BIOBASE

Final report

Establishing bio-based polymers from available resources as a cost-competitive alternative to synthetic polymers.

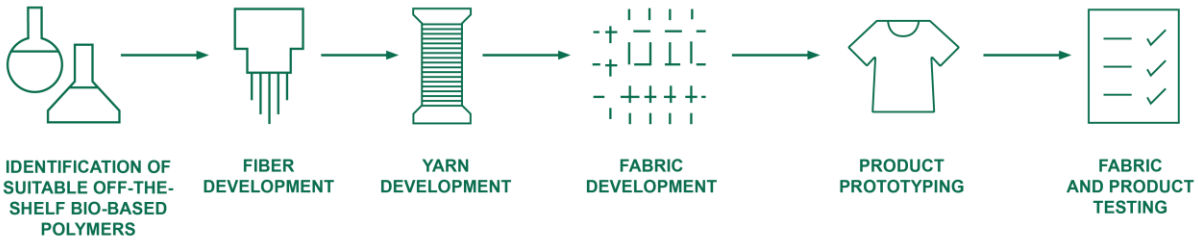
In 2019, global fibre production amounted to more than 120 million tonnes. Of these, 73 % were man-made fibres, which are produced based on natural or synthetic polymers (plastics). A central problem in the production of man-made fibres based on synthetic polymers is the dependence on fossil raw materials, which are subject to various ecological risks. Therefore, bio-based alternatives are urgently required, since until now, an entire one-to-one substitution has not yet been possible.

Thus, the aim of the BioBase project is to establish bio-based polymers in the textile industry and to demonstrate their full potential. In order to achieve this goal, we selected the four key sectors of the textile industry in Germany, automotive, sportswear, interiors and technical textiles, and replaced in each sector, a petroleum-based product by a product made of biopolymers with equivalent properties.

The technical process

In the project, we considered the entire textile value chain of the respective products and tried to increase the technological maturity level for the industrial production of bio-based and sustainable man-made fibers. In this framework, our aim was to achieve a leap from Technology Readiness Level (TRL) 4 to TRL 6 – 7 for the industrial application of bio-based fibers.

Each application area went through a similar process flow during the project: starting with the development of polymers and compounds, through the development of yarns to the production of textile surfaces and prototypes. In the process, we as researchers worked together with corresponding sector partners in the selected industries. The polymers, yarns and textile surfaces were developed in an application-oriented manner and with regard to technical requirements for each of the four key textile industries. We started by working with the benchmark (mostly polyester) to analyze the current challenges with regard to the polymers and to potential process limitations, to the be prepared for any problems that may occur when working with bio-based polymers later on.



Automotive Industry

For the automotive application, the objective was to produce flat-knitted surface for the automotive industry. Therefore, we used Polyamide 4.10, 70 % Castor Oil-based, and Polyamide 10.10, 100% Castor Oil-based. On this basis, the project partner produced yarn demonstrators and found out that in comparison to the common PET both polyamides showed good spinnability. PA 4.10 also showed good mechanical properties and good abrasion resistance. Sometimes, the yarn did not show uniform yarn thickness or undesirable row formation behavior. PA 10.10 could reach the benchmark properties of polyester, although the tension near the yarn needed to be controlled to ensure a stable process. In conclusion, the bio-based polymers showed good application options.

Geotextile Industry

For the geotextile application, the aim was to produce IDY 1100 DTEX. Therefore, we tried to work with bio-PET and High Viscose PLA. It turned out during the process, that the properties of the bio-PET were not sufficient for the application, as filament breaks occurred in the bio-PET yarn and the required tenacity could not be achieved. Unfortunately, High Viscose PLA was also unable to meet the required tenacity, even though it could be shown that PLA is suitable for short-term applications with low requirements for long-term tenacity. Consequently, it was not possible to produce any demonstrators that could meet the previously defined target.

Sport Industry

For the sports application the aim was to produce POY-100F72 and DTY: 83F72. Therefore, we again tested bio-based Polyamid 4.10 and Polyamid 6.9.

We tested PA 4.10 to replace conventional apparel and shoe yarn. In the application area of apparel, the bio-based yarn convinced us with good spinnability and tenacity that exceeds the rPET benchmark. It turned out to be easy to knit and stretchy and the fabric quality met most sportswear standards. There was, however, variation in yarn evenness due to tension variations on the winding machine. In the application area of footwear, we achieved similar results. The strength/elongation of PA 410 footwear yarn was even better than the rPET benchmark.

Interior Industry

For the interior textile application, the aim was to produce textile products based on POY-220F48 and ATY-980F240. Therefore, we worked with four different bio-based polyamides: PA 4.10, PA 10.10, PA 12, PA 5.10. With the exception of Polyamide 4.10, which showed slight weaknesses compared to the other Polyamides, all polyamides were able to achieve the same and satisfactory results. The polyamides can be produced on existing production facilities without major problems and offer the potential to achieve all technical properties by applying existing technology. Visually, They are characterized by a shinier, smoother, more transparent and more technical appearance compared to benchmark materials and current market products. However, the current raw material price for the bio-based polyamides is not competitive with the crude-oil-based

benchmark. In addition, we perceived fluctuations in color (yellowing) and odor between the different production batches. In the future, these challenges need to be addressed to ensure consistent reproducibility.

Final project results

In the BioBase project, we were able to successfully develop demonstrators made from bio-based polymers for three out of four textile application fields. We used existing machines and production facilities and did not require any additional investment. The results demonstrated that bio-based polymers are already technically suitable, if adapted to the specific application requirements. This underlines their potential as a sustainable alternative, even though the material price is currently still a challenge.

Outlook

We recommend to focus future research on several key areas: conducting comparable life cycle assessments to evaluate the carbon footprint of bio-based polymers to enable more informed decisions about sustainable solutions. Additionally, studies on the long-term stability and the uniformity of yarns made from bio-based polymers, particularly at higher production volumes, are necessary. Further exploration of post-processing steps, such as dyeing and finishing of bio-based textile products, could also provide valuable insights. Lastly, it remains crucial to improve the cost-efficiency of bio-based polymers to enhance their competitiveness.

Documentation

On completion of the project, we are delighted to present the following documents and compilations of our results on the BIOTEXFUTURE-Website:

- Demonstrator Book (German)
- Database Biopolymer
- Database Fiber
- Insights Session BioBase

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https://biotexfuture.info/projects/biobase/

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