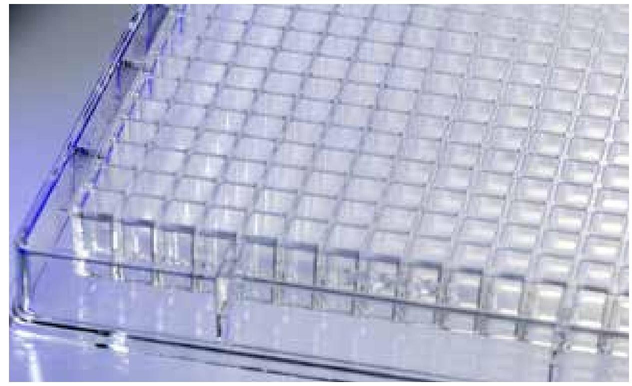
TOPAS
Advanced Polymers

TOPAS® COC
Cyclic Olefin Copolymer

Cyclic Olefin Copolymer



Important:

Properties of molded parts, sheets and films can be influenced by a wide variety of factors involving material selection, further additives, part design, processing conditions and environmental exposure. It is the obligation of the customer to determinewhether a particular material and part design is suit-able for a particular application. The customer is responsible for evaluating the performance of all parts containing plastics prior to their commercialization.Our products are not intended for use in medical ordental implants. – Unless provided otherwise, values shown merely serve as an orientation; such values alone do not represent a sufficient basis for any part design. – Our processing and other instructions must be followed. We do not hereby promise or guarantee specific properties of our products. Any existing industrial property rights must be observed.

Published in September 2019

Contents

Cyclic Olefin Copolymer

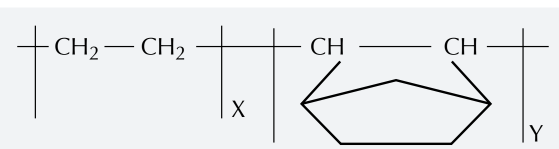
Effective January 1, 2006, the global COC business has been sold from Ticona/Celanese to the Japanese companies Daicel and Polyplastics and transfered into a new entity with the name TOPAS Advanced Polymers. The new company is located in Frankfurt/ Germany and Florence/USA and has about 100 people working in Research & Development, Marketing & Sales, Production and Administration.

The History of TOPAS® COC started in the early 90s at corporate research of Hoechst AG. In a new developed process first Norbornene will be synthesized from Dicyclopentadiene and Ethylene. In a second copolymerisation step with Etylene using Metallocene-Catalysts the final product Cyclic Olefin Copolymer is generated. The TOPAS® COC production plant in Oberhausen/ Germany went on stream in year 2000 with an annual capacity of 30,000 tons.

Topas Advanced Polymers is producing and marketing cyclic olefin copolymers under its trademarks TOPAS® COC and Crystal Dew® and a bi-cyclic olefin Norbornene.

1. Introduction

TOPAS® COC is the trade name for Topas Advanced Polymers' cyclic olefin copolymers (COC). The TOPAS® COC family, in contrast to the partially crystalline polyolefins PE and PP, consists of amorphous, transparent copolymers based on cyclic olefins and linear olefins.



Cyclic olefin copolymers are a new class of polymeric materials with property profiles which can be varied over a wide range during polymerization.

These new materials exhibit a unique combination of properties of which can be customized by varying the chemical structure of the copolymer. Performance benefits include:

- Low density
- High transparency
- Low birefringence
- Extremely low water absorption
- Excellent water vapour barrier properties
- Variable heat deflection temperature up to 170 °C
- High rigidity, strength and hardness
- Very good blood compatibility
- Excellent biocompatibility
- Very good resistance to acids and alkalis
- Very good electrical insulating properties
- Very good melt processability/flowability

TOPAS® COC resins are suitable for the production of transparent moldings for use in optical data storage, optics, e.g. lenses, sensors, and industrial products e. g. in the construction and lighting sectors.

These materials are also of particular interest for primary packaging of pharmaceuticals, medical devices and diagnostic disposables.

(Co)-extruded films made from TOPAS® COC offer opportunities in blister packaging, shrink sleeves, shrink films and stand-up pouches.

New applications have been developed for blends of TOPAS® COC, with a variety of polyolefins.

2. Grades, supply form, colors

TOPAS® COC resin is currently supplied as an unreinforced water-clear transparent material. Glass-filled, tinted and pigmented formulations are also under development.

Currently available basic grades differ primarily in their heat deflection temperature HDT/B. The heat deflection temperature is determined by the ratio of the comonomers. TOPAS® COC grades with higher cyclo-olefin content have higher heat resistance. Flow characteristics may be adjusted independently of heat resistance.

The product nomenclature contains a 4 digit number. The first two digits indicate the viscosity number, the last two digits describe the heat deflection temperature HDT/B. The flowability decreases with increasing viscosity number.

The table on the right lists the TOPAS® COC basic grades. Of these grades, specific sub-grades are avail-able on request, which are particularly well suited for optical, medical and diagnostic applications, for extrusion and injection blow molded applications.

Grade	Description
8007	Clear grade with a heat deflection temperature HDT/B of 75 °C. It is especially suited for packaging of moisture-sensitive products because of its low water absorption and very good barrier properties. Grade 8007 has a lower elastic modulus and higher elongation than other TOPAS® COC grades.
5013	Clear grade with a heat deflection temper-ature HDT/B of 130 °C. This grade is char-acterized by high flowability and excellent optical properties. Recommended for applications such as optical parts, e. g. lenses, and optical storage media, where low birefringence and high molding accuracy (pit replication) are essential, as well as for medical and diagnostic applications.
6013	Clear grade with a heat deflection temperature HDT/B of 130 °C, a value which cannot be attained by many amorphous polymers. Its combination of high purity, chemical resistance, high transparency and high HDT/B makes this material useful for prod-ucts such as labware. Parts made from 6013 can be gamma- and steam-sterilized.
6015	Clear grade similar to 6013, with a heat deflection temperature HDT/B of 150 °C, a value which cannot be attained by many amorphous polymers.
6017	Clear grade with a heat deflection temper-ature HDT/B of 170 °C. For parts requiring resistance to short-term, high-temperature exposure.

