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(71) Applicant: **J.W. SUOMINEN OY**
SF-29250 Nakkila (FI)

(72) Inventors:
- **Lampila, Erkki**
  29250 Nakkila (FI)
- **Utriainen, Mikko**
  29250 Nakkila (FI)
- **Hautojärvi, Joni**
  29250 Nakkila (FI)
- **Huldén, Margareta**
  29270 Hormisto (FI)
- **Parviainen, Kari**
  33210 Tampere (FI)

(74) Representative:
Eriksson, Svante Johan Christer et al
Oy Jalo Ant-Wuorinen Ab
Iso Roobertinkatu 4-6 A
00120 Helsinki (FI)

(54) **Hydroentangled nonwoven, method for its manufacture and its use**

(57) The present invention refers to a hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers comprising at least one polyolefin. The invention is characterized in that liquid absorption and drying properties has been improved by microcreping the nonwoven. The invention refers also to a method for manufacturing such a product as well as to the use of such a product in a wiping article.

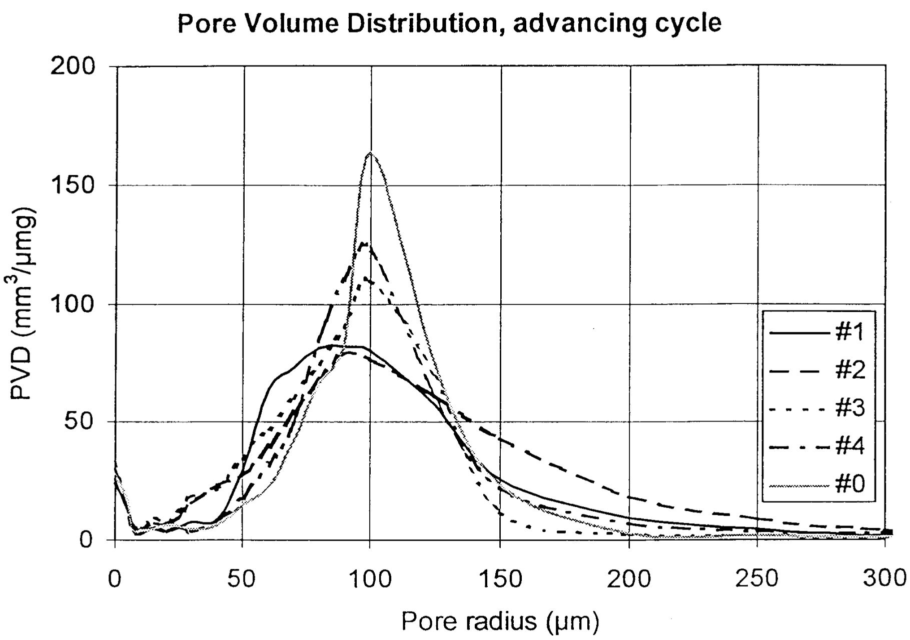

FIGURE 3

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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers comprising at least one polyolefin, a method for its manufacture, as well as its use.

BACKGROUND OF THE INVENTION

[0002] Hydroentanglement or spunlacing is a nonwoven production method, where a fiber web is bonded by means of fine water jets under high pressure. In the most widely applied process, a carded web is placed on a moving conveyor belt which transports the web under several rows of water jets. The water pressure in the jets is increased stepwise from the first array to the last array. The fibers in the web are entangled by the mechanical energy imparted to the web by the water jets. The entanglement holds the fibers in a nonwoven without the need for additional bonding such as thermal bonding or chemical bonding. Further general information about hydroentanglement can be found, for example, in the US patents nr 3,485,706 and nr 3,485,708 (Evans).

[0003] Various types of fiber compositions can be used to produce hydroentangled nonwovens. Typical fibers used are cellulose-based fibers such as cotton, pulp or viscose and synthetic fibers such as polyester (polyethylene terephtalate). The most widely used fiber mixture ratio is 30-70% viscose fibers and 70%-30% polyester fibers by weight of the web. However, there is a need to replace polyester by polypropylene (PP) in order to obtain softer and more bulky nonwoven which is a direct consequence of the lower density, lower shear modulus and lower elastic modulus of PP compared to polyester. Furthermore, from an environmental point of view it is favourable to use PP instead of polyester in disposable products such as in nonwoven wiping articles. This is because the disposing route for PP by thermal action, preferably by incineration, does not lead to emissions of any hazardous or even toxic aromatic by-products as is the case of polyester incineration. Another environmental concern of polyester is the antimon residue which is due to the use of Sb_2O_3 as a catalyst in the transesterification process in PET production. This fact questions the compatibility of PET in landfilling too. A further advantage of PP is the considerably lower raw material cost than for polyester fiber, which results from a lesser number of production steps which may also be associated with a reduced load for the environment according to a life-cycle analysis.

