forward am
a brand of MAM – Mass Additive Manufacturing GmbH

Ultrasint® PA11

Supertough | bio-based | Easy to use

Extended TDS

Complete Technical Documentation and Testing Summary

Version 1.2

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Are you looking for an updated TDS version? Check out the latest online version here.

Technical Data Sheet

Bio-based performance alternative to PA12 with enhanced toughness and ductility, compatible with many SLS machines and coming with USP, skin and food contact statements

General Properties	Method	Typical Values
Appearance	-	Natural white powder
Density (printed part)	DIN EN ISO 1183-1	1.02 g/cm³
Density (Bulk Density)	DIN EN ISO 60	0.52 g/cm³
Mean Particle Size d50	ISO 13320	40-10 µm
Melting Temperature (10 K/min)	ISO 11357	203°C
Crystallization Temperature (10 K/min)	ISO 11357	158°C
Melt Volume Flow Rate (220°C, 2.16kg)	ISO 1133	28 cm³/10min

Tensile Properties	Method	Typical Values X-Direction		Typical Values Z-Direction	
		Dry[1)]	Cond[2)]	Dry[1)]	Cond[2)]
E Modulus	ISO 527-2, 23°C	1750 MPa	1110 MPa	1800 MPa	1250 MPa
Ultimate Tensile Strength	ISO 527-2, 23°C	52 MPa	45 MPa	54 MPa	46 MPa
Elongation at Break	ISO 527-2, 23°C	28%	45%	24%	31%
E Modulus	ISO 527-2, 80°C	370 MPa	300 MPa	420 MPa	360 MPa
Ultimate Tensile Strength	ISO 527-2, 80°C	31 MPa	28 MPa	29 MPa	26 MPa
Elongation at Break	ISO 527-2, 80°C	>150 %	>150 %	51%	54%

The data contained in this publication is based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, this data does not relieve processors from carrying out their own investigations and tests; neither does this data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose.

Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed.

The safety data given in this publication is for informational purposes only and does not constitute a legally binding MSDS. The relevant MSDS can be obtained upon request from your supplier or you may contact Mass Additive Manufacturing GmbH directly at sales@forward-am.com.

Flexural Properties	Method	Typical Values X-Direction		Typical Values Z-Direction	
		Dry[1)]	Cond[2)]	Dry[1)]	Cond[2)]
Flexural Modulus	DIN EN ISO 178	1750 MPa	1250 MPa	1800 MPa	1300 MPa

Impact Properties	Method	Typical Values X-Direction		Typical Values Z-Direction	
		Dry[1)]	Cond[2)]	Dry[1)]	Cond[2)]
Charpy Notched, 23°C	DIN EN ISO 179-1	5.1 kJ/m²	8.3 kJ/m²	3.9 kJ/m²	4.5 kJ/m²
Charpy Unnotched, 23°C	DIN EN ISO 179-1	184 kJ/m²	198 kJ/m²	85 kJ/m²	85 kJ/m²
Izod Notched, 23°C	ISO 180	6.5 kJ/m²	7.7 kJ/m²	4.8 kJ/m²	5.2 kJ/m²
Izod Unnotched, 23°C	ISO 180	No break	No break	54 kJ/m²	86 kJ/m²

Thermal Properties	Method	Typical Values[1)]
HDT/A (1.8 MPa)	ISO 75-2	76°C
HDT/B (0.45 MPa)	ISO 75-2	176°C
Vicat/A (10 N)	DIN EN ISO 306	191°C
Vicat/A (10 N)	DIN EN ISO 306	177°C

Fire, Smoke, Toxicity (FST) properties	Method	Typical Values
Flammability	UL 94	HB (0.8 -3.1mm)

Electrical Properties	Method	Typical Values	
		X-Direction	Z-Direction
Dielectric Strength	IEC 60243-1	31 kV/mm (1 mm)	31 kV/mm (1 mm)
Volume Resistivity	IEC 62631-3-1	$1.2 \cdot 10^{14}$ Ωcm	$1.2 \cdot 10^{14}$ Ωcm
Specific Surface resistivity	IEC 62631-3-2	$>10^{16}$ Ω	$>10^{16}$ Ω

