

CE 221

CE 221 is a high-performance material with excellent strength, stiffness, and temperature resistance.

Table of Contents

Standard Technical Data Sheet:	Page 2-3
Extended Technical Data Sheet:	Page 4-9
- Mechanical Properties	Page 5
- Thermomechanical Properties	Page 6
- Chemical Compatibility	Page 7
- UV Aging	Page 8
- Biocompatibility	Page 9

Tensile Properties	Test Standard	Metric	US
Tensile Modulus	ASTM D638 Type V 1 mm/min	3900 MPa	570 ksi
Ultimate Tensile Strength		85 MPa	12 ksi
Elongation at Break		3%	3%

Flexural Properties	Test Standard	Metric	US
Flexural Stress at 5% strain	ASTM D790-B	130 MPa	19 ksi
Flexural Modulus (Chord, 0.5-1%)		3800 MPa	550 ksi

Impact Properties	Test Standard	Metric	US
Notched Charpy (Machine Notched)	ISO 179-1/1eA	1.2 kJ/m ²	0.6 ft-lb/in ²
Notched Izod (Machine Notched)	ASTM D256	15 J/m	0.3 ft-lb/in
Unnotched Izod	ASTM D4812	290 J/m	5 ft-lb/in

Thermal Properties	Test Standard	Metric	US
Heat Deflection Temperature at 0.455 MPa/66 psi,	ASTM D648	230 °C	450 °F
Heat Deflection Temperature at 1.82 MPa/264 psi		200 °C	390 °F
Coefficient of Thermal Expansion (-60, 100 °C)	ASTM E831	50 ppm/°C	30 ppm/°F
Coefficient of Thermal Expansion (100, 180 °C)		90 ppm/°C	50 ppm/°F
Coefficient of Thermal Expansion (180, 200 °C)		150 ppm/°C	80 ppm/°F
Heat Capacity, 23 °C	ASTM E1269	1.2 J/g-°C	0.3 BTU/lb-°F
Thermal Conductivity	ASTM C518	0.17 W/m-k	0.1 BTU/hr-ft-°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 washed using 50/50 (v/v) propylene glycol/isopropyl alcohol solvent.

Dielectric/Electric Properties	Test Standard	Metric	US
Dielectric Strength	ASTM D149	22 kV/mm	560 V/mil
Dielectric Constant	ASTM D150	3.1	3.1
Dissipation Factor		0.05	0.05
Volume Resistivity	ASTM D257	2.2×10^{14} ohm-cm	8.7×10^{13} ohm-in

General Properties	Test Standard	
Hardness	ASTM D2240	92, Shore D
Bulk Density	ASTM D792	120 g/mL
Taber Abrasion	ASTM D4060 CS-17, 1 kg, 100% vacuum	40 mg/ 1000 cycles
Water Absorption, Short Term (24 hours)	ASTM D570	< 0.5%
Water Absorption, Long Term (14 days)		< 1%

Liquid Properties	
Liquid Density (Part A)	1.18 g/mL
Liquid Density (Part B)	1.11 g/mL
Liquid Density (Part A+B)	1.15 g/mL
Part A:B Volume Ratio (Mass Ratio)	1.00 (1.06)
25 °C Viscosity (Part A)	300 cP
25 °C Viscosity (Part B)	5500 cP
25°C Viscosity (Part A+B)	1300 cP

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 washed using 50/50 (v/v) propylene glycol/isopropyl alcohol solvent.

