RPU 130

RPU 130 is a strong and tough engineering polyurethane offering a unique combination of durability, impact resistance, and performance at elevated temperatures.

Tensile Properties ASTM D638, Type I, 50 mm/min	**Metric**	**US**
Tensile Modulus	1000 MPa	145 ksi
Yield Strength	25 MPa	4 ksi
Strain at Yield	10%	10%
Ultimate Tensile Strength	35 MPa	5 ksi
Elongation at Break	100%	100%

Tensile Properties ASTM D638, Type V, 10 mm/min	**Metric**	**US**
Tensile Modulus	900 MPa	130 ksi
Yield Strength	25 MPa	4 ksi
Strain at Yield	10%	10%
Ultimate Tensile Strength	35 MPa	5 ksi
Elongation at Break	100%	100%

Flexural Properties ASTM D790-B	**Metric**	**US**
Flexural Stress at 5% strain	35 MPa	5 ksi
Flexural Modulus (Chord, 0.5-1%)	900 MPa	130 ksi

Impact Properties	**Metric**	**US**
Gardner Impact, ASTM D5420	> 30 J	> 22 ft-lb
Notched Charpy (Machined Notch), ISO 179-1/1eA	10 kJ/m^2	4.8 $ft\text{-}lb/in^2$
Notched Izod (Machined Notch), ASTM D256	75 J/m	1.4 ft-lb/in

Thermal Properties	**Metric**	**US**
Heat Deflection Temperature at 0.455 MPa/66 psi, ASTM D648	120 °C	250 °F
Heat Deflection Temperature at 1.82 MPa/264 psi, ASTM D648	55 °C	130 °F
Coefficient of Thermal Expansion (-60, 100 °C), ASTM E831	150 ppm/°C	82 ppm/°F

The information in this document includes values derived from printing various parts, reflects an approximation of the mean value of a range of values, and is intended for reference and comparison purposes only. This information should not be used for testing, design specification or quality control purposes. End-use material performance can be impacted by, but not limited to, design, processing, color treatment, operating and end-use conditions, test conditions, etc. Actual values will vary with build conditions. In addition, product specifications are subject to change without notice.

This information and Carbon's technical advice are given to you in good faith but without warranty. The application, use and processing of these and other Carbon products by you are beyond Carbon's control and, therefore, entirely your own responsibility. Carbon products are only to be used by you, subject to the terms of the written agreement by and between you and Carbon.

You are responsible for determining that the Carbon material is safe, lawful, and technically suitable for the intended application, as well as for identifying the proper disposal (or recycling) method consistent with applicable environmental laws and regulations. CARBON MAKES NO WARRANTIES OF ANY KIND, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR USE, OR NON-INFRINGEMENT. Further, it is expressly understood and agreed that you assume and hereby expressly release Carbon from all liability, in tort, contract or otherwise, incurred in connection with the use of Carbon products, technical assistance and information. No license with respect to any intellectual property is implied.

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent.

General Properties	
Hardness, ASTM D2240	77, Shore D
Density, ASTM D792	1.07 g/cm^3
Density (liquid resin)	1.03 g/cm^3
Poisson's Ratio	0.47
Taber Abrasion, ASTM D4060, CS-17, 1 kg, 100% vacuum	10 mg / 1000 cycles
Water Absorption, Short Term (24 hours) ASTM D570	< 2%
Water Absorption, Long Term (14 days) ASTM D570	5%

Flammability	
FMVSS 302	Pass

The information in this document includes values derived from printing various parts, reflects an approximation of the mean value of a range of values, and is intended for reference and comparison purposes only. This information should not be used for testing, design specification or quality control purposes. End-use material performance can be impacted by, but not limited to, design, processing, color treatment, operating and end-use conditions, test conditions, etc. Actual values will vary with build conditions. In addition, product specifications are subject to change without notice.

This information and Carbon's technical advice are given to you in good faith but without warranty. The application, use and processing of these and other Carbon products by you are beyond Carbon's control and, therefore, entirely your own responsibility. Carbon products are only to be used by you, subject to the terms of the written agreement by and between you and Carbon.

You are responsible for determining that the Carbon material is safe, lawful, and technically suitable for the intended application, as well as for identifying the proper disposal (or recycling) method consistent with applicable environmental laws and regulations. CARBON MAKES NO WARRANTIES OF ANY KIND, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR USE, OR NON-INFRINGEMENT. Further, it is expressly understood and agreed that you assume and hereby expressly release Carbon from all liability, in tort, contract or otherwise, incurred in connection with the use of Carbon products, technical assistance and information. No license with respect to any intellectual property is implied.

