woolchemy™

Revolutionising Hygiene: High-Performance,
Plastic-Free Materials with skin health benefits.

Woolchemy is a material technology company with Intellectual Property focused on absorbent wool-based hygiene products. The company has developed the world's first hygiene-grade wool fibre, designed specifically for use in hygiene materials.

This whitepaper aims to explore the current challenges in the disposable diaper market, particularly focusing on the environmental impact of non-biodegradable materials. It introduces Woolchemy's innovative neweFlex Acquisition Distribution Layer (ADL), a sustainable alternative designed to reduce the ecological footprint of hygiene products while maintaining high performance standards.

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Executive Summary

Wool has long been recognised for its remarkable functionality, versatility, and consumer benefits in durable products like clothing and carpets. As a natural, high-performance fibre, wool offers unique advantages in absorbent hygiene products, such as baby diapers, sanitary pads, and incontinence products. Wool's natural structure provides absorption, breathability, and odour control, making it an ideal material for improving the comfort and performance of hygiene products. As illustrated in Figure 1, the ACQUISITION DISTRIBUTION LAYER (ADL) plays an important role in liquid distribution and is a critical component of any high performing hygiene product.

This whitepaper introduces Woolchemy's neweFlex Acquisition Distribution Layer (ADL), an innovative, proprietary solution made from wool fibres that elevates the performance of hygiene products.

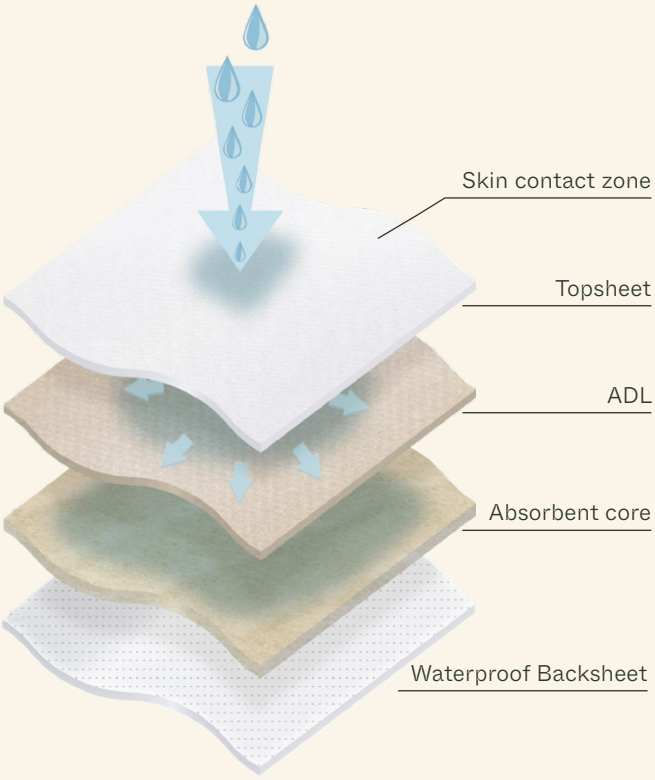


Figure 1 - Main textile layers of a diaper

Combining performance and sustainability, neweFlex ADL enhances product functionality while supporting the industry's shift towards biodegradable materials.

Engineered for excellent liquid management, softness, and breathability, neweFlex ADL enhances user comfort and satisfaction, providing a premium alternative to synthetic materials.

In addition to its functional benefits, neweFlex ADL is 100% biobased and plastic free, aligning with the industry's growing focus on sustainability. This material offers diaper manufacturers a chance to leverage the benefits of a material that gives excellent in application performance without the environmental drawbacks of plastic materials.

Through detailed analysis, market insights, and real-world case studies, this document highlights how neweFlex ADL can redefine hygiene product performance and sustainability. By adopting this innovative wool-based layer, manufacturers can not only meet consumer demand for comfort and efficiency but also play a vital role in supporting a greener future for the hygiene industry.

Woolchemy: Pioneering Sustainable Wool-Based ADL for Hygiene Products

Woolchemy is an innovative company specialising in developing high-performance, sustainable materials derived from wool. Recently, Woolchemy has developed and independently tested a wool-based spunlace ADL, neweFlex, with unique benefits for absorbent hygiene products. neweFlex has been successfully trialled in diaper and femcare products where it has replaced 1-2 layers of ADL/fluff pulp.

The high porosity of the nonwoven structure traps air for effective thermal insulation and high exposure of wool fibre surface for VOC capture. This porosity also enhances microorganism access, improving biodegradability at the product's end-of-life compared to denser materials.

100% Biobased Carbon

Beta Analytics analysis showed neweFlex ADL is comprised 100% Biobased carbon. Meaning 100% of carbon content is derived from natural sources and 0% is from petrochemical/fossil carbon sources.

Performance as the Key to Product Acceptance

To ensure acceptance by both industry and customers, any new product or component must meet or surpass the performance of existing materials. In hygiene products, liquid management is crucial for the performance of the ADL component, alongside comfort and skin health.

While customers are increasingly considering sustainability and disposal options when making purchases, maintaining high functional performance is key to ensuring customer satisfaction.

Basis weight:	68g/m²
Thickness:	0.72mm
Porosity:	94%
Dry Tensile Strength:	24N/50mm
Sustainable:	100% Biobased Carbon Content
Strike Through:	1.55s
Rewet:	0.3g
Comfort/Breathable:	Up to 15% more breathable compared to diapers made with PP
Thermal Regulating:	Resists heat loss providing warmer, more stable microclimate*
Skin Health & Safety:	Reduced microclimate humidity by 10%*. Tested to OekoTex100 Standard to Category 1 (infant) standard. No PFAS
Odour Reduction:	57% reduction in ammonia, 75% reduction in TMA

*Compared to diapers with Polypropylene ADL

Woolchemy holds multiple patents, with additional patent applications pending globally, related to the innovative use of wool in hygiene products.

neweFlex ADL Liquid Management Comparison

neweFlex ADL was tested for ADL specific performance indicators: liquid strike through and rewet according to WSP 070.3.R1 (19) and WSP 080.10.R2 (20) EDANA testing standards respectively.

These tests were used to benchmark the performance of neweFlex against commercially available ADLs comprising (biobased) cellulose. Results show that neweFlex ADL nonwoven outperforms cellulose containing ADL nonwovens in both main performance indicators, i.e. exhibiting a shorter liquid strike through and up to 14 times lower rewet mass. The results clearly demonstrate the ability of neweFlex ADL to distribute the liquid away from the inlet point towards the absorbent core, whilst cellulose based ADLs tend to absorb the liquid instead, compromising its distribution. The same phenomena, e.g. liquid absorption instead of wicking, results in more liquid mass being released back towards the diaper top surface under pressure (rewet) for the cellulose containing ADLs compared to neweFlex ADL.