3. Physical properties

The physical property values of TOPAS® COC are given in Table 1 below. Most of the properties were determined by standard test methods, as indicated in the table.

Although the typical values shown in Table 1, determined on development specimens by various standard test methods, are guide values and can be used as a basis for comparing different materials, in-service testing, using finished molded parts, is recommended. Also, mold shrinkage should be evaluated in proto-type parts.

3.1 Mechanical properties

TOPAS® COC resin is a clear thermoplastic resin with high strength, rigidity and, depending on the grade, heat deflection temperature. Because of its amorphous character, these properties are retained over a wide temperature range, from -50 °C to near the glass transition temperature. Fig. 1 shows shear modulus curves, which are particularly useful in characterizing the temperature-dependent behaviour of a plastic.

3.1.1 Behaviour under short-term stress

The behaviour of materials under short-term stress can be evaluated by the tensile test according to ISO 527. This test enables yield stress, tensile strength and elongation at break to be determined. Fig. 2 shows the stress-strain curves for TOPAS® COC grades. Note that grades 5013, 6013, 6015 and 6017 display similar behaviour.

Fig. 1: Shear modulus curves determined by DIN 53445 for various TOPAS® COC grades as a function of temperature

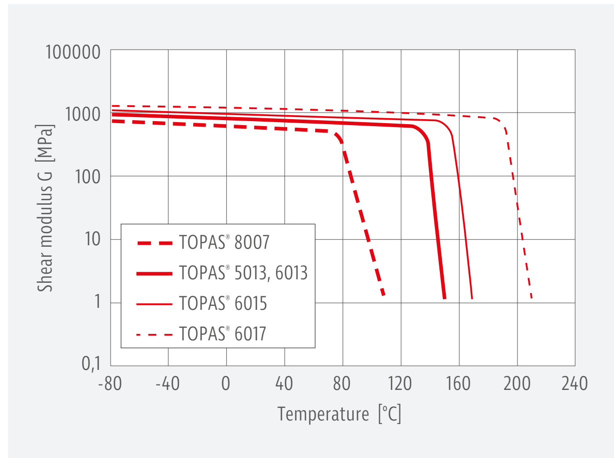


Fig. 2: Stress-strain curves according to ISO 527 for TOPAS® COC resins

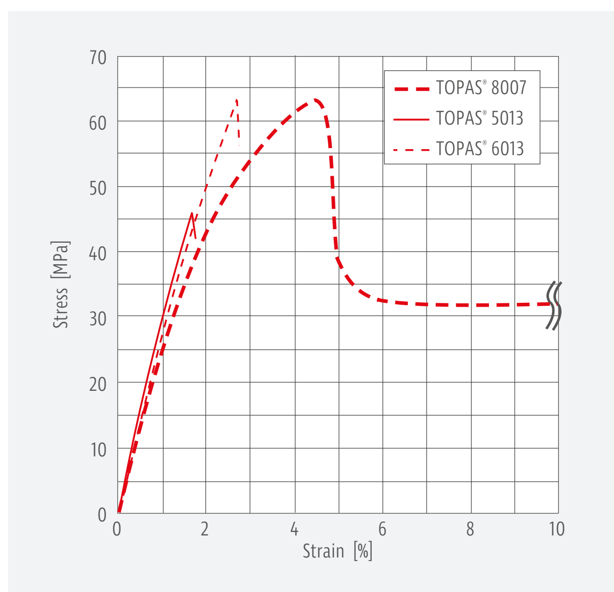


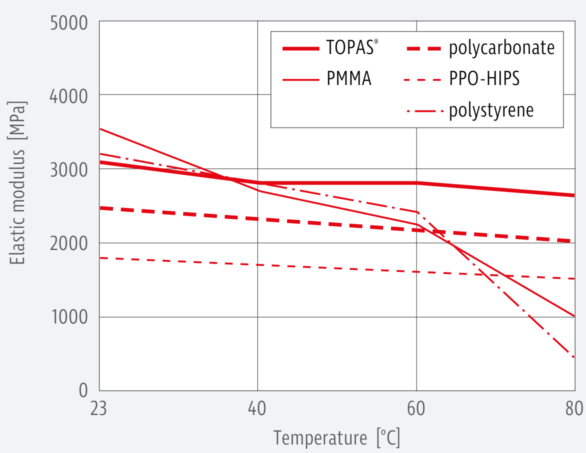
Table 1: Physical properties of TOPAS® COC

