Western Engineering

Improving Electrical Properties of Polypropylene/GNP composites Using Compatibilizer and Solvent-Assisted Melt Blending

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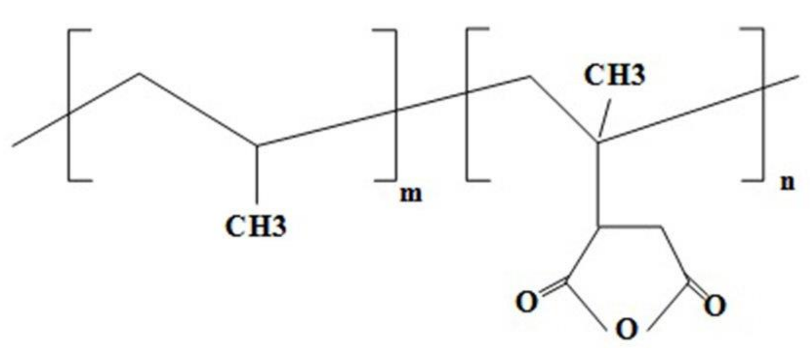
Chemical and Biochemical Engineering

Motivation and Background

Over the past few years, polymer products have become essential to our lives. Many people may think that polymers are simply plastics, however, that is just the tip of the iceberg. Polymer products are used in food, sport, medical, and technological industries. There have been numerous applications in all these areas, but in the technological industry, electronic devices, in particular, are affected by electrostatic discharge (ESD) generated by friction during handling, packaging, or transportation. This requires the use of antistatic packaging, a special package that has low electrical resistivity in order to avoid electron accumulation.

- There has been a demand increase for microinjection molding (µIM) due to high efficiency for large mass production, low cost, and excellent process control.
- Graphite Nanoplatelets (GNP), newly developed short stacks of individual layers of graphite, have been used to enhance the thermal, mechanical, and electrical properties of a product.
- This study is an attempt to address this knowledge gap by use of compatibilizer approach & filler system to deliver high value improvements to microinjection molded parts.



Chemical structure of PP-g-MA.

- Carbonaceous fillers like GNPs and CNTs have a very strong tendency to aggregate due to the presence of non-covalent attractions. This is mainly due to presence of π-π stacking and Van Der Waals forces.
- The homogeneous dispersion of fillers in PP matrix can be achieved by strong hydrogen bonding between hydroxyl groups of the CNTs and maleic anhydride groups of PP-*g*-MA.

Objective

To examine the effects of compatibilizer on morphological and electrical properties of microinjection molded microparts (PP-g-MA) that have undergone the process of sonication.

Research Methodology

- PP-g-MA pellets are grinded into its powder form.
- A mixture of the compatibilizer (PP-g-MA), filler (GNP), and PP are processed using a sonicator in the presence of isopropyl alcohol for approximately 2.5 hours under a 90% power rate.
- The mixture is then mixed using a Brabender twin-screw internal batch mixer for 10 minutes at 200 °C and 50 rpm.
- The mixture is then pelletized using a grinder, and micro parts were prepared using the microinjection molding machine.
- Finally, the electrical resistance of the final product was measured using an electrometer.

Equipment Used

Pure polymer , compatibilizer and filler were mixed using an Ultrasonic processor, followed by Brabender twin-screw internal batch mixed. Micro parts were then prepared using a micro injection molding machine, and electrical analysis was conducted using an electrometer.

