(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 187 236
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 85114714.0

(22) Date of filing: 19.11.85

(51) Int. Cl.[4]: D 04 H 1/54

(30) Priority: 21.12.84 JP 271561/84

(43) Date of publication of application:
16.07.86 Bulletin 86/29

(84) Designated Contracting States:
DE SE

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(54) **Process for producing nonwoven fabrics suited for use as wipers.**

(57) Nonwoven fabrics showing rubber-like elasticity in a wet condition, having good wear resistance and strength and retaining flexibility even in a dry condition are obtained by causing a nonwoven fabric containing, as essential constituent fibers, 60-90 weight percent of highly shrinkable polyvinyl alcohol fibers capable of absorbing water to shrink of which a maximum shrinking temperature in water is within the range of 65-90°C with a maximum shrinkage percentage of not less than 50 percent and 10-40 weight percent of binder fibers having a melting point not higher than 200°C to shrink by warm water treatment to an extent such that the areal reduction amounts to 35-65 percent and further melting the surface of the binder fibers by heating.

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Process for Producing Nonwoven Fabrics Suited for Use as Wipers

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a process for producing a nonwoven fabric in which highly shrinkable polyvinyl alcohol fibers capable of absorbing water to shrink (hereinafter such fibers being referred to as "shirinkable PVA fibers") are essential constituent fibers.

It is an object of the invention to provide improved wipers or wiping cloths for daily use or for business use (glass wipers, dish cloths, kitchen napkins, table napkins, automobile wipers, furniture wipers, toilet articles, and the like).

2. Description of the Prior Art

Wipers so far used are mainly made of sponges (e.g. foamed polyvinyl formal) or nonwoven fabrics consisting of natural or synthetic fibers. For nonwoven fabric products, however, it is necessary to bond fibers to a sufficient extent by intense needle-punching or with a binder such as a polyacrylate compound or a styrene-butadiene copolymer so that the falling off of fibers from the nonwoven fabrics upon use thereof (friction between them and metals, plastics, chinaware, human skin, etc.) can be prevented. Either of these bonding techniques renders nonwoven fabrics hard and stiff, and products made therefrom have unsatisfactory performance characteristics (ability to match the shape of an article to be wiped, feeling, ability to adsorb water) and insufficient wear resistance (repeated use resulting in napping and/or falling off of fibers), feel stiff when used, and sometimes give scratches or the like to articles wiped, hence are not always satisfactory. It is also known that impregnation of a nonwoven fabric in which PVA fibers are used with a PVA resin, followed by coagulation and insolubilization to give a sponge-like foamed layer of PVA resin gives wipers showing soft and flexible behavior in a wet condition. Products obtained by this technique, however, have a serious drawback in that they feel very hard and harsh when they are dry.

SUMMARY OF THE INVENTION

Our intensive studies in search of a process for obtaining high-quality wiper products at low cost by overcoming the above drawbacks have now led to the present invention. Thus, the invention provides a process for producing nonwoven fabrics suited for use as wipers which comprises first causing a nonwoven fabric containing, as essential constituent fibers, 60-90 weight percent of highly shrinkable polyvinyl alcohol fibers capable of absorbing water to shrink of which a maximum shrinking temperature in water is within the range of 65-90°C with a maximum shrinkage percentage of not less than 50 percent and 10-40 weight percent of binder fibers having a melting point not higher than 200°C to shrink by warm water treatment to an extent such that the areal reduction amounts to 35-65 percent and further melting the binder fiber surface by heating.

DETAILED DESCRIPTION OF THE INVENTION

A first constituent element of the invention consists in that shrinkable PVA fibers are used as main nonwoven fabric-constituting fibers and further in that the nonwoven fabric is caused to shrink by warm water treatment to an extent such that the areal reduction amounts to 35-65 percent. By taking these means, we have succeeded in obtaining nonwoven fabrics which have, in a wet condition, an elongation at break of about 100 percent and good rubber-like elasticity and, even in a dry condition, show soft feeling.

