Blending of PLA and TPU in a Single Screw Extruder to Create 3D Printing Filament

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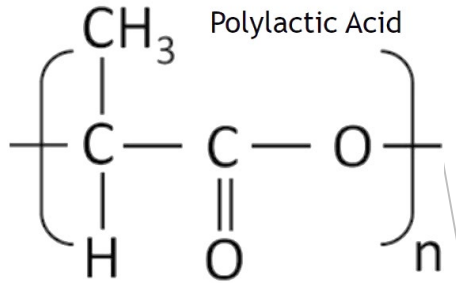
Introduction – 3D Printing

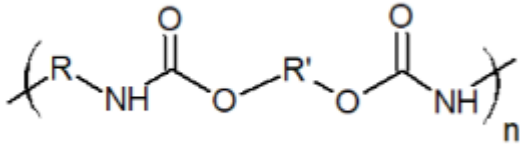
- 3D printing has become an area of increased interest to the plastics industry
  - Increased speed
  - Reduced production cost
  - Small production runs
  - Prototypes

Introduction – Materials

- Poly lactic acid (PLA)
  - Popular 3D printing material
  - Hard and strong thermoplastic material
  - Brittle
- Thermoplastic Polyurethane (TPU)
  - Highly flexible elastomer
  - Not extensively used for 3D printing
- Blending PLA and TPU will improve filament flexibility while retaining the desirable physical properties from the PLA



Polylactic Acid



Polyurethane

Project Objectives

- Established extrusion parameters for consistent diameter for blended PLA/TPU filament
- Performed thermal testing with thermogravimetric analysis (TGA)
- Performed tensile testing on extruded filament samples to determine modulus

