

# Advanced technological solutions for interlinings

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## ABSTRACT

*Textile researchers and interlining manufacturers constantly improve their offerings and invent new solutions. French company Chargeurs and German company Freudenberg are leaders in the market with their product innovations. Currently, the most important development directions are stated for sustainable interlinings, lightweight interlinings, high elasticity interlinings, heat-sensitive interlinings and increased bonding strength interlinings. Many producers manufacture interlinings from recycled materials: polyester, thermoplastic elastomers, polyamide (PA), cotton, and wool. Few advanced ones are announced as biodegradable products. The new interlinings can be fused at lower temperatures, thus supporting the energy saving concept. Very light interlinings are developed to manufacture garments form very light or even transparent fabrics. Special high-elasticity interlinings are created to manufacture highly comfortable active wear, underwear, and casual clothing. Enzyme wash interlinings are manufactured from hot melt PA adhesive powder to withstand garments' high washing and dyeing temperatures. Water-soluble base material interlinings replace traditional tear-away stabilizers, creating embroideries. Water-soluble resin interlinings can be used to create casual and vintage-looking garments.*

## Keywords

garment interlinings,  
fusible resin,  
recycled interlinings,  
biodegradable interlinings,  
high elasticity interlinings,  
enzyme washing interlinings,  
water soluble interlinings,  
ultra-fine interlinings

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## 1 Introduction

Interlining materials are widely used in producing various garments, including men's suits, shirts, women's jackets, skirts, and trousers, as well as specialized clothing designed for protection against different weather and workplace conditions. Traditionally, interlining is a layer of material placed between the outer fabric and the lining of a garment. It is secured between two layers of fabric through fusing or sewing. The primary purpose of using these materials is to effectively shape the garment and maintain

its structural integrity during manufacturing and use. Interlining in garments serves several purposes, such as providing support, maintaining garment contour, reinforcing components, enhancing strength and visual appeal, and improving overall performance during wear [1-3]. Nowadays, the functions and application of interlinings have expanded significantly, with materials and production technologies diversifying. Typically, interlinings are soft, thick, and flexible fabrics made from cotton, nylon, polyester, wool, viscose, or their blends, often coated with resins using weaving, knitting, and non-woven technologies [1,4,5]. The interlinings can be affixed to the face fabric of the garments with invisible stitches, adhesive resins, or other more advanced methods. The rapid and constant development of advanced textile materials with improved functional and aesthetic qualities necessitates researchers and interlining manufacturers to enhance the traditional range of interlinings and devise new solutions.

This review aims to explore and evaluate advanced technological solutions for interlinings in garment construction. It investigates the latest interlining materials and technology solutions, including smart textiles, eco-friendly options, and printed interlinings. The review also presents the trends and challenges in interlining manufacturing. Furthermore, it discusses sustainable interlining, produced from recycled raw materials, and biodegradable and energy-saving interlining materials manufacturing. The review also addresses specific interlinings for very light fabrics as well as water-soluble interlinings. Additionally, it presents the most prominent interlining manufacturers. By identifying current trends and future directions in developing and applying interlinings within the textile and fashion industries, this review aims to provide best practices for selecting and implementing advanced interlining solutions to enhance garment quality and production efficiency.

## **2 Results and discussion**

### **2.1 Advanced technological solutions**

The scientific and professional literature describes various new technologies that can be used to enhance the face material components of clothing in a revolutionary and innovative way. Several studies have been conducted to apply high-density macromolecular compounds and resin directly to the cut components of the face fabric of garments, using methods such as screen printing or digital printing. Such garment components could be kept two-dimensional or molded creating needed 3D shapes. Printed interlinings present several notable advantages as they eliminate the need for base material, thereby decreasing the consumption of raw materials and energy resources in the apparel manufacturing process [6,7].

Smart interlinings are expected to enhance the functionality of high-performance garments soon. They will be able to heat or cool down a garment, regulate the moisture level of the human body, and add antimicrobial properties to the clothing. Widely utilized digital printing methods make it possible to create also intricate patterns on interlinings and to add new, aesthetic values to garments [8].