Figure 1: Intelligent Ultrasonic Processor

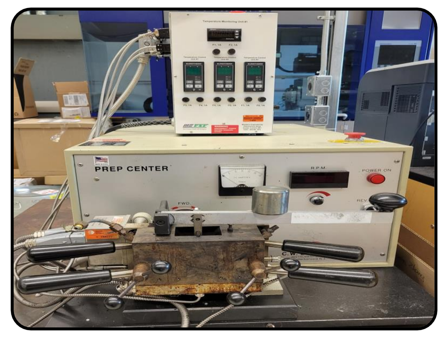


Figure 2: Internal batch mixer (C.W.Brabender Instrument)

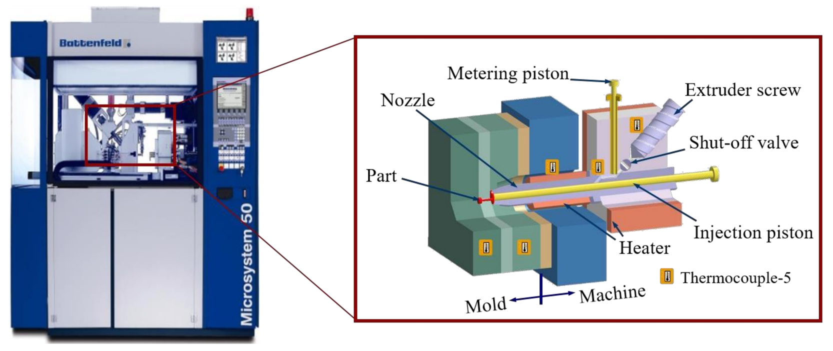


Figure 3: Battenfeld Microsystem 50 machine and the schematic layout of the plasticization unit, metering unit and injection unit.

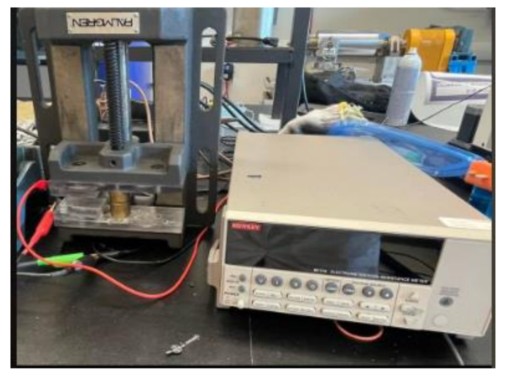


Figure 4: Keithley Electrometer Series 6517A

Figure 5: Measurement methods for Transverse Direction (TD) and Flow Direction (FD)

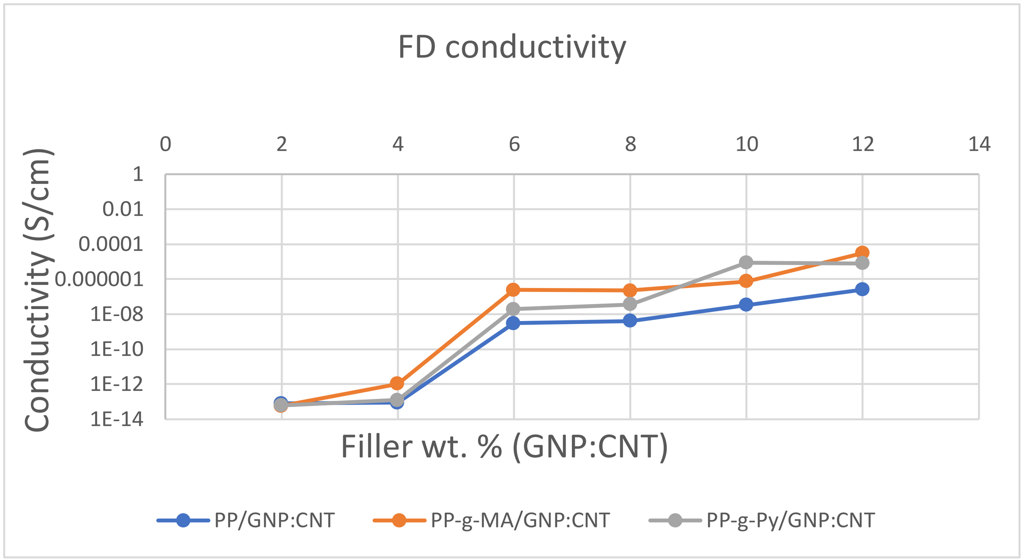
Naming convention

Sample	Description
PP	Neat polypropylene
PP-g-MA	Maleic anhydride compatibilized polypropylene
PP-g-Py	Pyrene compatibilized polypropylene

- The ratio of CNT to GNP is 1:1

Key results

- Previously conducted experiment using PP-g-MA that was only melt blended showed improvement in conductivity by one order.



