23-271SB: Thermo-rheological behavior of biopolymer and biopolymer blends

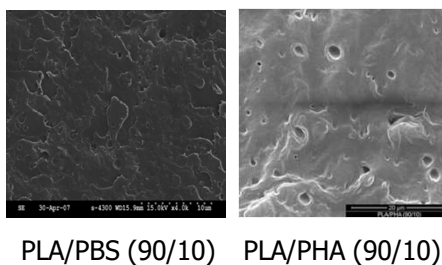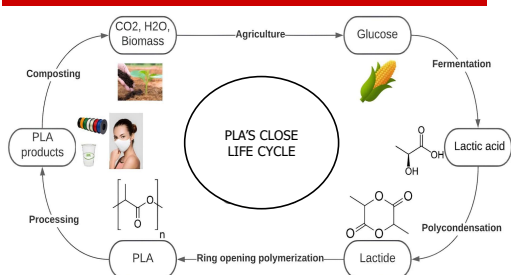## Sarvesh Anand Nadkarni, Dr. Saad Khan

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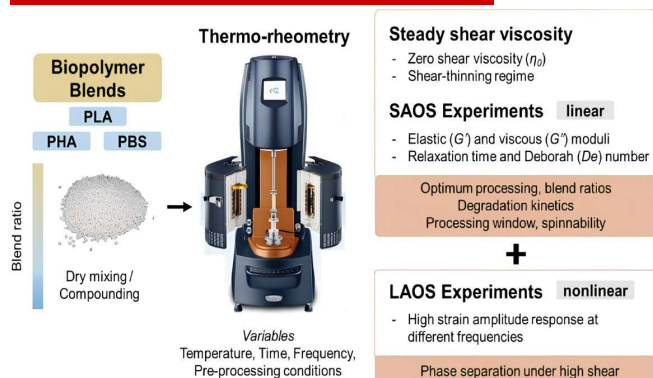
Objectives

- Evaluate the rheological behavior of biopolymer and their blends using steady-state shear, small and large amplitude oscillatory shear
- Investigate phase separation as a function of blend ratios and temperatures
- Characterize thermal properties - glass transition temperature, crystallization rate, and melting range of blends using DSC
- Correlate results of thermo-rheological measurements to fiber spinnability and mechanical properties
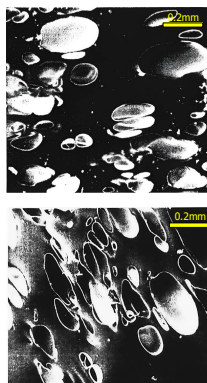
Why PLA Blends

PLA/PBS (90/10)   PLA/PHA (90/10)

Ebrahimi, H., 2021; Bhatia et al. 2007; Botta et al. 2015

Rheology

Thermo-rheometry

Biopolymer Blends
PLA
PHA   PBS

Blend ratio

Dry mixing / Compounding

Steady shear viscosity
- Zero shear viscosity (η_0)
- Shear-thinning regime

SAOS Experiments linear
- Elastic (G') and viscous (G'') moduli
- Relaxation time and Deborah (De) number

Optimum processing, blend ratios
Degradation kinetics
Processing window, spinnability

+

LAOS Experiments nonlinear
- High strain amplitude response at different frequencies

Phase separation under high shear

Variables
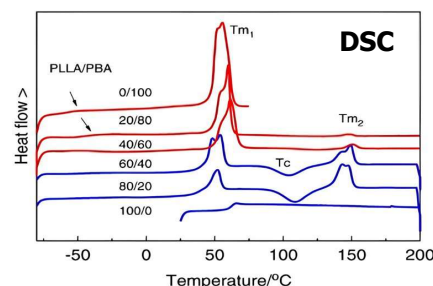Temperature, Time, Frequency, Pre-processing conditions
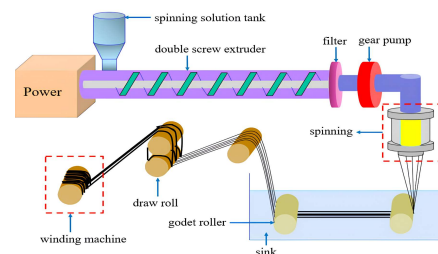
Under SAOS

Under LAOS

Thermal Characterization

DSC	TGA
DSC to identify potential blend ratios that may result in strong spun fiber structures	TGA to confirm degradation profiles of biopolymers and their blends

Zhao, L., Peng, X., Liu, X. et al., 2013

Mechanical Performance

- Develop and analyze spun fibers of optimized biopolymer blends
- Mechanical properties to be evaluated using a DMA accessory on the rheometer
- Determine how material properties differ at the same fiber size vs conventional petroleum-based PP

Wang, Yang & Song, Yuanjun et al., 2016

Conclusion

- Considerable work has been done on characterizing biopolymers, but there remains a significant knowledge gap in several areas
- This study will identify process critical information such as optimal blend ratio for different PLA blends, degradation kinetics, and Deborah number to obtain processing window for fiber spinning
- LAOS will help study the phase separation of PLA/PHA or PLA/PBS, to gain insight into their behavior during industrial processing