ADL Application Performance Requirements

Quick Liquid Acquisition

Rapid movement of liquid away from the diaper topsheet (i.e. diaper surface)

Prevent rewetting

Ensure that liquid is distributed evenly across the absorbent core, quickly and effectively absorbed, to prevent the fluid moving upwards back towards the diaper surface, especially when pressure is applied (sitting)

neweFlex ADL: Manufacturing & Converting

Wool fibre processability into an ADL nonwoven using readily available nonwoven manufacturing processes (carding and hydroentanglement) was proven in pilot and production trials accompanied by intensive quality control at Andritz Pulp & Paper, Nonwoven & Textile Division, in France and a commercial manufacturing line in Europe, respectively.

neweFlex ADL has been successfully incorporated into diaper products and validated in commercial trials on several industrial converting lines including on Fameccanica lines.

neweFlex ADL incorporation into femcare and incontinence products has also been proven in commercial converting trials.

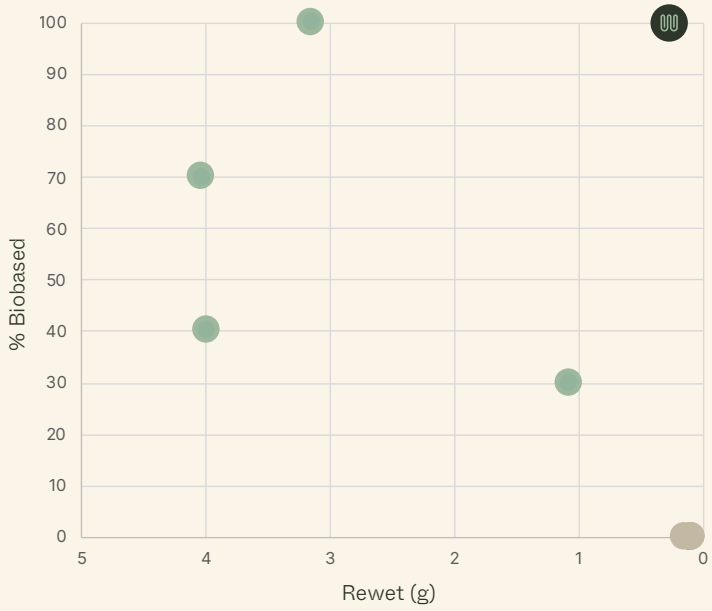
Biobased Content vs Performance

Key insights regarding performance of neweFlex can be compared to that of commercially available petroleum based and biobased ADL's by mapping Rewet and Strikethrough against % biobased content.

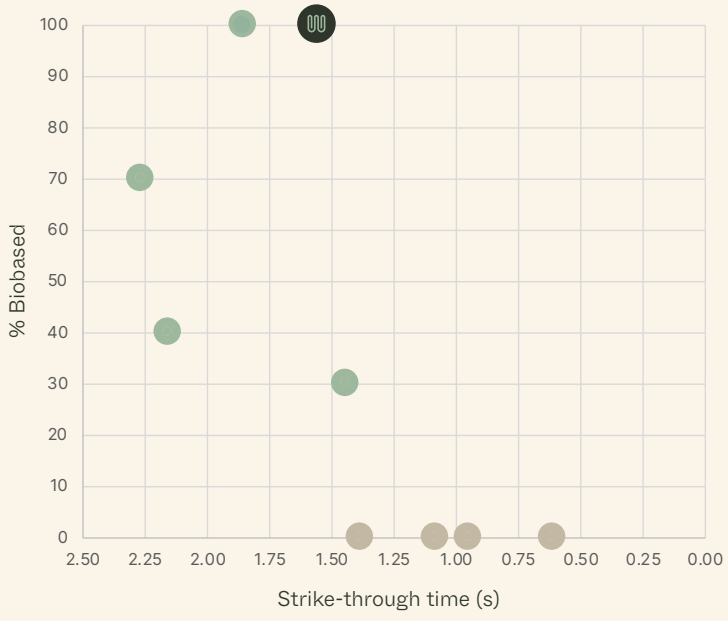
The biobased ADL's compared were not all completely free from plastic, with their Biobased content ranging from 30 to 100%.

The results clearly indicated that neweFlex ADL delivers lower strike through time and lower rewet whilst being 100% biobased (y-axis) than the cellulose based ADLs. neweFlex overall performance is closer to the industry approved petroleum-based ADLs than the performance of the cellulose based.

Rewet Performance



Strike-through Time



Key

- neweFlex ADL
- Biobased competitor products
- Petroleum based competitor products

neweFlex ADL is PFAS, Heavy Metal & Phthalate Free

neweFlex ADL fabric has undergone extensive testing at accredited laboratories to ensure its safety and compliance with international standards.

- **PFAS-Free:** Tested at Intertek, no Per- or poly-fluoroalkyl substances were detected, confirming neweFlex ADL is PFAS-free.
- **No Heavy Metals:** OEKO-TEX 100 testing at SGS found no extractable heavy metals above quantification limits, certifying compliance with category I standards.
- **Phthalate-Free:** SGS testing also confirmed no detectable phthalates, ensuring compliance with category I standards.

WHAT ARE PFAS?

Did you know?

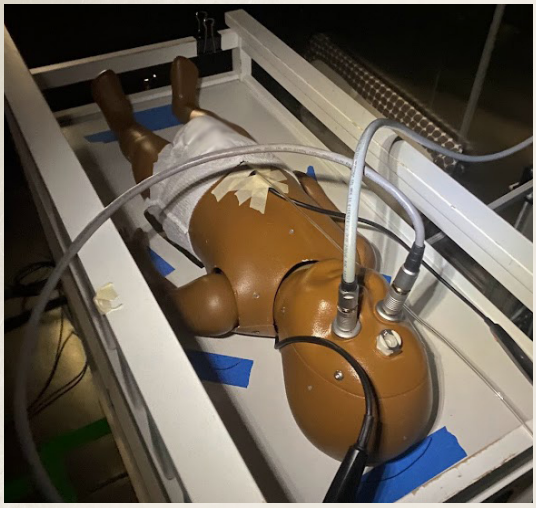
"Per- and poly-fluoroalkyl substances (PFAS), known as 'forever chemicals,' are non-degradable, persistent, and harmful to human health. Hygiene manufacturers face increasing pressure to eliminate PFAS from next-to-skin products."

Breathability Benefits of Wool-Based Components

Tests have shown that wool-based multilayer systems exhibit lower water vapour and thermal resistance compared to synthetic fabrics, allowing better heat and moisture transfer away from the skin.

Results from the Sweated Guarded Hotplate test on commercially manufactured diapers displayed an improvement from 7% to 15% breathability between a petroleum based ADL compared to neweFlex ADL respectively. This suggests that wool can improve breathability and comfort in hygiene products by preventing moisture buildup on the skin surface.

Independent testing confirms that diapers with neweFlex ADL reduce temperature fluctuations and improve thermal comfort.



