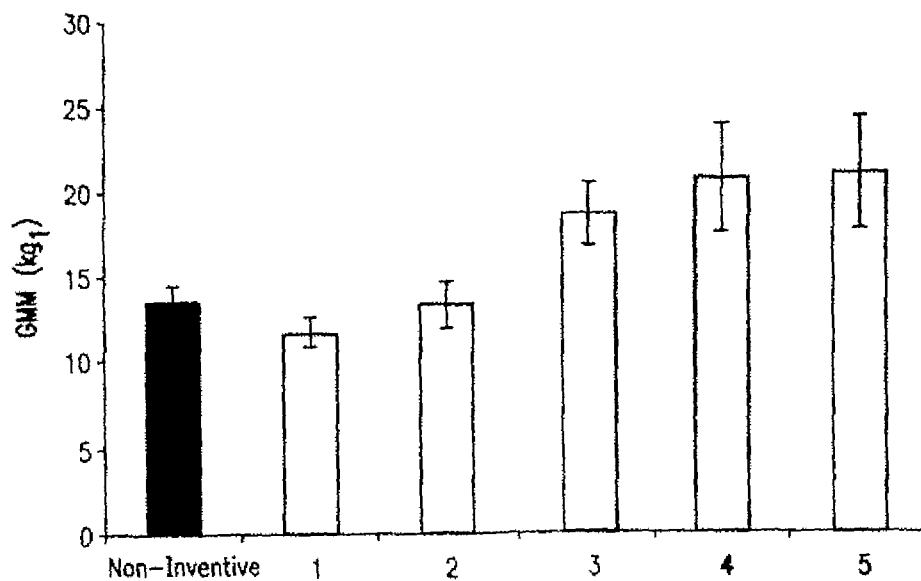
FIG. 2



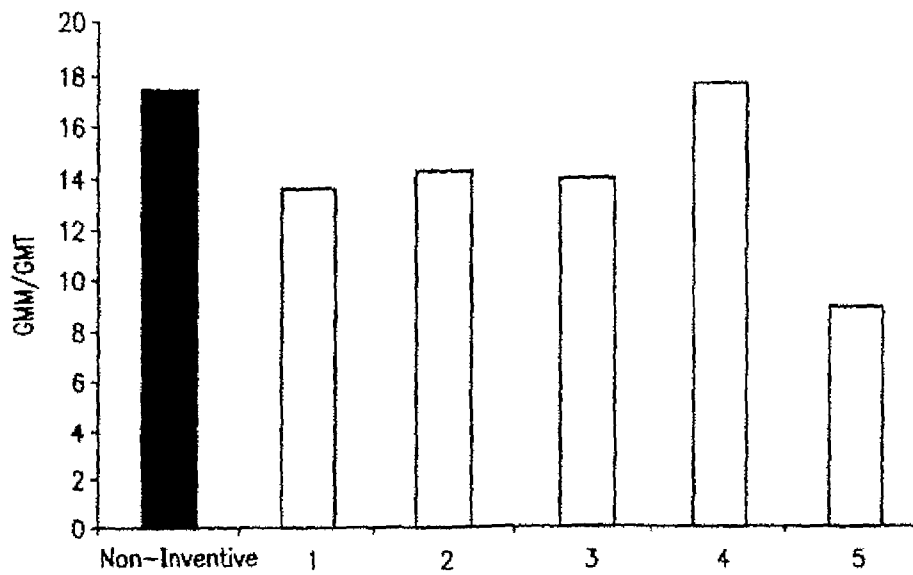
**FIG. 3**



