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SUSTAFIT project's Fiber Futures podcast, episode 1

Virpi Rämö:
In this podcast, we seek clarity in what actually is nonwoven material and why do we need it in our daily lives. What challenges are related to the environmental sustainability of these materials, and is it possible to make these materials less harmful for the environment? And why should we care about all of this in Finland?

In this series, I will interview different actors working towards a more sustainable future for nonwovens. My name is Virpi Rämö. I come from Tampere University of Applied Sciences, and I lead a research project called SUSTAFIT (Sustainable fit-for-purpose nonwovens), funded by Business Finland.

Today, I have in studio with me two guests from two different Finnish research organizations. Actually, the three of us are together behind this SUSTAFIT research project. So, warm welcome, Dr. Pirjo Heikkilä, principal scientist at VTT technical research center of Finland. And Ali Tehrani, associate professor of textile chemistry at Aalto University.

Pirjo Heikkilä:
Thank you. Hello.

Ali Tehrani:
Thank you so much, thank you for the invitation.

Virpi Rämö:
So, before we go any further, let's start from a very basic and very important question, which I think many are wondering about. What actually is nonwoven? So, Pirjo, you are leading many textile and nonwoven related research teams in VTT. Could you start by explaining to us, in a few concrete examples, what actually are nonwovens? Maybe something that we see in our daily lives?

Pirjo Heikkilä:
Yes, all of us really kind of use nonwovens in our daily lives. Baby diapers and sanitary napkins, for example, contain nonwoven materials. In homes, there are nonwovens in cleaning wipes and filters for vacuum cleaners or other appliances and ventilation systems. And during the COVID-epidemic, we all used these single-use face masks, which were mainly nonwoven materials.

Virpi Rämö:
As there are so many different applications for nonwovens, Ali, is there something you would like to add to the list of nonwoven materials?

Ali Tehrani:
Yeah, nonwovens have many industrial applications. Perhaps they are hidden from our daily lives and not easily seen. But I will give you a few examples. In ventilation systems, there are some nonwovens for air filtration. We also use nonwovens for water filtration and purification. In geotextiles, especially when dealing with soft soil for road construction, they normally use geotextiles to enforce the soil. In agriculture, for example, in gardening, nonwovens are used for suppressing weeds. They are also used for moisture regain of the soil. Some other applications include water-proof breathable layers in shoes, protective clothing, felts, and insulators in cars. These are some examples of industrial applications of nonwovens.

Virpi Rämö:
This is something we could maybe talk a whole day about, where all you can use nonwoven materials. But now that we got an introduction: where they can be used, let's then talk more about why nonwoven materials are so fantastic. What is common for all nonwoven materials? Or briefly, how are they made?

Pirjo Heikkilä:
nonwoven materials have similarities to other kinds of traditional textile materials. They are made of similar fibers, which can be viscose, cotton, polyester, and so on. However, for traditional textiles, fibers are first spun, and those fibers are woven or knitted into fabrics from which the products are made. But nonwovens, as the name says, skip weaving. So, we can skip those processes, and these textile-like materials are made directly from fibers. In that case, they also have similarities to paper because paper is made directly from pulp fibers from wood, a kind of press process. Some nonwoven processes are actually similar, but they also involve various technologies, creating different nonwoven materials with a wide range of properties.

Virpi Rämö:
Could you, Ali, continue on why these materials are so fantastic? Since you are a material science expert. What makes these materials so unique?

Ali Tehrani:
nonwovens are very interesting because of the speed of production. Normally, let me give you an example. A pair of jeans made from woven fabrics undergoes a long process. Fibers need to be collected, and then through several mechanical processes, they are aligned, combed, carded. After that, with a roving machine and spinning, they turn into yarns. Further mechanical processes, wet chemical processes, warping, sizing, and finally, a weaving or knitting process is involved to put everything together in the form of loops. The maximum speed of production in these knitting and weaving processes is one to two meters per minute. However, nonwoven production, for example, melt-blown or spun-bond production, typically reaches a speed of a hundred meters per minute. I recently learned that there are some large machines that can produce a thousand meters per minute. This is truly fascinating.

