Applications of nonwovens in technical textiles

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5

Nonwoven personal hygiene materials and products

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Abstract: Nonwoven fabrics have traditionally been used in medical applications, but owing to their relatively low cost of production, versatility in incorporating various mechanical properties, disposability, and low lint, which reduces cross-infection and enables high levels of hygiene to be maintained, they have made major inroads in the growing field of healthcare and hygiene applications. This chapter discusses one of the emerging areas of nonwoven applications: personal hygiene. It first reviews key issues of hygiene materials and then discusses the types and properties of nonwoven materials along with applications such as diapers, feminine hygiene and adult incontinence.

Key words: nonwoven hygiene materials, diaper, feminine hygiene, adult incontinence.

5.1 Introduction

Nonwovens are unique, innovative, versatile, indispensable, high-tech engineered fabrics made from fibers and are used across a wide range of applications and products. Modern life would be quite literally impossible without them.

Nonwoven fabrics have traditionally been used in medical applications, but owing to their relatively low cost of production, versatility in incorporating various mechanical properties, disposability, low lint, which reduces cross-infection and enables high levels of hygiene to be maintained, they have made major inroads in the growing field of healthcare and hygiene applications.[1–4] In this chapter nonwoven hygiene materials (NHMs) are discussed in detail.

The definition of nonwoven supported by the European Disposable and Nonwoven Association is :

> A nonwoven is a manufactured sheet of directionally or randomly oriented fibers, bonded by friction, and/or cohesion, and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitch-bonded incorporating binding yarns or filaments, or felt by wet-milling whether additionally needled or not. The fibers may be of natural or man-made origin. They may be staple or continuous filaments or be formed in situ.[5,6]

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5.1.1 Key issues of hygiene materials

Two main characteristics of nonwovens make them particularly suitable for use in an absorbent hygiene material: high bulk for imbibing and holding a large amount of fluid per unit mass of material and the low cost of converting raw material into final product. However, not-leaking is just a minimum standard. Several other properties that have significant impact on the use of nonwovens in an absorbent hygiene material are disposability, comfort, and ease of fabrication of the product. The product is usually composed of a number of components, each supporting different but important functions. These are to receive fluid, imbibe it rapidly, hold it for a period of time, keep the clothing from soiling, keep the skin of the wearer dry, mask odor, be easily worn and removed, and be conveniently disposed of.[7] It is very important that the absorbing web layer with superabsorbent powder or fiber is placed inside the composite.

In addition to high productivity and low cost, one of the key aims in designing hygiene materials is to reduce the size or weight without compromising the fluid holding capacity.[8] Additionally, concern is now being raised about environmental consequences, longer life, biodegradability or ease of recycling.[9]Absorbent hygiene materials are usually highly engineered composites whose in-use performance is ultimately judged by the consumer. Each manufacturer strives to produce consistently high performing product at a low cost. The major portion of the diaper is fluff pulp: its price and availability have a significant influence on the diaper market. Because pricing of these materials is largely dictated by the market, success or failure for the suppliers is driven by economies of scale. Increases in the price of petroleum and other feedstocks have driven up pricing of polypropylene (PP) and polyethylene (PE), which have led to strongly adverse conditions for nonwovens suppliers who use these materials to make products for the hygiene market. In order to ensure that these materials will meet the exacting demands of the consumer, producers must select appropriate fibers and polymeric materials, engineer individual components with desirable characteristics and assemble them into the desired article with optimum performance. In complex structures, different layers perform different functions, some are absorbent, some transport liquid, and some are repellent.[10]

In recent years, the hygiene market has subscribed to a three-point holy grail that defines product success – form, fit and function. Form has been achieved through the incorporation of superabsorbents,[11] which make products thinner, and textile-like back sheets, which make them softer. Fit continues to be honed through the increasing use of elastics and other stretchable materials throughout the chassis of the diaper. Once found only in the leg cuff, elasticized material is now found in the waistbands, on the side panels and is even being incorporated into closure systems. Larger sized baby diapers as well as adult incontinence products are becoming more pant-like and more discreet, meaning more comfort for the wearer.

While form and fit are increasing in importance, they can never surpass function

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in performance. After all, what is the point of a disposable garment, if it does not achieve its function? For baby diapers, this means no leaking and less frequent diaper changes; for adult incontinence, this means a more active lifestyle and for feminine hygiene, this means discretion.

