The American University in Cairo

Department of Chemistry

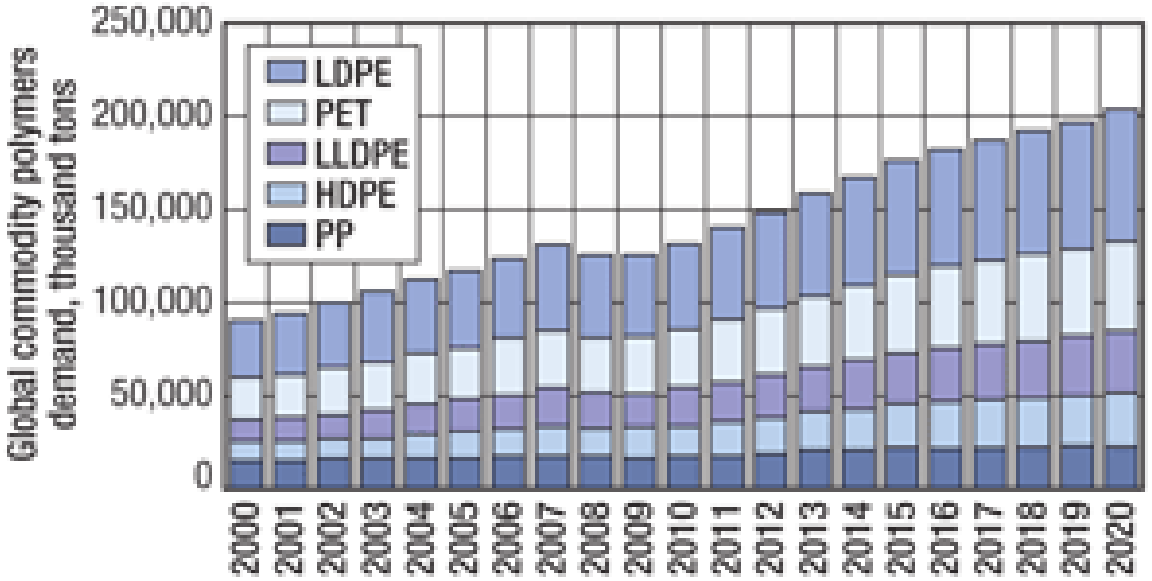
Biodegradable biorenewable polymeric nanocomposites for food packaging applications

By:

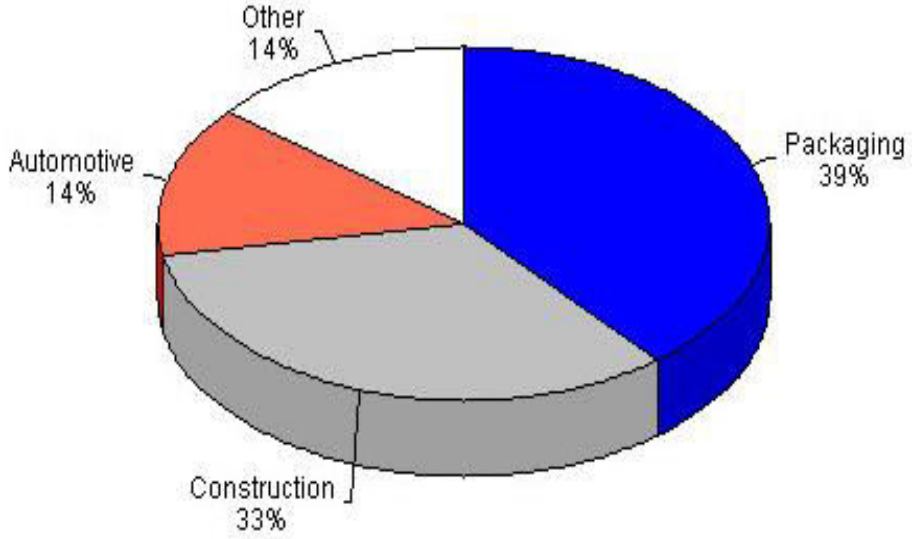
Tarek M. Madkour
Professor of Polymer Chemistry

The Current State of Plastics Production:

The unique attributes of plastics including processability, light weight and resistance to corrosion have led to the creation of new products that displaced paper, glass and metal from traditional applications



The main consumed plastic materials are PE, PP, and PET.



Major applications of these materials lies mostly in the packaging and construction industries.

Drawbacks of Plastic Products: Despite many advantages, concerns over health and environmental risks such as additives migration from plastics to food items, the role of degraded monomeric units in developing cancer tumors, dependency of plastics production on petroleum depleting non-renewable sources and plastics accumulation in the environment are few to mention.







The Challenge

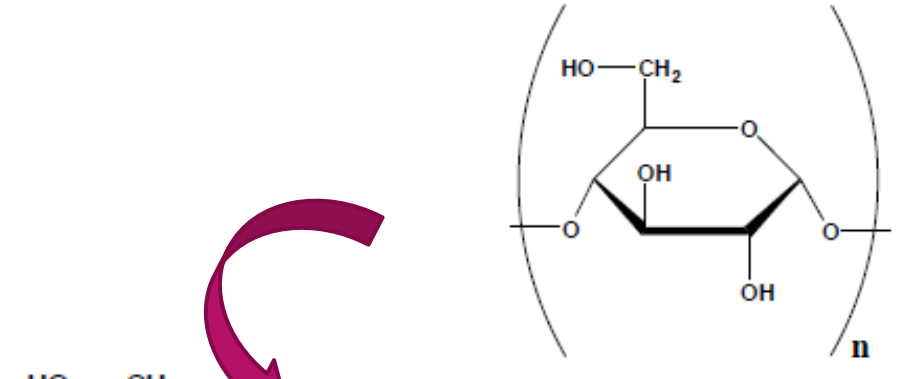
- Provide healthy packaging materials free of harmful additives and monomers.
- Provide renewable resources for raw materials production that are independent on fossil-based resources.
- Produce an environmentally friendly product that biodegrades naturally when discarded.
- Improve mechanical, thermal, and barrier properties and extend products shelf-life.



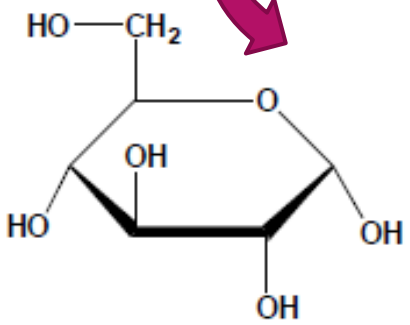
Development of biodegradable biorenewable nanocomposites for food packaging applications



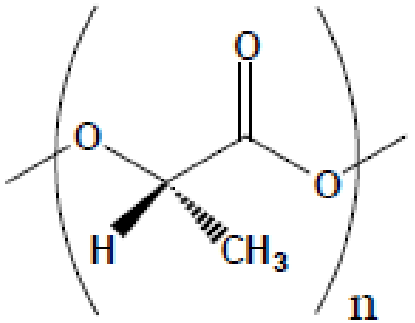
Use of PLA as Biodegradable Biorenewable Polymer



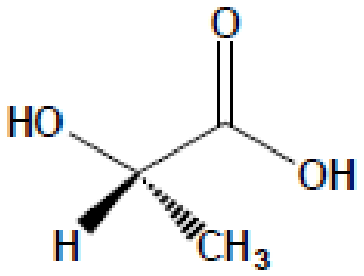
Starch



Dextrose



Poly(Lactic Acid)



Lactic Acid



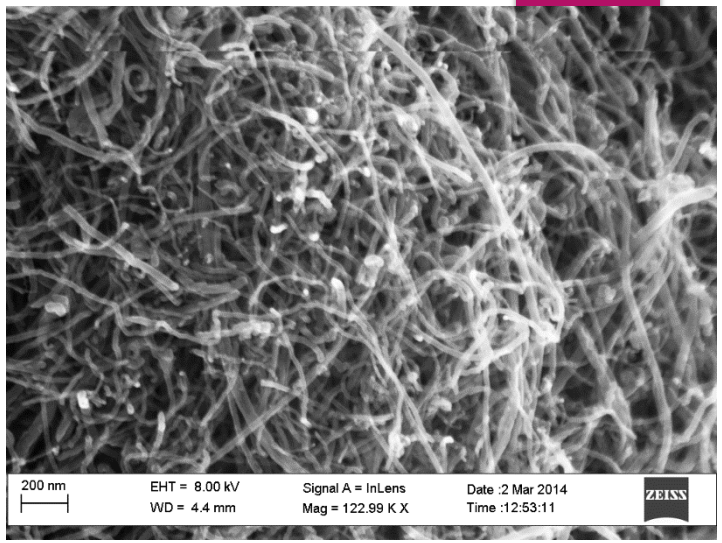


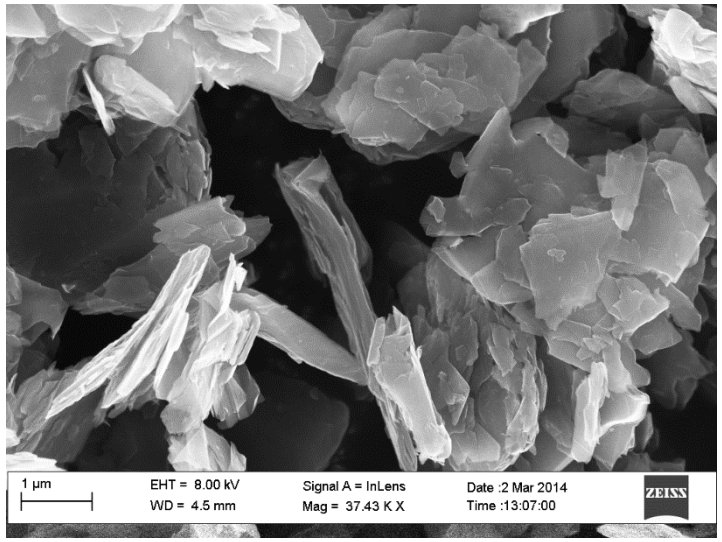


Use of Nano-fillers to Develop Nanocomposites

- Nanofillers are materials in the nanosize scale (10^{-9} m), added to the biopolymers to improve their properties:
  - Better mechanical properties
  - Better thermal properties
  - Better barriers for humidity, undesirable odors and microbial contamination

- Examples of nanofillers include nanoclays, carbon nanotubes, nanofibers, graphene, nanosilver, etc.

