

Research and Application of Nonwoven Materials in Fashion Design

Luning Li, Ying Zhang, Shuoyue Huang, Hejin Zheng, Huan Qi

College of Textile and Apparel, Quanzhou Normal University. Quanzhou, Fujian, China, 362000

Abstract: *This paper aims to promote the application research of non-woven materials in clothing design. It provides a detailed introduction to non-woven materials, covering their principles, origins, and types. Additionally, it summarizes the various types of non-woven materials and their application fields, and examines case studies of non-woven materials in clothing design. The analysis of the advantages and disadvantages of nonwoven materials in clothing design is presented, along with an exploration of the potential application of degradable nonwoven materials in this field.*

Keywords: *Non-woven materials; Fashion design; Medical protective materials; Functional clothing*

1. Introduction

The textile industry has high carbon emissions, causing serious environmental pollution in the industry. As the epidemic gradually comes under control, there is an accumulation of non-woven material inventory, posing problems of overcapacity that are difficult to resolve. In the 21st century, there has been a shift in consumer mentality, with people excessively pursuing the "new" and "change". The fashion industry is increasingly dominated by hedonism, encouraging and stimulating consumption by rapidly introducing new and glamorous products. The trend of fast fashion is unstoppable, with these fast fashion brands having large inventories and consumer bases. This leads to the so-called "fashion trends" becoming obsolete basically within a week, resulting in a large amount of waste clothing. Traditional weaving materials are difficult to recycle and reuse, leading to serious environmental pollution and resource waste.

Designing and producing clothing using biodegradable non-woven materials as the base material not only complies with China's current policy of 30/60 carbon neutrality, which is conducive to the sustainable development of fashion design, but also increases the value of non-woven materials in clothing design. This can alleviate the problem of overcapacity in woven products, reduce resource consumption and pollution caused by the clothing industry during production, and make people pay more attention to environmental protection and sustainable development. It encourages constant reflection on the profound meaning of current design and participation in carbon-neutral actions.

2. Overview

Nonwovens, also known as nonwovens or nonwovens, are fabrics that do not need to be formed by spinning and weaving processes. It forms a network structure by orienting or randomly arranging short fibers or filaments for textile purposes, and then reinforcing them by mechanical, thermal bonding or chemical methods. Its origin can be traced back to 3500-3000 BC, was originally made of various animal hair pressed, widely used in the production of protective clothing and tents. However, there are relatively few applications in the field of clothing. The research of non-woven fabrics at home and abroad is mainly concentrated in the field of medical and agricultural applications, and relatively little research in the field of clothing.^[1]

There are many types of non-woven fabrics, which can be classified into spunbond, meltblown, needle punched, spunlace, and thermal bonded, etc., according to different processing methods. Non-woven fabrics produced by different processing methods have different performance characteristics and are applied in various development fields such as medical hygiene, personal care, household cleaning, and industrial applications. Below is a brief summary and overview of the performance characteristics and application fields of different categories of non-woven fabrics.(See

table 1.)

Table 1: Types and applications of non-woven fabrics.

Processing mode	Taking advantage	Use defect	Application field
Spunlaced non-woven fabric	Feel good soft skin; High hygroscopicity; Comfortable and dry; ventilate	Hygroscopicity is determined by fiber composition. Poor structural stability, obvious difference in strength	Life beauty, medical health, civil cleaning industrial applications
Hot air non-woven fabric	Soft hand feel, good skin affinity, high shagginess	Poor moisture absorption, need to finish treatment	Sanitary material surface layer
Spunbond non-woven fabric	Good air permeability; High strength; Most widely used	Waxy texture, soft feel is not good	Agricultural medical storage packaging Clothing car lining, household household
Melt-blown non-woven fabric	Feel soft, breathable; Waterproof; Flame retardant	Fiber strength difference	Mask middle layer;
Needled non-woven fabric	Feel soft; Not easy to damage deformation; High hygroscopicity, water retention,	Have a certain thickness, strong sense of wool; Poor air permeability	Urinal pad, health care, transportation insurance
Stitch-bonded non-woven fabric	Feel soft and smooth; Good air permeability; High resilience; High strength; Various patterns can be printed	Low density is different from high density, and the higher the density, the higher the compactness	Eco-friendly shopping bags; Sofa cloth; Furniture tablecloth; Mattress cloth; Seat wrap cloth; Automotive supplies
SMS non-woven fabric	Light, high strength, not easy to tear, and has good fiber strength and filtration performance	The fiber is heavy and the processing process is complex	Medical field Sanitary materials
Elastic non-woven fabric	Soft, skin-friendly, comfortable; Be elastic; Good resilience; Pattern color choice	Poor tearing strength; Relatively light, strong penetration	Face mask, eye mask and ear band

3. Application of nonwoven materials in clothing

3.1. Medical protective clothing

Medical protective clothing is a protective clothing worn by medical personnel and people entering specific medical and health areas, mainly used to block viruses, bacteria, harmful particles and solutions and other substances to protect users from infection.^[2] According to different use occasions and needs, as shown in Figure 1, medical protective clothing is mainly divided into disposable medical protective clothing, isolation clothing and surgical clothing.

