METHOD TO DEBOND PAPER ON A PAPER MACHINE

Abstract: ABSTRACT Disclosed is a method of making a soft, strong cellulosic tissue sheet comprising the steps of forming a web of cellulosic fibers on a forming wire, thereafter treating the exposed surface of the web with a treatment composition comprising a chemical debonding agent, subjecting the opposing surface of the web to vacuum suction whereby the chemical debonding agent is distributed substantially through the entire thickness of the web, and through-air drying the web. The method allows grade changes to be made much more rapidly and with less waste than when adding debonder at the wet end of the paper making process.
METHOD TO DEBOND PAPER ON A PAPER MACHINE

BACKGROUND OF THE INVENTION

In the manufacture of paper products from cellulose fibers, such as facial tissue, bath tissue, paper towels, dinner napkins and the like, it is often desirable to enhance product properties by the addition of chemical additives. Properties that may be enhanced using additives include: dry strength, wet strength, softness, absorbency, opacity, brightness and color.

Softness is a key attribute in tissue products. A feeling of softness imparts to human skin a clean and soothing effect. Improving the balance of tissue softness and strength is a continuous effort in tissue making. Tissue product designers attempt to maximize the strength and softness of tissues. It has been recognized as a general rule of tissue manufacture that the greater the strength of a given tissue, the lower the softness of that tissue. There is usually an inverse relationship between strength and softness.

In general, prior efforts have been directed at achieving softness using debonders directed at reducing the inter-fiber bonding within the tissue structure or coating the tissue surface with such chemicals. Additionally and/or alternatively, mechanical means have been used in the art of tissue making to increase the softness of tissue paper. For example, many tissues are creped with a doctor blade to increase softness. Through-air drying processes, however, are not as amenable to creping as Yankee dryer processes. Uncreped tissues sometimes are subjected to a rush transfer step to increase softness.

During the papermaking process, additives are commonly added to fiber slurries in the wet end of a papermaking machine. Wet end chemical addition may provide a relatively uniform distribution of chemical additives on the fiber surfaces of a tissue product. Additionally, wet end chemical addition sometimes facilitates the selection of a particular fraction to be treated with a specific chemical additive in order to enhance the performance of the paper, or to enhance the performance of a chemical additive. Wet end chemical addition enables multiple additives of various types to be added to a fiber slurry, either simultaneously or sequentially, prior to formation of the paper web. However, adding debonder to the fiber furnish results in debonder being present in the whitewater that is recirculated after formation of the paper web. As there is often a large quantity of white water, the presence of additives in the whitewater can result in significant
down time for grade changes, or large amounts of waste material produced when changing chemical compositions. Topical spraying, printing and size press are other methods for chemical addition. However, such chemical addition methods result in higher concentrations of chemical at the surface of the paper sheet, with lower concentrations in the middle of the sheet.

What is needed in the industry is a technique of manufacture that will result in a softer, stronger tissue. A system that will provide a final tissue product having a desirable strength, with good tactile sensory softness characteristics in a process of manufacture that is relatively simple to apply at a reasonable cost would be highly desirable.

**SUMMARY OF THE INVENTION**

In one aspect of the invention, a method of making a tissue product includes the steps of: forming a web of cellulosic fibers on a forming wire; thereafter, treating the exposed surface of the web with a treatment composition that includes a chemical debonding agent; subjecting the opposing surface of the web to vacuum suction whereby the chemical debonding agent is distributed substantially through the entire thickness of the web; and through-air drying the web. In another embodiment, the chemical debonding agent is distributed at a substantially uniform concentration through substantially the entire thickness of the sheet. Desirably, the vacuum suction is applied without removing a substantial quantity of the chemical debonding agent from the web. The method may optionally include a rush transfer operation. In one embodiment the treatment composition is applied to the web in between a first through-air drying operation and a second through-air drying operation.

Desirably, the treatment composition may be applied to the web when the web has a consistency of greater than about 10%. More desirably, the treatment composition may be applied to the web when the web has a consistency of greater than about 15% and less than about 80%. Even more desirably, the treatment composition may be applied to the web when the web has a consistency of greater than about 15% and less than about 30%.

The treatment composition may include any of those chemical debonding agents known to one skilled in the art. In one embodiment, the chemical debonding agent comprises a quaternary amine compound, for example, an oleyl imidazolinium compound. In the dried
product, the chemical debonding agent may be present in the product in an amount of from about 0.01% to about 10% by weight. In another embodiment, the chemical debonding agent may be present in an amount effective to soften substantially the entire thickness of the sheet.

