EVONIK INDUSTRIES

TROGAMID® CX

Transparent polyamides with an outstanding combination of properties

Evonik. Power to create.

Evonik Industries is the creative industrial group from Germany focused on chemicals, energy and real estate. Evonik is a global leader in specialty chemicals. Together with the Acrylic Monomers and Acrylic Polymers Business Lines, the High Performance Polymers Business Line is part of the Performance Polymers Business Unit, and specializes in customized products and product systems. Our plastics have proven their worth in the automotive, communications and electrical engineering industries, in the engineering, and in medical technology for approximately 40 years. We also have established a presence in the field of optics with our unique transparent polyamide TROGAMID® CX.

Evonik. Power to create.

Content

1 Introduction

Nomenclature

The TROGAMID® product range of the High Performance Polymers Business Line consists of basic products and compounds that are distinguished by their permanent transparency and high chemical resistance. T grades comprise products based on polyamide 6-3-T (PA 6-3-T) only, while BX grades cover PA 6-3-T blends containing other semi-crystalline or amorphous polyamides. Specially designed polyamides are designated as CX grades and are followed by a four-digit number.

This four-digit number has now specific meaning, e.g., viscosity number or composition. The table below provides further information about the nomenclature of the TROGAMID® range according to the commonly used ISO standards.

T grades: PA 6-3-T-based polymers and compounds made of trimethyl hexamethylene diamine and terephthalic acid, e.g., TROGAMID® T5000 or TROGAMID® T-GF35.

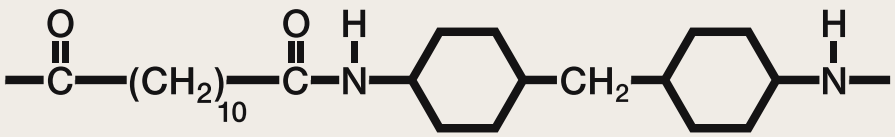
BX grades: PA 6-3-T and semi-crystalline polyamide blends, reinforced and unreinforced, e.g., TROGAMID® BX7304 or TROGAMID® BX9724.

CX grades: Specialty polyamide grades made of other monomers, e.g., TROGAMID® CX7323 or TROGAMID® CX9701

This brochure covers the TROGAMID® CX grades. Two other brochures contain information about the T and BX grades and about handling and processing of TROGAMID products.

Nomenclature of semi-aromatic/aliphatic amorphous polyamides

TROGAMID®	ISO 1043 nomenclature	ISO 1874 nomenclature	Monomers
T grades	PA 6-3-T	PA NDT/INDT	trimethyl hexamethylene diamine terephthalic acid
BX grades	PA 6-3-T/XX	not applicable	trimethyl hexamethylene diamine terephthalic acid
CX grades	not applicable	PA PACM 12	cycloaliphatic diamine dodecanedioic acid



Molecular base of TROGAMID® CX7323

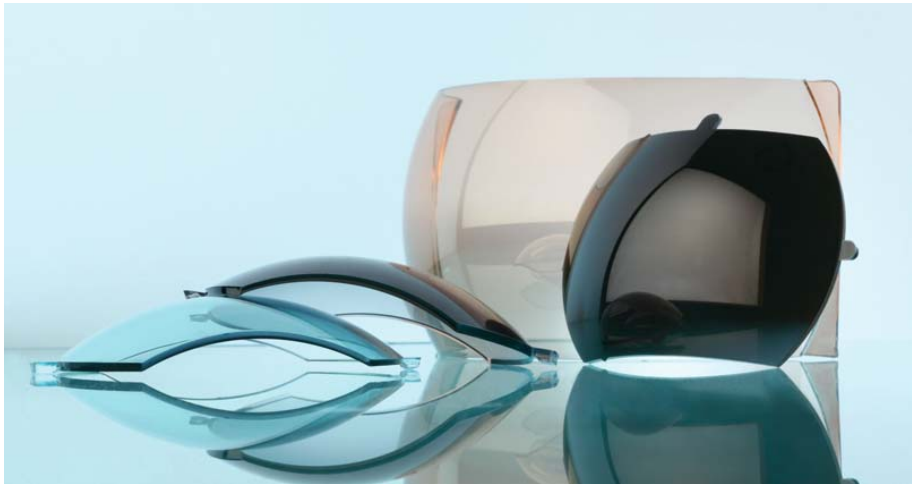
Properties

Common transparent polyamides consist in partially aromatic units that impart rigidity and high heat resistance. Our TROGAMID® T5000 is a typical representative of this group. Replacing aromatic constituents with aliphatic monomers improves the UV stability of transparent polyamides. TROGAMID® CX7323 is an example of this type of polyamides.

By selecting specific monomers, one can achieve a crystallizable and permanently transparent polyamide: TROGAMID® CX. The crystallites are so small that they do not scatter visible light, and the material appears transparent to the human eye—a property known as microcrystallinity. Because of its crystallinity, the microcrystalline structure retains important properties such as stress cracking resistance—without clouding. The degree of crystallinity is so negligible, however, that it has no adverse effect on the shrinkage behavior of molded parts. TROGAMID® CX undergoes a similar isotropic shrinkage like amorphous materials.

TROGAMID® CX combines the chemical resistance of semi-crystalline molding materials with the advantages of amorphous, UV-resistant materials. The outstanding properties of TROGAMID® CX are:

- crystal-clear, permanent transparency, high transmission
- superior chemical and stress cracking resistance
- high level of UV resistance
- low water absorption compared with many other polyamides, which leaves the mechanical properties virtually unaffected
- very balanced mechanical property profile
- high dimensional stability
- high impact resistance, even at low temperatures
- high level of dynamic strength (e.g., for internally pressurized parts)
- abrasion and scratch resistance
- high glass transition temperature
- very low isotropic shrinkage
- easy processing



The combination of good UV resistance, high mechanical strength, permanent transparency, high transmission and superior chemical resistance opens a wide range of applications for TROGAMID® CX. Typical areas of application are in the automotive industry, machinery and engineering, medical technology, the sports and recreation industry, the glasses production, the cosmetics industry and in water treatment and filter technology.

Product overview

The product range of TROGAMID® CX currently comprises the following products:

TROGAMID® CX7323:
Medium-viscous, permanently transparent polyamide for injection molding and extrusion

TROGAMID® CX9701:
High-viscous, permanently transparent polyamide for extrusion, with an external feeding aid

TROGAMID® CX9703:
Medium-viscous, permanently transparent polyamide for injection molding and extrusion, with UV absorber

TROGAMID® CX9704:
Low-viscous, permanently transparent polyamide for injection molding

TROGAMID® CX9710:
Medium-viscous, permanently transparent polyamide for injection molding and extrusion, with an internal mold release agent

Further products, e.g., transparent laser-markable and colored grades, or products for medical applications on request.

Delivery and coloring

Like all our products, the TROGAMID® CX range is manufactured, tested and delivered to our customers in accordance with the quality standard ISO/TS 16949. TROGAMID® CX compounds are normally supplied in their natural color as cylindrical granules in moisture-proof packaging, ready for processing. Special colors can be supplied when specific minimum quantities are ordered. Shelf life at room temperature is almost unlimited. We can also deliver TROGAMID® CX compounds in larger units upon request.

In general, TROGAMID® CX compounds can be colored without problem. The best choice is a coloring agent concentrate based on TROGAMID® CX. Dry coloring with finely dispersed coloring is also possible, but precludes pneumatic extraction. We do not recommend a “neutral” pigment paste, since it can result in incompatibility. The paste has an adverse effect on the mechanical or optical properties (e.g., a decline of the weld line strength or the loss of transparency because of streaking or clouding). Nonetheless, suitability for use should therefore be tested in each case.

More information about our TROGAMID® products and how they may be modified can be obtained from the stated contacts.