There are many kinds of nonwovens for medical protective clothing, the most important of which are laminate nonwovens and flash nonwovens for the production of medical disposable protective clothing, as well as SMS nonwovens and coated nonwovens for the production of isolation clothing and surgical clothing. Spunbonded nonwovens have become the most widely used nonwovens in medical disposable protective clothing because of their good water repellent properties and low price.^[3]

Compared with the international advanced level, China started late in the research and development and production of medical protective clothing, but the medical disposable protective clothing system is gradually established and improved. According to GB19082-2009 standard, the performance requirements of medical disposable protective clothing include protection, comfort and physical and

mechanical properties. Among them, the protection requirements include water resistance, moisture permeability, surface moisture resistance and filtration efficiency of non-oily particles. Comfort requirements include breathability, fabric thickness and softness; Physical and mechanical properties include breaking strength, elongation at break, breaking strength, wear resistance and so on.^[4]

At present, the development of new materials, the application of film coating technology, the preparation of composite nonwoven materials and functional finishing technologies have further improved the functionality, comfort and adaptability of protective clothing, which has become the leading direction of new medical protective clothing nonwoven materials. The application of these new materials and technologies will help to improve the performance and quality of medical protective clothing and better meet the protection needs of medical personnel.^[5]



Figure 1: SMS medical protective clothing, surgical clothing, disposable isolation clothing, in order.

3.2. Nonwoven materials for fashion design

Nonwoven interlining is one of the most widely used nonwoven materials in the field of clothing. It is made of non-woven material as a base cloth, after bonding coating or special processing, with light weight, soft, warm, breathable, moisture permeable, low cost, wide range of thickness change and strong adaptability.^[6] Back in the 1960s, Scott Paper Corporation^[7] Launched the paper mini skirt made of non-woven materials, which is the first appearance of non-woven materials clothing. The special texture and plasticity of this material go beyond the materials that designers are familiar with in traditional fields, and bring designers subversive innovation inspiration.

With the popularization of the concept of sustainable development, nonwoven materials have also received more and more attention. Today, nonwoven materials shine in the field of fashion, designers use unique design techniques to show the infinite possibilities and creativity of nonwoven materials, so that nonwoven materials in the fashion industry increasingly influential.



Figure 2: Design work of Textile College of North Carolina State University.

As shown in Figure 2, students at the College of Textiles at North Carolina State University skillfully used nonwovens to design and produce a range of fashionable clothing and accessories. Nonwoven materials are very different from traditional woven fabrics and can be bonded by hot melt, so the seams will not protrude. This characteristic makes the nonwoven fabric perfectly integrated into the clothing, adding a three-dimensional modeling sense to the clothing. In addition, because the nonwoven material has good drape property, the seams inside the garment do not need to be centralized.

In order to fully demonstrate the aesthetic effects and functional properties of nonwovens, students from the College of Textiles at North Carolina State University carefully curated a nonwovens fashion show at the 13th American Textile Center Forum and the opening dinner of the 84th Annual Textile Association World Conference. The show featured an amazing array of garments made from non-woven materials, including wedding dresses, gowns, dresses and hats. These works fully demonstrate the wide application and unlimited creativity of nonwoven materials in the field of fashion, and further consolidate the important position of nonwoven materials in the fashion industry.^[8]

The University of Leeds has been working on the application of nonwovens in clothing since 2005. As shown in Figure 3, important results of his research include unique series such as Colbond and Evolon. As a leading global producer of high-quality industrial nonwovens, Colbond's products were initially used in civil engineering, construction and other industrial sectors. The fabric of this material is mostly transparent, no drape, feel rough and strong rigidity. This means that in clothing design, the use of this material will face no small challenge. However, students at the University of Leeds have been ingenious in tackling these challenges, using multiple layers, folds and clusters to successfully incorporate these features into their designs. This initial success greatly motivated the Leeds students. As shown in Figure 4, they further explored and used Evolon and other nonwovens to develop more aesthetic and functional fashion clothing. In order to achieve this goal, students employ many advanced technologies such as combined elastic film composites, thermally active PCM, masterbatch additives, thermochromic finishes, as well as conductive fabrics, high temperature protective fabrics, metallized and multilayer spunbonded laminates. With the support of EDANA and its members, the collection was presented in 2008 at INDEX08 in Geneva and at the 7th Annual Conference of the Non-Woven Network UK, where it received widespread recognition and acclaim.

