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Ultracur3D® RG 3280

Rigid | HDT 280 | Ceramic-Filled

Extended TDS

Complete Technical Documentation and Testing Summary

Version 4.2

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Technical Data Sheet

Ceramic-filled resin with exceptionally high stiffness and temperature resistance.

General Properties	Method	Typical Values
Appearance	-	White
Ceramic content	-	≈ 65 wt% silica
Viscosity, 25°C	Cone/Plate Rheometer[1)]	300 mPas
Viscosity, 30°C	Cone/Plate Rheometer[1)]	230 mPas
Density (Printed Part)	ASTM D792	1.73 g/cm³
Density (Liquid Resin)	ASTM D4052-18a	1.65 g/cm³

Tensile Properties[2)]	Method	Typical Values	
		(UV)	(UV + Thermal[3)])
E Modulus	ASTM D638	10600 MPa	10500 MPa
Ultimate Tensile Strength	ASTM D638	87 MPa	85 MPa
Elongation at Break	ASTM D638	1.3%	1%
Poisson’s Ratio	ISO 527-2	0.31	-

Flexural Properties	Method	Typical Values (UV)
Flexural Modulus	ASTM D790	11200 MPa
Flexural Strength	ASTM D790	129 MPa

Impact Properties	Method	Typical Values
Notched Izod (Machined), 23°C	ASTM D256	24 J/m
Notched Charpy (Machined), 23°C	ISO 179-1	0.98 kJ/m²

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Thermal Properties	Method	Typical Values	
		(UV)	(UV +Thermal[3])
HDT at 0.45 MPa	ASTM D648	284°C	284°C
HDT at 1.82 MPa	ASTM D648	132°C	162°C
Glass transition temperature (DMA, tan(d))	ASTM D4065	164°C	168°C

Advanced Thermal Properties	Method	Typical Values (UV)
C.T.E. (-45°C to 0°C)	ASTM E831	23.2 µm/(m·K)
C.T.E. (0°C to 50°C)	ASTM E831	30.2 µm/(m·K)
C.T.E. (50°C to 100°C)	ASTM E831	61.4 µm/(m·K)
C.T.E. (100°C to 150°C)	ASTM E831	56.8 µm/(m·K)
Thermal conductivity, 23°C[4]	MTPS	0.47 W/(m·K)
Thermal conductivity, 200°C[4]	MTPS	0.69 W/(m·K)
Specific heat capacity, 23°C[5]	MTPS	1.01 J/(g·K)
Specific heat capacity, 200°C[5]	MTPS	1.81 J/(g·K)

Fire, Smoke, Toxicity (FST) properties	Method	Typical Values (UV)
Flammability	UL 94	HB (1.8 mm)

Dielectric/Electric Properties	Method	Typical Values (UV)
Dielectric Strength	DIN EN 60243-1	29 kV / mm
Volume resistivity	DIN EN 62631-3-1	2.80E+16 Ωcm
Surface resistivity	DIN EN 62631-3-2	3.40E+16 Ω
Comparative tracking index (CTI)	DIN EN 60112	PLC 0 (≥ 600 V)
RTI (Elec, Imp., Str.)	UL 746 B (generic value)	50°C

Biocompatibility	Method	Typical Values (UV)
Cytotoxicity – Neutral Red	EN ISO 10993-5 (2009)	PASS[6)]
Human Skin Irritation[7)]	EN ISO 10993-23 (2021)	PASS[6)]
In vitro Sensitization Testing-KeratinoSens™	EN ISO 10993-10 (2023); OECD 442D	PASS[6)]

Other	Method	Typical Values (UV)
Hardness Shore D	ASTM D2240	96
Volatile content, outgassing in vacuum (125°C, 24 hours)	ASTM E595-15	PASS (mass loss <0.1%)
Water Absorption, Short-Term (24 hours)	ASTM D570	0.29%
Water Absorption, Long-Term (>3000 hours)	ASTM D570	2.6%