2 Mechanical Properties

Mechanical properties of TROGAMID® CX

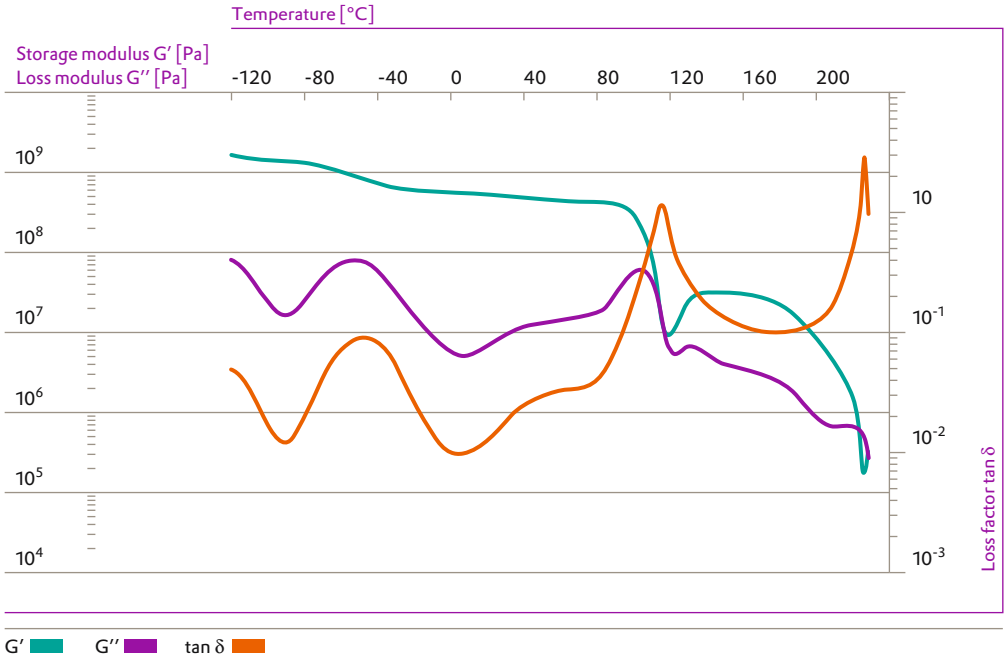
Property		Test method	Unit	TROGAMID® CX7323	CX9701	CX9704	CX9710
Tensile test 23 °C	50 mm/min	ISO 527-1/2					
Stress at yield			MPa	60	60	60	60
Strain at yield			%	8	8	8	8
Nominal strain at break			%	> 50	> 50	> 50	> 50
Tensile test 80 °C	50 mm/min	ISO 527-1/2					
Stress at yield			MPa	60	60	–	60
Strain at yield			%	8	8	–	8
Nominal strain at break			%	> 50	> 50	–	> 50
Tensile modulus	23 °C	ISO 527-1/2	MPa	1400	1500	1400	1400
	80 °C		MPa	1270	1270	–	1270
Tensile creep modulus		ISO 899-1					
	1 h		MPa	1300	1400	–	1400
	1000 h		MPa	700	700	–	700
Flexural test	5 mm/min	ISO 178					
Flexural strength			MPa	90	90	90	90
Flexural strength at 3.5 % strain			MPa	50	50	50	50
Outer fiber strain at maximum stress			%	9	9	> 10	9
Outer fiber strain at break			%	n. r.	n. r.	n. r.	n. r.
Flexural modulus		ISO 178	MPa	1700	1700	1500	1700
CHARPY impact strength		ISO 179/1eU					
	23 °C		kJ/m^2	N	N	N	N
	0 °C		kJ/m^2	N	N	N	N
	-30 °C		kJ/m^2	N	N	N	N
CHARPY notched impact strength		ISO 179/1eA					
	23 °C		kJ/m^2	14 C	16 C	11 C	14 C
	0 °C		kJ/m^2	12 C	15 C	11 C	14 C
	-30 °C		kJ/m^2	11 C	14 C	10 C	13 C
Shore hardness D		ISO 868		81	81	81	81
Ball indentation hardness H30		ISO 2039-1	N/mm^2	110	110	110	110
Dynamical behavior under load (filter cup)		DIN EN 13443-1	Cycles	$> 2 \cdot 10^5$	–	–	–

N = no break, C = complete break; n. r. = not reached

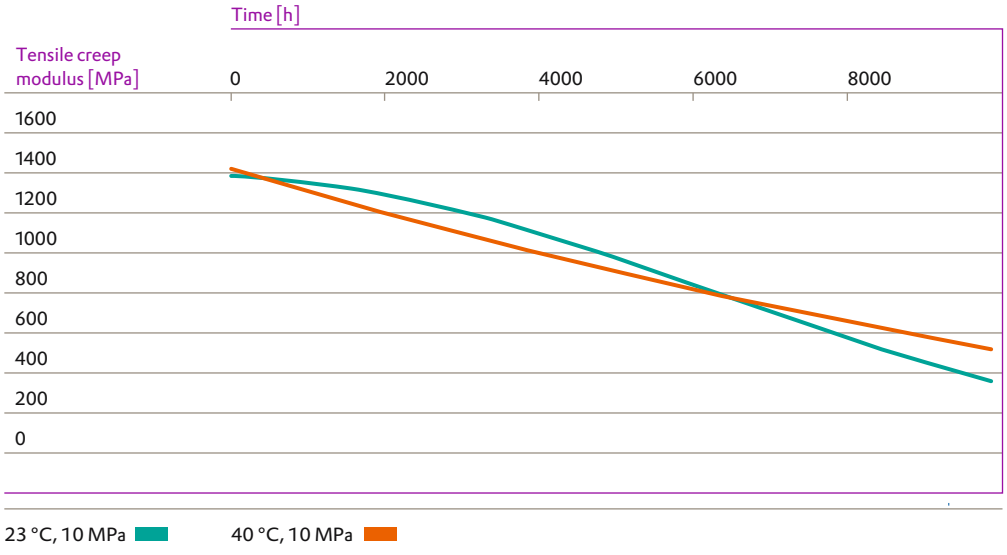
Resistance to internal pressure/dynamic load

Resistance to internal pressure and a high dynamic load are typical demands for parts in water treatment and filter technology. To conform with common safety regulations, the material must withstand internal pressure at least three times the operation pressure. Furthermore, one distinguishes between short-time stress (burst pressure) and dynamic load (number of load cycles). In this area in particular, TROGAMID® CX is the ideal material since it fulfils all the requirements, in short-time stress as well as in the field of dynamic load. In addition, its transparency and its high level of chemical resistance to most oils and greases make TROGAMID® CX exceptionally suitable in this field of application.

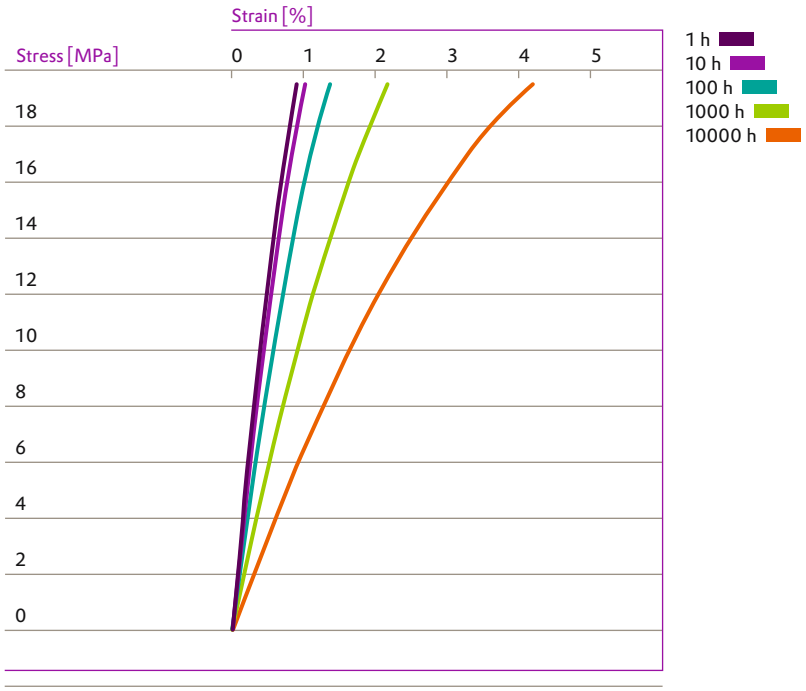
Torsional oscillation analysis of TROGAMID® CX7323