There is also the possibility to change the properties of the nonwoven being produced, such as thickness, density, and pore size. This allows for the addition of different materials with different properties. When the speed of production is that fast, nonwovens are also less costly compared to many textiles. Additionally, for the production of nonwovens, we typically don't use a lot of chemicals, such as colors. This is beneficial, and water consumption is also very low. In total, these are fantastic specifications of nonwovens.

Virpi Rämö:
So, many cost and environmental benefits in the processing of fibers to products through nonwoven technologies and the versatility of those technologies. What is happening with nonwovens in Finland? Let's talk about that for a while. So, if we think about nonwovens businesses, there is actually a lot of activity in Finland as well. We have here two of the biggest companies, two of the big players in nonwovens, Suominen and Ahlström-Munksjö. And then we also have many other actors: processors and converters of nonwovens. To mention one, maybe SharpCell, one of our company members in the SUSTAFIT project. Some of these companies are converting products, and some are involved in all the steps, like processing and converting, in sort of vertically integrated processes. We also have these kinds of companies in our project. For example, Mirka, producing adhesive materials, and Valmet Fabrics producing felt materials. Are there some specific aspects in the nonwoven sector in Finland that you would like to bring up? What do you think, Ali?

Ali Tehrani:
Forests and trees are the most abundant and valuable resources in Finland. Over the years, many companies have optimized the process to produce furniture, houses, paper, packaging, and many applications using this abundant resource. Now, this pulp can be used for a new application—producing textile fibers. This pulp can also be used directly in the production of nonwovens. For example, SharpCell turns pulp into nonwovens through a process called airlane production. During this production, fibers are snowed onto a conveyor belt, and later, binders adhere these small, short fibers together for the production of nonwovens. These are very interesting developments. The valuable resources in Finland, especially pulp, can be used for the production of bio-based nonwovens. Perhaps that is the strength of many of these companies working around this value chain.

Pirjo Heikkilä:
One aspect is that we do have existing expertise and technologies in Finland. Earlier, we also had clothing and textile industries in Finland. While those were moved to lower-wage countries some decades ago, technical textile production, including these nonwovens, can remain in Finland. This sector is more technology-oriented and requires more specific expertise, which we still have in our research institutions and companies alike. However, there is another change coming from the textile sector in general. Now, we are moving towards sustainability. The EU has started collecting textile waste to address the textile waste problem. Many of these end-of-life textiles have shorter fiber length and lower quality, but these shorter fibers are suitable for many nonwoven processes. So, we have a new raw material in addition to the bio-waste materials that Ali mentioned: we have recycled fibers that are produced, collected, and processed in Finland. This provides another possible raw

material source for the production of sustainable nonwoven products using locally sourced materials.

Virpi Rämö:
Further, I would like to highlight that we have surprisingly many fiber innovations for a small country like Finland. This may potentially find use in nonwoven applications as well. Actually, we have many of these fiber innovator companies involved in the SUSTAFIT project. Maybe, Pirjo, you could mention some of these fiber innovations that we have?

Pirjo Heikkilä:
Yeah, there are already further developed and investments planned in Finland for Kuura Fibers by Metsä and Infinna Fibers by Infinited Fiber company. Also, Spinnova is making a new type of cellulosic fibers. Then there are emerging technologies not yet going on that big scale: Norratex technology, which is now further developed by Nordic biorefinery group, and the biocelsol process is studied and tested in textile fiber production by VTT. Of course, we have ion cell by Aalto, which Ali can tell more about.