5.2 Types of nonwoven materials used for hygiene products

The textiles used for hygiene materials were conventionally cotton products that possessed the required level of durability, comfort, resistance to microbial contamination, and ease of washing and sterilization. Nowadays, these materials are made of tissue, reinforced with a cotton, viscose rayon, polyester or PP fiber spunlaid web.[12–14]

Lightweight nonwovens, i.e. less than 50 g/m^2, provide a major benefit for hygiene products in that such lightweight structures give the required performance at relatively low cost.[15] For adult incontinence diapers, fabrics of around 10–30 g/m^2 (ref. 16) are used. Low basis weight hygiene materials are commonly spunlaid nonwovens.[17,18] Cover stock for diapers and incontinence products is typically lighter spunbonded PP webs because they offer soft hand and hydrophobic properties.[19–41]

5.2.1 Spunbonded nonwovens

The use of spunbond fabrics in coverstock for diaper and incontinence devices has grown dramatically. This is mainly because of the favorable structural characteristics of spunbonds, which help keep the skin of the user dry and comfortable. Spunbond fabrics are seen as cost effective compared to other nonwovens. Current nonwoven materials used in topsheet applications include spunbonded PP (usually produced on a multibeam system), spunbond/meltblown/spunbond (SMS) PP composites and carded PP thermal bonds.[42–45]

5.2.2 Thermally bonded nonwovens[46,47]

Thermal bonding is an important technology for producing NHMs. It offers high production rates because bonding is accomplished at high productivity with heated calender rolls or ovens. It also offers significant energy conservation with respect to latex bonding because of more effective thermal contact and the fact that no water needs to be evaporated after bonding. It is environmentally friendly because there are no residual ingredients to be disposed of.[48] Thermally bonded nonwovens have practically replaced chemically bonded nonwovens all over the world. Until recently all napkins used chemically bonded nonwovens. They had two disadvantages: firstly chemically bonded coverstock remains wet and therefore is uncomfortable and secondly chemical binders might cause skin irritation for some wearers.[49]

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Acquisition/distribution layers made with through-air bonded nonwovens are considered by hygiene product manufacturers to be particularly efficient in attaining improved penetration and in preventing rewetting.[50]

Thermally bonded airlaid nonwovens are widely used as interior absorbent core materials in feminine hygiene materials, incontinence and baby diapers.[51,52] Thermally bonded technology uses PE/PP core/sheath bicomponent fibers (at a level of almost 30–40% in airlaid products) as a bonding fiber to bond pulp.[53]

Modern feminine hygiene materials comprise thin cores manufactured using airlaid technology and are low loaded with superabsorbent powder. The absorption of blood is another important requirement and superabsorbents such as HySorb™ provide this feature whilst retaining good integrity in airlaid cores. Superabsorbents are key to the trend towards smaller and thinner sanitary napkins, improving a woman's sense of well-being. Most sanitary products for women on the market today contain viscose rayon, a cellulose fiber made from wood pulp.[54] Some tampons are made of cotton/viscose rayon blends, while others may be completely cotton.[55] Bicomponent fibers, consisting of PE sheath and PP core, are also used for tampons and incontinence products.[56]

5.2.3 Composites

Spunbond and meltblown webs are often combined at the production stage to achieve a variety of composite structures providing barrier properties for applications in the hygiene sector.[57,58] The SMS concept was first introduced and patented by the Kimberly-Clark Corporation. SMS webs are characterized by having excellent physical properties (strength, elasticity, abrasion, secondary tearing, tear strength, etc.), uniformity, and excellent barrier qualities (preventing leakage of very fine particles and micro-organisms and aggressive liquids) while also providing controlled air permeability and softness.[59–61]

Cotton surfaced nonwovens (CSNs)

CSNs are produced with carded cotton/PP web on one or both sides of a spunbond, calendered or thermally bonded into two or three layers. CSNs have soft but strong fabric, excellent wetting, water absorption, retention, and are ideally suited for personal hygiene.

Cotton core nonwovens (CCNs)

CCNs are thermally bonded laminates with a carded bleached cotton web as core. The core is encapsulated with meltblown and/or spunbonded PP after the extrusion process, prior to calendering.[62] CCNs are highly suited for incontinence items due to the effective transport of liquid into the highly absorbent cotton core from the surface, their dry surface and absorbent core.