Mechanical properties overview

1) Determined with TA-Instrument DHR rheometer, cone/plate, diameter 60 mm, shear rate 100 s^{-1}. Remark: since this is a resin with a high loading of solid particles, the viscosity is strongly dependent on shear rate. If another shear rate is used, or a viscometer where the shear rate is less defined, viscosity values different from the ones reported here may be obtained.
2) Tensile type ASTM D638 type IV, Pulling speed 5 mm/min
3) Regular UV post-curing and additional thermal post-cure of 3h at 150°C, see User Guideline for more details.
4) Data at intermediate temperatures, as well as thermal effusively data are available on request
5) Data at different temperatures are available on request
6) For the statement on Biocompatibility data see Chapter: Biocompatibility.
7) Patch test on 10 volunteers
8) If not noted otherwise, all specimens are 3D printed. Samples were tested at room temperature, 23°C. ASTM sample size (L x W x H): ASTM D790 80 x 4 x10 mm, ASTM D256 63 x 3.2 x 12 mm, ASTM D648 127 x 3.2 x 13 mm, ISO 179-1 80 x 4 x 10 mm, ASTM E595-15 50 x 50 x 50 mm. Samples for ASTM D638, ASTM D790 and ASTM D648 were cleaned using IPA wipes.

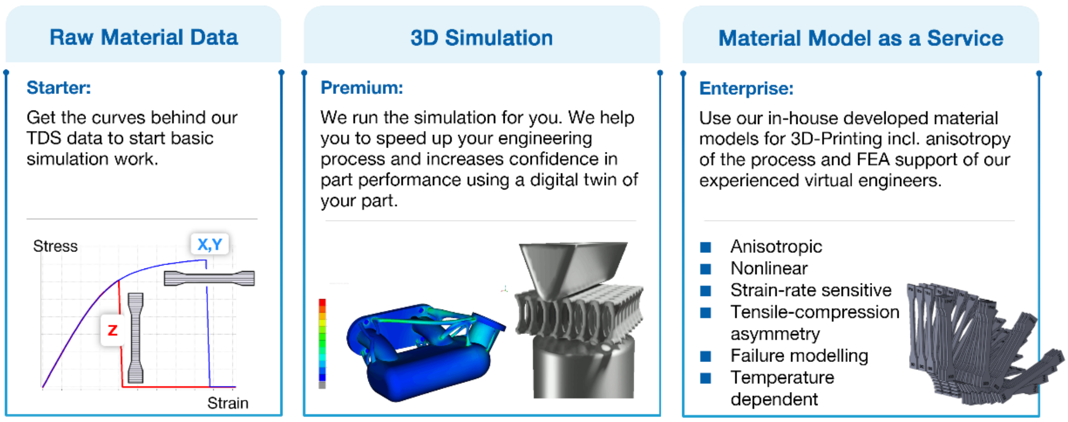
Printing Performance

The combination of 3D printer and material has a huge impact on the quality of the parts produced. The measured design characteristics as well as the printing speed can be found in the Printing Evaluation Guideline of Ultracur3D® Resins.

Material Model & FEA Simulation

FEA simulation can be used to predict how different parameters such as temperature and mechanical stress affect the final printed parts. This information can be used to significantly expedite application development, and to optimize the part design to ensure all performance requirements for the application are met. In order to run simulations with a specific material, a material model is required. This model is generated based on a wide range of testing data under different loads and at different temperatures and other relevant conditions.