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Biocompatibility	Method	Typical Values
Cytotoxicity - XTT	ISO 10993-5 (2009)	PASS[3)]
In Vivo Sensitization - Local Lymph Node Assay	ISO 10993-10 (2013); OECD Guideline No. 429	PASS[3)]
In Vitro Skin Irritation	OECD Guideline No. 439	PASS[3)]
USP Class VI	-	PASS[4)]

Mechanical properties overview

1) Measured after drying 14 days at 80°C / vacuum. Water content is about 0.05% acc. to DIN EN ISO 15512
2) Measured after conditioning 14 days at 70°C / 62% r.h. Water content is about 0.9% acc. to DIN EN ISO 15512
3) For the statement on Biocompatibility data see Chapter: Biocompatibility.
4) For the statement on USP Biocompatibility data see Chapter: USP Biocompatibility.
5) If not noted otherwise, all specimens are 3D printed. Samples were tested at room temperature, 23°C.

Printing Performance

The combination of 3D printer and material has a huge impact on the quality of the parts produced.

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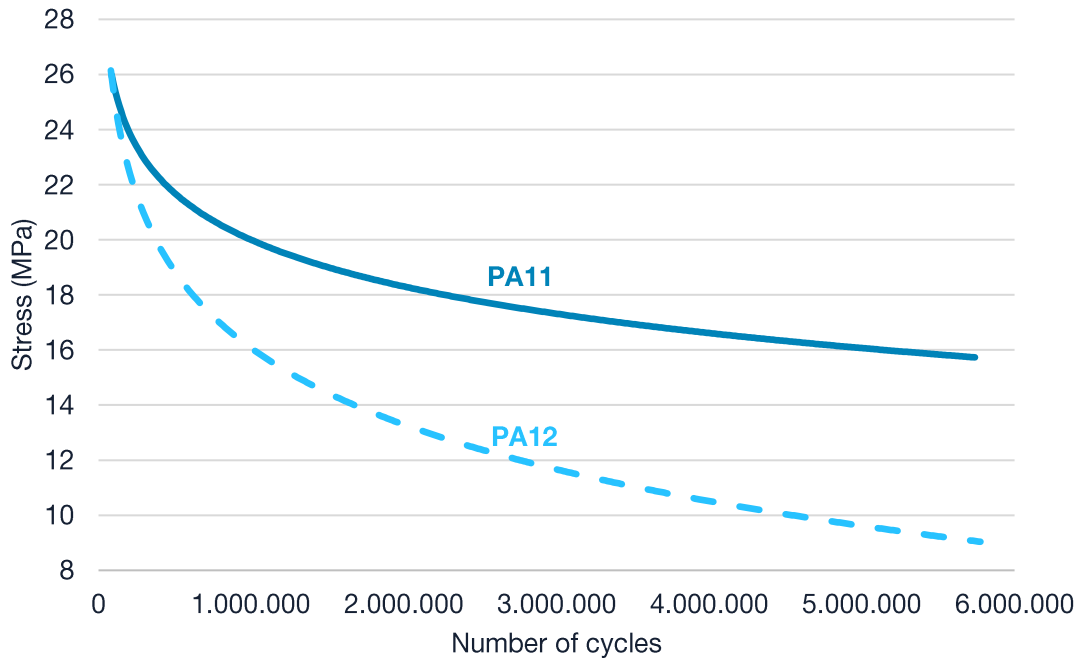
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Fatigue resistance

Fatigue refers to the progressive weakening or failure of a material caused by repeated or fluctuating stresses over time. In polymers, this phenomenon occurs as microscopic cracks accumulate and propagate under cyclic loading, leading to eventual material failure. The rate and extent of fatigue damage depend on factors such as the frequency, magnitude of stress, and environmental conditions.

Understanding fatigue is crucial for industrial applications involving polymer materials, as it directly impacts their performance, longevity, and safety. Components exposed to repetitive forces, such as seals, gaskets, or structural parts, must be engineered to resist fatigue failure to ensure reliability and reduce maintenance costs. Assessing fatigue resistance is vital for selecting appropriate polymers for demanding applications and optimizing material design to extend product lifespan.