Parts were processed using an M series printer and a Smart Part Washer with DPM as the solvent.

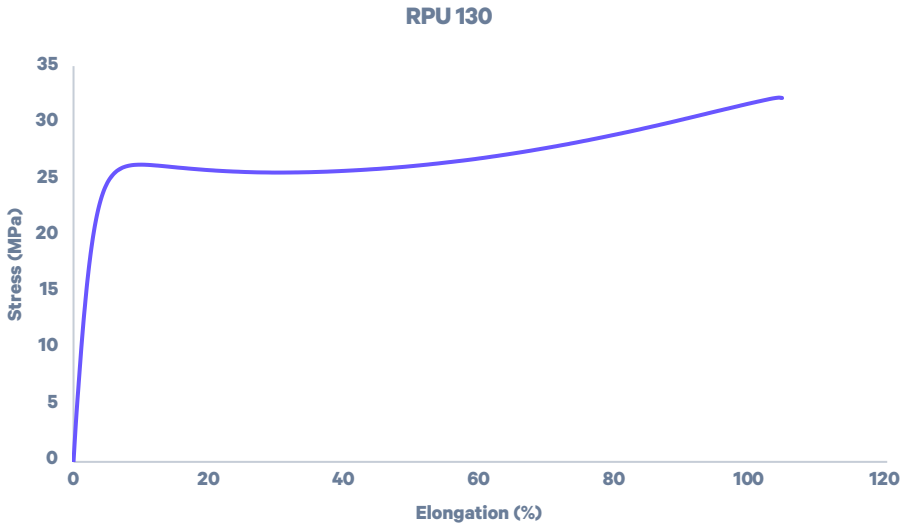
RPU 130

Extended TDS

RPU 130 Mechanical Properties

Representative Tensile Curve

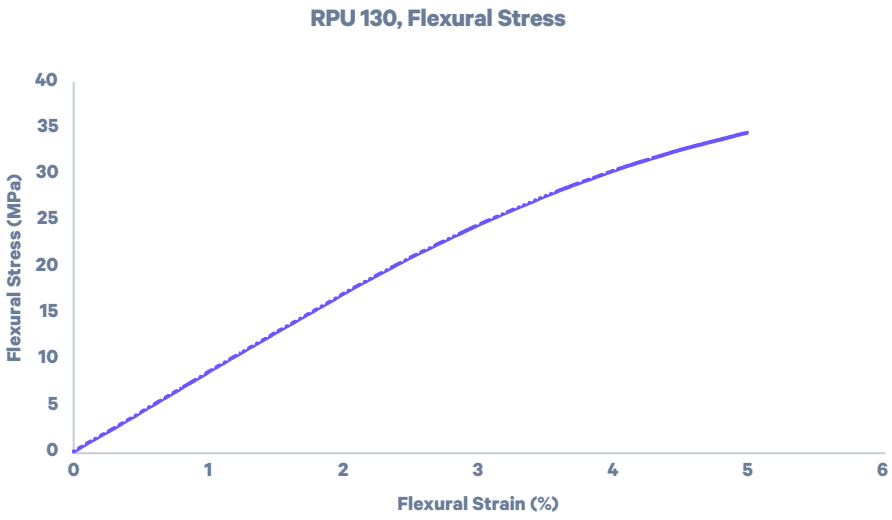
ASTM D638, Type V, 10 mm/min



Typical Flex Curve

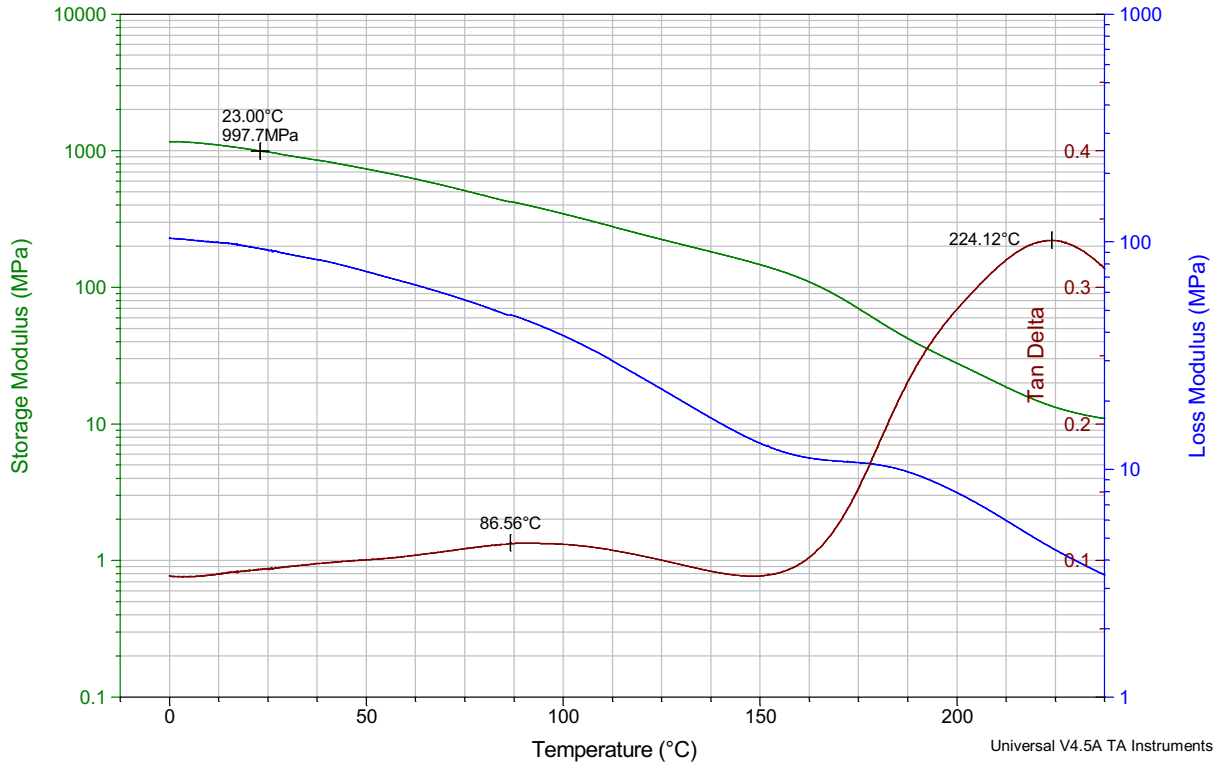
ASTM D790-B

Samples are tested to 5% extension.