A second constituent element of the invention lies in that thermoplastic fibers having a fiber surface melting point not higher than 200°C (hereinafter such fibers being referred to as "binder fibers") are incorporated in an amount of 10-40 percent into said nonwoven fabric. Said binder fibers, when heated, are partly melted and serve to bond the main component fibers, namely shrinkable PVA fibers, firmly. A further characteristic feature of the invention lies in that the nonwoven fabric is improved in wear resistance by applying to said nonwoven fabric a thermoplastic resin mainly consisting of a urethane resin, in an amount of 2-30 percent (resin solid weight/fiber weight).

The main component fibers constituting the nonwoven fabric are shrinkable PVA fibers and account for 60-90 percent by weight based on the whole web. Typical examples of the "shrinkable PVA fibers" as referred to herein are fibers obtained by wet spinning using an aqueous solution of polyvinyl alcohol having a degree of polymerization of 1,200-3,000 and a degree of saponification of not less than 98 mole percent, drawing the resulting continuous fibers at a rate of at least 4:1 in an atmosphere maintained within a temperature range not higher than 130°C in a condition such that said continuous fibers still contain moisture and salts and then heat-treating the continuous fibers in a taut condition so that the maximum shrinking temperature in water (temperature causing a maximum shrinkage of the continuous fibers in water) comes within the range of 65-90°C with a maximum shrinkage percentage of not less than 50 percent.

Various PVA fiber species have been so far known. Those intended for general use all have the so-called hot water resistance, namely the maximum shrinking temperature thereof in water exceeds 90°C with a maximum shrinkage percentage of less than 50 percent. Some PVA fiber species for uses that utilize their ready water solubility generally have a maximum shrinking temperature lower than 60°C. With the PVA fiber species so far in general use, therefore, the maximum shrinking temperature in water is either lower than 60°C or higher than 90°C. As will be evident from comparison, the PVA fibers to be used in accordance with the invention are very particular and are quite distinct from the PVA fibers so far used generally in the fields of clothing, materials for industrial use, and so forth.

As principal factors which determine the maximum shrinking temperature of PVA fibers in water and the maximum shrinkage percentage, there may be mentioned the drawing ratio and the drawing and heat treatment temperatures. Thus, for example, an increase in the drawing ratio will result in a higher maximum shrinking temperature. Raised drawing and heat treatment temperatures will give a decreased maximum shrinkage percentage and a higher maximum shrinking temperature. Therefore, a desired maximum shrinking temperature and a desired maximum shrinkage percentage can be obtained by varying the drawing ratio and the drawing and heat treatment conditions.

The binder fibers having a fiber surface melting point of not higher than 200°C account for 10-40 percent by weight based on the web. As examples of such fibers, there may be mentioned fibers of modified polyester, polypropylene, polyethylene, ethylene-propylene copolymer, modified nylon, and other single polymers having a melting point not higher than 200°C. Said binder fibers may of course be the so-called core-sheath fibers the core or inside of which is made of a polymer having a melting point not lower than 200°C and the sheath or external layer of which is made of a polymer having a melting point not higher than 200°C. They may also be mix-spun fibers composed of a polymer blend containing not less than 50 percent of a polymer having a melting point not higher than 200°C. The shrinkable PVA fibers, which are the main component fibers, when subjected alone to the shrinking treatment with warm water to be mentioned later herein, undergo pseudoadhesion of said PVA fibers with one another. This leads to hardening of the nonwoven fabric when this is dried. This hardening phenomenon can be prevented by the presence of said binder fibers. For the only purpose of preventing this hardening phenomenon, it would be sufficient to incorporate hydrophobic fibers (for example in an amount of not less than 20 percent) into the web. The use, according to the invention, of binder fibers having a melting point not higher than 200°C is very effective in increasing the strength of the nonwoven fabric, and preventing napping and falling off of the main component fibers on the occasion of practical use. These effects are produced by subjecting the shrinkable PVA fibers after shrinkage with warm water to heat treatment at a temperature not lower than the melting point of said binder fibers in the course of the subsequent process, to thereby cause the binder fibers to melt partially on the surface thereof and serve as bonding agents for the shrinkable PVA fibers. The use of such binder fibers is one of the most important constituent elements of the invention. It is of course possible to add a small amount of hydrophobic fibers which will not melt when the binder fibers are melted thermally.

