Bayer MaterialScience

MAKROLON® 2405, 2407 and 2456

Product Information

Polycarbonate Resins

2405 High-Productivity Grade with release
2407 High-Productivity, UV-Stabilized Grade with release
2456 High-Productivity, FDA-Food Contact Quality Grade with release

Description

Makrolon 2405, 2407, and 2456 polycarbonate resins are linear, low-viscosity, high-performance thermoplastics produced in pellet form for processing primarily by injection molding. A unique technology enables these polycarbonates to maintain mechanical properties similar to lower-melt-flow grades of polycarbonate, while offering improved flowability for increased design flexibility. Makrolon 2407 resin is UV stabilized. All resins contain an internal mold release additive. They are available in natural, clear tints, select transparent, translucent, opaque colors and special effects.

By broadening the processing window, Makrolon 2405, 2407, and 2456 resins are designed to permit faster cycling and higher productivity. Based upon tests conducted at Bayer laboratories, a processing comparison of Makrolon 2405 polycarbonate resin with production runs of standard polycarbonate has demonstrated increases in production rates in excess of 15%. Actual test results may vary, depending on the application and processing conditions. In addition, the increased productivity reduces energy consumption on a unit part basis.

These benefits are the result of low melt viscosity and ease of part ejection. The low viscosity is of particular interest in applications where thin walls exist or the flow length-to-wall thickness is high. Ease of processing at lower temperatures translates to faster cycles, as parts may be produced at lower mold-set-point temperatures and ejected after shorter cooling times. Although applicable to existing tools, new tool design can take advantage of the low melt viscosity of these grades. Thinner runners and distribution systems can be employed to minimize regrind and reduce cycle time. Wall sections in the part can be reduced to conserve materials and contribute faster cycling.

Although small parts offer some of the more attractive benefits of increased productivity, these grades are also candidates for applications involving large injection molded parts. In both large and small part molding, the same processing allowances exist. Lower melt temperatures and easy release permit demolding with less time necessary for stabilizing the part.

Makrolon 2456 resin complies with FDA food contact regulations 21 CFR 177.1580 (Polycarbonate Resins) and may be used in contact with all food types. Most colors may be used for all thermal food contact applications. However, some colors are limited by conditions of Use B through H, 21 CFR 175.300 and 176.170 and may not be used when the food is sterilized in the food contact article under autoclaving conditions. Please contact your Bayer MaterialScience representative with complete details when food contact is involved.

Makrolon 2456 resin, in natural 000000 and clear tints 550042 and 550115, is also listed under NSF standard 51 for use in food equipment. Please consult your Bayer MaterialScience representative for more information about food equipment applications.

Applications

Makrolon 2405, 2407, and 2456 resins are utilized over a wide range of applications in a variety of market areas. Typical applications include automotive light pipes, clear windows for business machines and instruments, and numerous consumer applications where multicavity tooling is used.

As with any product, use of Makrolon 2405, 2407, and 2456 resin in a given application must be tested (including but not limited to field testing) in advance by the user to determine suitability. The suitability of a

Bayer product in a given end-use environment is dependent upon various conditions including, without limitation, chemical compatibility, temperature, part design, residual stresses, and external loads. It is the responsibility of the Manufacturer to evaluate its final product under actual end-use requirements and to adequately advise and warn purchasers and users thereof.

Drying

All polycarbonate resins are hygroscopic and must be thoroughly dried prior to processing. A desiccant dehumidifying hopper dryer is recommended. To achieve a moisture content of less than 0.02%, hopper inlet air temperature should be 250°F (121°C) and inlet air dew point should be -20°F (-29°C) or lower. The hopper capacity should be sufficient to provide a minimum residence time of 4 hours. Additional information on drying procedures is available in the Bayer brochure *General Drying Guide*.

Processing

Makrolon 2405, 2407, and 2456 resins may be easily processed on commercially available molding equipment suitable for injection molding of polycarbonate. Barrel temperatures may be reduced by up to 45°F (25°C) below normal processing conditions for standard polycarbonate due to ease of cavity fill. Lower viscosity also means that lower primary and secondary injection pressures may be used and that molded-in stresses should be lower. A lower melt temperature permits the use of shorter hold and cure times. The shorter molding cycle is complemented by ease of part ejection at high part temperatures.

Typical processing parameters are noted below. Actual processing conditions will depend on machine size, mold design, material residence time, shot size, etc.