[0004] On the other hand, the use of PP fibers in nonwovens used as substrates for wiping articles is limited due to the hydrophobic nature of PP fibers. A water droplet forms a contact angle of about 105° on a polypropylene surface while it forms a contact angle of about 80° on a polyester surface. By definition, a surface is hydrophobic if the water contact angle is larger than 90° and hydrophilic if said contact angle is smaller than 90° Due to this difference in fiber wettability properties the water absorption properties of a nonwoven containing PP fibers are poorer than the absorption properties of nonwovens contaning more hydrophilic fibers. When the amount of hydrophobic polypropylene fibers is increased in the nonwoven, the water repellency of the nonwoven increases. This can be observed eg as an increasing run-off of liquid on the nonwoven surface, when the material is being wetted.

[0005] The hydrophobic nature of a nonwoven material containing PP fibers results in nonoptimal cleaning properties of the nonwoven used as a wiping article. The liquid absorption capacity and absorption rate of the nonwoven are low, resulting in relatively poor drying ability of the nonwoven during a wiping process. In order to improve the absorption properties, the nonwoven is typically treated with a hydrophilic wetting agent. However, chemical treatment is not the preferred technique particularly in the case where the nonwoven gets into contact with human skin. These wiping applications include wipes intended for hygiene use, such as baby wipes. In addition, incorporation of wetting agents increases material costs and they may interfere with other chemicals used in the moisturizing lotions of wet wipes.

[0006] Liquid is mostly absorbed and retained in nonwoven materials in the capillaries which are formed between the fibers in the nonwovens. The ability of a porous material, such as a nonwoven, to absorb and retain liquid can be characterized by the capillary pressure of liquid in the pores of the material. The capillary pressure is defined by the Laplace equation that is well known in the art:

$$P = (2\gamma \cos \theta)/r$$

where P is the capillary pressure, γ is the surface tension of the wetting liquid, θ is the contact angle between the liquid and the capillary wall, and r is the radius of the capillar. The liquid absorption rate is proportional to the capillary pressure, and the rate increases with increasing capillary pressure. The relation is given by the Washburn equation

$$dV/dt = (r^2 A/8\eta L) \times (2\gamma \cos \theta)/r = (\pi^2\ r^5 \gamma \cos \theta\ ) /4\eta\ V$$

where A is the cross-sectional area, L is the length and V is the volume of the capillar, and η is the viscosity of the wetting liquid.

[0007] In order to improve the liquid absorption properties of a nonwoven, the capillary pressure has to be increased. This can be done either by decreasing the contact angle of the liquid between the fibers or by decreasing the average pore size of the nonwoven. The decrease of the contact angle is generally achieved by chemical treatments with wetting agents or by decreasing the amount of hydrophobic fibers in the nonwoven. For the purposes of this invention, these techniques are not preferred. On the other hand, to decrease the average pore size of the nonwoven, the structure of the material has to be deformed by compressing the nonwoven. Unfortunately, this results in higher density reducing deleteriously the bulkiness and cloth-like properties of the nonwoven and, furthermore, according to the Washburn equation the reduction of the pore radius can also lead to significantly decreased absorption rate due to the strong contribution of the pore radius term for the absorption rate. Therefore, in an optimum case, the structure is deformed in such a manner that the pore radius distribution in the web includes small pores providing high capillary pressure, larger pores allowing a high absorption rate, and an optimum distribution of them in depth.

[0008] A preferred way of producing such a structure uses a longitudinal compressional treatment process also known as the Micrex/microcreping® process from Micrex Corporation, Walpole, Massachusetts, USA. The longitudinal compressional treatment is based on the principle that the material to be treated is over-fed, under pressure, into a converging passage or nip, for example in the gap between a rotating roller and a fixed guide plate forming a compacting zone. The difference in rate between the material entering the treatment zone and the material leaving the treatment zone defines the amount of residual compaction. The Micrex/microcreping process can be performed in different ways by using different configurations of microcrepers, as described in the patents by Walton. The configurations involve a compactor (US 2,765,513 and US 2,765,514), a bladed microcreper (US 3,260,778, US 3,426,405), a bladeless microcreper (US 3,810,280, US 3,869,768, US 3,975,806) and a two-roll microcreper (US 4,142,278). The intitial applications were in textile processing for improving shrinkproofness, stretch, softness and hand of woven or knitted fabrics. The applications for nonwovens are focused on healthcare applications, including bandages, gauzes, wound dressings, cast wraps and hospital gowns and drapes which all take advantage of stretch, softness, bulk, drape and extensibility provided by the microcreping treatment.

[0009] One application of microcreping used for improving the liquid handling properties is described by Walton (US 5,149,332). In this case a carded batt formed by cotton or rayon fibers or fluff pulp is employed in microcreping in order to compress the material and provide expansion upon wetting. Such material can be used in superabsorbent assemblages, tampons, pads, cushions, liquid distributing and liquid storage articles. Another patent utilising microcreping in producing absorbent articles (WO 97/37625) concerns increasing the wearing comfort and the fluid transport through a topsheet of a laminated structure, without aiming at absorption onto the microcreped sheet.