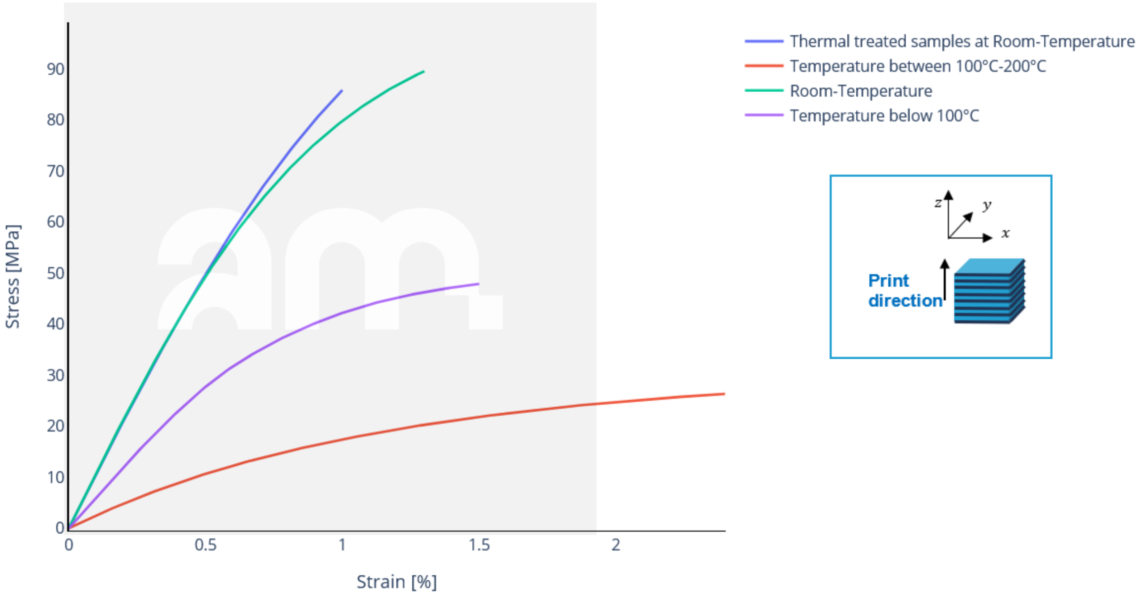
We can support you with 3D simulation in different ways, ranging from simply supplying you with raw test data, to doing the full simulation for you. These are the 3 options we offer:



Specifically for Ultracur3D® RG 3280, below you can find some of the data (at specific temperatures / mechanical loads) we have available in our Ultrasim® Material Model or that we could provide to you for your own simulations. More information is available on request (sales@forward-am.com).

	Available temperatures			Strain rate / loads	
	Low	23°C	High	Quasi static	High speed
Ultracur3D® RG3280		●	●	●	

● Validated, available as Material Data Set (can be converted into a Ultrasim® Material Model)
● Validated, available via Ultrasim® Material Model
○ ○ Preliminary



Stress-strain response of Ultracur3D® RG 3280 under quasi static load, loaded in x direction, at different temperatures. Sample "Thermal treated sample at Room-Temperature" underwent an additional thermal post-curing as described in the User Guideline for this material.

Warning: The description of polymer materials under large strains with standard hyperelastic material models (Mooney-Rivlin, Ogden, Polynomial type) offered by common FEM programs/solvers can lead to significant deviations from the experimentally observed mechanical response. To achieve realistic simulation results extended models have to be considered to account for effects like strain rate dependence, viscous behavior, strain softening (Mullins Effect) and permanent deformation. Forward AM has developed such models which are made available via Ultrasim® to support our customers with high confidence simulations.

Additional material data available on request

- **Quasi static Raw data (.csv/ASCII)**
- **Low temperature performance**
- **High temperature performance**
- **Higher strain rate performance**
- **Additional load cases (x,y,z,xy)**

Request raw data for internal use via
sales@forward-am.com
or your key account

See full material overview under:
Material data overview

For more information visit :
Ultrasim® 3D Simulation (FEA) (forward-am.com)

