Makrolon® 2205 and 2207

- **Polycarbonate (PC)**
- **General purpose grades**
- **Low viscosity**
- **Injection molding**

Short description

Makrolon® 2205:

Global grade; MVR (300 °C/1.2 kg) 35 cm³/10 min; general purpose; low viscosity; easy release; injection molding - melt temperature 280 - 320 °C; available in transparent, translucent and opaque colors

Makrolon® 2207:

Global grade; MVR (300 °C/1.2 kg) 35 cm³/10 min; general purpose; low viscosity; UV stabilized; easy release; injection molding - melt temperature 280 - 320 °C; available in transparent, translucent and opaque colors

Characterization

The Makrolon® 2205 and 2207 injection molding grades are transparent, very easy flowing, linear polycarbonates based on bisphenol A, with a low molecular weight.

These Makrolon® grades are noted for their very good melt flow properties and are thus suitable for the production of moldings with an unfavorable flow length/wall thickness ratio, i.e. for the production of large moldings with thin walls.

Compared with grades that have a high melt viscosity (Makrolon® 28.. and 3...), Makrolon® 2205 and 2207 have a lower level of toughness, but this is still adequate for a large number of applications.

Abbreviation to DIN EN ISO 1043-1: PC

Designation to DIN EN ISO 7391-1:

Makrolon® 2205:
Thermoplastics ISO 7391-PC, MR,(,,)-24-9

Makrolon® 2207:
Thermoplastics ISO 7391-PC, MLR,(,,)-24-9

Delivery form

Granules, packed in 25-kg polyethylene sacks, big bags, octatainer with a polyethylene inliner or in bulk.

All Makrolon® batches are homogenized after production.

Makrolon® 2205 and 2207 are supplied in transparent, translucent and opaque colors with an outstanding color depth.
Since the properties of these products are influenced by opaque pigments, grades with opaque pigments are only available on request.

The production plants for Makrolon® have been certificated to DIN ISO by the appropriate quality organizations. The certificates can be found in the INTERNET at http://www.bayermaterialscience.com
(Customer Services / Certificates).

Registered customers can access Safety Data Sheet on the Internet (bayerone.bayer.com). It can also be sent on request.
The Safety Data Sheet includes data on labeling, transport and storage, as well as information on handling, product safety and toxicological and ecological profiles.

Applications

The very good flowability of Makrolon® 2205 and 2207 makes these grades particularly suitable for the production of transparent, low-stress parts with thin walls and long flow paths (e.g. lamp diffusers).

Properties (see also table)

Makrolon® 2205 and 2207 display excellent flowability for polycarbonates.

Their thermal and electrical properties are largely identical to those of the higher-molecular grades; however, the higher-molecular grades offer greater toughness and resilience and better stress cracking behavior.

Processing

Pre-treatment / drying[1)]

Makrolon® must be dried before processing. For injection molding no more than 0.02 % residual moisture may be present in the granules and, for extrusion, no more than 0.01 %. Moisture in the melt leads to surface defects and a more marked reduction in molecular weight.

Makrolon® should be dried in suitable dryers at 120 °C.

The drying time for moist granules is largely a function of the nature and type of the drying unit and can take between 2 and 12 hours depending on the drying capacity. Drying times of 2 to 4 hours are sufficient in modern high-speed dryers. One means of dispensing with pre-drying is for the moisture to be removed during melting with the aid of a degassing unit, as is standard practice in extrusion.

Injection molding[1)]

Makrolon® can be processed on all modern injection molding machines. Shut-off nozzles are suitable given sufficient, uniform heating. At high melt temperatures, melt can flow out of open nozzles. Molding shrinkage is more or less identical in all directions and amounts to between 0.5 to 0.7 %.

The melt temperatures generally employed during processing are between 280 and 320 °C.

Material damage has to be expected with excessively high processing temperatures or excessively long residence times in the cylinder and hot runner. This can lead to a reduction in toughness and/or to surface defects in the form of streaks.

It should be possible for the molds to be heated intensively and uniformly, and the mold temperature should be at least 80 °C to ensure parts with a low inherent stress and a good surface. No demolding difficulties are encountered at up to 120 °C. It will not generally be necessary to employ mold release agents when Makrolon® grades with easy mold release are used.

Under the recommended processing conditions small quantities of decomposition product may be given off during processing. To preclude any risk to the health and well-being of the machine operatives, tolerance limits for the work environment must be ensured by the provision of efficient exhaust ventilation and fresh air at the workplace in accordance with the Safety Data Sheet.