SUMMARY OF THE INVENTION

[0010] The object of the present invention is to overcome the problems of water repellency and relatively poor drying properties of hydroentangled nonwoven materials containing polyolefin, especially PP fibers. This is achieved with a hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers comprising at least one polyolefin, wherein liquid absorption and drying properties has been improved by microcreping the nonwoven. Due to the microcreping treatment of the nonwoven the pore size distribution has been changed and the effective absorptive surface area of the nonwoven has been increased.

[0011] The invention is also directed to a method for manufacturing a hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers including at least one polyolefin, comprising the step of improving liquid absorption and drying properties of the hydroentangled nonwoven by subjecting it to a microcreping process.

[0012] Specifically the present invention concerns such a method which comprises the steps of

- forming a fiber web comprising polyolefin fibers or multicomponent fibers including at least one polyolefin,
- subjecting the so formed web to a hydroentanglement process to form a hydroentangled nonwoven,
- subjecting the so formed nonwoven to a microcreping process.

[0013] The invention is also directed to the use of a nonwoven according to the invention or manufactured according to the invention in a wiping article, for example in wet or dry wipes.

DESCRIPTION OF THE DRAWINGS

[0014] In the drawings,

Fig. 1 shows a typical hydroentanglement nonwoven production line,

Fig. 2 shows the surface pattern of some nonwoven samples according to the invention, and

Fig. 3 shows the pore volume distribution for the samples of Example 1 of the specification.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Thus according to the invention the nonwoven material is texturized by a microcreping process which imparts wavy depressions and ridges to the surface of the material. In addition, small pores capable of rapid liquid absorption are incorporated into the depressions of the nonwoven. Although the pore size distribution of the nonwoven material is significantly changed during the microcreping process, the bulk or thickness and cloth-like properties of the nonwoven are improved.

[0016] The nonwoven materials according to the invention are hydroentangled nonwovens having a basis weight of between 20 and 150 g/m^2 and are microcreped after the hydroentanglement. The polyolefin, such as polypropylene or polyethylene, forms at least 5% by weight of the nonwoven material, either in the form of single component polyolefin fibers, or multicomponent fibers containing at least one polyolefin component. The nonwovens can be characterized by their pore size distibution; at least 30% of the total pore volume is associated with pores having an effective radius of greater than 100 µm, or equivalently a capillary pressure smaller than 660 Pa during liquid absorption. They can further be characterized by that at least 5% of the total pore volume is associated with pores having an effective radius of less than 70 µm, or equivalently a capillary pressure greater than 940 Pa during liquid absorption.

[0017] The nonwoven materials according to the present invention are made by a hydroentanglement process that involves the general steps of forming a web of fibers, hydroentangling the web, drying the web and winding the hydroentangled nonwoven material. A typical hydroentanglement production line is schematically shown in Figure 1, where the parts are as follows: (11) fiber feeder, (12) card, (13) lst hydroentanglement station, (14) 2nd hydroentanglement station, (15) dryer and (16) nonwoven winder. The hydroentangled nonwoven material is then subjected to a microcreping process which compacts the material and imparts texture in the form of wavy depressions and ridges on the surface of the nonwoven.

[0018] Various fiber compositions can be used to produce the nonwoven material. Preferably, the composition should include hydrophobic, water-repellent fibers such as polyolefins, particularly polypropylene, at least 5% by weight of the nonwoven material. The water-repellent fibers can also be multi-component fibers including at least one polyolefin component. Other fibers suitable for the nonwoven materials are hydrophilic fibers such as viscose, pulp or cotton and synthetic polymer fibers having a surface that is hydrophilic by nature, such as polyester and nylon. Preferably, the fiber composition includes 20-80% of hydrophilic fibers and 80-20% of hydrophobic fibers, by weight of the nonwoven material.

[0019] The microcreping treatment can be made by several methods and apparatuses which are well-known in the art. Most preferred microcreping process uses the so called bladed microcreper described by Walton (US 3,260,778, US 3,426,405). This method and apparatus is also known as comb-roll microcreper. Another preferred microcreping process uses the so called bladeless microcreper described by Walton (US 3,810,280, US 3,869,786, US 3,975,806). Another preferred microcreping process uses the so called two-roll microcreper described by Walton (US 4,142,278).

[0020] Due to the microcreping process, the nonwoven materials are compacted longitudinally between 2% and 70% of their original dimension while their basis weight increases accordingly. In this context, compaction is determined by the difference in speed between the unwinding and rewinding units. In the case when the nonwoven is rewound after the microcreping treatment the most preferable compaction is below 20% providing sufficient tension to the nonwoven allowing the rewinding of the material into the roll. In the case when festooning is used for packaging, higher compaction than 20 % can be used.

