

ABSORBENT ARTICLE

BACKGROUND OF THE INVENTION

[Field of the Invention]

The present invention relates to absorbent articles typified by sanitary napkins, paper diapers and pads for incontinent people. In particular, the present invention relates to absorbent articles comprising an absorbent element which partially or wholly comprises a specified absorbent sheet and a highly absorbent polymer so as to improve the body fluid absorbing performance, particularly diffusing properties, prevention of liquid return from the absorbent element and prevention of liquid leakage.

[Description of the Prior Art]

Various absorbent articles have been proposed for the purpose of improving the body fluid absorbency, and various improvements have been achieved. Most of these proposals relate to improvements in the absorption velocity, inhibition of liquid return from the absorbent element to the surface, prevention of liquid leakage and reduction in the stickiness to the body.

As for, for example, the material of the absorbent element, there has been proposed the use of a highly absorbent polymer to absorb and hold the

liquid by a physicochemical action, i.e. ion osmotic pressure, so as to improve the absorption capacity and to prevent the return of the liquid once held, instead of using hydrophilic absorbent paper or pulp which absorbs and holds the liquid in minute physical spaces. According to this proposal, most of the absorbent articles have come to comprise an absorbent element composed of a combination of a pulp and a highly water-absorbent polymer.

However, the prevention of liquid leakage is yet insufficient even with these absorbent articles, as is suggested by the fact that the leakage is the main cause of user's dissatisfaction with respect to the absorbent articles. Namely, the body fluid absorbing velocity of the highly absorbent polymer which absorbs and holds the liquid by ion osmotic pressure is limited and, in addition, the highly absorbent polymer cannot absorb the body fluid unless it is wetted therewith. Therefore, the highly absorbent polymer could not be used without combination with pulp or the like having a high water absorption velocity.

When a soft fluffy absorbent layer is formed as the absorbent element from the pulp, however, the pulp exhibits only poor diffusing properties necessitated for efficiently utilizing the absorbent element as a

whole, since it absorbs blood from spot to spot. In addition, although the pulp exhibits recovery from compression and bending to some extent when it is dry, the strength of the pulp is seriously reduced and the recovery can be hardly exhibited when the pulp is wetted. Therefore, when a stress is applied to the wetted pulp, the pulp is compressed and deformed (this phenomenon will be hereinafter referred to as distortion) to seriously reduce the absorption spaces thereof, whereby the body fluid once absorbed easily returns. The reduction in the spaces in the pulp fibers, in turn, causes an increase in the migration resistance of the body fluid into the polymer to reduce the absorption efficiency of the polymer and also to seriously reduce the reabsorption velocity of the absorbent element as a whole after the distortion, leading to the leakage in many cases.

Although a technique of improving the diffusing properties of the fluffy pulp by increasing the density of the pulp by compression has been reported, this technique has disadvantages that the problem of the distortion of the pulp is not essentially solved and the fibers of the pulp becomes too close to each other, thereby seriously increasing the resistance to the migration of the body fluid into the polymer. As

a result, the absorption efficiency of the polymer is reduced disadvantageously.

To prevent the distortion, it has been also attempted to wrap the absorbent element composed of pulp and a highly absorbent polymer in a paper made from a natural pulp or the like by the wet process and to fix them with waterproof paper or the like.

Although the distortion can be only slightly prevented by this method, the prevention of the pulp from being distorted is essentially impossible. In addition, when a paper is to be made from an ordinary natural pulp by the wet process, an extremely tight bonding force takes place between the pulp fibers by hydrogen bonding when the paper is dehydrated and dried in the dehydration/wet pressing/drying steps. The pulp fibers are tightly bonded to each other by the tight bonding force due to hydrogen bonding and, as a result, a paper made from pulp fibers by the wet process has very low liquid absorption/permeation velocity. Namely, even when the distortion is inhibited by wrapping the absorbent element in the wet paper made of pulp, the absorption velocity of the absorbent element is rather reduced, resulting in a disadvantage that the liquid has leaked out before the absorbent polymer absorbs it.

Japanese Patent Laid-Open No. 60555/1981, Japanese Utility Model Publication No. 6096/1981, etc., disclose a technique for improving the diffusing properties by applying a diffusing sheet such as a spun-bonded rayon fabric to the upper surface or both the upper and lower surfaces of an absorbent sheet comprising a fluffy pulp and a water-absorbent polymer. Also in this absorbent element, the problem of the distortion of the pulp and a reduction in the distance between the pulp fibers due to the distortion have not yet been solved, as far as the element is basically composed of fluffy pulp and water-absorbent polymer.

Japanese Patent Laid-Open No. 158096/1979 reports a technique of interposing an absorbent polymer between nonwoven cellulose fabrics such as spun-bonded rayon fabrics. Although the diffusion and absorption efficiency of the polymer are improved to some extent by this technique, they are not yet on a satisfactory level, since no fluffy pulp is used therein. The blood-diffusing properties of a nonwoven absorbent sheet made of single fibers is contradictory to the permeability indicative of the liquid migration resistance of the polymer. More specifically, when

the fiber diameter is reduced, the distance between the fibers is reduced to reduce the liquid permeability, though the liquid-diffusing properties are improved. On the contrary, when the fiber diameter is increased, the diffusing properties are impaired, though the permeability is improved.

Thus the improvement in the diffusing properties is contradictory to the improvement in the permeability. Therefore it has been eagerly demanded to produce an absorbent article satisfying both the requirements, namely, an absorbent article having high diffusing properties and improved permeability and comprising an absorbent polymer having an extremely high absorption efficiency.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an absorbent article comprising an absorbent sheet having high diffusing properties and high permeability as a part of an absorbent element in order to exhibit the effect of the highly absorbent polymer to the full and to remarkably reduce the liquid return from the absorbent element, stickiness and leakage, thereby making the user comfortable.