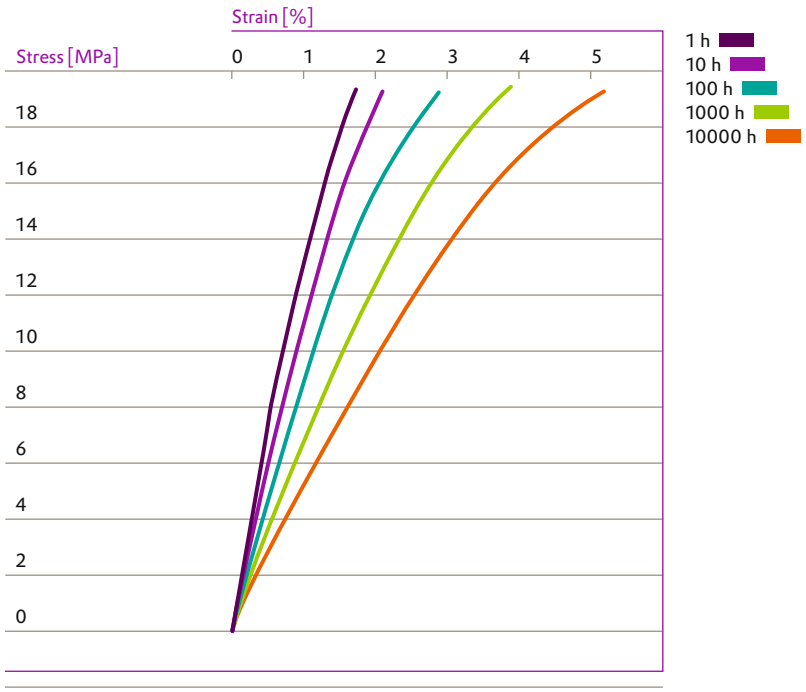
Tensile creep modulus of TROGAMID® CX7323 as a result of the tensile creep test



Isochronous stress/strain plots of TROGAMID® CX7323 at 23 °C



Isochronous stress/strain plots of TROGAMID® CX7323 at 40 °C



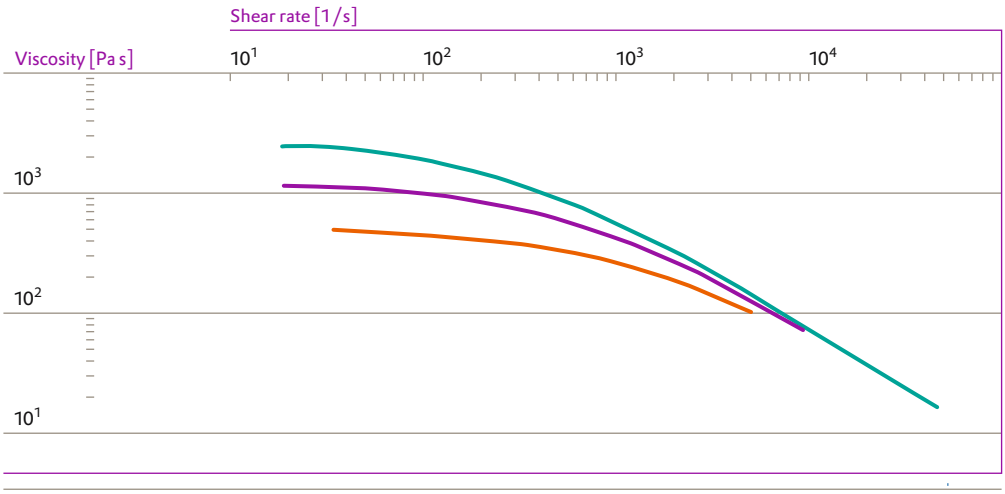
3 Physical, Thermal, and Electrical Properties

Physical, thermal, and electrical properties of TROGAMID® CX

Property		Test method	Unit	TROGAMID® CX7323	CX9701	CX9704	CX9710
Density	23 °C	ISO 1183	g/cm³	1.02	1.02	1.02	1.02
Viscosity number*		ISO 307	cm³/g	160 ± 10	190 ± 10	> 120	> 150
Vicat softening temperature		ISO 306					
Method A	10 N		°C	137	137	132	135
Method B	50 N		°C	130	130	125	130
Temperature of deflection under load		ISO 75-1/2					
Method A	1.8 MPa		°C	108	108	102	108
Method B	0.45 MPa		°C	122	122	120	122
Linear thermal expansion	23 °C - 80 °C	ISO 11359					
	longitudinal		10^{-4} K^{-1}	0.9	0.9	0.9	0.9
	transverse		10^{-4} K^{-1}	0.9	0.9	0.9	0.9
Temperature index (Criterion: stress at yield)		IEC 216	°C	100	100	–	100
Glass transition temperature Tg	10 K/min	ISO 11357	°C	140	140	132	140
Melt temperature DSC, 2nd heating			°C	250	250	–	250
Relative permittivity	23 °C	IEC 60250					
	100 Hz	DIN VDE		3.6	3.6	3.4	3.6
	1 MHz	0303-Part 4		3.2	3.2	3.3	3.2
Dissipation factor	23 °C	IEC 60250					
	100 Hz	DIN VDE	10^{-4}	115	115	130	115
	1 MHz	0303-Part 4	10^{-4}	325	325	215	325
Electric strength	K20/P50	IEC 60243-1	kV/mm	27	27	–	27
Comparative tracking index		IEC 60112					
Test solution A	CTI			600	600	600	600
	100 drops value			575	575	575	575
Glow wire test	Test thickness = 1 mm	IEC 60695-2-12/13					
	GWIT		°C	800	800	825	775
	GWFI		°C	960	960	960	800
Volume reststivity		IEC 60093	Ohm m	10^{14}	10^{14}	10^{13}	10^{14}
Surface resistance R_{OA}		IEC 60093	Ohm	10^{13}	10^{13}	10^{14}	10^{13}
Flammability acc. UL 94		IEC 60695					
	0.8 mm			HB	HB	HB	HB
	1.6 mm			HB	HB	HB	HB

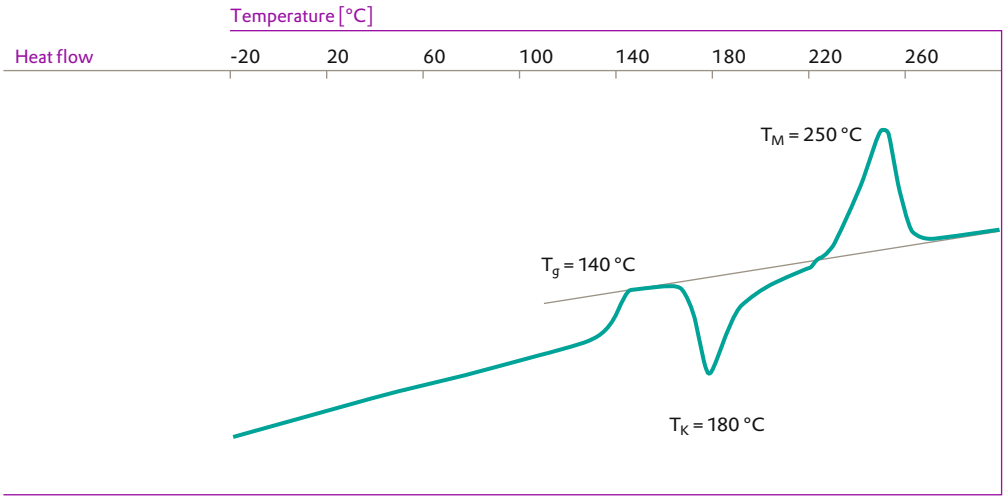
* Further viscosities upon request

Melt viscosity of TROGAMID® CX7323



Results of high pressure capillary rheometer testing at 280 °C 300 °C 320 °C

DSC plot of TROGAMID® CX7323



T_g = glass transition temperature
T_K = peak maximum of recrystallisation temperature
T_M = peak maximum of melt temperature