RPU 130 Dynamic Mechanical Analysis (DMA)

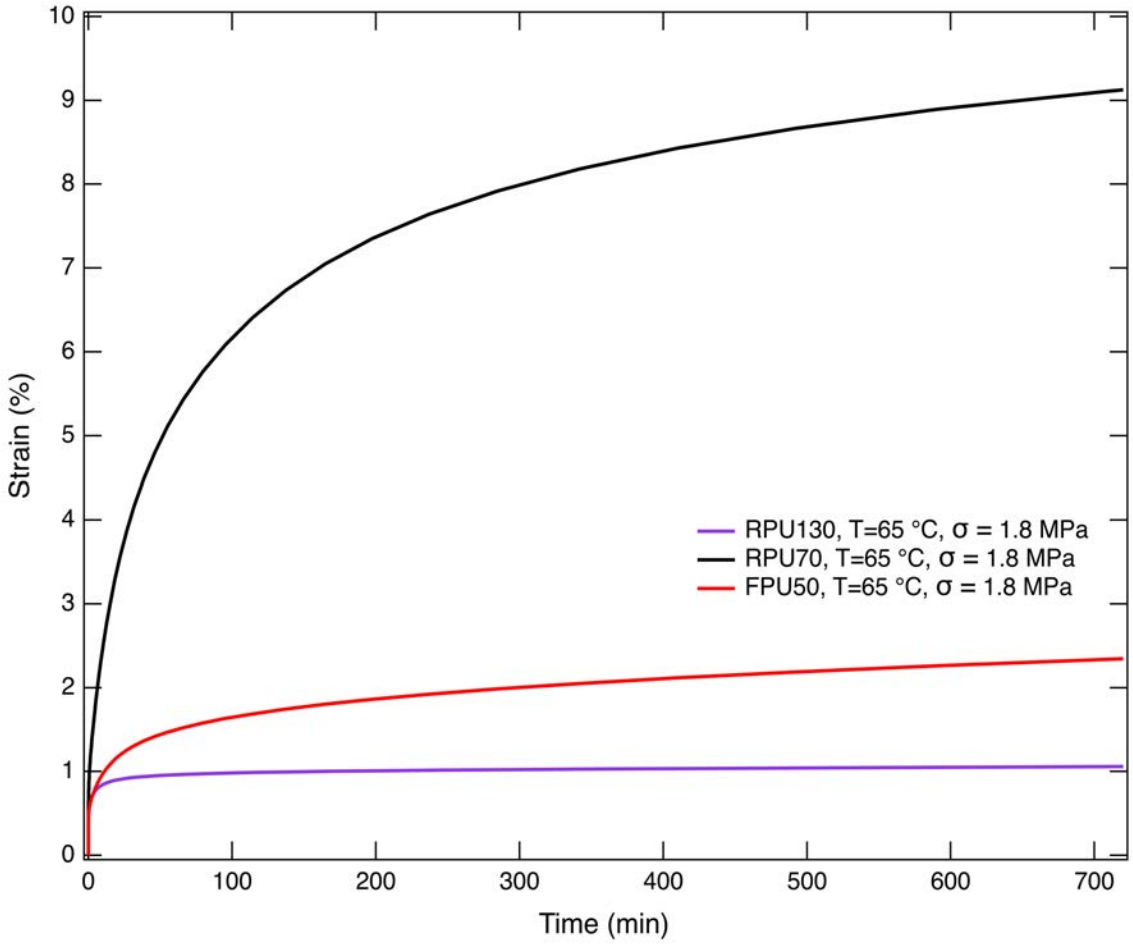
Dynamic mechanical analysis provides insight into a material's viscoelastic properties across a range of temperatures. The figure below shows a temperature ramp of RPU 130. This material exhibits two transition temperatures at 90 °C and 225 °C as indicated by the two peaks in the tan(d) curve.