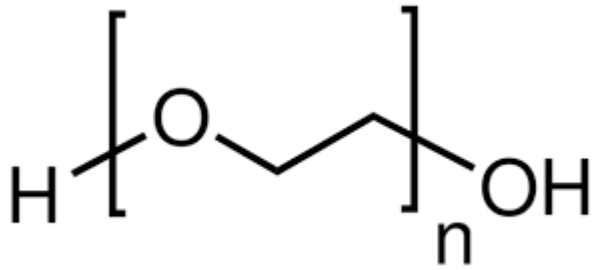




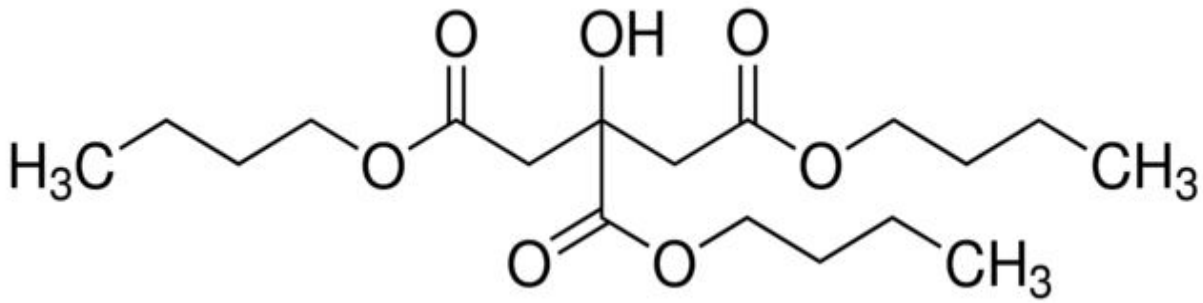
Use of Natural Plasticizers to Provide Flexibility for Bionanocomposites for Food Applications

Properties of used plasticizers:

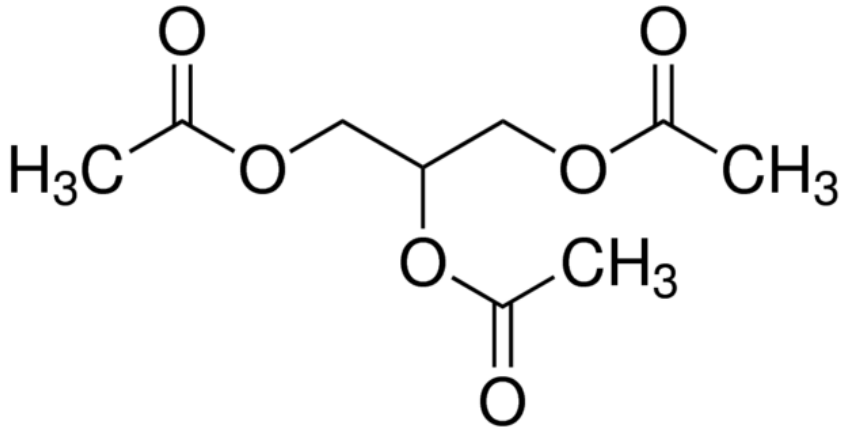
- **Compatibility with polymeric matrix**
- **Biocompatibility**
- **No toxicity**
- **Low tendency for migration**