In order to prevent the partial decomposition of the polymer and the release of volatile decomposition products, the prescribed processing temperatures should not be substantially exceeded.

1)
Details on this can be found in our Technical Information Sheet.

"Determining the dryness of Makrolon® by the TVI test"
""Processing data for the injection molder""
"The Injection Molding of High-Quality Molded Parts"

Recycling

Rejects and production waste can be reground, observing the drying and processing advice for virgin material, and made into new moldings. It is essential to check the property level and the color of molding compounds that contain regrind with respect to the envisaged application. The permissible regrind content must be established on a case-by-case basis.

When using regrind, it should be borne in mind that the granule geometry, which differs from that of extrusion granules, will influence the feed and plastication behavior. For this same reason, physical mixtures of regrind and granules tend to segregate on account of the movement they experience during transport, conveying and metering operations.

When Makrolon® is reprocessed, care should be taken to ensure that no foreign materials or dirt are incorporated. Waste that contains pollutants and mixed waste can be chemically recycled or incinerated with energy recovery.

Non-recyclable Makrolon® waste can be disposed of in an environmentally compatible manner through the correct form of incineration and subsequent dumping of the slag.

Parts should be identified in accordance with DIN EN ISO 11469; the marking to be applied to parts in Makrolon® 2205 and 2207 is as follows:

>PC<

Details on this can be found in our Technical Information Sheet "Part identification of thermoplastics for recycling".

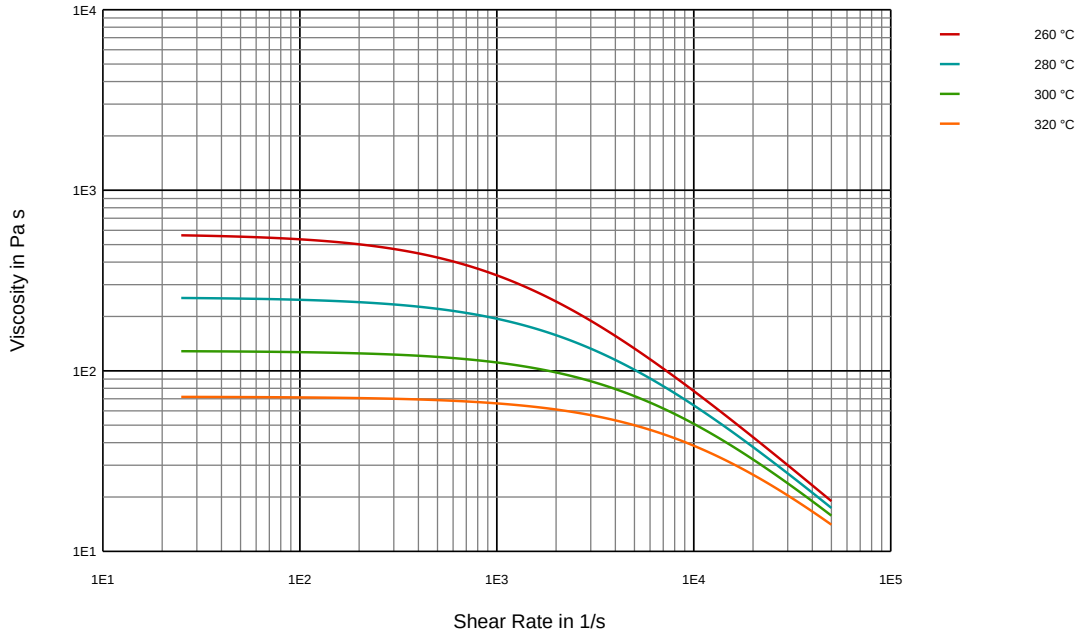

Fig. 1: Melt viscosity as a function of shear rate (Makrolon® 2205, 2207)