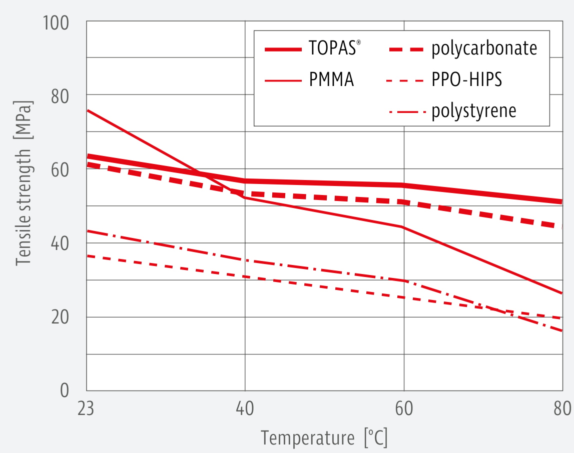
Property	Unit	Test method	8007	6013	6015	5013	6017
Volume flow index MVR at 260 °C, 2.16 kg	ml/10 min	ISO 1133	32	14	4	48	1.5
Volume flow index MVR at HDT +115 °C, 2.16 kg	ml/10 min	ISO 1133	2	6	5	24	5
Density	g/cm^3	ISO 1183	1.02	1.02	1.02	1.02	1.02
Water absorption (24 h immersion in water at 23 °C)	%	ISO 62	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Water vapour permeability (at 23 °C and 85% relative humidity)	$g \cdot mm / m^2 \cdot d$	DIN 53 122	0.023	0.035	0.035	0.030	0.045
Mold shrinkage (ϑ_W = 60 °C, 2 mm wall thickness)	%	–	0.1 - 0.5	0.4 - 0.7	0.4 - 0.7	0.4 - 0.7	0.4 - 0.7
Mechanical properties, measured under standard conditions, ISO 291 – 23/50							
Tensile strength [5 mm/min]	MPa	ISO 527 parts 1 and 2	63	63	60	46	58
Elongation at break [5 mm/min]	%	ISO 527, parts 1 and 2	10*)	2.7	2.5	1.7	2.4
Tensile modulus [1 mm/min]	MPa	ISO 527, parts 1 and 2	2600	2900	3000	3200	3000
Impact strength (Charpy)	kJ/m^2	ISO 179/1eU	20	15	15	13	15
Notched impact strength (Charpy)	kJ/m^2	ISO 179/1eA	2.6	1.8	1.6	1.6	1.6
Ball indentation hardness, 30-sec value	N/mm^2	ISO 2039 part 1, applied load 961N	130	184	184	184	191
Thermal properties							
Heat deflection temperature HDT/B (0.45 MPa)	°C	ISO 75 parts 1 and 2	75	130	150	130	170
Coefficient of linear thermal expansion	K^{-1}	ISO 11 359 parts 1 and 2	$0.7 \cdot 10^{-4}$	$0.6 \cdot 10^{-4}$	$0.6 \cdot 10^{-4}$	$0.6 \cdot 10^{-4}$	$0.6 \cdot 10^{-4}$
Electrical properties							
Relative permittivity ε_r at 1-10 kHz	–	IEC 60250	2.35	2.35	2.35	2.35	2.35
Comparative tracking index CTI	–	IEC 60112	> 600	> 600	> 600	> 600	> 600
Volume resistivity	$\Omega \cdot m$	IEC 60093	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
Flammability							
UL Flammability Rating	Class	UL 94	HB (1.6mm)	HB (1.6mm)	HB (1.6mm)	HB (1.6mm)	HB (1.6mm)
Optical properties							
Light transmission (2 mm wall thickness)	%	ISO 13468-2	91	91	91	91	91
Refractive index	–	–	–	–	–	1.53	–
Abbe number	–	–		–	–	56	–

*) Yield strain: 4.5%

Cyclic Olefin Copolymer

Fig. 3 and 4: Effect of temperature on the elastic modulus and tensile strength of TOPAS® COC resin compared with other transparent amorphous thermoplastics. This is valid with good approximation for grades 5013, 6013, 6015 and 6017





Figures 3 and 4 show the effect of temperature on the elastic modulus and tensile strength of TOPAS® COC resins compared with other transparent amorphous thermoplastics.

3.1.2 Behaviour under long-term stress

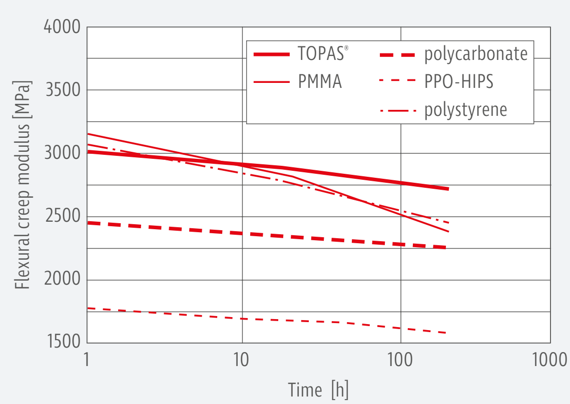
The results of long-term tests carried out under various conditions provide the design engineer with a basis for calculation when designing components subjected to prolonged stress. The behaviour of plastics under long-term tensile stress is tested by two basis methods:

- **Creep rupture test according to DIN 53 444**
- **Stress relaxation test according to DIN 53 441 (stress decay in specimen held under constant strain).**

The results are plotted as creep curves, creep modulus curves, time-stress curves and isochronous stress-strain curves. The graphs show initial results offering a preliminary guide to behaviour.

Fig. 5 shows the flexural creep modulus of TOPAS® COC grades (valid with good approximation for grades 5013, 6013, 6015 and 6017) compared with selected other transparent resins. Note the modulus level and low creep tendency of TOPAS® COC polymers in comparison with the other polymers shown.

Fig. 5: Flexural creep modulus over time for TOPAS® COC polymer grades and other polymers as a function of time



3.2 Thermal properties

The outstanding feature of this new class of polymer materials is the ability to vary its glass transition temperature. The TOPAS® COC development product line covers a wide range of glass transition temperatures from about 80 °C to 180 °C or, expressed in terms of the more meaningful heat deflection temperature under load, a HDT/B range of 75 °C to about 170 °C. The permissible service temperature for short-term heat stress comes close to the glass transition temperature.

The high transparency of the material remains unaffected by temperature. However, the maximum permissible service temperature should be assessed for the specific grade and stress conditions that the molded part will encounter in actual service. Values determined by standard test methods are designed to serve only as a general guide.

