FORMULATION OF BIO-BASED COMPOSITE FILAMENTS BY EXTRUSION/COATING FOR FUSED FILAMENT FABRICATION: A STRUCTURAL AND MECHANICAL ANALYSIS

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With the industrial development and the boost of industrial synthesis, current ecological issues come up as environmental pollution and resource shortage. Therefore, in the domain of composite materials processing, it is getting more and more favorable to use partially or fully bio-based composites with high mechanical performance in place of petroleum-based ones [1]. In addition, additive manufacturing (AM) has grown as a significant trend thanks to its advantages as flexible design, functional manufacturing and waste minimization over conventional methods [2]. More recently, continuous fiber reinforced bio-based composites manufactured by AM are getting attention as solutions for lightweight and multifunctional parts due to the freedom of deposition and the anisotropy control of this technology [3]. However, few polymers are commercially available as continuous composite filaments for AM, which limits the use of the additively manufactured composite technology [4].

The study aims to develop new formulations of bio-based and functionalized composite filaments by extrusion/coating for fused filament fabrication (see Figure 1). For this purpose, raw materials were analyzed by multi-physical characterizations (FTIR, DSC/TGA and capillary rheometer) to select a suitable matrix for the extrusion/coating process among bio-sourced polymers (PLA, PA11) and petroleum-based ones (PP, PA66). The matrix selection also included the compatibility with the continuous cellulosic filaments, namely flax fibers and cotton/hemp fibers. Unreinforced filaments from the selected matrix was then compared to reinforced filaments with each fiber regarding structural analysis by micro-tomography and TGA (morphology, porosity and fiber content analysis) and by tensile tests.

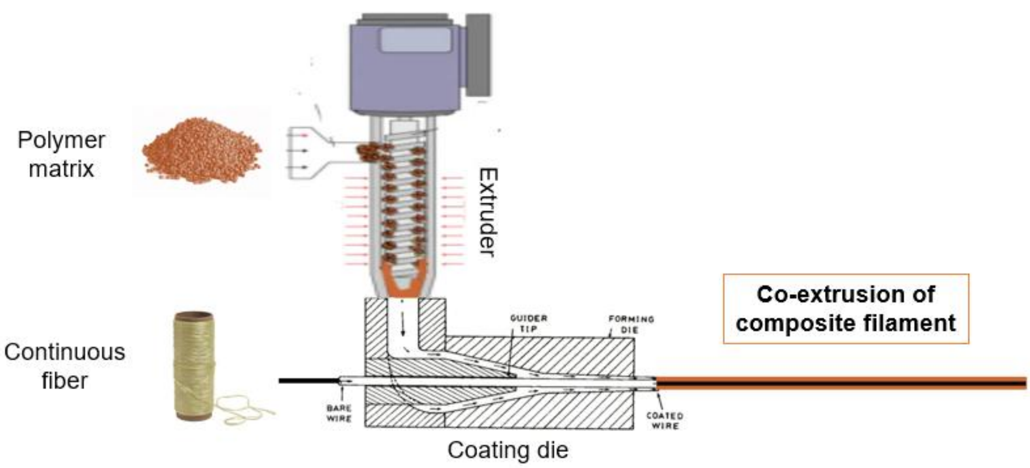

Figure 1. Schematic representation of the extrusion/coating process.

The tomography results of pre-impregnated fiber (see Figure 2) showed that the fiber is fully inside the matrix indicating a good coating effect. There is no porosity between the matrix and the fiber which means a good compatibility between the fiber and the matrix. Porosities can be observed in the matrix due to the insufficient drying of the fiber. Porosities also occur in the fiber which can be inferred that the matrix penetration effect on the fiber is weak. Different fiber types and contents between the two composite filaments lead to different structural and mechanical properties of the composites. The results are believed to bring more knowledge about the viability of bio-sourced composite filaments for the development of additively manufactured and highly technical continuous composites.

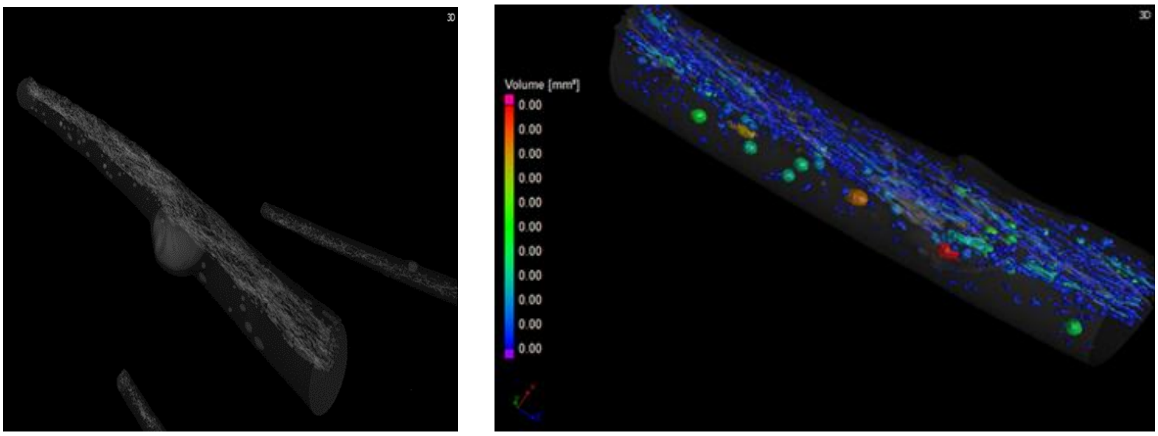

*Figure 2. (**Left**) Tomographic image of the PLA-coated flax fiber filament. Light grey represents the flax fiber and transparent grey represents the polymer matrix. (**Right**) Porosity analysis of PLA pre-impregnated flax fiber. Transparent area is PLA matrix, light grey area is flax fiber and the colorful elements are the porosities.*

References

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