The above object of the present invention can be attained by providing a substantially longitudinally

extended absorbent article which comprises a liquid-permeable surface material, a liquid-holding absorbent element and a liquid-impermeable leakproof material, and which is characterized in that the absorbent element at least partially comprises an absorbent sheet having high diffusing properties and high permeability and a highly absorbent polymer,

the absorbent sheet having high diffusing properties and high permeability being made of a wet nonwoven fabric produced by forming a sheet from a mixture of at least:

- (a) 20 to 80 parts by weight of bulky hydrophilic fibers,
- (b) 80 to 20 parts by weight of fine hydrophilic fibers, and
- (c) 0 to 30 parts by weight of hot-melt adhesive fibers,

and the absorbent sheet having a thickness of 0.3 to 2.0 mm under a load of 2.5 g/cm².

The absorbent article of the present invention comprising the absorbent sheet having high diffusing properties and high permeability exhibits the effect of the highly absorbent polymer to the full while the liquid return from the absorbent element, stickiness and leakage are extremely reduced, thereby making the

user comfortable.

Namely, the present invention can provide an absorbent article having extremely high absorbency and holding capacity which could not be obtained in the prior art, since it comprises an absorbent element composed of an absorbent sheet having a specified composition and a controlled space structure as well as high diffusing properties and high permeability and a highly absorbent polymer whereby the body fluid is very effectively and rapidly spread over the whole absorbent element and then very smoothly migrates into the highly absorbent polymer to be solidified therewith.

Since the absorbent element is prepared from a specified, bulky absorbent sheet having an extremely high permeability in combination, the body fluid which has passed through the surface sheet is rapidly absorbed in the bulky absorbent sheet and then very smoothly passes into the lower layer comprising an absorbent sheet having high diffusing properties and high permeability. Then the body fluid is rapidly spread over the whole absorbent element through the absorbent sheet having high diffusing properties and high permeability and then migrates into the highly absorbent polymer. Thus the migration path of the

excreted body fluid until it is absorbed in the highly absorbent polymer can be idealized and, in addition, a very thin, compact absorbent article can be thus provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a transverse cross section of a sanitary napkin which is one example of the absorbent article of the present invention and comparative absorbent articles.

Fig. 2 is a transverse cross section of a sanitary napkin which is another example of the present invention and a comparative example.

Fig. 3 is a transverse cross section of a sanitary napkin which is still another example of the present invention and a comparative example.

Fig. 4 is a cross section of an absorbent polymer sheet.

Fig. 5 is an enlarged perspective view of a surface sheet of a sanitary napkin.

Fig. 6 is a perspective view of an apparatus for determining the Klemm absorption height.

Fig. 7 is a perspective view of an apparatus for determining the liquid permeation time.

Fig. 8 is a cross section of an apparatus for determining the absorption time and dynamic liquid

return.

Fig. 9 is a perspective view of a movable model of a female loin to be used for the determination of dynamic liquid return and leakage test.

Fig. 10 is a perspective view of a movable model of a female loin wearing a sanitary napkin to be tested.

Fig. 11 is a graph showing the pore diameter distribution of an absorbent sheet (A).

Fig. 12 is a graph showing the pore diameter distribution of an absorbent sheet (B).

Fig. 13 is a graph showing the pore diameter distribution of an absorbent sheet (C).

Fig. 14 is a graph showing the pore diameter distribution of an absorbent sheet (D).

Fig. 15 is a graph showing the pore diameter distribution of an absorbent sheet (E).

Fig. 16 is a graph showing the pore diameter distribution of an absorbent sheet (F).

Fig. 17 is a graph showing the pore diameter distribution of an absorbent sheet (G).

DETAILED DESCRIPTION OF THE INVENTION

The absorbent element of the absorbent article of the present invention at least partially comprises the above-described absorbent sheet having high diffusing

properties and high permeability (hereinafter referred to merely as the absorbent sheet). In producing the absorbent sheet, a very important technique of controlling the space structure of the absorbent sheet is required.

This is because an ordinary absorbent paper mainly comprising pulp fibers has the defect that, as described above, a strong effect of hydrogen bonding is exerted between the pulp fibers in the wet sheet-forming step to make the fibers too close to each other to obtain a sufficient bulkiness, which makes the liquid permeability very poor.

It is possible to produce a bulky absorbent sheet by forming a bulky laminate of a pulp or the like by a dry process such as air laying and bonding the layer by means of a suitable binding material. Although the bulky absorbent sheet having a very low density and a considerably high permeability can be produced by this method, the sheet has only poor diffusing properties due to the large distance between the fibers of the pulp.

Thus, for the production of the absorbent sheet, it is a very important technique to control the space structure of the absorbent sheet so that both diffusing properties and liquid-permeability which are

contradictory to each other are satisfied in the production of the bulky absorbent sheet by suitably controlling the tight bonding force due to hydrogen bonding in the wet sheet-forming step.

The description will now be made on the bulky hydrophilic fibers constituting the absorbent sheet of the absorbent element.

Any hydrophilic fiber is usable as the bulky hydrophilic fiber so far as the stearic structure of the fiber is bulky, namely, it has a crimped structure, and it is bent or branched; so far as the cross section area of the fiber is at least 3.0×10^{-6} cm² and the roundness of the cross section is at least 0.5; or so far as the sectional area of the fiber is at least 5.0×10^{-6} cm² irrespective of the roundness of the cross section. Examples of the hydrophilic fiber include cellulose fibers such as pulp, cotton and rayon and hydrophilic synthetic fibers such as acrylonitrile and polyvinyl alcohol. They can be used either singly or in the form of a mixture of two or more of them. Particularly preferred are pulp fibers having a crimped structure, regenerated cellulose fibers the area and shape of the section of which can be controlled as desired, and a mercerized pulp having an increased section of the fibers and produced by

swelling by mercerization treatment, since they can be produced easily at a relatively low cost.

It has been found that the tight bonding force due to hydrogen bonding among the fibers in the wet sheet-forming step can be controlled when the fibers have a stearic structure or when the area and shape of the section of the fiber can be controlled.

The amount of the bulky hydrophilic fibers to be mixed is preferably 20 to 80 parts by weight, still preferably 30 to 70 parts by weight, based on the whole wet nonwoven fabric. When the amount of the bulky hydrophilic fibers is less than 20 parts by weight, no intended bulky absorbent sheet can be obtained and, on the contrary, when it exceeds 80 parts by weight, the diffusing properties become poor.

The description will now be made on the hydrophilic fine fibers constituting the absorbent sheet of the absorbent element.