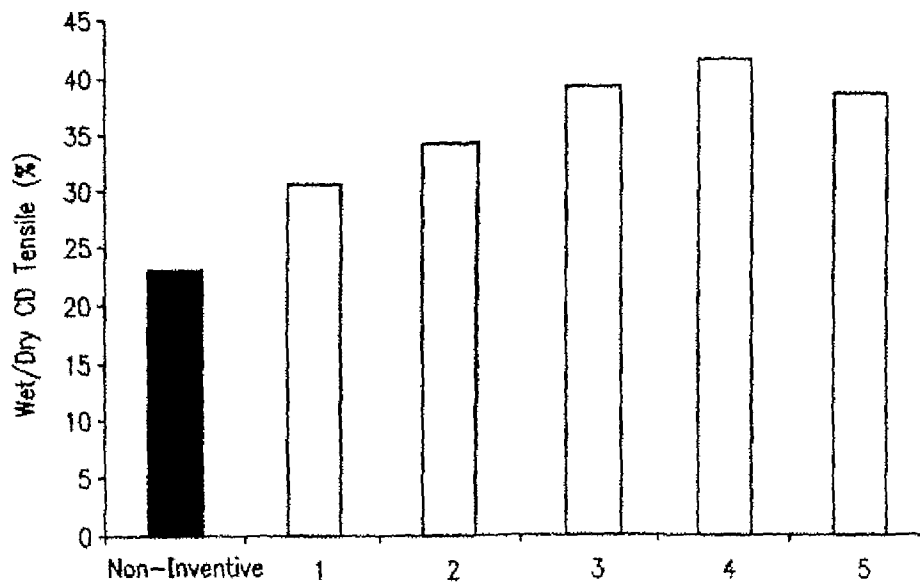
**FIG. 4**



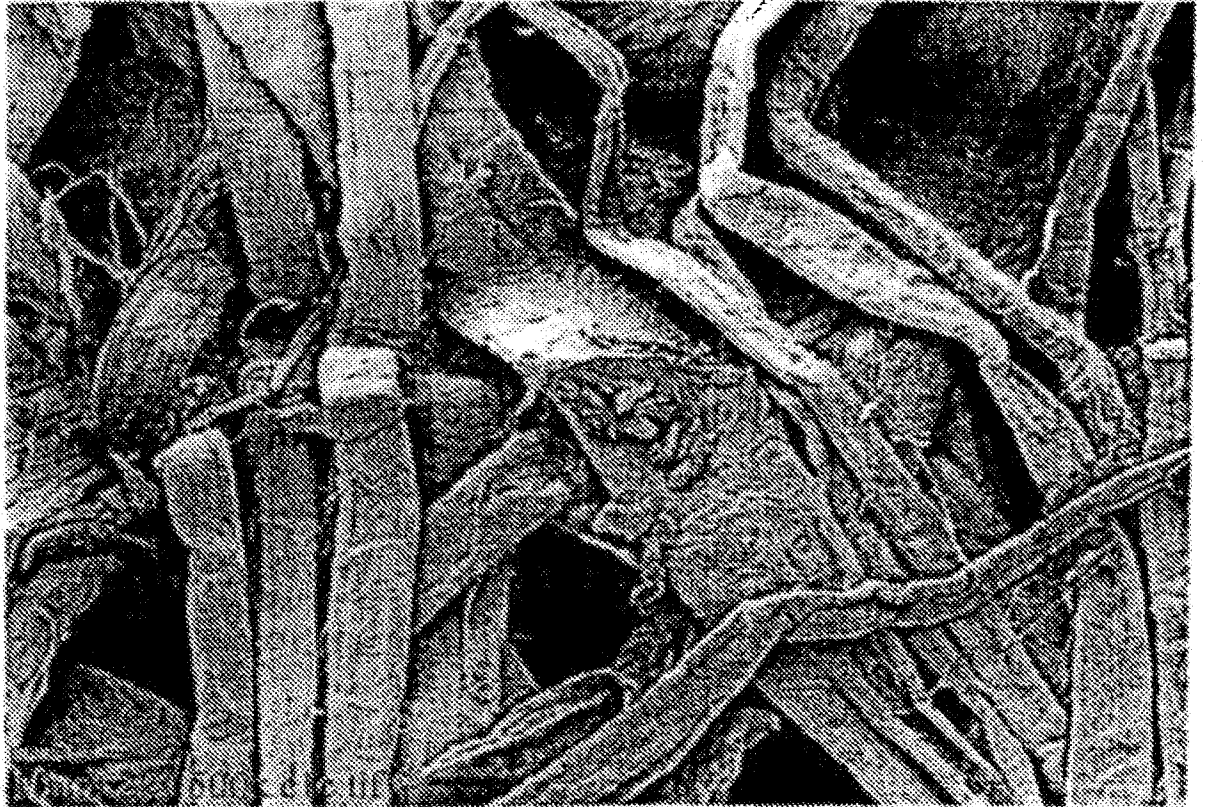
**FIG. 5**



**FIG. 6**