[0021] In the case of textile and textile-like materials, the web can be compacted longitudinally within its own plane, without folding the web itself or forming a crepe, but by crimping tiny invidual fibers. In the case of solid thin sheets, such as paper or plastic film, the longitudinal compaction can form barely perceptible undulations or crepes in the web as a whole. In the case of hydroentagled nonwoven both effects are possible depending on the fiber materials, fiber blend, and energy supplied by the water jets to form the hydroentangled process.

[0022] The advantages of the microcreping are particularly related to the improved liquid absorption and drying properties of the nonwoven material. In addition, the microcreping imparts cloth-like properties and bulkiness to the nonwoven material. These improved properties are due to the crimping action on the fibers, which is believed to modify the structure of the material as follows:

(a) The nonwoven is compacted from its original dimension while depressions and ridges are formed on the surface. These surface features increase the thickness of the material which is noticed as an increase of the bulkiness and cloth-like feel of the nonwoven material. Further, the depressions and ridges increase the effective surface areas of the nonwoven.

(b) The pore size distribution changes during the microcreping process. The depressions are formed by the longitudinal compressive action of the creping process and therefore the average pore size of the depressions is decreased compared to the original untreated material. The decrease of the pore size at the certain zones of the material is observed as an increase of the volume of relatively small pores. This increases the average capillary pressure of the nonwoven material and consequently the rate of absorption and the ability of the material to retain liquid are improved.

(c) The surface texture (*ie* the depressions and ridges) enhances the drying properties and reduces the water repellency of the microcreped nonwoven material. The reduced water repellency is observed as a smaller amount of run-off liquid expelled by the surface of the microcreped nonwoven than in the case of an untreated nonwoven, when the nonwovens are placed on an inclined plane. This difference can be assigned to two effects. First, the depressions on the microcreped nonwoven have a small average pore size and hence a more effective spontaneous absorption and spreading of liquid due to the higher capillary pressure. Second, the ridges act as obstacles resisting the run-off of liquid from the nonwoven surface. At the same time, the liquid striking at the ridges with an excess pressure is able to penetrate into the nonwoven material. The penetration efficiency increases with increasing average pore size of the surface ridges. Thus, the depressions consist preferably of small pores with a high capillary pressure for spontaneous absorption while the ridges consist preferably of larger pores that permit rapid strike-through of liquid.

[0023] The nonwovens can also be characterized by their pore size distribution, at least 30% of the total pore volume is associated with pores having an effective radius of greater than 100 μm, or equivalently a capillary pressure smaller than 660 Pa during liquid absorption. They can further be characterized by that at least 5% of the total pore volume is associated with pores having an effective radius of less than 70 μm, or equivalently a capillary pressure greater than 940 Pa during liquid absorption. In addition to this, preferably at least 10% of the total pore volume is associated with pores having an effective radius of greater than 150 μm, or equivalently a capillary pressure smaller than 440 Pa. According to a preferred embodiment, of the total pore volume, 5 - 40% is associated with pores having an effective radius of less than 70 μm, 40 - 85% is associated with pores having an effective radius of greater than 100 μm, and/or 10 - 40% is associated with pores having an effective radius of greater than 150 μm. Preferably, the pores have an effective radius of not greater than 800 μm. It should be noticed, however, that these values for pore radius and capillary pressure refer to the values measured during liquid absorption (advancing cycle). Due to contact angle hysteresis between liquid absorption and desorption, smaller pore radiuses or higher capillary pressures would be obtained when the pore volume distribution is measured from liquid desorption (receding cycle).

[0024] Hydroentangled nonwoven materials according to the invention are suitable for use as wipes in various applications including both dry wipes and premoistured wipes. In dry wipes, intended eg. for drying and cleaning of various surfaces, the main advantages of the invention are the improved liquid absorption and drying properties. In premoistured wipes, such as hygiene wipes, the improved bulkiness and cloth-like feel of the nonwoven material are particularly advantageous. In addition, the increased capillary pressure that results in the better ability of the nonwoven material to spontaneously absorb and retain liquid, is advantageous when the nonwoven is being moisturized for the purposes of premoisturized wipes.

[0025] The following examples illustrate, but do not limit, the properties and function of the nonwoven materials of the present invention. The test methods used to characterize the nonwoven materials were the following:

Tensile strength

[0026] The tensile strength of the nonwoven materials was determined according to the Edana Recommended Test Method ERT 20.2-89, except that the extension rate was 300 mm/min. The reported values are averages of 5 individual measurements.

Thickness

[0027] The thickness of the nonwoven materials was determined according to the Edana Recommended Test Method ERT 30.5-99. The reported values are averages of 5 individual measurements.

Run-off

[0028] The run-off of liquid from the surfaces of the nonwoven materials was determined according to the Edana Recommended Test Method ERT 152.0-99 with the modified method for testing hydrophobic nonwovens (table inclination 10°). The reported values are averages of 3 individual measurements.