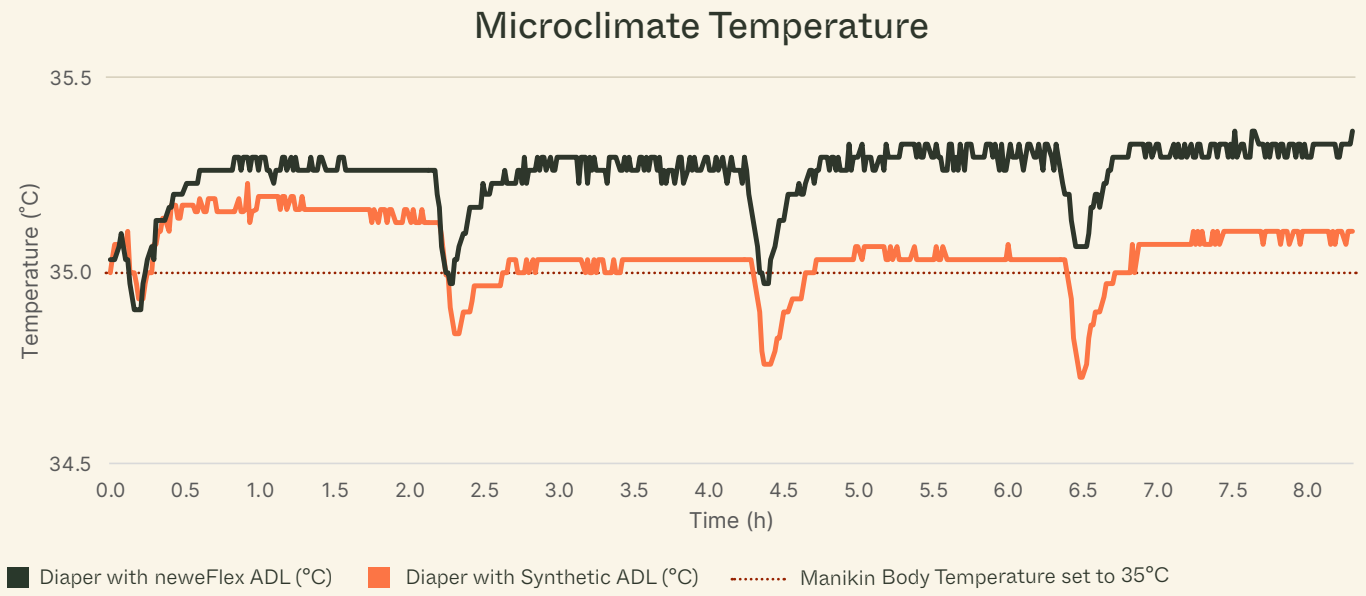
neweFlex: Thermal Comfort

Diapers with integrated neweFlex ADL were subjected to thermal comfort assessments over multiple liquid insults and compared with a standard petroleum-material based diaper. Tests were conducted by a Michigan Public Research Laboratory where a baby heated manikin was employed in accordance with an adapted test standard ASTM F1291.

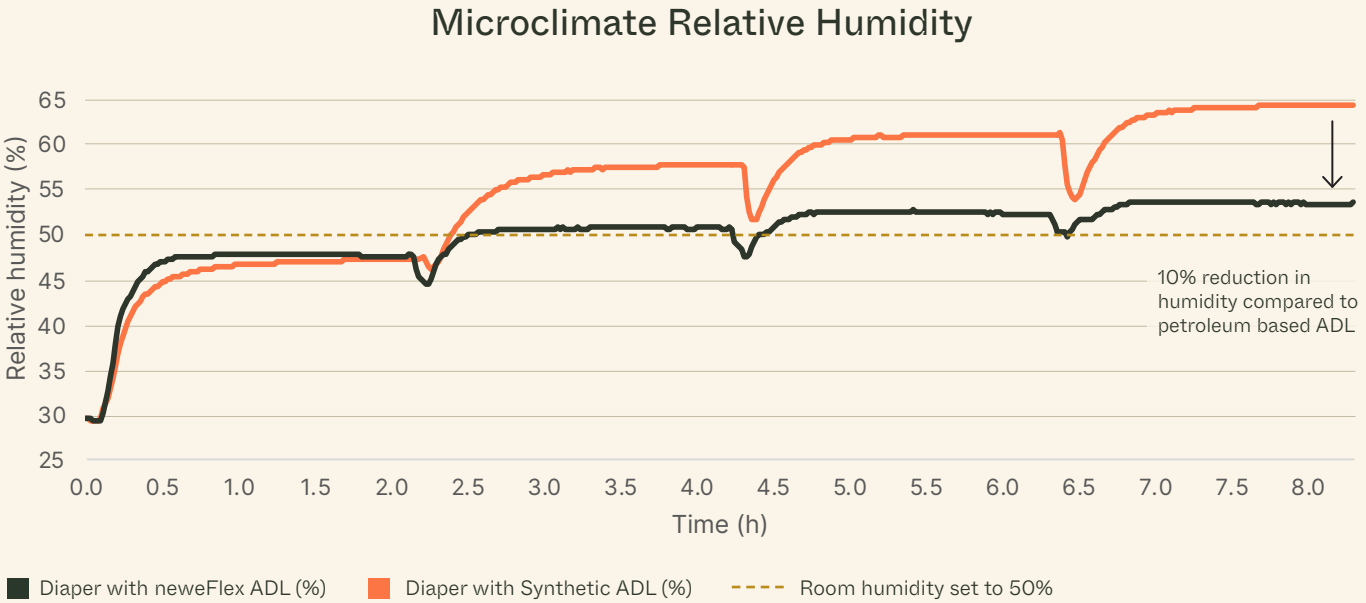
The thermal comfort was assessed using multiple temperature and humidity sensors located in different places on a baby manikin. Diapers were repeatedly insulted with liquid (80 ml) in 120 minute intervals between insults, simulating diaper use over an extended period of time (8 hours in wet state).
The main results across all 4 sensors and thermal camera data confirmed that diapers made with neweFlex were overall more stable and consistent in reducing temperature fluctuations between liquid insult periods compared to diapers made with petroleum based ADL.

Microclimate in Manikin Crotch Area

Analysis of the temperature and humidity inside diapers with an incorporated petroleum based ADL and wool-based ADL showed trends in favour of the wool fibre containing component with neweFlex ADL ( ) maintaining a warmer and more stable microclimate inside a diaper in the sensitive crotch area over an extended period of time (closer to human body temperature 36°C) whilst the microclimate surrounding the synthetic component ( ) in the diaper is gradually getting cooler.



Relative humidity data demonstrates lower humidities inside a diaper with the neweFlex component ( ) which is stable over multiple insults compared to the increasing humidity trend over time for the petroleum based component containing diaper ( ).