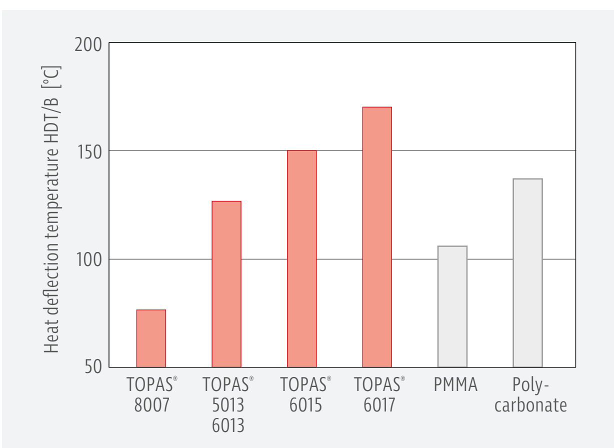
Thermal conductivity

The thermal conductivity of the TOPAS® COC grades at 20 °C varies between 0.12 to 0.15 W/m · K (dependent on grade). The thermal conductivity value is temperature dependent.

Coefficien fo linear thermal expansion

The coefficient of linear thermal expansion is about
a = 0.6 · 10^{-4}/°C.

Fig. 6: Heat deflection temperature HDT/B of TOPAS® COC and other amorphous polymers



3.3. Electrical properties

TOPAS® COC has very good electrical insulating properties and a low dissipation factor. It is therefore suit-able for use as an insulating material, particularly at higher end of its temperature capabilities. The dielectric constant of TOPAS® COC is around 2.35, which is typical of the values obtained with olefinic materials (Fig. 7). It stays constant in the high frequency area up to 20 GHz. The very low temperature dependence of the dielectric constant and dissipation factor is shown by measurements on biaxially oriented film (Fig. 8). At 10 kHz and 100 °C, a value of 0.2 · 10—4 was determined.

Volume resistivity

The volume resistivity of all TOPAS® COC grades at
23 °C rD > 10^{14} V · m.

Surface resistivity

Surface resistivity gives an indication of the insulation resistance across the surface of a material. The dependence of this value on humidity and surface contamination must be taken into account. The surface resistivity of all grades TOPAS® COC is > 10^{14} V.

CTI value

The comparative tracking index for TOPAS® COC polymer is
CTI > 600 V.

Fig. 7: Effect of temperature on the dielectric constant of various polymers

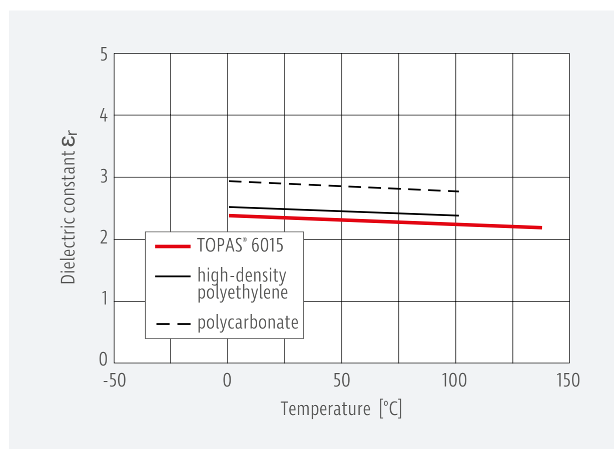
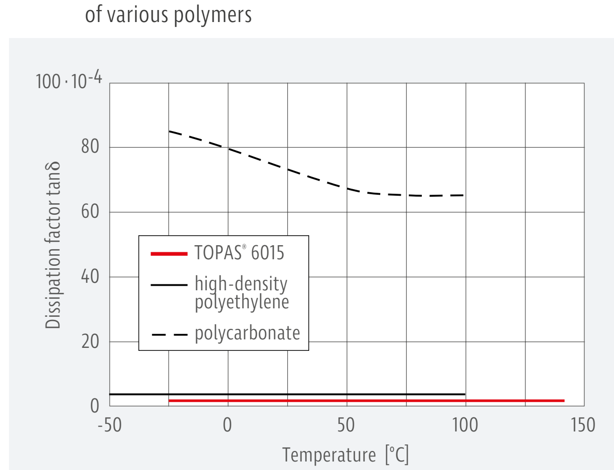


Fig. 8: Effect of temperature on the dissipation factor tand of various polymers



3.4. Optical properties

Transmission and refractive index

Light transmission in the visible region is an important optical property for optical applications such as lenses, prisms or optical storage media but is not the only important optical property. The high transparency of TOPAS® COC in the visible and near ultraviolet regions coupled with a refractive index of 1.53 (TOPAS® 5013) makes the polymer attractive for optical components. The chromatic aberration of TOPAS® COC, evidenced by a high Abbe number of 56 for TOPAS® 5013, is very low. TOPAS® COC is, therefore, suitable for the production of high-quality optical components for cameras and office machines.

Stress-optical constant and birefringence

Optical birefringence is a critical factor which must be controlled in a range of applications; from optical storage media and lenses to films.

Because of its aliphatic structure and the low optical anisotropy associated with this type of structure, TOPAS® COC has inherently low birefringence. This material property is accompanied by a low stress-optical constant. Fig. 10 shows the effect of applied tensile strength on the birefringence of various plastics. The following table shows that the stress-optical constant of TOPAS® COC is in the same range as that for PMMA but only around one tenth of the value for PC.

The advantageous optical properties of TOPAS® COC resin, combined with its very low moisture absorption, high elastic modulus and the possibility of tailoring flow make it especially suitable even for very thin optical parts. Very good molding accuracy (replication) is attained.