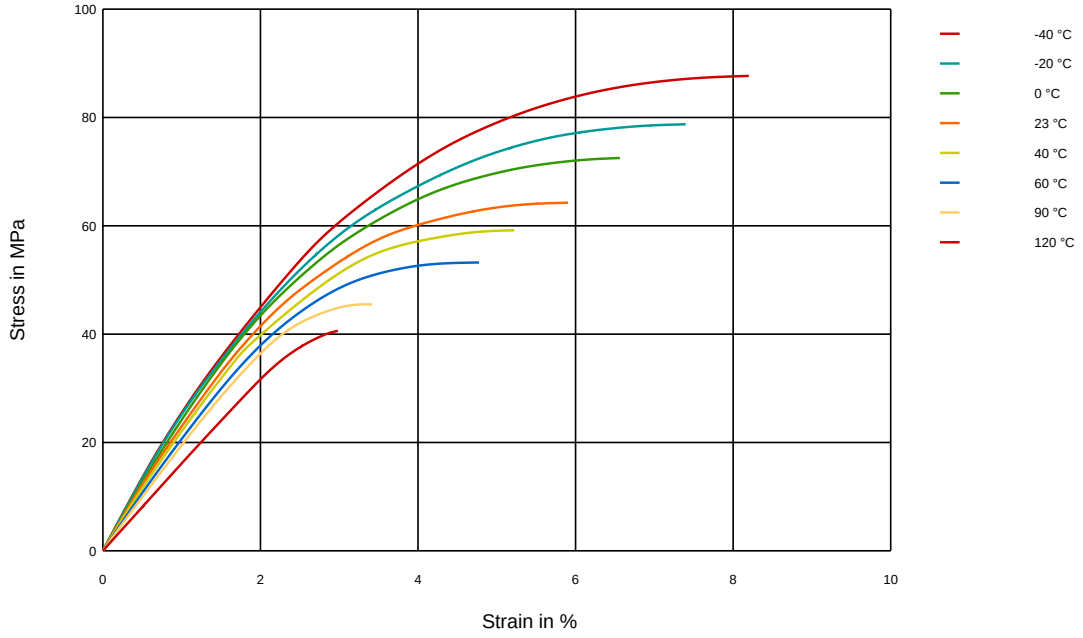

Fig. 2: Isothermal stress-strain curves from the short-time tensile test to ISO 527-1, -2 (Makrolon® 2205, 2207)

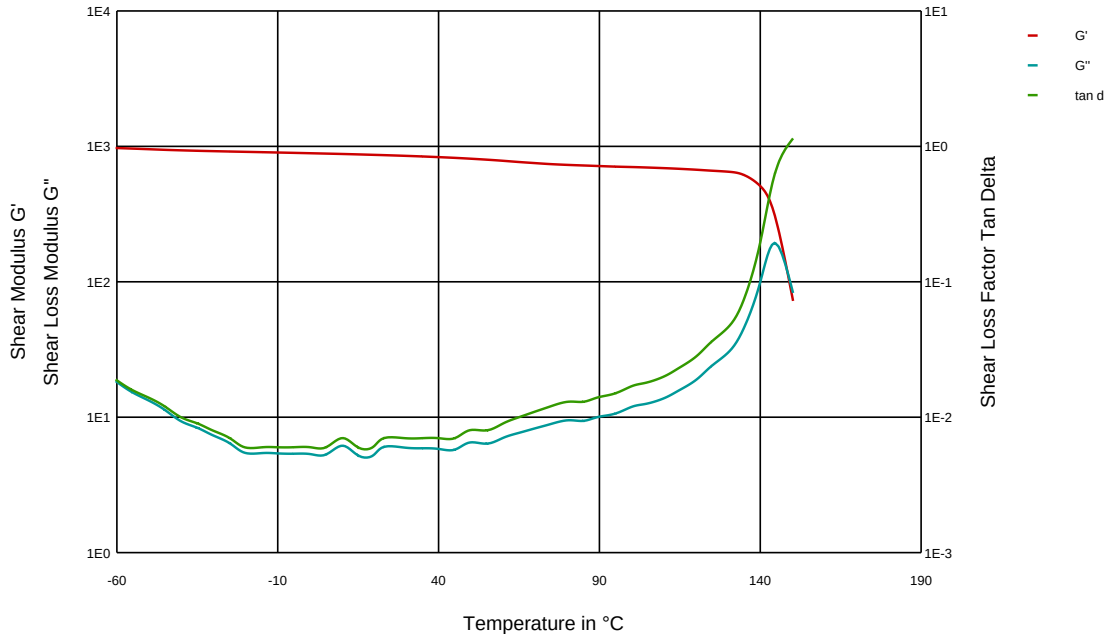

Fig. 3: Shear modulus as a function of temperature to ISO 6721-1, -2 (Makrolon® 2205, 2207)