Fatigue curve at 23°C and 5 Hz direction Z (ISO 527 1B notched 0.7 mm)

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Industrial Chemical Resistance

In general, Ultrasint® PA11 has good resistance to inorganic salts, alkalis, most solvents, and organic acids. Greater caution must be observed in applications involving inorganic acids, phenols and certain chlorinated solvents. In such cases, please contact MAM technical staff for assessment, specifying the practical problem involved: e.g nature of metal to be protected and the temperature and chemical composition of the liquid

Resistance	20°C	40°C	60°C	90°C
Inorganic bases				
Ammonium hydroxide (concentrated)	G	G	G	G
Ammonia (liquid or gas)	G	G		
Lime-wash	G	G	G	
Potassium hydroxide (50%)	G	L	P	P
Sodium hydroxide (5%)	G	G	L	
Sodium hydroxide (10%)	G	L	L	
Sodium hydroxide (50%)	G	L	P	P
Inorganic acids				
Chromic acid (10%)	P	P	P	P
Hydrochloric acid (1%)	G	L	P	P
Hydrochloric acid (10%)	G	L	P	P
Nitric acid (all concentrations)	P	P	P	P
Phosphoric acid (50%)	G	L	P	P
Sulphuric acid (1%)	G	L	L	P
Sulphuric acid (10%)	G	L	P	P
Sulphuric trioxide	L	P	P	P

Condition after 18 months contact:
G: Good - L: Limited - P: Poor

Resistance	20°C	40°C	60°C	90°C
Inorganic salts				
Alum	G	G	G	
Aluminum sulphate	G	G	G	G
Ammonium nitrate	G	G	G	
Ammonium sulphate	G	G	L	
Chlorides (barium/ calcium /saturated sodium)	G	G	G	G
Calcium arsenate	G	G	G	
Calcium sulphate	G	G	L	
Copper sulphate	G	G	G	G
Diammonium phosphate	G	G	L	
Magnesium chloride (50%)	G	G	G	G
Potassium ferrocyanide	G	G	G	
Potassium nitrate	G[6)]	G[6)]	P	P
Potassium sulphate	G	G	G	G
Sodium carbonate	G	G	L	P
Sodium silicate	G	G	G	
Sodium sulfide	G	L	L	
Trisodium phosphate	G	G	G	G

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing

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Resistance	20°C	40°C	60°C	90°C
Other inorganic products				
Agricultural sprays	G	G		
Bleach solution	L	P	P	P
Bromine / chlorine / fluorine	P	P	P	P
Hydrogen	G	G	G	G
Hydrogen peroxide (20 vol)	G	L	P	P
Mercury	G	G	G	G
Oxygen	G	G	L	P
Ozone	L	P	P	P
Potassium permanganate (5%)	P	P		
Sea water	G	G	G	
Soda water	G	G	G	G
Sulphur	G	G		
Hydrocarbons				
Acetylene	G	G	G	G
Alkanes (methane, propane, butane, hexane)	G	G	G	
Benzene	G	G[7)]	L	
Cyclohexane	G	G	L	
Decalin	G	G	L	
HFA	G			
Naphthalene	G	G	G	L
Styrene / toluene / xylene	G	G[8)]	L	L

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing
7) Yellowing
8) Swelling action

Resistance	20°C	40°C	60°C	90°C
Various products				
Beer, cider, fruit juices, milk, mustard, vinegar, wine	G			
Crude petroleum, high-octane petrol, kerosene (paraffin), normal petrol, solvent naphta, town gas	G	G	G[8)]	
Greases	G	G	G	G
Oils	G	G	G	G
Solutions or emulsions D.D.T. or lindane	G	G		
Hydroxyquinoline (agricultural sprays)	G			
Soap solution	G			
Stearin	G	G	G	
Turpentine	G	G	G[8)]	
Organic acids and anhydrides				
Acetic acid	L	P	P	P
Acetic anhydride	L	P	P	P
Citric acid	G	G	L	P
Formic acid	P	P	P	P
Lactic acid	G	G	G	L
Oleic / stearic acid	G	G	G	L
Oxalic acid	G	G	L	P
Picric acid	L	P	P	P
Tartaric acid (saturated solution)	G	G	G	L
Uric acid	G	G	G	L