4 Behavior against Outside Influences

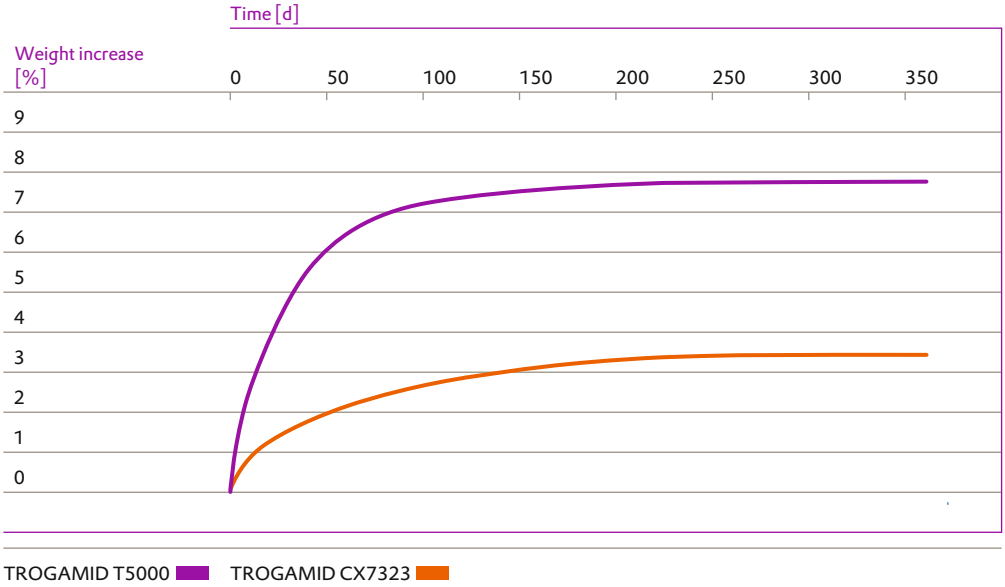
Water absorption and hydrolysis resistance

TROGAMID® CX compounds, like all other polyamides, absorb water. The rate of absorption depends on the temperature and the humidity of the ambient air. Compared to other polyamides, though, water absorption of microcrystalline TROGAMID® CX in a saturated state is very low, equaling of 3.5 % wt.-%. Molded part dimension changes to a maximum of 0.55 % (test specimen 130x12x3mm). The mechanical properties are virtually unaffected by water absorption; indeed, impact strength increases. To determine hydrolysis resistance, the molding material was immersed in boiling water. The relative solution viscosity (η rel) was measured in various intervals, since it permits a direct correlation with the degree of polymerization. After the material was immersed in boiling water for a period of one year, a reduction in solution viscosity of only 6 % was observed. (η rel = 1.63 when t = 0; η rel = 1.53 when t = 360 d).

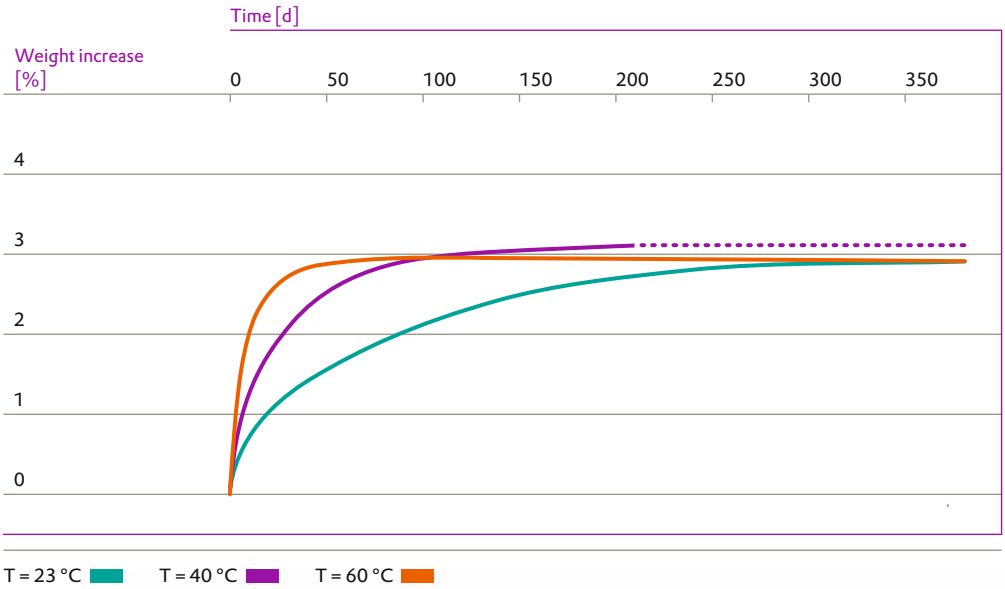
Permeability/water vapor permeability

Property		Test conditions	Unit	TROGAMID® CX7323
Water permeability		23 °C / 85 % rel. humidity, d = 0.108 mm	g / (m^2 24 h)	8.3
Gas permeability		20 °C, d = 0.05 mm	cm^3 / (m^2 24 h bar)	
carbon dioxide	CO_2			2540
oxygen	O_2			740
nitrogen	N_2			85
Permeation coefficient		20 °C, d = 0.05 mm	cm^3 / (cm s bar)	
carbon dioxide	CO_2			$14.2 \cdot 10^{-9}$
oxygen	O_2			$4.3 \cdot 10^{-9}$
nitrogen	N_2			$0.5 \cdot 10^{-9}$