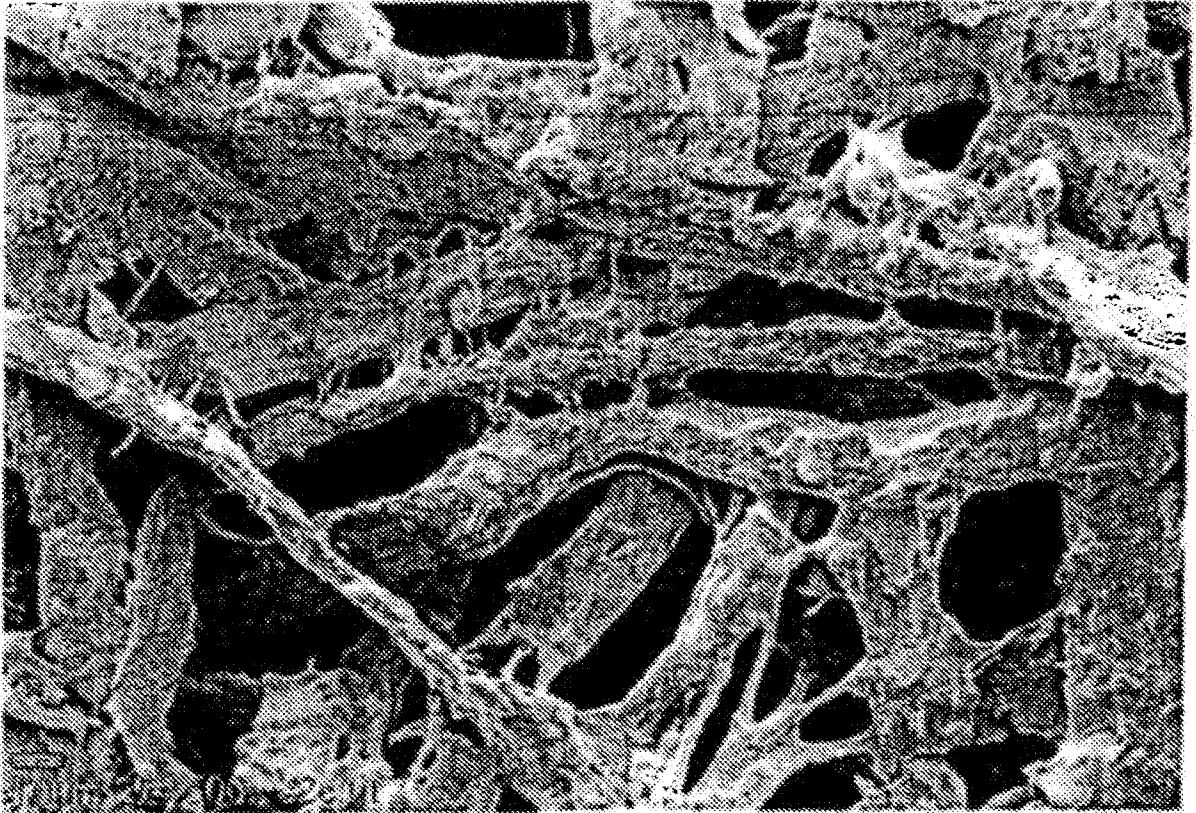


**FIG. 7**



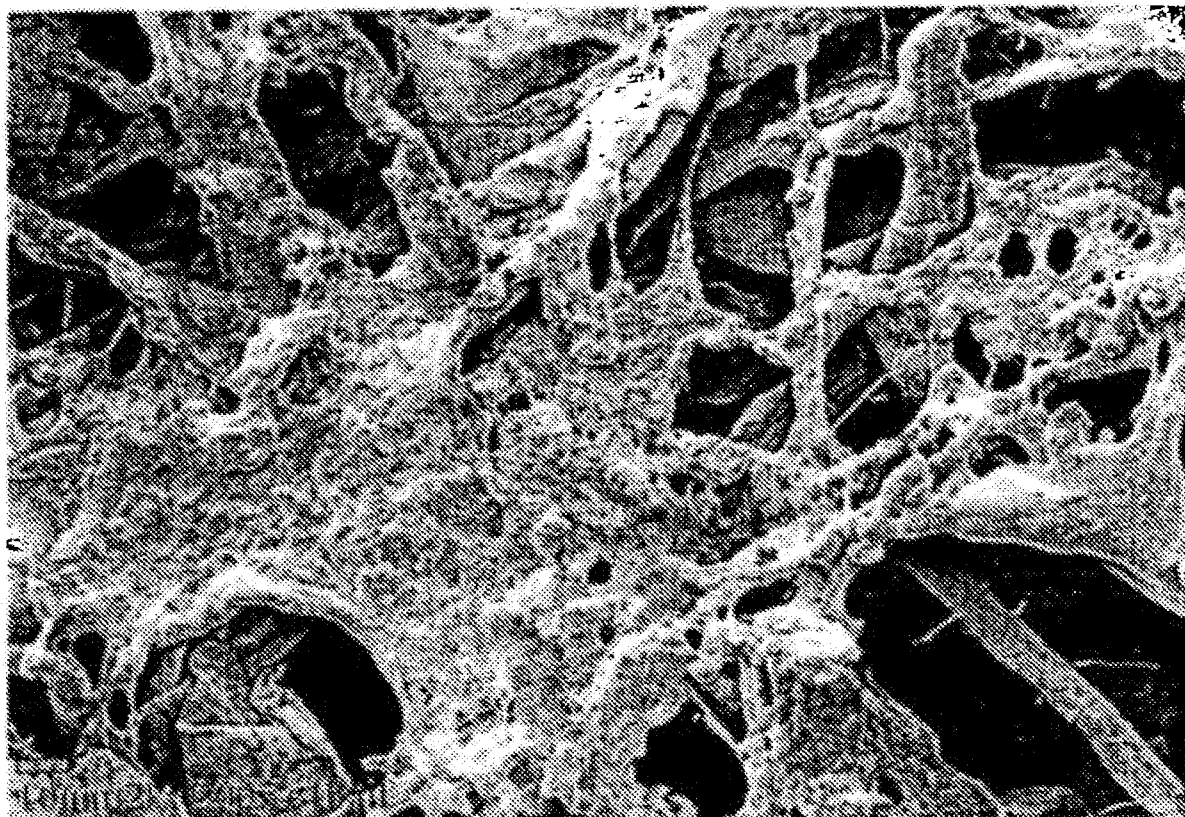
Control Sample at 500x magnification.