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5.3 Properties of nonwoven hygiene materials

Absorbency is the key property of materials used in the construction of NHMs.[63] A hygiene material should be very soft to the touch, maintaining high integrity while being stretched. For example, in a disposable diaper, it is highly desirable to have soft, strong, nonwoven components, such as topsheets or back sheets (also known as outer covers). The softness can be adjusted by adjusting spinning speed, polymer type and filament diameter.[64] For example, by reducing the filament diameter, one achieves a fabric that is softer to the touch.[65] It also must possess very good barrier properties to avoid unpleasantness caused by urine degradation.

It is important to have a very uniform web as this will provide a stronger product while eliminating the need for several layers, e.g. SMS.[66]

5.3.1 Fibers used

Fiber extensibility/elasticity is an important criterion because this characteristic translates to better comfort and fit as the article will be able to be more body conforming in all situations. Diapers with elastic components will have less sagging in general, as body size and shape and movement vary. With improved fit, the general well-being of the user is improved through improved comfort, reduced leakage, and a closer resemblance of the article to cotton underwear.[67–69]

Properties of importance are: wicking, water absorption, water retention and minimal linting characteristics. The use of wood fibers is key in this type of product as they can hold 33–35% water and are relatively cheap.[70] Considering the cost, cotton can certainly not replace wood fibers, but could make a contribution in products where the principle 'thinner is better holds'. Its use provides high absorption capacity, comfort, softness, chemical resistance and biodegradability. The use of PP fiber provides the desired hydrophobic nature to the facing at a reasonable cost as this polymer is one of the lowest cost, high volume, commercial polymers.

Superabsorbent fibers can be made from superabsorbent polymers (SAPs). SAPs are hydrogels that absorb water at one hundred times their own weight.[71–73] By comparison, conventional wood pulp and cotton filler absorbents absorb only six times their weight. SAPs' granulates retain large quantities of liquid by forming a gel when in contact with it. Their free swell absorbency after only 15 seconds is equal to or greater than their retention capacity. Superabsorbent fibers such as OASIS SAF®, Aquakeep®, and Norsocryl® give a number of benefits for the hygiene industry:

- low density enables the production of soft non-bulky products
- almost invisible blending with other fibers to both sight and touch, giving products a pleasing natural appearance to consumers
- no migration of the superabsorbent within fabric

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- fabrics are easier to slit and cut after manufacture with reduced blade wear and shedding of superabsorbent
- more uniform distribution of superabsorbent particularly with low base weights
- high surface area – for high absorbency rates and reduced blocking by large molecules found in blood and other body fluids.[74–77]

The most requested performance properties imparted by finishing treatments for NHMs are: hydrophilicity, durable hydrophilicity, softness, absorption, and appropriate combinations of these, e.g. hydrophilicity and softness.[78]

5.4 Applications of nonwoven hygiene materials

Modern disposable, absorbent NHMs have made an important contribution to the quality of life and skin health of millions of people. Market segments and products falling under the heading of NHMs are as given in Table 5.1.[79–93] The advantages of using NHMs instead of traditional textiles are: excellent absorption, softness, smoothness, stretchability, comfort and fit, strength, double fluid barrier effect allowing moisture to be absorbed and retained, good uniformity, high strength and elasticity, good strike-through, low wet-back and run-off, cost-effectiveness, stability and tear resistance, opacity/stain hiding power, and high breathability.

5.4.1 Diapers[94,95]

According to a diaper market sustainability report issued by EDANA, Brussels, Belgium, the average baby diaper comprises 35% fluff pulp, 33% SAP, 17% PP, 6% PE, 4% adhesives, 4% other, and 1% elastics.[96] The nonwoven PP fabric required is 20–25 gsm.[97] Disposable baby diapers were first introduced in the early 1960s and since then have been marked by continuous product innovations

Table 5.1 Market segments and products falling under the heading of NHMs

Diapers	Feminine hygiene	Adult incontinence
Baby diapers	Sanitary napkins	Adult diapers
Nappies	Feminine pads	Briefs
Training pants	Sanitary towels	Insert pad and pant
	Panty liners	Bladder control pads
	Panty shields	Undergarments
	Tampons	Guards
		Shields
		Panty liners
		Underwear
		Underpads
		Bed pads

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including the addition of SAP, resealable tapes and elasticized waistbands. Baby diaper-making machines available in the market have production speeds of around 250–750 pieces per minute.[98,99]

Diaper coversheet

The nonwoven fabric that is positioned next to the skin of the wearer of a hygiene material has been given various names, including: (a) cover, (b) coversheet, (c) coverstock,[100] (d) facing, (e) topsheet, and others. Fiber selection, processing conditions and binder considerations all are focused on the requirement for maximum absorbency of the diaper facing. Today, with the requirement of a dry surface in contact with the skin, which is supposed to be more comfortable and less irritating and toxic for the wearer, the fiber choice has shifted from the hydrophilic viscose rayon to the wholly synthetic hydrophobic fibers. In attempts to design a binder-free facing there has been a growing interest in the use of thermally bonded nonwoven technology in order to produce hydrophobic facings without chemical additives such as formaldehyde.