In accordance with the invention, there is a further requisite that the web having such constitution as mentioned above be subjected to warm water treatment for causing shrinkage until the areal reduction amounts to 35-65 percent. When the web area after shrinking treatment is above 65 percent of the original, the resulting nonwoven fabric does not show rubber-like elasticity in a wet condition, hence is unfit for the purpose of the invention. When the nonwoven fabric area is reduced to less than 35 percent of the original by warm water treatment, the nonwoven fabric has good rubber-like elasticity in a wet condition but, when dried, assumes a coarse and stiff feeling, hence is not suited for the uses intended by the inventors. On the contrary, the nonwoven fabric according to the invention that has been shrinked by warm water treatment to an areal reduction of 35-65 percent has good rubber-like elasticity in a wet condition and shows a soft feeling in a dry condition. Repeated wetting and drying cycles cause little change in its feeling.

The nonwoven fabric after warm water treatment and binder fiber-melting treatment can be used, as it is or after drying, as a wiper, such as a kitchen napkin, table napkin, automobile wiper, furniture wiper or toilet article, and can function satisfactorily as a product ready for use. For further improving the functionality and durability (wear resistance) in practical use thereof, it is preferable to subject the nonwoven fabric to resin treatment. The resin to be used in said resin treatment should not impair the feeling (flexibility) of the nonwoven fabric itself but can preferably provide the nonwoven fabric with wear resistance and prevent napping of the nonwoven fabric or falling off of fibers. The most suitable example of said resin is a urethane resin because of its good adhesiveness to shrinkable PVA fibers. Treatment with a urethane resin can be conducted either by the so-called dry coagulation technique which comprises dipping the nonwoven fabric in or coating the same with a solution of a solvent-type or water-dispersible or water-soluble urethane resin, followed by drying, or by the so-called wet coagulation technique which comprises dipping the nonwoven fabric in or coating the same with a solution of a solvent-type urethane resin and then immersing the same in water for extraction of the solvent to thereby cause coagulation of the urethane resin and formation of a porous structure simultaneously.

The amount of the urethane resin to be taken up by the nonwoven fabric should preferably be 2-30 percent (based on the fiber weight). An amount of less than 2 percent cannot produce wear resistance improving effect, whereas an amount of more than 30 percent hardens the nonwoven fabric and impairs the feeling thereof.

When a water-soluble or water-dispersible urethane resin is applied to the nonwoven fabric by dipping, this treatment and the above-mentioned shrinking treatment with warm water can rationally be conducted in one step by adjusting the temperature of the aqueous solution or dispersion.

For providing the wipers with functionality and flexibility, it is also effective to use a finishing agent such as a surfactant or a silicone-based softening agent. The step of such active agent treatment may either be carried out as an independent step or be incorporated into the step of shrinking treatment with warm water and simultaneous treatment with a urethane resin.

The step of melting the surface of the binder fibers contained in the nonwoven fabric to thereby bonding the shrinkable PVA fibers, which are the main constituents of said nonwoven fabric, with the binder fibers is now described. Although the intended purpose can be attained as well by heat treatment in a hot air oven maintained at a temperature above the melting point of the binder fibers, it is preferable to pass the nonwoven fabric through a calender roll unit the roll surface of which is maintained at a temperature not lower than the melting point of the binder fibers, preferably at a temperature higher than said melting point by at least 20°C, so that the nonwoven fabric can be surface-finished smoothly with reduced surface unevenness. The surface appearance of the nonwoven fabric is determined by the ratio of the calender roll clearance to the thickness of the nonwoven fabric. For obtaining a smooth surface appearance, it is preferable to adjust the calender roll clearance/nonwoven fabric thickness (before passage through the calender) ratio to 1/2 to 1/4.

The following examples, which are by no means limitative of the scope of the invention, illustrate the invention in more detail.