Filament Extrusion with the Yellow Jacket Single Screw Extruder

Filament Puller/Winder

Cooling Trough

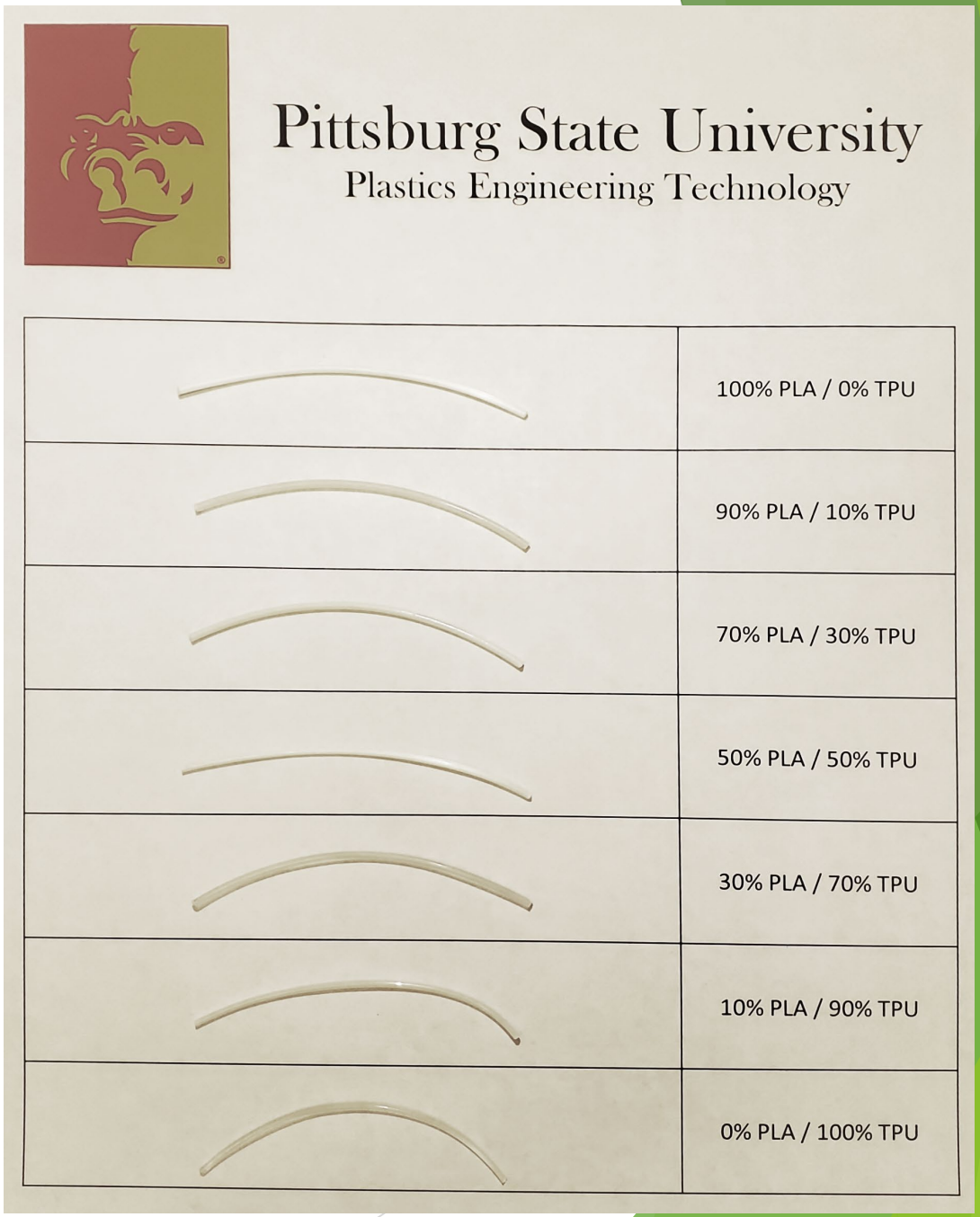
Single-screw Extruder

Single Screw Processing Parameters

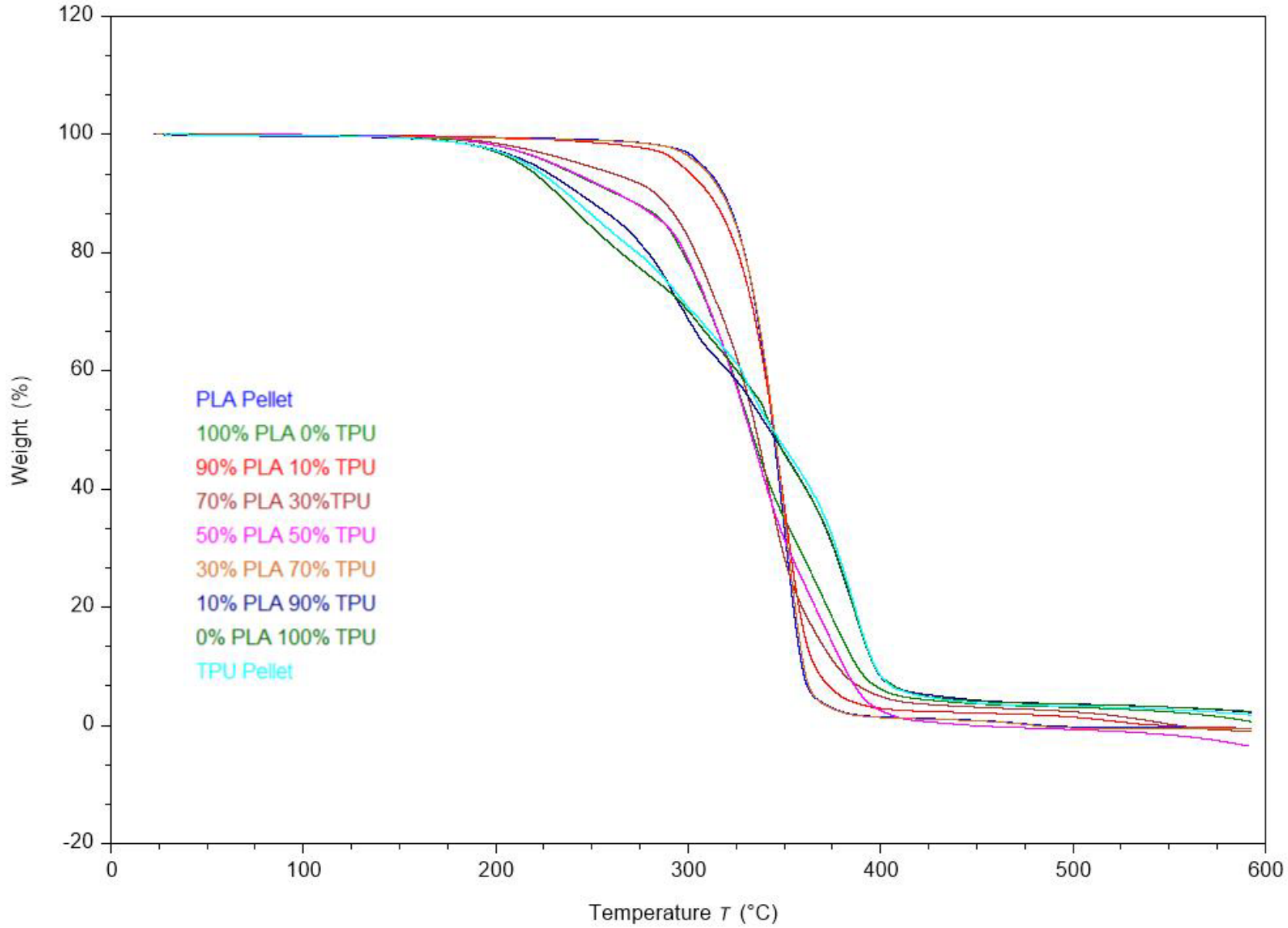
PLA 100% TPU 0%	30	400	400	400	375	325	7
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 90% TPU 10%	30	400	400	400	375	325	7
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 70% TPU 30%	30	400	400	400	375	325	7.5
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 50% TPU 50%	30	400	400	400	375	325	7
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 30% TPU 70%	30	400	400	400	375	325	7
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 10% TPU 90%	30	400	400	400	375	325	6.5
	Screw RPM	Dizone 2 °F	Dizone 1 °F	Zone 3 °F	Zone 2 °F	Zone 1 °F	Takeoff meter/min
PLA 0% TPU 100%	30	400	400	400	375	325	7

