Optimizing the PP/PS Blends for 3D Printing

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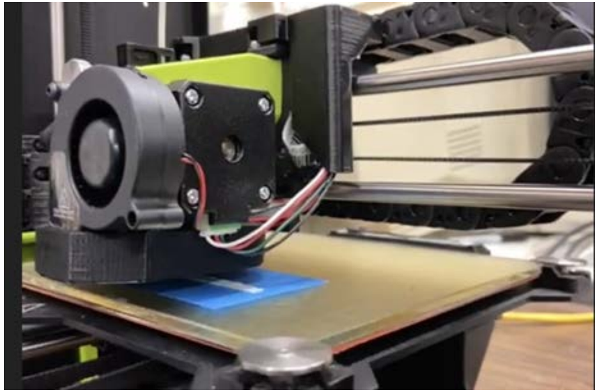
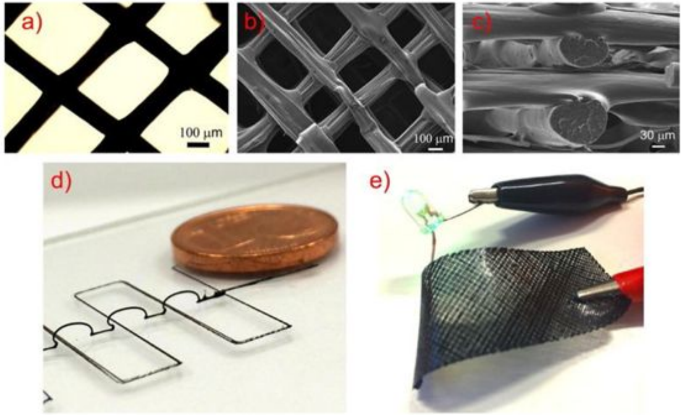
Introduction:

- Polypropylene (PP) has good chemical resistance to corrosion.
- PP allows high loading of graphene nanoplatelets, GNP, while still retaining ductility [nanocomposite].
- Printing with PP/GNP produced highly oriented layers, with high electrical conductivity
- PP is conformal to Graphene Nanoplatelets (GNPs), PP is a wonderful carrier of it for conductive
- PP as filaments for 3D printing has proven challenging due to warpage.
- Polystyrene very difficult print and usually resulting in filament clogging during the printing.
- **Incorporation of PP and PS to overcome the problems**



Cura Lulzbot min 2 printer

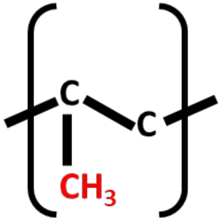


3D printing circuit with PLA nanocomposites

Levenhagen NP, Dadmun MD (2017) Bimodal molecular weight samples improve the isotropy of 3D printed polymeric samples. Polymer 122:232–241

Senatov FS, Niaza KV, Zadorozhnyy MY, Maksimkin AV, Kaloshkin SD, EstrinYZ. Mechanical properties and shape memory effect of 3D-printed PLA-basedporous scaffolds. J Mech Behav Biomed Mater 2016;57:139–48.