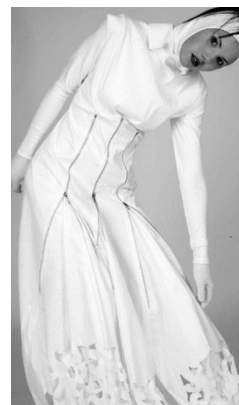


Figure 3: Leeds University series "Fashion synergy" Figure 4: Leeds University series "Function in action"

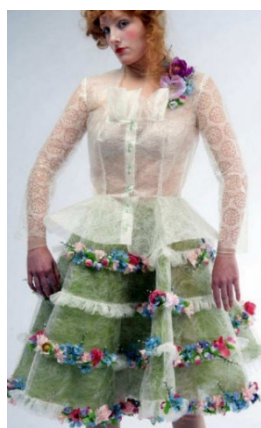


Figure 5: University of Leeds series transparency. Figure 6: University of Leeds series decoratif.

Students from the University of Leeds give full play to the transparent characteristics of nonwoven materials themselves, using laser cutting, beading, hand embroidery, etc., to make clothing present a strong sense of concept and story in the most modern way (Figure 5). High-frequency sonic energy is used to glue the seams around the body and cuff ridges, giving the garment a clean, sharp edge. "Decoration" is another series developed by the students (Figure 6), which combines exploratory research into beading, decoration, printing, and color techniques, from sketching with acrylic pigments

to machine dyeing and hand dyeing, to transform the fabric while also bringing out the diverse moods of clothing colors. In addition, in this series of clothing design, they replaced the traditional sense of zippers, buttons, hooks, etc., buttons are made of woven nonwovens, tie buckles instead of hooks and buttonholes, and elastic inserts instead of zippers, so as to make the clothing more fit and easy to wear.

In 2010, Lanzing Group, the world's leading artificial fiber marketing and manufacturing company, collaborated with the School of Design of the University of Leeds to design a series, as shown in Figure 7 and 8. This series of design students were asked to design a series of clothing using Lanzing Group's own unique bright fibers. Lanzing's eco-friendly cellulose fibers combined with bright colors, folds and seams give new definitions to garments that focus on the collision of colors, architecture and sculpture or shape, serious with a certain sense of fun. In April 2011, these fashionable nonwovens were presented at the Index11 PalExpo in Geneva under the theme "Architectural Color Clash".^[9]



Figure 7: University of Leeds Architectural colour clash. Figure 8: University of Leeds Architectural colour clash.

In 2013, the fashion design major of the School of Applied Arts of Helwan University in Egypt adopted non-woven materials to complete the design of a series of shirts. As shown in Figure 9 and 10, the design of this series of shirts not only adopted some original designs, but also combined beading, embroidery, digital printing, laser cutting and other means. This work has carried out the practice of applying nonwoven materials to clothing products.^[10]

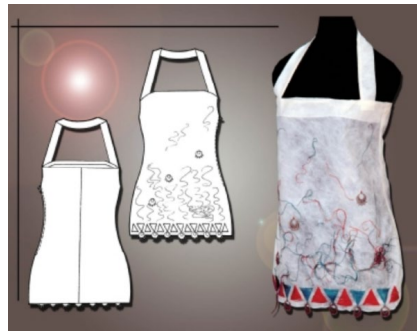


Figure 9: Series of works of the School of Applied Arts.



Figure 10: Series of works of the School of Applied of Helwan University in Egypt Arts of Helwan University in Egypt.

3.3. Nonwoven materials for functional clothing

As shown in Figure 11, in 2022, Nike launched the Nike Forward series to subvert tradition, using needled nonwoven fabric design to create a new sportswear, as Nike said, it has great potential to change the entire apparel industry. Use needles to create high-quality, sustainable clothing. It is worth mentioning that Nike Forward's innovative needling process combines multiple layers of fabric, and the fine holes generated in the process become the most iconic feature of this classic gray hoodie and crewneck hoodie, which is simple and reduces carbon emissions. This product does not have any superfluous modification such as zipper drawstring, on the one hand, it can reflect the original beauty, on the other hand, it can make the recycling process more convenient. Non-woven fabric gives this Nike Forward gray hoodie and crew-neck hoodie a soft, lightweight texture, and ribbed cuffs add texture. In addition, this series does not go through additional dyeing treatment, saving water resources, but also Nike's implementation of the concept of sustainable development.



Figure 11: Nike Forward collection of clothing.