In another embodiment, the treatment composition further comprises a lubricant and a surfactant. The lubricant may be, for example, a lanolin derivative. The surfactant may include a polyethylene glycol ester, a polypropylene glycol ester, mixtures thereof, and so forth.

The tissue product may include layers of different types of cellulosic fibers. For example, the tissue product may include a middle layer positioned in between a first outer layer and a second outer layer of fibers, the first and second outer layers comprising hardwood fibers and the middle layer comprising softwood fibers. In another embodiment, the method may further include the step of combining the tissue treated sheet with additional tissue layers to form a layered tissue product.

BRIEF DESCRIPTION OF THE DRAWINGS

A full and enabling disclosure of this invention, including the best mode shown to one of ordinary skill in the art, is set forth in this specification.

FIG. 1 shows a plan view of one embodiment of a system and process for producing uncreped through-air dried paper webs.

DETAILED DESCRIPTION OF THE INVENTION

Reference now will be made to the embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation of the invention, not as a limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in this invention without departing from the scope or spirit of the invention. For example, features illustrated or described as part of one embodiment can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations as come within the scope of the appended claims and their
equivalents. Other objects, features and aspects of the present invention are disclosed in or are obvious from the following 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 invention, which broader aspects are embodied in the exemplary constructions.

A "debonding agent" or "debonder" refers to any chemical that can be incorporated into paper products, such as tissue, to prevent or disrupt interfiber or intrafiber hydrogen bonding. In general, a debonder stops the hydrogen bonding and reduces the strength of the tissue by preventing the formation of bonds. As a general rule, use of a debonder softens the tissue. However, a debonding agent also can cause the tissue to lint or slough, which is undesirable. Therefore, softness is normally inversely proportional to strength when it comes to tissue.

Depending upon the nature of the chemical, debonding agents may also act as softening agents. A softening agent is generally any chemical additive that can be incorporated into paper products, such as tissue, to provide improved tactile feel. These chemicals can also act as debonding agents or can act solely to improve the surface characteristics of tissue, such as by reducing the coefficient of friction between the tissue surface and the skin on the hand.

In contrast, the term "bonding agent" refers to any chemical that can be incorporated into tissue to increase or enhance the level of interfiber or intrafiber bonding in the sheet. The increased bonding can be either ionic, hydrogen or covalent in nature.

The current invention is geared towards the addition of a debonder or softening agent during the manufacture of a paper product, such as a tissue. Typically, the debonder is added to the tissue at an add-on rate of from about 0.01 to about 10 weight percent of the fiber. For example, the add-on rate may be from about 0.1 to about 5 weight percent of the fiber. Desirably, the add-on rate may be from about 0.1 to about 0.5 weight percent of the fiber.

According to the present invention, various debonders can be used. Exemplary debonders include silicone compounds, mineral oil and other oils or lubricants, quaternary ammonium compounds with alkyl side chains, imidazolinium compounds, and so forth. Examples of quaternary ammonium compounds include hexamethonium bromide,
tetraethylammonium bromide, lauryl trimethylammonium chloride, dihydrogenated tallow 
dimethylammonium methyl sulfate, oleyl imidazolinium, and so forth. Other debonders 
can be tertiary amines and derivatives thereof; amine oxides, saturated and unsaturated 
fatty acids and fatty acid salts; alkenyl succinic anhydrides; alkenyl succinic acids and 
corresponding alkenyl succinate salts; sorbitan mono-, di- and tri-esters, including but not 
limited to stearate, palmitate, oleate, myristate, behenate sorbitan esters, and so forth. 
The above debonders can be used alone or in combination.

In one embodiment of the current invention, quaternary amine debonders such as, for 
example, Hercules® PPD D-1203 debonder may be used. Hercules® PPD D-1203 
debonder is manufactured and distributed by Hercules Incorporated of Wilmington, 
Delaware. Hercules® PPD D-1203 debonder is a proprietary mixture that is believed to 
include approximately 63% quaternary amine salt mixture. Hercules® PPD D-1203 
debonder is available as an amber liquid having a viscosity of 200 centipoise at 25 °C that 
is dispersible in water.

In another embodiment of the current invention, a blend of nonionic and cationic 
surfactants such as, for example, Arosurf PA777 debonder may be used. Arosurf PA777 
debonder is manufactured and distributed by the Goldschmidt AG of Essen, Germany 
("Arosurf" is believed to be a trademark of Goldschmidt). Arosurf PA777 debonder is a 
nonvolatile specialty formulation which imparts fiber debonding and softening, conforms to 
FDA regulations for food contact, and is believed to be based on an imidazolinium 
methosulphate. Arosurf PA777 debonder is available as a yellow-brown liquid having a 
vviscosity of 180 centipoise at 25 °C that is dispersible in water.