Odour issues in hygiene products

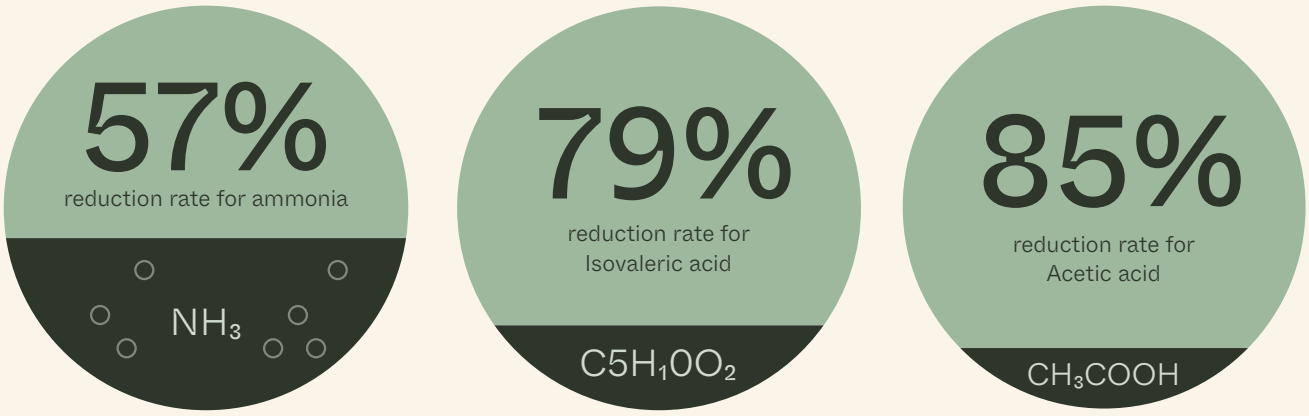
Odour control is a key performance factor for hygiene products that can have a strong impact on consumer perception and experience. Odour problems can arise from:

- **Diapers:** Soiled diapers can emit strong odours due to urine and faeces. Furthermore, urine breaks down into ammonia, which has a strong, pungent odour. The odour becomes more pronounced if diapers are not changed promptly.
- **Menstrual Products:** Sanitary pads can develop odours when they absorb menstrual blood, which has a natural smell that becomes stronger over time.

Wool has been proven to be able to capture volatile organic compounds (VOC's) associated with odours, such as ammonia. neweFlex was subject to VOC capture testing (including ammonia) at an independent laboratory which demonstrated successful gas molecule reduction.

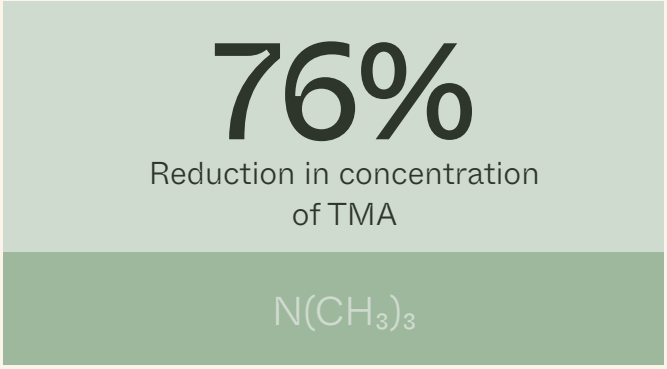
neweFlex ADL Deodorization Testing Results

Samples of neweFlex ADL were subjected to deodorisation of textiles testing and analysis at SGS laboratory. The test method evaluated gas reduction rate (%) after 2 hrs exposure measured by Gas Chromatography. The results showed:



Testing for reduction of concentration of Trimethyl amine (TMA) by Gas chromatography analysis was carried out at Olfasense laboratory.

The analysis also showed that a higher wool fibre content in the nonwoven increases the volatile organic compound (VOC) reduction rates.



neweFlex ADL Biodegradability & Toxicity

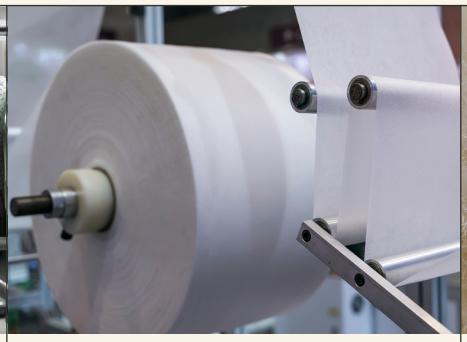
The lightweight and highly porous structure of neweFlex ADL makes fibre surface accessible to active microorganisms in soil.

In conjunction with its fibre composition (zero plastic content, PFAS free and toxic metal free status), neweFlex will likely completely biodegrade within a few months in standard soil conditions, generating microplastic and toxic free compost.

neweFlex ADL: summary

Reliable for Absorbent Hygiene Product Integration

neweFlex ADL nonwoven has a proven record in conversion into absorbent hygiene products.



Proven in Standard Nonwoven Manufacturing

neweFlex ADL nonwoven has a proven record in being manufactured using standard nonwoven processes.

100% Renewable & Plastic-Free

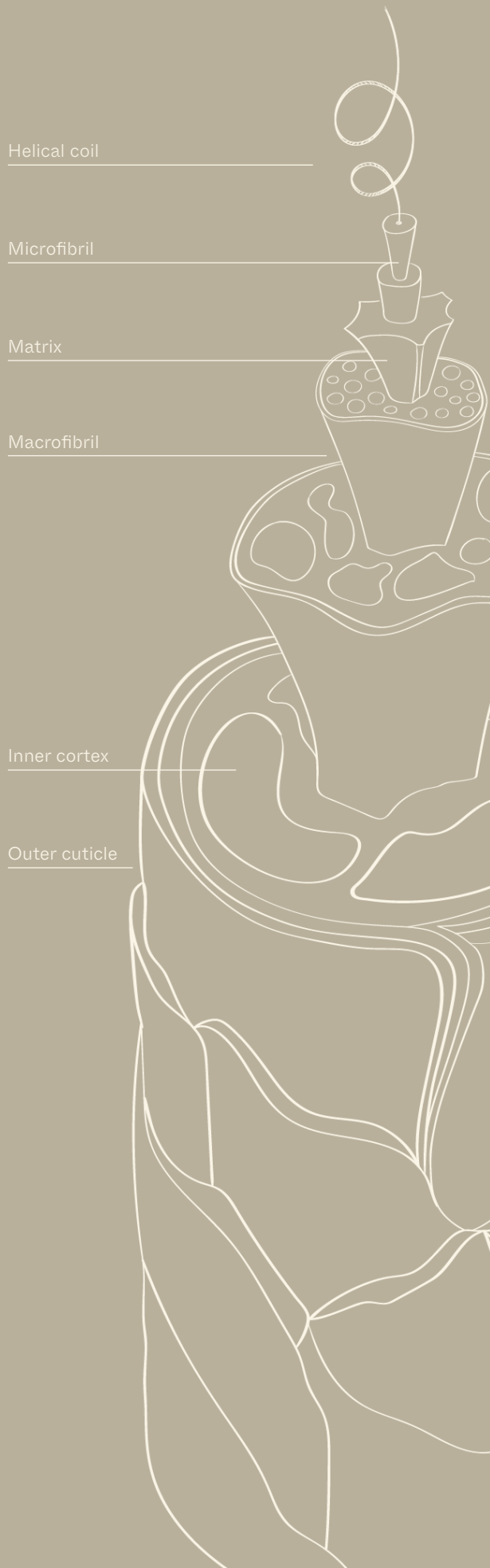
neweFlex is made of 100% renewable materials containing no plastics or bioplastics. It is free of toxic chemical substances and will release neither microplastics nor toxic substances during its decomposition process.