PEG

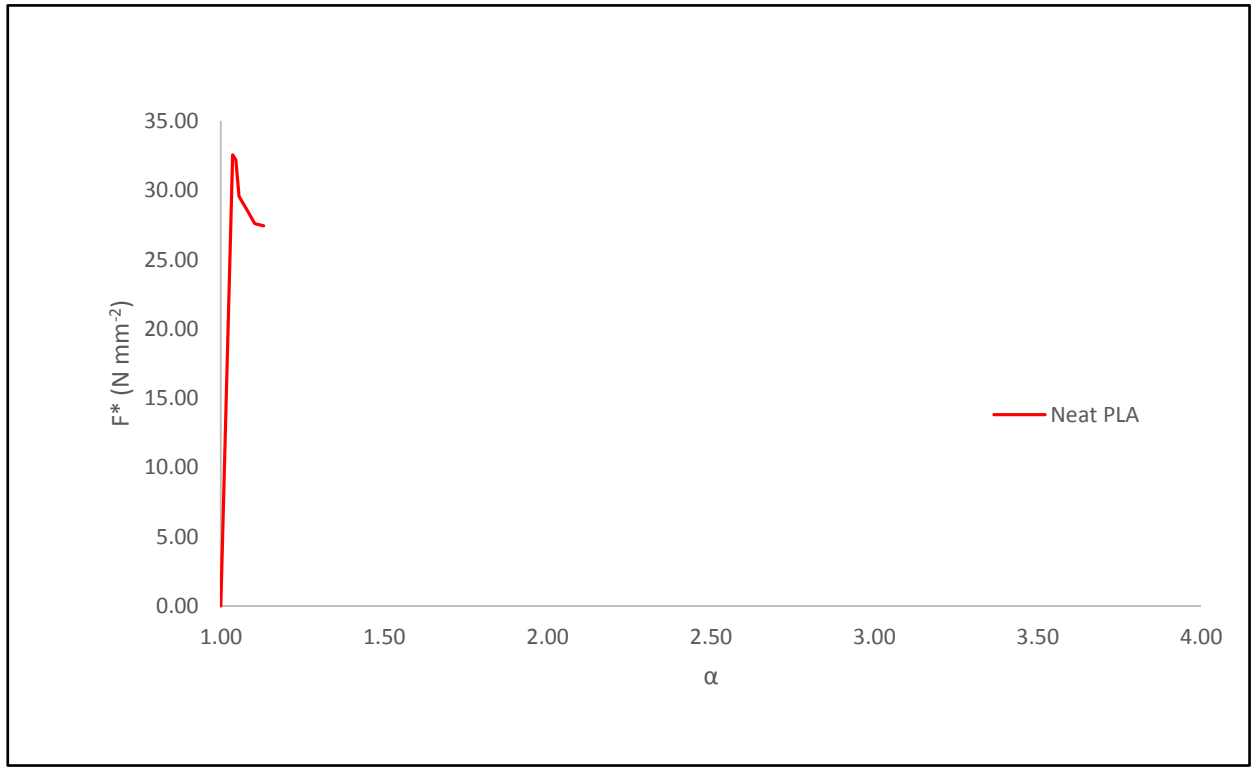


TBC



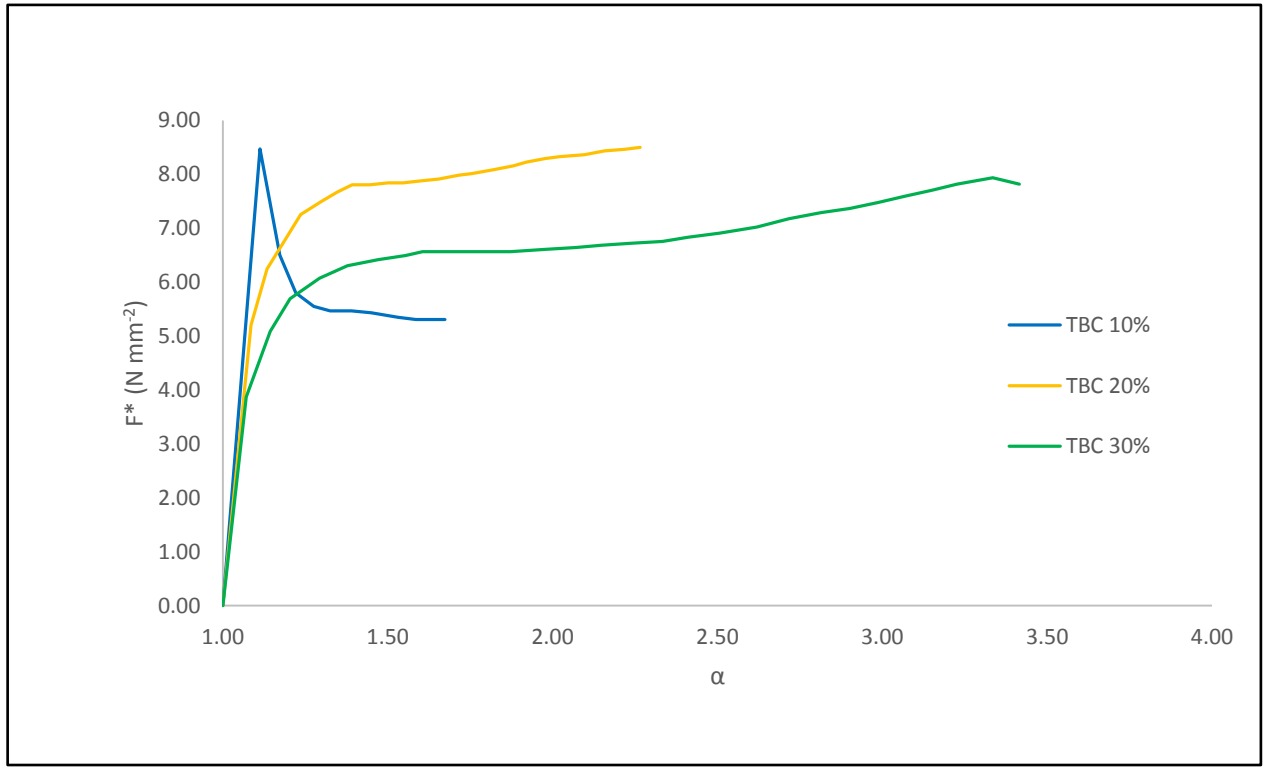
TA

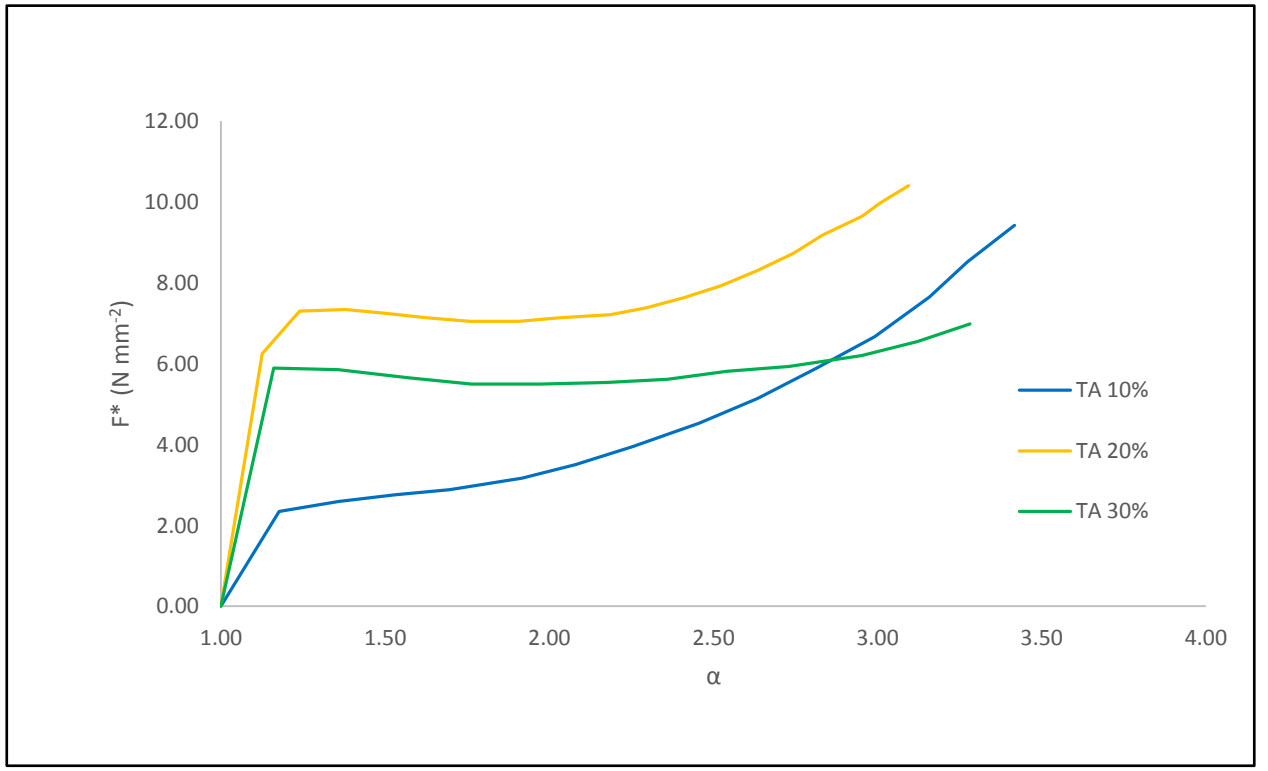
Physical Properties of non-plastizied PLA



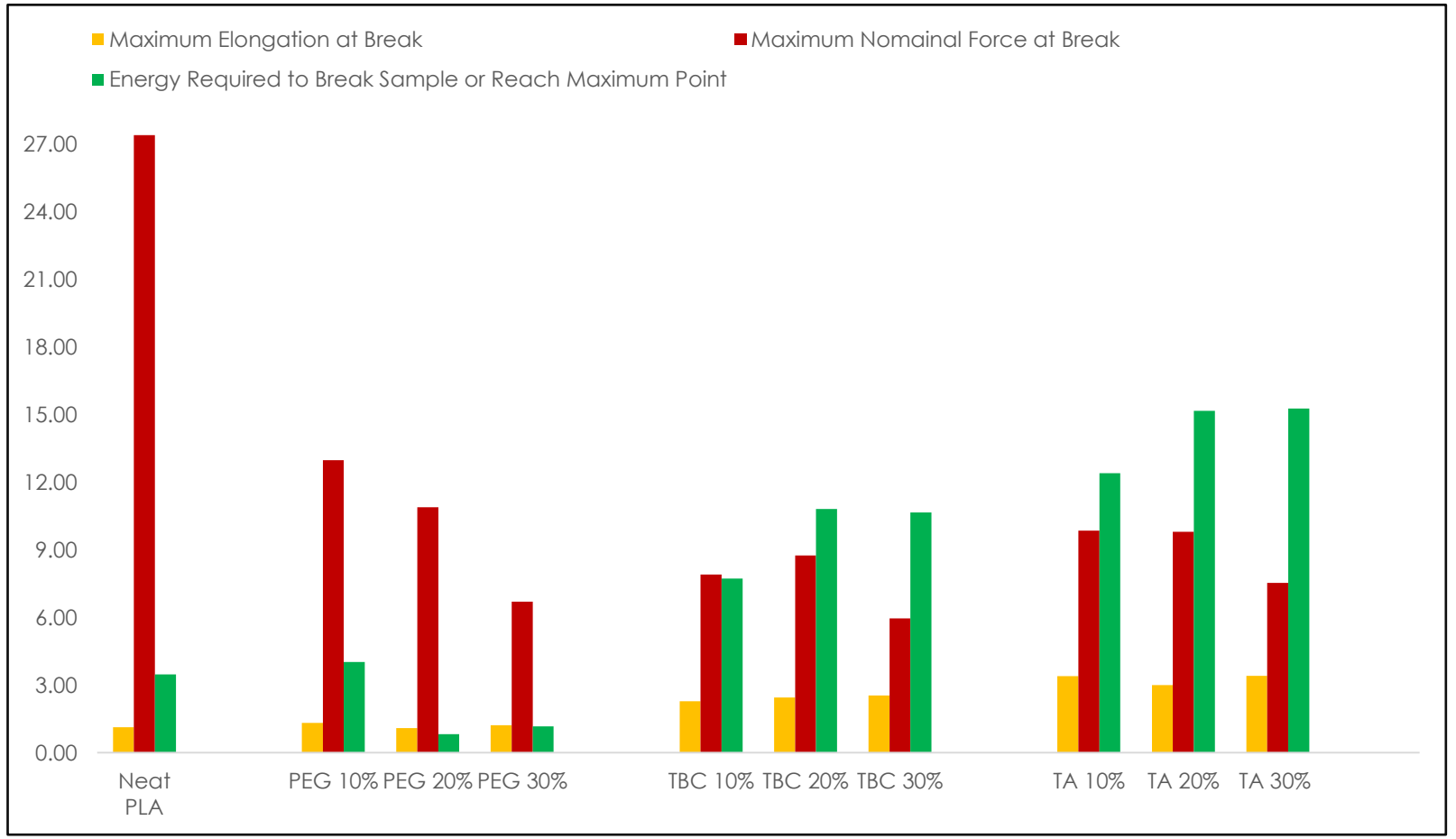
PLA exhibited high modulus and very low tensile elongation. This behavior was attributed to the high glass transition of PLA (about 63 °C) as proved by DSC analysis. Below Tg, PLA exhibits rigid behavior and low mobility that restrict its application to food packaging.