Debonders applied at the wet end of the papermaking process may increase surface 
softness by reducing base sheet strength. It has been discovered by the present 
invention, however, that topically applying the debonder directly on the sheet followed by 
drawing the debonder through the thickness of the sheet will provide increased surface 
softness at similar strength levels. Put another way applying the debonder directly on the 
sheet followed by drawing the composition through the thickness of the sheet will provide 
similar strength and softness at reduced chemical add-on levels.

Any of the debonders mentioned above may be added during the manufacture of the 
tissue. The debonder composition can be applied to the surface of the paper product by 
spraying, rotogravure printing, trailing blade coating, flexographic printing, and the like.
Desirably, the debonder composition is sprayed on the surface of the formed sheet. Spraying is performed using a spray nozzle that adds the debonder to the tissue. In one embodiment, the debonder may be applied to the exposed surface of the tissue while the tissue is on a forming wire or fabric, or while the tissue is on a transfer fabric. The debonder may also be applied to the outer layer of a multi-layer tissue.

The debonder may require dilution with water when applying using a spraying method. For example, the debonder may be present in an aqueous composition in an amount less than about 30% by weight, such as in an amount less than about 20% by weight. For example, in one embodiment, the debonder can be present in an aqueous composition in an amount less than about 10% by weight, such as less than 5% by weight. In one particular embodiment, the debonder can be present in an aqueous composition in an amount less than about 3% by weight.

The amount of moisture contained within the web when the debonder composition is applied to the web can vary depending on the particular application and process conditions. In general, the consistency of the web can be from about 10% to about 80%. More particularly, the consistency of the web can be from about 15% to about 30%.

After application of the composition to the surface of the paper, vacuum is applied to the opposite surface of the paper to draw the composition through the thickness of the paper web. The vacuum may be applied by conventional vacuum sources including uhle boxes, vacuum boxes, suction boxes, and so forth. The level of vacuum applied may be controlled to draw the debonder through the thickness of the web. Desirably, the level of vacuum is applied without removing substantial quantities of the debonder from the web, and more desirably the level of vacuum is applied without removing the debonder from the web. For example, the level of vacuum used for drawing the debonder through the web can be from about 3 to about 15 inches (about 75 to about 380 millimeters) of mercury. Water containing debonder that is vacuumed from the web can be recycled or sewerred.

Because the quantity of water in the spray system is small compared to the sheet forming process, grade changes can be made much more rapidly and with less waste than when adding debonder at the wet end of the paper making process.

In general, the debonder composition of the present invention can be applied to any suitable paper product, such as bath tissue, facial tissue, paper towels, industrial wipers, and the like. The paper product can be made in any suitable manner. For example,
paper products utilized in the present invention can be made utilizing adhesive creping, wet creping, double creping, embossing, wet-pressing, air-pressing, through-air drying, creped through-air drying, uncreped through-air drying, as well as other steps known in the paper art. By way of illustration, various tissue making processes are disclosed in U.S. patent 5,607,551 issued Mar. 4, 1997 to Farrington and U.S. patent 5,667,636 issued Sep. 16, 1997 to Engel et al., which are incorporated herein by reference.

A variety of conventional papermaking apparatus may be used in the application of this invention, as they are known by persons of skill in the art. Conventional operations may be used with respect to the stock preparation, headbox, forming fabrics, web transfers, and through-air drying.

Conventional stock preparation equipment may be used to prepare papermaking fibers according to one embodiment of the present invention. The stock preparation equipment may include one or more stock chests. When more than one stock chest is used, there may be a dewatering device between the stock chests. Papermaking fibers and water are added to the first stock chest to form a fiber slurry. The fiber slurry in the first stock chest typically has a consistency of about 20% or lower, and particularly about 5% or lower, such as about 3 to about 5%. The fiber slurry in the first stock chest is desirably under agitation using a mixing blade, rotor, recirculation pump, or other suitable device for mixing the fiber slurry.

One or more chemical additives may be supplied from a reservoir and added to the fiber slurry in the first stock chest. The amount of chemical additive may range from about 0 to about 20 kg/metric ton. The fiber slurry and chemical additive are desirably allowed to remain together in the first stock chest under agitation for a residence time sufficient to allow the papermaking fiber to absorb a substantial portion of the chemical additive. A residence time of about 15 to about 30 minutes, for example, may be sufficient.