Materials and Methods



PP pellet

Materials

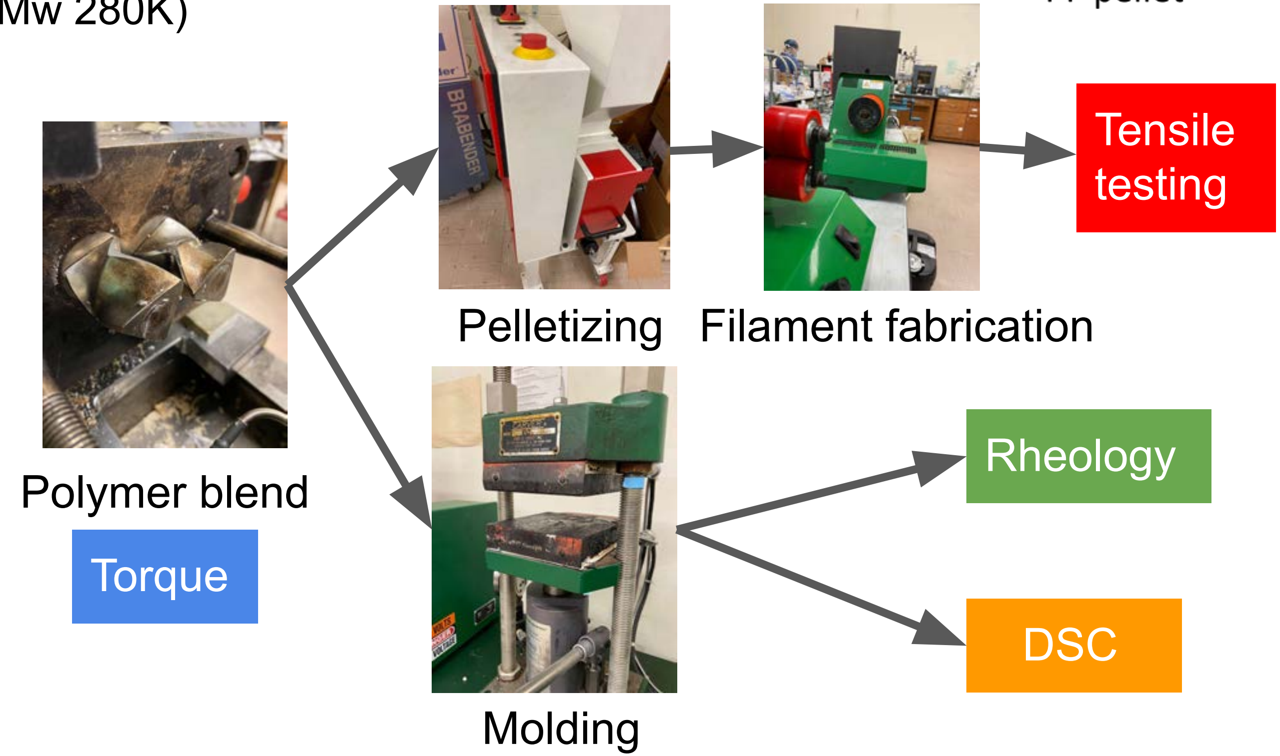
- Isotactic Polypropylene (Mw 280K)
- Polystyrene (Mw 250K)

Methods

- C.W. Brabender(180°C)
- molding(180°C)
- Pelletizer
- filabot extruder (162°C)

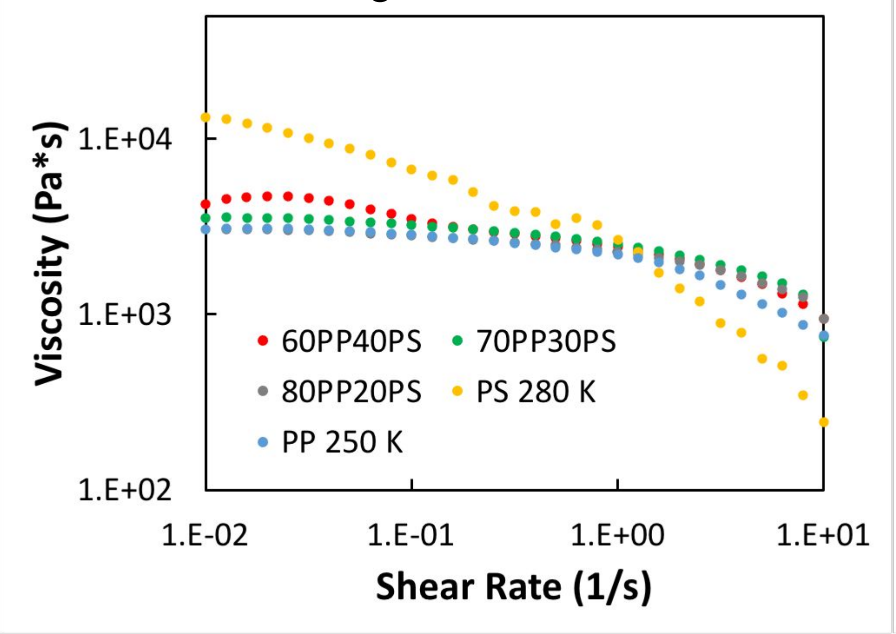
Characterization

- DSC (-20°C-200°C)
- Rheology (200°C)
- tensile testing(RT)

