ELECTROSPUN NANOFIBERS FOR SKIN-CONTACT APPLICATIONS

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ABSTRACT
The use of nanofibers is expanding from academic into industry as these lightweight and highly porous materials are advantageous in many application areas. The main objectives of this roject is to reveal the potential of the bioeconomy in Europe, to decrease the use of fossil-based products, lead to greener and more environmentally friendly growth by fighting against climate change. For this purpose, nonwovens are prepared from bio-based polymers using solution electrospinning method for cosmetics and wound-care applications.
Keywords: Bio-based polymers, electrospinning, nanofibers, wound-care, face masks

1. INTRODUCTION

Nanofibers are a unique class of nanomaterials due to several particular properties such as higher surface area and surface energy compared to bulk materials which enables the enhanced attachment of various (bio)molecules. The structural composition of the nanofibers can be arranged according to the desired properties and applications from a wide range of polymers. The physical resemblance of the nanofibers to the naturally occuring extracellular matrix is important especially for biomedical applications. The high porosity of nanofibers also enhance cell activities easing the cell attachment and nutrient transportation. Among various processing methods, electrospinning is the most common technique which uses electrical forces to fabricate continuous polymeric fibers using solutions of both synthetic and natural polymers (Fig 1). Electrospinning is a low-cost and straight-forward method that allows control over fiber diameter which can also be scaled up for mass production.

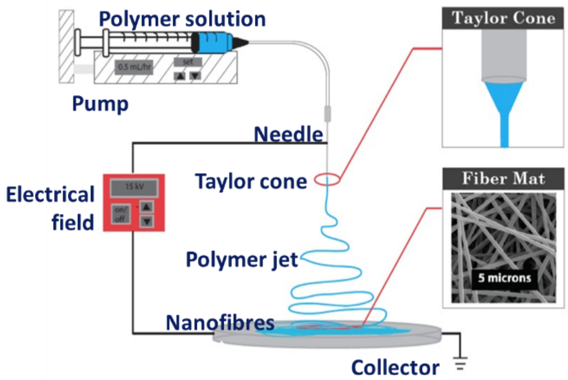

Figure 1. A basic electrospinning set-up

Biopolymers offer a high versatiliy of possible end-of-life options for products compared to the fossil resources. The end-of-life solutions are crucial especially for short-term single use products. Most of the large-volume single-use disposable products cannot be recycled due to varşous different materials in their composition and their after-use contamination. For this reason, they are currently treated in energy recovery or sent to landfills. Currently, most of the commercial diapers, and many cosmetic and biomedical skin-contact applications still use conventional plastic films, which is one reason for their poor position in the waste management hierarchy (Fig. 2B).

Another disadvantage of the conventional fossil-based materials currently used in these types of skin-contact applications is their tendency to cause skin irritations or inflammations. Biopolymers and other bio-based substances offer a high degree of biocompatibility and other unique features but are still not commonly used in this field.

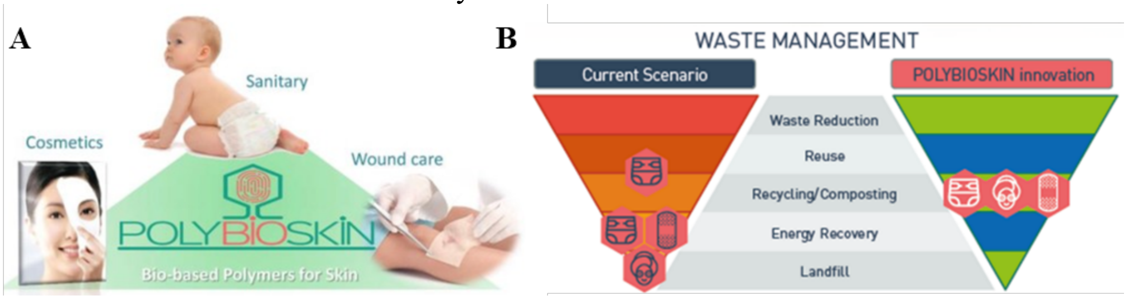

Figure 2. A) Products aimed in PolyBioSkin B) Diapers, facial beauty masks, and wound dressings in the European Waste Hierarchy

PolyBioSkin, aims to develop both optimal biopolymers and processes for the sanitary, biomedical, and cosmetic sectors. In this Project, it is aimed to produce biodegradable diapers, novel facial beauty masks based on textiles or films made from bio-based and biodegradable polymers for the skin and nano-structured highly skin-compatible non-wovens for wound dressings.

The selection of bio-based materials for the Project combines formulations based on engineered biopolymers like polylactic acid (PLA) with naturally available ones like polyhydroxyalkanoates (PHAs) or chitin, with a significant bio-based carbon content above 90 %. The biopolymers that will be used in the Project are biodegradable and offer unique antimicrobial, antioxidant, absorbence, and skin biocompatibility properties for high performance skin-contact applications. In addition to the materials, the Project also aims to optimise the process by producing films, fibers, and nonwoven textiles with properties tailored to each of the target applications.

2. MATERIAL AND METHODS

Several types of bio-based polymers and polymer blends are used for the Project. For skin contact applications, a water soluble biocompatible polymer is used. For wound care applications, polyhydroxyalkanoates based polymers are used. Polyhydroxyalkanoates can be synthesized directly in the cells of a number of microorganisms. PHAs structure can be different in terms of content of comonomers (3-hydroxybutyric acid, 4-hydroxybutyric acid, 3-hydroxyvaleric acid, etc.) or molecular weight, which in turn can lead to flexible or rigid plastics. In the case of wound dressings, these materials can help to avoid immune reactivity and maximise skin regeneration potential. Chitin is a polysaccharide present in the skeletons of insects and the shells of crustaceans and readily available from wastes of food industry. In its nanofibril form, chitin has been reported to be a potent skin inflammation suppressant to be applied. This feature is highly relevant for all skin-contact applications pursued in the project.

Solution electrospinning technique is used to produce the nonwovens for skin and wound care applications. Polymers are dissolved in proper solvents with stirring at room temperature for several hours, Then the polymer solutions are placed in a syringe which is fed by a pump. The syringe contains a needle which is connected to a power supply.

3. EXPERIMENTAL RESULTS

For wound-care applications, PHA-based polymers and polymer blends were electrospun from their solutions in suitable solvents. SEM images confirmed the formation of PHA-based nanofibers (Fig 3). For skin-care applications, a water soluble polymer was electrospun from aqueous solutions and a nanofibrous membrane was obtained

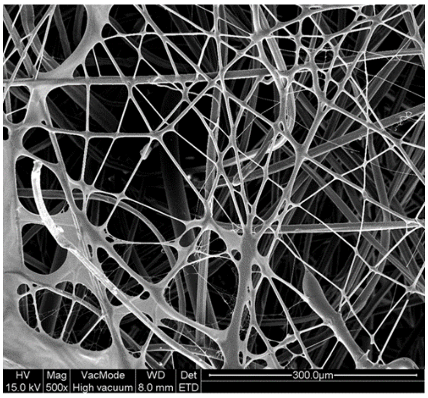

Figure 3. SEM image of PHA-based nanofibers

4. CONCLUSIONS

As a conclusion, nonwovens were prepared from bio-based polymers for wound-care and cosmetic applications using solution electrospinning method. The functionalization of nanofibers with various bioactive molecules is also being studied. The scaling-up and prototyping will further be evaluated.

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Acknowledgements

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 745839.