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Graphenic Nanocomposites for High-Barrier Applications

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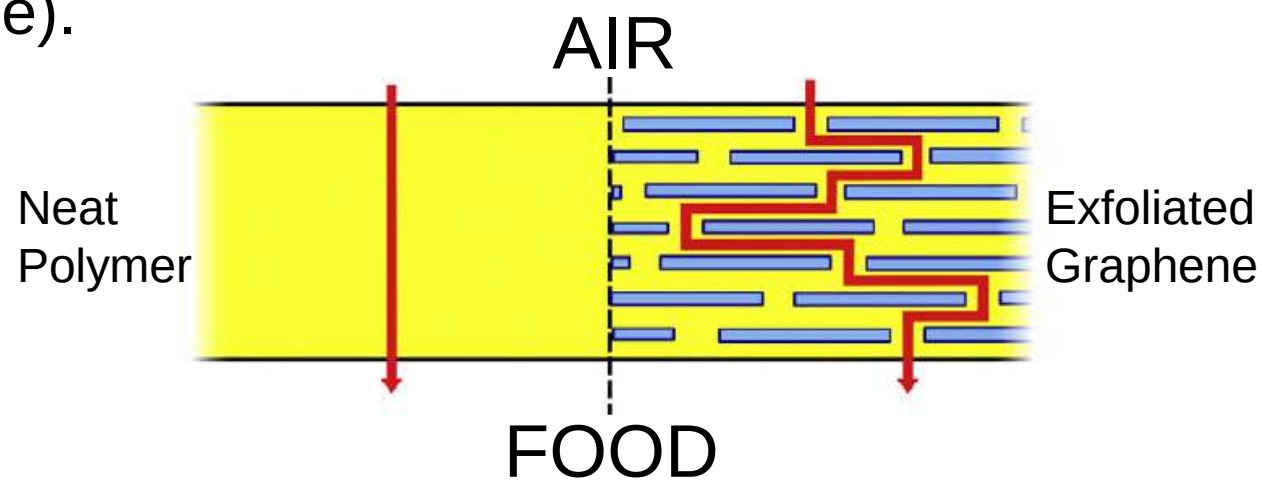
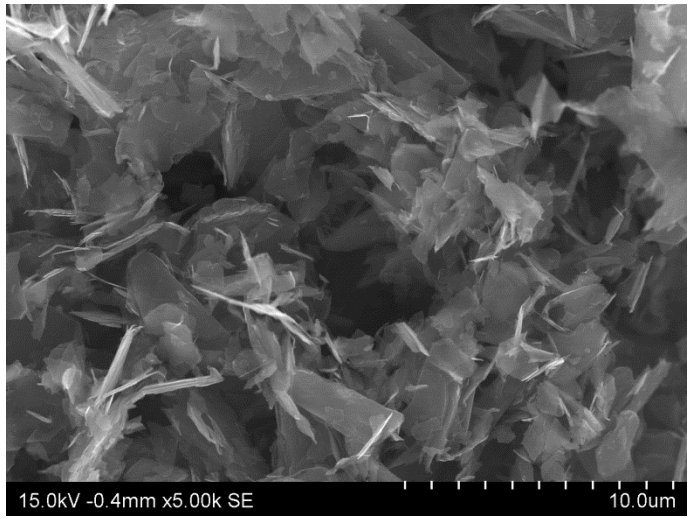
Introduction

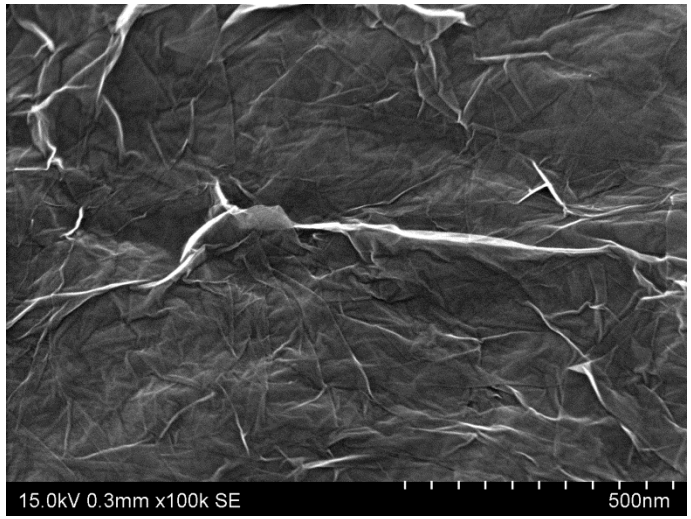
- Can extend the shelf-life of food by excluding oxygen.
- Improve barriers to oxygen diffusion in packaging materials by blending with nanoparticles.
- Creates a more tortuous path for the oxygen molecules to follow, thereby decreasing the permeability.
- Nano-platelets and nano-sheets are the most effective (e.g. graphene).



