Accepted Manuscript

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PII: S0266-3538(18)31033-9

DOI: 10.1016/j.compscitech.2018.08.032

Reference: CSTE 7365

To appear in: *Composites Science and Technology*

Received Date: 2 May 2018

Revised Date: 26 July 2018

Accepted Date: 23 August 2018

Please cite this article as: Shrestha S, Montes F, Schueneman GT, Snyder JF, Youngblood JP, Effects of aspect ratio and crystal orientation of cellulose nanocrystals on properties of Poly(vinyl alcohol) composite fibers, *Composites Science and Technology* (2018), doi: 10.1016/j.compscitech.2018.08.032.

Effects of Aspect Ratio and Crystal Orientation of Cellulose Nanocrystals on Properties of Poly(vinyl alcohol) Composite Fibers

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Abstract

This work reports a study on the effects of different types and aspect ratios of cellulose nanocrystals (CNCs) on properties of poly(vinyl alcohol) (PVA) composite fibers. CNCs were extracted from wood pulp and cotton and reinforced into PVA to produce fibers by dry-jet-wet spinning. The fibers were collected as-spun and with first stage drawing up to draw ratio 2. The elastic modulus and tensile strength of the fibers improved with increasing CNC content (5 – 15 wt. %) at the expense of their strain-to-failure. It was also observed that the mechanical properties of fibers reinforced with cotton CNC were higher than the fibers with wood CNC at the same amount of CNCs due to their higher aspect ratio. The degree of orientation along the spun fiber axis was quantified by 2D X-ray diffraction. As expected, the CNC orientation correlates to the mechanical properties of the fibers. Micromechanical models were used to predict the fiber performance and compare with experimental results. Finally, surface and cross-sectional morphologies of fibers were analyzed by scanning electron microscopy and optical microscopy.

Keywords: cellulose nanocrystals, polymer-matrix reinforced composite fibers; aspect ratios; mechanical properties; micromechanical modeling