### **2.2 Trends and challenges in interlining manufacturing**

While textile researchers are developing new revolutionary technologies, industry professionals improve their interlining offer to follow actual demands in the fashion market. Different sources of information point out the most important directions in interlining manufacturing for the following 5-10 years [6,9,10]:

- *sustainable interlinings* – to support manufacturing of sustainable clothing labeled with different eco-textile certificates,
- *lightweight and very thin interlinings* – to conform with the currently widespread use of very light and transparent fabrics in the fashion industry,
- *highly elastic, breathable, and moisture-wicking interlinings* – to conform with the increasing demand for high-comfort sportswear, underwear, and casual clothing,
- *heat-sensitive interlinings* – to bond with delicate heat-sensitive face fabrics and all other kinds of textiles at lower temperatures, thus reducing energy consumption,

- *interlinings with increased bonding strength and longevity* – to withstand ready garment dyeing and enzyme washing in high temperatures at the end of their manufacturing process, as well as to withstand multiple washing and dry-cleaning cycles during the use period of the garments.

The interlining manufacturers also mention several challenges in their business that have become actual during the last years [9,11]:

- following the current fashion trends, casual garments are manufactured with very few interlinings or without them at all;
- the market is saturated with wide offers of low-price fusible interlinings;
- part of apparel manufacturers' lack of good understanding of the role of interlinings in garments;
- lately, stringent regulations control the use of different chemicals in textile product manufacturing.

## 2.3 Sustainable interlinings

With the growing interest in eco-friendly products across various industries, interlining manufacturers are creating a variety of new solutions to cater to clothing brands that have different sustainable textile product certifications such as the Global Recycled Standard (GRS), OEKO-TEX® STANDARD 100, Organic Content Standard (OCS), Global Organic Textile Standard (GOTS), and others [10,12-17].

### 2.3.1 *Interlinings from recycled raw materials*

The advancement of recycling technologies [18] significantly impacts the production of interlining materials, as manufacturers are now exploring using recycled fibers and yarns. This shift is closely tied to the specific manufacturing technology employed for interlining, whether woven, non-woven, or knitting. Many interlining producers are manufacturing interlinings from recycled natural and man-made raw materials – recycled polyester, thermoplastic elastomers, polyamide, cotton, and wool [19,20]. Reused plastics and man-made textiles do not end up in landfills or oceans and do not pollute the environment. The quality of interlinings manufactured from recycled polyester and thermoplastic elastomers is as good as using virgin man-made raw materials. Polyamide 6 is used to manufacture thermal insulation waddings/paddings for clothing. It can keep the same high-performance characteristics even after multiple recycling processes [21].

Recycled raw materials in interlinings can be used in 100% or lower content (from 20%) mixed with other virgin or recycled materials, such as polyester, polyamide, cotton, and wool.

### 2.3.2 *Biodegradable interlinings*

Numerous studies are being conducted to find alternatives to petroleum-based synthetic materials traditionally used in interlinings. These alternatives include natural-origin synthetic or biodegradable polymers that can decompose in microbiologically active soil after their useful life [22,23]. Freudenberg Company is a pioneer in the field of developing biodegradable interlinings. They have created two kinds of biodegradable interlinings: biodegradable thermal insulation wadding for sportswear and outerwear and a biodegradable fusible cotton interlining for collars, cuffs of shirts, and other applications.

Biodegradable thermal insulation wadding comfortemp® NATURE HO 60xK by Freudenberg is manufactured from 100% cellulose-based Lyocell fibers. It degrades in soil within 2 months. In 2022 ISPO, Textrends was declared as a particularly innovative product in the fashion industry [24].

In 2023 company, Freudenberg announced the first biodegradable fusible interlining [25]. Petroleum-based synthetic materials (PES, PA, HDPE, LDPE, and others) are used as adhesive resin manufacturing fusible interlinings. They do not degrade in nature even when applied to natural-origin-based materials. Shirt fusible interlinings in the 46xx range by Freudenberg are developed from cotton based material (with Oeko-Tex 100 Class 2 certification) and a biopolymer adhesive. Both materials – the cotton based material and the adhesive are biodegradable – can degrade in soil within a month [26,27].