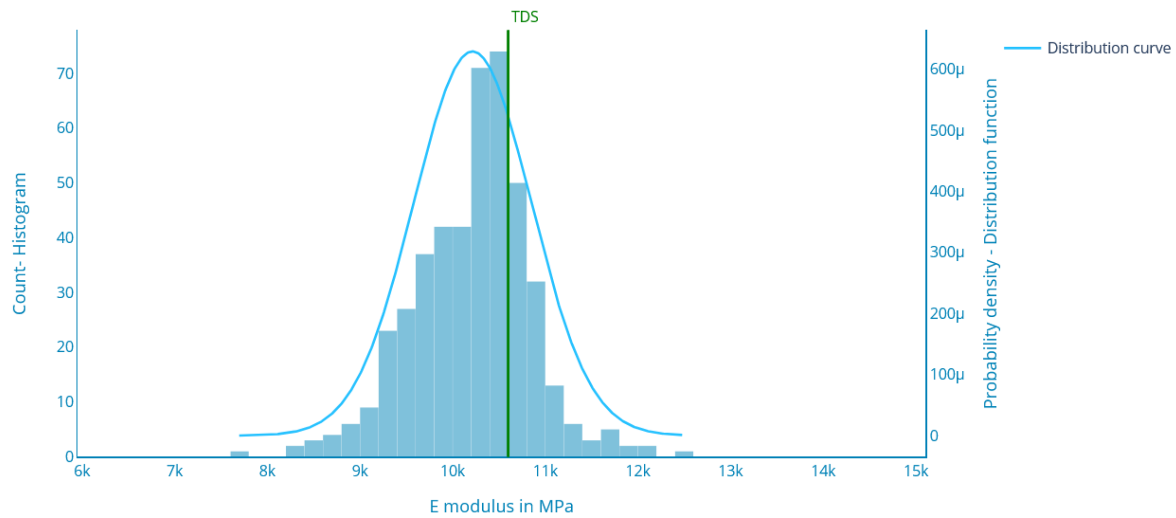
Mechanical properties - Statistic

Mechanical properties of 3D printed parts will always vary depending on the printer, post-curing unit and process workflow that is used. We find that especially post-processing can have a critical impact on the final performance. However, as long as the provided Workflow within the User Guideline is being followed correctly, any deviations from our Technical data sheet values should be limited. This section demonstrates the statistical variation we observe for the mechanical properties of Ultracur3D® RG 3280.

Test Method and Specimens

ASTM D638 type IV tensile bars were printed in different machines and tested under the same conditions. The mechanical data comes from 467 tensile bars printed in 71 builds from 21 different printers and post-cured in about 19 different post-curing units. In addition, the data set contains data from 15 different production batches.

Mechanical Testing



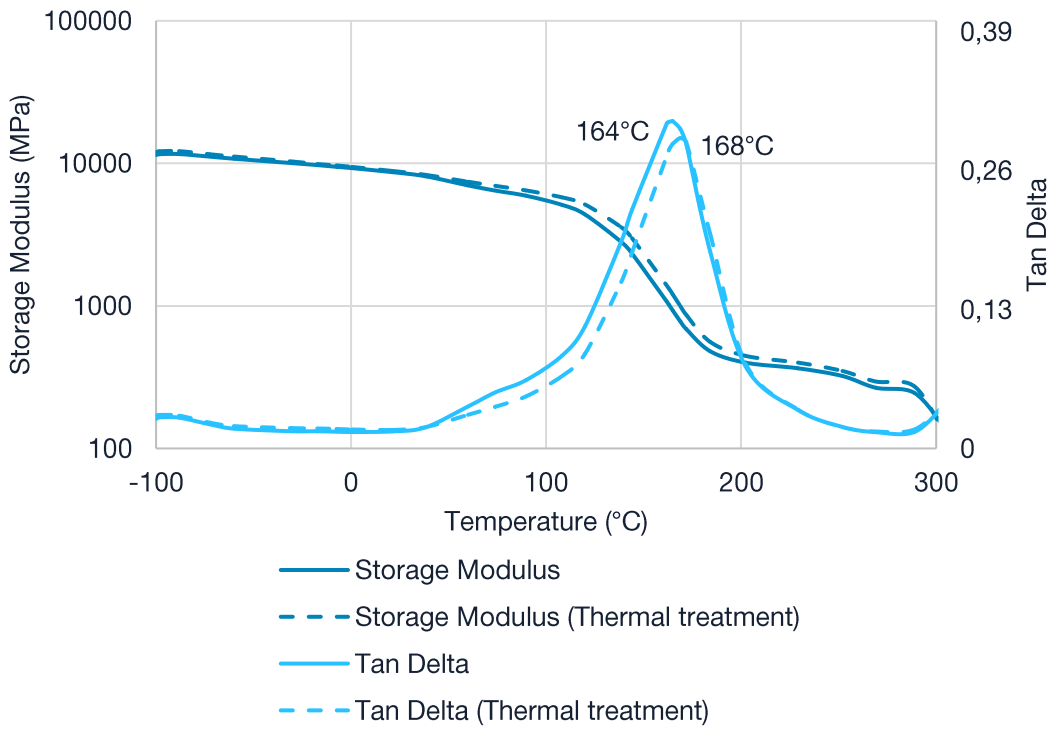
Result of mechanical properties using different machines

