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KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: METHOD FOR COMBINING WICKING AND EVAPORATION PROPERTIES INTO NON-WOVEN FABRIC STRUCTURES

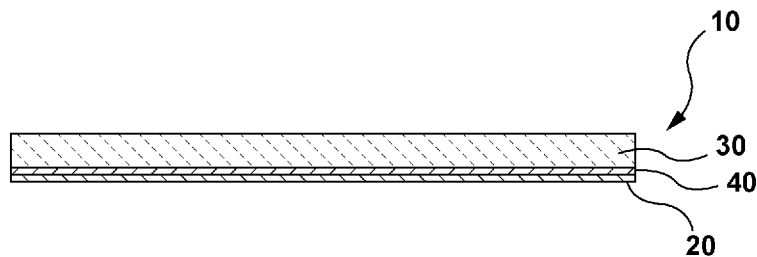


FIG. 1

(57) Abstract: The present technology generally relates to a method for improving evaporation of moisture from a fabric. The method comprises bounding a first layer of fabric having wicking properties to a second layer of non-woven fabric, wherein the second layer of non-woven fabric comprises a plurality of pores allowing movement of water molecules through the second layer of non-woven fabric.



## **METHOD FOR COMBINING WICKING AND EVAPORATION PROPERTIES INTO NON-WOVEN FABRIC STRUCTURES**

### **CROSS-REFERENCE TO RELATED APPLICATION**

[0001] The present application is related to and claims priority to U.S. Provisional Application Number 62/717,185, filed August 10, 2018, the content of which is incorporated by reference herein in its entirety.

### **TECHNICAL FIELD**

[0002] The present technology relates to a method improving evaporation of moisture from a fabric, to fabric structures obtained by such methods and to articles of manufactures comprising the fabric structures.

### **BACKGROUND INFORMATION**

[0003] The evaporation process of water and moisture involves the breakdown of the size of the water mass. In general, the rate of water evaporation is affected by many different factors such as the size of water mass, air temperature, relative humidity, etc. Further, the surface area of the water mass exposed to various environmental conditions that affect or induce evaporation plays a key role in the rate of evaporation of the water to the environment.

[0004] In the evaporation process of a given quantity of water mass, phase-change phenomena occur from the state of water in which the water molecules are cohesively held together by their own surface tension to the water molecules separating from the water mass. As such, it is the water molecules on the outer-most surface exposed to the environment that get released into the air. Hence, with all other conditions remaining consistent, as the surface area of a given volume of water increases, the rate of evaporation of the water increases as well. In other words, a given amount of water exposed to the surrounding environment through a small surface area would take longer to evaporate than the same quantity of water spread thinly across a larger surface area in the same surrounding environment.

[0005] Wicking, or also described as absorption, is a process of which water mass increases its surface area. While wicking properties contribute to accelerating the evaporation process, it

may, in some, circumstances undesirable for some daily used items to have wicking properties. As such properties may allow water penetration. It, however, is a key functionality for other items such as diapers, sanitary pads, or the like, as it helps wet surface dry quicker.

[0006] As mentioned above, the wicking property increases the rate of drying by increasing the surface area of water based liquid. However, it does not break down the size of water mass beyond its limit.

[0007] There is thus a need for methods of further breaking down the size of water mass after the wicking action so as to improve drying of the water-based liquid.

## SUMMARY OF DISCLOSURE

[0008] According to various aspects, the present technology relates to a method for improving evaporation of moisture from a fabric, the method comprising: bounding a first layer of fabric having wicking properties to a second layer of non-woven fabric, wherein the second layer of non-woven fabric comprises a plurality of pores allowing movement of water molecules through the second layer of non-woven fabric.

[0009] According to various aspects, the present technology relates to a method for improving evaporation of moisture from a fabric, the method comprising bounding a first layer of fabric having wicking properties to a second layer of non-woven fabric, wherein the non-woven fabric comprises a plurality of pores allowing movement of water molecules through the non-woven fabric.

[0010] According to various aspects, the present technology relates to a method for increasing the rate of evaporation of moisture from a fabric, the method comprising bounding a fabric having wicking properties to a non-woven fabric, wherein the non-woven fabric comprises a plurality of pores allowing movement of water molecules through the non-woven fabric.

