ESR 7

Project title and research strand:	Bio-based staple fibers from PBS. Strand 1: Fibers for technical application.	
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Abstract

In the area of disposable filter textiles such as coffee pads and hot seal teabags, the disposal of the product in household waste is the primary end-of-life (EoL) option. Due to the share of thermoplastic material in the filter textile (currently realized with PP, PET, PA, and PLA), sealing can be implemented for closure. At the same time, this share represents the most significant environmental impact when composting, as the product cannot be completely degraded. As the only bio-based and industrially processed plastic for this application, polylactic acid (PLA) cannot be broken down under home composting conditions. PLA can be composted in industrial facilities that use elevated temperatures of 58°C for degradation. It can not be composted at home, where the temperature is lower at around 28°C.

Therefore, it is necessary to evaluate other materials, a task undertaken as part of this project. Various home-compostable and industrially available biopolymers are initially spun alongside a state-of-the-art petrochemical polymer (PP) using the same machine and settings. In this comparison, PBS emerges as the top performer among the home-compostable polymers. The subsequent phase of the study focused on examining the impact of different dwell times during the spinning process as part of the upscaling process. This study focuses on spinning PLA and PBS on Lab, Pilot, and Industrial Scales. It was observed that PBS exhibits excellent process stability but is more susceptible to degradation when compared to PLA, which demonstrates the opposite behavior. By increasing the dwell time, the stress on the molecular structure of the polymer increases, and the degradation time of the fiber decreases. Nonetheless, if the samples are pre-exposed to UV radiation and hydrolysis in a quick weathering scenario, this pre-loading impacts the degradability more significantly than the dwell time.

Visual Summary – Poster

Faculty of Science and Engineering

A comparison of PLA and PBS in Upscaling: How dwell time and UV pre-exposure change degradability

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Background

- State-of-the-art is a study of an isolated degradation mechanism [1].
- Fibers from one production scale are compared, the upscaling aspect is missing until now.
- A combined observation of dwell time and pre-exposure for PLA and PBS has not been studied so far [2, 3].
- It has been found, that pre-exposure of the sample influences the degradability of the sample more significant than the difference in dwell time.
- A weathered fiber from an industrial-scale spinning line more accurately predicts the behavior of a product placed on the market before ending up in the environment.

Methods

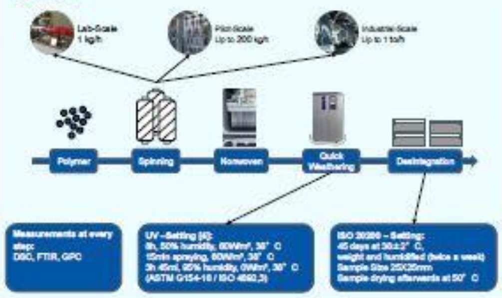

Table 1: Machine Settings and Physical Properties

Sample	Throughput [kg/h]	Dwell Time [min]	Draw Ratio	Titer [dtex]	cN/tex	Elongation [%]	Crystallinity [%]
PLA_LAB	1	5	2.4	3.91	19.28	43.78	39.03
PLA_IND	368	7	1.9	2.6	26.96	45.66	39.88
PLA_SF	30	36	1.82	2.19	23.73	39.55	33.84
PBS_LAB	1	5	3.2	4.18	23.41	116.21	54.3
PBS_IND	351	7	1.75	9.06	15.97	214.74	51.46
PBS_SF	23	22	1.76	4.24	12.86	184.51	64.51

Observation

Summary

Table 2: Summary of conclusion PLA. Green shading indicates process parameters that we controlled.

Parameter	Change toward	Crystallinity	Tenacity	Elongation	CI	VI	HI	Mₙ	Degradability
Dwell time	↑	↓	↘	↘	↗	↗	↔	↓	↑
Draw ratio	↗	↗	↗	↘	↗	↗	↘	↔	↘
Fiber diameter	↘	↗	↗	↓	↗	↘	↗	↔	↑
Tenacity	↗	↗		↘	↗	↗	↘	↔	↘
Elongation	↘	↗	↗		↗	↗	↘	↔	↘
UV exposure before disintegration	Yes	↑			↗	↗	↗	↓	↑

Table 3: Summary of conclusion PBS. Green shading indicates process parameters that we controlled.

Parameter	Change toward	Crystallinity	Tenacity	Elongation	CI	VI	HI	Mₙ	Degradability
Dwell time	↑	↑	↘	↘	↘	↔	↔	↘	↘
Draw ratio	↗	↔	↑	↘	↗	↔	↔	↗	↗
Fiber diameter	↘	↗	↑	↘	↗	↘	↔	↗	↗
Tenacity	↗	↘		↘	↘	↗	↔	↗	↗
Elongation	↘	↘	↗		↘	↗	↔	↗	↗
UV exposure before disintegration	Yes	↑			↑	↑	↘	↔	↗

Key Takeaways

- Processing conditions impact PLA more, than PBS
- Weathering accelerates the degradation more significant than process induced stress
- PLA with longest dwell time was degraded at 38° C in 45 days

References

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