When more than one stock chest is used, the fiber slurry is thereafter transferred through suitable conduits and a pump to the dewatering device. In this illustrated embodiment, the dewatering device can comprise a belt press, although alternative dewatering devices such as a centrifuge, a nip thickening device or the like may be used. The fiber slurry is injected between a pair of foraminous fabrics such that press filtration removes water from the slurry. The press filtrate comprises a portion of the process water along with unabsorbed chemical additives in the water. The belt press or other dewatering device
suitably increases the fiber consistency of the slurry to about 20% or greater, and particularly about 30% or greater. Desirably, at least a portion of the unabsorbed chemical additive can be removed from the process to minimize the amount sent forward with the chemically treated finish.

When more than one stock chest is used, the thickened fiber slurry is then transported through conduits to a subsequent stock chest. The fiber slurry is then re-diluted with fresh water from a suitable reservoir and optionally agitated using a mixing device. The fiber consistency of the slurry is suitably decreased to about 20% or less, and particularly about 5% or less, such as about 3 to about 5%. The fiber slurry may then be removed from the subsequent stock chest through suitable conduits and a pump for subsequent processing. Alternatively, the fiber slurry may be processed through the foregoing procedure again in an effort to further increase the chemical additive retention level.

In an alternative embodiment of the present invention, the stock preparation equipment may be used to additionally mechanically treat the fibers. Dispersers suitable for use in the present method are disclosed in U.S. patents 5,348,620 and 5,501,768 which are incorporated herein by reference.

One suitable process for making paper products from the fiber slurries is the uncreped through-air drying method (UCTAD). One or more embodiments of the uncreped through-air drying method is disclosed in U.S. patent 5,656,132 to Farrington, Jr. et al., which is incorporated herein by reference.

As shown in FIG. 1, one embodiment of the present invention includes a twin wire former having a papermaking headbox 10 that injects or deposits a stream 11 from the fiber slurry onto a forming fabric 13 to form a cellulosic web. The web is then transferred to a fabric 15 which serves to support and carry the newly-formed wet web downstream in the process as the web is partially dewatered to a consistency of about 10 dry weight percent. Additional dewatering of the wet web can be carried out, such as by vacuum suction, while the wet web is supported by the fabrics.

The transfer fabric 15 travels at a slower speed than the forming fabric in order to impart increased MD (machine direction) stretch into the web. A so-called "kiss" transfer is completed in many embodiments to avoid compression of the wet web, preferably with the assistance of a vacuum shoe. The transfer fabric may be a fabric having impression
knuckles or it may be a smoother fabric such as Asten 934, 937, 939, 959 or Albany 94M, which are fabrics known to persons of skill in the art.

If the transfer fabric is of the impression knuckle type described herein, it can be utilized to impart some of the same properties as the through-air drying fabric and can enhance the effect when coupled with a through-air drying fabric also having the impression knuckles. When a transfer fabric having impression knuckles is used to achieve the desired CD (cross direction) stretch properties, it provides the flexibility to optionally use a different through-air drying fabric, such as one that has a decorative weave pattern, to provide additional desirable properties not otherwise attainable.

One or more spray nozzles 17 apply a debonder to a surface of the web. A vacuum source 18 draws the debonder through the thickness of the web.

The web then may be transferred from the transfer fabric to a through-air drying fabric 19 with the aid of a vacuum transfer roll 20 or a vacuum transfer shoe. The through-air drying fabric typically travels at about the same speed or a different speed relative to the transfer fabric. If desired, the through-air drying fabric may be run at a slower speed to further enhance MD (machine direction) stretch. Transfer is preferably carried out with vacuum assistance to ensure deformation of the sheet to conform to the through-air drying fabric, thus yielding desired bulk, flexibility, CD stretch and appearance. The through-air drying fabric is preferably of the impression knuckle type, but it is not necessary that it be of that type.

The level of vacuum used for the web transfers can be from about 3 to about 15 inches (about 75 to about 380 millimeters) of mercury, such as from about 10 to about 15 inches (about 254 to about 380 millimeters) of mercury. The vacuum shoe (negative pressure) used in the rush transfer step can be supplemented or replaced by the use of positive pressure from the opposite side of the web to blow the web onto the next fabric in addition to or as a replacement for sucking it onto the next fabric with vacuum. Also, a vacuum roll or rolls can be used to replace the vacuum shoes.