Stress-Strain behavior of PLA Plasticized with TA and TBC



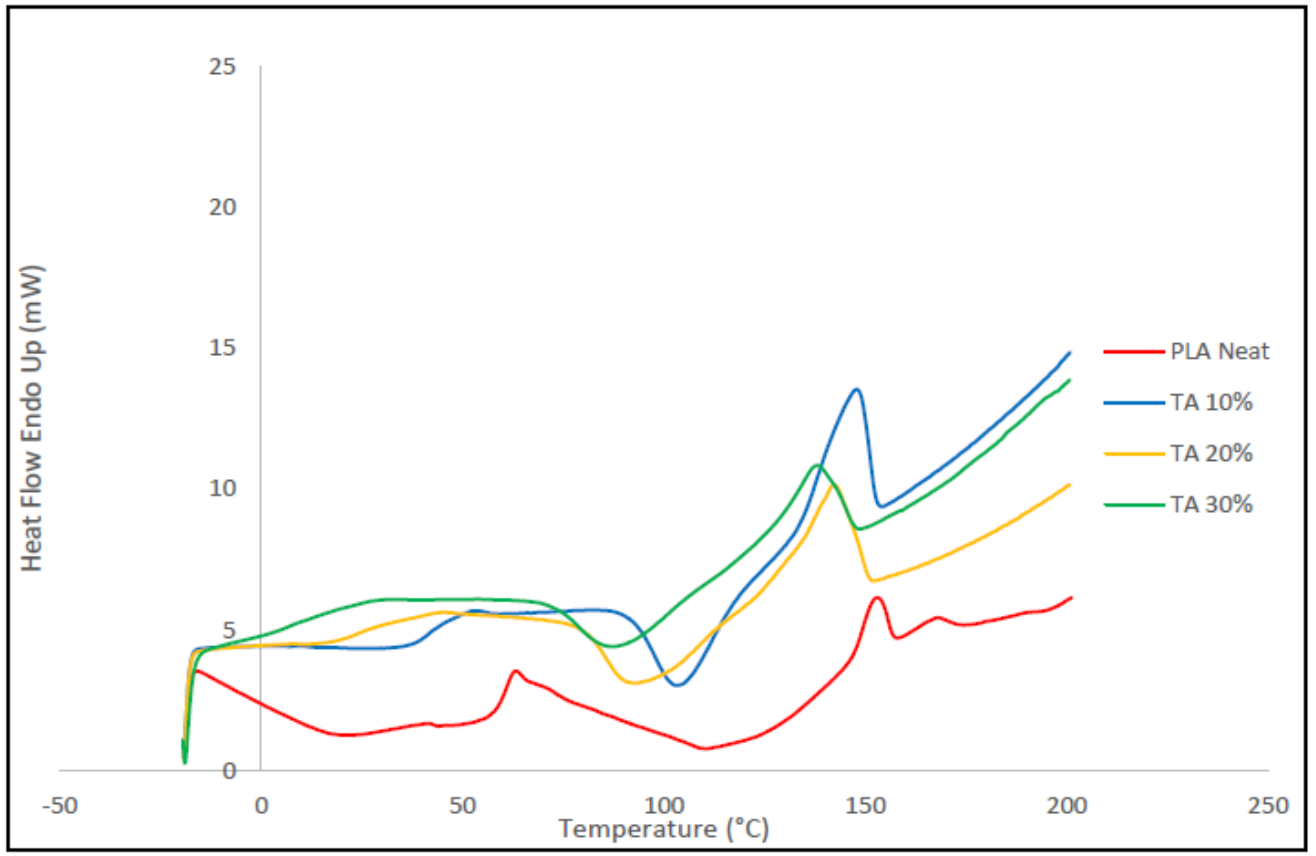


Ultimate Properties of PLA Plasticized with Different Plasticizers

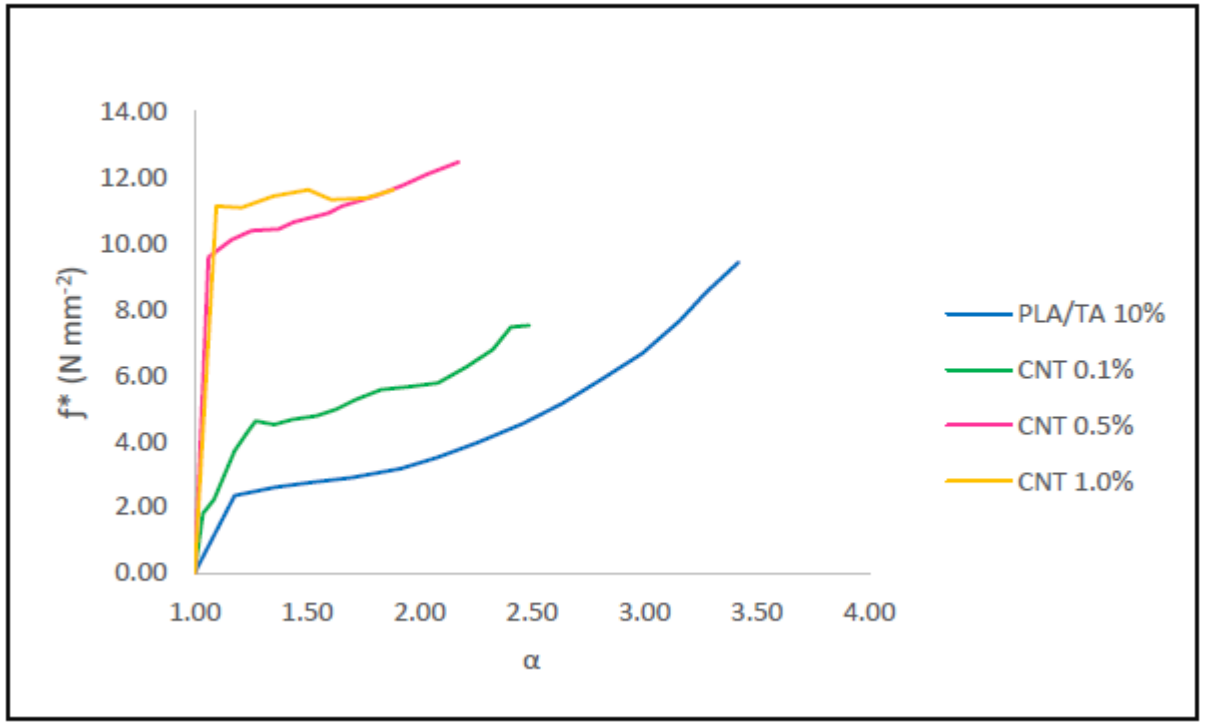


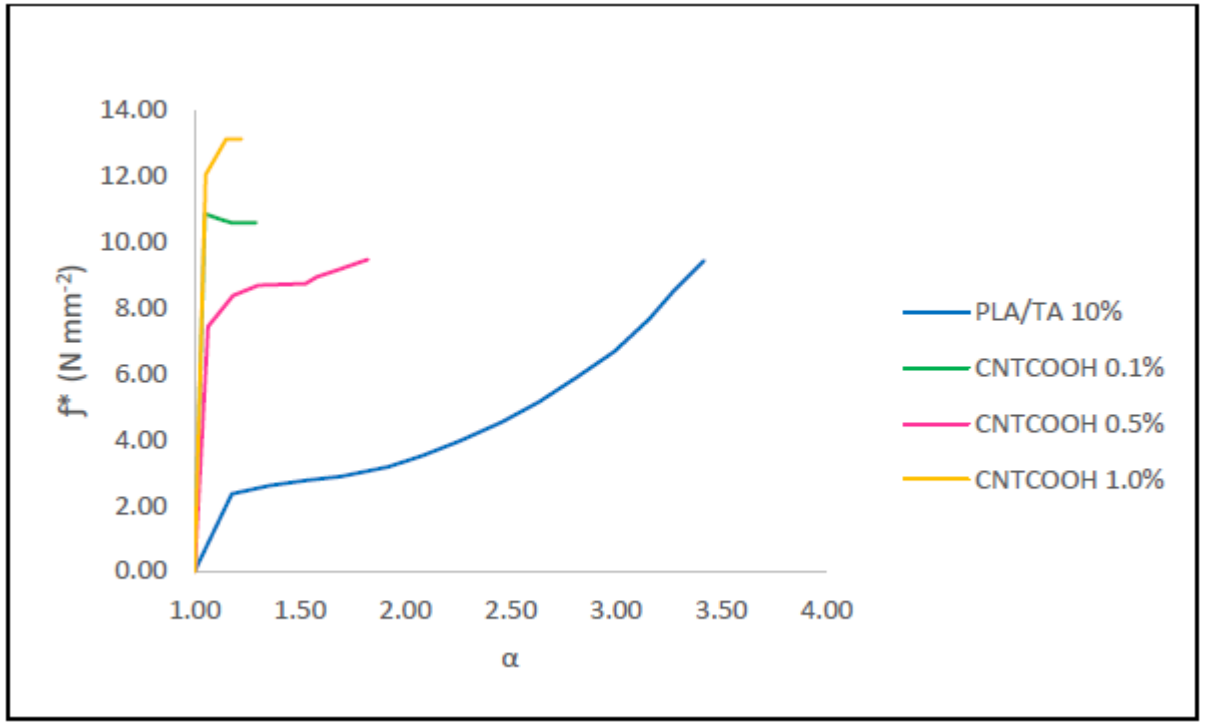
DSC of TA-Plasticized PLA

The addition of TA to PLA has shifted the melting peaks to lower values due to the decrease in the crystallites size