The property of hydrophobicity in a diaper facing is necessary but not sufficient for optimum performance. The fabric must also quickly pass liquid through to the interior of the diaper. The perfect facing must function as a 'one-way valve', quickly passing the liquid through (rapid strike-through), restricting passage of the liquid back through in the reverse direction (wet-back), and presenting a dry and soft fibrous surface to the skin. Consequently, a technology for conveying wetting properties to the surface of the facing to ensure rapid strike-through of the voided liquid is necessary. This is most easily achieved by uniformly adding onto the surface of the facing a small amount (0.2–0.6 wt%) of an effective rewetting agent. This is generally applied by spraying. For example, Sandler sawabond® thermally bonded topsheet qualities are made from co-polymer fibers, bi-component fibers or even blended-in viscose rayon fibers, and fine PP fibers with a hydrophilic or permanently hydrophilic finish, in various softness grades and bonding patterns.

Secondary facing

The secondary facing is intended to facilitate rapid passage of liquid from the back of the cover into the adjacent pulp pad or ply. This takes the form of a very lightweight fiber web with little or no bonding between the primary facing and the absorbent core. In another form, the single facing is fabricated with a rough top (outer surface) and a smooth bottom (inner surface). In this system, liquid tends to move from the rough side to the smooth side, enhancing wicking toward the center.

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Acquisition/distribution layer

The mechanism of enhancement of liquid movement has been further advanced by the use of an acquisition[101]/distribution layer (ADL) between the topsheet and the absorbent core.[102] The ADL provides for more rapid liquid acquisition (minimizing flooding in the target zone), and more rapid transport and thorough distribution of the fluid into the remainder of the absorbent region.

The absorbent core

The absorbent core is the heart of an absorbent hygiene material. There are several properties to be considered in the design of the polymer matrix for the diaper core. The absorption rate of the diaper must not be slower than the urination rate of the baby, otherwise leakage will occur. The absorption rate of the composite is influenced by the absorption rate of the SAP. However, fast swelling of the polymer may or may not be desirable: in some diaper designs, fast swelling may cause the diaper to leak if the result of the swelling is that the porosity and permeability of the composite is reduced. The absorption rate of SAP is affected by the maximum absorption capacity of the polymer and its particle size and shape. The placement of fast or slow absorbing polymers in the composite structure therefore has important implications for the effectiveness of the composite. In addition, particle size, placement, and relative amounts play a large role in the optimization of absorption. When the superabsorbent swelling is delayed in the wetting region of some diaper designs, there is more time to distribute urine through the diaper. By distributing the liquid better throughout the diaper, there is less saturation of the core in the wetting region, so further wetness may be absorbed.

With a refined understanding of the impact of SAP on the absorbent core in the early 1990s ultra-thin diapers became possible. The amount of cellulose pulp fluff used in these diapers was reduced by half, yielding a thinner diaper with a higher concentration of SAP in the absorbent core. As polymer properties become increasingly understood, diapers become thinner as the ratio of polymer to fluff increases. In modern diapers, the core consists of hydrophilic wood pulp and SAP.[103–105] The fluffy pulp used is between 13 and 25 g/m^2, depending upon diaper thickness. It can also consist of grafted cellulose and starch, interlinked carboximethyl cellulose derivatives and modified hydrophilic polyacrylics.[106] Because the core must often withstand several insults, it must be able to absorb, transport, distribute and hold body fluid at more than 50% of its own weight. SAPs are added to baby diapers in basically two ways: layered or blended. Japanese diaper manufacturers commonly adopt the layered application. The blended application of SAP is representative of American diaper manufacturers.

The back sheet

Finally, the back sheet is an impermeable thin film or barrier fabric that prevents

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leakage. To improve the handle and aesthetics, it is often embossed for flexibility and to provide a cloth-like appearance.