Example 1 and Comparative Example 1

Continuous fibers were produced by the wet method by extruding an aqueous solution of PVA with a degree of polymerization of 1,700 and a degree of saponification of 99.9 mole percent into a saturated aqueous solution of Na_2SO_4, drawn, at a ratio of 4.5:1, in air at 40°C and in a saturated aqueous solution of Na_2SO_4 at 90°C and then, in a constant length condition, dried with hot air at 130°C to attain an absolute dry condition and heat-treated in hot air at 180°C to give a maximum in-water shrinking temperature of 80°C. Since these continuous fibers were liable to marked swelling and shrinkage upon exposure to water, they, with a sufficient tension to maintain a constant length, were washed with water at 30°C to remove Na_2SO_4 retained on fibers, subjected to wet treatment including oiling and, in a taut condition, dried at 80°C until the moisture content reached 40 percent based on the fibers and further in hot air at 120°C. After the subsequent crimping as required in manufacturing nonwoven fabrics, the continuous fibers were cut into staple fibers having a fineness of 1.5 denier and a length of 51 mm.

These fibers showed a maximum in-water shrinkage percentage of 68 percent and a maximum shrinking temperature of 80.5°C

A nonwoven fabric having a weight of 100 grams per square meter was produced by the random webber and needle-punching technique (200 punchings per square centimeter) using the shrinkable PVA fibers prepared as above and, as binder fibers, ES fibers (3 denier x 51 mm; produced by Chisso Corporation; core-sheath fibers, the surface portion being of low density polyethylene and the core portion being of polypropylene) in a mixing ratio of 80/20. The nonwoven fabric thus produced had a thickness of 2.0 mm.

Nonwoven fabrics produced in the same manner as above were subjected to shrinking treatment by immersing in warm water at different temperatures for 1 minute to give nonwoven fabrics differing in shrinkage percentage. The nonwoven fabrics were then dried at 70°C for 10 minutes. A 10% aqueous dispersion of a urethane resin was applied, at ordinary temperature, to the above nonwoven fabrics to cause the urethane resin to be taken up by the fabrics in an amount of 10 percent on the solid (resin) weight/nonwoven fabric weight basis. After drying at 70°C for 10 minutes, the nonwoven fabrics were passed through a calender roll unit maintained at a roll surface temperature of 140°C (roll clearance: four tenths of the nonwoven fabric thickness before calendering) to thereby melt the surface of the binder fibers. The results thus obtaiend are shown in Table 1.

As is evident from the data given in Table 1, that nonwoven fabric of which the areal reduction upon warm water treatment was 30 percent did not show rubber-like elasticity in a wet condition. That one of which the areal reduction was 70 percent was coarse and stiff when it was dry, hence unfit for achieving the objects of the invention, although it showed good rubber-like elasticity when it was wet.

Example 2 and Comparative Example 2

Using the shrinkable PVA fibers produced in Example 1 and the same binder fibers (ES fibers), webs differing in shrinkable PVA fiber/binder fiber mixing ratio were prepared by the same procedure as used in Example 1 and subjected to warm water treatment to cause shrinkage to an extent such that the reduction in nonwoven fabric area amounted to about 50 percent. The subsequent urethane resin solution treatment and calendering were conducted under the same conditions as used in Example 1. The results of the runs made are shown in Table 2.

When the shrinkable PVA fibers alone were used, the nonwoven fabric obtained showed good rubber-like elasticity in a wet condition but, once dried, became coarse and rigid as a result of pseudoadhesion among fibers; said fabric thus failed to achieve the expected results from the quality viewpoint. On the contrary, those nonwoven fabrics with 10 percent and 30 percent, respectively, of the binder fibers incorporated therein had satisfactorily good quality from both the wet rubber-like elasticity and dry feeling viewpoints. The nonwoven fabric with the binder fibers incorporated therein in an amount of 50 percent, in spite of warm water treatment thereof to attain an areal reduction of 50 percent, did not show that rubber-like elasticity in a wet condition since the number of sites of adhesion among said fibers by means of the binder fibers was too great; it had coarse and rigid feeling when it was dry.

Example 3 and Comparative Example 3

Nonwoven fabrics prepared by using the shrinkable PVA fibers produced in Example 1 and the same binder fibers (ES fibers) in a mixing ratio of 80/20 by weight were subjected to warm water shrinking treatment (areal reduction: 50 percent) and urethane resin treatment in the same manner as in Example 1, followed by an investigation as to the conditions of thermal melting of the binder fibers. The results of the investigation are shown in Table 3.