Fig. 9: Light transmission of TOPAS® 6015 as a function of wavelength

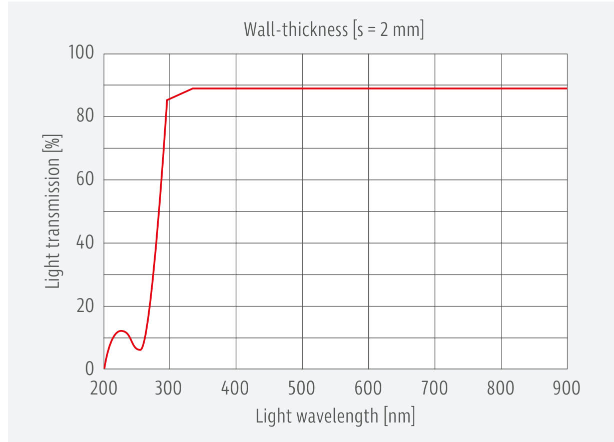
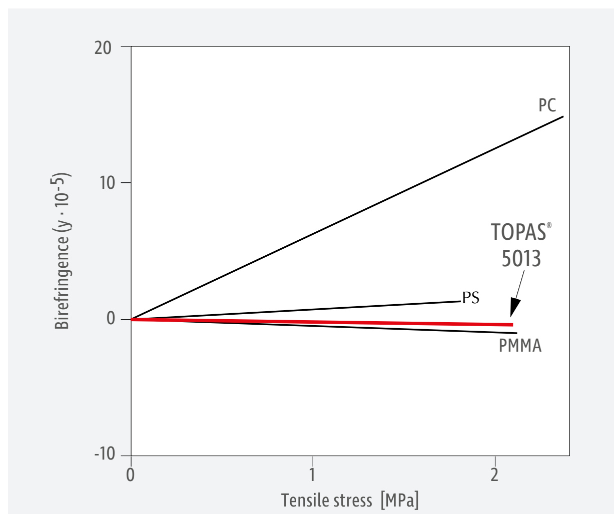


Fig. 10: Stress birefringence of various plastics (birefringence as a function of tensile stress)



Stress-optical constant C

MATERIAL	C [10^{-6} mm²/N]
TOPAS® COC	-2 to -7
PMMA[1])	-4.5 to -4.8
PS[1])	4 to 7
PC[2])	66 to 70

1) Kunststoff Handbuch vol. 1, published by B. Carlowitz, Hanser Verlag München 1990, page 779.

2) M.-J. Brekner, "Polymers in Information Storage Technology" pub-lished by K. L. Mittal, Plenum Press, New York 1989, page 199.

4. Effect of service environment on properties of TOPAS® COC

This section describes the effects on the properties of TOPAS® COC by:

- Air at elevated temperature
- Water
- Motor fuels
- Chemicals
- Weathering
- High-energy radiation
- Flammability

4.1 Behaviour in air and water at elevated temperatures

Air

Most grades are stabilized against thermooxidative degradation to ensure that both the melt, during processing, and finished parts, in service, can withstand heat stresses. Progressive deterioration in properties through heat ageing is influenced in various ways by many service condition factors. Terms such as "heat resistance" and "continuous service temperature" do not, therefore, describe material constants but should be regarded only in the context of particular application requirements.

However, molded parts made from TOPAS® COC remain dimensionally stable almost to the glass transition temperature of the particular grade on short-term exposure to high-temperature stresses.

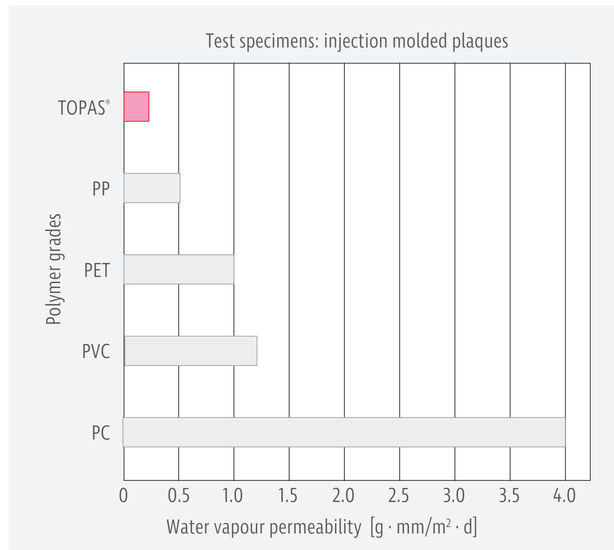
Water

TOPAS® COC is water-repellent (hydrophobic) and therefore exhibits only negligible swelling when immersed in water. Changes in the relative humidity of the environment have virtually no effect on material properties. The very slight water uptake that can be measured when there is a change of temperature in a warm, humid atmosphere mainly results from traces of moisture on the surface. If this situation is encountered the pellets need to be dried before molding.

Water absorption after immersion for 24 h/23 °C is 0.01 %; after immersion in demineralized water for 28 days/80 °C, it is 0.11 %. The water absorption of PC is about four times greater and that of PMMA about 10 times greater under identical conditions.

TOPAS® COC has excellent water vapour barrier properties (fig. 11).

Fig. 11: Water vapour permeability of various polymers (measured at 40 °C/90 % RH)



4.2 Chemical resistance

Because of their olefinic character, all TOPAS® COC grades are resistant to hydrolysis, acids and alkalis, as well as to polar solvents such as methanol. However, TOPAS® COC is attacked by non-polar organic solvents such as toluene and naphtha. Decisions to use COC resins in the presence of certain chemicals should always be made with knowledge of the requirement profile, and in cases where suitability is in doubt, resistance should always be confirmed by end-use testing.

The resistance of TOPAS® COC to selected chemicals tested at room temperatures is shown in Table 2.

