Process-Integrated Functionalization of 3D Meltblown Structures for Wound Healing Applications

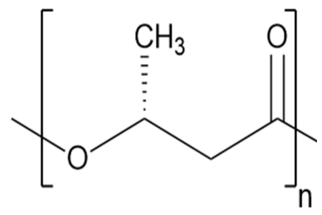
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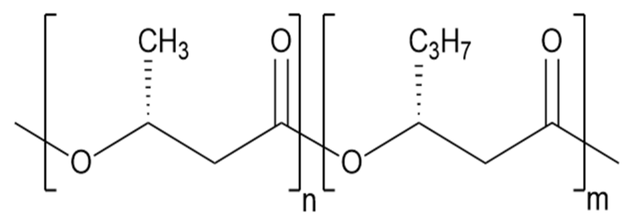
PHB2Med - Development and characterization of meltblown polyhydroxybutyrate (PHB) wound dressings for ecologically sustainable wound care

Aim

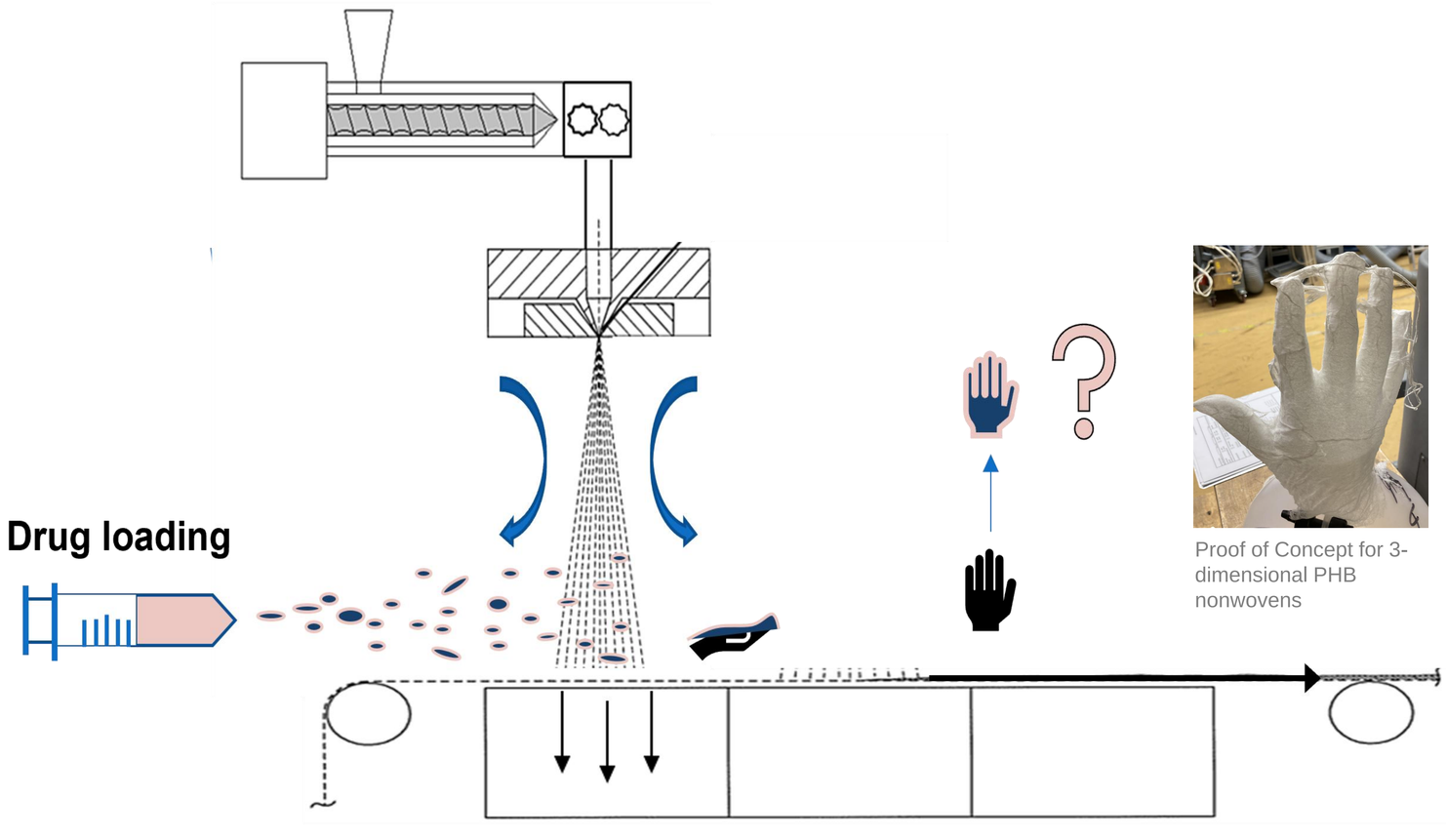
- Development of a sustainable three-dimensionally adapted wound dressing made of Polyhxdroxyalcanoate (PHA) in the meltblow process
- Online drug loading during the process enables the integration of drug delivery functionality into the final product



