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Biodegradable and tough pla-cellulose based composites via stereo-complexation

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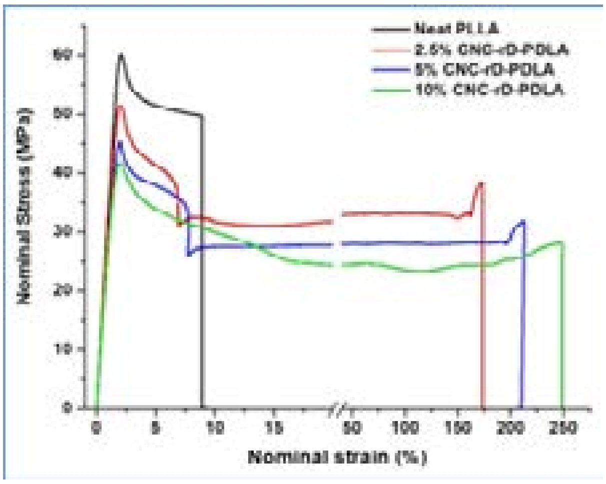
In recent years, sustainability and industrial ecology concerns have driven the search for alternatives to petrochemical based products to a whole new level. As such biobased polymers have a competitive advantage, due to their eco-friendly properties. Among biobased polymers, poly (lactide) (PLA) has been a frontrunner based on its good mechanical properties, coupled with its 'green' attributes. However, PLA is inherently brittle, slow in crystallization and low thermal stability. PLA, therefore, does not meet some market requirements for high end applications. Research has shown that these limitations are 'improvable' and PLA applications landscape widened by careful design of rigid-rubber matrix PLA modifiers. In order to obtain a good matrix-filler interface adhesion, phase morphology at the interface can be tailored with the aid of stereocomplex crystallites. In this work, Poly(L-lactide) cellulose nanocrystals-filled nanocomposites were fabricated by blending of cellulose nanocrystals-g-rubber-g-poly(D-lactide) (CNC-rD-PDLA) and commercial PLLA, in which CNC-g-rubber was synthesized by ring opening polymerization (ROP) of D-lactide and ε-caprolactone mixture to obtain CNC-P(CL-DLA), followed by further polymerization of D-lactide to obtain CNC-rD-PDLA. X-ray diffraction (XRD), nuclear magnetic resonance (NMR) and solubility tests confirmed successful grafting of the rubber segment and the PDLA segment onto CNC. Stereocomplexation between CNC-rD-PDLA nanofillers and PLLA matrix was confirmed by FT-IR, XRD and differential scanning calorimetry (DSC) characterization. The PLLA/CNC-rD-PDLA nanocomposites exhibited greatly improved tensile toughness. With 2.5% CNC-rD-PDLA loading, strain at break of PLLA/CNC-rD-PDLA was increased 20-fold, and the composite shows potential to replace poly (ethylene terephthalate). SEM and small angle x-ray scattering (SAXS) investigations revealed that fibrillation and crazing during deformation of PLLA/CNC-rD-PDLA nanocomposites were the major toughening mechanisms in this system. The highly biodegradable and tough cellulose nanocrystals-filled PLLA nanocomposites could tremendously widen the range of industrial applications of PLA.



Biography

Joseph Kinyanjui Muiruri is currently a Ph.D student in Material Science and Engineering (MSE) at National University of Singapore (NUS) and Institute of Material Science and Engineering (IMRE). Joseph graduated with a Master's degree from University of Nairobi, Kenya in 2011. He is a recipient of A*Star Singapore International Graduate Award (SINGA). He holds a Bachelor's degree in Textile engineering from Moi University, Kenya. His research interests focuses on biopolymers and their nanocomposites for industrial applications.

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