The hydrophilic fine fiber to be used herein is one having a hydrophilic surface, a large surface area, a sectional area of preferably 2.0×10^{-6} cm² or below and a roundness of the section of below 0.5 or one having a surface area of the fiber of at least 1.0 cm²/g. Examples of such fibers include cellulose fibers such as pulp, cotton and rayon and hydrophilic

synthetic fibers such as acrylonitrile and polyvinyl alcohol. They can be used either singly or in the form of a mixture of two or more of them.

Particularly preferred are pulp fibers, since they are available at an extremely low cost and the surface area of them can be controlled by varying the beating conditions. Examples of them include finely beaten craft pulp NBKP (trade name: SKEENA PRIME; Skeena Cellulose Co.), LBKP (trade name: PRINCE ALBERT ASPEN HARDWOOD; Weyerhaeuser Paper Company) and straw pulp.

The amount of the hydrophilic fine fibers to be mixed is preferably 20 to 80 parts by weight, still preferably 30 to 70 parts by weight, based on the whole wet nonwoven fabric. When it is below 20 parts by weight, no intended diffusing properties can be obtained and, on the contrary, when it exceeds 80 parts by weight, the fibers are too close to each other to obtain a high permeability.

By mixing hot-melt adhesive fibers into the material in order to stabilize the space structure of the absorbent sheet in the wet sheet-forming step, the resultant space structure can be kept stable even when it is wetted and, therefore, the resultant product can be comfortably used.

The description will now be made on the hot-melt

adhesive fibers constituting the absorbent sheet of the absorbent element.

The hot-melt adhesive fibers are fibers which are melted by heating and adhere to each other. Preferred examples of them include olefin fibers such as polyethylene, polypropylene, polyester and polyvinyl alcohol fibers; polyethylene/polypropylene conjugate fibers, polyethylene/polyester conjugated fibers, low-melting polyester/polyester conjugated fibers, polyvinyl alcohol/polypropylene conjugated fibers having a hydrophilic surfaces, and polyvinyl alcohol/polyester conjugated fibers.

The amount of the hot-melt adhesive fibers to be mixed is preferably 0 to 30 parts by weight, still preferably 0 to 20 parts by weight, still more preferably 2 to 20 parts by weight, based on the whole wet nonwoven fabric. When it exceeds 30 parts by weight, the absorbing and diffusing properties of the absorbent sheet are impaired unfavorably.

The description will now be made on the bulkiness of the absorbent sheet of the absorbent element.

The thickness of the absorbent sheet produced from the fiber mixture of the above-described composition is 0.3 to 2.0 mm, preferably 0.3 to 1.0 mm, under a load of 2.5 g/cm². When the thickness of the absorbent sheet under a load of 2.5 g/cm² is below

0.3 mm, the space in which the liquid is temporarily held is small and the quantity of the diffused liquid is also small and the absorption efficiency of the absorbent sheet, particularly highly absorbent polymer, cannot be sufficiently exhibited. When the thickness exceeds 2.0 mm, on the contrary, the space for holding the liquid is too large to smoothly transfer the liquid into the lower layer, in particular, highly absorbent polymer.

The absorbent sheet preferably has a Klemm absorption height of at least 50 mm after 1 min and at least 100 mm after 10 min for physiological saline. The absorbent sheet still preferably has a Klemm absorption height of at least 60 mm after 1 min and at least 120 mm after 10 min for physiological saline. As for the absorbing and diffusing properties, when the Klemm absorption height after 1 min is below 50 mm or when that after 10 min is below 10 mm as determined by using physiological saline, the absorbing and diffusing powers of the absorbent sheet are insufficient and the absorption efficiency of the highly absorbent polymer is poor.

The description will now be made on other structures of the absorbent element of the present invention.

The absorbent sheet constituting the absorbent article of the present invention must be used in combination with a highly absorbent polymer. To use it more effectively, the sheet is used in contact with a highly absorbent polymer. In particular, an absorbent polymer sheet having extremely high absorbency and holding capacity can be advantageously obtained by interposing a highly absorbent polymer between the absorbent sheets.

For the smooth migration of the liquid into a highly absorbent polymer, it is desirable that the permeability of the absorbent sheet to the liquid migrating into the lower layer is as high as possible. In particular, the time taken for passing 10 g of an 85% aqueous glycerol solution therethrough is desirably 100 sec or below (as to the determination method, refer to the Examples given below). When this time is longer than 100 sec, the migration of the liquid into the highly absorbent polymer becomes difficult unfavorably.

In each of the absorbent sheets used in the present invention, the space diameter structure/distribution can be controlled in the range of a large space diameter which is connected with the permeability to a small space diameter which brings

about a large surface area connected with the diffusing properties by forming the sheet from a mixture of the above-described hydrophilic fibers having a high bulkiness and the hydrophilic fine fibers in a specified mixing ratio. Thus the absorbent sheet having excellent liquid permeability and liquid-diffusing properties which are usually thought to be contradictory to each other can be obtained.

The space diameter distribution of the absorbent sheet can be determined with a mercury porosimeter. A preferred space diameter distribution is such that in the determination of the distribution of the space diameter ranging from 0.003 to 200 μm , the total surface area of the pores is preferably at least 1.0 cm^2/g , the surface area of the pores having a diameter in the range of 10 to 200 μm closely connected with the permeability is preferably 18 to 35% based on the total surface area of the pores and the surface area of the pores having a diameter in the range of 0.003 to 1 μm closely connected with the diffusing properties is preferably 50 to 80% based on the total surface area of the pores. Still preferably, the total surface area of the pores is at least 1.3 cm^2/g , the surface area of the pores having a diameter in the

range of 10 to 200 μm is 20 to 30% based on the total surface area of the pores. Still preferably, the surface area of the pores having a diameter in the range of 0.003 to 1 μm is 50 to 70%.

When the total surface area of the pores of the absorbent sheet is below 1.0 cm^2/g or when the proportion of the surface area of the pores having a space diameter of 0.003 to 1 μm is below 50%, no sufficient diffusing properties can be exhibited unfavorably and, on the contrary, when it exceeds 80%, the surface area of the fine pores becomes too large to obtain sufficient permeability. When the proportion of the surface area of the pores having a space diameter in the range of 10 to 200 μm is below 18%, no intended sufficient permeability can be obtained and, on the contrary, when it exceeds 35%, the diffusing properties become insufficient.