[0011] According to various aspects, the present technology relates to a method for combining wicking properties and water-vapor evaporation into non-woven fabric structures to increase the rate of evaporation through the fabric structures. In some implementations of these embodiments, the methods of the present technology further improve softness, strength, rigidity, thermal insulation, anti-bacteria, heat-generation, far-infrared and negative ion emission, water-

repellency, water-resistance, wind resistance, and down-proofing of the non-woven fabric.

[0012] According to various aspects, the present technology relates to a method for increasing the rate of evaporation of water from a non-woven fabric structure. The method comprises increasing the surface area of the water molecules with the wicking properties and providing a fiber structure to create other properties such as adsorption and diffusion to promote water-vapor evaporation.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0013] Figure 1 is a schematic representation of a two layer fabric in accordance with an embodiment of the present technology; and

[0014] Figure 2 is a schematic representation illustrating the wicking and evaporation of water from a two layer fabric with combined wicking and water-vapor evaporation properties, in accordance with an embodiment of the present technology.

[0015] The various embodiments of the present technology will hereinafter be described in conjunction with the appended drawings, wherein like designations denote like elements.

## **DETAILED DESCRIPTION OF EMBODIMENTS**

[0016] The present technology is explained in greater detail below. This description is not intended to be a detailed catalog of all the different ways in which the technology may be implemented, or all the features that may be added to the instant technology. For example, features illustrated with respect to one embodiment may be incorporated into other embodiments, and features illustrated with respect to a particular embodiment may be deleted from that embodiment. In addition, numerous variations and additions to the various embodiments suggested herein will be apparent to those skilled in the art in light of the instant disclosure which do not depart from the instant technology. Hence, the following specification is intended to illustrate some particular embodiments of the technology, and not to exhaustively specify all permutations, combinations and variations thereof.

[0017] As used herein, the singular form “a”, “an” and “the” include plural referents unless the context clearly dictates otherwise.

[0018] The term “about” is used herein explicitly or not, every quantity given herein is meant to refer to the actual given value, and it is also meant to refer to the approximation to such given value that would reasonably be inferred based on the ordinary skill in the art, including equivalents and approximations due to the experimental and/or measurement conditions for such given value.

[0019] The expression “and/or” where used herein is to be taken as specific disclosure of each of the two specified features or components with or without the other. For example “A and/or B” is to be taken as specific disclosure of each of (i) A, (ii) B and (iii) A and B, just as if each is set out individually herein.

[0020] It will be understood that when an element is referred to as being “on” another element, it can be directly on the other element or intervening elements may be present therebetween.

[0021] It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers, and/or sections, these elements, components, regions, layers, and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer, and/or section from another element, component, region, layer, and/or section.

[0022] Relative terms, such as “lower” or “bottom”, “upper” or “top”, “left” or “right”, “above” or “below”, “front” or “rear” may be used herein to describe one element’s relationship to another element as illustrated in the Figures. It will be understood that relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures.

[0023] As used herein, the term “wicking” refers to the process of water absorption or the drawing off of liquid by capillary action.

[0024] Various performance features based on a variety of different performance criterion may be added to different types of finished products. A wide range of currently available non-woven fabric materials with a variety of properties offer different functionalities such as, for

example, thermal insulation for apparel items, liquid absorption for sanitary pads or dippers, filtration for vehicles, acoustic protection for construction, etc. Such products may be designed and produced to comprise certain desired performance features. For example, sanitary pads may be designed with water absorption being the key performance feature, while also comprising certain complimentary performance features such as softness and strength.

[0025] In some embodiments, the present technology relates to a method for improving evaporation of moisture from fabric. The method comprising placing a non-woven fabric onto a fabric having improved wicking properties. In some implementations of these embodiments, the non-woven fabric comprises a plurality of pores for allowing adsorption and diffusion of moisture from the fabric with improved wicking properties through the non-woven fabric and eventually to the exterior environment. In some instances, the pores are micropores. In some instances, the pores are nanopores. In some instances, the pores are a mixture of micropores and nanopores.

[0026] In some embodiments, the non-woven fabric comprises a high portion of micro-and/or nano-fibers in the range of between about 0.1 Denier and about 0.5 Denier fibers in case of microfibers and fibers with a thickness or diameter of only a few nanometers.

