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## 5.1

# Future Research Endeavours

*Pia Hautamäki, Ali Tehrani & Antti Oksanen*

In this chapter we cast our thoughts into the future and lead you to think about the activities that need to take place to pave the way for sustainable nonwovens in the future. The SUSTAFIT research project, conducted from September 2022 to 2024, focused on studying fit-for-purpose nonwovens. Our goal was to develop segment-specific sustainable nonwoven materials using eco-friendly fibres and chemicals, while also creating

environmentally friendly variants with enhanced performance through the exclusive use of natural agents for hydrophobising and antimicrobial purposes. We developed an understanding of various perspectives by studying sustainable nonwovens. Based on our work in the research project and the studies we reviewed, this chapter focuses on illustrating future research areas within the nonwovens sector.

# Sustainable Alternatives to Nonwovens


**The exploration of sustainable alternatives to traditional nonwoven products is a critical research avenue.**

As evidenced by the market's positive response to reusable products like cotton pads, menstrual cups, and beeswax wraps, there is significant potential for more environmentally friendly products that could replace or complement existing nonwovens (EDANA, 2023b).

Identifying materials that are both sustainable and capable of meeting the diverse requirements of nonwoven applications remains a promising yet challenging research goal. This effort aligns with the need to expand on exploring both the materials and the technological innovations that can enhance product life cycle sustainability. Thermoplastics like polypropylene are widely employed in single-use nonwovens manufacturing, yet substituting these with biodegradable alternatives like Polyhydroxyalkanoates (PHA) represents a significant advancement. Although current PHA production levels fall short of market demands, the landscape is set to rapidly evolve in the near future, promising a transformative shift toward more sustainable material choices.

Forests are, additionally, a valuable natural resource in Finland, providing an abundant source of wood-based cellulose fibres essential for nonwoven production. Cellulose is not thermoplastic and therefore meltblowing, the most common nonwoven production method, cannot be adopted for the production of cellulosic nonwovens. Common alternative methods for converting short wood-based fibres into nonwovens include airlaying, wetlaying, and foamlaying, while carding and needle punching are suitable for longer fibres. Each method presents distinct advantages and shortcomings when it comes to water and energy consumption. Future studies should delve deeper into these aspects, conducting thorough techno-economic analyses to provide a comprehensive understanding.

The majority of fossil-based synthetic nonwovens find application in single-use products such as nappies/diapers, medical textiles, and face masks. These materials typically exhibit hydrophobic and antibacterial properties. To incorporate similar functionalities into cellulosic nonwovens, eco-friendly methods are needed. Through the exclusive use of bio-based, biodegradable chemicals, we have successfully developed hydrophobic and antimicrobial cellulose nonwovens in SUSTAFIT, thereby enhancing the market position of cellulose-based nonwovens.



**To advance the development of fully bio-based and biodegradable medical textiles, filters, and face masks, it is essential to prioritise further studies focusing on testing various parameters.**

Potential parameters for testing include particle and bacterial filtration efficiency, breathability, fluid resistance, splash resistance, flammability, and more. By rigorously assessing these factors, we can ensure the efficacy, safety, and environmental sustainability of these innovative bio-based materials, facilitating their successful integration into healthcare settings and beyond.

Further, there exist sustainable fibres for nonwoven manufacture such as PLA (polylactic acid). However, in many cases they are too expensive, and their availability is limited. Sustainable techniques to produce cellulosic fibres (for example IONCEL and BIOCELSOL spinning processes) with high performance and reasonable cost are developing fast, promising new products to markets in the future. Alternative nonwoven manufacture technologies such as foam forming may enable the use of otherwise inapplicable raw materials such as recycled textiles. Further, combining different nonwoven

manufacturing techniques to produce layered structures can be used to achieve high performance, for example, to extended lifetime and durability, but also sustainability with the recyclability and high cellulose fibre content at same time.