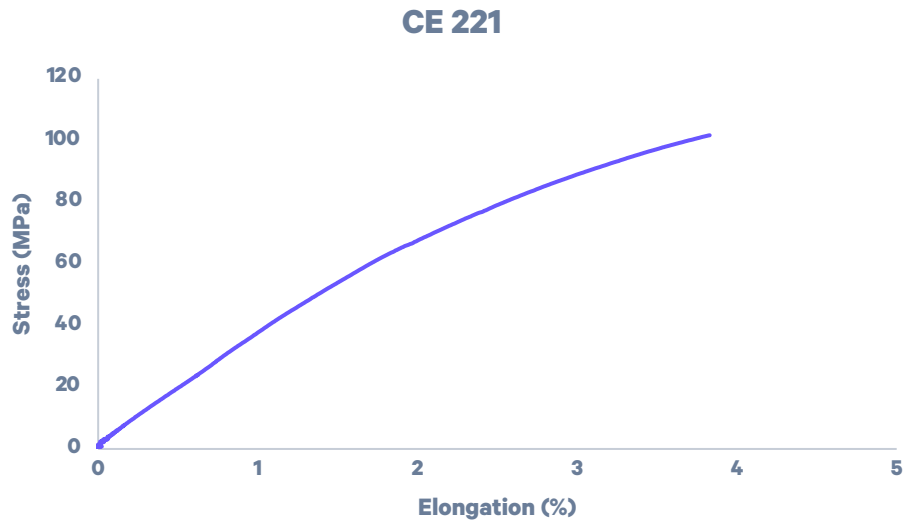
CE 221

Extended TDS

CE 221 Mechanical Properties

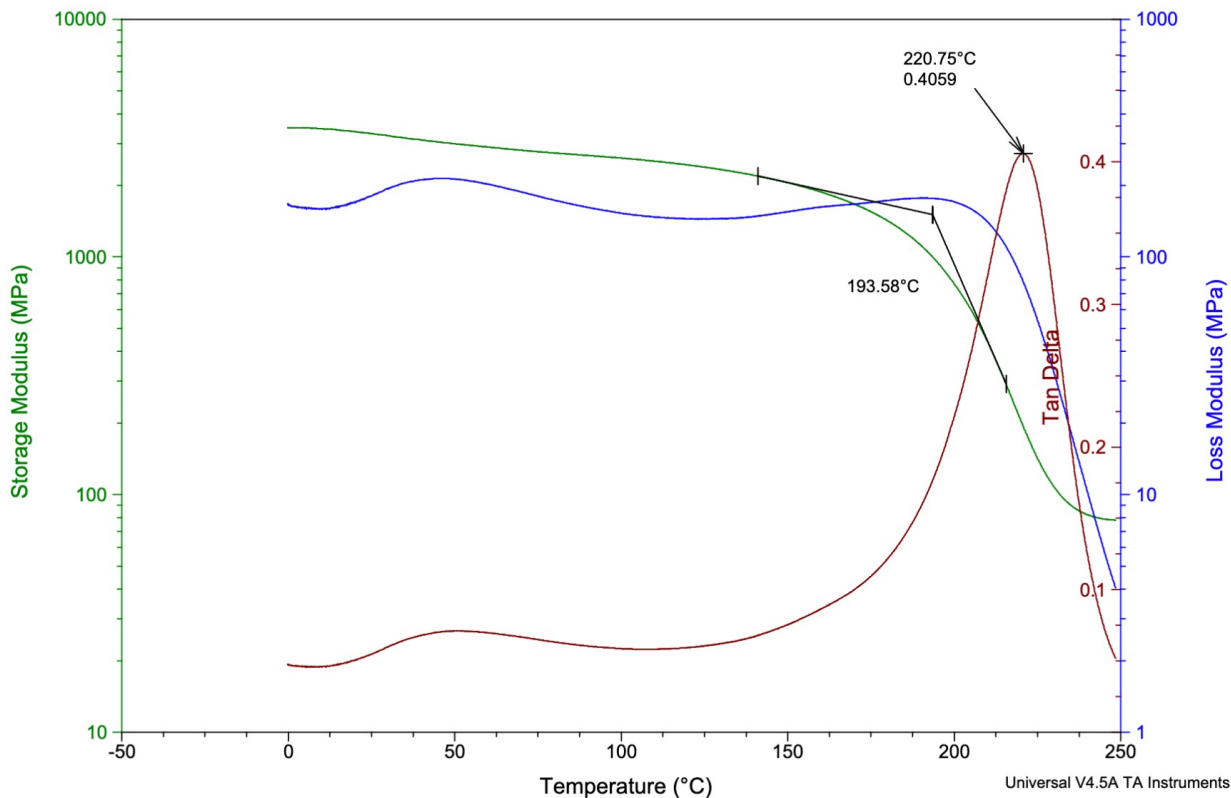
Representative Tensile Curve

ASTM D638, Type V, 1 mm/min



CE 221 Dynamic Mechanical Analysis (DMA)

Dynamic mechanical analysis provides insight into the resin's viscoelastic properties across a range of temperatures. The figure below shows a temperature ramp of CE 221. This material exhibits a flat and high storage modulus up to a softening onset temperature of 190 °C, which reflects its rigid and temperature-resistant performance. The peak in the tan(δ) curves indicates that the glass transition temperature of CE 221 is approximately 220 °C.



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.