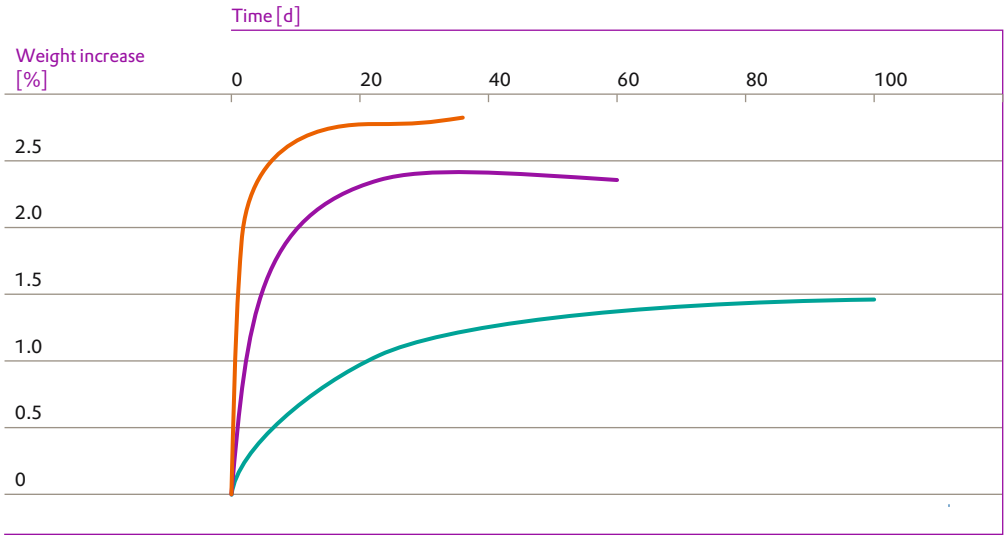
TROGAMID® CX7323 water absorption



TROGAMID® CX7323 water absorption depending on temperature and time

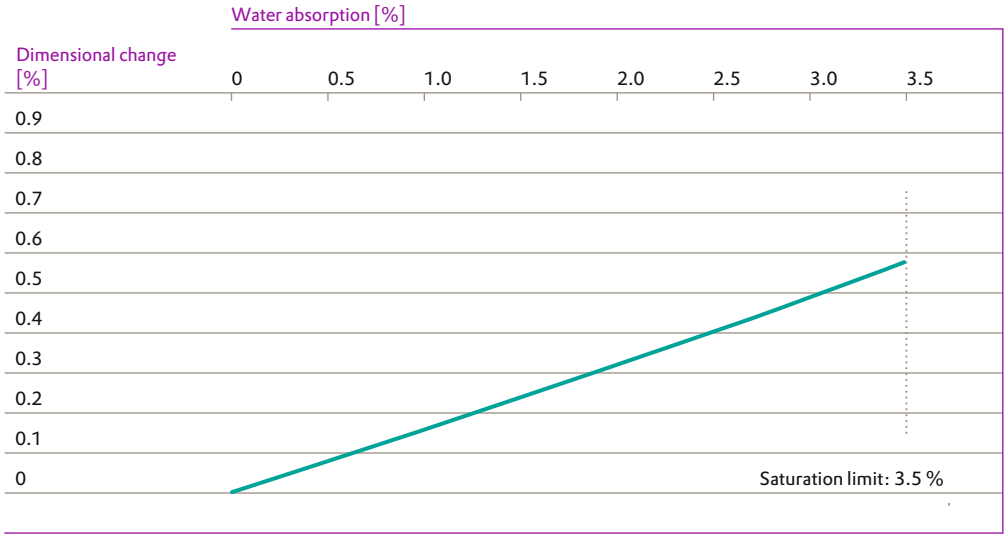


Moisture absorption of moldings from TROGAMID® CX7323



T = 23 °C / 50 % rel. humidity T = 40 °C / 80 % rel. humidity T = 60 °C / 90 % rel. humidity
Test specimen 50 x 50 x 3 mm

Dimensional stability of moldings from TROGAMID® CX7323



Test specimen 130 x 12 x 3 mm

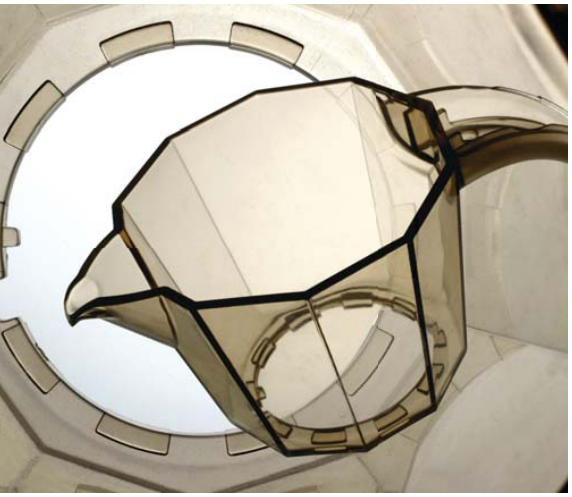
Abrasion and scratch resistance

Since transparent materials like TROGAMID® CX are often used as covers, the demand on abrasion and scratch resistance is, as expected, very high. With a value of 18 mg per 100 revs (DIN 53754), TROGAMID® CX thus outperforms even standard grades of polycarbonate (PC) or polymethyl methacrylate (PMMA). The values given in the following table have been determined using the Taber Abrasion method.

Resistance against ionizing radiation/sterilization

Moldings or semi-finished parts made of TROGAMID® CX are sterilizable in the usual way by gamma radiation or with ethylene oxide. The sterilization with gamma radiation up to 56 kGy does not affect the molecular weight significantly; therefore no change in the overall physical properties is expected.

The sterilization of TROGAMID® CX with water vapor is limited due to the water absorption effect.



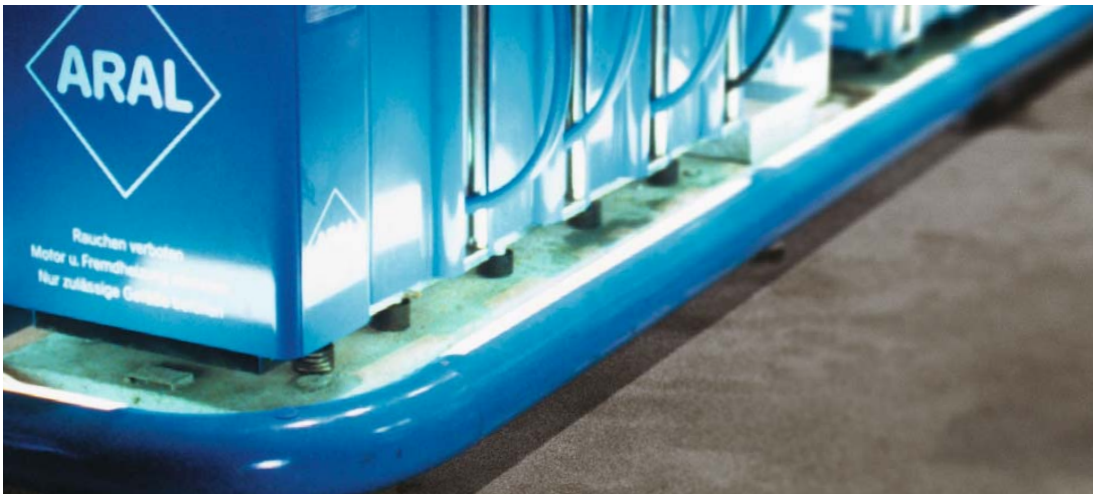
Abrasion and scratch resistance

Property	Test method	Unit	TROGAMID® CX7323	TROGAMID® T5000	PC	PMMA
Abrasion resistance	DIN 53754	mg/100 rev.	18	23	27	66
Scratch resistance	DIN 52347	% turbidity increase	32	28	40	30

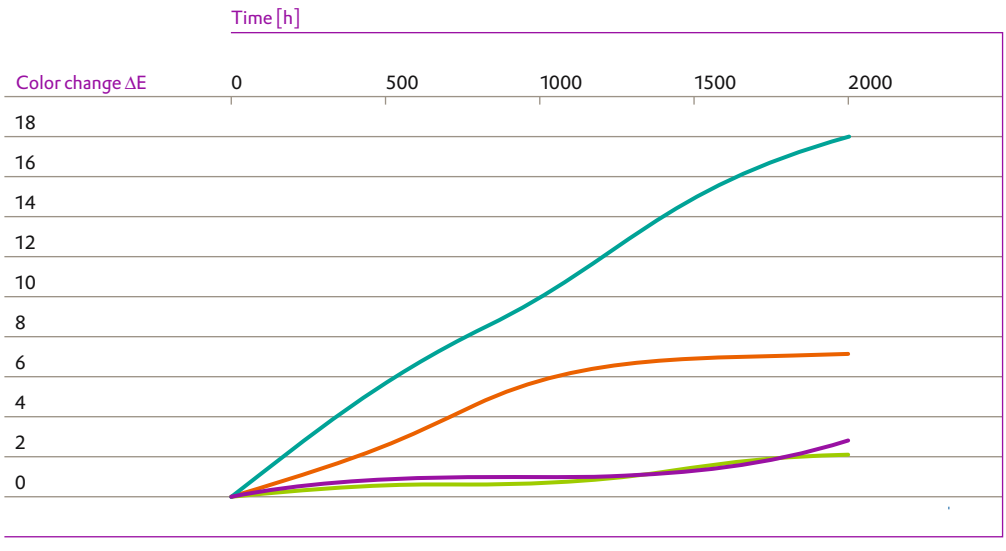
UV radiation and weathering

If any plastic is exposed to short-wave light of wavelengths less than 300 nm, molecular mass diminishes at an increasing rate, leaving moldings or semifinished products brittle. Due to its all aliphatic monomers TROGAMID® CX exhibits a high stability against UV light and weathering. This is also true for its mechanical properties and color (yellowing). The addition of light stabilizers is usually not necessary. As shown in the following figure, the color change of TROGAMID® CX is comparable to values for PMMA.