Nonwoven materials are pivotal across diverse industries, from healthcare to consumer goods, due to their versatile applications. Despite the growing number of regulations promoting more sustainable materials in the EU, particularly the directives related to single-use products (SUP) that impact nonwovens, the applications of nonwoven materials continue to expand, as reported by EDANA (2023a). In the nonwovens industry, the opportunities for innovation are increasingly geared toward sustainability. This chapter explores these innovation opportunities and revisits the pressing need for research into sustainable alternatives, consumer behaviour, recycling technologies, and industry compliance with evolving standards.

# Consumer Awareness, Disposal Practices and the Market

A gap remains in consumer awareness regarding the proper disposal of nonwoven products (EDANA, 2023b). This situation suggests a need for focused research on the effectiveness of educational programs and labelling, such as the 'Do Not Flush' symbol for feminine hygiene products, to promote proper disposal practices.

More information, marketing, and communications are needed for consumers to change consumer behaviour.

Additionally, there is a noted reluctance to adopt reusable alternatives for products such as nappies/diapers and menstrual products, necessitating further research into making these products more appealing and practical for everyday use (EDANA, 2023b). These findings could lead to broader research themes around consumer behaviour, examining how the dissemination of information affects recycling and reuse rates in the context of nonwoven products.

## What About These Possibilities?

Furthermore, these findings could lead to activities aimed at increasing marketing awareness throughout the entire B2B value network of the nonwovens industry. This expansion would also necessitate forays into further research areas, such as investigating how to promote sustainable products initially within the value network and identifying marketing tactics that increase consumer

acceptance of sustainable purchases. Additionally, it is essential to investigate pricing strategies for sustainable alternatives. Research should evaluate how pricing influences consumer choice, particularly in contexts where sustainable products are priced higher than their less sustainable counterparts. Understanding consumers' willingness to pay for sustainability across various market segments could lead to more effective marketing and production strategies.

## Advancing Recycling Technologies and Sustainability Practices

Research is crucial in the area of recycling technologies for single-use nonwovens, especially those used in hygiene products. According to the Waste to Resource Initiative report, there is a significant gap in effective recycling methods, pointing to an urgent need for innovative solutions that can transform nonwoven waste into a resource (Berninger, Frick & Burgstaller, 2023). Furthermore, nonwovens are extensively used in critical areas such as the medical industry, where their use has surged by 40% from 2019 to 2022 (EDANA, 2023b). This underscores the necessity of single-use nonwovens for maintaining hygiene and safety standards.

Recycling 100% cellulose nonwovens into new nonwovens and textile fibres is feasible, although challenges arise from the presence of binders and impurities, necessitating their removal, which may increase recycling costs. In the SUSTAFIT research project, successful recycling of textile waste into nonwovens using carding and needle punching techniques has yielded promising results.

Within the project, we also managed to convert cellulosic nonwovens into textile fibres successfully through IONCELL technology.

Future research should explore the sustainability of these practices, particularly in industries where disposable products are mandatory. The development of nonwovens that meet both safety and environmental standards could be a significant step forward, requiring a multidisciplinary approach that balances regulatory compliance with environmental sustainability.

## Heading into the Future

There are multiple ways to address the waste problem in the nonwovens industry, including reducing overproduction and overconsumption, extending product lifetimes, and designing products for increased circularity. There is room for new innovations, and we still need more research on how to turn textile waste into new fibres that can then be used to create new clothes or other textile products, or material for nonwoven products. Additionally, we need to investigate the traceability within nonwovens, which is still in its early stages due to the multi-layered materials that comprise nonwovens. Some reports indicate that a large amount of textile waste could be recycled fibre-to-fibre, while some may require open-loop recycling or other solutions. However, recycling textiles for use as textiles material that can be used in nonwoven products offers potential for the future.

In summary, future research directions in nonwovens call for a comprehensive approach that addresses technological innovation, consumer behaviour, economic factors, and regulatory compliance. By focusing on these areas, the nonwovens industry can better align with global sustainability goals while continuing to meet the diverse needs of consumers. The insights gained from the SUSTAFIT research project and other research initiatives could help pave the way for a more sustainable future in the production and usage of nonwovens, benefiting both the industry and the environment.

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