Versatility of Wool in Modern Textiles

Wool is a natural, renewable fibre produced by sheep, who grow wool in the same way humans grow hair.

Wool has a complex fibre and chemical structure enabling it to deliver many properties. Wool has a proven record in thermal insulation, moisture management, and the ability to capture volatile organic compounds (VOCs).

Wool’s complex fibre structure offers unmatched versatility, providing thermal insulation, moisture management, and the capture of volatile organic compounds.



Wool: Fibre morphology and thermal properties

The thermal resistance of wool is primarily due to its unique fibre structure and intrinsic properties. Two key mechanisms contribute to wool's excellent thermal resistance; fibre morphology and inherent characteristics such as low thermal conductivity, thermal absorption and moisture management [1, 2, 3].

Wool fibres have a complex morphology, where two main features are decisive in wool fibres thermal comfort regulation; the inner cortex and outer cuticle. The inner cortex is responsible for many of wool's key properties, such as its strength, elasticity, and ability to absorb moisture. The outer cuticle is the outer surface of a wool fibre formed from microscopic scales that overlap like shingles on a roof. This structure helps to trap additional air and contributes to the fibres' insulating properties. Additionally, wool fibres are naturally crimped, creating a three-dimensional structure that traps a significant amount of air within a fabric. This trapped air acts as an insulator, reducing heat transfer.

WHY WOOL?

Did you know?

Wool can retain or release heat and moisture, helping the body stay comfortable in hot, cold, dry, or wet microclimates [4].

Thermal conductivity and absorption

When wet, all fibres demonstrate an increase in thermal conductivity as water is more heat conductive than air.

A similar trend applies for thermal absorptivity (cool or warm touch). Dry materials feel warmer due to low thermal absorptivity. When wet, the absorptivity increases as water conducts heat away from skin and therefore materials feel cooler.

Wool's Thermoregulating Properties for Enhanced Comfort

Dry wool fibres have a low thermal conductivity, meaning they do not easily transfer heat. This property helps to maintain warmth by preventing heat loss from the body.

When wet, wool fibres initially feel cool, but as water is absorbed into the inner cortex, the wool fibre surface dries and quickly feels warm to touch again.

Wool's natural thermoregulating properties, means it can buffer temperature changes, contributing to its insulating effect. This results in wool-based materials providing improved thermal comfort compared to synthetic materials.

Wool: The Ultimate Fibre for Comfort and Odour Control

Wool fibres offer exceptional benefits in textiles, particularly for comfort and odour control. Wool's natural crimp and structure create air pockets that provide excellent insulation, keeping the body warm in cold conditions while remaining breathable in warmer climates. Its hygroscopic nature allows it to absorb up to 30% of its weight in moisture without feeling wet, effectively managing and maintaining comfort [5]. Wool also has natural affinity to gas molecules due to its unique chemical structure, which makes wool effective in binding and trapping odour-causing substances. This combination of moisture management, breathability, and odour capture makes wool a conspicuous choice for application beyond standard clothing and high-performance textiles.

WHY WOOL?

Did you know?

Wool's natural moisture absorption and odour control make it a game changer for hygiene products.

Unlocking Wool's Untapped Potential in Technical Nonwovens

Wool's unique properties offer added benefits in nonwoven applications where these performance advantages have not previously been considered, such as hygiene products.

Wool Use in Hygiene Applications

Although wool has not been widely used in modern disposable sanitary products, wool has played a key role in historical hygiene solutions, such as cloth diapers, menstrual garments, and even early forms of tampons. Wool's natural absorbency and breathability made it a preferred material for reusable products like diaper covers and period garments for many decades. However, with the rise of petroleum-based materials, the sustainable and practical benefits of wool for hygiene applications have largely been forgotten.

Today, wool is experiencing a resurgence as consumers increasingly seek environmentally friendly personal care options.

Wool: Thermal Comfort and Wellbeing

Closely related to thermal comfort is the human perception of wellbeing with regards to temperature sensations. Skin is the largest organ in the human body equipped with thermoreceptors responsible for detecting temperature changes.

Babies have thinner skin and larger skin surface area to body mass than adults therefore are more sensitive to temperature changes and their effects. Babies are unable to regulate their body temperature as well as adults and use a large amount of energy to keep warm, especially in cold environments [6]. It has been suggested that just a one degree celsius change in skin temperature can shift a baby's oxygen use by 10% [7].

Sleep is the primary activity of the baby brain during early development. Ideally undisturbed sleep is critically important for infants' cognitive development. Undisturbed sleep is possible due to regulated thermal conditions during sleep. A reported infant weight gain of up to 61% was recorded for underweight newborn babies when they slept on wool underlay instead of cotton due to superior thermoregulatory properties [8].

Wool: Odour Control

Wool's gas adsorption mechanisms involve both physical and chemical interactions due to its complex structure and functional groups. Wool fibres have an intricate physical structure with many scales and pores. This structure allows the physical entrapment of odour molecules within the fibre matrix. This is followed by chemical interactions between wool and odour compounds [9, 10].

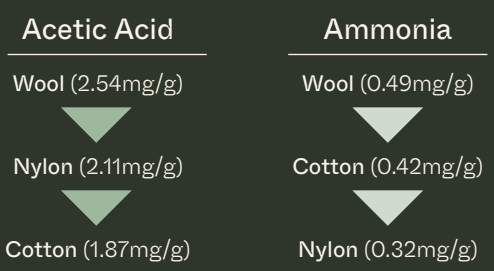
Wool is composed mainly of keratin, a fibrous protein also found in human hair and nails. Keratin contains a variety of functional groups such as amino (-NH^2), carboxyl (-COOH), hydroxyl (-OH) and sulfyldryl (-SH) which are key to wool's ability to interact and neutralise odour molecules. These functional groups allow wool to form hydrogen bonds and ionic interactions with volatile organic compounds (VOCs) responsible for bad odours, such as ammonia and acetic acid.

Due to their chemical structure, wool fibres have a natural affinity for odour-causing molecules. The amino groups (NH2) in keratin can react with acidic odorants (like acetic acid) through hydrogen bonding and ionic interactions allowing binding and trapping of odour molecules within the wool fibre structure [9]. Similarly, basic odour molecules like ammonia can also be captured by wool through adsorption onto the fibre surface.