Table 2: Chemical resistance of TOPAS® COC

Medium	
Soap solution	+
Hydrochloric acid 36%	+
Sulphuric acid 40%	+
Acetic acid > 99%	+
Nitric acid 65%	+
Caustic soda solution 50%	+
Ammonia solution 33%	+
Methanol	+
Ethanol	+
Isopropanol	+
Acetone	+
Butanone	+
Benzaldehyde	o
Methylene chloride	–
n-Pentane	–
Heptane	–
Toluene	–
Hexane	–
Naphtha	–
Oleic acid	–

Assessment is based on the following criteria:

+ resistant	o limited resistance	– not resistant
weight increase < 3 % or weight loss < 0.5 %	weight increase 3 to 8 % or weight loss 0.5 to 5 %	weight increase > 8 % or weight loss > 5 %
elongation at break not substantially altered	elongation at break reduced by < 50 %	elongation at break reduced by > 50 %

4.3 Stress cracking resistance

The combined action of certain media with internal molded-in stresses and, in some cases, with imposed mechanical stresses, can result in chemically induced stress cracking in moldings made from TOPAS® COC resins. Temperature, duration of exposure to the medium and the level of internal and external stresses in the molded part all have an influence on stress crack initiation. Vegetable and animal fats and continuous contact with hot water, for example, can initiate stress cracking. It is therefore essential to carry out end-use tests to assess the suitability of a molded part for the specific service conditions.

Experience with injection molded parts has shown that resistance to stress cracking may be improved by the following measures:

- Processing with the highest possible melt temperature
- Filling the mold cavity rapidly
- Correct adjustment of in-mold residence time and pressure
- Carefully designed mold cooling system.

Parts can be designed to minimize stress cracking by:

- Avoiding large wall thickness variations
- Radiusing corners and edges
- Avoiding stress concentration peaks (notches).

4.4 Light and weathering resistance

Like most plastics, TOPAS® COC resin undergoes little or no change when exposed to radiation in the visible light region. However, prolonged exposure to direct sunlight can have an adverse effect on the properties of TOPAS® COC due to ultraviolet rays. For parts likely to be exposed to outdoor weathering, UV-stabilized grades are under development.

Table 3

TOPAS® COC	Hot steam			ETO	High-energy radiation	
	121 °C	134 °C	143 °C		gamma	electron
8007	–	–	–	+	+	+
5013	+	–	–	+	+	+
6013	+	–	–	+	+	+
6015	+	+	+	+	+	+

The data presented herein show the typical effects of sterilization procedures on the nominal physical properties, using standardized test specimens. The actual sterility of the parts have not been evaluated for either single or multiple use applications. It is the responsibility of the medical device manufacturer to determine the necessary steps to ensure the safe and efficacious use of their products and to obtain the necessary regulatory approvals for the intended applications.

5. Food packaging, medical and diagnostic

TOPAS® COC exhibits a unique combination of properties – glass-clear transparency, superior water vapour barrier, low water absorption and good chemical resistance to aqueous media, acids and alkalis and to polar organics. Thus, together with their excellent biocompatibility, these materials are of particular interest for primary packaging of pharmaceuticals, medical devices and diagnostic disposables.

5.1 Sterilizability

The use of plastics in the pharma and diagnostics sector in many cases requires sterilizability of the plastic material.
The effect of various sterilization methods, using high energy radiation (gamma and electron beam), ETO, hot air and hot steam, has been investigated for TOPAS® COC . Standard test specimens were subjected to conditions simulating one time exposure. Table 3 summarizes the results of these testings. TOPAS® COC should not be used in applications requiring more than one or two sterilization cycles.
TOPAS® COC test specimens maintain mechanical properties after exposure to gamma radiation doses of 50 kGy. Like many other plastics, TOPAS® COC shows a dose-dependent discoloration after exposure to gamma radiation. Grades with improved color stability in gamma irradiation can be requested.

5.2 Biocompatibility

Criteria for the use of plastics in the pharma and diagnostics sector are specified in the national pharmacopoeias (US, EU and JP), and by the appropriate regulatory agencies. Material test program guidelines are given by the FDA, and the International Organization for Standardization (ISO 10993). The test program depends on the particular application and the duration of contact with the human body.

TOPAS® COC material biocompatibility testing was carried out according to guidelines given in the FDA Blue Book Memorandum, and by the International Organization for Standardization (ISO 10993). A range of TOPAS® COC grades were subjected to this material biocompatibility test program. The protocol included the following: Acute Systemic and Intra-cutaneous Toxicity, Muscle Implantation, Physico-Chemical tests, Blood Compatibility (Hemolysis), and Cytotoxicity. These grades meet the specification of US Pharmacopoeia XXIII – Class VI. Corresponding certificates for specific grades are available.
Chemical characterization and extraction tests have been carried out successfully according to the protocols described in the US, EU and Japanese Pharmacopoeia.
These tests are intended as a general screening of the materials. The information discussed here should only be used as a starting point for the package/device manufacturer's consideration of the protocol to be used for testing specifically to the particular application. The presentation of these results is thus not intended to replace the testing required of the manufacturer of the package or device. Nor should it be considered a recommendation of the material for any particular application. It is the package/device manufacturer's responsibility to ensure that the materials used for a particular application are suitable for the intended use.
TOPAS® COC products are not be used in any kind of implants in the human body.

5.3 Regulatory

Approval for use in food contacting applications has been obtained. The monomers used for manu-facturing the material are listed in the EU directives 90/128/EEC, 92/39/EEC, 93/9/EEC, 95/3/EEC, 96/11/EEC, 99/91/EEC and 2002/72/EC.
Effective May 20, 2004 the FDA is amending the food additive regulations to allow for the safe use of norbornene-ethylene copolymers for dry food applications. The FDA regulation number is 21 CFR 177.1520.
In the USA, a Drug Master File (number 12132) and a Device Master File (number 1043) have been established for TOPAS® COC.

6. Processing

TOPAS® COC can be processed by all commonly used methods for thermoplastics such as injection molding, extrusion (film, sheet and profile), blow molding and injection blow molding.

6.1 Safety and health information

Before starting the injection molding process, obtain and read the appropriate Material Safety Data Sheet (MSDS) for detailed safety and health information.

Use process controls, work practices, and protective measures described in the MSDS sheets to control workplace exposure to dust, volatiles, etc..