Water absorption capacity

[0029] The water absorption capacity of the nonwoven materials was determined according to the Edana Recommended Test Method 10.3-99 chapter 5 "Liquid absorptive capacity". Purified water was used as the test liquid. The reported values are averages of 3 individual measurements.

Pore volume distribution

[0030] The pore volume distribution of the nonwoven materials was determined with the liquid porosimetry technique (TRI Autoporosimeter) developed at the Textile Research Institute (TRI) in Princeton, New Jersey, USA. The technique is described more in detail by Miller and Tyomkin in the Journal of Colloid and Interface Science, volume 162 (1994), pages 163-170. The chamber of the Autoporosimeter was equipped with a nitrocellulose-cellulose acetate membrane having a nominal pore diameter of 1.2 µm (Millipore type RAWP, Millipore Corporation, Bedford, Massachusetts, USA). The liquid used was a 0.1 wt% water solution of Triton X-100 (surface tension 33 mN/m). A 5.5x5.5 cm^2 specimen was cut from the nonwoven samples and it was covered with a plexiglass plate having the same dimensions and a weight of 23.9 g (corresponding to a pressure of about 80 Pa). The pore volume distribution was determined from the liquid absorption data (advancing run) for the pore radius range of 0 to 800 µm. For the analysis, a blank measurement without the sample and the cover plate was subtracted from the original data.

Example 1

[0031] A roll of hydroentangled nonwoven material (basis weight 60 g/m^2) containing 50% viscose and 50% PP fibers, by weight of the material, was microcreped using the Micrex process (Micrex Corporation, Walpole, Massachusetts, USA) based on the bladeless and the comb-roll processes. After the creping, the compacted nonwoven (10% degree of compaction) was wound on-line into a roll. The temperature of the main roll, line speed and pattern of the flexible retarder were varied. The creping parameters are listed in Table 1. Photographs of the samples are shown in Figure 2 illustrating the surface pattern of the nonwoven samples. Figure 3 shows the pore volume distributions for the samples.

Table 1

Sample #	Process	Line speed m/min	Temperature °C	Retarder gap, mm	Retarder finger, mm
0 (uncreped)	-	-	-	-	-
1	Bladeless	30	80	-	-
2	Comb-roll	105	80	solid	solid
3	Comb-roll	30	80	solid	solid
4	Comb-roll	107	25	9.5	3.2

[0032] The nonwoven samples were characterized by means of mechanical properties (tensile strength and thickness), liquid run-off and pore volume distribution. These data are listed in Table 2. As a comparative sample, a hydroentangled nonwoven with a fiber composition of 30 wt% of polyester and 70 wt% of viscose fibers was used. The pore volume distribution (PVD) of the nonwoven samples is expressed as the proportion of the volume of small pores (effective radius less than 70 µm), the proportion of the volume of the characteristic pores (effective radius less than 100 µm), and the volume of large pores (effective radius geater than 150 µm) to the total pore volume of the sample. The small pores are capable of spontaneous liquid absorption and retention, while the large pores allow liquid penetration into the material.

[0033] Based on the data shown in Table 2 the following conclusions can be drawn: The microcreping has increased the thickness of the nonwovens while the tensile properties have not changed significantly. The most remarkable effect is that the run-offvalues of the nonwovens have decreased from over 20% down to 0, that is the value observed for the comparative sample containing polyester fibers. The microcreping process has increased the amount of small pores in the nonwoven material between 15 and 120%, while the amount of large pores has increased in the samples #1, #2, and #4.

Table 2.

Property	Sample #					
	0	1	2	3	4	comparative
Basis weight	60.1	73.2	69.4	61.9	67.5	60.4
Thickness, mm	0.70	0.81	0.93	0.73	0.79	0.47
MD tensile, N/cm	61.0	65.4	60.4	57.2	55.4	84.7
MD elongation, %	35	53	49	39	38	16
CD tensile, N/5cm	21.7	25.5	21.7	23.0	17.0	23.0
CD elongation, %	126	119	114	118	115	115
Liquid run-off, %	22.3	0.8	0	0.8	0	0
PVD, %: 0-70 μm	7.4	14.0	12.4	16.6	8.4	46.5
100-800 μm	74.5	61.4	69.6	60.0	67.7	21.7
150-800 μm	17.8	25.6	38.6	13.0	22.6	9.8

Example 2

[0034] In order to demonstrate the improved wiping properties of the microcreped nonwoven materials, the nonwoven samples prepared in Example 1 were subjected to a test that simulates the drying properties of nonwovens during a wiping action.