[0027] In some instances, the pores are created at random (randomly distributed) into the non-woven fabric, for example by random deposit of fibers (or microfibers/nanofibers) throughout the structure of the non-woven fabric. These pores increase the surface area and promote the adsorption of water-vapor molecules due to the change of surface excess and surface free energy. In some instances, diffusion of moisture is caused by differences in relative humidity or is caused by convective evaporation (e.g., heavy perspiration, or the like).

[0028] In some implementations, the pores have an average size ranging from between about 10 nm and about 1000  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 50 nm and about 1000  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 100 nm and about 1000  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 500 nm and about 1000  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 10 nm and about 500  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 50 nm and about 500  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 100 nm and about 500  $\mu\text{m}$ . In some implementations, the pores have an average

size ranging from between about 10 nm and about 250  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 50 nm and about 250  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 100 nm and about 250  $\mu\text{m}$ . In some implementations, the pores have an average size ranging from between about 2 nm and about 250  $\mu\text{m}$ .

[0029] In some implementations of these embodiments, the fabric with improved wicking properties is woven, knitted or non-woven structure with either mechanical or chemical means of providing wicking properties, such as, for example TANA<sup>®</sup> FINISH HPX, to boost the capillary action. Such chemical treatments improve affinity of water for the treated fabrics towards moisture, thereby helping improve the capillary actions.

[0030] Figure 1 illustrates a fabric structure with improved evaporation properties according to one embodiment of the present technology where the fabric structure (10) comprises a first fabric layer (20) and a second fabric layer (30). In some implementations, the first fabric layer (20) faces towards to skin of a user when the fabric structure is in use and the second fabric layer (30) faces the exterior environment and/or other finishing fabric when the fabric structure is in use. In some implementations, the first layer (20) is referred to as an inward fabric layer and the second fabric layer is referred to as an outward fabric layer. The first fabric layer may be made from woven, knitted or non-woven fabric layer that may be made using a wide range of materials currently available on the market that have strong wicking properties.

[0031] The second fabric layer may be made from a non-woven fabric comprising a plurality of pores that promotes adsorption and diffusion actions of vapor in order to accelerate the evaporation of water and moisture. These structures also help dry air penetrate into the fabric, which in turn provides a suitable environment for drying of the fabric.

[0032] The first fabric layer (20) and the second fabric layer (30) may be joined together by one or more means such as, for example: chemical bonding, thermal bonding, stitching, or the like.

[0033] In some embodiments, the first fabric layer (20) is made by manufacturing techniques such as, but not limited to: weaving, knitting, spun-bonding, spun-lacing, melt-blowing, thermal-bonding, dry-laying, stitch-bonding, and chemical bonding.

[0034] In some embodiments, the first fabric layer (20) comprises one or more of: polypropylene, viscose, polyester, acryl, nylon, cotton, wool, acetate, modal, Tencel, and hemp.

[0035] In some embodiments, the second fabric layer (30) comprises one or more of: poly(lactic acid) (PLA), poly(glycolic acid) (PGA), poly(ethylene oxide) (PEO), nylon, polyesters, polypropylene, polyamides, poly(amic acids), polyimides, polyethers, polyketones, polyurethanes, polycaprolactones, polyacrylonitriles, polyaramides, conjugated polymers such as the electroluminescent polymer, poly(2-methoxy, 5 ethyl (2' hexyloxy) para-phenylene vinylene) (MEH-PPV), polyphenylenevinylenes, polyarylene-vinylenes, polythienylene-vinylenes, polypyrrolo-vinylenes, polyheteroarylene-vinylenes, polyanilines, polyphenylenes, polyarylenes, polythiophenes, polypyrroles, polyheteroarylenes, polyphenylene-ethynylenes, polyarylene-ethynylenes, polythieno-ethynylenes, polyheteroarylene-ethynylenes, and mixtures thereof.

[0036] In one embodiment, the second fabric layer (30) comprises one or more of: bioabsorbable and biodegradable linear aliphatic polyesters such as polyglycolide (PGA) and its random copolymer poly(glycolide-co-lactide) (PGA-co-PLA). Other suitable bioabsorbable materials are biopolymers which include collagen, gelatin, alginic acid, chitin, chitosan, fibrin, hyaluronic acid, dextran and polyamino acids.