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing
7) Yellowing
8) Swelling action

Resistance	20°C	40°C	60°C	90°C
Various organic compounds				
Anethole	G			
Carbon disulfide	G[8)]			
Diacetone alcohol	G	G[8)]	L	
Dimethyl formamide	G	G	L	
Ethylene chlorohydrin	P	P		
Ethylene oxide	G	G	L	P
Furfural	G	G[8)]	L	P
Glucose	G	G	G	G
Tetraethyl lead	G			
Tetrahydrofuran	G	G	L	
Phenols	P	P	P	P
Organic bases				
Aniline (pure)	L	P	P	P
Diethanolamine (20%)	G	G[8)]	G[8)]	L
Pyridine (pure)	L	P	P	P
Urea	G	G	L	L

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing
7) Yellowing
8) Swelling action

Resistance	20°C	40°C	60°C	90°C
Salts, esters, ethers				
Acetate esters (amyl, butyl, methyl)	G	G	G	L
Phosphate esters (dioctyl, tributyl, tricesyl)	G	G	G	L
Diethyl ether	G			
Dioctyl phthalate	G	G	G	L
Fatty acid esters	G	G	G	G
Methyl sulfate	G	L		
Alcohols				
Benzyl alcohol	L	P	P	P
Butanol	G[8)]	L	P	P
Ethanol (pure)	G[8)]	G[8)]	L	
Glycerin (pure)	G	G	L	P
Glycol	G	G	G	P
Methanol (pure)	G[8)]	L	P	
Chlorinated solvents				
Carbon tetrachloride	P	P		
Methyl bromide	G	P		
Methyl chloride	G	P		
Perchloroethylene	G	G	L	
Trichloroethane	L	P		
Trichloroethylene	G	L		

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing
7) Yellowing
8) Swelling action

Resistance	20°C	40°C	60°C	90°C
Aldehydes and ketones				
Aldehydes (acetaldehyde / benzaldehyde / formaldehyde)	G	L	P	
Acetone (pure)	G	G	L	P
Cyclohexanone	G	L	P	
Methylethylketone (MEK) Methyl Isobutyl Ketone (MIBK)	G	G	L	P

Condition after 18 months contact:

G: Good - L: Limited - P: Poor

6) Slight yellowing
7) Yellowing
8) Swelling action

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Long-term UV

Durability is a key feature for components across many industries. The materials used in automotive or consumer applications for instance, must be put through a variety of severe tests to ensure that they can withstand years of exposure to the elements. Plastics are chemically degraded by the effect of UV radiation. The degree of ageing depends on duration and intensity.

Test method and specimens

The UV resistance was examined both for outdoor weathering condition use and indoor use applying conventional accelerated weathering tests as per the Norm ISO 4892-2:2013 Method A and ISO 4892-2:2013 Method B, using ISO 527-2:2012 tensile bars and ISO 179-1for charpy notched.

Cycle No.	UV exposure	Exposure period	Black standard temperature in °C	Chamber temperature in °C	Relative humidity in %
1	Daylight filters	102 min dry 18 min water spray	65 ± 3	38 ± 3	50 ± 10