The basis weight of the absorbent sheet is desirably 10 to 200 g/m^2 , more desirably 20 to 100 g/m^2 . The absorbent sheets are usable either singly or in the form of a laminate of several of them.

When a highly absorbent polymer is interposed between the absorbent sheets, the amount of this polymer is preferably 10 to 80 parts by weight, still preferably 20 to 70 parts by weight, for the whole.

absorbent polymer sheet [parts by weight of the absorbent sheet plus parts by weight of the highly absorbent polymer plus parts by weight of a hot melt or binder when it is used for fixing the highly absorbent polymer]. When the amount of the highly absorbent polymer is below 10 parts by weight, the polymer for fixing the liquid becomes insufficient in the absolute quantity unfavorably and, on the contrary, when it exceeds 80 parts by weight, a gel blocking is caused in the polymer layer unfavorably in the step of absorbing the liquid in the highly absorbent polymer.

To further improve the effect of the absorbent sheet and the highly absorbent polymer constituting the absorbent article of the present invention, a bulky sheet having an extremely high permeability is used as the top layer (the layer, to be not brought into contact with the skin, of the liquid-permeable surface material) of the absorbent element and this top layer is laminated with the above-described absorbent sheet or highly absorbent polymer sheets containing the highly absorbent polymer interposed between them, the absorbent sheets being arranged below the top layer. By forming such a structure, the body fluid which has passed through the surface

material is extremely rapidly absorbed in the absorbent element and then spread over the whole highly absorbent polymer through the diffusing absorbent sheet, so that the body fluid can migrate very smoothly into the highly absorbent polymer. Therefore, an extremely thin, highly absorbent article which can be used comfortably by the user without suffering leakage can be obtained.

It is preferable to use as a bulky sheet having an extremely high permeability a sheet made by mixing at least:

- (a) 30 to 98 parts by weight of bulky hydrophilic fibers with
- (b) 2 to 30 parts by weight of hot-melt adhesive fibers,

and forming a sheet from the mixture, the sheet being characterized by having a thickness of 0.3 to 2.0 mm under a load of 2.5 g/cm², a Klemm absorption height for physiological saline after 1 min of 20 to 80 mm, a Klemm absorption height after 10 min of 30 to 100 mm and a time taken for passing 10 g of an 85 wt.% aqueous glycerol solution of 10 to 50 sec.

Thus it has become possible to obtain a bulky sheet having extremely high diffusing properties and high permeability by mixing the bulky hydrophilic

fibers with the hydrophilic fine fibers in the specified mixing ratio and controlling the pore structure of the bulky sheet.

According to the present invention, the above-described absorbent sheet is used as at least a part of the absorbent article and other sheets and constituting elements may be arranged above or below the absorbent sheet.

The absorbent sheet can be formed from a mixture of at least the bulky hydrophilic fibers, hydrophilic fine fibers and hot-melt adhesive fibers in the above-specified ratio. The mixture may further contain other fibrous components.

When the absorbent article of the present invention is used, the body fluid passes through the surface material and is then absorbed in the absorbent element, wherein the body fluid is rapidly spread over the whole highly absorbent polymer through the absorbent sheet having high diffusing properties and high permeability, and thus the body fluid very smoothly migrates into the highly absorbent polymer and can be extremely effectively trapped in the absorbent element.

In the absorbent article of the present invention comprising the combination of the absorbent sheet with

the highly absorbent polymer, the absorption efficiency of the polymer can be exhibited to the full, the return of the liquid to the surface is inhibited because the liquid holding capacity is very high. Thus the absorbent article having an extremely high absorbency and free from leakage can be provided. In addition, by forming the absorbent element by combining with the specified bulky absorbent sheet having an extremely high permeability the resultant absorbent article has a lower thickness and a lower possibility of leakage as compared with those of ordinary absorbent articles. Since the absorbent article is a right fit for the user, the user can use it more comfortably.

The following Examples will further illustrate the absorbent part of the present invention.

Although the description is made with reference to sanitary napkins in the following Examples, the present invention is applicable also to paper napkins and so forth.

The absorbent article in the Examples of the present invention basically comprises a liquid-permeable surface material 1, a liquid-holding absorbent element 2 and a liquid-impermeable leakproof material 3 as show in Fig. 3, wherein at least the

absorbent element 2 contains an absorbent sheet 2A having high diffusing properties and high permeability (absorbent sheet) and a highly absorbent polymer 2B.

The absorbent sheets, absorbing/holding sheets and surface sheets to be used in the Examples and Comparative Examples were prepared as described below and the functions of them were determined.

Absorbent sheets (A) to (G) described below were prepared as the absorbent sheets 2A.

[Absorbent sheet (A)]

Each of 40 parts by weight of a pulp having a crimped structure [trade name: High Bulk Additive (hereinafter referred to as HBA); Weyerhaeuser Paper Company] as the bulky hydrophilic fibers, 50 parts by weight of a craft pulp NBKP (trade name: SKEENA PRIME, Skeena Cellulose Co.) having a sectional area of the fiber of $1.9 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.32 as the hydrophilic fine fibers and 10 parts by weight of polyethylene terephthalate (hereinafter referred to as "PET") (trade name: TMOTNSB, Teijin Limited) having a thickness of 1.1 denier and a length of 5 mm as the hot-melt adhesive fibers was dispersed in water. After forming a sheet from the resultant dispersions, the sheet was dried to obtain an absorbent sheet (A) having a basis weight of

40 g/m². In the sheet-forming step, the absorbent sheet was creped ten percent.

[Absorbent sheet (B)]

Each of 60 parts by weight of a mercerized pulp having a sectional area of the fiber of 3.8×10^{-6} cm² and a roundness of the section of the fiber of 0.80 (trade name: POROSANIER-J, ITT RAYONIER INC.) as the bulky hydrophilic fibers and 40 parts by weight of a craft pulp NBKP (trade name: SKEENA PRIME, Skeena Cellulose Co.) having a sectional area of the fiber of 1.9×10^{-6} cm² and a roundness of the section of the fiber of 0.32 as the hydrophilic fine fibers was dispersed in water. After forming a sheet from the resultant dispersions, the sheet was dried to obtain an absorbent sheet B having a basis weight of 40 g/m². In the sheet-forming step, the absorbent sheet was creped ten percent.