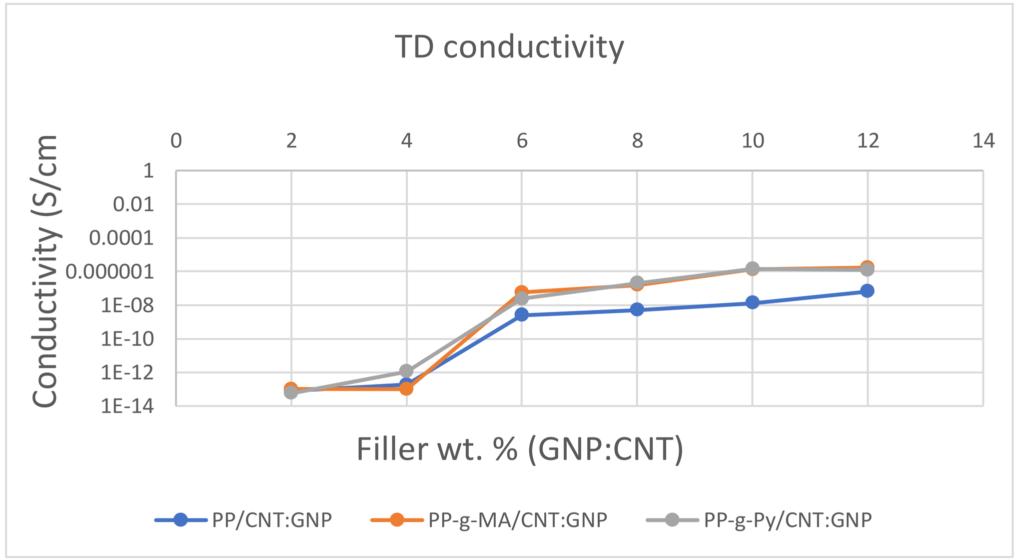


Figure 5: The flow direction and transverse direction measurements of the microparts for the previously conducted experiment that uses the process of melt blending as its mixing method.

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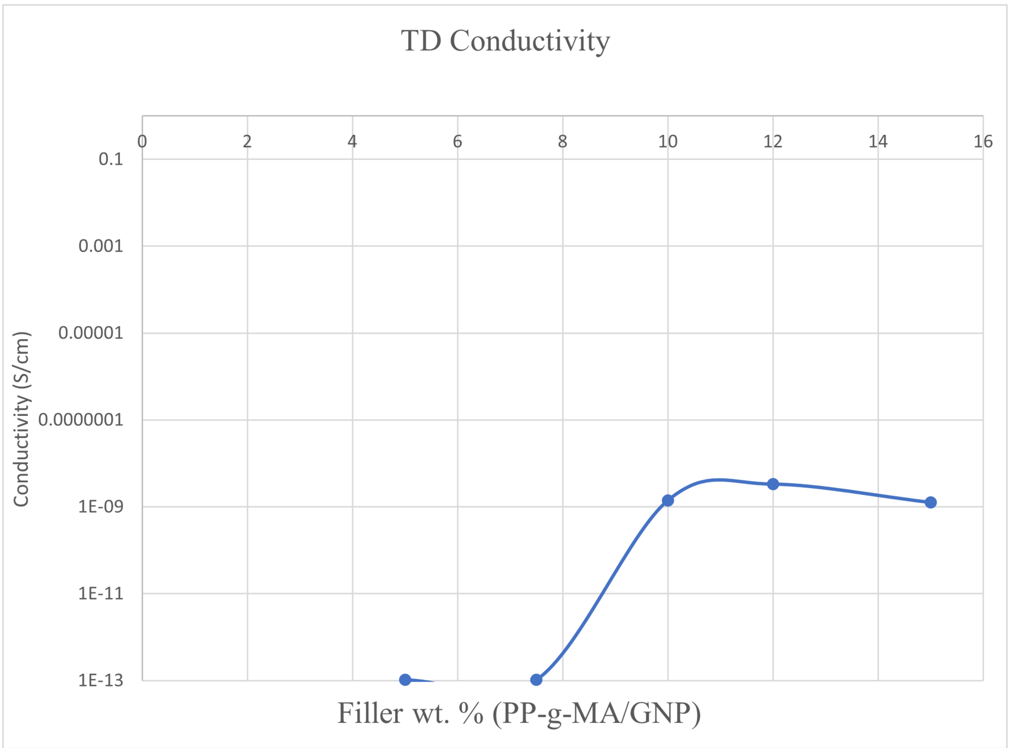