Diaper test methods

Properties that are commonly tested include such special tests as 'strike-through' (time in seconds for liquid to penetrate the topsheet), 'run-off' (volume of liquid not absorbed into the porous material when the fabric is maintained at a specified angle), and 'wet-back' (volume of liquid squeezed out of an absorbent and back through the facing under standard conditions). Other properties of interest that relate to the performance of the diaper include 'total absorption' (saturation to the drip-free point), and 'absorption under load' (total amount absorbed and held under a standard load).[107–111]

5.4.2 Feminine hygiene

Feminine hygiene is a general term used to describe personal care products used by women during menstruation, vaginal discharge, and other bodily functions related to the vulva. Sanitary towels (also known as maxi-pads or napkins), panty liners, tampons, menstrual cups, and feminine wipes are the major categories of feminine hygiene products.

Sanitary napkins

The functions of sanitary napkins are to absorb and retain menstrual fluid, and isolate menstrual fluids from the body. Important and desired properties are: no leakage, no unaesthetic appearance or color, no odor, no noise, stay in place, comfortable to wear (thin body shape), and a high level of hygiene.

The average sanitary napkin comprises 48% fluff pulp, 36% PE, PP and PET, 7% adhesives, 6% superabsorbent and 3% release paper. Options are available for napkins with fluff, airlaid or double fluff core, in combination with panty liners, additional core or materials, embossings,[112] elastic cuffs, and with trifolders or single wrappers. Sanitary napkin-making machines available in the market have production speeds of around 500–1000 pieces per minute.

Panty shields

The function of panty shields is to protect underwear from vaginal discharge. Important and desired properties are sufficient absorption capacity, discretion, comfortable to wear (softness, body shape), and good hygiene. Pads and panty liners are mainly made of materials such as wood pulp, nonwoven fabrics made from polymers (PE, PP), SAP, and adhesives of natural and synthetic resins. These raw materials are chosen for their ability to absorb and retain fluids, to avoid

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leakage and to provide comfort.[113] Panty shield-making machines available in market have production speeds of around 1500 pieces per minute.

Tampons

The most common type of tampon in daily use is a disposable plug that is designed to be inserted into the vagina during menstruation to absorb the flow of blood. Its function is to absorb and retain menstrual fluid inside the body. Important and desired properties are no leakage, no odor, easy to insert, easy to remove, softness, comfortable to wear (dimensionally correct), high level of hygiene; the tampon should also be discreet.

Modern tampons are mainly composed of cellulosic absorbent material, either viscose rayon or a mixture of these fibers. In most instances, the absorbent core is covered by a thin, smooth layer of nonwoven or perforated film helping to reduce loss of fibers and making the tampon easy to insert and remove. The withdrawal cord that is necessary to remove the tampon is usually made of cotton or other fibers and can be colored.

5.4.3 Adult incontinence

Incontinence is the lack of voluntary control of excretory functions; the term is a contraction of a complete expression, such as 'incontinence of urine' or 'incontinence of feces'. Adult incontinence products (AIPs) need to combine performance, comfort, discretion and aesthetics to fulfill all the needs of this emerging market.

Comfort is a vital element for AIPs. Part of comfort is fit – the garment must fit snugly to prevent leakage, but should not bind or chafe the skin of individuals wearing them all day. Skin health can be even more important for an adult user than for babies. Pulling liquid away from the skin is a top priority for an AIP – absorption rate and wicking action are essential.

Part of the comfort experience for adults is discretion. AIPs need to be 'a silent partner in protection'. People do not want them to rustle like a baby's diaper. Beyond sound, adults worry about odor. Odor has a function in baby diapers – it's an alarm that signals to parents when to change their children's diapers. For adults, however, that alarm becomes a source of embarrassment. Odor control is highly important for the adult market. Cotton is receiving renewed interest as a sustainable and eco-friendly fiber, while being good for comfort, and is hypoallergenic next to the skin.

AIPs are designated according to the severity of the incontinence problem to be managed as light, moderate or heavy/double incontinence. The average incontinence product composition according to EDANA is: 62% fluff pulp, 12% SAP, 10% PE film, 10% nonwoven PP, 3% adhesives, 2% others and 1% elastics.

Basic processes in the manufacture of incontinence products are: the fiberization of fluff pulp, addition of SAP and absorbent core formation; lamination with films,

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nonwoven substrates, elastic elements and tapes; printing of wetness indicator and traceability markings; shaping, cutting, folding, and packaging.