[Absorbent sheet (C)]

Each of 10 parts by weight of a rayon having a sectional area of fiber of 5.9×10^{-6} cm² and a roundness of the section of the fiber of 0.68 (trade name: CORONA SB Rayon, Daiwabo Rayon) and 40 parts by weight of a mercerized pulp having a sectional area of the fiber of 3.8×10^{-6} cm² and a roundness of the section of the fiber of 0.80 (trade name:

POROSANIER-J, ITT RAYONIER INC.) as the bulky hydrophilic fibers, 45 parts by weight of a craft pulp NBKP (trade name: SKEENA PRIME, Skeena Cellulose Co.) having a sectional area of the fiber of $1.9 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.32 as the hydrophilic fine fibers and 5 parts by weight of a polyvinyl alcohol (trade name: Fibrilbond, Sansho Co., Ltd.) as the hot-melt adhesive fiber was dispersed in water. After forming a sheet from the resultant dispersions, the sheet was dried to obtain an absorbent sheet (C) having a basis weight of 40 g/m^2 . In the sheet-forming step, the absorbent sheet was creped ten percent.

[Absorbent sheet (D)]

Each of 80 parts by weight of a rayon having a sectional area of fiber of $5.9 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.68 (trade name: CORONA SB Rayon, Daiwabo Rayon) as the bulky hydrophilic fibers, 10 parts by weight of a craft pulp NBKP (trade name: SKEENA PRIME, Skeena Cellulose Co.) having a sectional area of the fiber of $1.9 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.32 as the hydrophilic fine fibers and 10 parts by weight of a polyvinyl alcohol (trade name: Fibrilbond, Sansho Co., Ltd.) as the hot-melt adhesive fiber was

dispersed in water. After forming a sheet from the resultant dispersions, the sheet was dried to obtain an absorbent sheet (D) having a basis weight of 40 g/m². In the sheet-forming step, the absorbent sheet was creped ten percent.

In the absorbent sheet (D), the amount of the hydrophilic fine fibers in the mixture was 10 parts by weight, which was outside the range (80 to 20 parts by weight) of the present invention.

[Absorbent sheet (E)]

A craft pulp NBKP (trade name: SKEENA PRIME, Skeena Cellulose Co.) having a sectional area of the fiber of 1.9×10^{-6} cm² and a roundness of the section of the fiber of 0.32 was dispersed in water. After forming a sheet from the resultant dispersion, the sheet was dried to obtain an absorbent sheet E having a basis weight of 40 g/m². In the sheet-forming step, the absorbent sheet was creped ten percent.

The absorbent sheet (E) comprised only the hydrophilic fine fibers (craft pulp NBKP) and was free from the bulky hydrophilic fibers.

[Absorbent sheet (F)]

A spun-bonded nonwoven fabric having a basis weight of 40 g/m² obtained by tangling 0.7-denier rayon staple fibers having a length of 38 mm (Daiwabo Rayon)

was used as absorbent sheet F.

The absorbent sheet F was free from the bulky hydrophilic fibers.

[Absorbent sheet (G)]

A dry pulp sheet having a basis weight of 40 g/m² (trade name: KINOCLOTH, Honshu Paper Co., Ltd.) was used as absorbent sheet G.

The absorbent sheet G was free from the hydrophilic fine fibers and bulky hydrophilic fibers and it was not the dry nonwoven fabric.

The sectional area of the fiber was determined by slicing the fiber perpendicularly so that the sectional area of the fiber is not varied, taking an electron photomicrograph of the section, and measuring the area of the section with an image analysis apparatus (Avio EXCEL, Nippon Avionics Co., Ltd.). The sectional area of each of 100 arbitrary sections of the fibers were determined and the average of them was taken as the sectional area of the fibers.

The roundness of the section of the fiber was determined also from the picture of the section with the image analysis apparatus according to formula (1) given below. The roundness of each of 100 arbitrary sections of the fibers was determined and the average of them was taken as the roundness of the fibers.

Roundness of section of fiber

$$= \frac{4 \times \pi \times (\text{sectional area of fiber})}{(\text{perimeter of section of fiber})^2} \quad (1)$$

Then various absorbing/holding polymer sheets 2E shown in Fig. 4 were prepared.

The description will be made on absorbing/holding polymer sheets (A) through (G).

[Absorbing/holding polymer sheet (A)]

Hot-Melt Topco P-618 B (a product of Toyo Petrolite Co., Ltd.) in a basis weight of 10 g/m² was spirally spread on the absorbent sheet (A) and then a highly absorbent polymer comprising a polyacrylate was spread thereon in a basis weight of 50 g/m². Another absorbent sheet (A) was placed thereon to form the absorbent polymer sheet (A) comprising the absorbent sheets 2A containing the highly absorbent polymer 2B interposed between them as shown in Fig. 4.

[Absorbing/holding polymer sheets (B) through (G)]

Absorbing/holding polymer sheets (B) through (G) were prepared from the absorbent sheets (B) through (G), respectively, in the same manner as that of the preparation of the absorbing/holding polymer sheet (A) from the absorbent sheet (A).

The description will be made on the preparation of the surface sheet 1.

Surface sheets (A) and (B) were prepared as described below.

[Surface sheet (A)]

25- μ m low-density polyethylene 21 (a product of Mitsui Petrochemical Industries, Ltd.) was arranged on a dry hot-melt adhesive nonwoven fabric 22 having a basis weight of 25 g/m² prepared from polyethylene/polypropylene conjugate fiber (a product of Chisso Corporation) containing 0.34% by weight of a mixed surfactant comprising an alkyl phosphate/sorbitan fatty acid ester adherent thereto as shown in Fig. 5 to form a surface sheet having a size of pores 24 in the wall part 23 of 0.1 to 2 mm² and a pore density of 52/cm². This product will be referred to as surface sheet (A).