Dynamic Mechanical Analysis (DMA)

In this DMA measurement, a cyclic strain is applied to the sample, and the response of the sample is recorded as a function of temperature. This can give a good impression of the changes in material behavior, both at low and high temperatures. The measured Storage modulus is a good indication of the stiffness of the material. The maximum in Tan Delta gives the glass transition temperature.

	Setting
Measurement	Strain-controlled
Temperature sweep	1°C / min
Strain	0.014% (linear viscoelastic regime)
Type of loading	Dual cantilever
Frequency	1 Hz

Testing conditions DMA



DMA curve

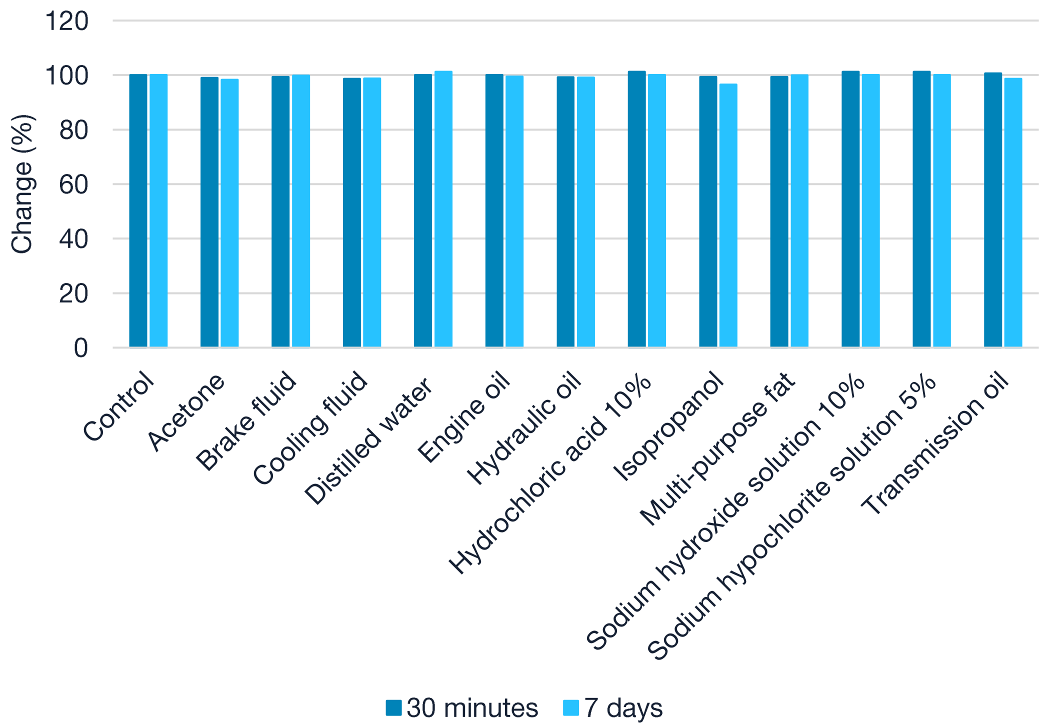
Industrial Chemical Resistance

The resistance of resin materials against chemicals, solvents and other contact substances is an important criterion of selection for many