PHA Textiles Development through Material Driven Design

Jian Yu*†[1], Ron Wakkary[2,3], Tim Saenger[4], and Amanda Kulessa[4]

[1]Simon Fraser University – Canada
[2]Simon Fraser University – Canada
[3]Eindhoven University of Technology – Netherlands
[4]Institut für Textiltechnik der RWTH [Aachen] – Germany

Abstract

The dominance of petroleum-based polymer fibers in the textile industry has led to significant plastic pollution in water and land ecosystems. One sustainable alternative is bio-based and biodegradable polymers. Polyhydroxyalkanoates (PHAs), a polymer family biosynthesized and biodegraded by microbes, stand out among other biopolymers for their degradability in natural environments without microplastic residues. However, melt-spinning PHA fiber is still challenging.
This poster presents a material driven design approach to explore opportunities in melt-spinning and weaving PHAs. According to the supplier, the PHAs used in this study are a blend of P(3HB), P(3HB-co-4HB), and proprietary additives. The P(3HB) and P(3HB-co-4HB) contents are each certified by TÜV Austria as home compostable and biodegradable in soil, water, and marine environments. This study was guided by a material-centric perspective that explores a generative design space unconstrained by traditional design concerns that try to match PHA fiber with performance standards set by non-degradable fibers.

Initial results demonstrate success in producing PHA monofilaments using a lab-scale melt-spinning line. At this stage, only manual tools were used to fabricate complete textile samples, interweaving commercial degradable thread as warp and 4-ply PHA thread as weft. In response to the unique material properties of PHA monofilaments, manual toolsets such as 3D-printed spindles and looms were iteratively prototyped to ply and weave PHA textiles, producing samples of approximately 10×10 cm. This points to promising future development in improving melt-spinning quality that could lead to machine textile processes at larger scales.

This study responds to the sustainability shift in the textile industry through a cross-disciplinary, cross-sectoral, material driven research approach, with a horizontal scope from material sourcing to design prototyping. The development of PHA monofilaments further expands sustainable solutions in textiles and contributes a material driven approach that integrates design and material development.

Our future work will include advanced PHA monofilament development, as well as studies of PHA textile degradation under realistic conditions, such as a home composter or a soil

*Speaker
†Corresponding author: jian_yu@sfu.ca

planter, beyond controlled lab environments, in addressing the gap between lab-based and field-based knowledge of how PHA degrades.

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