Sample Appearance

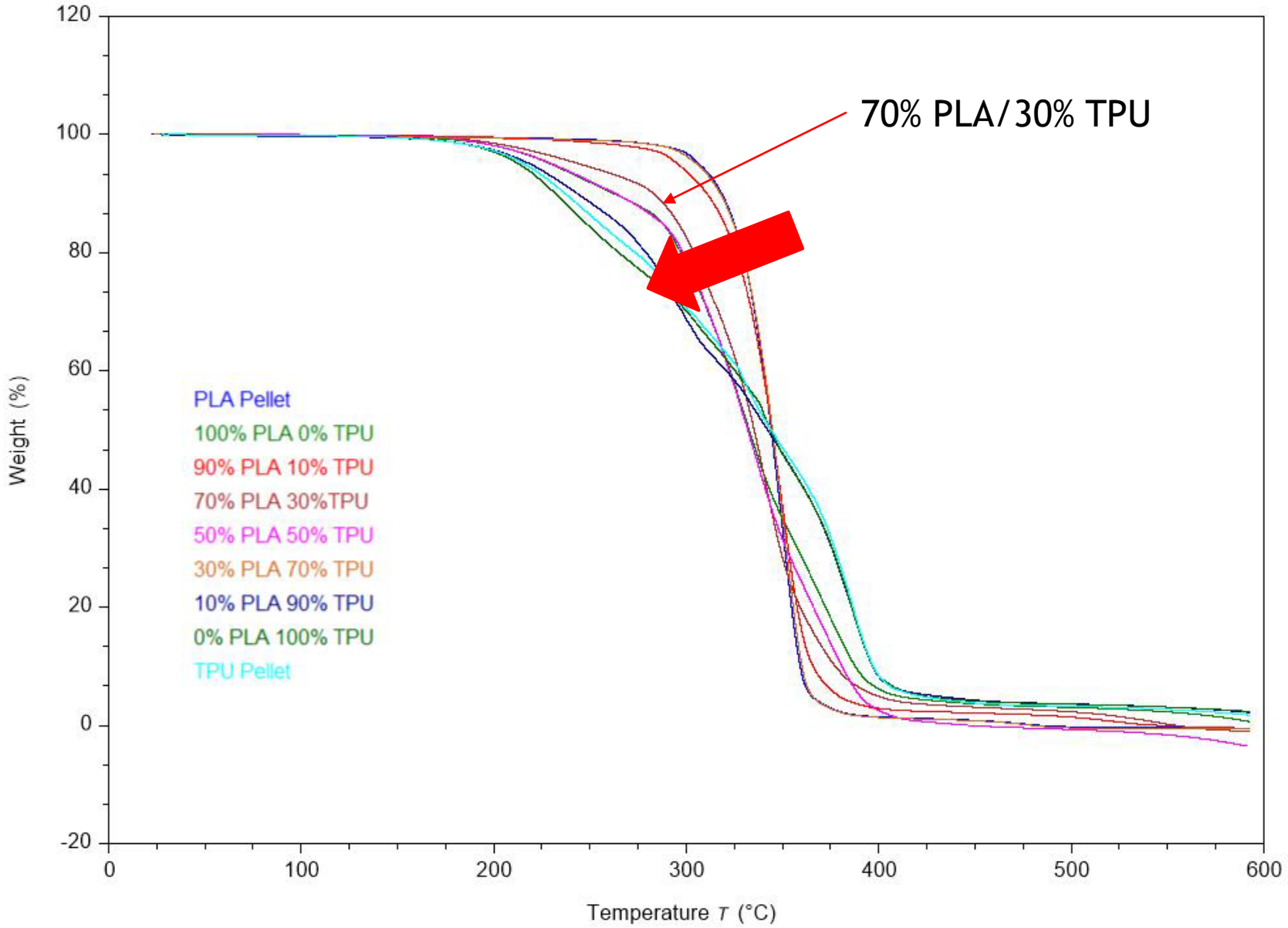
- PLA/TPU blending in the single-screw extruder was successful
- 70% PLA 30% TPU and 50% PLA 50% TPU had the most consistent diameters



Thermogravimetric Analysis Curves



Thermogravimetric Analysis Curves



- As %TPU increased, the onset of degradation decreased to lower temperatures
- For example: 70% PLA/30% TPU is equidistant from the PLA and TPU curves