Wool's Superior Odour Adsorption

Wool outperforms both cotton and nylon in neutralising odours, with a higher adsorption capacity for acetic acid and ammonia [10]. Thanks to its unique keratin structure, chemical functional groups, and balance of hydrophilic and hydrophobic properties, wool effectively traps and neutralises odour molecules, making it a powerful natural solution for odour control.

Wool exhibits a higher adsorption capacity for acetic acid and ammonia compared to cotton and nylon, which can respectively represent cellulose and hygroscopic synthetic materials commonly used in hygiene products.



Wool: Biodegradability

Biodegradation is a natural process in which microorganisms break down matter and consume it without generating compounds which are hazardous to the environment. Wool fibres are made of keratin (like human hair) and grow naturally on sheep.

Wool products demonstrated close to complete degradation after 6 months in moist and warm conditions such as soil, whilst acting as soil conditioner and fertiliser [11].

Fibres buried in soil are exposed to activity of microorganisms, bacteria and fungi which exploit fibres as a nutrient source [12]. The gradual decomposition of wool fibres occurs by cleavage of disulphide bonds and hydrolysis of peptide bonds catalysed by extracellular keratinolytic enzymes.

Wool Degradation in Marine Environments

Research has been conducted into marine condition degradation, with advanced deterioration after 7-8 months, the evidence also showed that if consumed, wool fibres are likely to be processed by the animal digestive system [13].

Wool is comprised of 50% carbon and other key nutrients to support plant growth, such as nitrogen, hydrogen, potassium, sodium, iron, phosphorus [14].

Provenance of Wool

Wool is one of nature's most extraordinary renewable materials, known for its versatility and long history as a trusted fibre. As one of the earliest fibres used by humans, wool has clothed and sheltered people for thousands of years due to its warmth, insulation, and durability.

Today, wool stands out not only as a sustainable and functional material but also for its health and wellbeing benefits. Its natural ability to regulate temperature, manage moisture, and capture allergens and pollutants makes it ideal for enhancing comfort and promoting healthier living environments.

Regenerative farming practices are transforming the wool industry by improving biodiversity and promoting animal welfare.

Regenerative Farming & Wool: A Path to Sustainability & Animal Welfare

Wool growers are at the forefront of regenerative land management, enhancing biodiversity, soil, and water quality while significantly reducing wool's environmental impact [15]. Many initiatives, especially in countries with a rich sheep farming heritage, have driven positive changes in farming practices, with a strong focus on promoting animal welfare and sustainable land use.

Strict standards now govern both environmental stewardship and animal welfare, ensuring wool is ethically sourced. Farmers and suppliers adhering to these standards receive certification, and traceability of wool fibres back to the farm is now standard practice. This transparency offers consumers confidence that wool products are sourced responsibly.

New Zealand, in particular, has become a global leader in this movement, maintaining high animal welfare standards and becoming the first country to ban mulesing in 2018, setting an example for others to follow.

SHEARING WOOL

Did you know?

Wool shearing isn't just for harvesting – it plays a vital role in animal wellbeing.

Shearing relieves sheep from heat stress, prevents parasites, improves mobility and helps maintain the sheep's general health and wellbeing of their offspring during the lambing season.

Wool & Carbon

Wool grows from the follicles in the skin of sheep, and its growth is powered by the nutrients the animal consumes, particularly carbon. The carbon in wool comes from the atmosphere, absorbed by the plants sheep eat through the process of photosynthesis. As sheep consume grass and other vegetation, they ingest carbon, which is then transformed into the keratin protein that makes up wool fibres. During photosynthesis, plants convert carbon dioxide (CO_2) from the air into organic compounds like glucose, which become part of the plant structure. When sheep eat the plants, this carbon is incorporated into their bodies and ultimately into the wool they produce. Wool thus serves as a natural reservoir for carbon, temporarily locking it in a durable, renewable fibre [16].

Wool's Life Cycle Assessment (LCA) is comparable to cotton but offers better water management and biodiversity benefits. As a renewable, biodegradable resource, wool sequesters carbon, with 50% of its weight being organic carbon. It decomposes naturally, returning back to the soil to repeat the natural carbon cycle.

Despite methane emissions from sheep increasing its carbon footprint, regenerative farming can offset emissions by improving soil carbon sequestration [17].

Diaper materials and construction, market size

Millions of people around the globe use disposable absorbent hygiene products on a daily basis. These absorbent hygiene products, such as baby diapers, femcare and adult incontinence care, offer a practical, convenient and affordable solution for personal hygiene and care needs across diverse global communities. Disposable products are especially popular because they reduce the need for cleaning and maintenance, save time, and provide a hygienic solution that minimises exposure to bacteria and infections. In short, disposable hygiene products are a daily life essential for many people.

Components such as topsheet, ADL, core and leg cuffs are constructed from nonwoven fabrics. According to European nonwoven association (EDANA), in 2019 absorbent hygiene products constitute the largest market share to the nonwovens industry by volume [18].

Key Components of Absorbent Hygiene Products

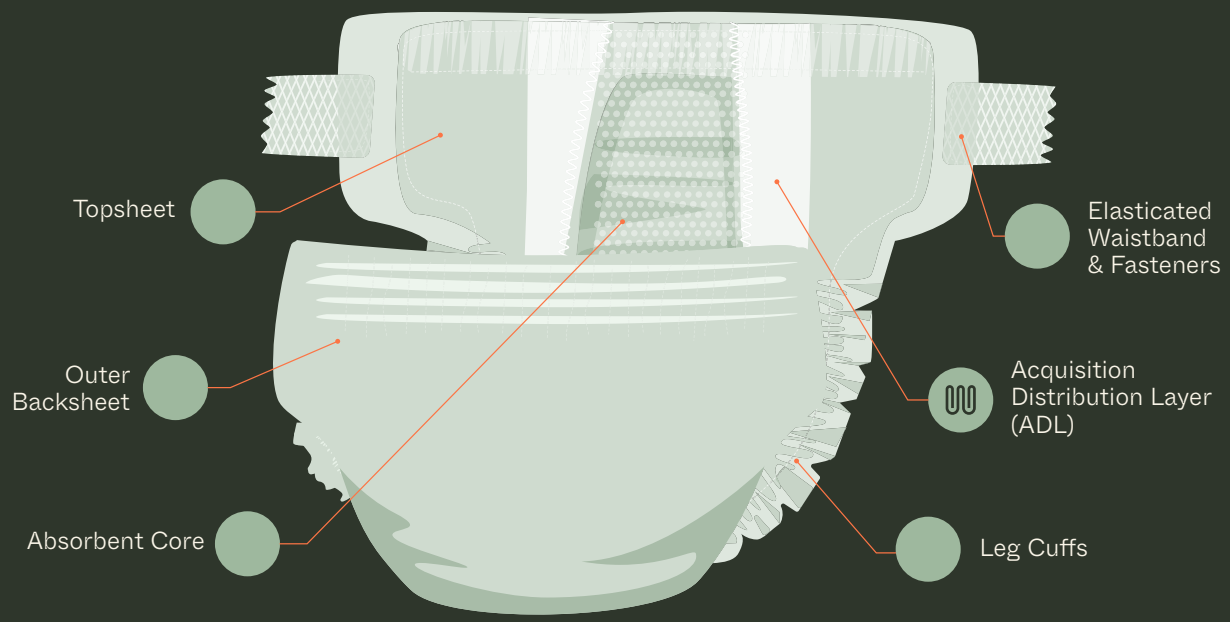
Absorbent hygiene products are complex, multicomponent designs, comprising layers of nonwoven textiles, each of which is designed and chosen to impart specific functionalities to the final hygiene product.