6.2 Injection molding

6.2.1 Machine requirements

TOPAS® COC can be processed on conventional injection molding machines. The plasticizing cylinders can be fitted with standard screws. Three – section screws with a compression ratio 1:2.3 should be preferred.

Drying

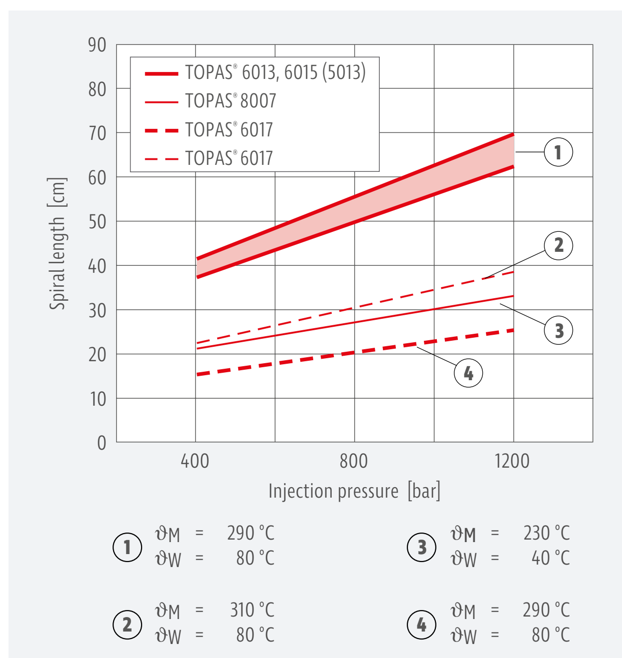
Special pretreatment (drying prior to molding) generally is not necessary. TOPAS® COC that has become moist as a result of unsuitable storage conditions must be dried in a dehumidifying oven at 80 °C to remove surface moisture. For special applications imposing high surface quality requirements, TOPAS® COC should be predried in a dehumidifying oven at temperatures of > 100 °C for a period of 4-6 hours. Grade 8007 should be dried at lower temperatures (max. 60 °C) because of its lower glass transition temperature.

6.2.2 Flow behaviour

The melt index is commonly employed to characterize the flow behaviour of TOPAS® COC grades under processing conditions. However, a more practical method of determining flow behaviour is the non-standardized spiral flow test. The spiral length measured in this test provides a meaningful guide to flowability. Figure 12 shows the spiral length of the TOPAS® COC grades for a wall thickness of s = 2 mm under different processing conditions.

However it is important to note that the rheological properties of any thermoplastic material are strongly influenced by processing parameters such as injection pressure, injection speed, melt and mold temperature and on mold design (and machine operating data).

Fig. 12: Spiral flow length of TOPAS® COC grades with different glass transition temperatures as a function of pressure (2 mm-thick test spiral). The processing parameters (qM5 melt temperature, qW5 mold wall temperature) were matched to the glass transition temperature of the TOPAS® COC grades



6.2.3 Gate and mold design

The suitability of a plastic molding for a particular application is basically determined by the following factors:

- Properties of the molding material
- Processing of the molding material
- Design of the molded part and mold.

Only optimization of all three factors will ensure a high-quality molded part. This requires close cooperation between the material manufacturer, designer and end user.

The type of gate and its location are determined by various factors such as:

- Wall thickness
- Flow path
- Flow direction
- Weld lines
- Sink marks, etc.

The size of the gate depends on the wall thickness of the molded part. If the gate is too large, cooling time and hence cycle time may be unacceptably long.An undersized gate may cause premature freeze-off or may cause excessive shear heating of the melt.

With submarine and pinpoint gates, no finishing is required. Submarine gates must be matched as closely as possible to the deformation behaviour of the TOPAS® COC resin, which is a hard, rigid material. They are in effect like undercuts and can obstruct part removal from the mold.

6.2.4 Range of processing conditions

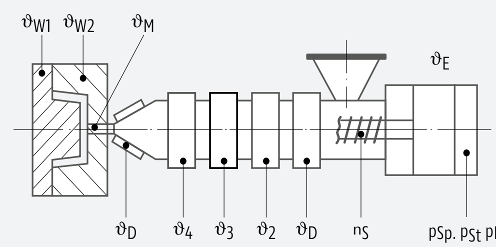
The melt temperature range varies for the different TOPAS® COC grades according to the glass transition temper-ature and flowability (viscosity). Melt temperature can be adjusted over a wide range. The following table gives a guide:

TOPAS® 8007	190 °C	<	melt temperatur	<	250 °C
TOPAS® 5013	240 °C	<	melt temperatur	<	300 °C
TOPAS® 6013	240 °C	<	melt temperatur	<	300 °C
TOPAS® 6015	260 °C	<	melt temperatur	<	310 °C
TOPAS® 6017	270 °C	<	melt temperatur	<	320 °C

Excessive mold residence times or melt temperatures may cause yellowing of the melt. When the cycle is only briefly interrupted, barrel temperatures should be reduced to 170 °C.

Mold wall temperatures have to be adjusted to each TOPAS® COC grade respectively. Improved surfaces can be realised with wall temperatures 10 °C below the transition temperature and high injection speed Typical injection molding conditions for the standard grade 6015 are shown in Fig. 13.

Fig. 13: Processing conditions for TOPAS® 6015



ϑ_E = 110 °C
ϑ_1 = 240-270 °C
ϑ_2 = 250-290 °C
ϑ_3 = 260-310 °C
ϑ_4 = 260-310 °C
ϑ_D = 250-310 °C
ϑ_M = 260-310 °C
Maximum residence time: < 15 min.
Short interruption pressure to cycle: reduce ϑ_x to 170 °C!
$p_{Sp.}$ = Injection pressure 500-1000 bar (specif.)
p_N = Hold-on pressure 300-600 bar (specif.)
$p_{St.}$ = Back pressure < 150 bar (specif.)
n_S = Screw speed 50-200 ¹/min
Injection speed: moderate to fast (50 mm/s-150 mm/s)
ϑ_{W1}, ϑ_{W2}: 110-145 °C
Nozzle type: free-flow
Note: typical shrinkage value 0.4-0.7 %

To obtain low-stress moldings, phased injection speeds, relatively low pressure and relatively high mold temperatures are recommended. Injection hold time should be set just long enough to avoid sink marks. Since stress cracking resistance depends to a large extent on the stress condition of the molded part, it is important to try and avoid internal stresses and to verify the results by tests under end-use conditions.