Materials

- Currently investigating graphenic materials for improving barrier properties in polyethylene (PE) films.
- Pristine graphene (pG) and reduced graphene oxide (RGO) from exfoliated natural graphite (Graphene Leaders Canada).



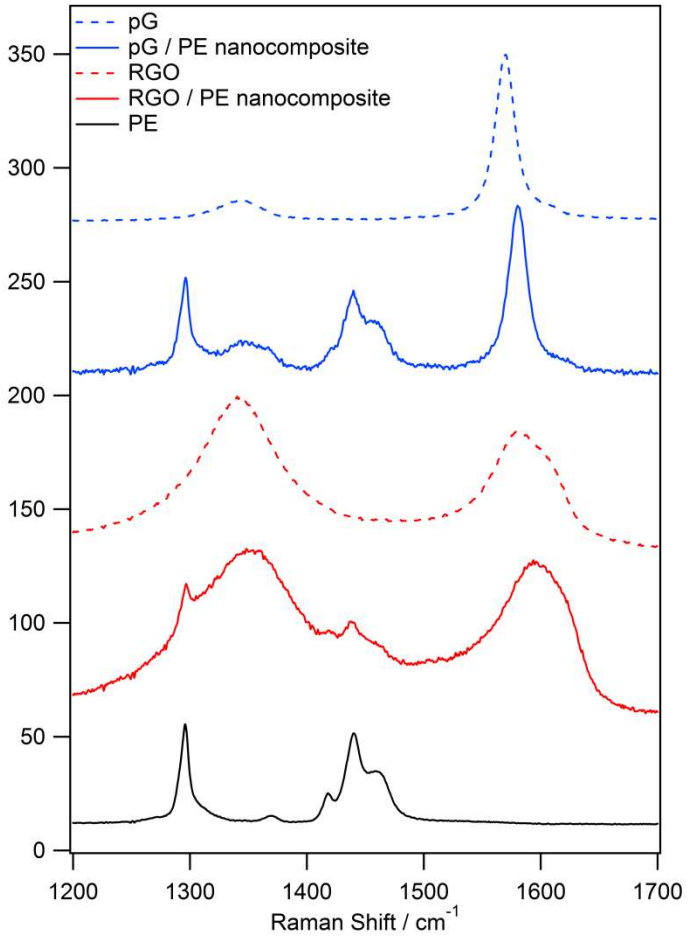


Processing

1. Compound the PE with the graphenic materials (4 wt%) using a Brabender internal mixer.
2. Melt compress the nano-composite into a plaque.
3. Pelletize the plaque.
4. Extrude the pellets into a 50 μm thick film using a DSM micro extruder.

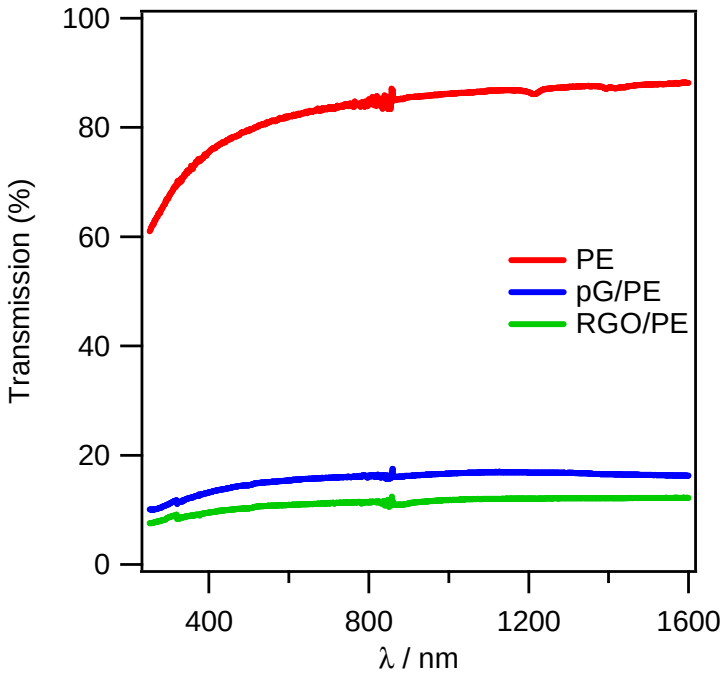
Physicochemical Characterization – Raman