Chemical Structure of Polyhydroxybutyrate (PHB)



Chemical Structure of Poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH)



Manufacturing process for 3-dimensional meltblown nonwovens charged with active ingredients

Proof of Concept for 3-dimensional PHB nonwovens

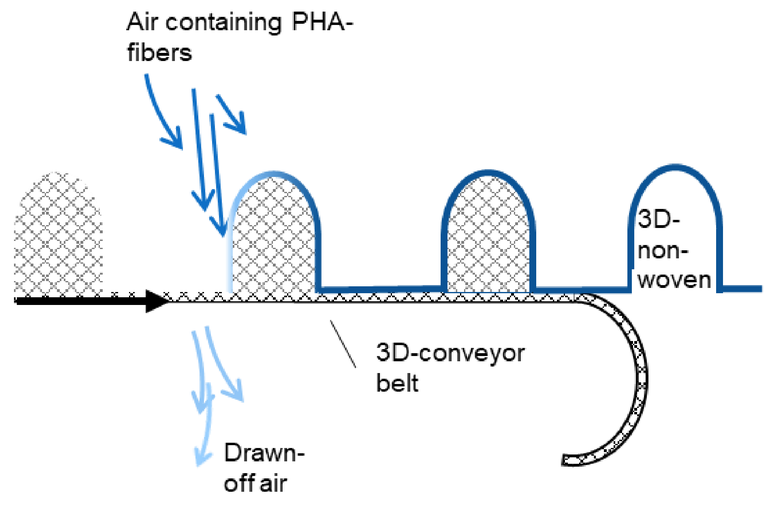
State of the Art

- PHAs are bio-based, biocompatible and biodegradable [1] and comprise a diverse group of polymers, including various types such as Polyhydroxybutyrate (PHB) and Poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBH)
- Numerous research projects and publications at PHA in the field of tissue engineering, applications: suture material, cardiac patches, stents, implants,… [2,3]
- technologically limited to solution-based processes: film or fibre formation via Electro- / Solutionspinning [2]

  → discontinuous, unproductive, unsuitable for mass production
- Resorption behavior of PHA positive [4]
- Fundamental investigation into the release of active ingredients from PHA systems [5]
- Possible model active ingredients: PHMB, AGXX, Curcumin,…

Approach

- Development of a novel three-dimensional meltblown deposition system, including the design and fabrication of customized formable structures
- The variation in fiber diameter, basis weight and the associated porosity and fluid permeability must be evaluated and adapted to the requirements developed
- Development of a spray device for the novel incorporation of the active ingredient
- Comprehensive textile-physical and chemical characterization of PHB nonwovens in our state-of-the-art laboratories
- Analysis of model drug loading in nonwovens, carried out in our well-equipped laboratory facilities