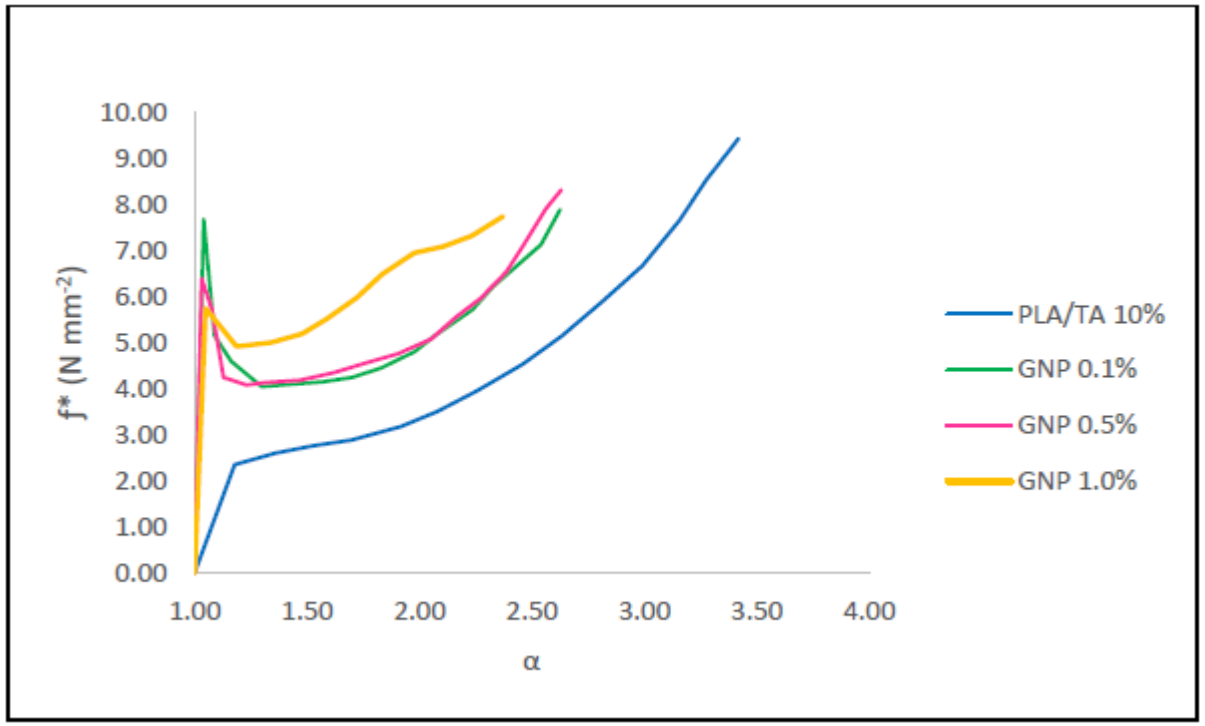


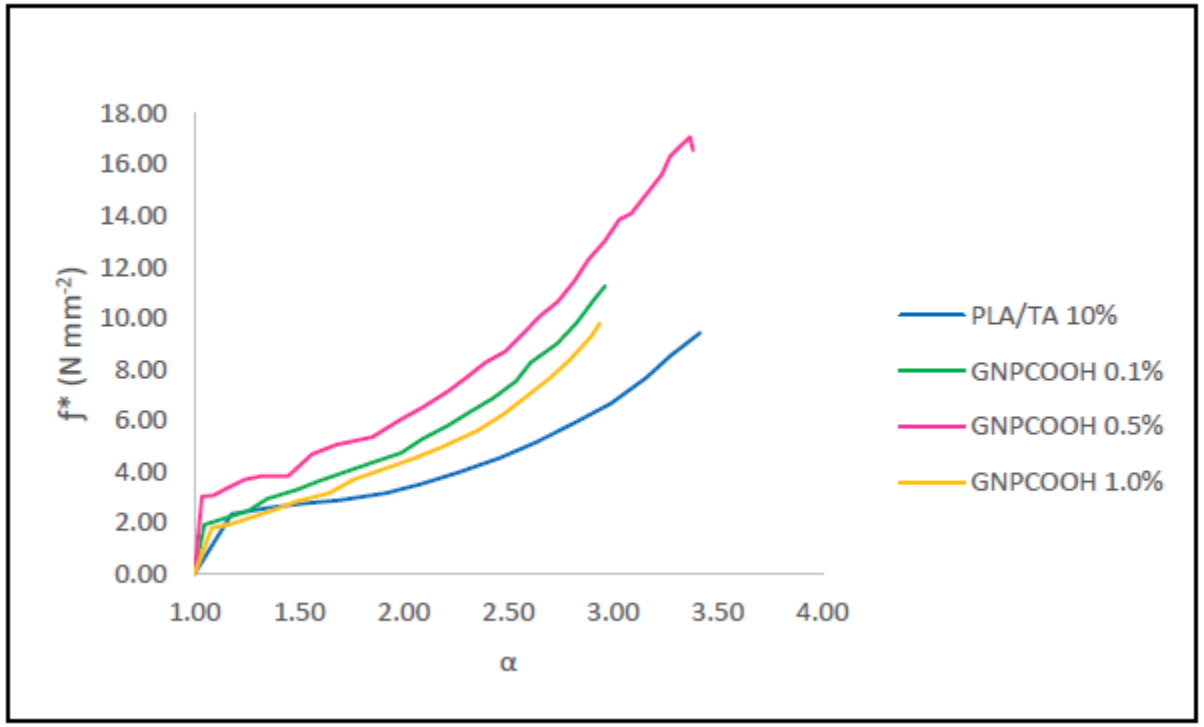
Stress-Strain behavior of CNT-loaded PLA Nanocomposites