Ali Tehrani:
Yeah, ion cell technology at Aalto was developed in 2010 when Professor Herbert Sixta joined Aalto University, bringing all the experiences and knowledge from Lensing where he was working in the R&D section. When he joined Aalto, he decided that there is a possibility to produce man-made cellulosic fibers with a different ionic liquid. Normally, for the production of lyocell-type fiber, they use N-methylmorpholine oxide, typically. But when he joined, he decided to do research towards finding a new ionic liquid. The process involves dissolving the pulp in an ionic liquid, creating a dough. The dough is then injected into a spinner that is pumped, and at high temperatures, it turns into a viscous, honey-like material. This material is then spun through a coagulation bath, typically water. The ionic liquid dissolves in water, and the cellulosolidifies in the coagulation bath. This is how it is produced.

The good things about ion cell fiber are that the mechanical properties are comparable to that of cotton and lyocell. Also, the wet strengths of them are really high, which is essential, compared to, for example, viscose fibers. If you consider the sustainability aspect, considering that the pulp can be obtained, for example, in the wood industry and in each square meter of forest, how much wood can be extracted and turned into pulp compared to what we can extract from one square meter of a cotton farm. This is really amazing that we have a renewable source, a valuable resource in Finland. The wood-based materials can be turned into fibers. Perhaps the bottleneck here is to recycle and reuse the solvent because the solvents are normally expensive. If this is achieved, we will perhaps have larger companies coming into the picture, and this will be produced on a larger scale.

Virpi Rämö:
Thank you, Ali. A very fascinating example of how to make fibers from wood biomass. Also, good to keep in mind that many of these fiber innovations are versatile in the kinds of materials they can use, such as wood and recycled materials. The opportunities are manifold.

Now, if we talk a bit about the needs and opportunities of companies in Finland, that was also the starting point of the SUSTAFIT project when we were ideating how we can help the industry. We had many workshops, and we got to learn what kind of support these companies need to grow nonwoven businesses. Some of the companies are already in the nonwoven business, but we also work with companies that are not yet there but are exploring the opportunities to enter the nonwovens field and create sustainable businesses. What we noticed is that especially the raw material producers are very interested to know about the opportunities in the nonwoven sector. But also, companies from all the steps of the value chain are interested in quite similar questions. So perhaps, Ali, you could open up some of these questions that the companies are jointly wondering about?

Ali Tehrani:
Cellulose is the most abundant natural polymer, and it has very fascinating physical and chemical properties. One is that it absorbs water; it has many hydroxyl groups in the polymer chain that absorb water. It's really hydrophilic. It can be potentially used in many applications. For example, if we need water absorption, this is a perfect material to be used in those applications like tissue papers and tablecloth… But considering synthetic fossil-based nonwovens that are in the market, they are typically really hydrophobic and are not prone to growths of mold and bacteria, right? But that's actually intrinsic properties of cellulose. So, if we want to replace fossil-based nonwovens, we should actually give some functional properties to cellulose. And that's adding, for example, hydrophobicity and antimicrobial properties on cellulose. We can at the moment produce nonwoven made of cellulose. But however, they cannot be used in the same application.

What we actually do during the workshops that we have with the companies? One request was, can we add this functionality in a green and sustainable way? Obviously, there are many products in the market that are not sustainable. For example, we can add hydrophobicity by using perfluorocarbons. But they have been banned. Or silicon-based, they have some environmental issues. So, one of the requests was actually adding these properties using only bio-based materials and bio-based binders. And that's what we are going to do in SUSTAFIT. So, in SUSTAFIT, we also have in mind to use ioncell fibres that are considered bio-based materials, and turn them into nonwovens with different processes at VTT. So, that's why the collaboration is important and meaningful here. And then we will find correlation between mechanical and physical properties of ioncell fibres and the final products. And if we can add these functionalities, hydrophobicity and antimicrobial, perhaps these nonwovens can be used in some applications like face masks. This is exactly what we need. We need something that is on one side hydrophobic and also is resistant against the growth of mold and bacteria. So, this is what we are going to promise.

We have three approaches here. One is that we have these processes like ioncell, and we can add these functional materials, for example, hydrophobising agent during the fiber production. This is one approach. Then, at VTT, they have different laboratory settings for the production of nonwovens. So they can add, like these functional materials for the binder for the production of the nonwovens. So this is the second approach we are following. And the last approach that can normally be scaled up easily in the textile industry is to do pulse

treatment. That means by adding some binders when we have the nonwoven ready, we can apply these functional materials on them and then evaluate the properties.