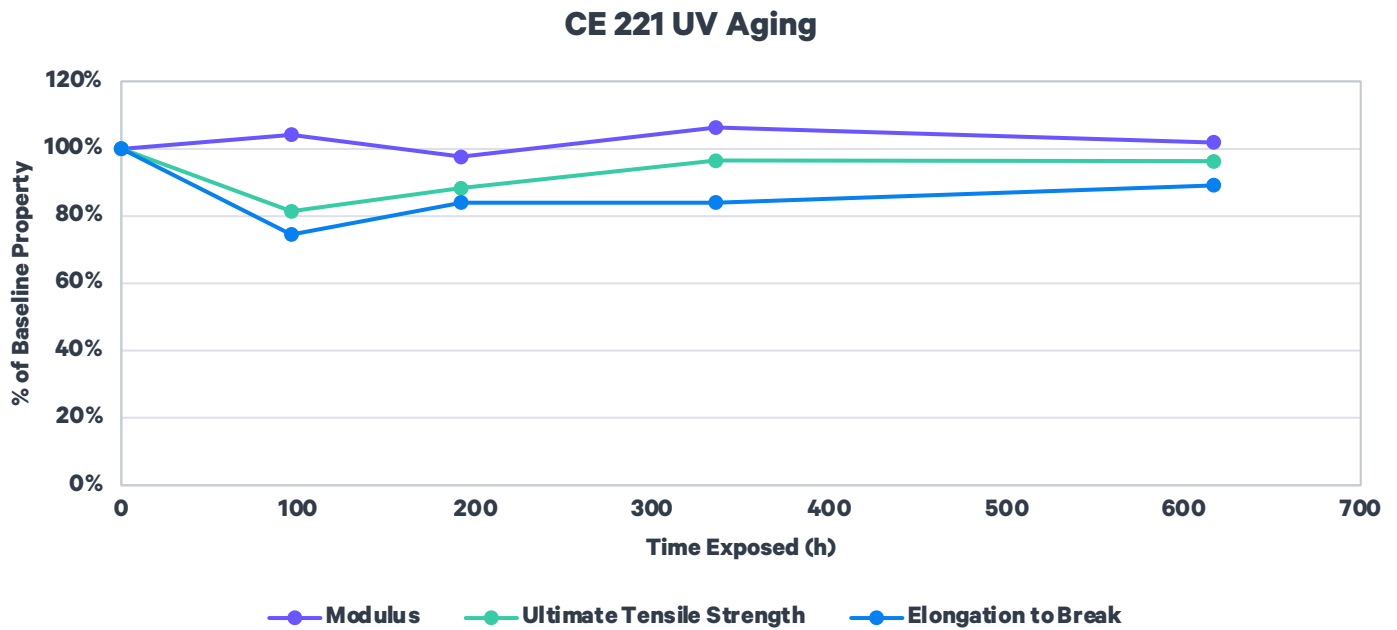
CE 221 Chemical Compatibility

	Mass Gain* (%)
Household Chemicals	
Bleach (NaClO, 5%)	< 5%
Sanitizer (NH ₂ Cl, 10%)	< 5%
Distilled Water	< 5%
Sunscreen (Banana Boat, SPF 50)	< 5%
Detergent (Tide, Original)	< 5%
Windex Powerized Formula	< 5%
Hydrogen Peroxide (30%)	< 5%
Ethanol (95%)	< 5%
Industrial Fluids	
Engine Oil (Havoline SAE 5W-30)	< 5%
Brake Fluid (Castrol DOT-4)	< 5%
Airplane Deicing Fluid (Type I Ethylene Glycol)	< 5%
Airplane Deicing Fluid (Type I Propylene Glycol)	< 5%
Airplane Deicing Fluid (Type IV Ethylene Glycol)	< 5%
Airplane Deicing Fluid (Type IV Propylene Glycol)	< 5%
Transmission Fluid (Havoline Synthetic ATF)	< 5%
Engine Coolant (Havoline XLC, 50%/50% premixed)	< 5%
Diesel (Chevron #2)	< 5%
Gasoline (Chevron #91)	< 5%
Skydrol 500B-4	< 5%
Strong Acid/Alcohol/Base	
Sulfuric Acid (30%)	< 5%
Sodium Hydroxide (10%)	< 5%

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

CE 221 UV Aging

Natural polymer aging can occur in the presence of light, sun, and heat. Carbon evaluated the UV aging performance of CE 221 using ASTM D4459, which is intended to simulate indoor exposure of solar radiation through glass.



ASTM 4459: Q-Sun XE-1, 0.8 W/m²/nm at 420 nm, 55 °C

ASTM D638: Type V, 1 mm/min, average values represented

CE 221 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*. Parts were printed using an M series printer and washed in 50:50 (v:v) propylene glycol (PG) and isopropyl alcohol (IPA). The results indicated that CE 221 passed the requirements for biocompatibility according to the above test. **Carbon has not conducted ISO 10993-10, *Biological evaluation of medical devices - Part 10: Tests for irritation and skin sensitization (GPMT)* testing. 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