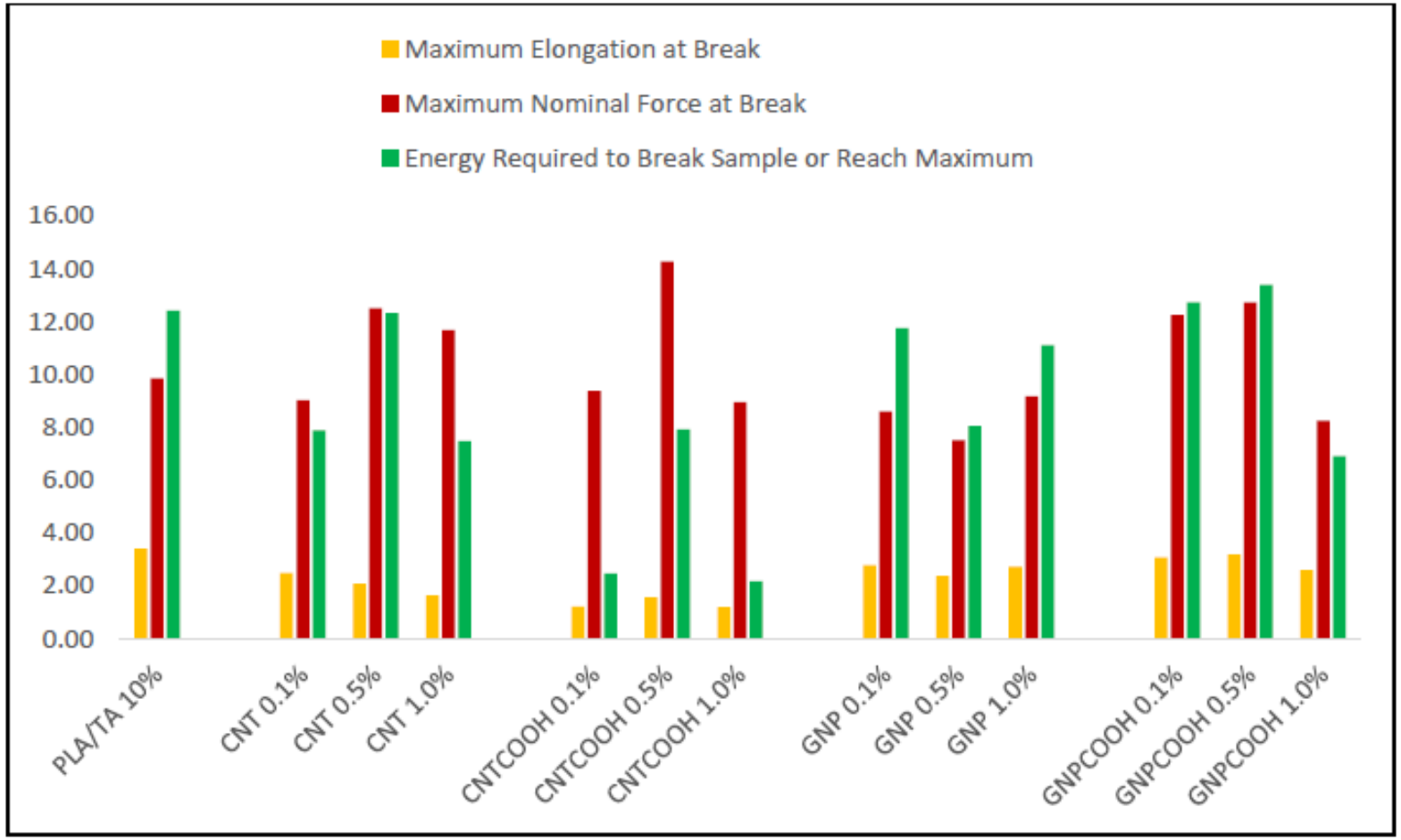


Stress-Strain behavior of GNP-loaded PLA Nanocomposites

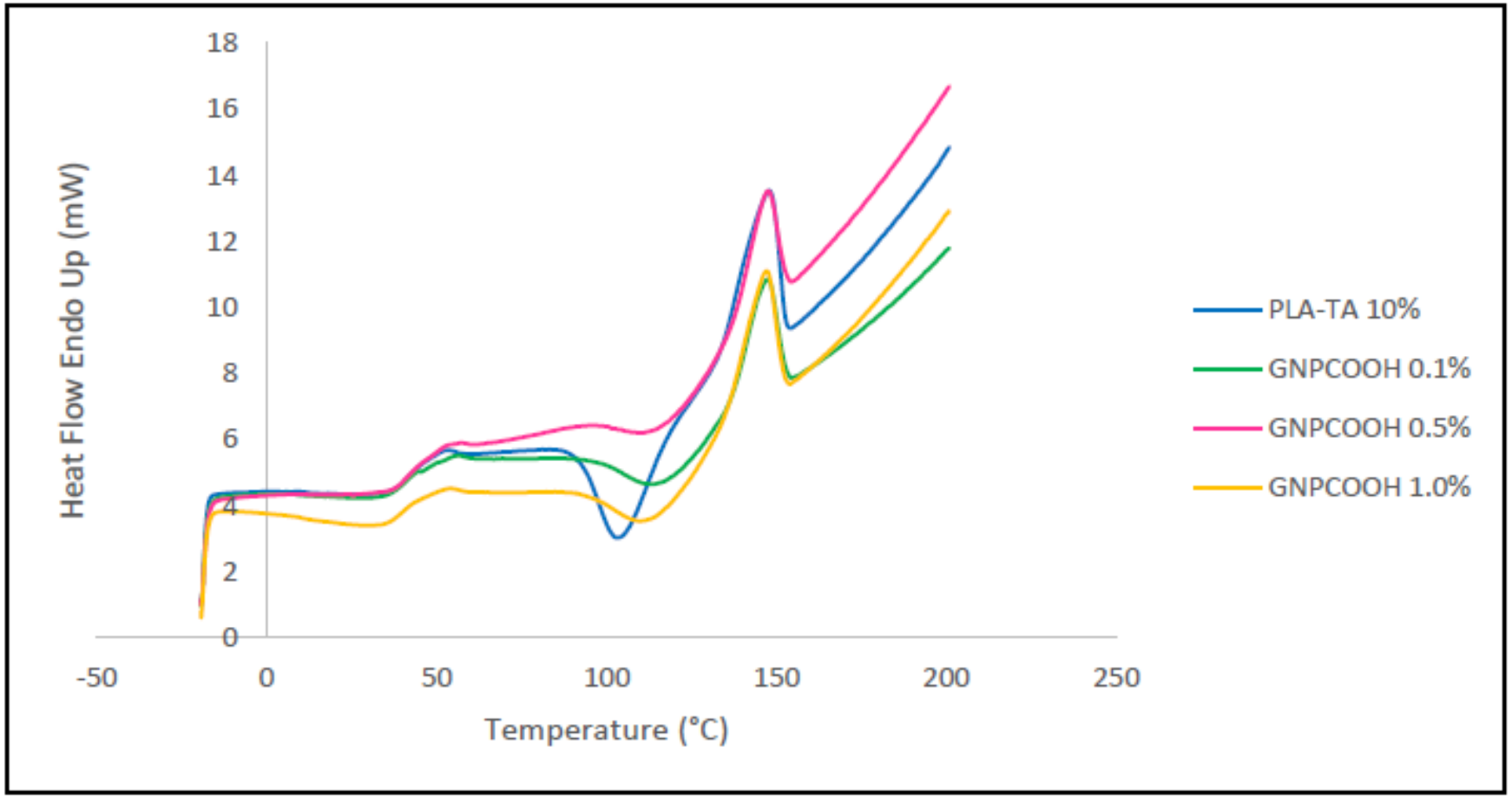




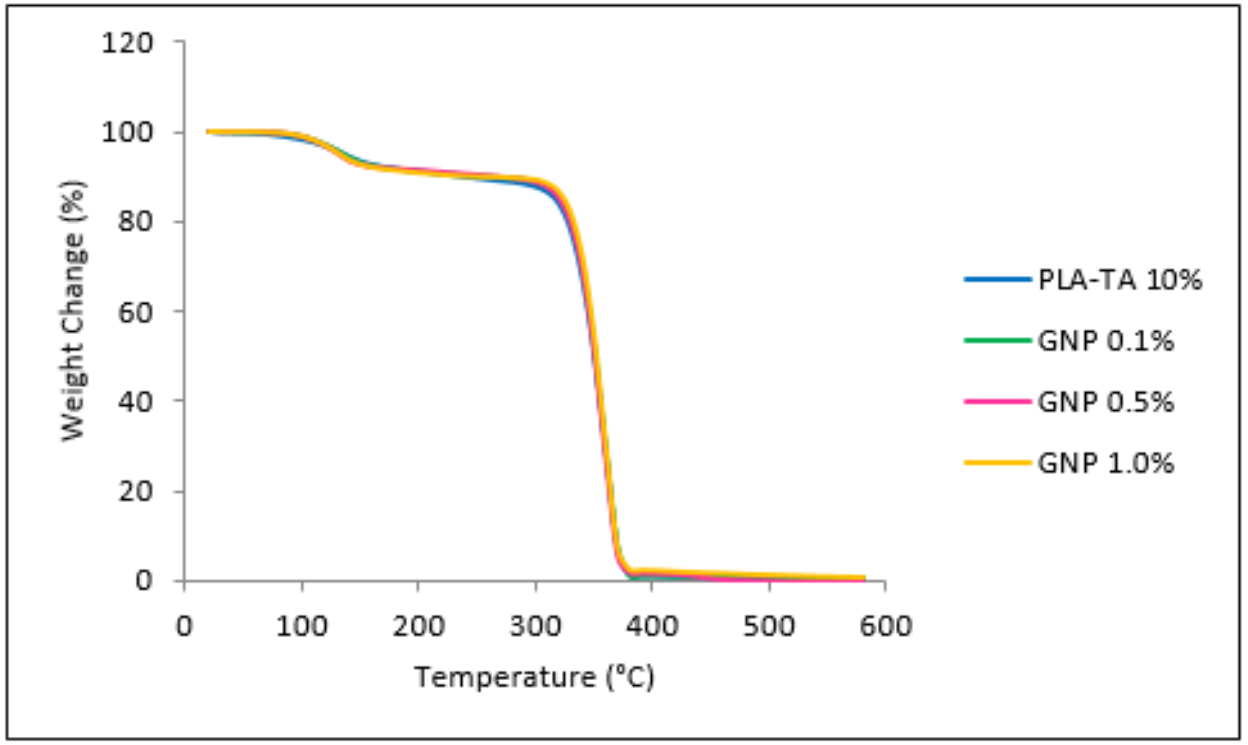
Ultimate Properties of CNT- and GNP-loaded PLA Nanocomposites