industrial applications. General chemical resistance depends on the period of exposure, the temperature, the quantity, the concentration and the type of the chemical substance. When exposed to industrial chemicals, the chemical bonds of photopolymers can break or degrade, causing a change in the mechanical properties.

Test Method and Specimens

ASTM D638 type IV tensile bars were soaked in each fluid at room temperature, one set for 30 minutes and one set for 7 days. Upon completion of the soaking time, the parts were removed from the test fluid and were dried to measure the weight and the mechanical properties.

Weight Measurement



Change in weight after immersion time

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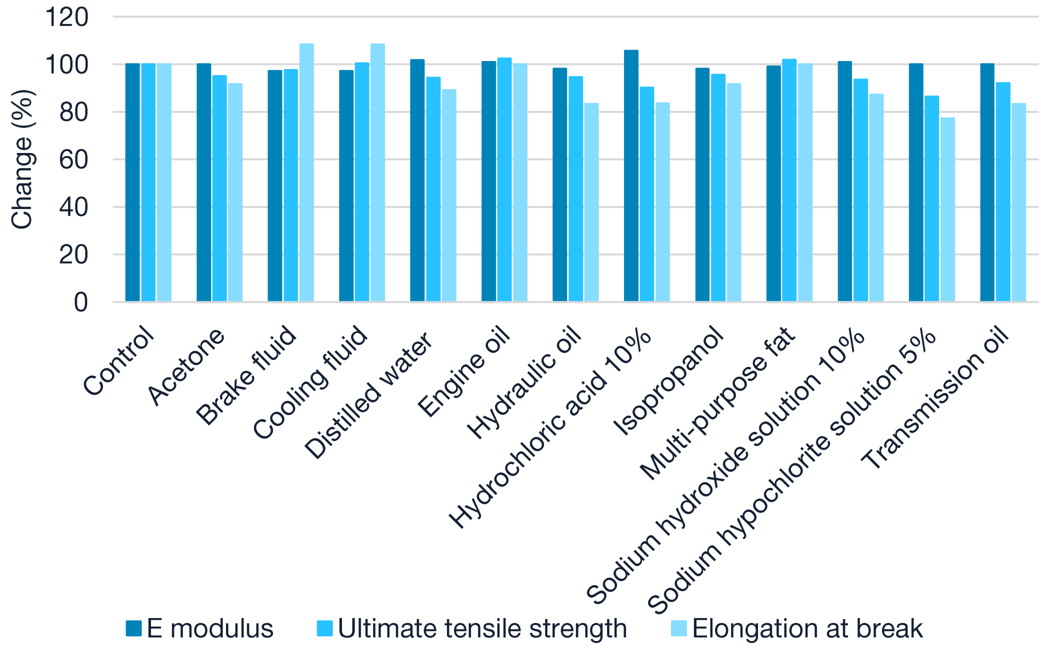
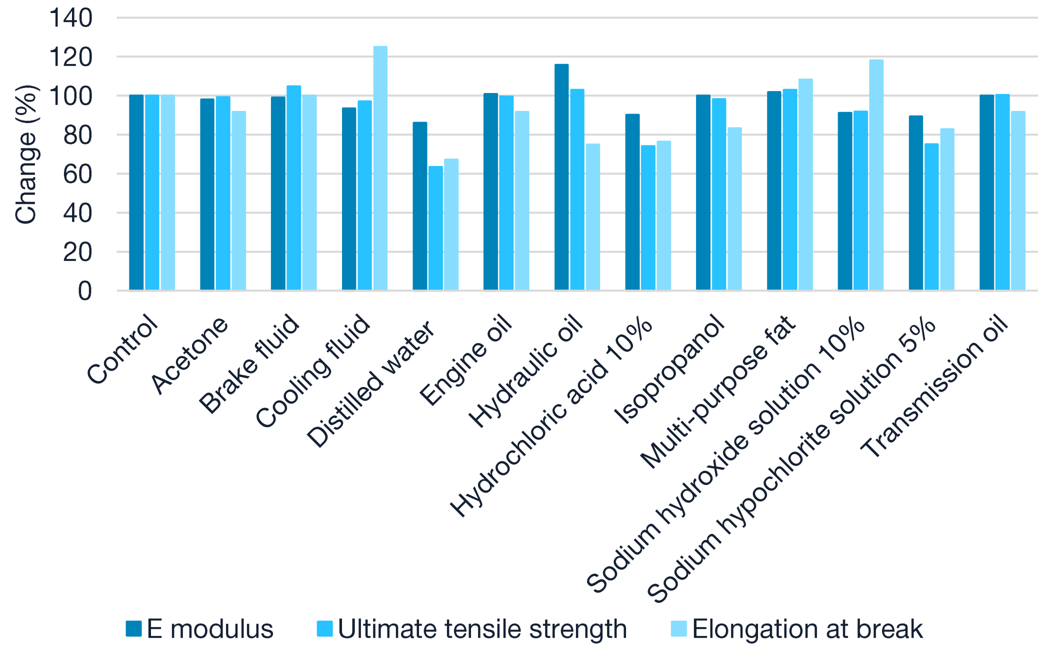
Mechanical Testing