As shown in Figure 12, Coperni 2023 spring/summer series release show showed a liquid spray from the upper body and quickly formed form-fitting dress, spray the upper body in only 15 minutes, and then through simple cutting and adjustment, then a white one-shoulder dress. The spray-on fabric, developed by technology company Fabrican, is a liquid made up of natural and synthetic fibers such as wool and mohair, cotton, nylon and cellulose, which is sprayed on the body by an aerosol or airbrush and then evaporates on contact with a surface to form a non-woven fabric. The fabric is not only capable of making ready-made garments on site, but can also achieve the effect of customizing and repairing garments, and is also strong enough to be re-worn and washed. As shown in Figure 13, Manel Torres presented a collection of creative spray-on clothes at the Science of Fashion show in 2010.



Figure 12: Coperni 2023 fashion show.



Figure 13: Manel Torres at the "Science of Fashion" fashion show.

4. Analysis of advantages and disadvantages of nonwoven materials in the application of clothing design

4.1. Advantages of nonwoven materials used in clothing

4.1.1. Improving production efficiency

The traditional clothing production process usually involves a number of tedious processes, and the production of non-woven fabrics is different. Non-woven fabrics are made by using heat bonding or adhesive bonding between fibers and fibers. In the production process of non-woven fabrics, the preparation of spinning and weaving is eliminated, and all these steps can be completed in the same factory, along a production line.^[11] In contrast, traditional woven fabric production requires more land and labor resources, while non-woven fabric production has a relatively low demand for both, which not only improves production efficiency, but also reduces production costs. Therefore, non-woven fabric production has significant advantages in terms of efficiency and cost.

4.1.2. Cater to consumer psychology

The trend of fast fashion development in today's clothing industry is unstoppable, and the trend of fast fashion is redefining the life cycle of clothing and related life cycles in certain industries. Nonwoven fabrics, depending on structure and composition, can be designed for single use and quick handling, or can be durable and able to withstand multiple washes and other losses. The life expectancy of a garment can be defined in days, months or years. These fabrics are designed according to the requirements. Therefore, the design and production of clothing based on degradable nonwoven materials is fully in line with the contemporary young people's pursuit of the trend, and the consumer psychology of the cost can better cater to the development trend of fast fashion.

4.1.3. Promoting the innovation and development of fashion design

The core of fashion design innovation lies in "new", and designers can promote the "new" of fashion design through materials, methods, concepts or new science and technology. And non-woven materials for designers to provide new materials, is also a new design ideas, so that designers are not limited to the traditional design materials, design ideas, to create a new design play, bring a new design concept. In the long run, the progress of nonwoven materials technology will bring transformative development to clothing design and constantly promote the innovative development of the clothing design industry.

4.1.4. Green and sustainable

At present, traditional clothing will produce a large number of chemical raw materials in the process of production and processing, which not only pollute and destroy the environment, but also difficult to degrade, and the recycling rate is low. Degradable nonwoven materials Non-woven fabrics are made of polylactic acid as raw material, and polylactic acid is a polymer obtained by polymerization of lactic acid as the main raw material. The production process of polylactic acid is pollution-free, and the product can be biodegradable to achieve recycling in nature. The design and production of clothing based on non-woven materials has deeply implemented the concept of sustainable development, which is very in line with the development trend of green environmental protection in the future clothing industry.

4.2. Problems existing in the application of nonwoven materials in clothing

The application of non-woven materials is limited by their material composition. Most non-woven fabrics are made from materials such as PP and polyester, which exhibit poor biodegradability and comfort properties. Material selection is constrained; for instance, spunlace, meltblown, and spunbond elastic non-woven fabrics offer softness, skin-friendliness, comfort, and good resilience, but they have lower tear strength and require improvement in abrasion resistance. Conversely, most spunbond, wet-laid skeleton process, needle-punched, edge-sealed, and SMS non-woven fabrics boast high strength, abrasion resistance, and tear resistance, but they lack in skin-friendliness and comfort. It is challenging to surpass the inherent properties of the original materials, and theoretical research in this area remains limited. Therefore, the author believes that domestic research should be supplemented and updated in a timely manner, and the market value can be realized through research from multiple perspectives.

5. Summary and outlook

There is a wide variety of non-woven fabrics, each with different tactile and performance characteristics based on their respective materials. Leveraging these diverse material properties, along with various coloring methods and design techniques, and integrating innovative design concepts, can not only fully utilize the advantages of the materials but also promote the diversified development of clothing design, bringing about profound changes in fashion design. As a green and environmentally friendly material, non-woven materials align well with China's policies regarding 30/60 carbon peak, carbon neutrality, and carbon footprint reduction, reflecting the principles of sustainable development and environmental protection.

From the consumer's perspective, the contemporary "Generation Z" has emerged as a major force in fashion consumption. This generation possesses independent cognitive abilities and distinct personalities, with a higher pursuit and acceptance of unique materials and textures. Therefore, for special materials like non-woven fabrics, they are more likely to be accepted, providing a potential customer base for the application of non-woven materials in fashionable products. Thus, we can see the vast development prospects of non-woven materials in clothing design.

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