Typical Injection Molding Conditions

Barrel Temperatures:	
Rear	445˚–495˚F (229˚–257˚C)
Middle	510˚–550˚F (266˚–288˚C)
Front	530˚–570˚F (277˚–299˚C)
Nozzle	510˚–530˚F (266˚–277˚C)
Melt Temperature	535˚–565˚F (279˚–296˚C)
Mold Temperature	150˚–220˚F (66˚–104˚C)
Injection Pressure	10,000–20,000 psi
Hold Pressure	50–70% of Injection Pressure
Shot Size	25–75% of Barrel Capacity
Back Pressure	50–100 psi
Screw Speed	50–75 rpm
Injection Speed	Moderate to Fast
Cushion	1/8–1/4 in
Clamp	3–5 ton/in^2

Additional information on processing may be obtained by consulting the Bayer publication *Makrolon Polycarbonate — A Processing Guide for Injection Molding* and by contacting a Bayer MaterialScience technical service representative.

Regrind Information

Where end-use requirements permit, up to 20% Makrolon resin regrind may be used with virgin material, provided that the material is kept free of contamination and is properly dried (see section on Drying). Any regrind used must be generated from properly molded parts, sprues, and/or runners. All regrind used must be clean, uncontaminated, and thoroughly blended with virgin resin prior to drying and processing. Under no circumstances should degraded, discolored, or contaminated material be used for regrind. Materials of this type should be properly discarded.

Improperly mixed and/or dried regrind may diminish the desired properties of Makrolon resin. It is critical that you test finished parts produced with any amount of regrind to ensure that your end-use performance requirements are fully met. Regulatory or testing organizations (e.g., UL) may have specific requirements limiting the allowable amount of regrind. Because third party regrind generally does not have a traceable heat history or offer any assurance that proper temperatures, conditions, and/or materials were used in processing, extreme caution must be exercised in buying and using regrind from third parties. Third party regrind must not be used in end-uses that are to comply with FDA's food-contact regulations.

The use of regrind material should be avoided entirely in those applications where resin properties equivalent to virgin material are required, including but not limited to color quality, impact strength, resin purity, and/or load-bearing performance.

Typical Properties* for Natural Resin	ASTM Test Method (Other)	Makrolon® 2405/2407/2456 Resins U.S. Conventional	SI Metric
General			
Specific Gravity	D 792	1.20	
Density	D 792	0.043 lb/in³	1.20 g/cm³
Specific Volume	D 792	23.1 in³/lb	0.83 cm³/g
Mold Shrinkage	D 955	0.005–0.007 in/in	0.005–0.007 mm/mm
Water Absorption, Immersion at 73˚F (23˚C):	D 570		
24 Hours		0.12%	
Equilibrium		0.30%	
Melt Flow Rate[a] at 300˚C/1.2-kg Load	D 1238	20 g/10 min	
Optical			
Transmittance at 0.125-in (3.2-mm) Thickness	D 1003	88%	
Haze at 0.125-in (3.2-mm) Thickness	D 1003	<0.8%	
Refractive Index	D 542	1.586	
Mechanical[b]			
Tensile Stress at Yield	D 638	9,400 lb/in²	65 MPa
Tensile Stress at Break	D 638	8,700 lb/in²	60 MPa
Tensile Elongation at Yield	D 638	6%	
Tensile Elongation at Break	D 638	115%	
Tensile Modulus (1 mm/min)	D 638	350,000 lb/in²	2.4 GPa
Flexural Stress at 5% Strain	D 790	12,000 lb/in²	83 MPa
Flexural Modulus	D 790	340,000 lb/in²	2.4 GPa
Compressive Stress at Yield	D 695	11,000 lb/in²	76 MPa
Impact Strength, Notched Izod:	D 256		
73˚F (23˚C)			
0.125-in (3.2-mm) Thickness		14 ft·lb/in	750 J/m
Tensile Impact Strength, “S” Specimen:	D 1822		
0.125-in (3.2-mm) Thickness		250 ft·lb/in²	525 kJ/m²
Rockwell Hardness:	D 785		
M Scale		75	
R Scale		120	
Thermal			
Deflection Temperature, Unannealed:	D 648		
0.250-in (6.4-mm) Thickness			
264-psi (1.82-MPa) Load		259˚F	126˚C
66-psi (0.46-MPa) Load		273˚F	134˚C
Coefficient of Linear Thermal Expansion	D 696	3.34 E-05 in/in/˚F	6.0 E-05 mm/mm/˚C
Thermal Conductivity	C 177	1.39 Btu·in/(h·ft²·˚F)	0.20 W/(m·K)
Specific Heat	D 2766	0.28 Btu/(lb·˚F)	1,172 J/(kg·K)
Relative Temperature Index:	(UL746B)		
0.059-in (1.5-mm) Thickness			
Electrical		125˚C	
Mechanical with Impact		115˚C	
Mechanical without Impact		125˚C	
Vicat Softening Temperature, 50 N, 50°C/h	D 1525	291˚F	144˚C
Flammability**			
Oxygen Index	D 2863	28%	
UL94 Flame Class:	(UL94)		
0.75-mm (0.030-in) Thickness		V-2 Rating	
1.5-mm (0.059-in) Thickness		V-2 Rating	
2.7-mm (0.106-in) Thickness		HB Rating	
3.0-mm (0.118-in) Thickness		HB Rating	
Weatherability			
UV Light Exposure and Hot Water Immersion Tests	(UL746C)		
Makrolon 2407 and 2458 resins		f1 rating	
Electrical			
Volume Resistivity (Tinfoil Electrodes)	D 257	1.0 E+16 ohm·cm	
Surface Resistivity	D 257	1.0 E+16 ohm	
Dielectric Strength (Short Time Under Oil at 1-mm [0.04-in] and 73˚F [23˚C])	D 149	810 V/mil	32 kV/mm
Dielectric Constant (Tinfoil Electrodes): 60 Hz	D 150	3.0	
1 MHz		2.9	
Dissipation Factor (Tinfoil Electrodes): 60 Hz	D 150	0.0008	
1 MHz		0.01	
Arc Resistance: Stainless Steel Electrodes	D 495	11 s	
Tungsten Electrodes		120 s	