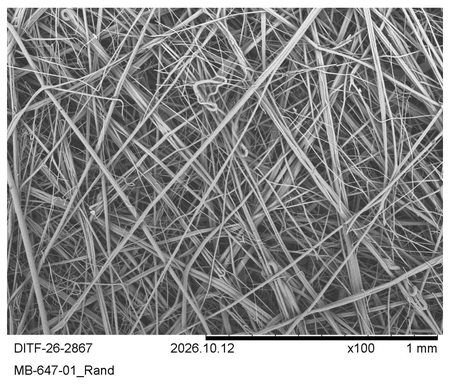
Novel conveyor belt manufactured by Siebfabrik Arthur Maurer GmbH & Co. KG

Own research / development

- Successful processing of melt-based PHA into a nonwoven fabric using the meltblown process
- Development of a direct, time- and temperature-stable three-dimensional arrangement of nonwoven fabric

Initial trials

Production of flat nonwoven fabrics from three different types of PHA

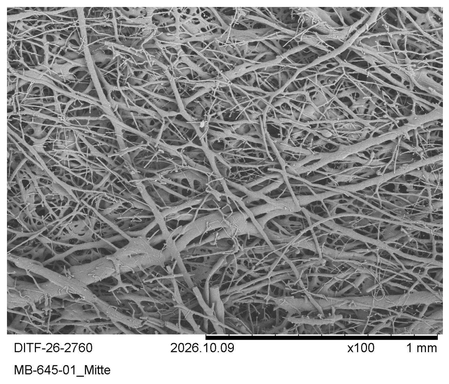


PHBH (PHA BP330-05, Bluepha®)

» Thickness: 0,6 – 0,8 µm

» Grammage 125 – 220 g/m²

» Air permeability: 240 – 300 l/m²/s

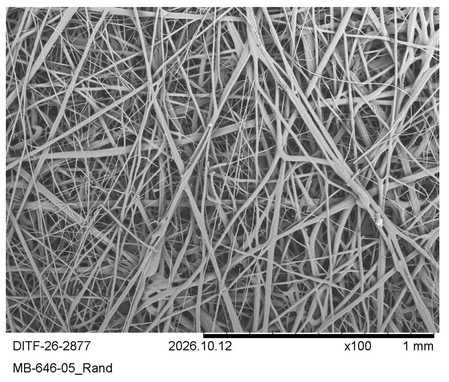


PHB (P316-01, Biomer)

» Thickness: 0,7 – 0,9 µm

» Grammage 240 – 270 g/m²

» Air permeability: 275 – 345 l/m²/s



PHB (P316-02, Biomer)

» Thickness: 0,35 – 0,4 µm

» Grammage 66 – 100 g/m²

» Air permeability: 850 – 1170 l/m²/s

[1] C. S. K. Reddy, R. Ghai, Rhashmi, V. C. Kalia: Polyhydrohyalkanoates: an overview; Bioresour. Technol. 87 (2), 2003

[2] Xiao-Hong Zhao, Yi-Nuo Niu, Chen-Hui Mi, Hai-Lun Gong, Xin-Yu Yang, Ji-Si-Yu Cheng, Zi-Qi Zhou, Jia-Xuan Liu, Xue-Liang Peng, Dai-Xu Wie: Electrospinning nanofibers of microbial polyhydroxyalkanoates for applications in medicaltissue engineering; Jour-nal of Polymer Science; 2021

[3] J. Sun, J. Wu, H. Li, J. Chang: Macroporous poly(3-hydroxybutyrate-co-3-hydroxyvalerate) matrices for cartilage tissue engineering; European Polymer Hour-nal, VOl. 41, Issue 10; 2005

[4] C. Constantinides, P. Basnet, B. Lukasiewicz, R. Carnicer, E. Swider, Q. Majid, M. Srinivas, C. A. Carr, I. Roy: In vivo tracking and H/19F Magnetic Resonance Imaging of Biodegradable Polyhydroxyalkanoate/Polycaprolactone Blend Scaffold Seeded with Labeled Cardiac Stem Cells; Applied Materials & Interfaces; 2018

[5] F. Pourhojat, M. Sohrabi, S. Shariati, H. Mahdavi, L. Asadpour: Evaluation of poly ε-caprolactone electrospun nanofibers loaded with Hypericum perforatum extract as a wound dressing; Research on Chemical Intermediates, Vol. 43, 2017, S. 297 – 320

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