6.2.5 Shrinkage
Shrinkage of TOPAS® COC resin depends on the volume contraction of the melt due to cooling. The additional contraction as a result of crystallization which typifies partially crystalline molding materials does not occur. Mold shrinkage of unreinforced TOPAS® COC grades is grade dependent and typical of amorphous resins. Typical values are 0.1-0.7.

6.2.6 Demolding
Undercuts in the part or runner system should be kept to a minimum. A sufficient number of large-area ejectors or stripper devices should be provided.
The greatest possible draft angle should be employed, such as is used for polystyrene.

6.2.7 Compatibility with thermoplastics
Contamination or mixture with other, even transparent, thermoplastics causes severe turbidity. When changing material, special cleaning is not normally necessary. The material is simply purged. Polypropylene has been found to be a good purge material.

6.3 Extrusion/injection blow molding/extrusion blowing
TOPAS® COC resin can be processed by injection molding and is also suitable for extrusion and injection blow molding.

6.3.1 Film extrusion
Extrusion conditions/temperatures for TOPAS® COC are determined primarily by softening point and molecular weight, as well as by specific machine requirements. Flowability data for the individual TOPAS® COC grades are given in table 4 (measured volume flow indices). For specific recommendations for individual TOPAS® COC grades please refer to the corresponding processing data sheet.
TOPAS® COC grades can be processed by extrusion into flat films or blown films. Their properties can be considerably improved by stretching at temperatures of 20-30 °C above the glass transition temperature (see table 5).

Table 4: Volume flow indices for TOPAS® COC

TOPAS® grade	Volume flow indices (ml/10min)/2.16 kg			Extrusion temperatures [°C]
	190 °C	230 °C	260 °C	
8007	2	10	30	220 - 250
6013	–	3	13	240 - 260
6015	–	< 1	4	260 - 280

Table 5: Mechanical properties of extruded flat films and biaxially oriented films

Property	Unoriented flat film	Biaxially oriented Film
Tensile modulus (GPa)	1.5 - 2.2	3.0 - 4.0
Tensile strength (MPa)	60 - 70	100 - 150
Elongation at break (%)	2 - 5	50 - 90

TOPAS® COC provides high shrink and high stiffness for shrinkable round-about labels (sleeves). In addition PET bottles and TOPAS® COC based sleeves can easily be separated and recycled by flotation due to their density difference.
In addition TOPAS® COC is used in special packaging films where high twist retention is required.
(Co)-extruded films, COC-Blends, respectively TOPAS® COC as an additive in polyolefins offer new opportunities, by adding additional film stiffness, seal- and hot tack strength, while keeping high clarity.

6.3.2 Injection blow molding/extrusion blowing
Injection blow molding technology can be used to produce bottles and vials from TOPAS® COC. These bottles open the medical market by offering high water vapour barrier, high transparency and chemical resistance. They are a shatter-resistant alternative to pharmaceutical glass. Unlike glass, they contain no traces of metals or free alkali-oxides and do not chip or craze in production. In particular 8007 and 6013 grades are well suited for injection blow molding.

6.4 Secondary operations

6.4.1 Welding

Various welding methods, except for high-frequency welding, can be used to join molded parts made from TOPAS® COC resin. The most suitable welding method will depend primarily on the specific part.

6.4.2 Adhesive bonding

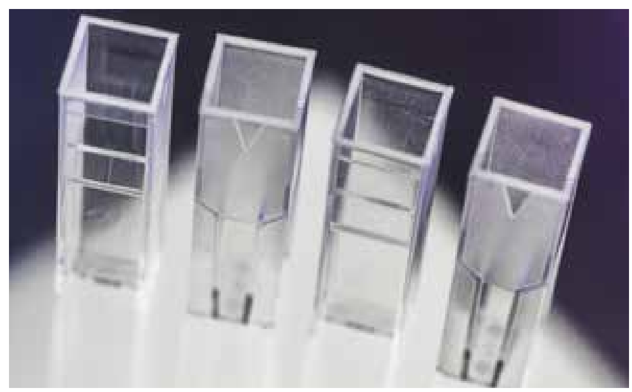
TOPAS® COC shows in principle the same behavior in respect to adhesive bonding as other polyolefins like polyethylene or polypropylene. Due to the low surface energy pretreatment such as plasma or flame treatment is typically required.

6.4.3 Metallization

TOPAS® COC shows good adhesion to metals. Reflective metal surfaces can be achieved by common vacuum metallizing methods. In many cases metallization can be done without pretreatment. Aluminium layers produced by vacuum deposition provide high glass surfaces.

7. Typical applications

7. Typical applications



8. Subject index

Polyplastics
DAICEL Group

TOPAS Advanced Polymers GmbH

Am Prime Parc 9
65479 Raunheim, Germany
Phone: +49 (0)1805 1 86727
eMail: info@topas.com

www.topas.com

Polyplastics USA, Inc.

27240 Haggerty Road, Suite E-20
Farmington Hills, MI 48331, USA
Phone: +1-248-479-8928
eMail: info@topas-us.com

www.topas.com

Polyplastics Co., Ltd.

JR Shinagawa East Building, 13F
18-1 Konan 2 - Chome, Minato-Ku
Tokyo, 108-8280, Japan
Phone: +81 03 6711 8610

www.polyplastics-global.com