To avoid the use of non-recyclable and harmful substances in fashion goods, non-fusible cotton interlinings have become available in the market during the last years [9]. As cotton is an organic biodegradable material and chemical adhesives are not applied to the base fabric, the interlinings are eco-friendly. Compared to traditional fusible interlinings, they are lighter, have better breathability, with higher durability and moisture-wicking properties. They help to create ready garments with a soft hand feel and casual or vintage look. Non-fusible interlinings from 100% organic cotton can be used for GOTS-certified fashion goods manufacturing [26,28,29].

### 2.3.3 *Energy-saving interlinings*

The new generation interlinings also have good potential to support energy saving concepts as the fusing process can be performed in lower temperatures and shorter periods [9]. Most parts of traditional fusible interlinings are coated with adhesives that require fusing temperatures above 140 °C [4]. High temperatures can easily damage many of the latest, new-generation heat-sensitive and delicate fabrics. The heat-sensitive advanced interlinings bond with the face fabric at lower temperatures – only up to 130 °C, thus reducing energy consumption by up to 10-20% [9,27,28]. Interlinings from recycled raw materials can also be claimed as energy-saving products as the recycling process does not require petroleum, and it can be done using less energy and natural resources than manufacturing new raw materials [26].

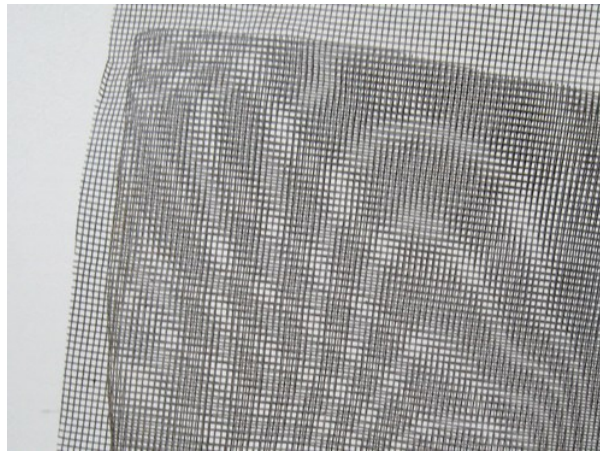
## 2.4 **Interlinings for very light fabrics**

Many fashion brands manufacture garments from very light, sheer, and even transparent textile materials. The manufacturing process of such delicate fashion goods is rather challenging. The interlining must support the stitching process without material distortions or seam puckering, and it also has to ensure the formation of correct and very precise shapes of small components. At the same time, the interlining has to maintain the initial flexible structure of the face fabric, must not add bulk to the face material, and has to be nearly invisible in a ready garment [8,28,31,32].

Leading interlining manufacturers have developed and still improve their special interlining offer for super light and delicate fabrics. These kinds of interlinings are extremely light – while the weight of the woven and knitted fabrics lies generally at 50-100 g/m<sup>2</sup>, the interlinings for light face fabrics are only 20-23 g/m<sup>2</sup>. The interlinings have bi-elastic woven or knitted base materials that are covered with higher mesh number micro-dot coatings to maintain the breathability of the face fabric and avoid adhesive strike back problems. To make interlining almost invisible in ready goods, black-dot, coloured, or transparent coatings are used, or base fabric is dyed in different colours (for example, Zero-Water Rainbow Collection by Chargeurs in 15 colors dyeing coating of the interlining) [31].

An undesirable optical moiré effect can appear when fixing light and transparent fabrics with low-weight woven interlinings (Figure 1). To prevent its appearance, the interlining needs to have a different weave construction and irregular pattern and can be knitted or manufactured from textured yarns.

The company Chargeurs produces knitted ultra-light interlinings that can prevent the creation of undesirable moiré effects on very thin face fabrics [28,31]. The company Freudenberg manufactures their super light interlinings in plain weave construction using textured yarns [32].