[Surface sheet (B)]

A surface sheet (nonwoven fabric) of a sanitary napkin on the market (trade name: LAURIER, Kao Corporation) was used as the surface sheet (B).

The thickness under a load of 2.5 g/m², Klemm absorption height for physiological saline after 1 min and 10 min, 85 wt.% glycerol permeation time, total surface area of the pores, proportion of surface area of pores having a diameter of 0.01 to 1 μ m, and proportion of surface area of pores having a diameter

of 10 to 20 μm of each of the absorbent sheets (A) to (G) were determined to obtain the results given in the following Table 1.

Table 1

Absorbent sheet		A	B	C	D	E	F	G
Thickness (under load of 2.5 g/cm ²) (mm)		0.38	0.33	0.41	0.42	0.28	0.27	1.05
Klemm absorption height (mm)	after 1 min	72	85	58	13	31	88	3
	after 10 min	141	168	128	32	70	167	4
Liquid permeation time (sec)		68	88	47	16	430	205	130
Total pore surface area (m ² /g)		1.60	1.83	1.45	0.82	1.72	1.40	1.90
Proportion of pore surface area (%)	range of 0.01 to 1 μ m	52.7	57.0	66.4	41.1	58.2	57.6	46.5
	range of 10 to 200 μ m	23.5	20.7	21.9	39.3	15.5	13.2	37.3

The description will now be made on each of the determination items given in Table 1.

① Thickness under load of 2.5 g/cm^2 :

The absorbent sheet was cut into pieces of $50 \times 50 \text{ cm}$, a load of 2.5 g/cm^2 was applied to the pieces (loaded area: 10 cm^2) (a disc having a radius of 17.8 mm) and the thickness of the absorbent sheet was determined with a thickness meter. The average of ten repeated tests was taken as the thickness under a load of 2.5 g/cm^2 .

② Klemm absorption height after 1 and 10 min:

The absorbent sheet was cut into pieces having a size of $250 \text{ mm} \times 20 \text{ mm}$. The test piece 30 thus obtained was hung tight with a support 31, both of the upper and lower ends of the piece being fixed as shown in Fig. 6. Physiological saline 33 was fed as the measurement liquid into a rectangular vessel 32 having a size of $300 \times 100 \times 50$ (depth) mm to a depth of 40 mm . The test piece 30 was immersed in the physiological saline 33. The height of the measurement liquid absorbed in the test piece 30 from the level of the liquid surface was measured after 1 min and after 10 min. The test was repeated by using 10 test pieces and the average of the results was taken as the absorption height h of the physiological saline 33

after 1 min and the absorption height h_{10} after 10 min.

③ Determination of liquid permeation time:

The liquid permeation time was determined with an apparatus shown in Fig. 7.

The absorbent sheet was cut into test pieces 40 having a size of 50 mm x 50 mm. The test piece 40 was fixed between two glass tubes 41 and 41 having an inner diameter of 35 mm as shown in Fig. 7. The test piece 40 was fixed through a silicone rubber 42 with a clip on both sides so that the liquid would not ooze out from the side. 10 g of an 85% aqueous glycerol solution 43 prepared as will be described below was taken as the test liquid in a 10-ml beaker 44 and then gently poured in the tube. After the completion of the pouring, the time taken for the appearance of at least 50%, based on the open area of the glass tube 41, of the surface of the test piece was determined as the liquid permeation time.

The test liquid (85% aqueous glycerol solution) was prepared as follows: 85 g of glycerol (a product of Wako Pure Chemical Industries, Ltd.) was mixed with 15 g of ion-exchanged water and the resultant mixture was colored blue with 0.01 g of Food Blue Dye No. 1 (a product of Tokyo Kasei Kogyo K.K.).

④ Determination of total pore surface area,

proportion of surface area of pores having a space diameter of 0.01 to 1 μm , and proportion of surface area of pores having a space diameter of 10 to 200 μm :

The absorbent sheet was cut into pieces having a size of 10 mm x 20 mm. Three pieces thus obtained were set in a sample cell of a mercury porosimeter (a product of Shimadzu Seisakusho Ltd.) so that these pieces did not lie one upon another, and the pore distribution ranging from a pore diameter of 0.003 to 200 μm was determined. The pore distribution curves (differential and integral curves) of the absorbent sheets (A) to (G) are given in Figs. 11 through 17. From Figs. 11 to 17, the total surface area of the pores having surface diameters of 0.003 to 200 μm , the proportion of surface area of pores having a surface diameter of 0.003 to 1 μm , and the proportion of surface area of pores having a surface diameter of 10 to 200 μm to the total surface area of the pores were determined.

Example 1

The absorbing/holding polymer sheet (A) was used as the absorbing/holding polymer sheet 2E having a length of 195 mm and a width of 75 mm as shown in Fig. 1. Each of the following components was dispersed in water: 70 parts by weight of a mercerized pulp (trade

name: POROSANIER-J, ITT RAYONIER INC.) having a sectional area of the fiber of $3.8 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.80 and 20 parts by weight of a rayon (trade name: CORONA SB Rayon, Daiwabo Rayon) having a sectional area of the fiber of $5.9 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of the fiber of 0.68 as the bulky hydrophilic fibers; 5 parts by weight of a polyvinyl alcohol (trade name: Fibrilbond, Sansho Co., Ltd.) as the hot-melt adhesive fibers; and 10 parts by weight of a craft pulp NBKP (trade name: SKEENA PRIME Skeena Cellulose CO.) as another component. A sheet was formed from the resultant dispersions and dried. The bulky permeable absorbent sheet (2C) having a basis weight of 30 g/m^2 was cut into pieces having a length of 195 mm and a width of 170 mm, and an absorbent element was formed. The bulky permeable absorbent sheet had a thickness of 0.39 mm under a load of 2.5 g/cm^2 , an absorption height for physiological saline of 35 mm after 1 min and 50 mm after 10 min and a time taken for the permeation of 10 g of an 85% aqueous glycerol solution of 25 sec. The obtained absorbent element 2 was incompletely wound up in a waterproof poly laminated paper 3 (length: 225 mm, width: 95 mm), and then wrapped in the surface sheet (A) as the surface sheet 1 having a

length of 225 mm and a width of 172 mm, with a fixing tape 4 to form a sanitary napkin having a structure shown in Fig. 1. In Fig. 1, 6 indicates a fixing adhesive and 5 indicates a release paper.