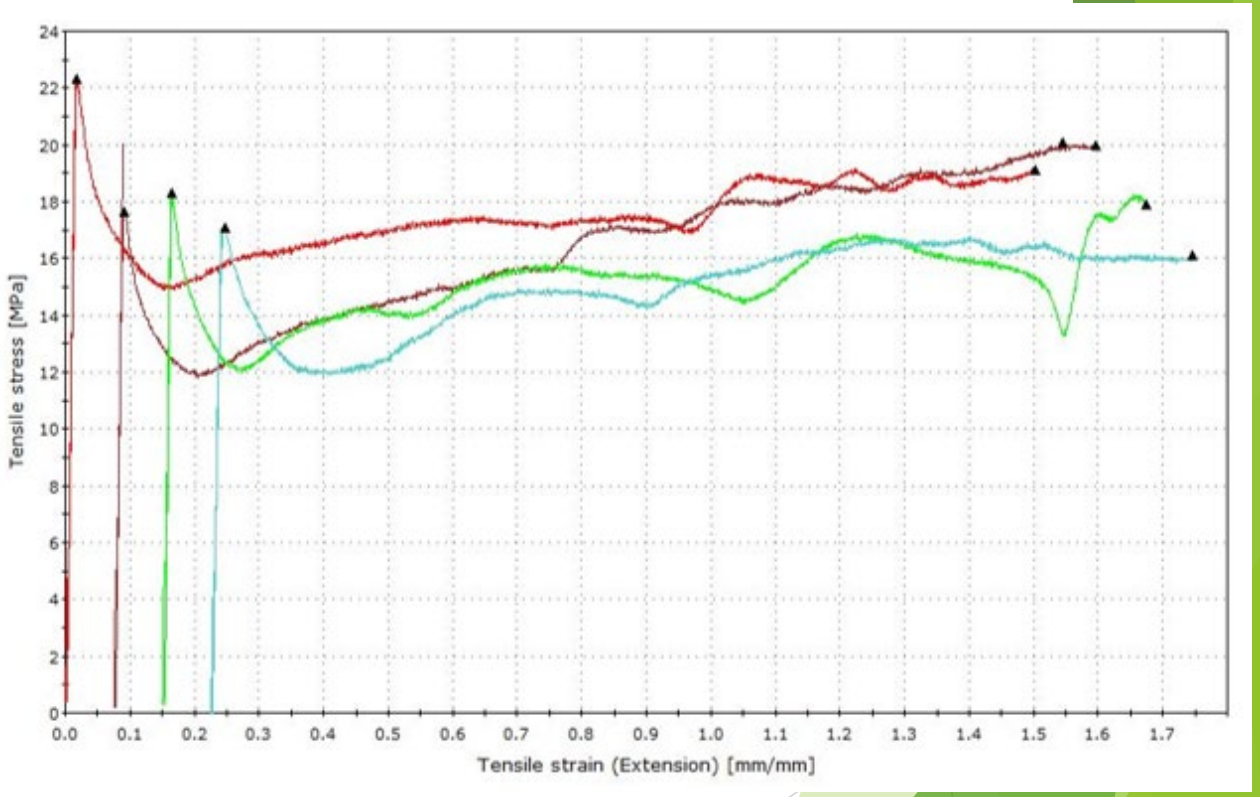
TGA Data Table

Sample	Temperature at 10% Weight Loss (°C)	Temperature at 50% Weight Loss (°C)	Residue (%)
PLA Pellet	319	344	0
%100 PLA/0% TPU	263	333	0.7
%90 PLA/10% TPU	311	344	0
%70 PLA/30% TPU	284	336	0
%50 PLA/50% TPU	263	332	0
%30 PLA/70% TPU	318	345	0
%10 PLA/90% TPU	244	342	2.2
%0 PLA/100% TPU	232	344	2.3
TPU Pellet	237	344	1.7

Tensile Data

Sample	Modulus (Mpa)
%100 PLA/0% TPU	1397 (±200)
%90 PLA/10% TPU	4304 (±355)
%70 PLA/30% TPU	3125 (±270)
%50 PLA/50% TPU	1762 (±100)
%30 PLA/70% TPU	3545 (±270)
%10 PLA/90% TPU*	25.52 (±16.3)
%0 PLA/100% TPU*	11.32 (±2.44)

Tensile Data from 50/50 PLA TPU Filament



* These behaved like elastomers and were highly ductile in nature.

Summary and Next Steps

- PLA and TPU were successfully blended using single-screw extrusion
- Blend ratios of 70% PLA 30% TPU and 50% PLA 50% TPU were found to be the most consistent
  - Dimensional stability
  - Thermal testing
  - Tensile testing
- These ratios will be used first in 3D printing

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