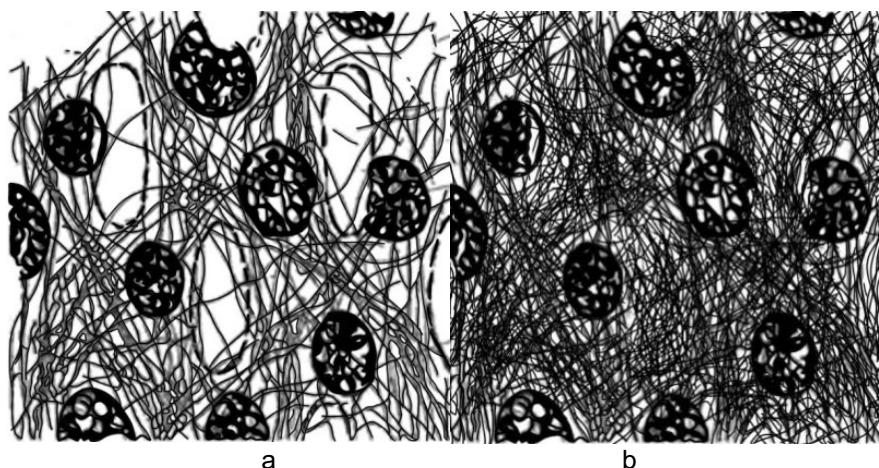


*Fig. 1 Moiré effect seen when two geometrical patterns such as grids are visually superimposed [33].*

## **2.5 High elasticity interlinings**

Manufacturing active wear, underwear, and casual clothing using highly elastic textile materials with special interlinings can maintain a flexible fabric structure for comfortable and well-fitting garments. The interlinings must ensure two important qualities – high elasticity and good shape recovery capabilities. Traditionally, elastic interlinings are manufactured from knitted base material due to its good adaptability and flexibility. However, new increased elasticity textile materials demand correspondingly increased flexibility interlinings.

Increased elasticity interlinings by Freudenberg are created with patented mesh/grid kind of base material – weakly, only in selected areas bonded fibrous web or non-woven textile (Figure 2) [29,34]. Such a structure ensures increased reversible elasticity and also good breathability of the interlining. In 2021, Freudenberg announced one more new solution to support highly elastic face fabrics – a bonding component in the shape of small dots is applied to the face material of the garment directly, not using any base material [35].



*Fig. 2 Fusible non-woven textile (a) bonded only in selected areas and (b) traditional fusible non-woven textile[35].*

Some manufacturers produce different weight elasticity woven and knitted interlinings from textured yarn base material (Figure 3). Relaxed yarn creates additional elasticity in the weft direction manufacturing bi-elastic interlinings.

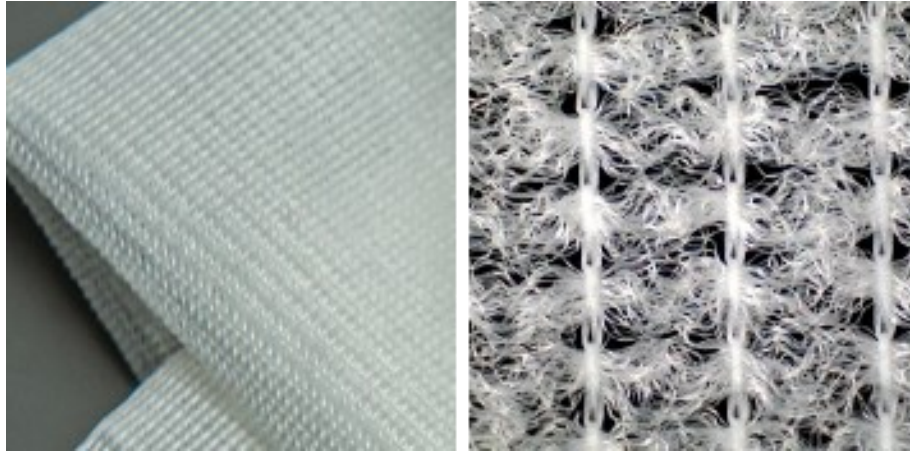


Fig. 3 Textured yarn base material by company Chargeurs [36].

## 2.6 Interlinings for dyeing and enzyme washing

Following current fashion trends, many clothing manufacturers use ready-made dyeing and enzyme washing to increase the material's softness and create a faded, vintage look to their casual garments. Most of these treatments are performed at high dyeing, washing, and drying temperatures. In manufacturing such garments, interlinings with special high-melt adhesives have to be used to withstand extreme treatment conditions [37].