[0035] A 12.5x12.5 cm^2 specimen was cut from the nonwoven samples. A sample holder containing a 10x10x2.5 cm^3 polyurethane foam covered with a 10x10 cm^2 plexiglass plate and a polyethylene film wrap, was prepared. The weight of the sample holder was 226 g, and the holder was connected to a wetback apparatus (Lenzing Technik, Lenzing, Austria) that is capable of lifting and lowering the sample holder with a constant rate. A 12x12 cm^2 plexiglass plate was placed on the table of the wetback apparatus after which an amount of 2.00 g of purified water was instilled on the surface of the plate. The nonwoven specimen was attached to the sample holder and secured with a tape so that the smooth contact surface area of the nonwoven was 10x10 cm^2. The sample holder containing the nonwoven specimen was lowered on the wetted plate. The contact surface pressure between the nonwoven and the wetted plate was about 230 Pa. After a contact time period of 1.0 s the nonwoven specimen was lifted from the wetted plate, and the amount of residue water that was not absorbed by the nonwoven specimen was determined by weighing the plate. The amount of residue water was expressed as a relative amount of the residue water in percentages from the initial 2.00 g amount of water.

[0036] The results of the test (averages of 5 individual measurements) are shown in Table 3 for the nonwoven samples #0-4 together with the comparative sample containing 30 wt% of polyester and 70 wt% of viscose fibers. In addition to the relative residue amount of water, the water absorption capacity per unit area for the samples are shown. The following conclusions can be drawn from the results:

[0037] Correlation between the total absorption capacity and the residue amount of water cannot be observed. The ability of a nonwoven material to remove water from a surface during a wiping action does not depend on the absorption capacity of the material. Hence, the drying properties are more related to the surface capillary action (average pore volume distribution and water contact angle) and penetration of liquid into the material than to the total absorption capacity. It can be clearly observed that after the microcreping the nonwoven materials show considerably improved drying properties demonstrated by the smaller amount of residue water on the plate, when compared to the uncreped material. Due to the hydrophilic nature of polyester fibers, the amount of residue water is the lowest for the comparative sample.

Table 3

Sample #	Absorption capacity, g/m^2	Residue water %
0 (uncreped)	485	19
1	501	16
2	459	13
3	461	13

Table 3 (continued)

Sample #	Absorption capacity, g/m^2	Residue water %
4	526	10
comparative	409	4

Claims

1. Hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers comprising at least one polyolefin, **characterized** in that liquid absorption and drying properties has been improved by microcreping the nonwoven.

2. A nonwoven according to claim 1, **characterized** in that the fabric has a pore size distribution according to which at least 30% of the total pore volume is associated with pores having an effective radius of greater than 100 µm.

3. A nonwoven according to claim 1 or 2, **characterized** in that at least 5% of the total pore volume is associated with pores having an effective radius of less than 70 µm.

4. A nonwoven according to any one of the preceding claims, **characterized** in that at least 10% of the total pore volume is associated with pores having an effective radius of greater than 150 µm.

5. A nonwoven according to any one of the preceding claims, **characterized** in that it contains at least 5% of a polyolefin, as single component fibers, or multicomponent fibers containing at least one polyolefin.

6. A nonwoven according to claim 5, **characterized** in that the polyolefin is polypropylene or polyethylene, preferably polypropylene.

7. A nonwoven according to any one of the preceding claims, **characterized** in that it has a basis weight of between 20 and 150 g/m^2.

8. A nonwoven according to any of the preceding claims, **characterized** in that the nonwoven is bonding agent free.

9. Method for manufacturing a hydroentangled nonwoven comprising polyolefin fibers or multicomponent fibers including at least one polyolefin, **comprising** the step of

   - improving liquid absorption and drying properties of the hydroentangled nonwoven by subjecting it to a microcreping process.

10. The method according to claim 9, **comprising** the steps of

    - forming a fiber web of polyolefin fibers or multicomponent fibers including at least one polyolefin,
    - subjecting the so formed web to a hydroentanglement process to form a hydroentangled nonwoven, and
    - subjecting the hydroentangled nonwoven to a microcreping process.

11. The method according to claim 9 or 10, **characterized** in that the nonwoven is compacted in the machine direction 2 - 70% of the original dimension of the uncreped nonwoven.

12. The method according to claim 9, 10 or 11, **characterized** in that a nonwoven is formed comprising at least 5% by weight of a polyolefin, in the form of single component fibers or multicomponent fibers containing at least one polyolefin.

13. The method according to claim 12, **characterized** in that the polyolefin used is polypropylene or polyethylene, preferably polypropylene.

14. Use of a nonwoven according to any one of the preceding claims 1 to 8 or manufactured by a method according to any one of the preceding claims 9 to 13 in a wiping article.