[0037] In some embodiment, the second fabric layer (30) is prepared by electrospinning. Electrospinning is a process by which high voltages are used to produce an interconnected membrane-like web of small fibers (10-500 nm in diameter). This fiber spinning technique provides the capacity to lace together a variety of types of polymers, fibers, and particles to produce ultrathin layers. At a voltage sufficient to overcome surface tension forces, fine jets of liquid shoot out toward a grounded target. The jet is stretched and elongates before it reaches the target, dries and is collected as an interconnected web of small fibers. The technique provides the capacity to lace together a variety of types of polymers and fibers to produce ultra thin layers, which are useful for chemical protective clothing. Depending on the specific polymer being used, a range of fabric properties, such as strength, weight and porosity, can be achieved. Electrospinning results in submicrometer size fibers laid down in a layer that has high porosity but very small pore size. For fibers spun from polymer solutions, the presence of residual solvent in the electrospun fibers facilitates bonding of intersecting fibers, creating a strong cohesive porous structure. The nanofibers assemble into a membrane-like structure that exhibits good tensile strength, excellent moisture vapor transport, extremely low air permeability and good

aerosol particle protection. Water vapor transport properties of electrospun wovens are excellent and indicate that layers based on electrospun fiber technology are thin, lightweight, and very breathable with respect to allowing evaporative cooling to take place through the protective clothing system.

[0038] In some embodiment, the fabric structure (10) further comprises an area of lamination (40) located in between the first fabric layer (20) and the second fabric layer (30).

[0039] In some embodiments, the first fabric layer comprises a non-woven fabric with wicking properties and/or a woven or knitted fabric with additional wicking properties.

[0040] Due to its wicking properties, the first fabric layer absorbs the water from the skin of the wearer of the fabric structure (10) and spreads the water throughout its structure, thereby increasing the surface area of the water mass (Figure 2). As the surface area of the water increases, the rate of phase change from water to moisture increases (Figure 2).

[0041] While the above-described method is designed to primarily increase the evaporative properties of fabrics so that they may dry quicker, additional functionalities may be also be provided to both the first fabric layer (20) and the second fabric layer (30). Examples of such functionalities include softness, strength, rigidity, thermal insulation, anti-bacteria, heat-generation, far-infrared and negative ion emission, water-repellency, water-resistance, wind resistance, and down-proofing. Any combination of such functionalities may be added to enhance the performance of a finished product.

[0042] In some embodiments, the second fabric layer (30) may be made using manufacturing techniques such as, for example: spun-bonding, spun-lacing, melt-blowing, thermal-bonding, dry-laying, needling punching, chemical bonding, or the like. In some embodiments, the second fabric layer (30) comprises one or more of: polypropylene, viscose, polyester, cotton, wool, acetate, and hemp, nylon, acryl, or the like. Further, in order to create property as effective as possible, a non-woven fabric structure to create largest possible surface areas may be adopted in the manufacturing. Some examples of such structure is to deposit fine fibers in micro- and/or nano-fiber range, and/or fibers with irregular sectional shapes which maximize its surface area, into the non-woven structure.

[0043] In some embodiments, the second fabric layer (30) has a density ranging between about 0.05 lb/ft<sup>3</sup> and about 100 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.5 lb/ft<sup>3</sup> and about 100 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 1 lb/ft<sup>3</sup> and about 100 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.05 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.5 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 1 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.05 lb/ft<sup>3</sup> and about 25 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.5 lb/ft<sup>3</sup> and about 25 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 1 lb/ft<sup>3</sup> and about 25 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.05 lb/ft<sup>3</sup> and about 10 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 0.5 lb/ft<sup>3</sup> and about 10 lb/ft<sup>3</sup>. In some embodiments, the second fabric layer (30) has a density ranging between about 1 lb/ft<sup>3</sup> and about 10 lb/ft<sup>3</sup>.

[0044] In some embodiments, the second fabric layer (30) has a weight ranging between about 1 gsm to 200 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 1 gsm to 100 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 1 gsm to 75 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 1 gsm to 50 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 10 gsm to 200 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 10 gsm to 100 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 10 gsm to 75 gsm. In some embodiments, the second fabric layer (30) has a weight ranging between about 10 gsm to 50 gsm.

