COVALENT
Material Insights

Mechanical Comparison of UP and PETG Polymers

CM000058880

Andrea Westlie, Unplastic

Authors Stephanie Currie, M.S.
Josh Campbell, Ph.D.

Reviewers Shivesh Sivakumar, M.S.

April 15, 2026

Statement of Work and Summary of Results

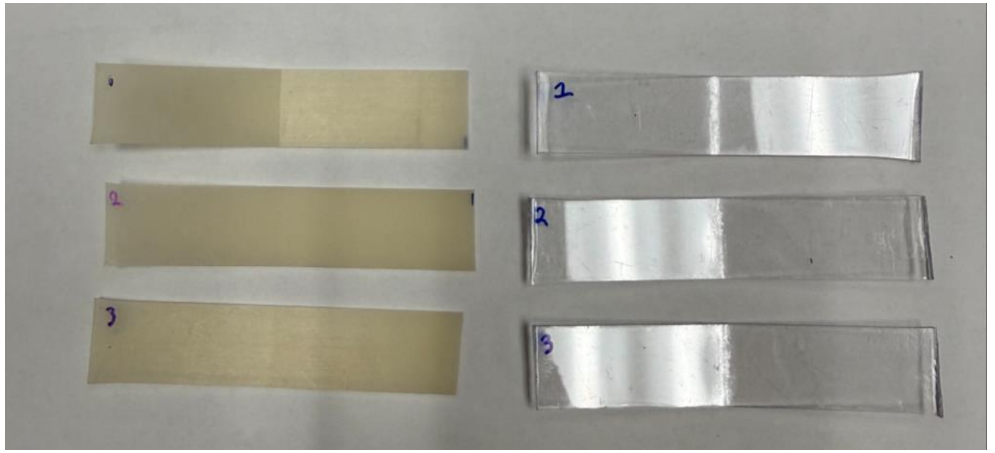
COVALENT Material Insights

Goal:

- Evaluate mechanical behavior of PETG and UP polymers under conditions simulating clinical use.

Methods:

Analysis	Instruments & Operating Parameters
Flex Testing (ASTM D790)	Instron 68SC-5 Universal Testing Machine *(Appendix 2)*
	• 3-point bend fixture w/ 5-mm radius anvils • ASTM D790 Procedure A, Type I* • 500 N load cell • Ambient Environment: 22°C, 47% RH
Creep Testing	Anton Paar MCR 702 Multidrive *(Appendix 3)*
	• Constant tensile load of 1.0 N • Extensional strain monitored for 60 minutes • Ambient temperature and 37°C



Flexural Samples – After Testing

Summary of Results:

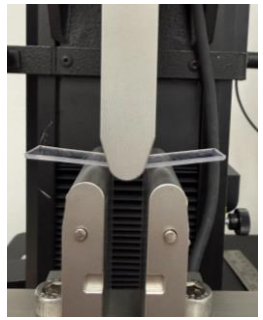
- Flexural testing shows PETG to have higher Yield Strength and Flexural Strength, while UP has higher Modulus of Elasticity.
- Creep testing shows UP polymer to be more resistant to creep deformation at both ambient and 37°C.
- Stress relaxation test was not feasible using Anton Paar MCR 702.
  - An alternative test method is proposed in “Next Steps”.

** Strain rate of 0.01 mm/mm/min (Procedure A) with strain calculated from crosshead displacement (Type I)*

Results Summary

COVALENT Material Insights

Specimen	Modulus of Elasticity* [GPa]	Yield Stress (0.2% offset) [MPa]	Flexural Strength [MPa]**
PETG - 1	2.73	92.0	96.9
PETG – 2	2.73	87.5	96.0
PETG - 3	2.70	90.5	95.7
Average	2.72	90.0	96.2
Std. Dev.	0.02	2.3	0.1

