Effects of Mechanical Stretching on Cellulose Nanocrystal Polymer Composites

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Objectives

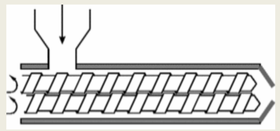
- Increase mechanical strength of cellulose nanocrystal (CNCs) reinforced nanocomposites via mechanical stretching to achieve tensegrity-inspired microstructures
- Study dispersion of CNCs in poly(ethylene-co-vinyl alcohol) (EVOH) through solution processing followed by extruder compounding

Materials

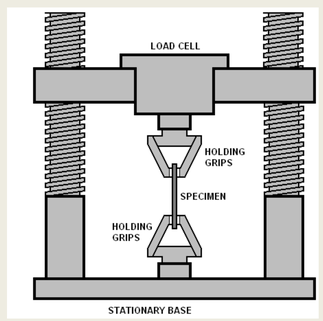
- Cellulose nanocrystals
  - USDA Forest Service - Forest Products Laboratory (CNC)
- 48 mol% ethylene poly(ethylene-co-vinyl alcohol) (48EVOH)
- 44 mol % ethylene EVOH (44EVOH)

Method

Solution Process



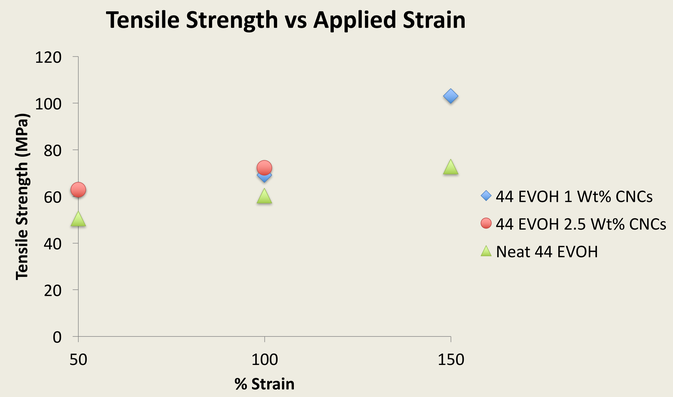
Melt Process in twin screw extruder



Mechanical Stretching on Instron at Tg

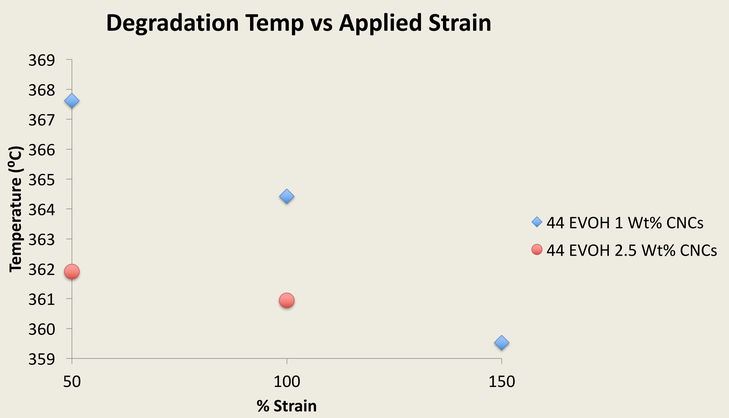
- Samples with 0, 1 and 2.5 wt% CNCs in 44 and 48 EVOH were prepared with the above materials and methods
- Mechanical stretching was done uniaxially at 50C, the glass transition temperature for EVOH to 50, 100, and 150% strain levels

Mechanical Stretching Effects on Tensile Strength



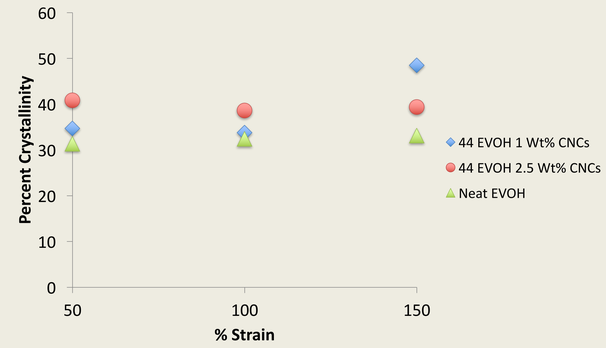
- Films stretched on the Instron were cut into strips and tested to tensile failure in the machine direction at room temperature
- 44 EVOH 2.5 Wt% 150% strain data was confounded due to machine issues and has been omitted. Retesting will be included in future work.

Variation of Degradation Onset Temperature



- 10mg samples of stretched films were tested in a TA Q50 Thermogravimetric Analyzer
- Degradation onset temperature was determined at 5% mass loss post water evaporation
- Neat samples have not been tested yet, but will be completed in future work.

Variation of Percent Crystallinity



- 10mg samples of stretched films were tested in a TA Q200 Differential Scanning Calorimeter
- First heat data was analyzed to determine percent crystallinity of samples containing CNCs compared to neat samples.

Results

- Ultimate tensile strength (UTS) increased with applied strain, most likely due to alignment of polymer chains in the machine direction
- UTS increased further with addition of CNCs, though reinforcing effect did not seem to increase with higher loadings of CNCs
  - Agglomeration of CNCs at higher concentrations
- Xc increased with increased loadings of CNCs, potentially due to crystalline nature of CNCs
- Xc did not vary significantly with induced strain
- Degradation onset temperature decreased with increased loadings of CNCs
  - Attributable to lower degradation temperature of CNCs
- Further investigation needed to characterize neat 44 EVOH and identify cause of downwards trend

Summary

- Tensile strength increased by mechanical stretching as well as addition of CNCs
- CNCs contributed to increase in crystallinity in EVOH matrix (higher Xc)
- Degradation onset temperature decreased with more CNCs, though future work includes completing neat 44 EVOH characterization
- Analysis/characterization needs to be completed on 48 EVOH

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