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Biocomposites Made of PLA Reinforced with Lignin Containing Nanocellulose Fibrils

To Yu Troy Su[1], Ning Yan[2], Patrick C. Lee[1]
[1]Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, Canada
[2]Department of Chemical Engineering & Applied Chemistry, University of Toronto, Toronto, Canada

ABSTRACT

Poly-Lactic Acid (PLA) has exhibited an exceptional potential for use as a bio-based and biodegradable alternative to traditional petroleum-based polymers in a variety of industries and applications. Despite its promises, PLA suffers from chain degradation as a result of thermal processing and hydrolytic chain scission, which compromises its mechanical properties significantly. Lignin containing nanocellulose fibrils (LCNFs) have been shown to possess exceptional mechanical properties while being more thermally stable than PLA, and as such, are being investigated as a viable reinforcing agent in this study. Historically, lignin-free nanocellulose fibrils has been difficult to incorporate into PLA due to their hydrophilic nature. Furthermore, these fibrils tend to have an agglomerating effect, which can prevent proper dispersion, thus reducing the effective interfacial area between the filler and matrix. It has been shown previously the presence of lignin had a "shielding" effect which helped to improve dispersion of the LCNFs in polymer matrices. In this study, the addition of LCNF in PLA resulted in improvements in the tensile properties without the need for coupling agent or surface modification of fibrils. Preliminary work has shown an improvement in tensile properties at just 1wt% concentration of LCNF in PLA. At only 1wt% LCNF, the PLA/LCNF blend experienced a 20.5% improvement in Young's Modulus compared to neat PLA and an 18% improvement of ultimate tensile strength. Moreover, the effect of LCNF addition on the barrier properties of the biocomposites, such as oxygen and water vapour transmission rates, is characterized. The underlying mechanistic structure-property relationship is examined in terms of LCNF dispersion, fibril/matrix interfacial interaction, and the impact of LCNF on PLA crystallinity. In the coming months, the water vapour and oxygen gas transfer rates of this blend will be characterized and compared to that of pure PLA to understand the effect of LCNF as a crystal nucleating agent. In addition, the thermal stability of the blend will be tested to observe the impact of LCNF in strengthening PLA across a variety of temperatures. This study demonstrates the efficacy of the PLA/LCNF biocomposites as a suitable replacement for traditional petroleum-based plastics.

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