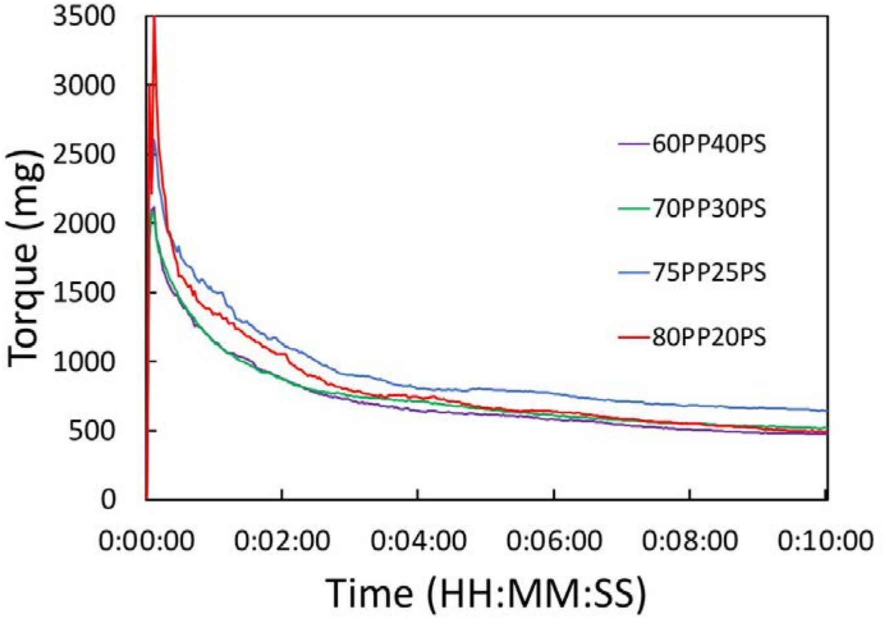


Rheology and torque

Rheological measurement

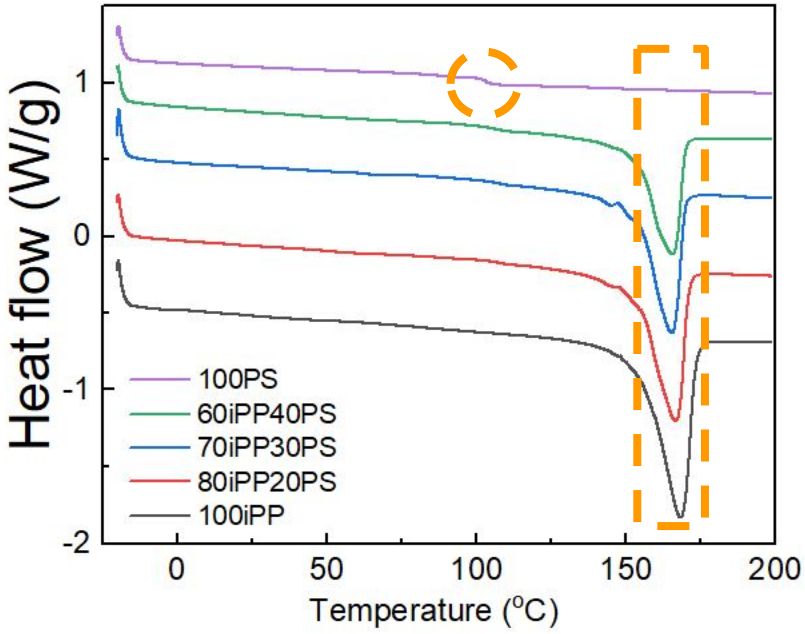


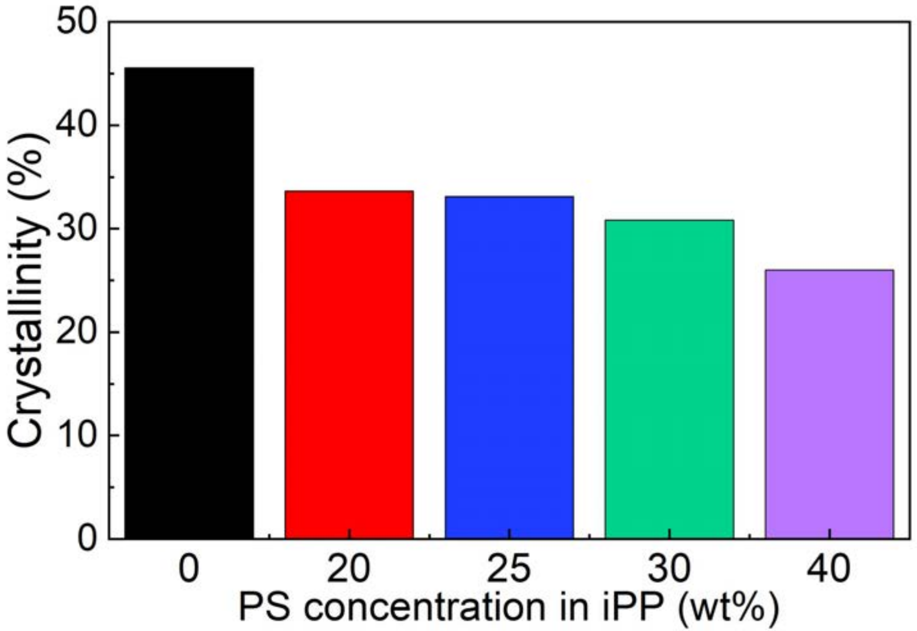
Torque value from melt blending



- The viscosity decreases as a function of shear rate suggesting the shear thinning of the PP/PS blends. This shows that the PP/PS blends are potentially good for printing
- The torque of the blends are decreasing below 1000 which indicated that the melt blending mixture are easily blending and form a homogeneous blend