Example 2

An absorbent element was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (B). A sanitary napkin having a structure shown in Fig. 1 was prepared from the absorbent element.

Example 3

An absorbent element was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (C). A sanitary napkin having a structure shown in Fig. 1 was prepared from the absorbent element.

Example 4

An absorbent element was prepared in the same manner as that of Example 1 except that the surface sheet (A) was replaced by the surface sheet (B). A sanitary napkin having a structure shown in Fig. 1 was prepared from the absorbent element.

Example 5

An absorbent element 2 was prepared by using the absorbing/holding polymer sheet (A) as the absorbing/holding polymer sheet 2E having a length of 195 mm and a width of 70 mm, placing two absorbent sheets 2D having a basis weight of 25 g/m² and cut to a size of 195 mm x 75 mm on the sheet (A) and wrapping these sheets in an absorbent paper (195 mm x 170 mm) comprising 100% pulp and having a basis weight of 18 g/m² in a body, as shown in Fig. 2, the absorbent sheets 2D being prepared by forming a sheet from a mixture of 75 parts of SA Rayon (Daiwabo Rayon) having a thickness of 1.7 denier and a length of 5 mm, 25 parts of pulp and 10 parts of PVA (Gosenol P-250).

A sanitary napkin having a structure shown in Fig. 2 was prepared from the absorbent element 2, paper 3 laminated with polyethylene, surface sheet A used as the surface material 1 and fixing tape 4. In Fig. 2, 6 indicates a fixing adhesive and 5 indicates a release paper.

Example 6

A sanitary napkin having a structure shown in Fig. 2 was prepared in the same manner as that of Example 5 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (B).

Comparative Example 1

A sanitary napkin having a structure shown in Fig. 1 was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (D).

Comparative Example 2

A sanitary napkin having a structure shown in Fig. 1 was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (E).

Comparative Example 3

A sanitary napkin having a structure shown in Fig. 1 was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (F).

Comparative Example 4

A sanitary napkin having a structure shown in Fig. 1 was prepared in the same manner as that of Example 1 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (G).

Comparative Example 5

A sanitary napkin having a structure shown in Fig. 1 was prepared in the same manner as that of Example 4 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (E).

Comparative Example 6

A sanitary napkin having a structure shown in Fig. 2 was prepared in the same manner as that of Example 5 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (F).

Comparative Example 7

A sanitary napkin having a structure shown in Fig. 2 was prepared in the same manner as that of Example 5 except that the absorbing/holding polymer sheet (A) was replaced by the absorbing/holding polymer sheet (G).

To evaluate the absorbing function of each of the absorbent articles 1 to 6 prepared in Examples 1 to 6, respectively, and comparative absorbent articles 1 to 7 prepared in Comparative Examples 1 to 7, respectively, the absorption time, liquid spreading area, dynamic liquid return and leakage of each napkin were determined to obtain the results given in the following Table 2.

Table 2

	Surface sheet	Absorbing/ holding sheet	Absorption time (sec)	Liq. spreading area (cm ²)	Dynamic liq. return (g)	No. of times of leakage		
						3 g	6 g	9 g
Present invention	1 A	A	15	79	0.1	0	0	0
	2 A	B	19	85	0.2	0	0	0
	3 A	C	13	73	0.2	0	0	1
	4 B	A	20	80	0.3	0	1	3
	5 A	A	18	75	0.2	0	0	1
	6 A	B	22	82	0.3	0	0	2
Comparative	1 A	D	18	35	0.8	0	6	10
	2 A	E	85	53	0.7	0	5	9
	3 A	F	62	82	0.5	0	3	6
	4 A	G	15	28	0.9	0	4	10
	5 B	E	102	55	1.0	1	7	10
	6 A	F	72	78	0.6	0	5	8
	7 A	G	17	27	1.2	0	6	10

(1) Absorption time and liquid spreading area (cm²):

As shown in Fig. 8, each of the sanitary napkins 80 prepared in the Examples and Comparative Examples was horizontally placed and then an acrylic plate 82 having an inlet 81 having a diameter of 10 mm was placed thereon. Weights 83 were further placed thereon so that a load of 5 g/cm² would be applied to the sanitary napkin 80 to be tested. 6 g of defibrinated equine blood (a product of Nippon Bio-Test Laboratories Inc.) was poured through the inlet and the time (sec) taken for the complete absorption of the blood was determined. The average of 10 samples was taken as the absorption time (sec).

After the liquid had been completely absorbed, the samples were left to stand for 20 sec. Then the sanitary napkins were destructed to determine the blood spreading area (cm²) in the absorbing/holding polymer sheet. The average of 10 samples was taken as the liquid spreading area.

(2) Dynamic liquid return

As shown in Fig. 8, each of the test sanitary napkins 80 prepared in the Examples and Comparative Examples was horizontally placed and then an acrylic plate 82 having an inlet 81 having a diameter of 10 mm was placed thereon. Weights 83 were further placed

thereon so that a load of 5 g/cm² would be applied to the sanitary napkin 80 to be tested. 10 g of defibrinated equine blood (a product of Nippon Bio-Test Laboratories Inc.) was poured through the inlet 81. After leaving to stand for 20 min, 10 absorbent sheets cut to a size of 75 x 195 mm and having a basis weight of 30 g/m² were placed on the upper surface (to be brought into contact with the skin of the user) of the sanitary napkin 80. The sanitary napkin 80 laminated with the 10 absorbent paper sheets was applied to a movable female loin model 90 as shown in Fig. 9. A pair of shorts was put on the model and the model was run at a speed of 100 steps per min (50 m/min) for 1 min.

Thereafter, the sanitary napkin 80 and 10 sheets of the absorbent paper were taken out the model and the weight of the defibrinated equine blood absorbed in the absorbent paper sheets was determined as the amount (g) of the returned liquid. The average of 10 samples of the sanitary napkin 80 was taken as the dynamic liquid return.