**FIG. 8**



**2.5% add-on of the additive composition at 500x magnification.**

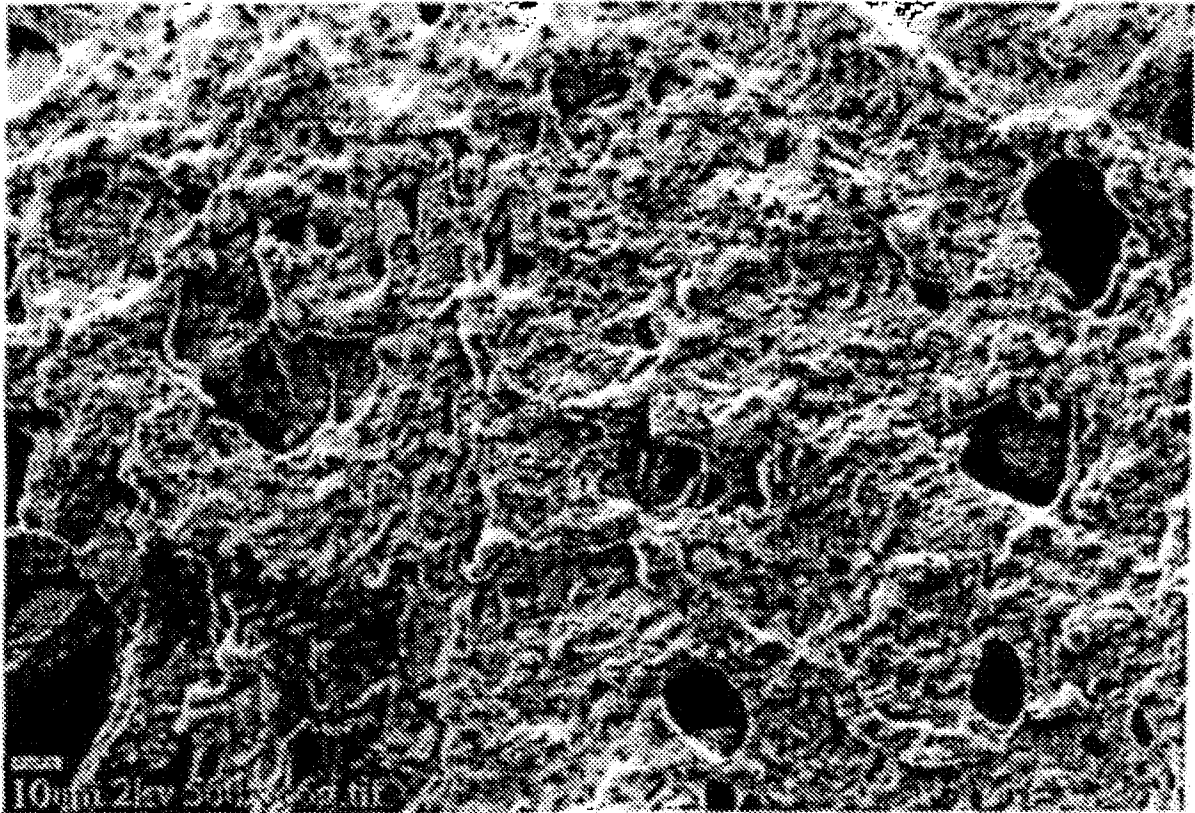
**FIG. 9**



**5% add-on of the additive composition at 500x magnification.**

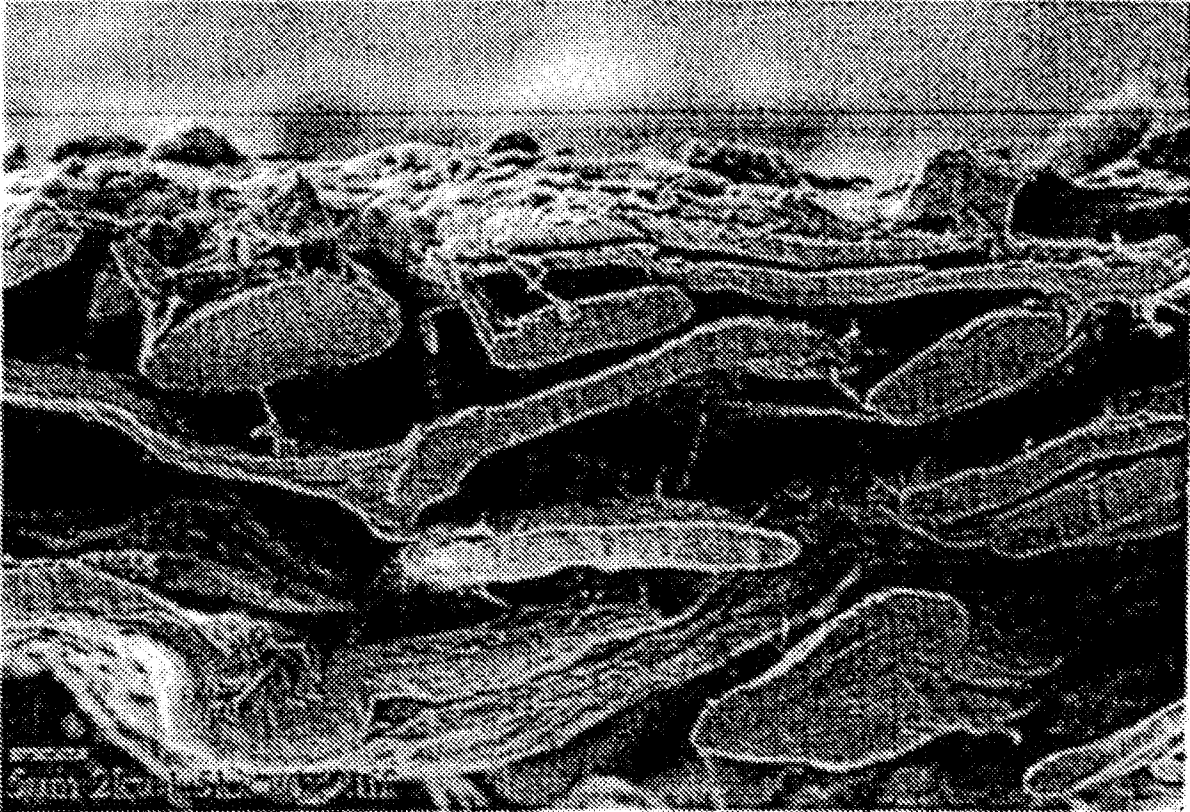
**FIG. 10**





10% add-on of the additive composition at 500x magnification.

