Dynamic mechanical characterization of ternary polylactide nanocomposites reinforced with montmorillonite/carbon nanotubes hybrid for high-performance applications

O. M. Sanusi[a], A. Benelfellah[a,b], Z. Terzopoulou[c], D. N. Bikiaris[c], N. Aït Hocine[a]

[a]Laboratoire de Mécanique Gabriel Lamé (LaMé), INSA Centre Val de Loire, Blois, France

[b]DRII, IPSA, 63 boulevard de Brandebourg, 94200 Ivry-Sur-Seine, France

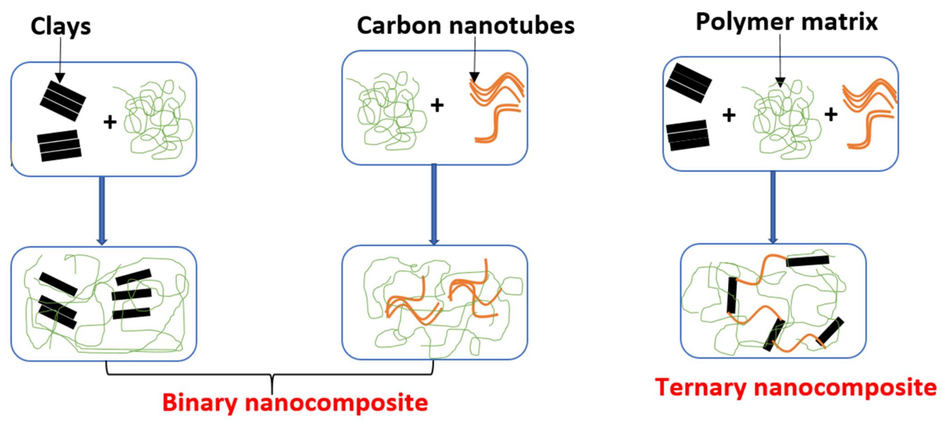
[c]Department of Chemistry, Lab. of Polymer Chemistry & Technology, Aristotle University of Technology, Greece

Email address: sanuthwale@gmail.com; olawale.sanusi@insa-cvl.fr

Introduction

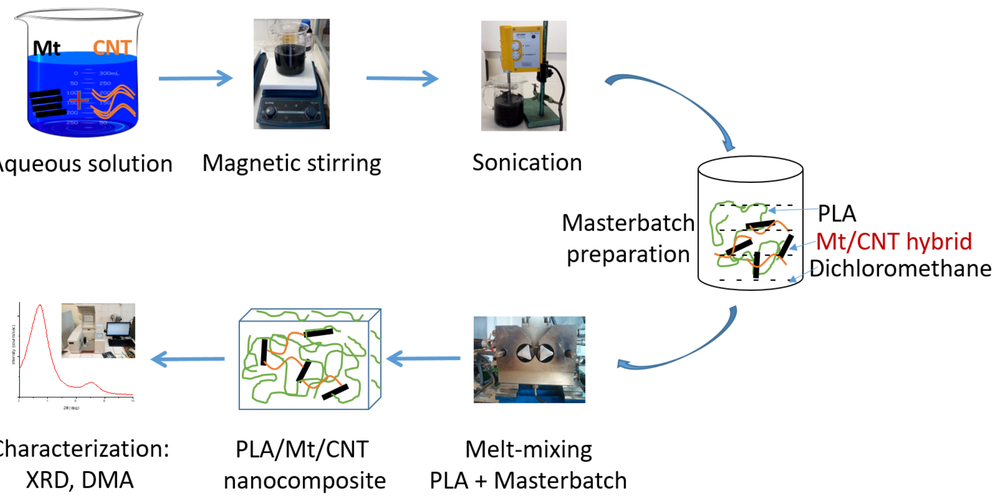
Incorporation of inorganic rigid nanoparticles remains the most effective means of improving polymer properties; montmorillonite and multi-walled carbon nanotubes are legendary in this field for their individual exceptional physical characteristics. Hybridization of the montmorillonite (MMT) and carbon nanotubes (CNT) is anticipated to create a synergistic role in polymer. At a definite nanofillers concentration, termed percolation threshold, there exists a strong structured-network formation leading to improved bulk polymer properties. This research presents the preparation of polylactic acid (PLA) nanocomposites, reinforced with hybrid of MMT/CNT, through a combined solution and melt mixing methods. A unique investigation on the dynamic mechanical parameters in relation to incorporation of MMT/CNT hybrid and identification of the percolation threshold through the viscoelastic behaviour is presented. Comparatively, binary nanocomposites reinforced solely with CNT, equivalent to the mass fraction of MMT/CNT hybrid used in ternary nanocomposite, is studied.

