Flax to the Future: Processing–Structure Relationships in Continuous Natural Fiber Thermoplastic Tapes.

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ABSTRACT

Continuous natural fiber-reinforced thermoplastic (NFRTP) tapes have gained increasing attention as sustainable alternatives to glass or carbon fiber composites for lightweight structural applications. While thermoplastic tapes based on glass and carbon fibers are well established, comparable natural fiber tapes have not yet been fully realized through tape manufacturing processes. Flax fibers, in particular, offer a sustainable alternative with favorable mechanical properties, low density, and renewability. However, their sensitivity to processing conditions and limited compatibility with thermoplastic matrices present significant challenges in achieving consistent tape quality. This study focuses on continuous production of flax fiber-reinforced thermoplastic tapes while investigating the influence of matrix type and manufacturing parameters on the impregnation quality, microstructural integrity, and thermal stability of flax fiber tapes.

Two thermoplastic resins—polypropylene (PP) and polyamide 11 (PA11)—were selected to represent non-polar and polar polymer systems, respectively, to be combined with flax through continuous tape manufacturing (Figure 1) . Their different melting behaviors and polarities allow assessment of how matrix chemistry affects interfacial bonding and impregnation during tape consolidation. The process parameters examined include processing temperature (180–250 °C), calendering pressure, drawing speed, and calender configuration.

The produced tapes were analyzed using a combination of spectroscopic, microscopic, and thermal techniques. Fourier-transform infrared spectroscopy (FTIR) was employed to detect possible chemical or thermal degradation flax fibers and matrix during processing. Optical microscopy and scanning electron microscopy (SEM) were used to assess morphological changes, impregnation uniformity, fiber distribution, and interfacial characteristics. Differential scanning calorimetry (DSC) was applied to study the crystallization behavior and thermal transitions of the polymer matrices within the composite, while thermogravimetric analysis (TGA) was used to evaluate the thermal stability and degradation onset of the processed systems.

Through a systematic comparison of resin types and processing conditions, this work aims to establish relationships between processing parameters, resin chemistry, and resulting tape quality. The findings contribute to the development of optimized manufacturing protocols for flax fiber thermoplastic tapes, enabling improved processability and performance of bio-based composite materials designed for secondary structural applications.

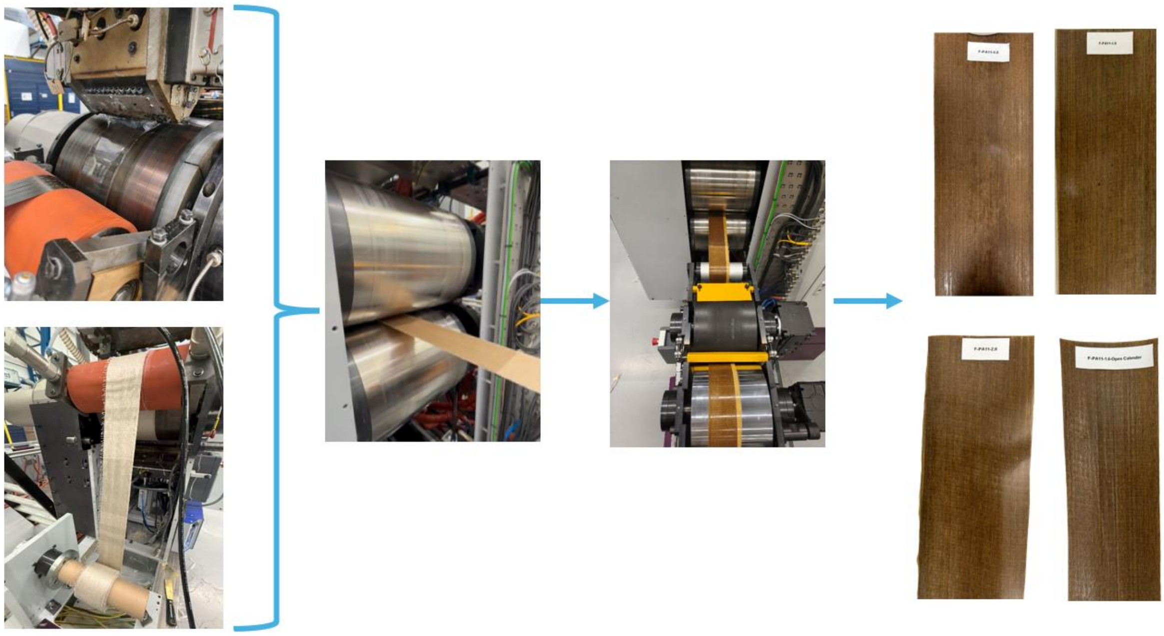

Figure 1 Continuous manufacturing process of flax-PA11 tapes