Heavy incontinence

The primary functional requirements of products designed to deal with heavy incontinence are to absorb and retain urine, retain feces inside the product, isolate wetness from the skin, and reduce odor. Important/desired properties are maximizing comfort, simplicity (ease of use and putting on/taking off), low noise factor (particularly for non-institutionalized persons), and hygiene.[114]

Odor-control SAP products such as Hysorb™, which inhibit the generation of ammonia, have been specifically developed for heavy incontinence. By enhancing absorption capabilities, SAPs improve incontinence protection and create a new level of confidence and comfort.[115]

Medium–low incontinence

The primary functional requirements are to absorb urine during micturition and distribute the urine throughout the absorption pad, provide medium capacity absorption, retain urine effectively in the absorbent core, isolate wetness from the skin, and reduce potential odor problems caused by urine degradation. Important and desired properties are maximizing wearer comfort, good product fit, good level of discreetness with the product, and a high level of hygiene. The structure of these products is similar to feminine hygiene products like sanitary pads and panty liners, but they are specifically designed for incontinence with sophisticated leakage protection for urine. These products are sandwich-structured with an absorbent core comprising a blend of fiberized fluff pulp and SAP.[116] The topsheet is a layer of PE or PP nonwovens or can be a mix of both. The back sheet is usually composed of a PE film or a nonwoven/film composite, which may be breathable. It prevents wetness transfer to the clothes. The product is fastened to the underwear by an adhesive strip on the back sheet, protected by release paper prior to use.

5.4.4 Products for adult incontinence

The absorbent product sector of the personal care industry related to adult incontinence contains the products such as adult diapers, adult pant diapers, two-piece insert items, personal/medical wipes, protective underwear, briefs, undergarments, guards, underpads and panty shields. The current product range is extensive and designed to meet the needs of people of all ages and both sexes. Additional protection can also be provided by products such as underpads. Adult diaper-making machines available in the market have production speeds of around 400–800 pieces per minute depending upon whether they are producing light or heavy incontinence products.

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Protective underwear

There is a way to achieve effective adult incontinence protection without compromising dignity. Protective underwear is a stretchable, disposable low-profile undergarment that offers superior containment and fit. Less bulky and without the tapes or belts of traditional adult briefs and undergarments, it slips on and off just like ordinary underwear for easier, more dignified and discreet use.

Adult brief with waistband

The adult brief meets the need for the most demanding protection against urinary and fecal incontinence. Its SAPs lock in fluid for maximum absorption, aiding patient comfort and skin protection. The brief's innovative design features a flexible waistband and six adjustable tape tabs that provide superior fit and security. The addition of a dryness strip promotes optimum skin care by keeping moisture in the brief and preventing it from coming back onto the skin.

Underpads

The underpad is designed in an extra-large size and offers maximum absorbency, making it ideal for overnight use. Its SAP gels fluid, pulling it away from the skin, and the strong waterproof PP backing protects against leakage. Its oversized 30 inch × 36 inch (76 cm × 91 cm) dimensions protect a larger area of the bed, reducing bedding changes and laundry costs.

5.5 Future trends

The engineering of improved levels of thermo-physical and tactile comfort in wearable hygiene materials is a further area of fundamental research. In terms of product developments, we are likely to see increased levels of absorbency performance and the use of thinner materials, resulting in higher levels of comfort as well as discretion.[117] A future trend is in the use of bioactive fibers processed into nonwoven material by needlepunching or hydroentanglement. These are used in blends with synthetic fibers to prevent the cross-infection of diseases and to suppress the generation of unpleasant odors.[118,119] Alloy fibers consisting of sodium carboxymethyl cellulose and regenerated cellulose may be used.[120]

Because of the promise of a growing market, in the future, there will be a lot more innovation in AIPs in fiber development and in nanotechnology with performance coatings such as inclusion of skin health additives and progress toward infection and bedsore control. One can foresee AIPs looking more and more like normal adult underwear.

Recent developments in polymer technology including the availability of metallocene PP and alternative web-forming technologies, such as those of Ason

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Engineering, Ft Lauderdale, FL and Kobe, Tokyo, Japan that provide the capability to produce bicomponent and microdenier webs, can produce materials with better web formation, better softness and improved strength, allowing a reduction in web weight and consequently the possibility of a reduction in cost.

5.6 Sources of further information and advice

- M.D.VIOLA MACCHINE SRL, Via Lombardia 16/18 27010 Valle Salimbene (PV) – Italy.
- DIATEC SRL, Strada Statale 151, Km. 13 – 65010 Collecorvino, Pescara, P. IVA 01813600689.
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