30 minutes



Change in mechanical properties after 30 minutes immersion

7 days



Change in mechanical properties after 7 days immersion

Long-Term UV

Durability is a key feature for the components utilized within many industries, as they expect the materials used to withstand years of exposure to the elements. Through the effects of UV radiation, photopolymers can degrade over time. The aging can be caused by the influence of UV light, heat and water. The degree of ageing depends on duration and intensity.

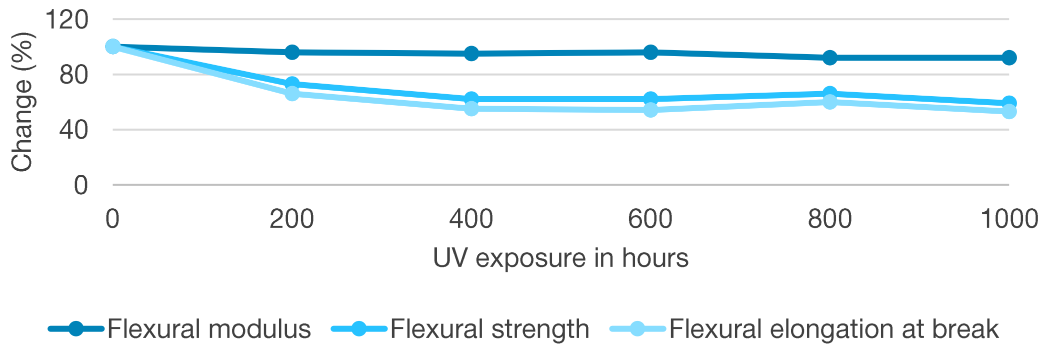
Test Method and Specimens

The ageing tests were performed with ASTM D790 flexural bars and color plates as per ISO 4892-2:2013 method A, cycle 1. Exposed samples were always removed at the end of a dry cycle, and conditioned for 24 hours at 22°C before mechanical testing.