(3) Leakage test

Each of the test sanitary napkins 80 prepared in the Examples and Comparative Examples was applied to a movable female loin model 90 as shown in Fig. 10. A

pair of shorts was put on the model and the model was run at a speed of 100 steps per min (50 m/min) for 10 min. Then 3 g of defibrinated equine blood was injected into the napkin through a tube 91 while running the model and the model was run at the same speed for additional 10 min. The injection of 3 g of defibrinated equine blood followed by running for 10 min were repeated. The number of cases of leakage in tens of the samples was counted.

Examining the absorption time and liquid spreading area in the results shown in Table 2, it is noted that the sanitary napkins of the present invention exhibited excellent results, i.e., the absorption time of 13 to 22 sec and the liquid spreading area of 73 to 85 cm². On the contrary, both of the absorption time and liquid spreading area could not be satisfied at the same time by the comparative sanitary napkins. Namely, though some of the comparative ones exhibited relatively excellent absorption times of 15, 17 and 18 sec, the liquid spreading areas in them were as small as 28, 27 and 35 cm², respectively.

It is apparent that the dynamic liquid return was as small as 0.1 to 0.3 g in the samples of the present invention, while that was as large as 0.7 to 1.2 g in

the comparative ones.

When the amount of the liquid was 6 g or 9 g, the number of times of leakage was as small as 0 to 3 in the samples of the present invention, while that was as large as 4 to 10 in the comparative ones.

Thus, it is apparent that the absorbent article of the present invention is excellent in all of the absorption velocity, diffusing properties and return of blood (holding of blood), the number of times of leakage of the absorbent article is very small and it has excellent absorption performance, since it comprises a combination of the highly absorbent polymer and the absorbent sheet having high diffusing properties and high permeability.

It will be understood that in virtue of the structure of the absorbent element composed of the specified bulky absorbent sheet having very high permeability, an extremely thin, highly absorbent article substantially free from leakage which can be comfortably used by the user can be provided.

The present invention is not limited by the above Examples and is variable without departing from the gist of the invention.

For example, as shown in Fig. 3, the absorbent article of the present invention may comprise another

element 2F in addition to the absorbent sheet having high diffusing properties and high permeability and the highly absorbent polymer.

The highly absorbent polymer is not only interposed between the two absorbent sheets having high diffusing properties and high permeability but also wrapped in only one absorbent sheet having high diffusing properties and high permeability.



CLAIMS

1. A substantially longitudinally extended absorbent article which comprises a liquid-permeable surface material, a liquid-holding absorbent element and a liquid-impermeable leakproof material, wherein said absorbent element at least partially comprises an absorbent sheet having high diffusing properties and high permeability and a highly absorbent polymer,
said absorbent sheet having high diffusing properties and high permeability being made of a wet nonwoven fabric produced by forming a sheet from a mixture of at least:
 - (a) 20 to 80 parts by weight of bulky hydrophilic fibers,
 - (b) 80 to 20 parts by weight of fine hydrophilic fibers, and
 - (c) 0 to 30 parts by weight of hot-melt adhesive fibers,and said absorbent sheet having a thickness of 0.3 to 2.0 mm under a load of 2.5 g/cm².

2. An absorbent article according to Claim 1, wherein the highly absorbent polymer is interposed



between the absorbent sheets having high diffusing properties and high permeability.

3. An absorbent article according to Claim 1 or 2, wherein the distribution of the space diameter in the absorbent sheet, determined by means of a mercury porosimeter, ranges from 0.003 to 200 μm , the total

surface area of the pores is at least 1.0 cm^2/g , the surface area of the pores having a space diameter in the range of 0.003 to 1 μm is 50 to 80% based on the total surface area of the pores and the surface area of the pores having a space diameter in the range of 10 to 200 μm is 18 to 35% based on the total surface area of the pores.

4. An absorbent article according to Claims 1 to 3, wherein the absorbent sheet having high diffusing properties and high permeability has a Klemm absorption height for physiological saline of at least 50 mm after 1 min and at least 100 mm after 10 min.



5. An absorbent article according to Claims 1 to 4, wherein the absorbent sheet having high diffusing properties and high permeability is one wherein the time taken for passing 10 g of an 85 wt.% aqueous glycerol solution therethrough is 100 sec or below (as determined by a given determination method).

6. An absorbent article according to Claims 1 to 5, wherein the bulky hydrophilic fiber has a sectional area of at least $3.0 \times 10^{-6} \text{ cm}^2$ and a roundness of the section of at least 0.5.

7. An absorbent article according to Claims 1 to 5, wherein the bulky hydrophilic fiber has a sectional area of at least $5.0 \times 10^{-6} \text{ cm}^2$.

8. An absorbent article according to Claims 1 to 7, wherein the fine hydrophilic fiber has a sectional area of $2.0 \times 10^{-6} \text{ cm}^2$ or below and a roundness of the



section of below 0.5.

9. An absorbent article according to Claims 1 to 8 comprising the absorbent element composed of a highly permeable bulky sheet as the top layer of said absorbent element and said absorbent sheet having high diffusing properties and high permeability and said highly absorbent polymer arranged below the bulky sheet, wherein said highly permeable bulky sheet is one made by mixing at least:

(a) 30 to 98 parts by weight of bulky hydrophilic fibers with

(b) 2 to 30 parts by weight of hot-melt adhesive fibers,

and forming a sheet from the mixture, said sheet having a thickness of 0.3 to 2.0 mm under a load of 2.5 g/cm², a Klemm absorption height for physiological saline after 1 min of 20 to 80 mm, a Klemm absorption height after 10 min of 30 to 100 mm and a time taken for passing 10 g of an 85 wt.% aqueous glycerol solution of 10 to 50 sec.



10. An absorbent article comprising a liquid retentive absorbent element adjacent to at least one surface of which is a liquid permeable surface sheet and adjacent to the opposed surface of which is a liquid impermeable sheet, the absorbent element comprising at least one absorbent sheet in contact with an absorbent polymer material, the absorbent sheet having a thickness of 0.3 to 2.0 mm under a load of 2.5 g/cm² and comprising a nonwoven fabric made by a wet process from a mixture including 20 to 80 parts by weight of relatively bulky hydrophilic fibres, 80 to 20 parts by weight of relatively fine hydrophilic fibres and 0 to 30 parts by weight of hot melt adhesive fibres.