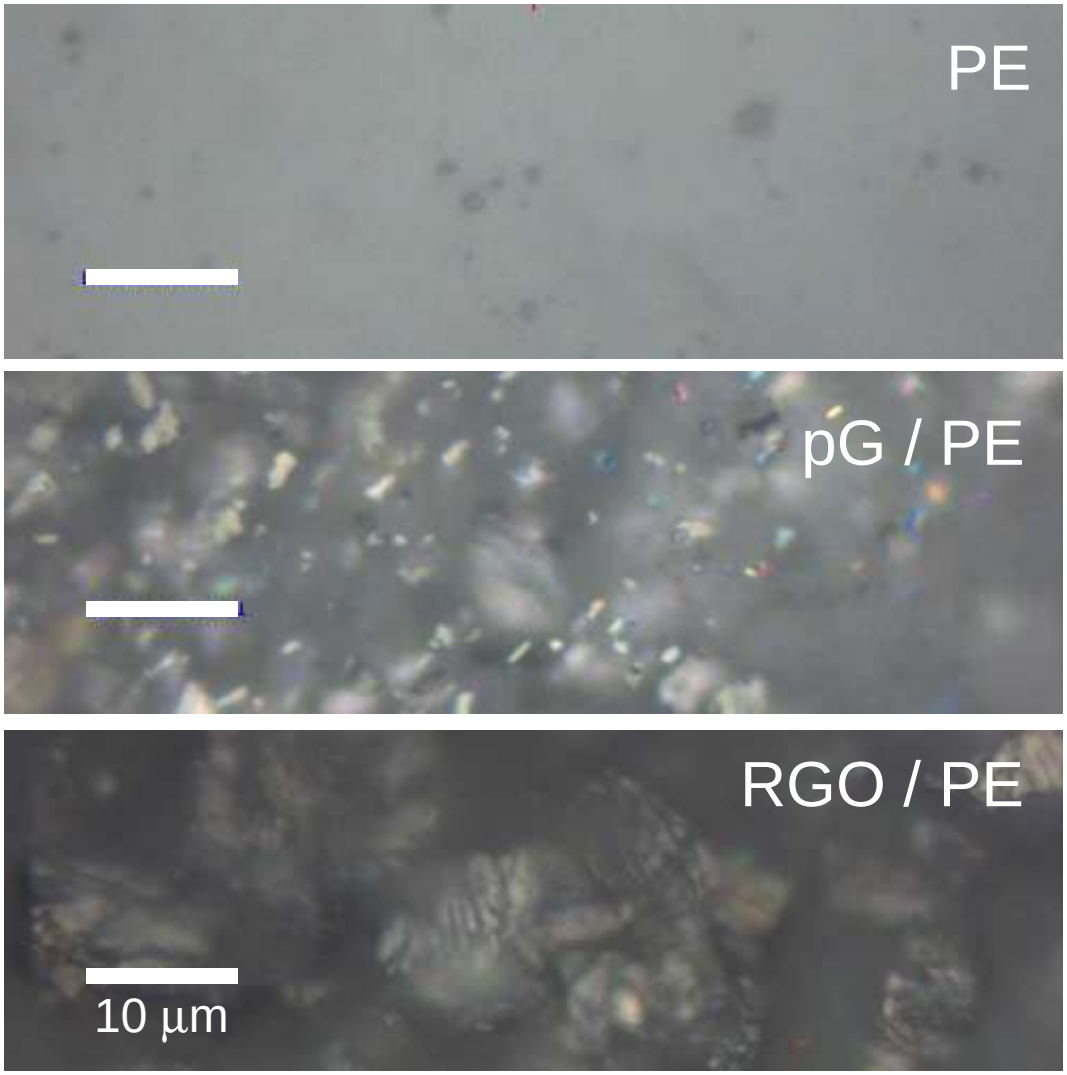
- Raman spectra of the nanocomposites are a superposition of the filler and the matrix spectra.
- Graphenic G and D peaks are up-shifted by ~10 cm^{-1} when embedded in the matrix for both the pG and RGO nanocomposites.