Natural-colored TROGAMID® CX showed no change in CHARPY impact strength after 2000 hours of radiation (Xenotest Alpha S120). The use of pigments and colorants may have an effect on UV and weathering stability. At any rate, suitability should be tested in each case.



TROGAMID® CX7323 color change ΔE at artificial weathering

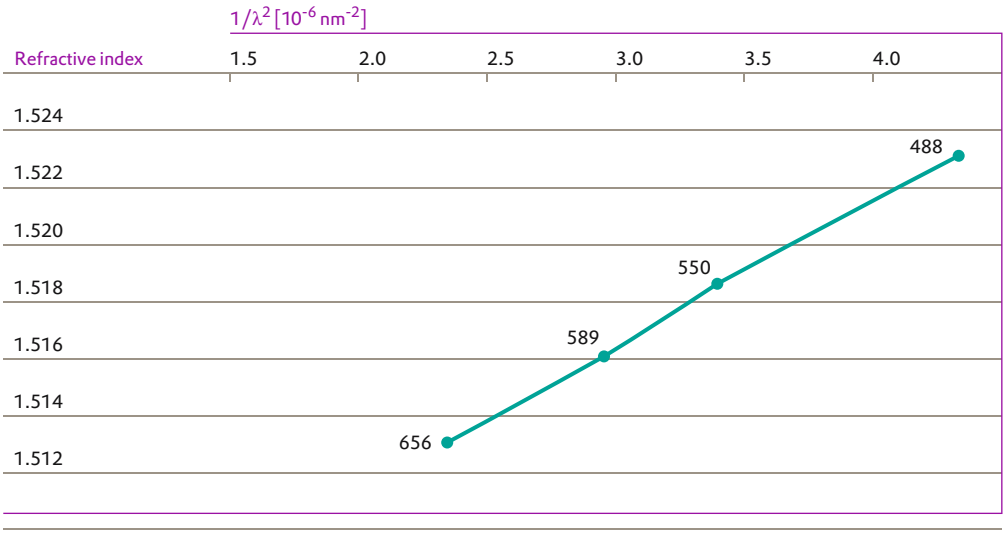


TROGAMID® CX7323 TROGAMID® T5000 PMMA PC
Xenotest Alpha 150 S

5 Optical Properties

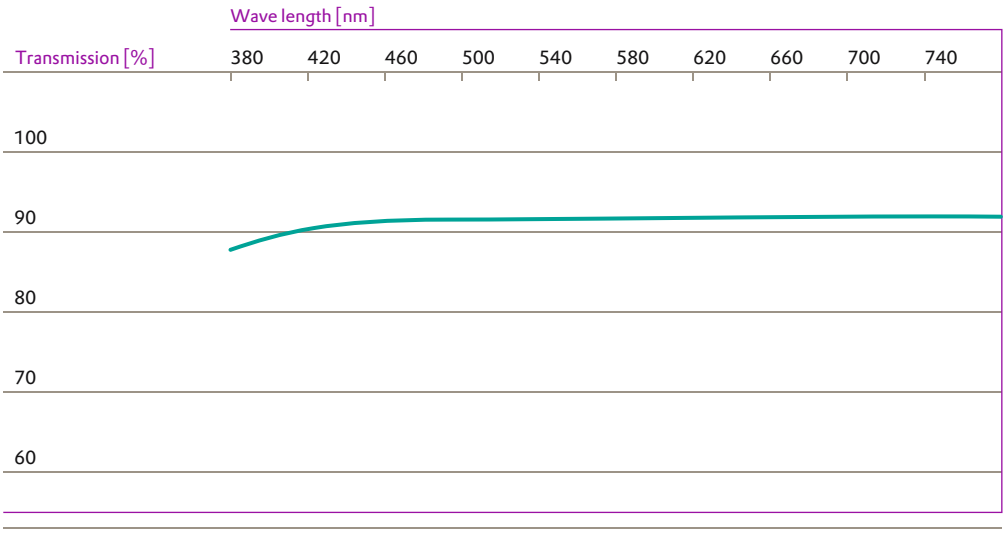
TROGAMID® CX features excellent, permanent, crystal-clear transparency and outstanding optical properties—in spite of it's microcrystallinity. The light transmission in the range of visible light (λ = 400-960 nm) even at a wall thickness of 4 mm is > 85 %. At a wall thickness of 2 mm, TROGAMID® CX7323 has a total transmission (standard illuminant D65/2°) of approximately 92%, which is very close to the transparency of PMMA. Standard illuminant D65 corresponds to daylight. Further information is available in our brochure „TROGAMID® CX—The Outstanding Material for Optics". The refractive index n_D^{20} is 1.516, the average Abbe value 52.

Refractive index of TROGAMID® CX7323



T = 20 °C

Transmission of TROGAMID® CX7323



2 mm plate thickness

6 Chemical Resistance

Effects of various media

The chemical resistance of molded parts made of TROGAMID® CX depends on the internal and external stress levels, the orientation of the part, and changes in the swelling behavior in relation to temperature.

To test the chemical resistance of TROGAMID® CX, we have therefore carried out strip bending tests according to ISO 4599 (DIN 53449/3, bent strip test) in the respective medium. To test strip bending, tensile bars are inserted into a template with radii of different flexural stresses (equivalent to different levels of outer fiber strain). An outer fiber strain of 0 % equals a stress-free stored tensile bar. The test specimen is immersed in the respective medium completely. The use of tensile bars enables tensile tests as well as visual assessment. Unless indicated otherwise, test specimens are stored for 22 hours at 20 °C in the respective medium.

TROGAMID® CX 7323, 9701, and 9710 are resistant to such common influences as moisture, perspiration, ink, lipstick, alkalis or weak acids. Because of the short-term contact of the medium with parts made of TROGAMID® CX, its mechanical properties are typically left unaffected. The high level of chemical resistance makes it possible to use TROGAMID® CX in areas where other transparent materials cannot be used.

In general, it is possible to make the following statements about TROGAMID® CX and its resistance to the different classes of solvents/media:

Hydrocarbons (e.g., benzene, xylene)
Resistance to aliphatic hydrocarbons and aromatic hydrocarbons is generally very good (except grade CX9704). Apart from outer fiber strain, neither stress cracking nor swelling can be observed. Thus, contact with this type of media does not cause any problems.

Halogenated hydrocarbons (e.g., chloroform, carbon tetrachloride, 1,1,1-trichloroethane)
Depending on time and temperature halogenated hydrocarbons affect TROGAMID® CX to a lesser or greater extent. It is difficult to make a general statement, so suitability should therefore be tested in each case.

Alcohols/phenols (methanol, ethanol, isopropanol, cresol, 1,2-propane diol)
Alcohols often cause stress cracking. Especially monovalent alcohols like methanol and ethanol are highly likely to cause stress cracking. The resistance of TROGAMID® CX (except grade CX9704) to these type of chemicals is outstanding. Even to the most aggressive alcohol of all, methanol, the chemical resistance of TROGAMID® CX is superior compared to all other transparent materials. Transparent polyamides are generally limited in their use with polyvalent alcohols like propane diol or cresol; the suitability should therefore be tested in each case.