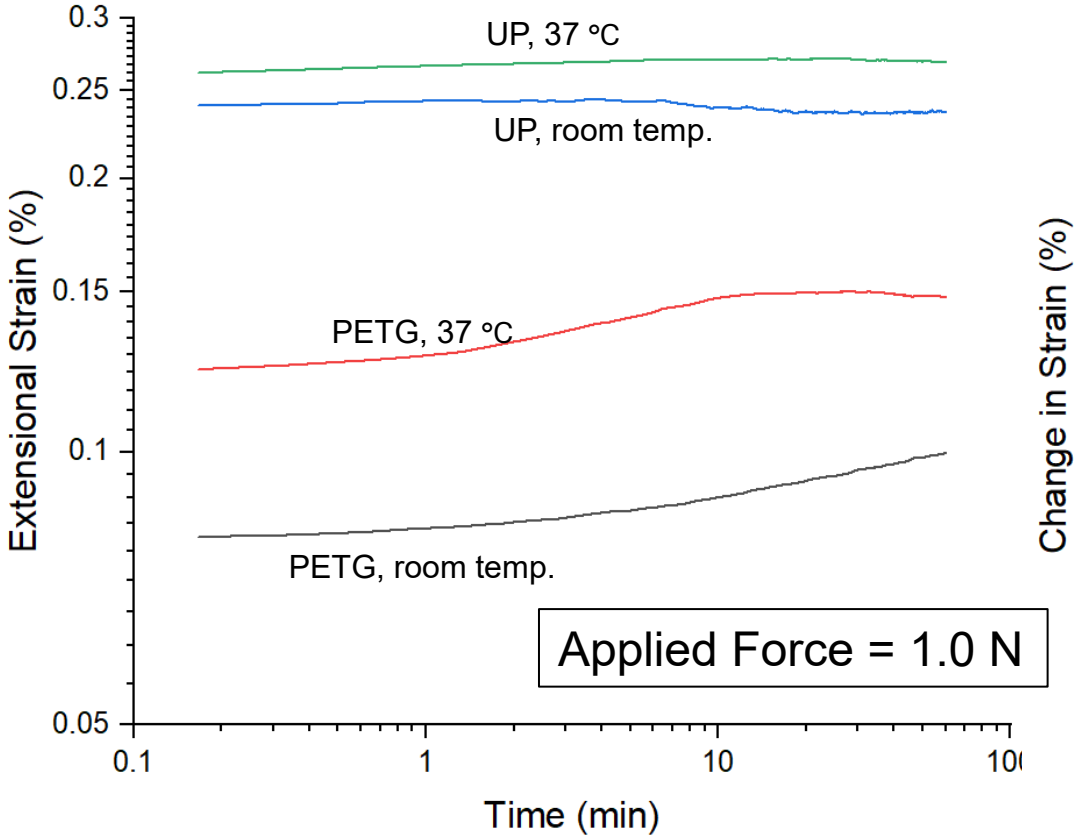


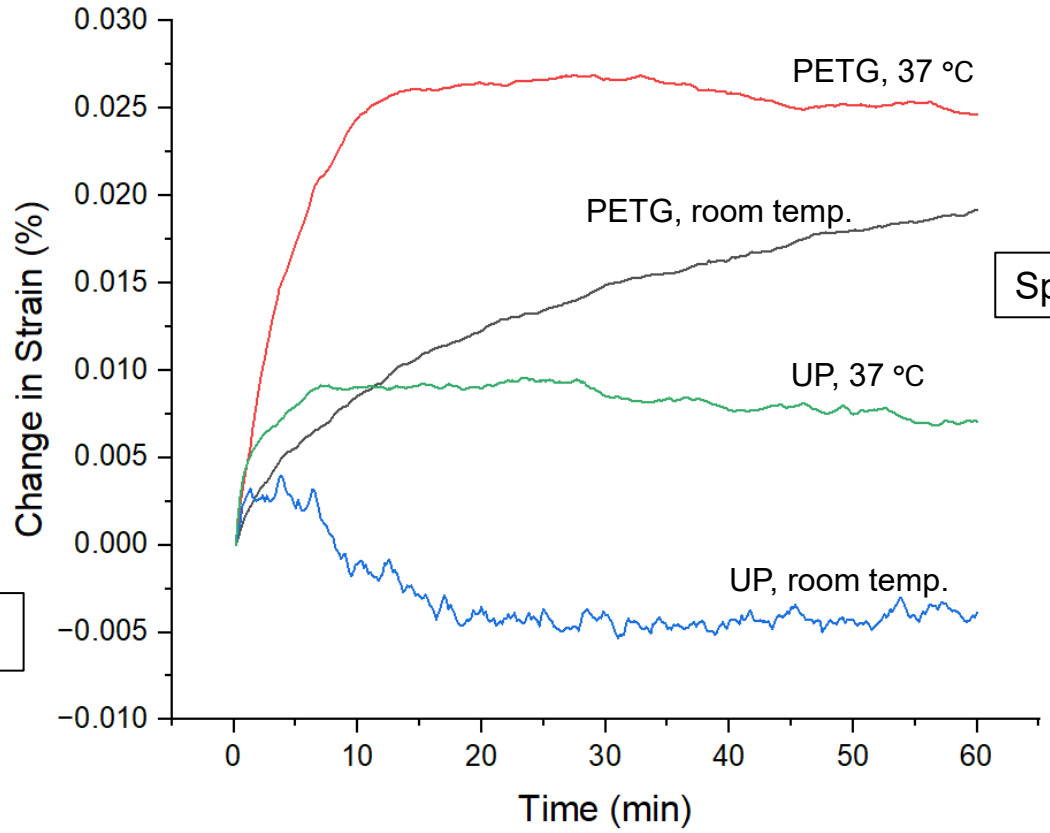
Specimen	Modulus of Elasticity* [GPa]	Yield Stress (0.2% offset) [MPa]	Flexural Strength [MPa]
UP- 1	3.13	51.8	77.6
UP – 2	3.02	43.9	71.6
UP - 3	3.05	74.1	82.6
Average	3.07	56.6	77.3
Std. Dev.	0.06	15.7	5.5