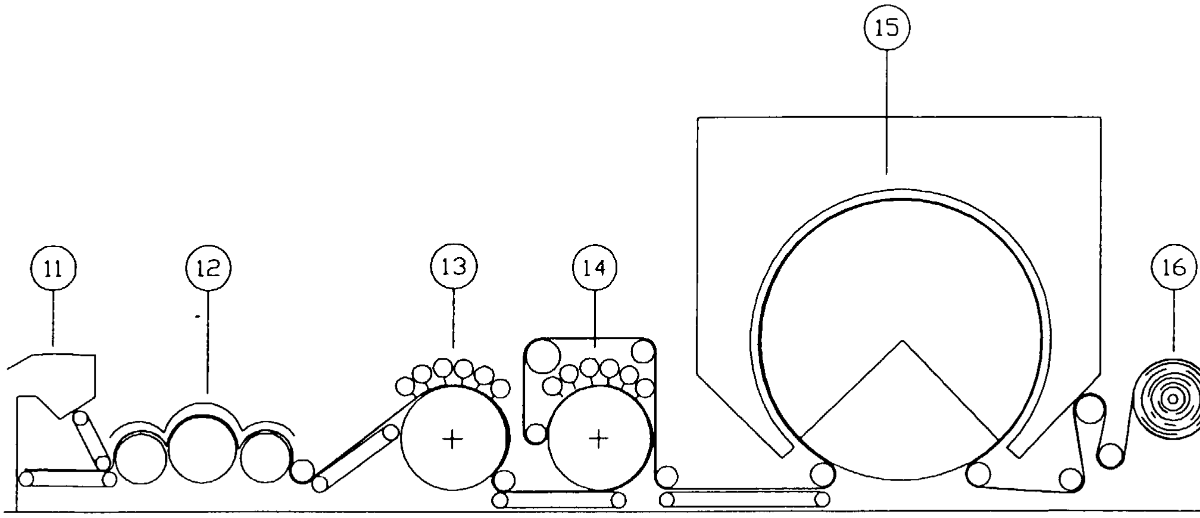

FIG. 1.