* These items are provided as general information only. They are approximate values and are not part of the product specifications. Type and quantity of pigments or additives used to obtain opaque colors and special effects can affect material properties.

** Flammability results are based on small-scale laboratory tests for purposes of relative comparison and are not intended to reflect the hazards presented by this or any other material under actual fire conditions.

[a] For information on using melt flow as a quality control procedure, see the Bayer publication Makrolon Polycarbonate — A Processing Guide for Injection Molding.

[b] Type and quantity of pigment used in opaque colors can affect mechanical properties, especially toughness.

General Characteristics of Polycarbonate

Hydrolytic Stability. Parts molded from polycarbonate absorb only 0.15 to 0.19% water at room temperature and 50% relative humidity. Dimensional stability and mechanical properties remain virtually unaffected. Even with immersion in water, dimensional changes measure only about 0.5%. Although frequent, intermittent contact with hot water does not harm polycarbonate, continuous exposure to humidity or water at high temperatures (>140°F/60°C) is not recommended due to hydrolytic degradation, which reduces impact strength and tensile properties.

Gas Permeability. Steam permeability, measured on 100-µm thick film, is 15 g/m^2·24 h (0.97 g/100 in^2·24 h). Significant permeability also exists for other gases, such as hydrogen, carbon dioxide, sulfur dioxide, helium, ethylene oxide, and oxygen.

Chemical Resistance. Polycarbonate is resistant to mineral acids (even in high concentrations), a large number of organic acids, many oxidizing and reducing agents, neutral and acidic saline solutions, some greases and oils, saturated aliphatic and cycloaliphatic hydrocarbons, and most alcohols. It is important to note that polycarbonate is degraded by alkaline solutions, ammonia gas and its solutions, and amines.

Polycarbonate dissolves in a number of organic solvents, such as halogenated hydrocarbons and some aromatic hydrocarbons. Other organic compounds cause polycarbonate to swell or stress-crack, e.g., acetone and methyl ethyl ketone. Since chemical resistance to various media is dependent on variables, such as concentration, time, temperature, part design, and residual stresses, the above information should serve only as a guideline. It is imperative that production parts be evaluated under actual application conditions prior to commercial use.

Regulatory Compliance Information

Some of the end uses of the products described in this bulletin must comply with applicable regulations, such as FDA, NSF, USDA, and CPSC. If you have any questions on the regulatory status of these products, contact your Bayer MaterialScience representative or Bayer's Regulatory Affairs Manager in Pittsburgh, PA.

Health and Safety Information

Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the Makrolon resins described in this bulletin. Before working with these products, you must read and become familiar with the available information on their hazards, proper use, and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your Bayer MaterialScience representative or contact Bayer's Product Safety and Regulatory Affairs Department in Pittsburgh, PA.

Note: The information contained in this bulletin is current as of September 2007. Please contact Bayer MaterialScience to determine whether this publication has been revised.

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