Standard: ASTM D4065
Instrument: TA DMA Q800
DMA Mode: Tension
Sample Dimensions: L=20 mm, W=10 mm, t=1 mm (rectangular block)
Strain Amplitude: 0.1% (linear regime of viscoelasticity)
Oscillation frequency: 1 Hz
Temperature Range: 0 °C to 250 °C
Ramp Rate: 1.5 °C/min
Print Conditions: Samples were hand-wiped and not washed with solvent. The thermal cure for all materials complies with the Carbon user manual. Values may differ based on post processing conditions.

RPU 130 Creep Behavior

A creep test measures a polymer's rate of deformation under constant load at a fixed temperature and is a fundamental property for materials that need to operate under load. The figure below highlights RPU 130's ability to withstand 1.8 MPa of applied load compared to RPU 70 and FPU 50 at elevated temperatures. Low creep behavior is necessary for performance and dimensional stability over time.



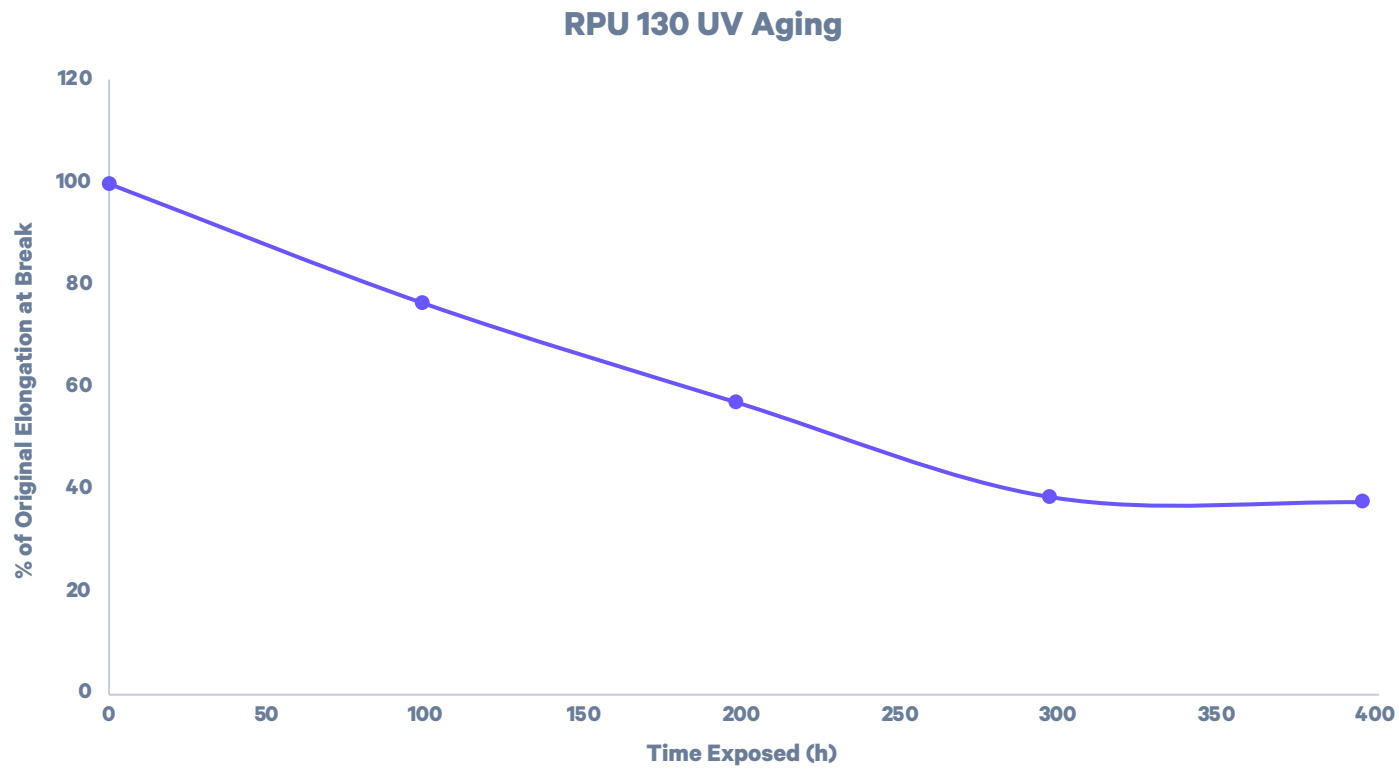
RPU 130 Chemical Compatibility

	Mass Gain* (%)
Household Chemicals	
Sunscreen (Banana Boat, SPF 50)	5 - 15%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Diesel (Chevron #2)	15 - 30%

Percent weight gained after one week submersion following ASTM D543. Values do not represent changes in dimension or mechanical properties.

RPU 130 UV Aging

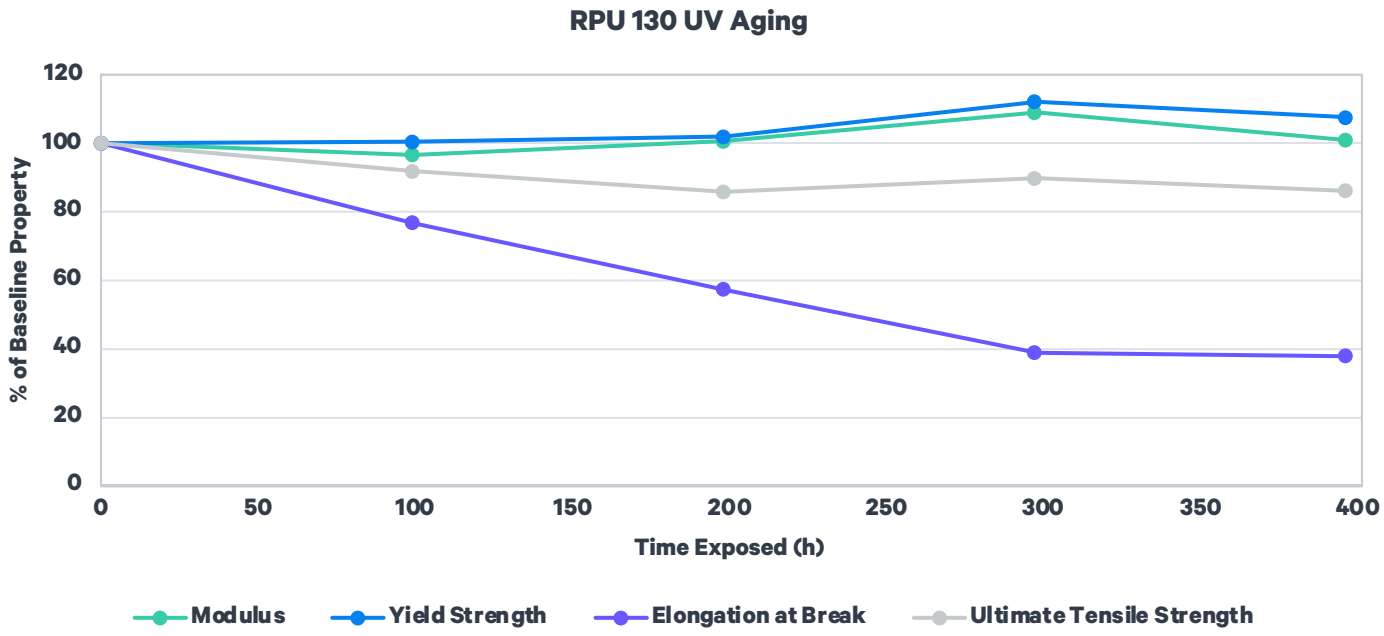
Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of RPU 130 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.



ASTM D4459: Q-Sun XE-1, 0.8 W/m^2 at 420 nm, 55 °C
ASTM D638: Type V, 10 mm/min, average values represented

RPU 130 UV Aging

Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of RPU 130 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.