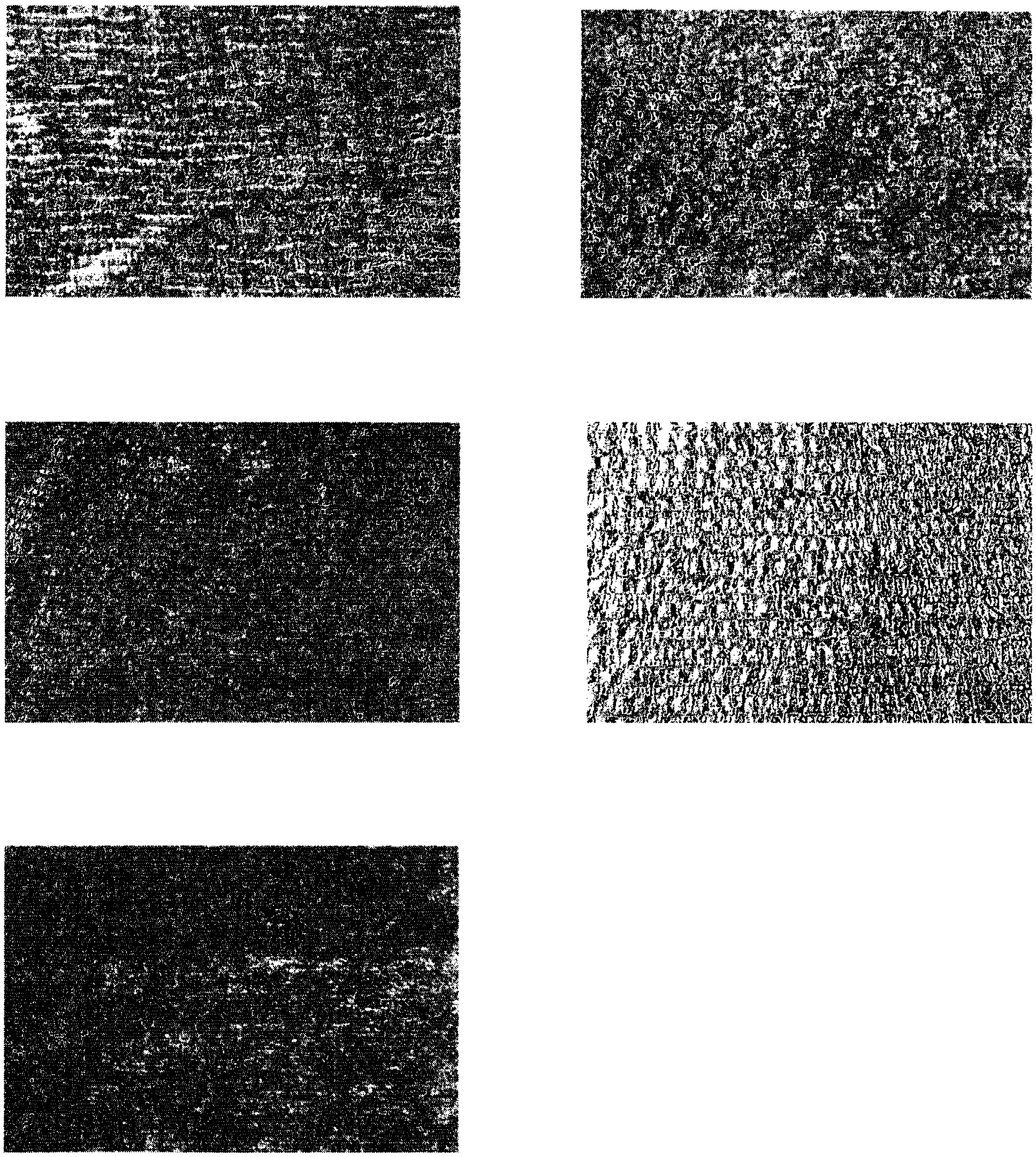

Figure 2. From left to right and from up to down: sample #1, #2, #3, #4 and #0.

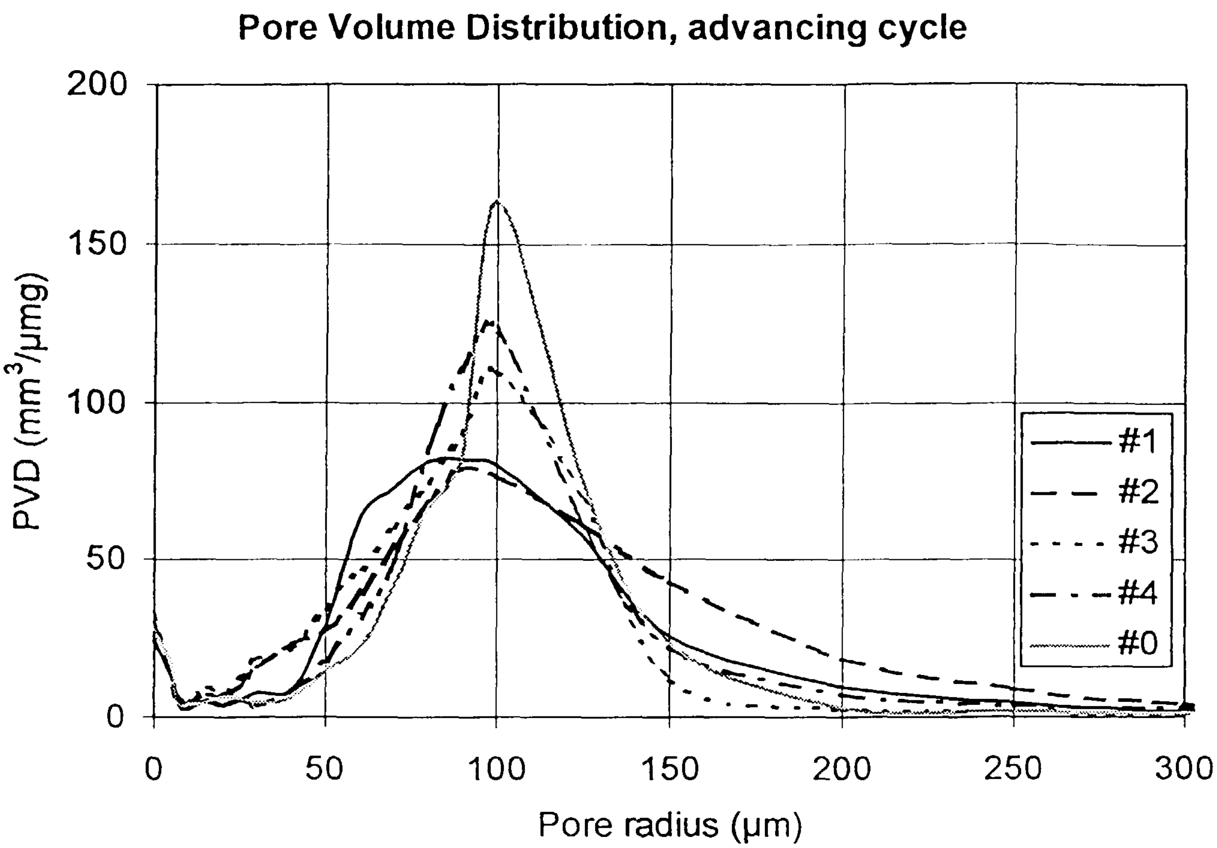
Pore Volume Distribution, advancing cycle
PVD (mm^3/µmg)
Pore radius (µm)
200
150
100
50
0
0
50
100
150
200
250
300
#1
#2
#3
#4
#0

FIGURE 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 66 0175

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 704 113 A (SCHOOTS PETER J) 3 November 1987 (1987-11-03) * column 3, line 55 - column 4, line 33 *	1,5-10, 12-14	D04H1/46
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D04H
A47L
A61F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 January 2001	V Beurden-Hopkins, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 66 0175

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82