**FIG. 11**



**Cross-Section of the 2.5% add-on sample.**

**FIG. 12**

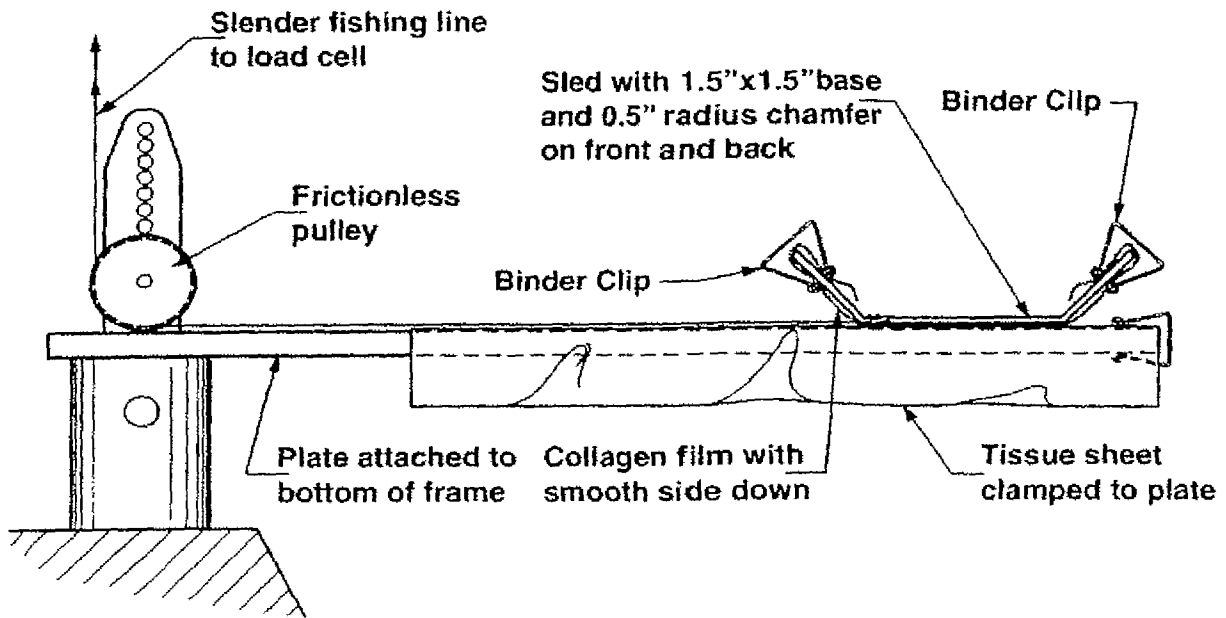