1. Context: Synergistic effect of MMT with CNT in polymer matrix

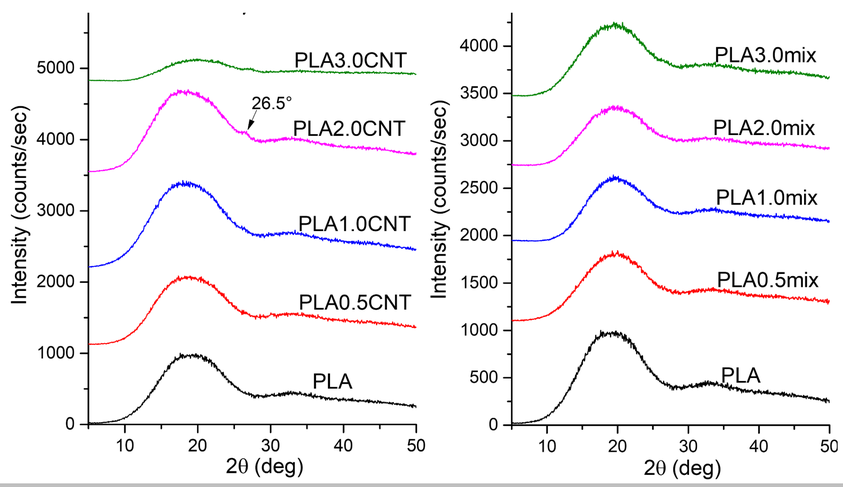


Using MMT to disperse CNT, reduce percolation threshold and create 3D network structure of nanofillers [1]