Oils, greases (lubricant oil, hydraulic oil)
The resistance of TROGAMID® CX to oils and greases is generally good. TROGAMID® CX9704 was not tested. Lubricant oils are less aggressive than hydraulic oils. Due to the large number of oils and greases commonly used in the market, an overall statement is difficult, so suitability should therefore be tested in each case.

Lipids
In medical applications, stress cracks can cause serious complications. Such cracks can be caused by medicinal drugs, disinfectants, fat emulsions or lipids. This is where TROGAMID® CX is far superior to polycarbonate, for example see the following table. A practical examination of the molded part is absolutely necessary.

Stress-crack formation, caused by media used in medical technology, in TROGAMID® CX and polycarbonate

	Number of parts (%)											
	no cracks		few cracks		many cracks		internal cracks		penetrating cracks		destructive cracks	
	CX	PC	CX	PC	CX	PC	CX	PC	CX	PC	CX	PC
Cyclosporin	100	18	0	20	0	14	0	34	0	8	0	6
Lipids	100	22	0	64	0	14	0	0	0	0	0	0
Phenytoin Sodium	100	52	0	12	0	8	0	20	0	2	0	6
Propofol 1 %	100	34	0	32	0	14	0	20	0	0	0	0

CX = TROGAMID® CX7323; PC = Polycarbonate

Solvents for TROGAMID® CX

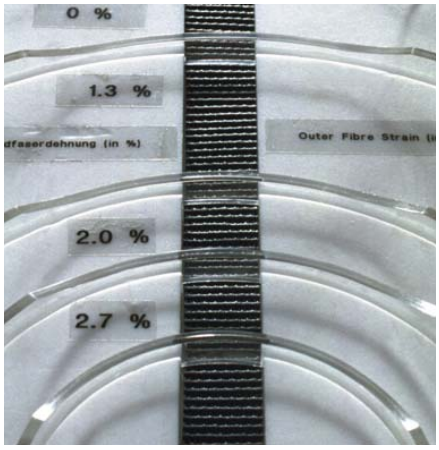
Due to the outstanding chemical resistance of TROGAMID® CX, only a few solvents are known to be usable. M-cresol, sulfuric acid (98 %) and mixtures of phenol/o-dichlorobenzene are among the very few solvents of TROGAMID® CX. In addition, only hexafluoroisopropanol, hexamethylene phosphoric acid triamide, and trifluoroethanol are able to dissolve TROGAMID® CX. We would like to emphasize that the later chemicals are either strong acids or toxic, and thus safety should be practiced at all times.

Accelerated testing

For accelerated testing, some granules or a molded part should be dipped into the solvent/chemical in question and kept submerged over night. After the material is dried, a visual inspection is the only way to reach a definite assessment.

In practice, the behavior of molded parts has a marked effect on the resistance of TROGAMID® CX. The data given in the following table should be understood as a reference, how molded parts of TROGAMID® CX will react under practical conditions. Compatibility should therefore be tested in each case before TROGAMID® CX is used. It can best be achieved under circumstances as close to the later conditions of use as possible.

Not all substances that we have tested so far have been included in the following table; if you need more information on the resistance of TROGAMID® CX to other media, please contact the indicated persons.



Chemical resistance of TROGAMID® CX7323, 9701, and 9710

Medium	Test temperature/ time	Outer fiber strain 0 %	1.10 %	1.89 %	2.61 %
Acetone	20 °C / 22 h	+	+	-	-
Benzene	20 °C / 22 h	+	+	+	+
Break Free (lubricating oil)	20 °C / 22 h	+	+	+	+
Carbon tetrachloride	20 °C / 22 h	+	-	-	-
Chloroform	20 °C / 22 h	(1)	(1)	(1)	(1)
Cresol	20 °C / 22 h	(2)	(2)	(2)	(2)
	70 °C / 22 h	(2)	(2)	(2)	(2)
Dichloromethane	20 °C / 22 h	(1)	(1)	(1)	(1)
Diesel fuel	20 °C / 22 h	+	+	+	+
Econa PG32 (Hydraulic fluid)	20 °C / 22 h	+	+	-	-
Ethanol	20 °C / 22 h	+	+	+	(3)
Ethyl acetate	20 °C / 22 h	+	+	+	-
Eucalyptus oil	20 °C / 22 h	+	+	+	+
Formaldehyde solution/formalin (37 w/w-%)	20 °C / 22 h	+	+	+	+
Glycerol	20 °C / 22 h	+	+	+	+
Heating oil	20 °C / 22 h	+	+	+	+
Isopropanol	20 °C / 22 h	+	+	+	+
Methanol	20 °C / 22 h	+	+	+	(3)
	50 °C / 30 min.	+	+	+	+
Mountain pine oil	20 °C / 22 h	+	+	+	+
Petroleum ether	20 °C / 22 h	+	+	+	+
Potassium hydroxide (25 w/w-%)	20 °C / 22 h	+	+	+	+
	70 °C / 22 h	+	+	+	+
Potassium hydroxide (50 w/w-%)	20 °C / 22 h	+	+	+	+
	70 °C / 22 h	+	+	+	+
Premium gasoline	20 °C / 22 h	+	+	+	+
1,2-propane diol	20 °C / 22 h	+	+	-	-
Regular gas	20 °C / 22 h	+	+	+	+
Sulfuric acid (98 w/w-%)	20 °C / 22 h	(2)	(2)	(2)	(2)
	70 °C / 22 h	(2)	(2)	(2)	(2)
Test fuel (M15)	20 °C / 22 h	+	+	+	+
Toluene	20 °C / 22 h	+	+	+	+
1,1,1-trichloroethane	20 °C / 22 h	+	-	-	-
Xylene	20 °C / 22 h	+	+	+	+

Supplementary data for the listed chemicals:

+ = Resistant, no stress cracks detected
– = Not resistant, stress cracks detected

(1) = Swells, softens
(2) = Dissolves
(3) = Surface turns cloudy

7 Registrations and Listings

The Environment, Health, Safety & Quality department, whose domain includes the High Performance Polymers Business Line, provides general information on the toxicological properties of TROGAMID® CX compounds and all evaluations dealing with the compound's contact with foodstuffs. This department is also responsible for providing information on product safety and for compiling EC Safety Data Sheets for TROGAMID® CX. Please direct all questions on the subject to the indicated contacts.

Food contact—EU-status
Uniform regulations for plastics that come into contact with foodstuffs exist at the European level. The consolidated EU Directive 2002/72/EC and its amendments apply. The grades TROGAMID® CX7323, TROGAMID® CX9704 and TROGAMID® CX9710 are approved for direct food contact in the European Union because they are based on monomers that are listed favorably in this directive. It is necessary to observe restrictive migration limits on the finished article.

Concernig additives, a binding statement about the status of our TROGAMID® CX resins is available on request.

Drinking water contact
Substances that come into contact with drinking water must satisfy the various national regulations that govern both the finished product and to some extent the material from which it was made. In Germany, the applicable regulations are the KTW recommendations and the guidelines of the Federal Environmental Agency (Umweltbundesamt).

Since the above grades TROGAMID® CX7323, TROGAMID® CX9704 and TROGAMID® CX9710 are approved under EU food regulations, they may be recommended as materials for drinking-water contact. They satisfy the requirements of the plastics-drinking water (KTW) tests, although these tests have in general not been performed on our raw materials but on the finished products. The KTW test certificate is an important component of the DVGW certificate (German Association for Gas and Water, DVGW), because it covers the health requirement. Only DVGW-certified components may be installed into the drinking water distribution system.

Medical applications
TROGAMID® CX7323 and TROGAMID® CX9710 are certified according to USP Class VI, the highest classification of the United States Pharmacopeia (requirements in conformity with ISO 10993). They are therefore suitable for the manufacture of medical products.