ASTM D4459: Q-Sun XE-1, 0.8 W/m^2/nm at 420 nm, 55 °C
ASTM D638: Type V, 10 mm/min, average values represented

RPU 130 Thermal Aging

High thermal stability is an important property for high performance rigid polymers. RPU 130 offers better thermal stability compared to previous polyurethane offerings. The figures below illustrates the change in mechanical properties after thermal aging at 40 °C, 85 °C, and 105 °C.

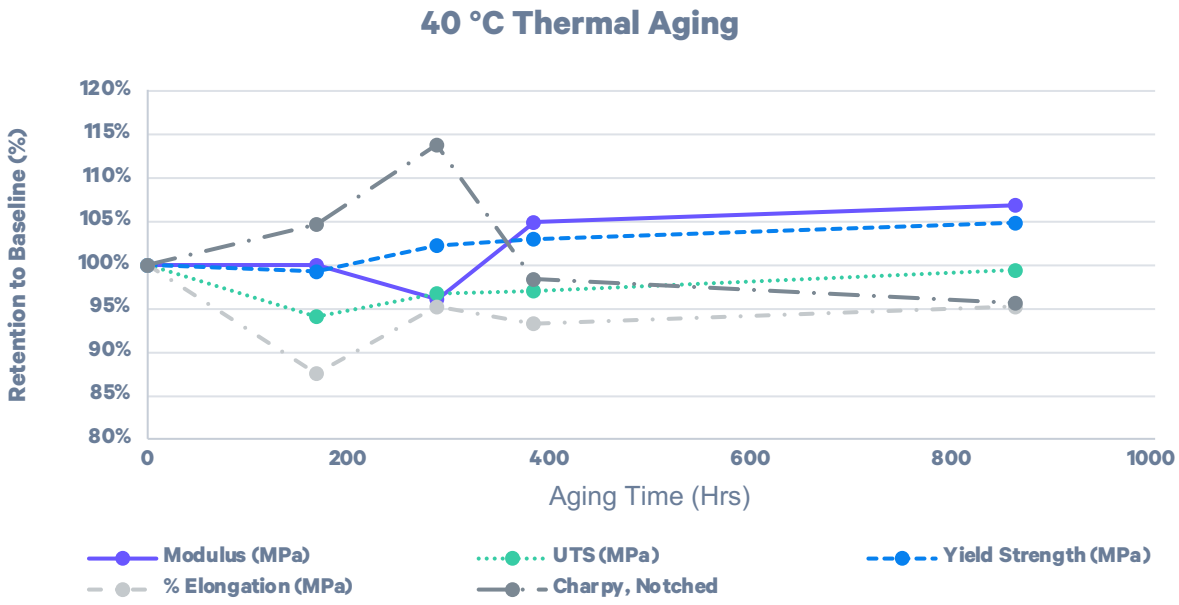


Figure 1: Effect of 40 °C thermal aging on RPU 130 mechanical properties. ASTM D638, Type I, and ISO 179 notched Charpy

RPU 130 Thermal Aging cont.