2. Preparation procedure and characterization

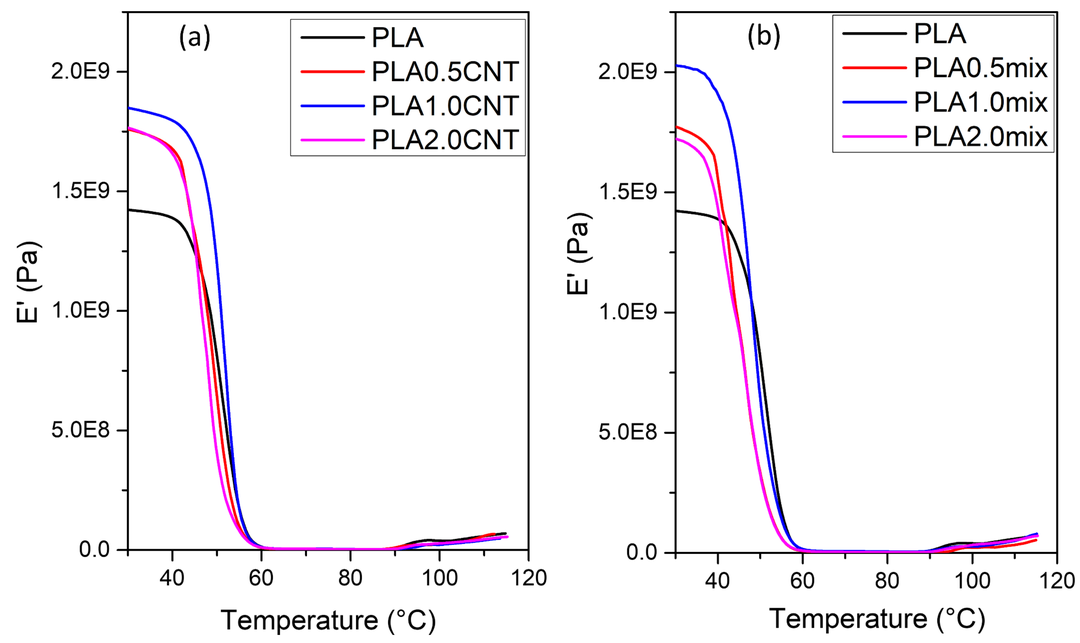


3. WAXD of (a) PLA/CNT and (b) PLA/mix



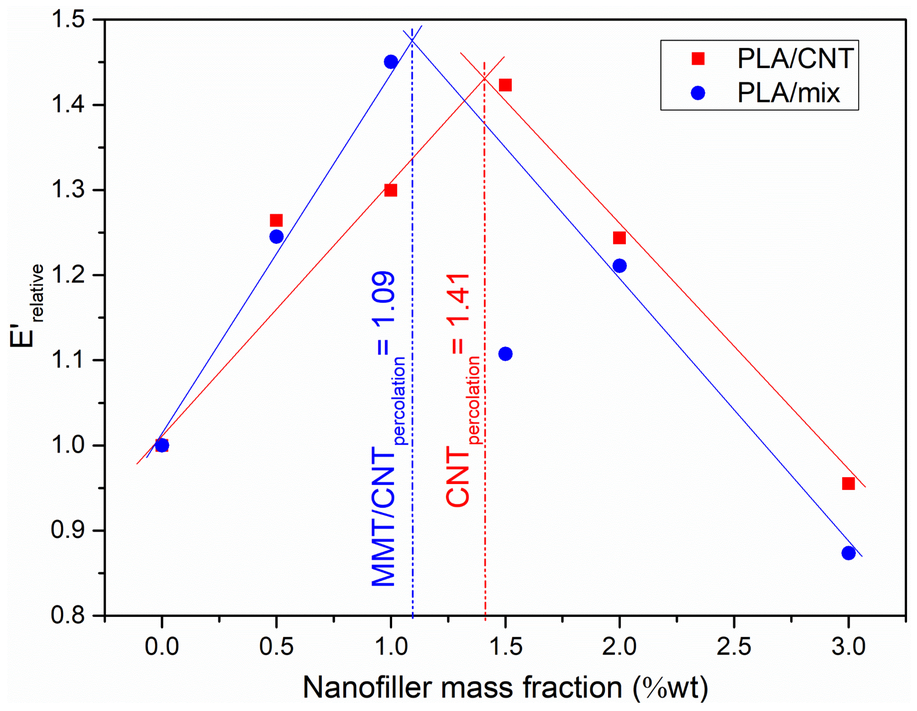
- ✓ **Structural changes in PLA/CNT ≥ 2.0 wt% ⇒ CNT aggregates**
- ✓ **PLA/mix are unchanged**

4. Storage modulus of (a) PLA/CNT and (b) PLA/mix



Addition of MMT & CNT resulted in the optimum storage modulus (E') of 2.03 GPa in PLA1.0mix, compared with PLA/CNT

5. Determination of percolation threshold by tangent method



Percolation threshold:

- ✓ **1.41 wt% (CNT) in PLA/CNT**
- ✓ **1.09 wt% for (MMT:CNT) in PLA/mix**

Conclusion

Incorporation of MMT enhanced the dispersion of CNT in PLA and prevented aggregation as against single CNT in the PLA; and reduced the percolation threshold of CNT from 1.41 to 1.09 wt% MMT/CNT hybrid. Based on the sedimentation experiment, 1.09 wt% of MMT/CNT is equivalent to 0.69:0.4 of MMT:CNT. This implies that in the presence of MMT, 0.4 wt% of CNT is required to achieve higher storage modulus than binary nanocomposite PLA/CNT with 1.41 wt% single CNT.

Acknowledgement

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Reference

[1] O. M. Sanusi, A. Benelfellah, N. Aït Hocine (2020). Clays and carbon nanotubes as hybrid nanofillers in thermoplastic-based nanocomposites – A review. Applied Clay Science, 185, pp. 105408. https://doi.org/10.1016/j.clay.2019.105408