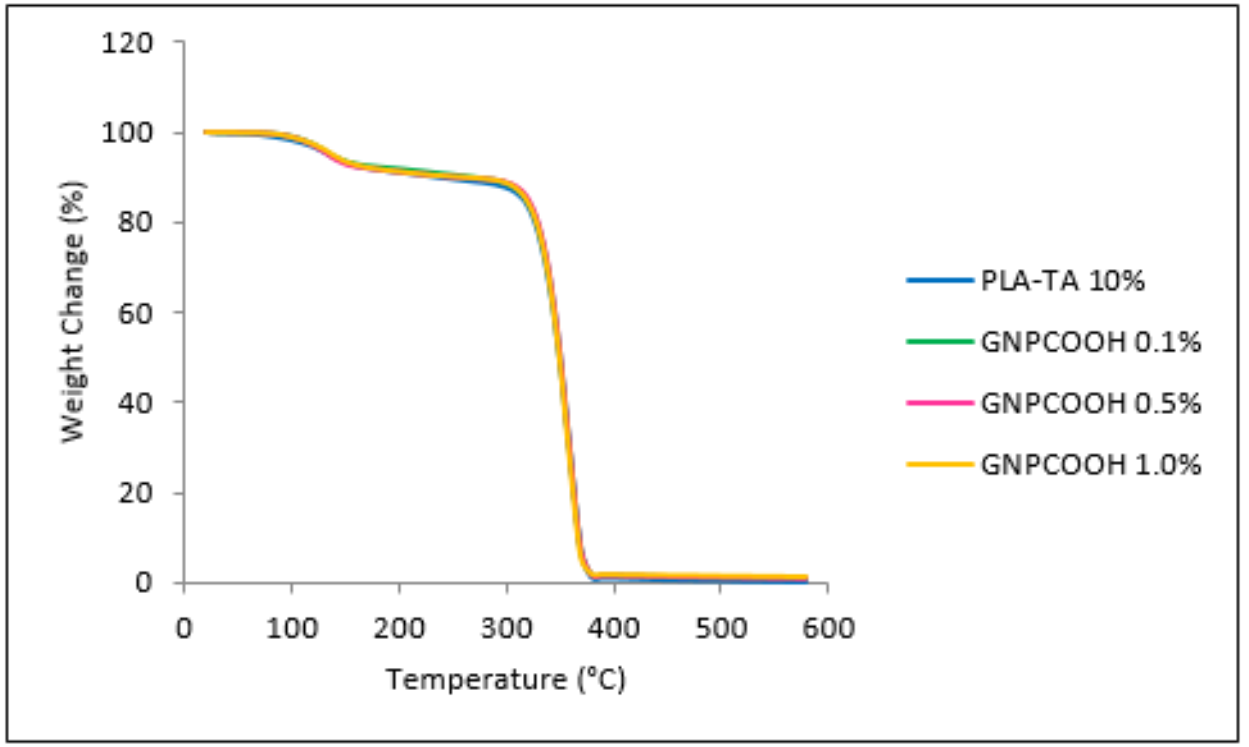


DSC of GNP-loaded PLA Nanocomposites



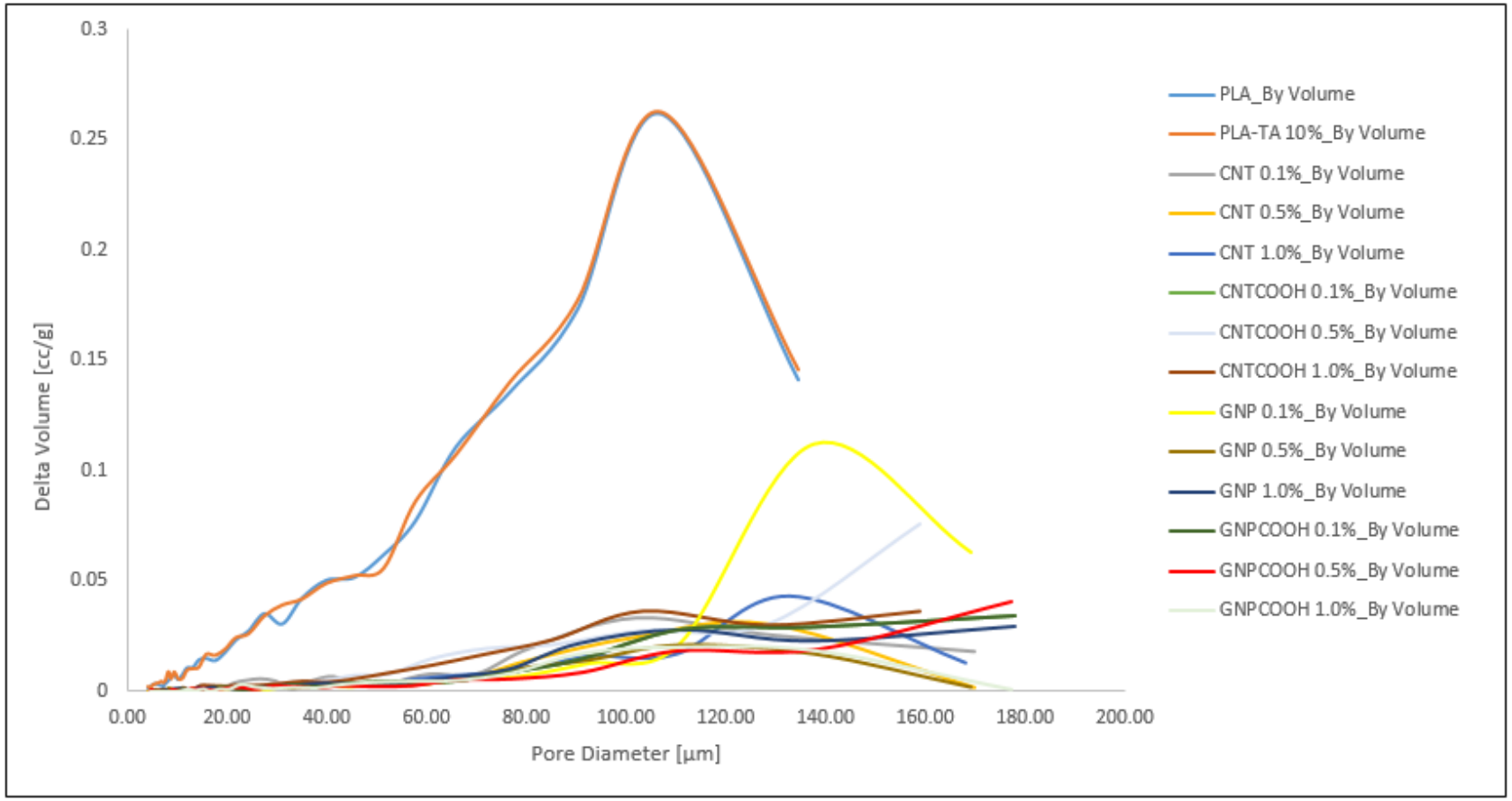
TGA of GNP-loaded PLA Nanocomposites



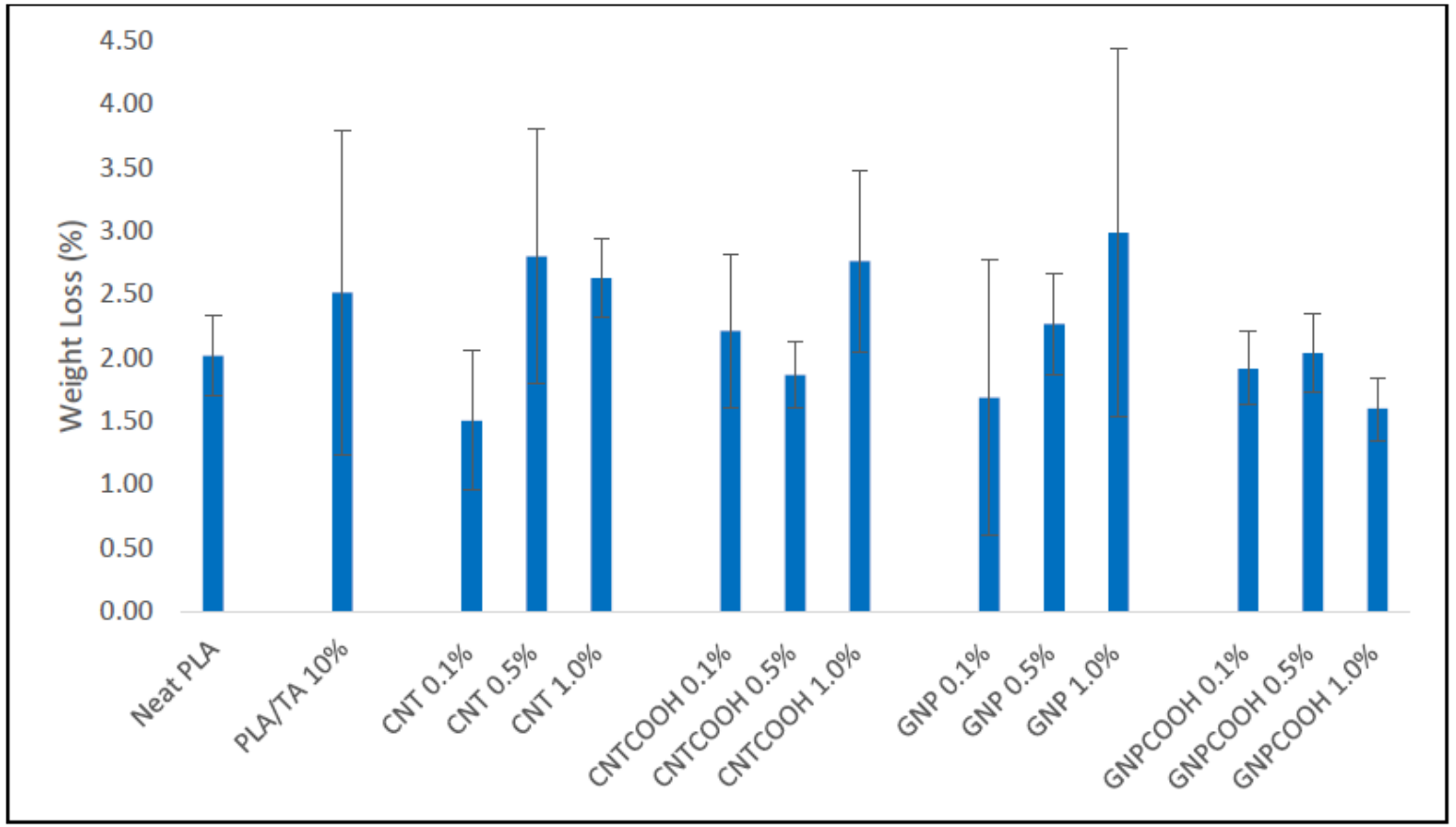


Mercury Porosimetry Test of CNT- and GNP-loaded PLA Nanocomposites

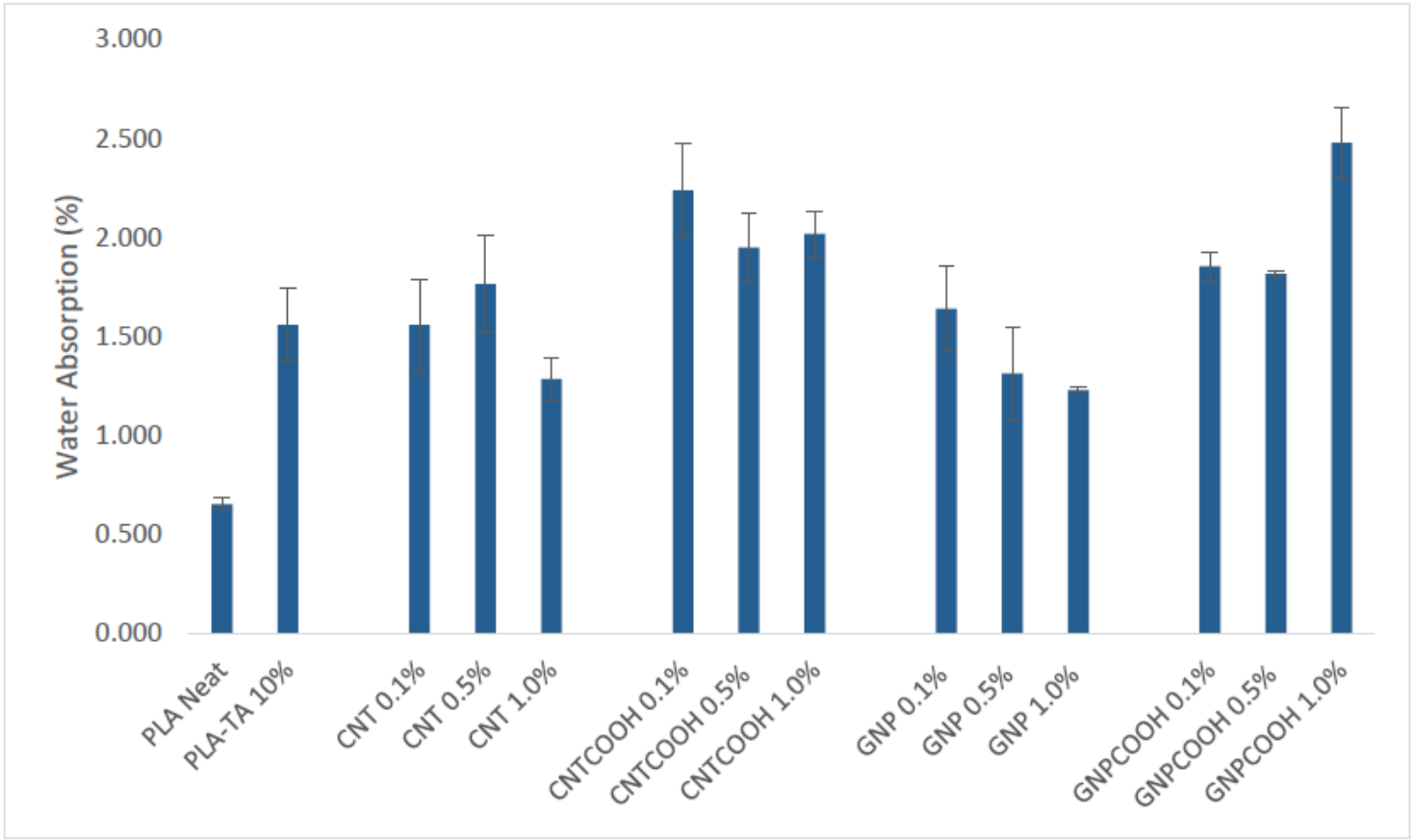
The incorporation of various nano-fillers has increased the porosity by as much as 80% and the decrease in the overall pore size thus affecting the barrier properties of the nanocomposites



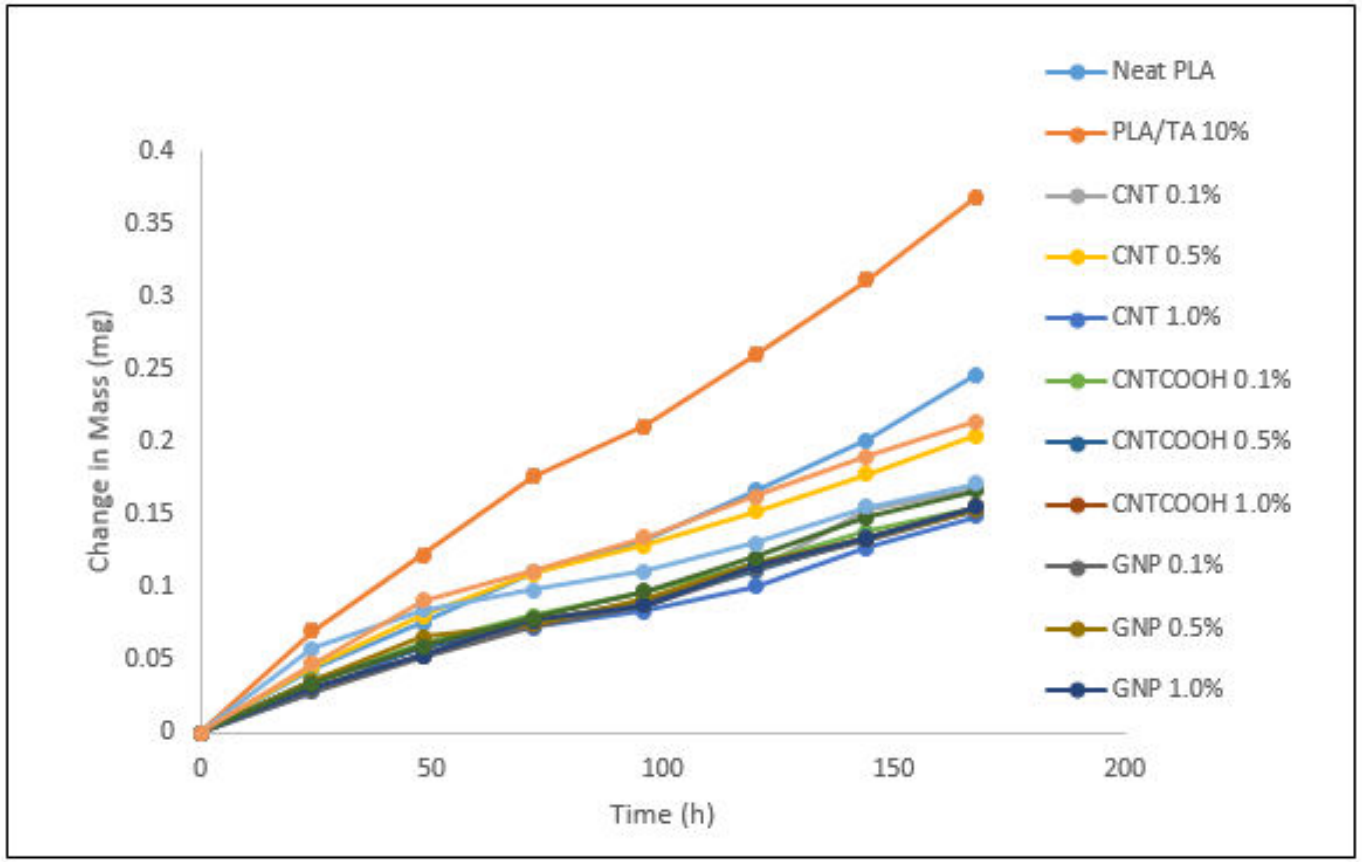
Compost Biodegradation of CNT- and GNP-loaded PLA Nanocomposites



Water Absorption of CNT- and GNP-loaded PLA Nanocomposites



Water Vapor Transmission of CNT- and GNP-loaded PLA Nanocomposites



Conclusion

- Biodegradable biorenewable plastics, if loaded with proper biocompatible plasticizer and nano-fillers exhibit excellent overall performance as food packaging materials.
- The best plasticized system that served as the basis for PLA nanocomposites was PLA/TA 10%.
- In terms of mechanical properties, GNPCOOH 0.5% showed best performance that can be applied for wrapping applications.
- GNP and GNPCOOH showed no specific effect on the thermal stability or landfill biodegradation of PLA nanocomposites.
- The incorporation of different nanofillers has decreased water vapor transmission.


Thank You!