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 2205	Makrolon® 2207
Rheological properties						
C	Melt volume-flow rate	300 °C; 1.2 kg	cm³/10 min	ISO 1133	35	35
C	Molding shrinkage, parallel	60x60x2; 500 bar	%	ISO 294-4	0.65	0.65
C	Molding shrinkage, normal	60x60x2; 500 bar	%	ISO 294-4	0.65	0.65
	Molding shrinkage, parallel/normal	Value range based on general practical experience	%	b.o. ISO 2577	0.5 - 0.7	0.5 - 0.7
	Melt mass-flow rate	300 °C; 1.2 kg	g/10 min	ISO 1133	37	37
Mechanical properties (23 °C/50 % r. h.)						
C	Tensile modulus	1 mm/min	MPa	ISO 527-1,-2	2400	2400
C	Yield stress	50 mm/min	MPa	ISO 527-1,-2	65	66
C	Yield strain	50 mm/min	%	ISO 527-1,-2	6.0	6.0
C	Nominal strain at break	50 mm/min	%	ISO 527-1,-2	> 50	> 50
	Stress at break	50 mm/min	MPa	ISO 527-1,-2	60	60
	Strain at break	50 mm/min	%	b.o. ISO 527-1,-2	115	115
C	Tensile creep modulus	1 h	MPa	ISO 899-1	2100	2100
C	Tensile creep modulus	1000 h	MPa	ISO 899-1	1700	1700
	Flexural modulus	2 mm/min	MPa	ISO 178	2350	2350
	Flexural strength	2 mm/min	MPa	ISO 178	97	98
	Flexural strain at flexural strength	2 mm/min	%	ISO 178	7.1	7.0
	Flexural stress at 3.5 % strain	2 mm/min	MPa	ISO 178	73	74
C	Charpy impact strength	23 °C	kJ/m²	ISO 179-1eU	N	N
C	Charpy impact strength	-30 °C	kJ/m²	ISO 179-1eU	N	N
	Charpy impact strength	-60 °C	kJ/m²	ISO 179-1eU	N	N
	Charpy notched impact strength	23 °C; 3 mm	kJ/m²	ISO 7391/b.o. ISO 179-1eA	55P(C)	55P(C)
	Charpy notched impact strength	-30 °C; 3 mm	kJ/m²	ISO 7391/b.o. ISO 179-1eA	12C	12C
	Izod notched impact strength	23 °C; 3.2 mm	kJ/m²	b.o. ISO 180-A	65P(C)	65P(C)
	Izod notched impact strength	-30 °C; 3.2 mm	kJ/m²	b.o. ISO 180-A	12C	12C
C	Puncture maximum force	23 °C	N	ISO 6603-2	4900	4900
C	Puncture maximum force	-30 °C	N	ISO 6603-2	5900	5900
C	Puncture energy	23 °C	J	ISO 6603-2	55	55
C	Puncture energy	-30 °C	J	ISO 6603-2	60	60
	Ball indentation hardness		N/mm²	ISO 2039-1	115	116