Physicochemical Characterization – Optical

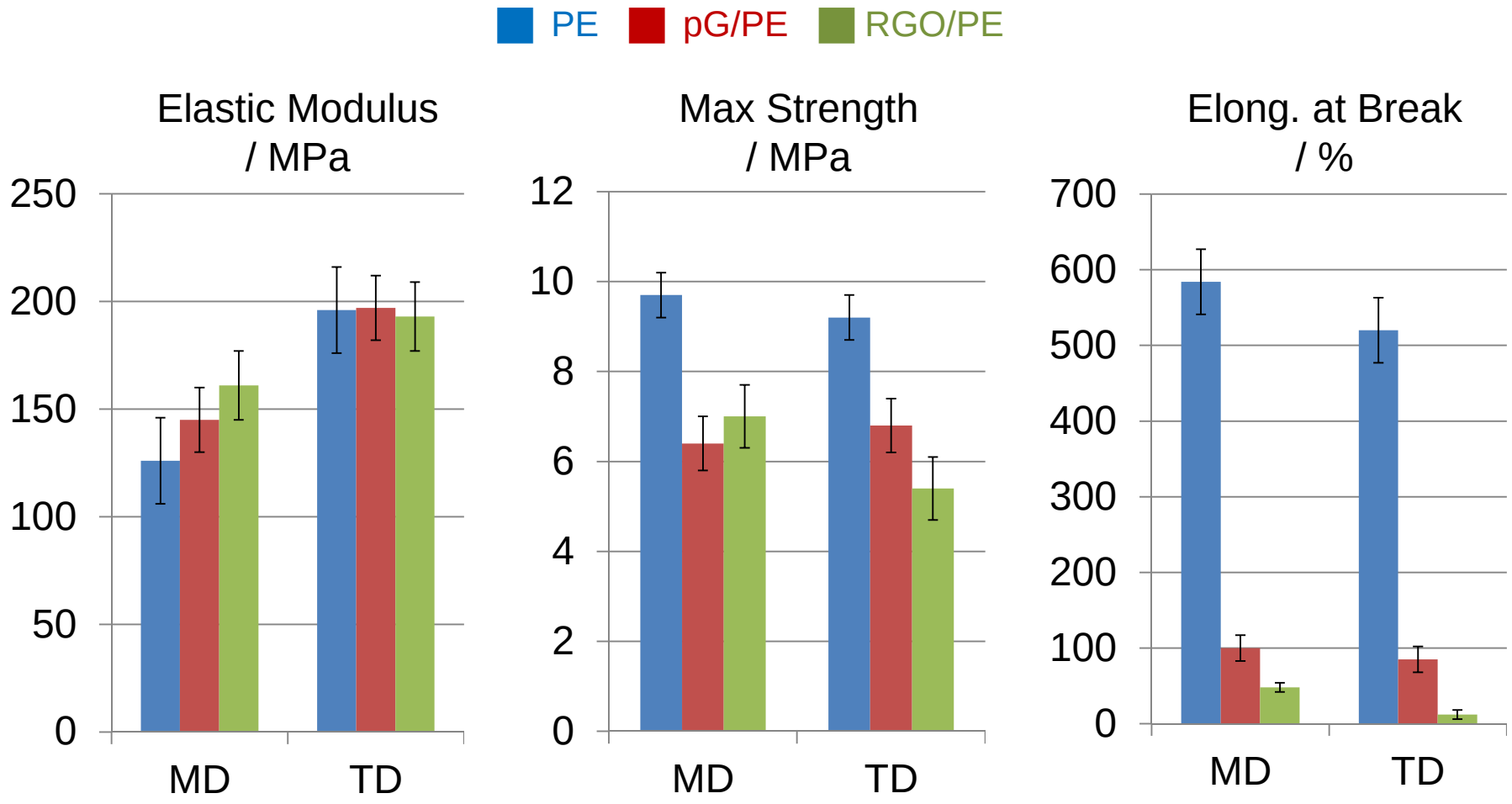
Material	Transmission (550 nm)
PE	81 %
pG / PE	15 %
RGO / PE	11 %