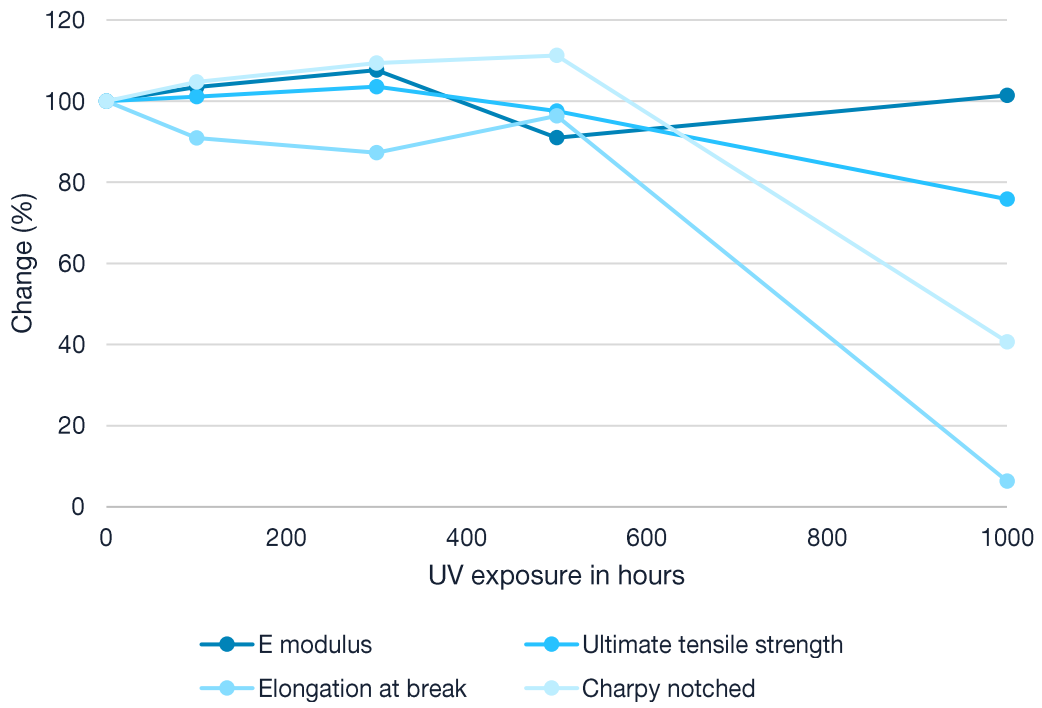
Testing conditions for ISO 4892-2 method A, cycle 1 (Weathering; Example: Outdoor conditions)

Cycle No.	UV exposure	Exposure period	Black standard temperature in °C	Chamber temperature in °C	Relative humidity in %
3	Window glass filters	Continuously dry	100 ± 3	65 ± 3	20 ± 10

Testing conditions for ISO 4892-2 method B, cycle 3 (UV exposure; Example: Car dashboard)

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Mechanical Testing



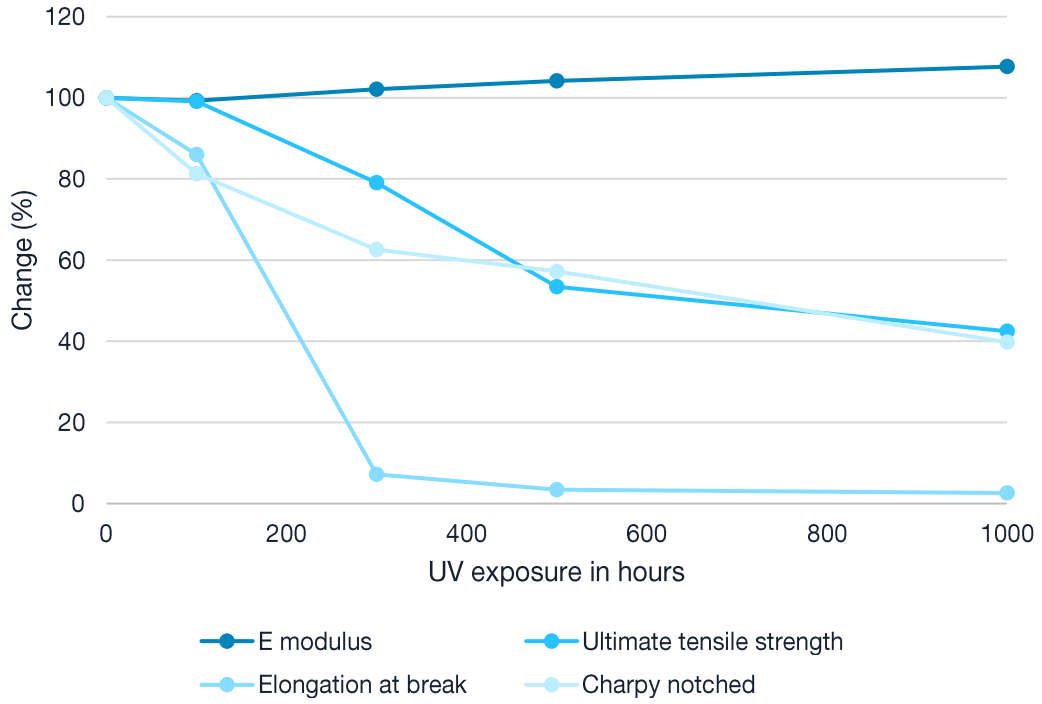
Change in mechanical properties after accelerated weathering (ISO 4892-2 method A)