Cycle No.	Exposure period	Irradiance		Black standard tempera-ture in °C	Chamber tempera-ture in °C	Relative humidity in %
		Broadband (300 nm to 400 nm) in W/m²	Narrowband (340 nm) in W/(m² nm)			
1	102 min dry	60 ± 2	0.51 ± 0.02	65 ± 3	38 ± 3	50 ± 10
	18 min water spray	60 ± 2	0.51 ± 0.02	-	-	-

Testing conditions for ISO 4892-2 method A, cycle 1

Mechanical Testing



Change in mechanical properties after accelerated weathering

The final values after 1000 hours of long-term UV exposure can be found below.

Property	Before long-term UV exposure	After 1000 hours of UV exposure
Flexural modulus	11200 MPa	10300 MPa
Flexural strength	129 MPa	76 MPa
Flexural elongation at break	1.4%	0.74%

Mechanical properties before and after 1000 hours of UV exposure as per ISO 4892:2 method A

Coloration

After being exposed up to 1000 hours, Ultracur3D® RG 3280 shows a yellow change in color.

Effect of UV exposure on color of the specimens

Sterilization

Sterilization is an essential requirement in many applications especially when used in the medical field. Testing not only ensures the material quality but also determines how effectively the chosen sterilization process is eliminating potential microorganisms.

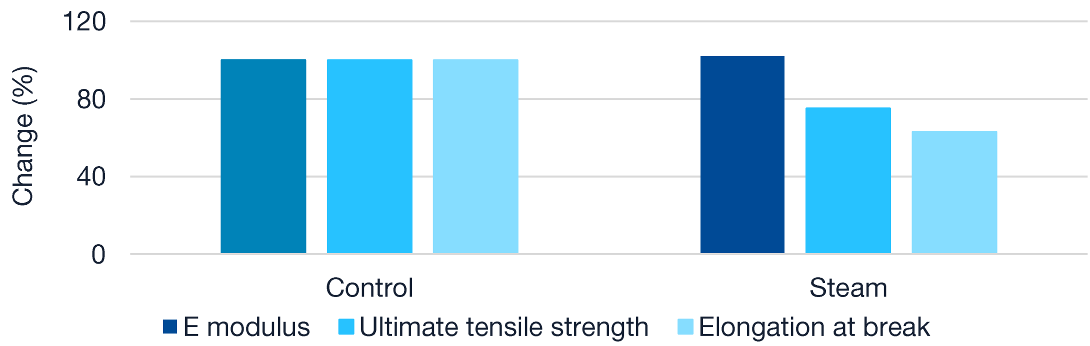
Test Method and Specimens

Steam Sterilization

Steam sterilization parameters	Settings
Vacuum pulses	4
Temperature	134°C
Pressure	210 kPa
Holding time	4 minutes
Drying time	20 minutes

Testing conditions steam sterilization

Mechanical Testing



Change in mechanical properties after sterilization

Coloration

Color samples before and after sterilization

Biocompatibility

Product: Ultracur3D® RG 3280

Revision: 27th of November 2024

3D printed test items of the above stated product have fulfilled the requirements of tests as stated below:

Cytotoxicity Testing- Neutral Red:

(EN ISO 10993-5 (2009))

Human Skin Irritation Test:

(EN ISO 10993-23 (2021))[9)]

In vitro Sensitization Testing- KeratinoSens™

(EN ISO 10993-10 (2023); OECD 442D)

9) Patch test on 10 volunteers

The biocompatibility tests were recorded on test specimen of the referenced product to show compatibility of the material in general. The biocompatibility tests listed are not part of any continuous production protocol. The test assessments reflect only the test specimen and have to be retested on the final product. It remains the responsibility of the de-vice manufacturers and /or end-users to deter-mine the suitability of all printed parts for their respective application.

For notice:

We give no warranties, expressed or implied, concerning the suitability of mentioned pro-duct for use in any medical device and pharmaceutical applications.

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