8 Laser-Marking of Transparent Plastics

Laser-marking of transparent plastics has so far been restricted to colored thermoplastics; selective coupling in of the laser energy was not formerly possible in transparent plastics. The problem could be solved by the use of suitable additives or pigments, but at the cost of transparency and colorlessness.

Laser-marking by NIR-absorbers

Evonik's technicians have now overcome these difficulties and have succeeded in extending the process also to transparent polymers. This uses nanoscale metal oxides, which, on account of their small particle size, do not scatter visible light but absorb the wavelength of the laser in the near infrared (NIR) region. Because the Nd:YAG laser (1064 nm) is most commonly used in practice, the additives have been formulated for the wavelength of this laser.

The skill in the incorporation of the metal oxides lies in controlling their tendency to agglomeration and dispersing them as homogeneously as possible in the polymer matrix. Only under these conditions can high-contrast markings with the highest resolution and contour sharpness be obtained.

These infrared absorbers are dispersed in TROGAMID® CX, new compounding processes being used for this purpose. If a laser beam now falls on the metal oxides, they absorb the energy and heat their immediate environment, which results in foaming by formation of gaseous degradation products in the micrometer region or carbonization (degradation to carbon). The result is a locally confined change of refractive index, rendering the marking, such as an inscription, visible. The additives do not produce a color change, but appear in a shade of gray ranging from white to black, depending on the polymer and the choice of laser parameters. Markings can be obtained with layer thicknesses of less than 100 micrometers. Multilayer designs are also possible in which the laser-sensitive layer is embedded between two transparent covering layers.

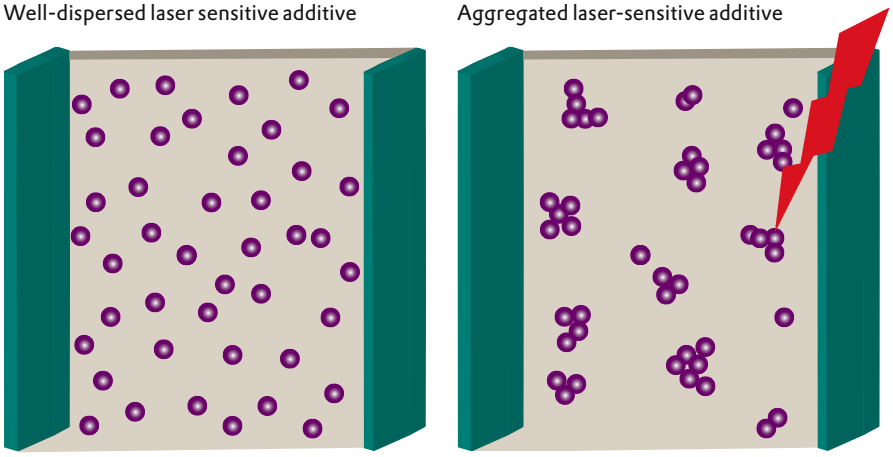


Figure: Dispersion of NIR-absorber

Use of nanoscale NIR absorbers in transparent polymers such as TROGAMID® CX for laser-marking or subsurface engraving

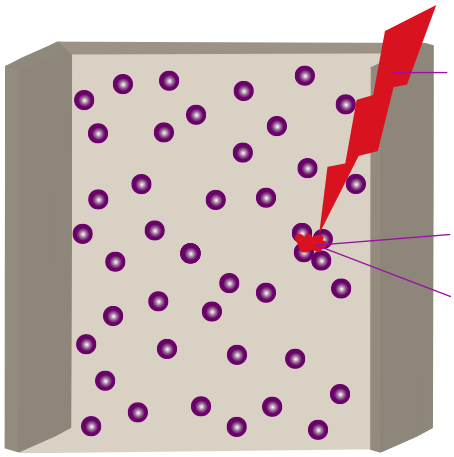


Figure: Mechanism of laser-marking and sub-surface engraving by NIR absorbers

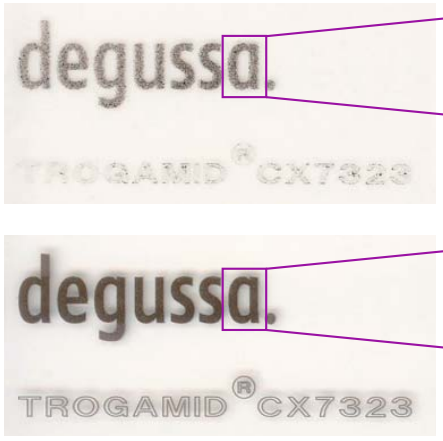


Figure: 2D laser-marking of TROGAMID® CX

Application fields

The possible fields of application of this new technology for laser-marking transparent plastics are many and varied. Because the marking is forgery-proof and highly durable, it is suitable for, e.g., identity cards, barcodes, and pharmaceutical packaging. Medical technology could also benefit from this contactless process because, in contrast to other marking processes such as printing or milling, there are no impurities and no contamination with chemical compounds or abrasion particles. Entirely different fields of application, such as personalized art objects or inscriptions for office doors, are also conceivable. Also the possibility of engraving high-resolution 3D motifs in components exists. It has the potential for improving the visual aesthetics of transparent plastics, as in architectural applications.

9 Ecology and Safety

TROGAMID® resins are non-hazardous substances that are not governed by any particular safety regulations. TROGAMID® CX resins are classified under Water Hazard Class 0. They can be disposed of in landfills or incinerated as normal household waste in accordance with local ordinances. Further information can be obtained from the TROGAMID® CX material safety data sheets that we send upon request. Recycling is, however, preferred and advisable for economic reasons. How reclaimed materials affect the functional properties of a molded part has to be judged in each individual case. Further information about the use of regrind can be obtained from the indicated contacts.

No dangerous by-products are formed if TROGAMID® CX is processed correctly. Care should be taken, however, to ventilate the working area properly.

TROGAMID® resins contain no halogenated flame retardants, e.g., brominated biphenyls or diphenylethers. No pigments or additives containing cadmium are used.

If the melt is discolored or black specks appear, this is a sign that the material has degraded during processing. Degraded material should be removed quickly from the machine and cooled under water to minimize any offensive odors or fumes. At higher temperatures, most TROGAMID® CX resins will burn. At melt temperatures between 360 °C and 370 °C, flammable gases are released. Combustion with a sufficient supply of air produces carbon monoxide, carbon dioxide, water, and nitrogen containing compounds as end products. Since the crack and combustion spectrum depends to a great extend on the combustion conditions, it is not possible to make any general statement here.

10 CAE Data, Campus® Material Database

Our philosophy is to sell high perfomance polymers and solutions that satisfy the requirements of our customers. The use of CAE methods significantly reduces development risks. Changes at an early stage of development are a fraction of what the costs could be at later stages or during series production. Take advantage of our overall application advice, which includes CAE methods for each type of high performance polymers. Please contact our Technical Marketing department if you are considering building a new component or tool, or are having difficulties with existing tools.

CAE data of TROGAMID® CX

Property	Unit	TROGAMID® CX7323	TROGAMID® CX9710
Density of melt	g/cm³	0.90	0.90
Specific heat capacity	J kg^{-1} K^{-1}	2490	2500
Heat conductivity in the melt	W m^{-1} K^{-1}	0.25	0.28
Carreau-WLF values			
K1		559.3	250.6
K2		0.001870	0.005889
K3		0.7486	0.9137
K4		300	295
K5		176.3	150.5
Transition temperature	°C	132	193
Ejection temperature	°C	120	120

Campus® material database

Plastic suppliers and processors have been acquainted with our Campus® database for a long time. It contains important information on plastic raw materials available from Evonik. From a given specific profile it is possible to pre-select materials suitable to your application from a multitude of grades. The properties of the thermoplastic raw material are based on ISO-Standard and, therefore are interchangeable.

You can download Campus® from the web at: www.evonik.com.

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