Enzyme wash interlinings are manufactured from hot melt PA adhesive powder and chemical additives with double-point coating. Hot melt PA rubber powder is resistant to high-temperature washing (40-95 °C), dry cleaning, and enzyme washing. Double point coating ensures stronger bonding fastness. It is created from two layers of adhesive – a gel-like adhesive as the base, and a powdered adhesive is sprayed on it [388].

### 2.6.1 Water-soluble interlinings

Two types of water-soluble interlinings are available in the market: interlinings, which can dissolve in the water, and fusible interlinings covered with dissolvable resin. The first type of soluble interlinings is an alternative to tear-away fabric stabilizers traditionally used to stabilize a base on which embroidery embellishments, free-standing laces, and mesh-like fabrics are created. After embroidering is finished, the base material has to be removed. In the case of tear-away stabilizers, the base material is ripped off continuously using mechanical forces that can damage light and delicate fabrics. This problem is avoided using water-soluble interlining that can be thoroughly washed away by soaking finished embroidery in cold or warm water within few seconds. The water-soluble embroidery backings are also widely used in denim clothing manufacturing subjected to post-production ready garment washing [39-41].

Water-soluble interlinings are made from polyvinyl alcohol (PVA) fibers as thermos-bonded non-wovens (Figure 4a), films, or felt. Most dissolve in 20 °C water within 10-30 seconds (Figure 4b). The colorless and transparent solution is non-toxic and can decompose quickly, not creating any environmental pollution.

This kind of water-soluble interlinings can also be used as temporary support for stitching small and precise details (like collars, others) from very light and difficult to sew fabrics [40,41].

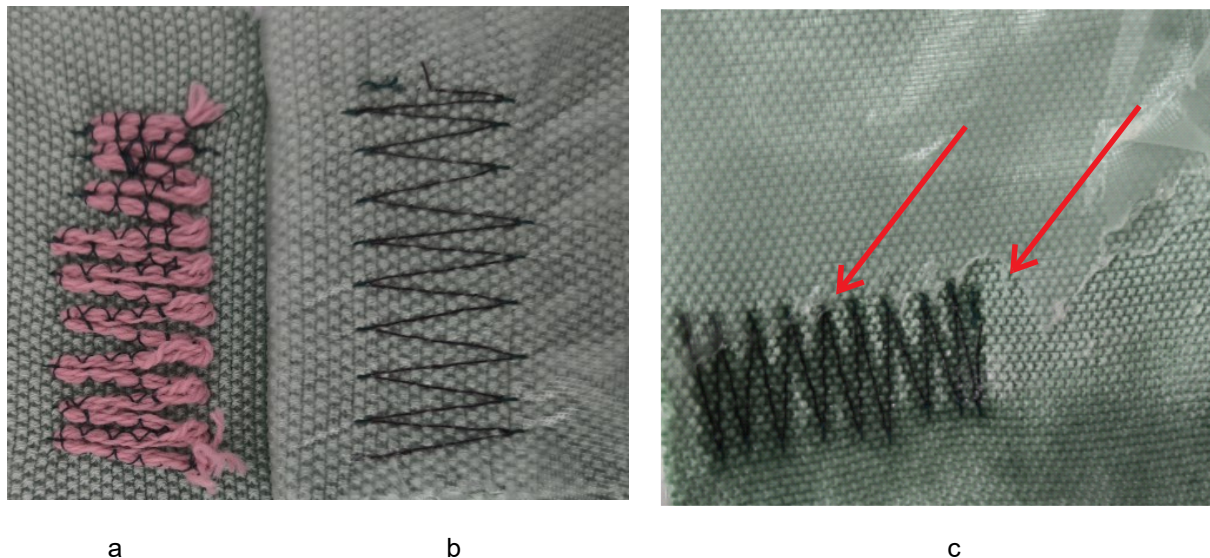


Fig. 4 Embroidery created on a water-soluble interlining: (a) ready embroidery, (b) back side of the embroidery with interlining before dissolving in water, and (c) back of embroidery with half soluble interlining.