Currently, the majority of diapers are constructed from nonbiodegradable petroleum-based polymers (such as polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET)), cellulose fibres and non-biodegradable superabsorbent powder (SAP).

Hygiene applications

Hygiene applications are the largest market for nonwoven disposable products. The global baby diaper market was valued at USD 85.2 billion in 2023 with projections to reach USD 159.3 billion in 2032, at 7% CAGR between 2024 and 2032 [19].

Key Components of Absorbent Hygiene Products

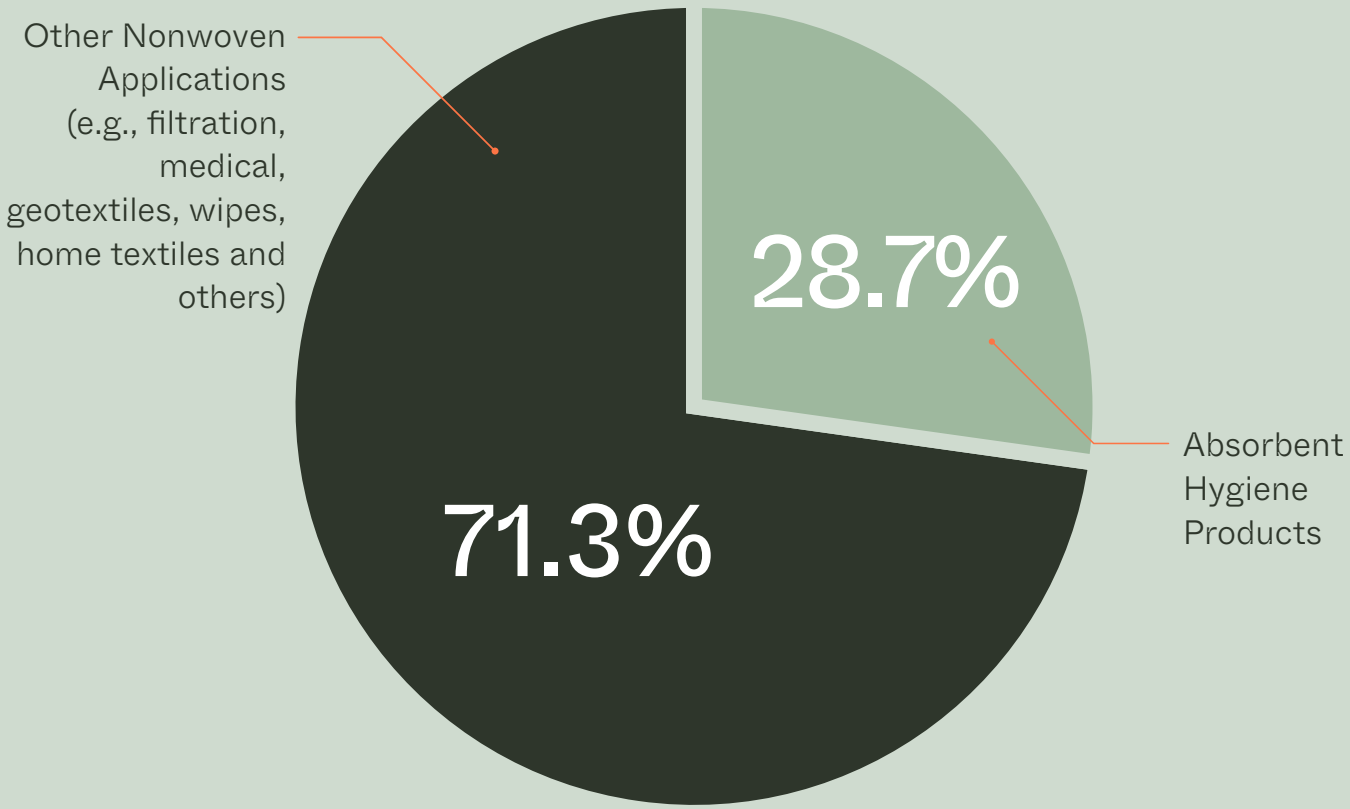


It is estimated that a total of 167 million disposable baby diapers are produced worldwide each year from 248.5 million barrels of crude oil. Globally, this generates 38.4 million tons of solid diaper waste each year. The Ellen McArthur Foundation reports that over 300,000 disposable diapers are landfilled, incinerated or disposed of every minute [20].

This data excludes other hygiene products such as femcare (pads/ liners) and incontinence products (liners, pads and diapers).

This evidence shows the excessive amount of absorbent hygiene product waste and demonstrates the burden they pose at the point of their disposal [20].

Absorbent hygiene products in the European nonwoven industry (2019) Market share by volume [EDANA][18].



From Landfills to Compost: Evolving Diaper Disposal Methods

Rising consumer environmental awareness, and heightened product end-of-life responsibility of producers in the shift towards a more circular economy model, have motivated initiatives to minimise the environmental impact of single use diapers and resource extraction, emissions and water usage in their manufacture. European and North American hygiene products brands are leading the way in advancing these initiatives.

INITIATIVE MAIN GOALS

01. **Short Term:** Create toxic free waste for landfill disposal

02. **Medium Term:** Adopt alternative disposal routes like industrial or home composting.

03. **Long Term:** Advance the waste recycling and reuse of the recovered materials.

Additionally, in many second and third world countries, the infrastructure for collection of communal waste is limited or non-existent. Some of these communities seek the use of disposable hygiene products as limited water sources restrict the option of washing soiled reusable diapers.

These communities would benefit significantly from the use of alternative disposal options independent to existing infrastructure, such as soil composting.

The Shift Towards Biobased Materials in Diapers

The shift away from the use of petroleum-based materials in disposable diapers is undeniable.

Manufacturers are increasingly focusing on the origin of materials used in diaper construction, often highlighting the use of environmentally friendly components by reporting percentage of biobased content in their products. In 2019 only 30% of raw materials used in nonwoven industry are renewable-based materials, leaving the larger 70% portion of petroleum based to be gradually replaced by renewables as one of the main industry targets for sustainable supply chain initiative (part of the nonwoven association vision (EDANA sustainability vision 2030))[21]. Renewable materials are generally known as natural materials or materials derived from natural renewable sources (bio-polymers). For diaper construction mainly polylactic acid (PLA), biobased polyethylene (bio-PE), biobased polypropylene (bio-PP), regenerated cellulose fibres (viscose and bamboo viscose), and natural fibres (cotton, woodpulp) have been reported to be used, hemp and seaweed-based fibres have been reported as emerging in the application space [22].