Virpi Rämö:
So, making cellulose to compete with these fossil materials, that's one really important thing we are doing. But what else? Pirjo, could you open up, what else are we doing in SUSTAFIT?

Pirjo Heikkilä:
Yeah, we are focusing also on these new processes and demonstrations. The nonwoven sector, like the textile sector in general, is focusing on sustainability and green transition, and there are also interesting technologies at VTT, like the foam technology for making nonwoven materials. It opens up new possibilities. We can combine these new materials and new processes and innovations in interesting ways for the industry to take a look at if there are new approaches they can apply. We have unique new materials, and we can collect ideas together with the industry and VTT's technologies but also other nonwoven technologies within our network. We can test new material concepts, find new bases to achieve certain material properties in new ways within non-typical processes, let's put it like that. And that can be kind of trying to meet the industrial needs of certain products.

Virpi Rämö:
Then if we talk about some of the environmental challenges with nonwovens. First of all, nonwoven waste is recognized as an environmental problem, even in Europe. When the SUP directive was established, there was a study by the EU Commission of the top marine litter items, and actually, nonwovens were among the top ten of those, especially with wipes and feminine hygiene products. Are there some other environmental issues that you would also like to take up?

Pirjo Heikkilä:
Well, challenges in answering or reducing environmental impacts and increasing sustainability of nonwoven materials is that it is such a wide range of different materials, so different kinds of applications. And depending on what we are doing, we might need to apply a different kind of strategy to reduce impacts and to be more sustainable. So for example, these single-use items like hygiene products, making them from bio-based materials or biodegradable material could be a valid strategy. But if we are making these geotextiles to support embankment on the built environment, they shouldn't necessarily be biodegradable because they should stay there for a long time and give support to the built environment. So there we should focus on more durable materials, or maybe less impactful technologies. We need to select different strategies. And that is the challenge: getting this understanding of what kind of strategies and what kind of things to highlight in improved sustainability on a certain type of products.

Virpi Rämö:

That is also something we are doing in the SUSTAFIT Project, building segment-wise sustainability strategies for different kinds of nonwoven segments. Are there some other environmental issues that Ali, you would like to still mention?

Ali Tehrani:
This is a topic that perhaps we can talk about for hours and hours and not find a solution. And it's actually very challenging. There are many aspects to this matter, environmental challenge. So, one of the aspects is that we are using mostly, let's say, 60–70% nonwovens currently in the market made of fossil-based synthetic materials, right? And then if they rely on oil production – I was checking actually the oil production; we are now in the peak of oil production. From like 120 years ago, the oil production started, and now we are somewhere at the top. And with this rate of production and estimation, perhaps it will last another 150 years. So, maybe in 100 years, they will become very expensive, and we will not have them for production. From now on, we should really think and do research for replacing them.

There are some other aspects of them. You mentioned also in the beginning that they will end up in environments as part of, and they will degrade into microplastics, small pieces that can harm the marine environment. The small particles can be eaten, for example, by fish, and then they will end up in our food chain. These are some really important aspects. If we can actually replace these nonwovens and give those functionalities to cellulosic or bio-based materials to produce nonwovens that can beat in the market and replace many of those synthetic nonwovens in the market, it is a very good solution. But, however, we should also know that we may not really fix this problem of microplastic and production of small particles because cellulose as well will degrade in nature and they may have a lot of particles. But we are hoping that by using a renewable resource that can degrade over years, they will actually have some sort of diminish in the environment and will be less harmful than the synthetics.

Virpi Rämö:
SUSTAFIT Project is about helping the industry to find answers to the questions we have just discussed. Could we briefly say concretely what is happening at VTT in SUSTAFIT Project, Pirjo?