When the binder fibers were not heat-melted, the nonwoven fabric had very low tensile strength and no good wear resistance although it showed rubber-like elasticity when it was wet. Based on this finding, it is to be understood that thermal melting or binder fibers is a very important factor. When the binder fibers were melted in hot air, the resultant nonwoven fabric had a wavy surface, hence an unfavorable appearance, although it produced nonwoven fabric functions to a satisfactory extent. It is therefore preferable that when the binder fibers are heat-melted in hot air, the nonwoven fabric be again subjected to finishing treatment on a calender roll unit having a surface temperature not lower than the melting point of the binder fibers to thereby improve the appearance of the product nonwoven fabric.

Example 4 and Comparative Example 4

Needle-punched (200 punchings per square centimeter) nonwoven fabrics having a weight of 100 g/m^2 were prepared by using the shrinkable PVA fibers and binder fibers (ES fibers) in a mixing ratio of 80/20 and subjected to warm water treatment for attaining an areal reduction of 50 percent in the same manner as in Example 1. The same water-dispersible polyurethane resin as mentioned in Example 1 was allowed to be taken up by the nonwoven fabrics in different amounts and the fabrics were then subjected to heat treatment for melting the binder fibers by calendering in the same manner as in Example 1. The results thus obtained are shown in Table 4.

It was found that attachment of only 2 percent of the polyurethane resin already can improve the wear resistance of the nonwoven fabric to a considerable extent. However, attachment of the polyurethane resin in an amount exceeding 30 percent gave the nonwoven fabric a hard and rigid feeling in a dry condition although good wear resistance was obtained; the fabric thus failed to attain the objects of the invention.

Example 5

For conducting the warm water treatment and urethane resin impregnation steps simultaneously, an aqueous urethane resin dispersion having a concentration of 10 percent was warmed to 63°C, and a needle-punched web as prepared by the procedure of Example 1 was immersed therein for 1 minute. The web was squeezed on a mangle until the amount of the solution contained in the web was 100 percent (per 100 weight parts of web), then dried at 70°C for 10 minutes, and passed through a calender roll unit having a surface temperature of 140°C in the same manner as in Example 1 to thereby cause melting and adhesion of the binder fibers. The performance characteristics of the resultant nonwoven fabric were comparable to those of sample No. 1-2 as shown in Example 1.

Table 1

No.	1-1 (for comparison)	1-2	1-3	1-4 (for comparison
Nonwoven fiber constituents (weight ratio)				
Shrinkable PVA fibers	80	80	80	80
Binder fibers (ES fibers)	20	20	20	20
Warm water treatment (°C)	59	63	66	70
Shrinkage percentage (areal) (%)	30	45	60	70
Wet tenacity (lengthwise) (kg/cm)	3.9	4.1	4.4	4.3
Wet elongation (lengthwise) (%)	65	98	112	159
Wet rubber-like elasticity*	Poor	Good	Good	Good
Dry tenacity (lengthwise) (kg/cm)	4.6	4.9	5.2	5.0
Dry elongation (lengthwise) (%)	39	46	55	74
Dry hardness** (cm)	8.2	9.5	10.8	20.7
Dry hardness (feeling)*	Good	Good	Good	Poor

*: Feeling to the hand touch.
**: Cantilever method

Table 2

No.	2-1 (for comparison)	2-2	2-3	2-4 (for comparison
Nonwoven fiber constituents (weight ratio)				
Shrinkable PVA fibers	100	90	70	50
Binder fibers (ES fibers)	0	10	30	50
Warm water treatment (°C)	64	64	64	64
Shrinkage percentage (areal) (%)	54	52	52	50
Wet tenacity (lengthwise) (kg/cm)	2.8	4.0	3.9	4.2
Wet elongation (lengthwise) (%)	121	101	108	50
Wet rubber-like elasticity	Good	Good	Good	Poor
Dry tenacity (lengthwise) (kg/cm)	3.4	4.6	4.4	4.9
Dry elongation (lengthwise) (%)	107	51	49	28
Dry hardness (cantilever) (cm)	18.7	11.0	11.6	20.6
Dry hardness (feeling)	Poor	Good	Good	Poor