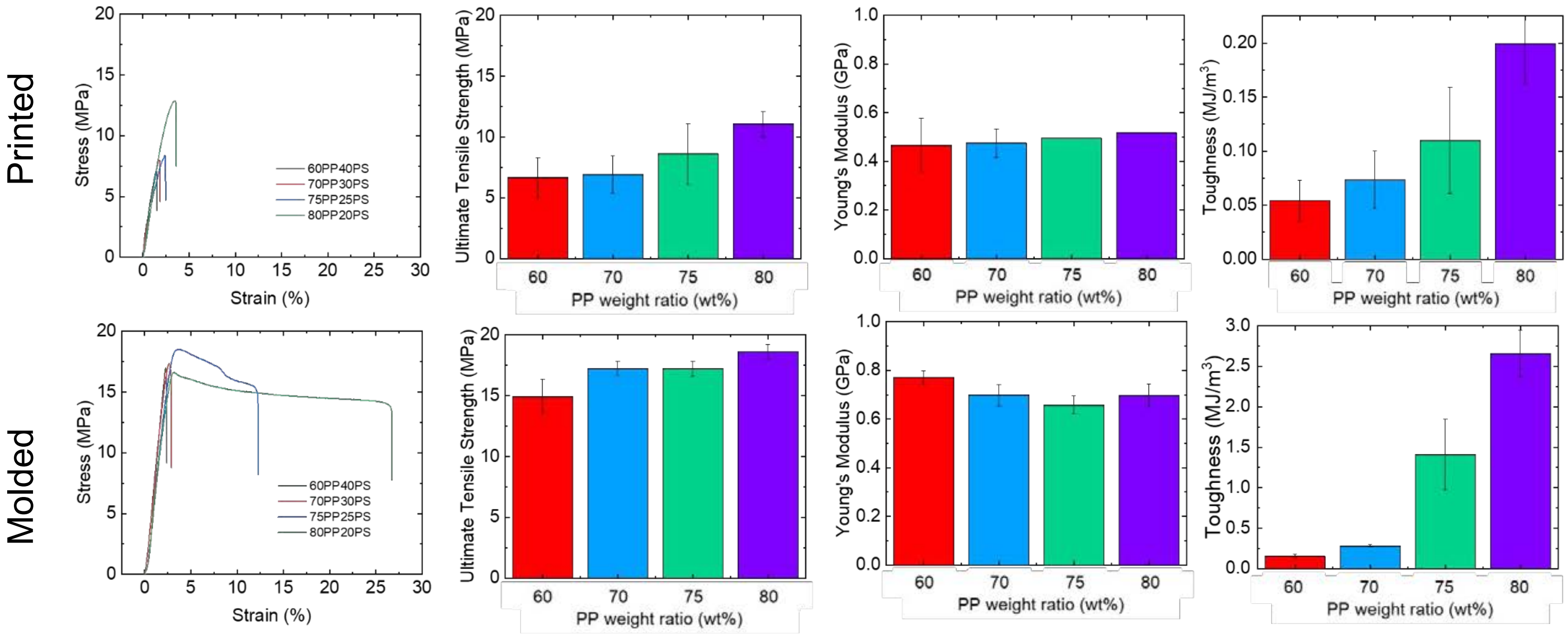
Thermal Response of Polymer Blend: DSC





1. The glass transition of the PS is still remain at 100C which indicated the PP/PS blends are immiscible
2. The crystallinity of the blends are decreasing due to the phase separation of the PP/PS blends

Mechanical Properties:



- The tensile testing data shows that although all four blends have a similar Young's Modulus, the 80PP20PS blend had a significantly higher toughness, ultimate tensile strength, and elongation at break. This is because as we add PS, the blends become more brittle and have phase separation, reducing their mechanical properties.
- In general, in comparison to the molded samples, the printed samples at the horizontal orientation has a decreased in mechanical properties due to the anisotropic mechanical properties of the 3D printed parts.

Conclusion

- Blends of these polymers could be made, extruded into filaments, which are then easily printed and could produce large multilayer structures.

- The rheological measurements showed shear thinning behavior, which is advantageous for nozzle extrusion

- Tensile data indicates that the mechanical of 80/20 PP/PS was higher than the rest of the composition.

- The 75/25 blend also shows good mechanical properties compared to the 70/30 and 60/40 blends.

- In the future, we will be incorporating GNP into the 75/25 blend and doing conductivity measurements.