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
E modulus	1440 MPa	1460 MPa
Ultimate tensile strength	45 MPa	34 MPa
Elongation at break	55%	3.5%
Charpy notched	9.34 kJ/m²	3.8 kJ/m²

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

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Change in mechanical properties after accelerated weathering (ISO 4892-2 method B)

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
E modulus	1430 MPa	1540 MPa
Ultimate tensile strength	45 MPa	19 MPa
Elongation at break	50%	1.3%
Charpy notched	9.4 kJ/m²	3.7 kJ/m²

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

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Flammability

Ultrasint® PA11 does not contain any flame retardants and passes UL94 “HB” rating down to a wall thickness of 0.8 mm.

***** Flame testing *****
Flammability HB acc. to UL 94 : 2021

Information about test procedure and test specimens

M 0 0321			Measurements & observations after application of flame (30 s)					Flame class
Dimensions of test specimens 127 * 12,7 * d mm³			Flame front ceases before 25mm mark	Flame front ceases before 100mm mark	Damaged length beyond 25mm mark [mm]	Burning time beyond 25mm mark [s]	Burning rate [mm/min]	
Requirements	for d < 3 mm		---	---	---	>= 60	<= 75	= HB
	for d >= 3 mm		---	---	---	>= 112,5	<= 40	= HB
Pre-conditioning	Spec. no.	Thickn. [mm]						
Conditioning (2d / 23°C / 50%)	1	0.84	Yes	Yes	0	0	0	HB
	2	0.84	Yes	Yes	0	0	0	HB
	3	0.84	Yes	Yes	0	0	0	HB
Comments			First test	2022-02-04 11:06 - 2022-02-04 11:09				
Conditioning (2d / 23°C / 50%)	1							
	2							
	3							
Comments			Repeated test	-				**HB @0.8mm**

Biocompatibility

Product: Ultrasint® PA11

Revision: 27th of February 2023

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

Cytotoxicity Testing- XTT:

(ISO 10993-5 (2009))

In vitro Skin Irritation Testing – Human Skin Model:

(OECD Guideline No.439)

In vivo Sensitization Testing – Local Lymph Node Assay:

(ISO 10993-10 (2013) OECD Guideline No.429)

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 device manufacturers and /or end-users to determine the suitability of all printed parts for their respective application.

For notice:
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USP Biocompatibility

Product: Ultrasint® PA11

Revision: 21st of June 2024

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

USP Class VI:

(Acute Systemic Injection Test Extracted in Normal Saline, Alcohol in Saline, PEG 400 and Vegetable oil (Cottonseed and Sesame Oil) at 50°C, for 72 hours. Injected in Mouse.)

USP Class VI:

(Intracutaneous Irritation Test Extracted in Normal Saline, Alcohol in Saline, PEG 400 and Vegetable oil (Cottonseed or Sesame oil) at 50°C, for 72 hours. Tested with Rabbit.)

USP Class VI:

(Intramuscular Implantation Test Implanted in Rabbit for 1 week)

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 device manufacturers and /or end-users to determine the suitability of all printed parts for their respective application.

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Food Contact

Product: Ultrasint® PA11

Revision: 19th of September 2024

European Union:

Presuming appropriate processing the product can be used in the countries of the European Community for food contact materials or articles according to article 3 of Regulation (EC) No 1935/2004 (Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27th October 2004 on materials and articles intended to come into contact with food).