While supported by the through-air drying fabric, the web is dried to a consistency of about 94% or greater by a through-air dryer 21 and thereafter transferred to a carrier fabric 22 as a dried base sheet 23. The dried base sheet 23 is transported to a reel 24
using the carrier fabric 22 and an optional carrier fabric 25. An optional pressurized turning roll 26 can be used to facilitate transfer of the web from the carrier fabric 22 to the optional carrier fabric 25.

Many fiber types may be used in the practice of the present invention including hardwood or softwoods, straw, flax, milkweed seed floss fibers, abaca, hemp, kenaf, bagasse, cotton, reed, and the like. Numerous different types of papermaking fibers may be employed, including bleached and unbleached fibers, fibers of natural origin (including wood fiber and other cellulosic fibers, cellulose derivatives, and chemically stiffened or crosslinked fibers), some component portion of synthetic fibers (synthetic papermaking fibers include certain forms of fibers made from polypropylene, acrylic, aramids, acetates, and the like), virgin and recovered or recycled fibers, hardwood and softwood, and fibers that have been mechanically pulped (e.g., groundwood), chemically pulped (including but not limited to the kraft and sulfite pulping processes), thermomechanically pulped, chemithermomechanically pulped, and the like.

Mixtures of any subset of the above mentioned or related fiber classes may be used. The fibers can be prepared in a multiplicity of ways known to be advantageous in the art. Useful methods of preparing fibers include dispersion to impart curl and improved drying properties.

Further, a single headbox or a plurality of headboxes may be used in the practice of the invention. The headbox or headboxes may be stratified to permit production of a multilayered structure from a single headbox jet in the formation of a web. In particular embodiments, the web may be produced with a stratified or layered headbox to preferentially deposit shorter fibers on one side of the web for improved softness, with relatively longer fibers on the other side of the web or in an interior layer of a web having three or more layers. The web is desirably formed on an endless loop of foraminous forming fabric which permits drainage of the liquid and partial dewatering of the web. Multiple embryonic webs from multiple headboxes may be couched or mechanically or chemically joined.

In one embodiment, the formed paper web contains three layers of fibers. In particular, the web may contain a middle layer of softwood fibers surrounded by two outer layers of hardwood fibers. Paper broke can also be added to the outer layers in an amount less than about 25% by weight of the layer, for example, in an amount of less than about 10%
by weight of the layer. In this embodiment, each of the outer layers can comprise from about 20% to about 40% of the total weight of the web.

In one embodiment, application of the debonder is performed between a rush transfer step and a through-air drying step. Prior to the through air drying step, the consistency of the web in one embodiment is less than about 40% such as from about 10% to about 30%. For example, in one embodiment, the consistency is from about 26% to about 29% after rush transfer and prior to drying.

In an alternative embodiment, the papermaking process can include a first through-air dryer and a second consecutive through-air dryer. Application of the debonder can be performed in between the through-air dryers. In this embodiment, the consistency of the web can be from about 40% to about 80%.

Other chemical additives may be used in conjunction with the present invention. These additives include: dry strength aids, wet strength aids, softening agents, debonding agents, absorbency aids, sizing agents, dyes, optical brighteners, chemical tracers, opacifiers, dryer adhesive chemicals, and the like. Additional forms of chemical additives may include: pigments, emollients, humectants, virucides, bactericides, buffers, waxes, fluoropolymers, odor control materials and deodorants, zeolites, perfumes, debonders vegetable and mineral oils, humectants, sizing agents, superabsorbants, surfactants, moisturizers, UV blockers, antibiotic agents, lotions, fungicides, preservatives, aloe vera extract, vitamin E, or the like. Suitable chemical additives are adsorbable by the cellulosic papermaking fiber and are usually water soluble or water dispersible.

The following Examples serve to illustrate possible approaches pertaining to the present invention. The particular amounts, proportions, compositions, and parameters are meant to be exemplary, and are not intended to specifically limit the scope of the invention.

**EXAMPLES**

Uncreped through-air dried tissue products were produced as described below. The chemicals screened included the following examples:

1) Hercules® PPD D-1203 debonder
2) Arosurf PA 777 debonder

The speed of the continuous sheet former machine used in the testing was about 50 ft./minute. The headbox used was a Voith three-layer headbox. The fiber furnish used for each layer was 53% recycled fiber, 31% northern softwood kraft fiber, and 16% southern softwood kraft fiber. The forming wire was a Voith 2164B. After formation, the wet sheet is transferred to a transfer wire, Voith 2164. The chemical composition sprayed on the sheet was according to Table 1.