Table 3

No.	3-1 (for comparison)	3-2	3-3
Nonwoven fiber constituents (weight ratio)			
Shrinkable PVA fibers	80	80	80
Binder fibers (ES fibers)	20	20	20
Heat treatment by	Calendering	Calendering	Exposure to hot air
Heat treatment temperature (°C)	50	140	140°C x 1 min.
Appearance after heat treatment	Good	Good	Rather poor (wavy)
Wet tenacity (lengthwise) (kg/cm)	2.9	4.4	4.6
Wet elongation (lengthwise) (%)	128	112	107
Wet rubber-like elasticity	Good	Good	Good
Dry tenacity (lengthwise) (kg/cm)	3.5	5.2	5.3
Dry elongation (lengthwise) (%)	109	55	61
Dry hardness (cantilever) (cm)	9.7	10.8	11.4
Dry hardness (feeling)	Good	Good	Good
Wet wear resistance*	Poor	Good	Good

* After 100 rubbings of the test specimen on a wear tester described in JIS L 0823 at the second type under the conditions given below, the specimen was examined for surface appearance (napping):
Stroke: 20 strokes/minute;
Friction surface: Polished metal.

Table 4

No.	4-1	4-2	4-3	4-4	4-5
Amount of urethane resin taken up* (%)	0	2	10	20	40
Dry tenacity (lengthwise) (kg/cm)	4.3	4.5	5.2	5.4	5.9
Dry elongation (%)	51	51	52	49	40
Dry hardness (cantilever) (cm)	10.2	10.5	10.8	11.2	16.0
Dry hardness (feeling)	Good	Good	Good	Good	Rather poor
Wet wear resistance	Rather poor	Good	Good	Very good	Very good

* Solid weight %/100 nonwoven fabric

Comparative Example 5

A nonwoven fabric was produced following the procedure of Example 1 except that commercial Vinylon fibers (maximum shrinkage percentage: 10 percent; maximum shrinking temperature: 95°C) were used as the starting material PVA fibers and that the warm water treatment was conducted at 90°C, and impregnated with a urethane resin. In this case, the areal shrinkage percentage was 16 percent. The nonwoven fabric thus obtained showed no rubber-like elasticity in a wet condition at all and, furthermore, had a low water absorbency, hence was unsuited for use as a wiper. When the warm water treatment temperature was raised to above 90°C, the Vinylon fibers began to melt and failed to give a nonwoven fabric suited for use as a wiper.

Comparative Example 6

A nonwoven fabric was produced following the procedure of Example 1 except that the so-called readily water-soluble Vinylon fibers with a maximum shrinkage percentage of 55 percent and a maximum shrinking temperature of 50°C were used as the starting PVA fibers, that the warm water treatment was performed at 30°C and that the drying was conducted at 40°C for 30 minutes. In this case, the areal shrinkage percentage was 72 percent. The nonwoven fabric obtained had a dry hardness of more than 30 cm, as measured by the cantilever method, and a very coarse and rigid feeling, and, therfore, was quite unsuited for use as a wiper.

WHAT IS CLAIMED IS:

1. A process for producing nonwoven fabrics suited for use as wipers which comprises first causing a nonwoven fabric containing, as essential constituent fibers, 60-90 weight percent of highly shrinkable polyvinyl alcohol fibers capable of absorbing water to shrink of which a maximum shrinking temperature in water is within the range of 65-90°C with a maximum shrinkage percentage of not less than 50 percent and 10-40 weight percent of binder fibers having a melting point not higher than 200°C to shrink by warm water treatment to an extent such that the areal reduction amounts to 35-65 percent and further melting the surface of the binder fibers by heating.

2. The process of Claim 1, wherein a polyurethane resin is caused to be taken up by the nonwoven fabric in an amount of 2-30 percent by weight on the fiber weight basis.

3. The process of Claim 1, wherein the binder fiber surface melting is effected by passing the nonwoven fabric through a heated calender roll unit.

4. The process of Claim 3, wherein the calender roll clearance is 1/2 to 1/4 of the thickness of the nonwoven fabric.