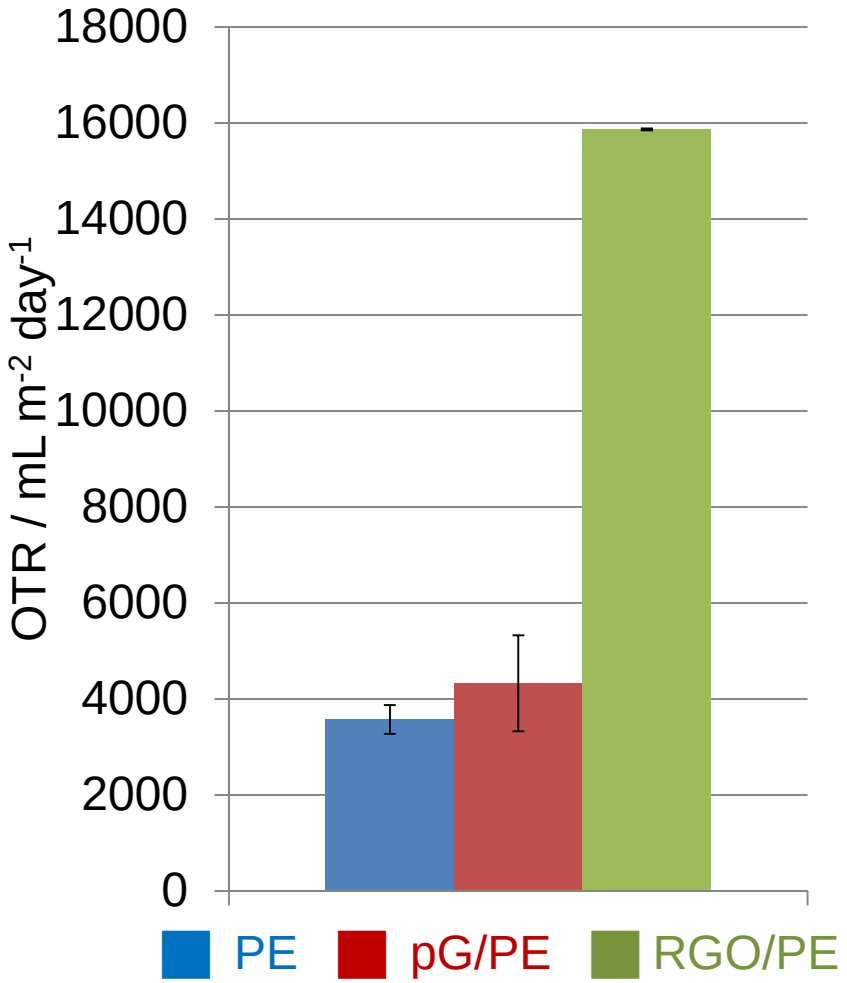
Mechanical Characterization – Tensile

Measured on a micro-tensile tester in the machine (MD) and transverse (TD) directions.



Mechanical Characterization – Barrier

- Oxygen transmission rate (OTR) at 30% RH.
- OTR of pG/PE nano-composites is comparable to pure PE while it is much higher for the RGO in PE.
- Initial OTR experiments confirm the challenges of generating a good dispersion / exfoliation of graphenic materials in PE.



Conclusion

- Pristine graphene and reduced graphene oxide were successfully blended with polyethylene at 4 wt% and extruded into a 50 μm thick packaging film using lab-scale equipment.
- Prototype films were characterized optically, mechanically, and for their barrier properties (oxygen transmission rate).
- The mechanical properties show the reinforcing effects of graphenic materials in PE: an increased stiffness with a reduced ductility.

Conclusion

- The barrier properties were not improved by the addition of graphenic materials. Challenges related to graphene exfoliation and dispersion are likely the cause of this behavior.
- Experiments are underway to optimize the compounding process in order to improve graphene dispersion and maximize impact on barrier properties.
  - Scaling up the process using large-scale production equipment would likely lead to better results.

Acknowledgements

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Thank you

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