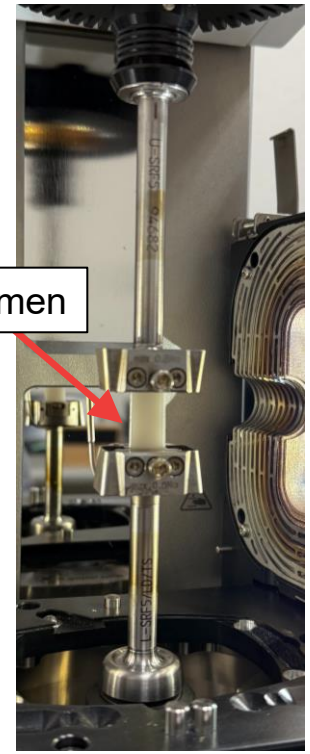
** 0.5 – 1.0% Chord Modulus, per ASTM D790, section 5.1.8.3.*
*** Per ASTM D790 requirements, test terminates at 5% strain.*

- PETG samples show higher Yield stress and Flexural Strength.
- UP shows higher Modulus of Elasticity.
- Deformation behavior is more variable with the UP samples.
  - As indicated by higher standard deviations for Yield Stress & Flexural Strength.

Creep Testing Results







- Extensional Strain as a function of time (left plot) shows that UP polymer has higher strains at the applied load of 1.0N.
- Looking at the change in strain from the start of the test (right plot) shows that UP is more dimensionally stable with time at both room temperature and 37 °C.
- Both polymers show increased creep strain as temperature is increased (for the temp. range investigated).

Next Steps – Stress Relaxation Testing

- Stress Relaxation Testing was attempted on the Anton Paar MCR 702 (Appendix 3), by applying a fixed strain and monitoring stress over a 24-hour period.
  - ➢ This instrument was unable to sufficiently hold the prescribed strain value.

- The Instron 68SC-5 universal testing machine (Appendix 2) will likely be better able to hold the prescribed strain value.
  - ➢ Covalent proposed attempting the stress relaxation test on this instrument.
  - ➢ Due to lack of an environmental chamber, it will only be possible to perform this test at ambient temperature.

Appendix 1 – Specimen & Experimental Dimensions

COVALENT Material Insights

Flexural Testing

Specimen	Width (mm)	Thickness (mm)	Load Span (mm)
PETG 1	12.83	1.37	22
PETG 2	12.88	1.37	22
PETG 3	12.86	1.37	22
UP 1	12.94	0.86	14
UP 2	12.91	0.84	14
UP 3	12.94	0.89	14

Creep Testing

Specimen	Width (mm)	Thickness (mm)	Length (mm)
PETG, RT	9.99	1.37	24.95
PETG, 37	9.79	1.37	19.08
UP, RT	10.17	0.76	15.90
UP, 37	9.40	0.68	15.79

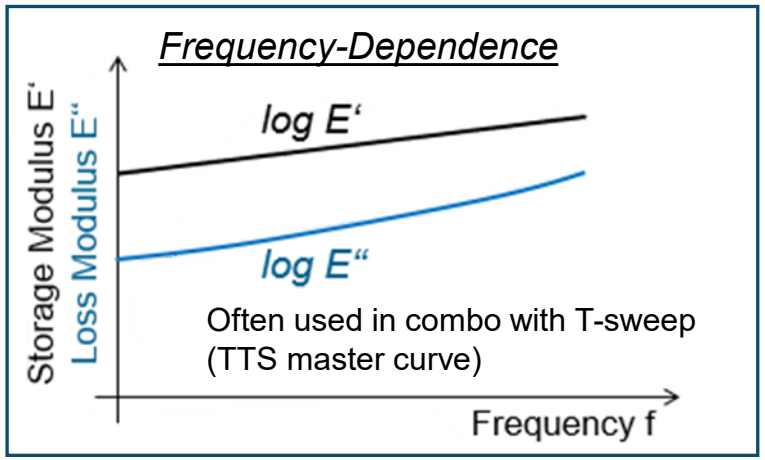
Appendix 2 – Instrument: Instron 68SC-5

Parameter	Value
Maximum Load	5000 N
Load Accuracy	± 0.5% of reading down to 1/1000 of load cell capacity
Speed Range	0.005 to 2000 mm/min
Crosshead Travel	Up to 1120 mm (44 in.)
Software	Bluehill Universal

Appendix 3 – Instrument: Anton Paar MCR 702 Rheometer

DMA is a measurement of a material's viscoelastic properties as a function of time, temperature, and frequency.

E', E", tan delta, frequency sweep, temperature sweep, time-temperature superposition (TTS).



Mode	Length (mm)	Width (mm)	Thickness (mm)	Temperature range (°C)	Stiffness range (MPa)	Example materials
Tension/Torsion	5-35	5-15	0.01 - 5	-100 - 350	0.1 - 10000	Films, fibers, flat samples
Compression	1-40	1-40	0.5 - 5	-100 - 220	0.0001 - 100	Foams, elastomers, cylinders/discs
3-pt Bend	45-50	10-12	stiff = 0.2-0.3 soft = 1-2	-100 - 350	100 - 1000000	Composites, glass, ceramics, cured resins/polymers