Solid-State Compounding of Flax Fibers with Engineering Thermoplastics to Combat Thermal Degradation

Katsuyuki Wakabayashi[1], Frederik Desplentere[2], Aart W. Van Vuure[2]

[1]Bucknell University, Department of Chemical Engineering, Lewisburg, Pennsylvania, U.S.A.
[2]Katholieke Universiteit Leuven, Composites Materials Group, Leuven, Belgium

kat.wakabayashi@bucknell.edu

As natural fiber composite materials continue to gain prominence in the manufacturing industry, their processing technology needs to adapt to the increasing market demand. For thermoplastic-based short fiber composites, continuous, compounding processes would be preferred over small-scale processes like film stacking and batch compounding. Limitations in melt compounding include the relatively low-thermal resistance (i.e. low degradation temperature) of natural fibers compared to the melting temperatures of matrix polymers, and the complex morphological hierarchy of natural fibers' structure, whose properties highly depend on processing. A robust method to compound natural fibers with a wide range of thermoplastic matrices would broaden the application portfolio of biocomposites.

Solid-state shear pulverization (SSSP) is an alternative processing technique to conventional twin screw melt-extrusion (TSE), in which chilled screws and barrels in a modified twin screw extruder apply high shear and compressive forces to the materials in the solid state, well below their melting or glass transition temperatures. The process is continuous, and the low-temperature nature of SSSP not only prevents undesirable thermal degradation, but also provides a pathway for composite development without limitations in viscosity, thermodynamics, and kinetics.

We present the first study to apply the SSSP process to the production of natural fiber-reinforced composites. In this model composite study, Belgian flax fibers are compounded with polyamide 6, a common industrial plastic with relatively high melting temperature. We benchmark the physical properties of SSSP-compounded composite material against those of TSE-compounded and hand-blended analogues, and assessed its viability in real-world applications.