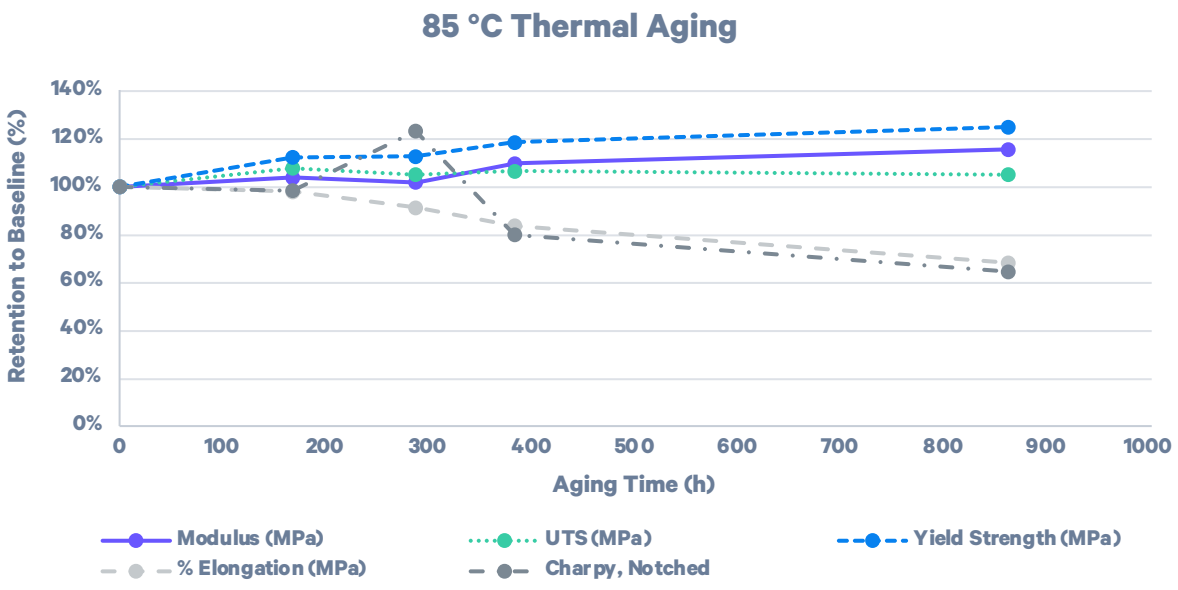


Figure 2: Effect of 85 °C thermal aging on RPU 130 mechanical properties. ASTM D638, Type I, and ISO 179 notched Charpy

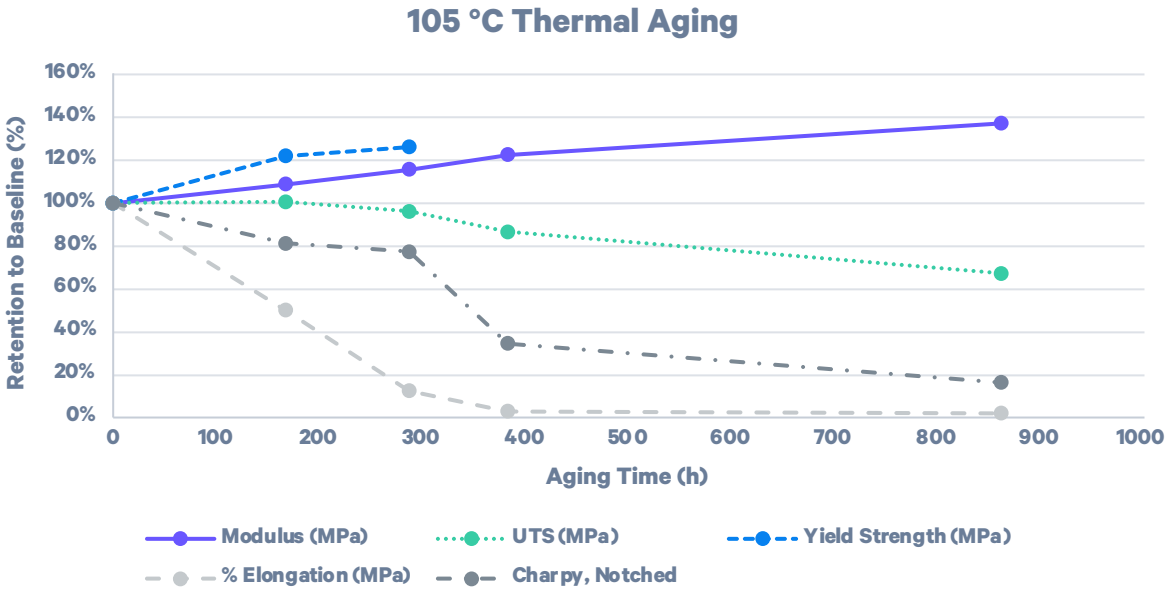


Figure 3: Effect of 105 °C thermal aging on RPU 130 mechanical properties. ASTM D638, Type I and ISO 179 notched Charpy

RPU 130 Environmental Aging

PV 1200

Stability to environmental factors such as temperature and humidity is a key performance aspect for plastic materials. PV 1200, a standard developed by the Volkswagen Group to evaluate material durability, is used here as a representative climate cycling test. This standard designates one cycle to be a 720 minute period in which both temperature and humidity are varied from 80 °C/80% RH to -40 °C (Figure 1).

Carbon evaluated RPU 130 after 20 cycles per PV 1200 with the results reported in Table below. RPU 130 shows >75% retention in tensile and impact properties after this exposure.

Further testing is recommended for applications that require performance under differing environmental conditions.