Compliance with the provisions of Regulation (EC) No 1935/2004, especially the suitability of the articles for the given application, the effect on smell and taste of the food, and observance of any limitations that are specified, must be ensured by the person who introduces the articles into circulation (see the last paragraph).

The specific restrictions mentioned in Commission Regulation (EU) No 10/2011 most recently amended by Commission Regulation (EU) 2020/1245 of 2 September 2020 have to be ensured.

Substances	FCM Reference	SML
11-aminoundecanoic acid	443	5 mg/kg
1,6-hexamethylene-bis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionamide)	631	45 mg/kg[9)]

9) Fat Reduction Factor is applicable

100% calculation for migration carried out on the above mentioned Product (or a specimen representative of this material) have shown that the specific migration limit was not exceeded for the mentioned Additives:

- 1,6-hexamethylene-bis(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionamide) with 6 dm2 surface and a thickness of 125 µm.
- 11-aminoundecanoic acid with 6 dm2 surface and a thickness of 250 µm.

The aforementioned data shall constitute the agreed contractual quality of the product at the time of passing
of risk. The data are controlled at regular intervals as part of our quality assurance program. Neither these data nor the properties of product specimens shall imply any legally binding guarantee of certain properties or of fitness for a specific purpose. No liability of ours can be derived therefrom.

TÜVRheinland ZERTIFIZIERT
Management System ISO 9001:2015
www.tuv.com ID 9000003927

For notice:
Appropriate conditions have to be applied when processing the product. The suitability of the articles for the application concerned, including their effect on smell and taste of the food, and observance of any given limitations (for example overall migration, specific limits and other analytical requirements) must be tested and ensured in each case by the person who places any finished food contact article on the market. The product is strictly not recommended for any medical or pharmaceutical application. We give no warranties, expressed or implied, concerning the suitability of above-mentioned products for these applications. Formulation disclosure for medical and pharmaceutical applications is not supported All information contained in this document is given in good faith and is based on sources believed to be reliable and accurate at the date of publication of this document. THIS STATEMENT EXPIRES 18 MONTHS AFTER THE DATE OF ISSUE or in case of regulatory changes before such date. Please ask for a new confirmation if needed. It is the responsibility of those to whom we supply our products to ensure that any proprietary rights and existing laws and legislation are observed. The certificate is exclusively for our customers and respective competent authorities. It is not intended for publication either in printed or electronic form (e.g. via Internet) by others. Thus, neither partial nor full publication is allowed without written permission. This product information was generated electronically and is valid without signature.

Aids to Polymerization may be present in the product in accordance with Article 6(4)(b) and Article 19 of Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food most recently amended by Commission Regulation (EU) 2020/1245 of 2 September 2020.

The product complies with the GMP requirements laid down in Regulation (EU) No 2023/2006 on the Good Manufacturing Practices applicable to materials and articles intended to come into contact with foodstuffs.

USA:

We confirm that this product fulfils the requirements on materials used for articles or components of articles intended to come into contact with food as described in Code of Federal Regulations Food and Drugs Title 21- 2017 - §177.1500:
For use only in articles intended for repeated use in contact with food or side-seam cements for articles intended for 1-time use in contact with food and which are in compliance with 21 CFR §175.300.
This product may be used as articles or component of articles used in contact with all food types under Conditions of Use B through H, as described in Table 2 of 21 CFR 176.170(c).

The aforementioned data shall constitute the agreed contractual quality of the product at the time of passing
of risk. The data are controlled at regular intervals as part of our quality assurance program. Neither these data nor the properties of product specimens shall imply any legally binding guarantee of certain properties or of fitness for a specific purpose. No liability of ours can be derived therefrom.

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For notice:
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Bio-Based content statement

Product: Ultrasint® PA11

Revision: 09th of July 2024

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

This is to confirm that the bio-based content of Ultrasint® PA 11 amounts to 100%.

The above-mentioned information has been provided by our raw material suppliers. The bio-based content is of vegetal origin and has been measured according to ASTM D6866-12.

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