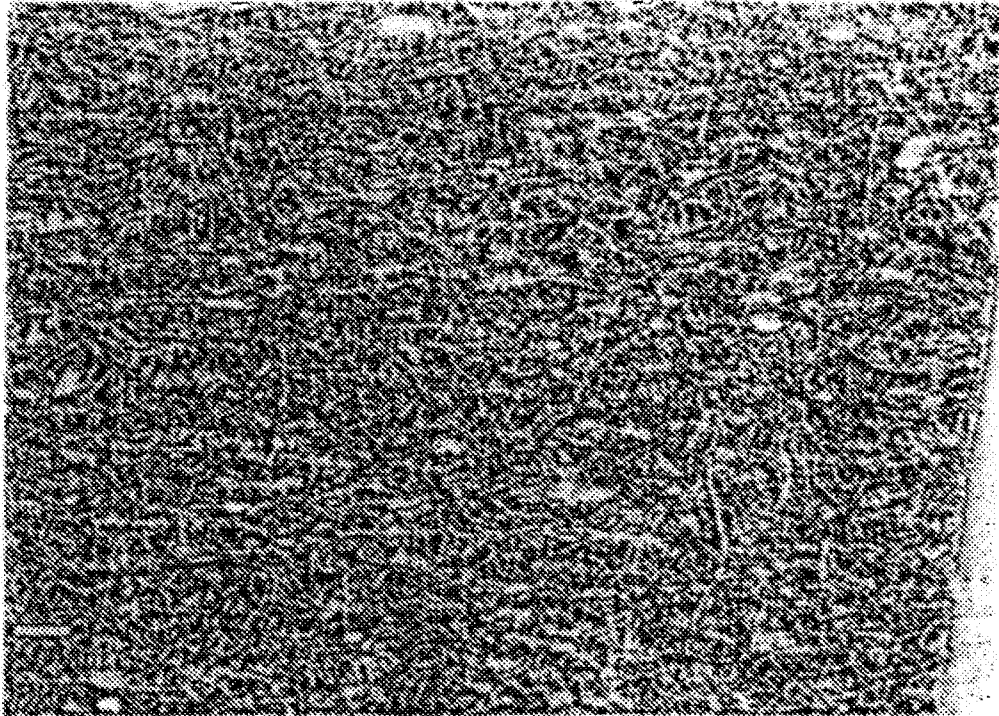
FIG. 13



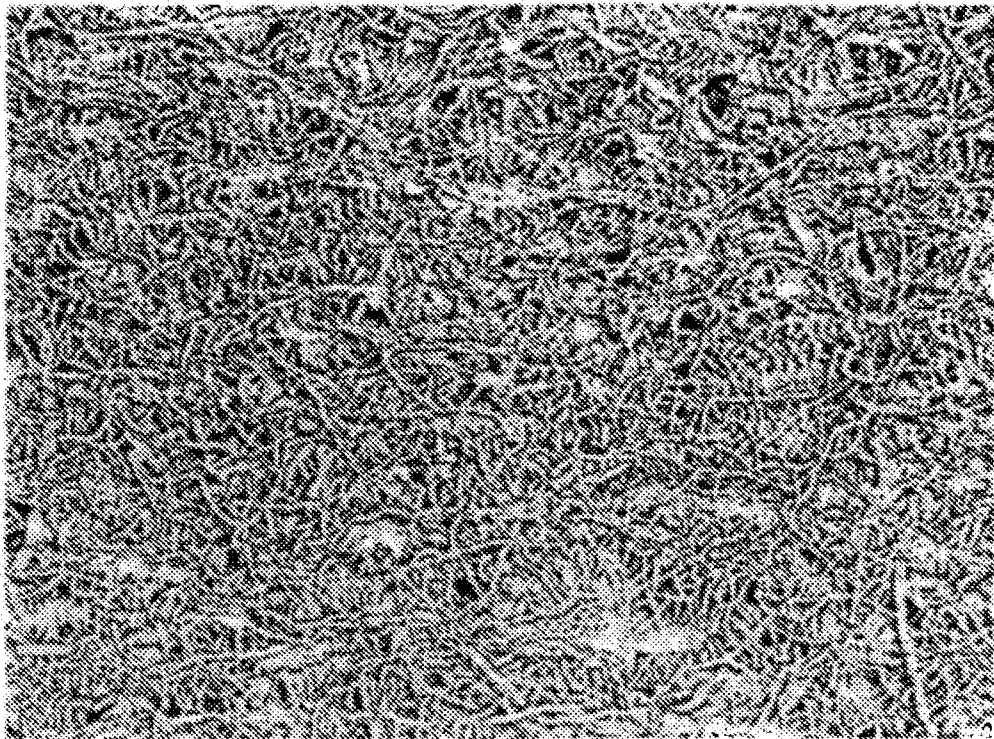
**FIG. 14**  
**SEM surface image, magnification = 15X**