The second type of water-soluble interlinings are fusible 100% cotton woven interlinings covered with water-soluble PVA resin [40]. They are used for processing small details, such as collars and cuffs of casual men's shirts. The resin dissolves during the ready garments' washing or dyeing process, leaving the interlining as a simple lay of permanent sew-in support. In this way, processed components of a shirt are not stiff; they get a relaxed, casual look and feel [42].

## 2.7 Leading interlining manufacturers

Two interlining companies – the French company Chargeurs PCC and the German company Freudenberg Performance Materials Apparel – are leading the fashion market with their sales results and significant product innovations.

### 2.7.1. French company Chargeurs (Chargeurs PCC)

The company Chargeurs manufactures interlinings and other inner components of garments for diverse applications, cooperating with the world's leading haute couture, luxury, and ready-to-wear fashion brands. It has production sites in France, China, Sri Lanka, Bangladesh, Argentina, and Brazil and innovation laboratories in New York, Shanghai, Hong Kong, Milan and Paris. Currently, Chargeur manufactures a wide range of traditional as well as advanced articles: anti-microbial, anti-abrasion, anti-moiré effect, flame resistance, water resistance, high elasticity, and moisture managing interlinings. At the end of 2022, Chargeurs announced its Zero-Water Rainbow Collection of sustainable knitted interlinings for luxurious and lightweight clothing manufacturing. The new interlinings are available in more than 15 colors, dyeing the adhesive material (not the base fabric) in a revolutionary waterless process. Chargeurs has also developed many eco-friendly interlinings manufactured from recycled or sustainable fibers. In 2023, 40% of products by Chargeurs were produced from recycled polyester, reducing water consumption in production processes by 80% [2828,31,44]. Already in 2020, cooperating with a company called CLO Virtual Fashion, the Chargeurs developed a "digital showroom" that enables testing newly developed garments, adding also interlinings into their 3D virtual prototypes [455].

### 2.7.2. German company Freudenberg (Freudenberg Performance Materials Apparel)

The company Freudenberg manufactures interlinings for different segments of the fashion industry. Their main business is concentrated on customers at the middle and lower price levels market of garment mass production and tailor-made solutions. The company is headquartered in Weinheim, Germany, with 33 production sites in 14 countries. Until last year, the interlinings for the European mass market were manufactured in Germany, while high-quality canvas for luxury men's suit brands was made in

Sant'Omero, Italy. In 2023, Freudenberg finished redesigning their production site in Sant'Omero into a center for finishing and coating of interlinings made in Germany [46,47].

For 40 years, Freudenberg has developed various wadding materials for sports and casual wear. The company has innovation centers and production sites in Europe, China, Japan, and South Korea for thermal insulation materials. In 2020, Freudenberg started to manufacture the H080x series of new generation wadding materials from polyamide 6 – the only synthetic fiber that can be recycled several times without losing its initial qualities. Currently, other parts of waddings by Freudenberg contain already 60-100% recycled polyester [468]. In 2021, the company presented its first biodegradable wadding made from Lyocell fibers, and in 2023 the first biodegradable fusible interlining from 100% cotton base fabric and biopolymer adhesive. In 2023, Freudenberg announced advanced cotton feel interlinings of the 37xx PES series from a 100% polyester base material and special finish. Having qualities and application similar to traditional cotton interlinings, the new polyester interlinings are more cost-effective and have increased durability, elasticity, and shape recovery than cotton ones, as well as, they are OEKO-TEX® STANDARD 100 Class I certified, making them fully safe for a human body and environment [478].

### 3 Conclusion

The interlinings in garments are a kind of auxiliary material as they cannot be seen visually in ready goods by their users. That is why clothing manufacturers do not always pay maximal attention to their right choice and application. However, they influence a wide range of very important garment qualities, starting from the design, manufacturing conditions, wear process, and recycling or degradation of goods at the end of their use period. Although current fashion trends support minimal and cursory use of interlinings, they demand sustainable products and the wish of society to end the fast fashion era and purchase ecologically responsible, high quality, and long-lasting textile goods, according to the interlining manufacturer's new resinous tasks.

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