How do thermodynamics and nanofiller geometry affect the stereocomplexation in polylactide nanocomposites?

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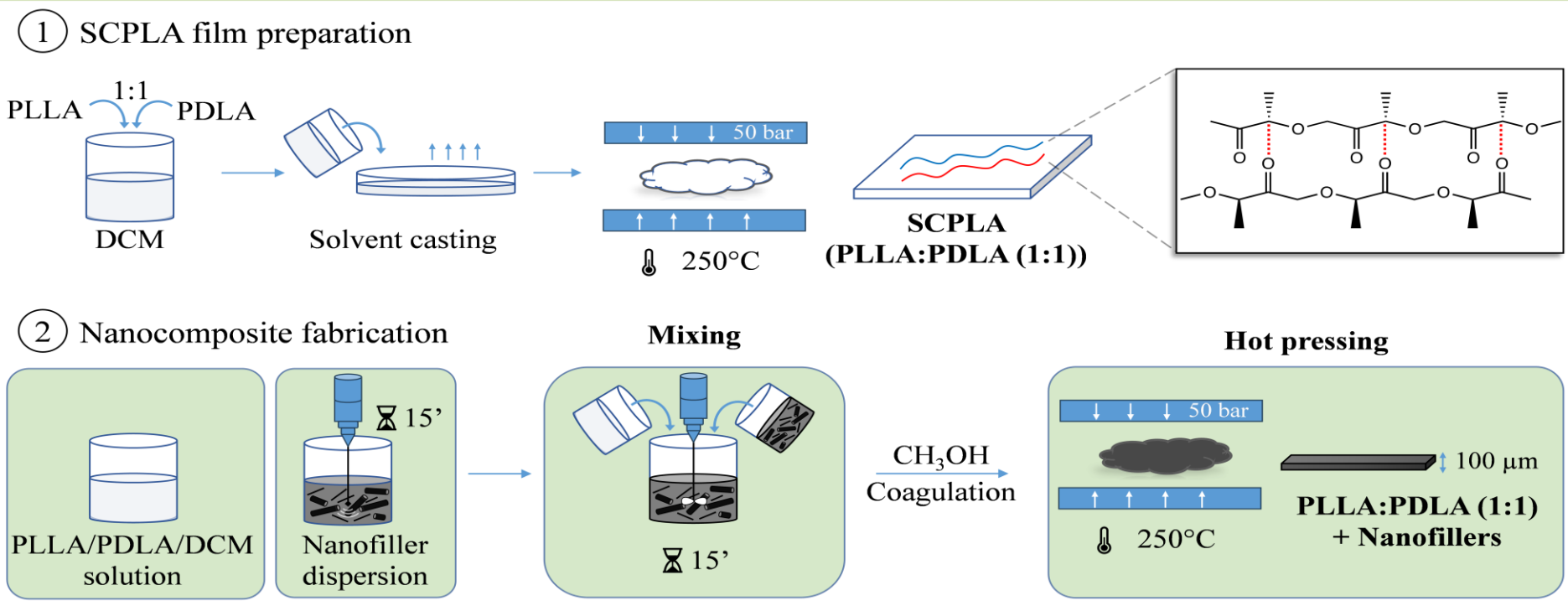
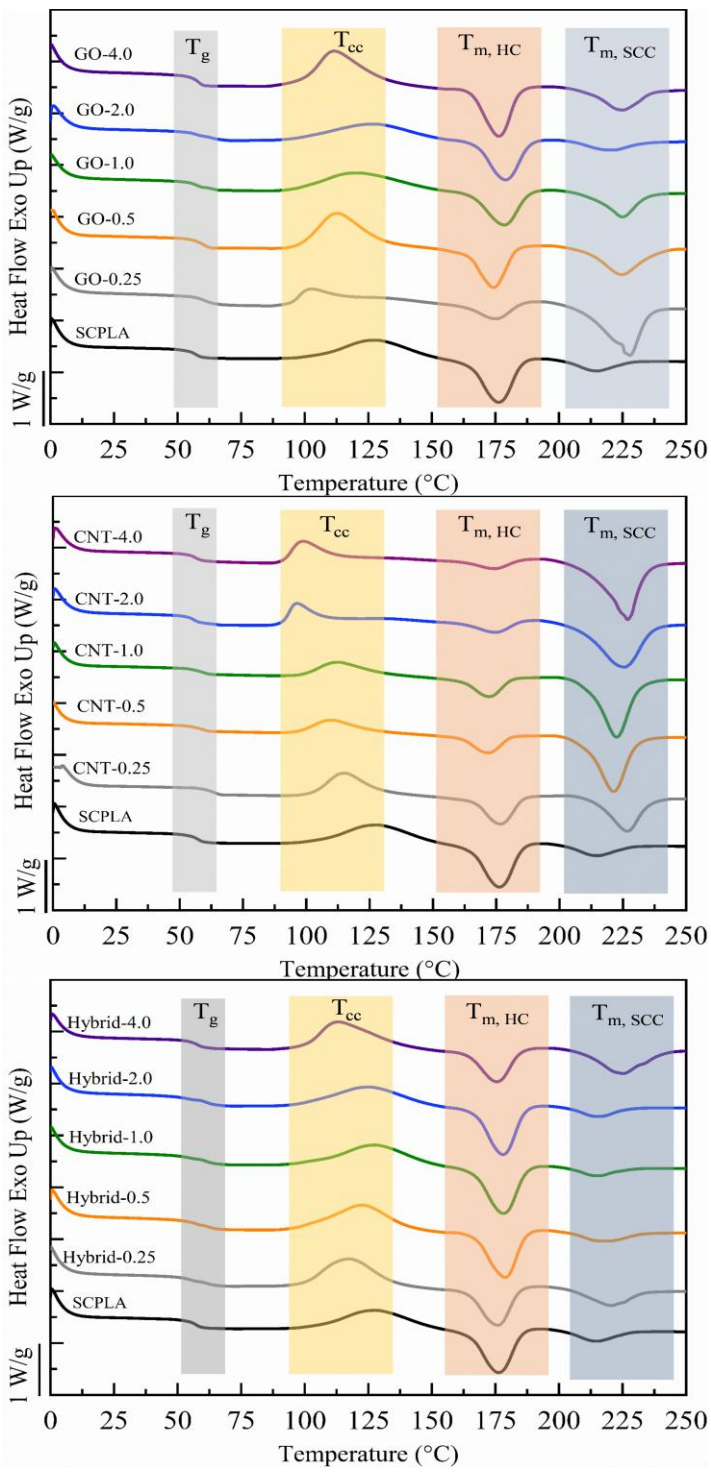
Abstract: The wettability, stereocomplex-crystallization behavior, and thermal degradation properties of stereocomplexed-polylactide (SCPLA) nanocomposites filled with graphene oxide (GO), carbon nanotubes (CNTs) and their hybrid was investigated from an interface-geometry combinational point of view. It was demonstrated that thermodynamics and nanofiller geometry are determinant in modulating the degree of stereocomplexation and thermal stability. The interfacial interactions in a three-component system were measured to predict the dispersion/filler-polymer wettability. Our results pave the way towards a feasible interface engineering to control the stereocomplexation for the desired application of SCPLA-filled nanocomposites.