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 2205	Makrolon® 2207
Thermal properties						
C	Glass transition temperature	10 °C/min	°C	ISO 11357-1,-2	145	144
C	Temperature of deflection under load	1.80 MPa	°C	ISO 75-1,-2	124	123
C	Temperature of deflection under load	0.45 MPa	°C	ISO 75-1,-2	137	136
C	Vicat softening temperature	50 N; 50 °C/h	°C	ISO 306	145	144
	Vicat softening temperature	50 N; 120 °C/h	°C	ISO 306	146	145
C	Coefficient of linear thermal expansion, parallel	23 to 55 °C	10^{-4}/K	ISO 11359-1,-2	0.65	0.65
C	Coefficient of linear thermal expansion, transverse	23 to 55 °C	10^{-4}/K	ISO 11359-1,-2	0.65	0.65
C	Burning behavior UL 94	0.75-2.8 mm	Class	UL 94	V-2 (CL)	V-2 (CL)
	Burning behavior UL 94	2.9 mm	Class	UL 94	HB (CL)	HB (CL)
C	Oxygen index	Method A	%	ISO 4589-2	27	27
	Thermal conductivity	23 °C	W/(m·K)	ISO 8302	0.20	0.20
	Resistance to heat (ball pressure test)		°C	IEC 60695-10-2	136	135
	Relative temperature index (Tensile strength)	1.5 mm	°C	UL 746B	80	80
	Relative temperature index (Tensile impact strength)	1.5 mm	°C	UL 746B	80	80
	Relative temperature index (Electric strength)	1.5 mm	°C	UL 746B	80	80
	Glow wire test (GWFI)	1.0 mm	°C	IEC 60695-2-12	850	850
	Glow wire test (GWFI)	1.5 mm	°C	IEC 60695-2-12	850	850
	Glow wire test (GWFI)	2.0 mm	°C	IEC 60695-2-12	850	850
	Glow wire test (GWFI)	3.0 mm	°C	IEC 60695-2-12	930	930
	Glow wire test (GWFI)	4.0 mm	°C	IEC 60695-2-12	960	960
	Glow wire test (GWIT)	1.0 mm	°C	IEC 60695-2-13	875	875
	Glow wire test (GWIT)	1.5 mm	°C	IEC 60695-2-13	875	875
	Glow wire test (GWIT)	2.0 mm	°C	IEC 60695-2-13	875	875
	Glow wire test (GWIT)	3.0 mm	°C	IEC 60695-2-13	875	875
	Glow wire test (GWIT)	4.0 mm	°C	IEC 60695-2-13	875	875
	Application of flame from small burner	Method K and F; 2.0 mm	Class	DIN 53438-1,-3	K1, F1	K1, F1
	Needle flame test	Method K; 1.5 mm	s	IEC 60695-11-5	5	5
	Needle flame test	Method K; 2.0 mm	s	IEC 60695-11-5	5	5
	Needle flame test	Method K; 3.0 mm	s	IEC 60695-11-5	10	10
	Needle flame test	Method F; 1.5 mm	s	IEC 60695-11-5	60	60
	Needle flame test	Method F; 2.0 mm	s	IEC 60695-11-5	120	120
	Needle flame test	Method F; 3.0 mm	s	IEC 60695-11-5	120	120
	Burning rate (US-FMVSS)	>=1.0 mm	mm/min	ISO 3795	passed	passed
	Flash ignition temperature		°C	ASTM D1929	480	480
	Self ignition temperature		°C	ASTM D1929	550	550
Electrical properties (23 °C/50 % r. h.)						
C	Relative permittivity	100 Hz	-	IEC 60250	3.1	3.1
C	Relative permittivity	1 MHz	-	IEC 60250	3.0	3.0
C	Dissipation factor	100 Hz	10^{-4}	IEC 60250	5	5
C	Dissipation factor	1 MHz	10^{-4}	IEC 60250	90	90
C	Volume resistivity		Ohm·m	IEC 60093	1E14	1E14
C	Surface resistivity		Ohm	IEC 60093	1E16	1E16
C	Electrical strength	1 mm	kV/mm	IEC 60243-1	34	34
C	Comparative tracking index CTI	Solution A	Rating	IEC 60112	250	250
	Comparative tracking index CTI M	Solution B	Rating	IEC 60112	125M	125M
	Electrolytic corrosion		Rating	IEC 60426	A1	A1

Typical Values

	Property	Test Condition	Unit	Standard	Makrolon® 2205	Makrolon® 2207
Other properties (23 °C)						
C	Water absorption (saturation value)	Water at 23 °C	%	ISO 62	0.30	0.30
C	Water absorption (equilibrium value)	23 °C; 50 % r. h.	%	ISO 62	0.12	0.12
C	Density		kg/m³	ISO 1183-1	1190	1190
	Water vapor permeability	23 °C; 85 % RH; 100 µm film	g/(m²·24 h)	ISO 15106-1	15	15
	Gas permeation	Oxygen; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	800	800
	Gas permeation	Oxygen; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	3150	3150
	Gas permeation	Nitrogen; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	160	160
	Gas permeation	Nitrogen; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	630	630
	Gas permeation	Carbon dioxide; 100 µm film	cm³/(m²·24 h*bar)	b.o. ISO 2556	4800	4800
	Gas permeation	Carbon dioxide; 25.4 µm (1 mil) film	cm³/(m²·24 h*bar)	b.o. ISO 2556	18900	18900
	Bulk density	Pellets	kg/m³	ISO 60	660	660
Material specific properties						
	Refractive index	Procedure A	-	ISO 489	1.586	1.586
	Haze for transparent materials	3 mm	%	ISO 14782	< 0.8	< 0.8
	Luminous transmittance (clear transparent materials)	1 mm	%	ISO 13468-2	89	89
C	Luminous transmittance (clear transparent materials)	2 mm	%	ISO 13468-2	89	89
	Luminous transmittance (clear transparent materials)	3 mm	%	ISO 13468-2	88	88
	Luminous transmittance (clear transparent materials)	4 mm	%	ISO 13468-2	87	87
Processing conditions for test specimens						
C	Injection molding-Melt temperature		°C	ISO 294	280	280
C	Injection molding-Mold temperature		°C	ISO 294	80	80
C	Injection molding-Injection velocity		mm/s	ISO 294	200	200

C These property characteristics are taken from the CAMPUS plastics data bank and are based on the international catalogue of basic data for plastics according to ISO 10350.

Impact properties: N = non-break, P = partial break, C = complete break

colored fields = UL recognition

Burning behavior UL 94: CL = Clear

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