The Rise of Eco-Friendly Diaper Alternatives

Many companies currently offer eco-friendly diaper alternatives (ECO by Naty, Bamboo nature, Beaming Baby, Dyper Bamboo, Ecoriginals, Kit &Kin, etc.). However, most of these diaper constructions are based on cellulose, plant-based bio-polymer fibres, and with some still containing nonbiodegradable components to maintain acceptable functionality. Many do not list an ADL layer, which if not present, inevitably hinders their performance. The biobased content is definitely a move in the right direction regarding minimising negative environmental impact of diapers. However, some biobased materials still possess challenges for the diapers' disposal.

The Environmental Impact of Diaper Materials in Landfills

In landfill, diapers constructed using extruded petroleum-based polymers may leach toxic heavy metals into the environment as these are often used as catalysts in their synthesis [23].

Bio-PE and bio-PP are often preferred by manufacturers and converters for their well understood behaviour in processing as they are structurally similar to their petroleum-based counterparts, which therefore hinders their biodegradation rate and they are considered non-biodegradable.

PLA is fully biodegradable in specific controlled conditions, which likely differ from conditions in landfills, hence limiting its degradation rate.

DIAPER INNOVATIONS

Did you know?

Drylock has developed a baby diaper made from up to 90% natural, plant-based materials that is fully biodegradable in industrial settings. Companies like Ontex, in collaboration with Woosh, are also innovating with hybrid diaper systems, combining reusable cotton outer layers with disposable, industrially compostable pads [24, 25].

Comparing Compostability: Biopolymers vs. Natural Fibres

It is understood that biobased PE and PP are not biodegradable and hence unsuitable for composting. It is also well established that PLA is compostable only in specific controlled conditions and therefore products comprising PLA must be collected and subjected to composting in designated industrial facilities.

PLA, although manufactured from renewable feedstock, is still considered to generate microplastics during its decomposition process which accumulate in the environment and are harmful to living organisms. Soil (home) composting is not a viable option for PLA containing products. On the contrary, natural fibres, including wool, and cellulose fibres have been reported to be successfully biodegraded in soil without generating microplastics [11, 26].

Barriers to Economically Viable Diaper Recycling

The complex, multi-layered construction of disposable diapers presents significant hurdles for recycling. Currently, diaper recycling remains in its trial stages, with companies like Unicharm, Woosh, Fater, and Kimberly-Clark ANZ exploring potential solutions. Progress, however, has been slow due to challenges in waste collection logistics, the low market value of recovered materials, and concerns about contamination from biological waste. As a result, most hygiene products continue to be disposed of through traditional methods like landfill or incineration, leaving the industry searching for more sustainable, economically viable options.

To achieve fully compostable, plastic-free diapers, the industry must shift towards renewable, biodegradable materials.

Challenges & Opportunities in Creating Plastic-Free Diapers

The absorbent hygiene industry faces an urgent need to advance towards fully compostable, plastic-free products by incorporating renewable, natural, and biodegradable materials. While biopolymers were once seen as a solution, their tendency to generate microplastics during degradation has shifted the focus towards more sustainable options, such as nonwoven fabrics made from natural or cellulose fibres.

Although cellulose fibres excel at absorbing liquids, they can sometimes hinder permeability and fluid transport within key layers like the topsheet and Acquisition Distribution Layer (ADL). In contrast, wool, with its proven performance, offers a promising natural alternative that can enhance liquid management and contribute to the industry's goal of creating eco-friendly, high-performance diapers.

Rethinking Sustainability in Consumer Products

The global push for plastic reduction, increased use of renewable resources, and improved product recyclability is reshaping the way consumer products are designed, manufactured, used, and disposed of. Single-use products, in particular, are under scrutiny, as the resources invested in their production far outweigh the brief time they serve before being discarded. However, simply banning these products isn't a practical solution, as they often play an essential role in improving consumers' quality of life. Instead, the focus is on redesigning these products to minimise their environmental impact while maintaining their functionality.

Achieving greater sustainability in consumer goods is a multifaceted challenge. Some changes, such as the selection of raw materials, can be relatively straightforward—especially when choosing natural, ethically sourced materials with a proven track record of performance and safe disposal options. However, other aspects may require more complex, long-term solutions, with success varying across regions and societies. In all cases, moving toward sustainability is essential for creating a more responsible, eco-friendly future.

Revolutionising Single-Use Products with Wool-Based Innovation

Single-use consumer products, while essential for convenience and hygiene, often come with significant environmental costs due to the materials used and their disposal methods. Items like wipes, hygiene products (babycare, femcare, incontinence care), and medical devices such as wound dressings, are key examples that benefit society but burden the planet.

Integrating wool fibre-based nonwoven components into these products, particularly diapers, offers a sustainable solution. When designed effectively, wool ensures:

Renewable Origin

Materials derived from sustainable, renewable sources to reduce environmental impact.

Ethical Traceability

Fully traceable supply chain, ensuring materials are ethically sourced from farm to consumer.

Performance Compliance

Constructed to meet stringent industry standards for quality, safety, and reliability.

Enhanced Comfort

Provides superior thermal insulation and effective odour capture for maximum comfort.

Toxin-Free Disposal

Biodegradable materials that leave no microplastics or harmful toxins upon disposal.

Unlocking the Potential of Wool-Based ADL Solutions

neweFlex ADL stands as the only plastic free acquisition distribution layer (ADL) that not only matches the performance of synthetic alternatives but also provides enhanced thermal comfort and superior odour capture.

Wool-based solutions offer the perfect balance of performance, comfort, and environmental responsibility.

Beyond its clear environmental benefits, wool's ability to improve comfort may lead to a better night's sleep for babies - something every parent values. Additionally, the advanced functionality of wool will undoubtedly appeal to consumers of incontinence and femcare products, where leak prevention and odour control are top priorities. Wool-based solutions provide a sustainable, high-performing alternative for these essential products.

The versatility of wool fibre-based nonwoven structures opens up limitless possibilities for product design. Wool can be re-engineered to serve as a topsheet, an absorbent core component to maximise liquid distribution, or even as a nonwoven layer laminated with a backsheet to further improve odour control and moisture management. With the right innovations, natural wool fibres can transform product performance across multiple applications.

The future of sustainable hygiene starts today.
Contact info@woolchemy.com to transform your products with neweFlex.

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woolchemy™

Woolchemy is an innovation ‘mother’ company, formed with one goal in mind: to transform an abundant base material [wool] into something more valuable, using sustainable, environmentally friendly and ethical processes.

Inspired by a love of the land and versatility of sheep, Woolchemy transforms an underutilized traditional natural fibre [wool] into truly innovative, multi-use products. Woolchemy, is committed to providing ecological solutions to the everyday problems we all face in this fast-changing world.

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