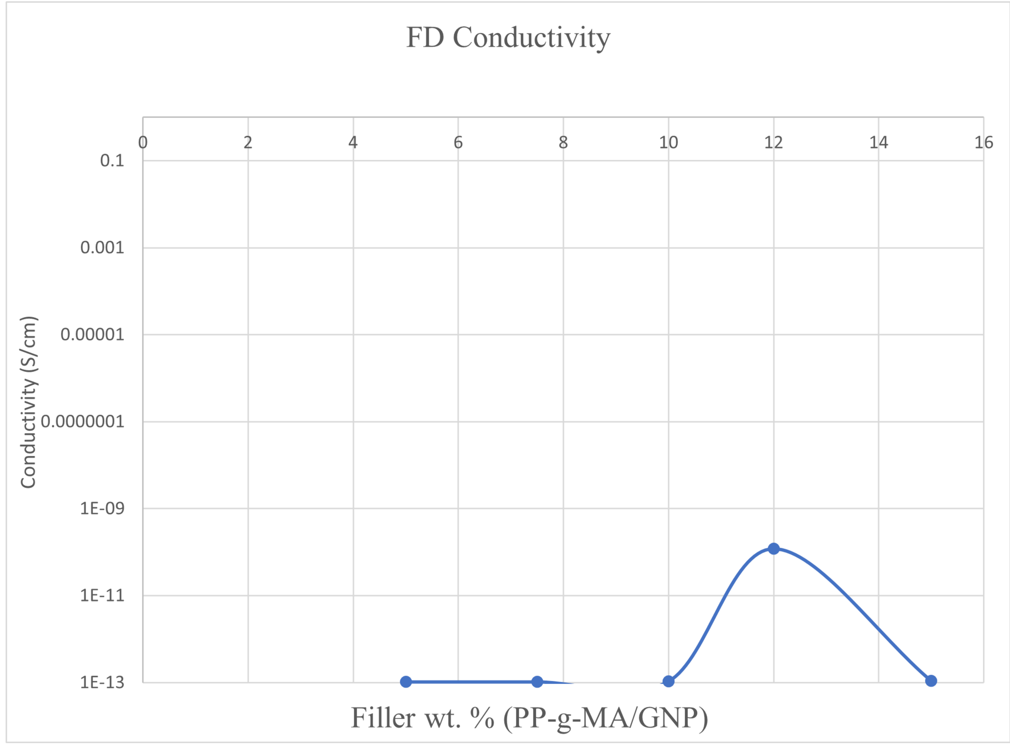

Figure 6: The Flow Direction and Transverse Direction measurements of the microparts for the currently conducted experiment that uses the process of sonication as its mixing method.

Key Conclusions

☑ Maleic anhydride grafted polypropylene in powder form is not able to work as compatibilizer. This can be because maleic anhydride is unable to dissolve properly in isopropyl alcohol.

☑ In most experiments done using melt blending, the material is only grinded once. However, in this experiment sonication and melt blending was used, thus, materials mixture had to be grinded twice. This shows that the melt blending process has shown improvements in electrical conductivity for PP-GNP-CNT case, but clearly not for PP-g-MA/GNP case which uses sonication mixing process.

Acknowledgements

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