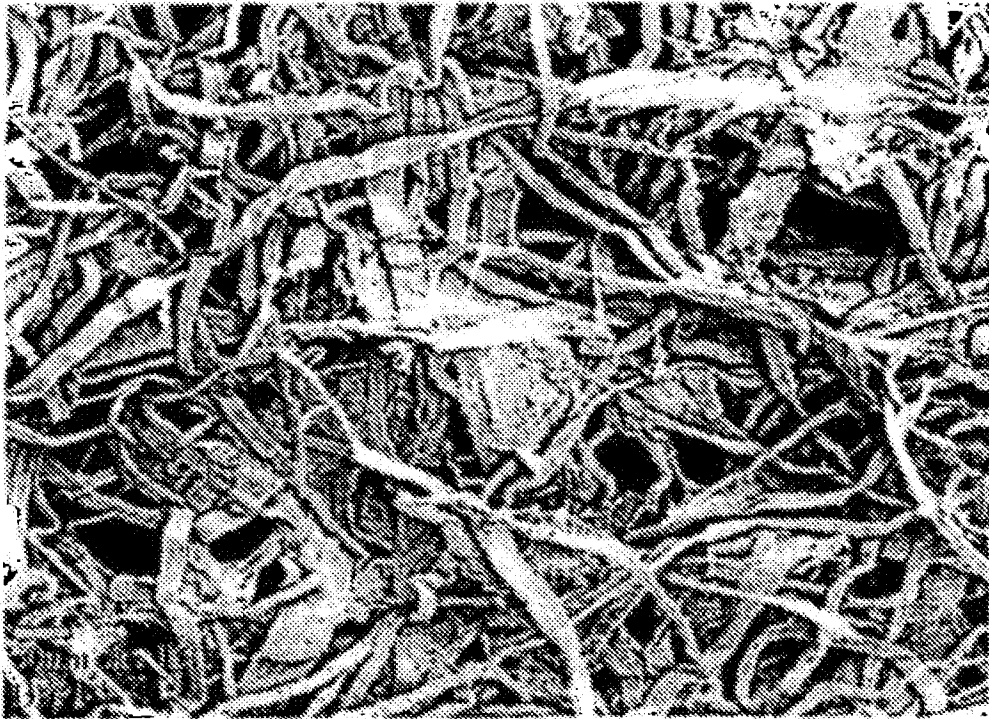
**FIG. 15**  
**SEM surface image, magnification = 30X**



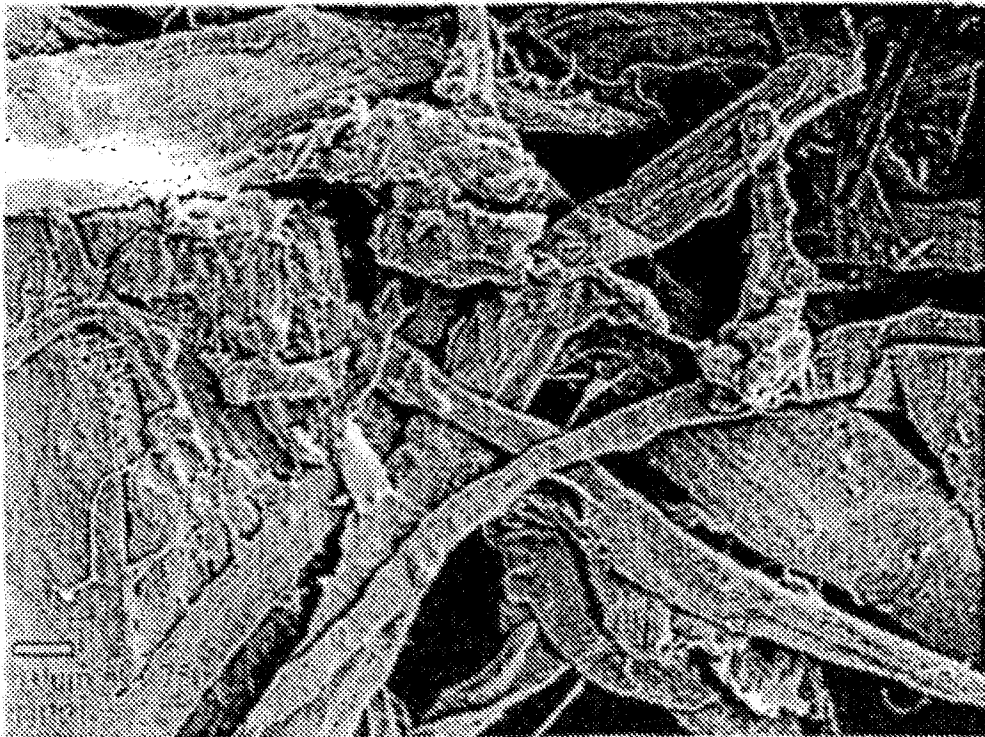
**FIG. 16**  
**SEM surface image, magnification = 15X**