Pirjo Heikkilä:
Yes. Within this project, VTT has two main focus areas. We are really focusing on these sustainability strategies. How to build them, which kind of things to highlight in certain types of products or application areas. Having a kind of overview of the possibilities and what is important in which type of products. But also, we will study and demonstrate the making of different kinds of nonwoven materials. We do have unique pilot capabilities with the foam in Jyväskylä, but we can use it for testing new material concepts and innovative structures in lab scale and pilot scale. But also, we do have a network of other actors, so we can utilize also a wider range of capabilities and plan with the industry those pilot runs.

Virpi Rämö:
And what about Aalto University? What happens in Aalto in the SUSTAFIT Project?

Ali Tehrani:
Let me give you a larger picture of what is happening in the Department of Bioproduction and Biosystems at Aalto University. Researchers in our department are set to work on bio-based materials, harness the natural properties of cellulose, and produce advanced materials out of them. So this is generally the idea of the researchers there. And I can also highlight that the EU waste framework directive has set ambitious targets for recycling of solid waste. In 2025, 55% of solid waste should be recycled. Especially about the tech solids and nonwovens, we are not there. So, maximum recycling is 15-20%. This is what has been reported. For me, also as part of the SUSTAFIT team, this is really important to see what we can do to reduce the impact of materials we are producing, right?

So, some of these nonwoven materials are difficult to recycle. They become composite materials, as an example, diapers. There are layers of different materials that have bonded together. So, recycling them is very difficult because it's from different materials that cannot be easily recycled. As part of our goal for having bio-based materials with added higher value materials, it's very important to also think about if we can recycle them in the end. This is what we are also promising in SUSTAFIT, that we will make bio-based nonwovens and we will add functionality by using bio-based materials in a way that we are thinking will be recycled in the end. Having this in mind that we should actually reach this ambitious target to reach 55% recycling of the materials is something that is the driving force of our research.

Virpi Rämö:
And what happens at Tampere University of Applied Sciences, briefly? We are looking and focusing on the business side of things. How are new value chains created? We have these kinds of series of workshops where we attract actors outside of our consortium to talk about these topics together with the Finnish companies. We want to activate the discussion around the team and also have the voice of a customer heard and international collaboration partners for our Finnish companies. On the other hand, we also look at TAMK, what happens to the nonwovens they have used. These kinds of end-of-life scenarios. For example, we do disintegration testing of these bio-based nonwoven materials: how do they actually disintegrate after the first use?

We are approaching the end of our discussion today. But I would like, still before letting you go, to ask about future scenarios. In an ideal case, how would you envision that the nonwoven sector, or broader the nonwovens, would look like when it is as sustainable as possible? Any good-day scenarios to leave us thinking?

Ali Tehrani:
For researchers, it is really exciting to see how the work can very quickly impact the industry. I am very happy to see, for example, the formulation of the methods we are using for functionalization of bio-based nonwovens that will be adapted in the industry. This is something that, for me, would be interesting. To see the impact of my research quickly, in a meaningful way in the industry.

Virpi Rämö:
Thank you. Very important. What about Pirjo, what do you think?

Pirjo Heikkilä:
I really hope that we have an even stronger nonwoven sector in Finland. And that the industry will use these new locally sourced materials, bio-based and recycled alike. Novel concepts and technologies. And in this, we gain a competitive edge from sustainability in the global market. They will be sustainable and fit-for-purpose nonwovens like our project name says.

Virpi Rämö:
In these feelings, I think it's good to end our discussion today. Thank you very much, Pirjo and Ali, for the interesting discussions and joining the podcast and making the nonwovens a bit easier for us to understand. My name is Virpi Rämö, and I hope that this podcast helps you understand the environmental challenges that we are tackling and the pathways to make sustainable transformation happen. We at the SUSTAFIT research project, funded by Business Finland, are developing pathways for a more sustainable future. And you are very welcome to listen to all of the other episodes, too. We have several interesting guests both from academia and industry coming up to open the world of nonwovens. See you soon again.

Fiber Futures

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