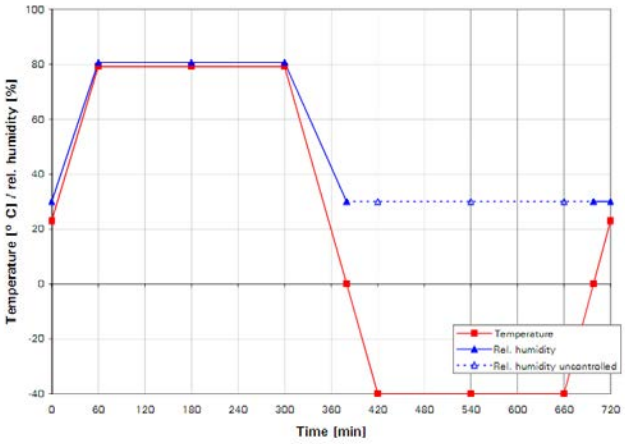


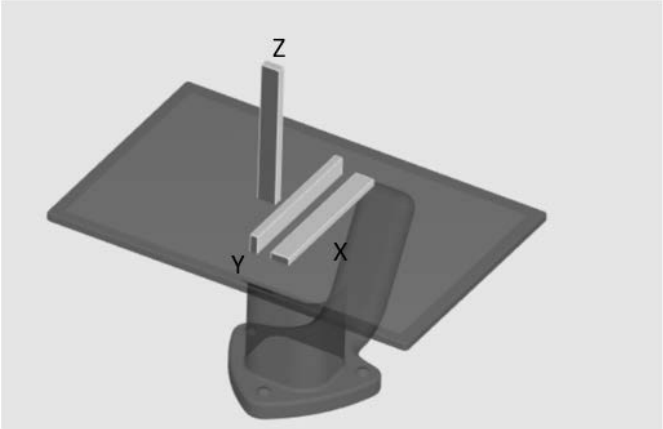
Figure 1 – Test cycle for PV 1200

Resin	Test	Property	Sample Size	Baseline RT	20 Cycles, PV1200
RPU 130	Tensile (ASTM D638, Type I)	Modulus (MPa)	6	1000	1000
		UTS (MPa)		30	30
		Yield Strength (MPa)		25	25
		Elongation at Break (%)		100	110
	Impact	Charpy, Notched (kJ/m^2)	8	10	10

RPU 130 Isotropy

Type I and Charpy bars

Carbon's dual cure materials yield parts that have a higher degree of isotropy than other additive manufacturing materials. To highlight this, we evaluated the tensile and impact properties of RPU 130 printed in three orientations—flat on the platform (x), on edge lengthwise (y), and on end (z). The tensile gage area printed in the y-orientation required additional supports to be properly adhered on the platform. All sample bars were machine notched. The table below shows the results of the tested samples in the three orientations.



	Test	Property	Orientation		
			X	Y	Z (Baseline)
RPU 130	Tensile (Type I, ASTM D638)	Modulus (MPa)	1000	1000	1000
		UTS (MPa)	30	35	35
		Yield Strength (MPa)	25	25	25
		Elongation at Break (%)	105	110	100
	Charpy Impact (Machine Notched)	Impact Energy (kJ/m^2)	20	30	10

RPU 130 Biocompatibility

Biocompatibility Testing

Printed parts were provided to NAMSA for evaluation in accordance with ISO 10993-5, *Biological evaluation of medical devices - Part 5: Tests for in vitro cytotoxicity*, and ISO 10993-10, *Biological evaluation of medical devices - Part 10: Tests for irritation and skin sensitization (GPMT)*. Parts were processed using an M series printer and dipropylene glycol mono methyl ether (DPM) as the wash solvent. The results for all tests indicated that RPU 130 passed the requirements for biocompatibility according to the above tests. **Carbon makes no representation and is not responsible for the results of any biocompatibility tests other than those specified above.**

Disclaimer

Biocompatibility results may vary based on printing and/or post-processing procedures.

Subscriber acknowledges the contents of this document are subject to the Terms and Conditions outlined in the Subscription Agreement, including the Restrictions on Use section.

DO NOT USE CARBON MATERIALS IN MEDICAL APPLICATIONS INVOLVING IMPLANTATION IN THE HUMAN BODY OR CONTACT WITH BODY FLUIDS OR TISSUES UNLESS THE MATERIAL HAS BEEN PROVIDED FROM CARBON UNDER A WRITTEN CONTRACT THAT IS CONSISTENT WITH THE CARBON POLICY REGARDING MEDICAL APPLICATIONS AND EXPRESSLY ACKNOWLEDGES THE CONTEMPLATED USE. CARBON MAKES NO REPRESENTATION, PROMISE, EXPRESS WARRANTY OR IMPLIED WARRANTY CONCERNING THE SUITABILITY OF THESE MATERIALS FOR USE IN IMPLANTATION IN THE HUMAN BODY OR IN CONTACT WITH BODY FLUIDS OR TISSUES. If Carbon has permitted in the Subscription Agreement use of the Carbon printer for applications that require biocompatibility, Subscriber acknowledges that it is the responsibility of Subscriber, its respective customers and end-users to determine the biocompatibility of all printed parts for their respective uses.

Carbon, Inc. | www.carbon3d.com
1089 Mills Way Redwood City, CA 94063
1 (650) 285-6307