**FIG. 17**  
**SEM surface image, magnification = 30X**



**FIG. 18**  
SEM surface image, magnification = 150X



**FIG. 19**  
SEM surface image, magnification = 750X

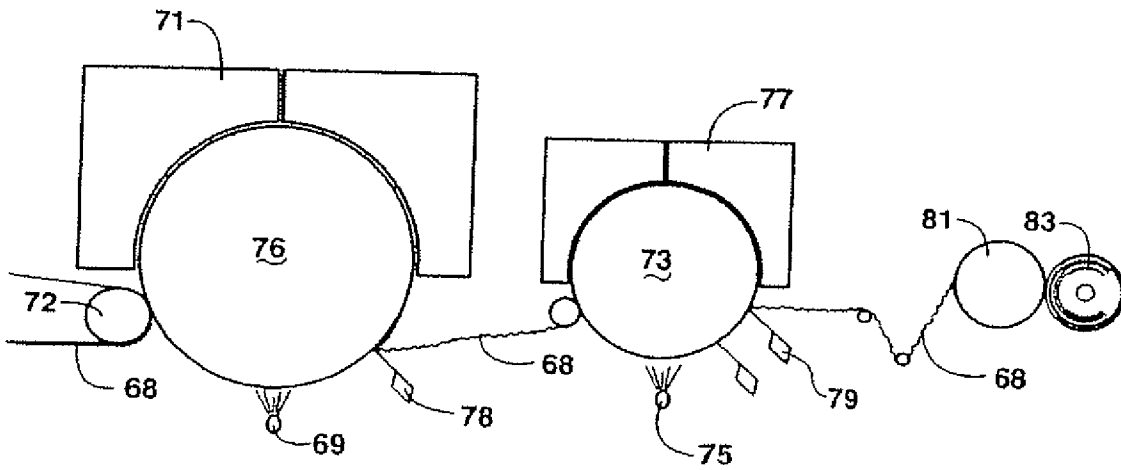


FIG. 20

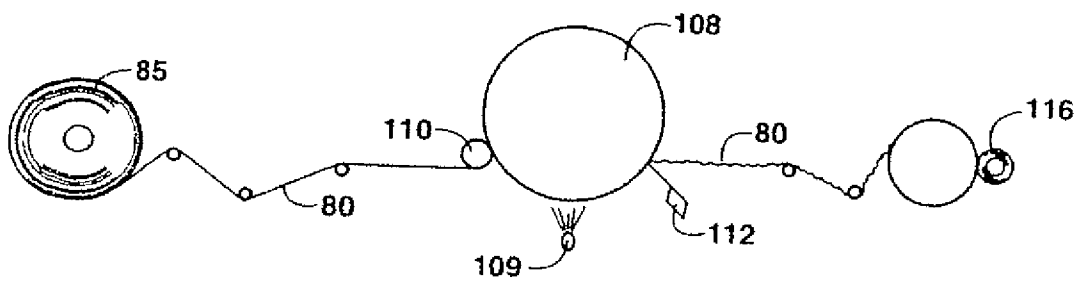


FIG. 21



# INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2008/066471

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. D21H25/00

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 practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/116259 A1 (SAYOVITZ JOHN JOSEPH. [US] ET AL) 26 June 2003 (2003-06-26) the whole document	1-5,7, 20,21,28
X	WO 99/23290 A (KIMBERLY CLARK CO. [US]) 14 May 1999 (1999-05-14) claims 1-41; figure 2	28
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See patent family annex.

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6 November 2008

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17/11/2008

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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2008/066471

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