The spraying equipment used comprised Spraying Systems Company spray nozzles 1/4 JCO –SS+SUE15B-SS with SUE 15B spray set-up. The spray boom was located just prior to the vacuum slot on the fabric. The spray fans were aimed directly at the sheet. Given the configuration of the machine, this resulted in the debonder formulation being sprayed at the exposed surface of the tissue.

Two nozzles were placed to improve uniformity. The concentration of the chemical solutions was adjusted accordingly to obtain the desired target add-on. The geometry and pressure were maintained constant for all samples. All samples had a dry basis weight of 41 gsm.
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<th>Debonder</th>
<th>Add-On %</th>
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<th>% Stretch (MD)</th>
<th>Tensile (CD)</th>
<th>% Stretch (CD)</th>
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It is 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 invention, which broader aspects are embodied in the exemplary constructions. The invention is shown by example in the appended claims.
CLAIMS:

1. A method for making a soft, strong cellulosic tissue sheet comprising the steps of:
   forming a web of cellulosic fibers on a forming wire,
   thereafter, treating the exposed surface of the web with a treatment composition
   comprising a chemical debonding agent,
   subjecting the opposing surface of the web to vacuum suction whereby the
   chemical debonding agent is distributed substantially through the entire thickness of the
   web, and
   through-air drying the web.

2. The method of claim 1 wherein the vacuum suction is applied without removing a
   substantial quantity of the chemical debonding agent from the web.

3. The method of claim 1 wherein the chemical debonding agent comprises an oleyl
   imidazolinium compound.

4. The method of claim 1 further comprising the step of combining the tissue sheet
   with additional tissue layers to form a layered tissue product.

5. The method of claim 1, wherein the treatment composition is applied to the web
   when the web has a consistency of greater than about 10%.

6. The method of claim 1, wherein the treatment composition is applied to the web
   when the web has a consistency of greater than about 15% and less than about 80%.

7. The method of claim 1, wherein the treatment composition is applied to the web
   when the web has a consistency of greater than about 15% and less than about 30%.

8. The method of claim 1, wherein the treatment composition is applied to the web in
   between a rush transfer operation and the through-air drying operation.

9. The method of claim 1, wherein the treatment composition is applied to the web in
   between a first through-air drying operation and a second through-air drying operation.
10. The method of claim 1, wherein the treatment composition further comprises a lubricant and a surfactant.

11. The method of claim 10, wherein the lubricant comprises a lanolin derivative.

12. The method of claim 10, wherein the surfactant comprises a polyethylene glycol ester, a polypropylene glycol ester, or mixtures thereof.

13. A tissue product made according to the method of claim 1, the tissue product comprising: (a) cellulosic fibers, and (b) the chemical debonding agent.

14. A tissue product made according to the method of claim 1, the tissue product comprising: a paper web comprising cellulosic fibers; and the chemical debonding agent topically applied to the paper web, the chemical debonding agent being present in the web in an amount of from about 0.01% to about 10% by weight.

15. The tissue product of claim 14, wherein the debonding agent being applied to the paper web while the web has a consistency of less than about 80%.

16. The tissue product of claim 14, wherein the debonding agent comprises an oleyl imidazolinium compound.

17. The tissue product of claim 14, wherein the debonding agent comprises an imidazoline quaternary ammonium salt.

18. The tissue product of claim 14, wherein the tissue product is multi-layered.

19. The tissue product of claim 14, wherein the tissue product includes a middle layer positioned in between a first outer layer and a second outer layer of fibers, the first and second outer layers comprising hardwood fibers, the middle layer comprising softwood fibers.
20. In a method for making a soft, strong cellulosic tissue sheet wherein a web of cellulosic fibers is formed on a forming wire and thereafter through-air dried, the improvement comprising treating one face surface of the web with a dilute aqueous solution of a chemical debonding agent in an amount effective to soften substantially the entire thickness of the sheet and thereafter, prior to the sheet being through-air dried, subjecting the web to vacuum suction whereby, after through-air drying of the sheet, the chemical debonding agent is distributed at a substantially uniform concentration through substantially the entire thickness of the sheet.
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC 7 D21F11/14 D21H21/22 D21H23/28

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)

IPC 7 D21F 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, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<th>Category</th>
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<th>Relevant to claim No.</th>
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Date of the actual completion of the international search 25 May 2005

Date of mailing of the International search report 06/06/2005

Name and mailing address of the ISA

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