[0045] In some embodiments, additional properties are added to the fabric structure. Examples of additional properties include, but are not limited to: softness, strength, rigidity, thermal insulation, anti-bacteria, heat-generation, far-infrared and negative ion emission, water-repellency, water-resistance, wind resistance, and down-proofing. There is a wide range of methods known in the art to create such additional properties. One example is to add fine particles of clay, carbon nano tube (CNT), ceramics, or the like, to provide such properties as anti-bacteria, heat-generation, far-infrared, negative ion emission, or the like. Another example is

to treat the fabrics or fibers with chemicals to provide such properties as anti-bacteria, wicking, water-repellency, or the like.

#### **INCORPORATION BY REFERENCE**

[0046] All references cited in this specification, and their references, are incorporated by reference herein in their entirety where appropriate for teachings of additional or alternative details, features, and/or technical background.

#### **EQUIVALENTS**

[0047] While the disclosure has been particularly shown and described with reference to particular embodiments, it will be appreciated that variations of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also, that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following embodiments.

**CLAIMS:**

1. A method for improving evaporation of moisture from a fabric, the method comprising: bounding a first layer of fabric having wicking properties to a second layer of non-woven fabric, wherein the second layer of non-woven fabric comprises a plurality of pores allowing movement of water molecules through the second layer of non-woven fabric.
2. The method according to claim 1, wherein the first layer of fabric is obtained from weaving, knitting, spun-bonding, spun-lacing, melt-blowing, thermal-bonding, dry-laying, stitch-bonding, or chemical bonding.
3. The method according to claim 1, wherein the first layer of fabric comprises one or more of polypropylene, viscose, nylon, polyester, cotton, wool, acetate, and hemp.
4. The method according to any one of claims 1 to 3, wherein the second layer of non-woven fabric is obtained from spun-bonding, spun-lacing, melt-blowing, thermal-bonding, dry-laying, needling punching, or chemical bonding.
5. The method according to any one of claims 1 to 3, wherein the second layer of non-woven fabric comprises one or more of: poly(lactic acid) (PLA), poly(glycolic acid) (PGA), poly(ethylene oxide) (PEO), nylon, polyesters, polypropylene, polyamides, poly(amic acids), polyimides, polyethers, polyketones, polyurethanes, polycaprolactones, polyacrylonitriles, polyaramides, conjugated polymers such as the electroluminescent polymer, poly(2-methoxy, 5 ethyl (2' hexyloxy) para-phenylene vinylene) (MEH-PPV), polyphenylenevinylenes, polyarylene-vinylenes, polythienylene-vinylenes, polypyrrolovinylenes, polyheteroarylene-vinylenes, polyanilines, polyphenylenes, polyarylenes, polythiophenes, polypyrroles, polyheteroarylenes, polyphenylene-ethynylenes, polyarylene-ethynylenes, polythieno-ethynylenes, polyheteroarylene-ethynylenes, and mixtures thereof.
6. The method according to any one of claims 1 to 3, wherein the second layer of non-woven fabric comprises one or more of: bioabsorbable and biodegradable linear aliphatic polyesters such as polyglycolide (PGA) and its random copolymer poly(glycolide-co-lactide)

(PGA-co-PLA). Other suitable bioabsorbable materials are biopolymers which include collagen, gelatin, alginic acid, chitin, chitosan, fibrin, hyaluronic acid, dextran and polyamino acids.

7. The method according to any one of claims 1 to 3, wherein the pores have an average size ranging from between about 50 nm and about 1000  $\mu\text{m}$ , about 100 nm and about 1000  $\mu\text{m}$ , about 500 nm and about 1000  $\mu\text{m}$ , about 10 nm and about 500  $\mu\text{m}$ , about 50 nm and about 500  $\mu\text{m}$ , about 100 nm and about 500  $\mu\text{m}$ , about 10 nm and about 250  $\mu\text{m}$ , about 50 nm and about 250  $\mu\text{m}$ , about 100 nm and about 250  $\mu\text{m}$ , or about 2 nm and about 250  $\mu\text{m}$ .

8. The method according to any one of claims 1 to 7, wherein the non-woven fabric has a density ranging between about 0.05 lb/ft<sup>3</sup> and about 100 lb/ft<sup>3</sup>, about 1 lb/ft<sup>3</sup> and about 100 lb/ft<sup>3</sup>, about 0.05 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>, about 0.5 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>, or about 1 lb/ft<sup>3</sup> and about 50 lb/ft<sup>3</sup>.

9. The method according to any one of claims 1 to 8, wherein the non-woven fabric has weight ranging between about 1 gsm to 200 gsm, about 1 gsm to 100 gsm, or about 1 gsm to 50 gsm.