Materials and Methods

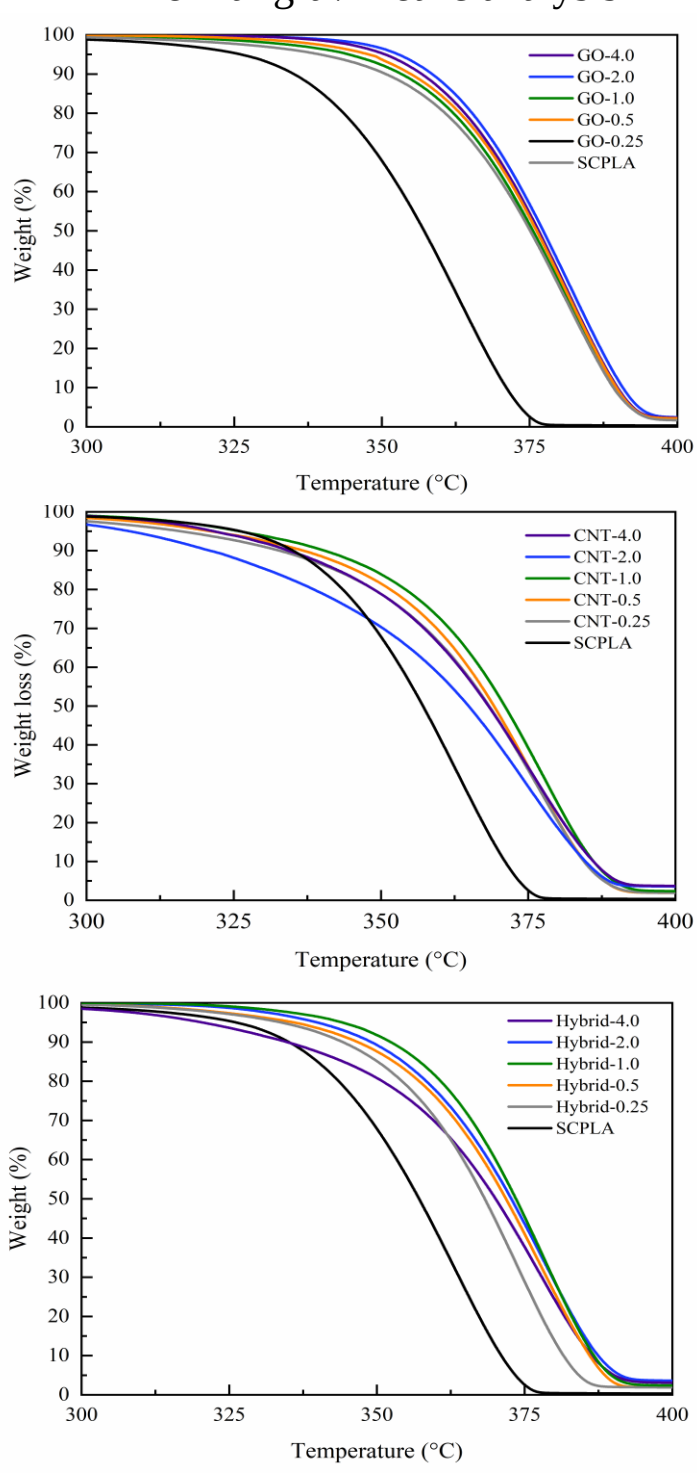


Results and Discussions

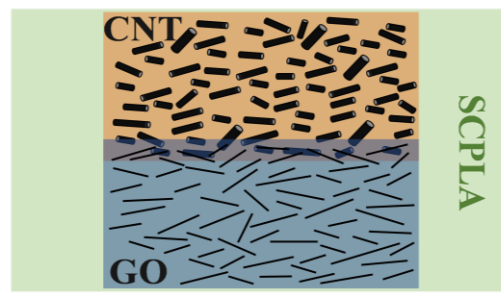
Differential scanning calorimetry



Thermal gravimetric analysis



Thermodynamics



$W_{CNT\text{-}GO\text{-}SCPLA} > 0$

$\gamma_{CNT\text{-}SCPLA} > \gamma_{CNT\text{-}GO} + \gamma_{GO\text{-}SCPLA}$

$\gamma_{CNT\text{-}SCPLA} + \gamma_{GO\text{-}SCPLA} > \gamma_{CNT\text{-}GO}$

Graphene oxide

- Higher affinity
- Restricted mobility
- Reduced stereocomplexation
- Higher thermal stability

Carbon nanotubes

- Lower wettability
- Facilitated chain coupling
- High stereocomplexation
- Deteriorated T_{onset}

Hybrid

- Dual network
- Limited mobility
- Low stereocomplexation
- Improved thermal stability

Conclusions: Stereocomplexation is mainly influenced by thermodynamic and nanofiller geometry. While the enantiomeric chains wetted GO surface well—favoring better dispersion—the platelets restricted nucleation and chain coupling, limiting stereocomplexation. In contrast, SCPLA had poor wettability on CNTs, but their high nucleation efficiency led to significant stereocomplexation. Thermal stability was correlated to wettability—enhanced in GO-filled nanocomposites but reduced with incorporating CNTs. Strong interfacial adhesion led to the improvement of thermal stability and shifting the thermal degradation temperature towards higher temperatures.

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References

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2. Israelachvili, J. N. 2010/2011. Academic Press. https://doi.org/10.1016/B978-0-12-375182-9.10017-X.