10. A fabric structure obtained by the method as defined in any one of claims 1 to 9.

11. An article of manufacture comprising the fabric structure as defined in claim 10.

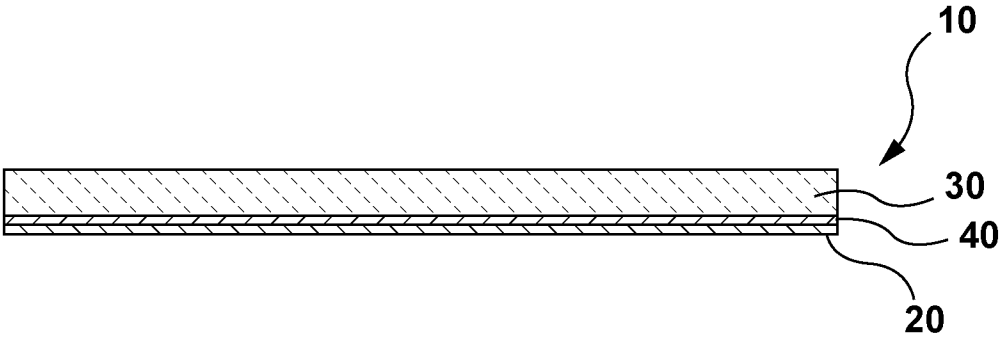


FIG. 1

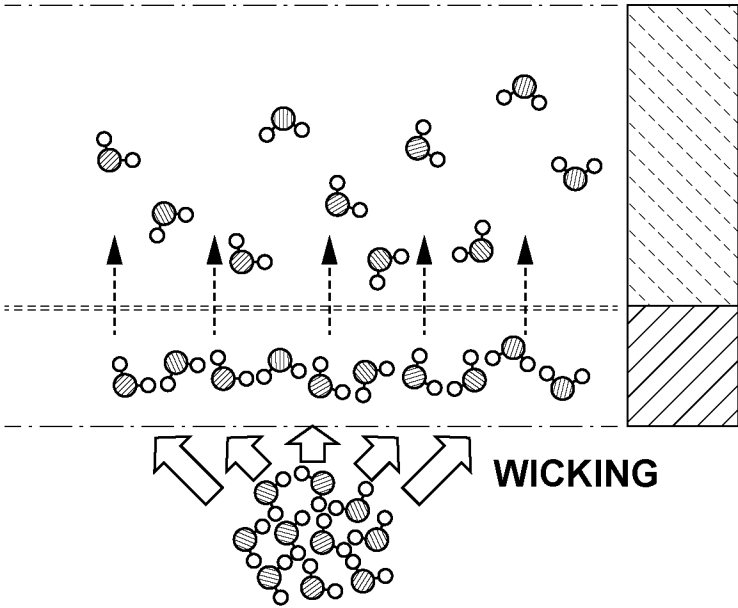


FIG. 2

## INTERNATIONAL SEARCH REPORT

International application No.

**PCT/CA2019/051073**

## A. CLASSIFICATION OF SUBJECT MATTER

IPC: **B32B 5/26** (2006.01) , **B32B 7/02** (2019.01) , *D04H 1/4326* (2012.01) , *D04H 1/4282* (2012.01) , *D04H 3/005* (2012.01)

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: B32B; D04H; A41D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)  
QUESTEL-ORBIT (FAMPAT); CANADIAN PATENT DATABASE; GOOGLE PATENTS

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                            | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | WO 2013/043397 A2; ROCK; 28 March 2013 (28-03-2013)<br>Abstract; pages 2-5,19-25,29-30,Figs. 2-10                                             | 1-11                  |
| X         | US 2015/0065002 A1; BENADDI; 5 March 2015 (05-03-2015)<br>Abstract; paragraphs 0002,0011-0015,0020,0029-0041; Example 1; Fig.1                | 1-11                  |
| X         | US 2005/0079379 A1; WADSWORTH ET AL.; 14 April 2005 (14-04-2005)<br>Abstract; paragraphs 0003,0006,0081,0166,0222-0227,0235; Figs. 1,2        | 1-11                  |
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
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Date of the actual completion of the international search  
20 August 2019 (20-08-2019)

Date of mailing of the international search report  
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International application No.

**PCT/CA2019/051073**

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