BOLD+
BRIGHT

ADVANCED MATERIALS FOR LED DESIGN

CHEMISTRY THAT MATTERS™

CONTENTS

ABOUT SABIC

SABIC's businesses are grouped into Chemicals, Polymers, Agri-Nutrients, Metals and Specialties. SABIC has significant research resources with 21 dedicated Technology & Innovation facilities in Saudi Arabia, the USA, the Netherlands, Spain, Japan, India, China and South Korea. The company operates in more than 50 countries with around 34,000 employees worldwide.

VISION

To be the preferred world leader in chemicals.

MISSION

To responsibly provide quality products and services through innovation, learning and operational excellence while sustaining maximumvalue for our stakeholders.

INNOVATING FOR CUSTOMER SUCCESS

We believe that SABIC customers deserve the full benefit of our broad portfolio of products and solutions. After all, our success is defined by our customers' success. And with over 80 years of experience pioneering advanced engineering thermoplastics, SABIC is striving to help our customers create new opportunities for growth and breakthrough applications.

We offer expertise and experience to our customers in a variety of ways:

- Material solutions to help drive innovation and market leadership
- Design, logistics and processing expertise to spark new ideas and better efficiencies
- Unwavering commitment to build long term relationships with ingenuity, trust and continuous improvement

It's what we strive for and work to deliver...
a mutual benefit.

Excellence and nothing less.

A BRIGHT FUTURE IS DAWNING FOR LEDS

SABIC is helping them shine. Delivering more energy-efficient illumination and potentially longer lifetimes than conventional light sources, light-emitting diodes (LEDs) also pack a rainbow of intense colors into compact form factors. The bold new options these solid-state sources introduce to lighting design have attracted interest from OEMs in residential and commercial lighting, automotive, architectural illumination, displays and dozens of other industries.

SABIC offers LED makers an extensive portfolio of specialty resins and compounds. And with that portfolio comes the technological expertise, personal drive and collaborative culture to help you optimize the performance, lifespan and aesthetics of your LED sources and lighting designs.

Compared to conventional glass, silicone or metal materials, SABIC's leading-edge engineering plastics introduce expanded design freedoms through lower weight, better mechanical properties, enhanced aesthetics and fewer secondary operations. Combining the industry's widest selection of materials platforms with decades of design expertise, SABIC supports a wide spectrum of performance solutions for LED design consideration, including:

- Transparency and diffusion
- Flame resistance (non-brominated, non-chlorinated, non-phosphorus)
- Heat resistance
- Direct metallization
- UV resistance and weatherability
- Thermal and electrical conductivity
- Impact resistance
- Excellent moldability
- High reflectivity

TRANSPARENT GRADES

The clear choice: LEXAN™ resin (a polycarbonate material) – Optical clarity and more for transparent LED applications.

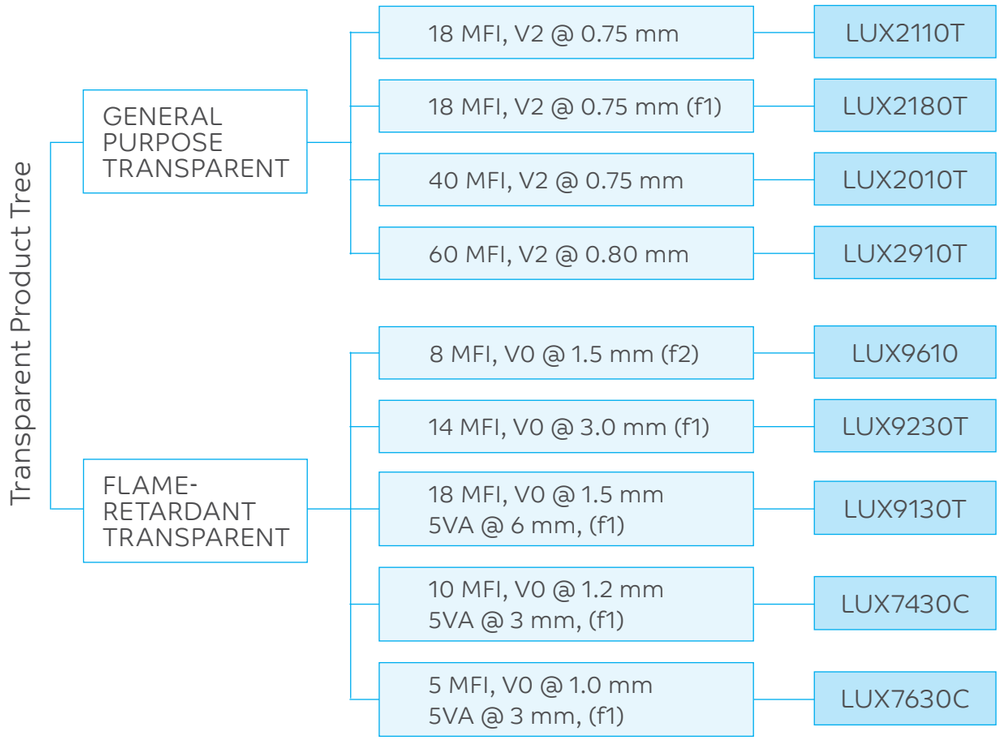
LED light-guides, lenses and other components often demand stronger or more focused emission of light. In these applications, transparent grades of Lexan polycarbonate (PC) shine, delivering high transmission of light plus other high-value performance qualities.

Transparent LEXAN LUX resins offer expansive design freedom for LED light-guides through excellent processability and a broad range of flow profiles. Plus, they offer better impact resistance than glass, as well as flame-retardant options unavailable from competitive plastic materials like PMMA (acrylic).

These qualities make LEXAN LUX resin an excellent candidate for transparent LED assemblies that must meet stringent requirements for heat and impact resistance.

LEXAN resin is available globally, and offers critical performance characteristics, such as:

- Excellent processability
- Flow availability (g/10 min, 300 °C/1.2 kg
- Improved optical clarity
  (Also for thick flame retardant lenses)
- Superior high transmission
- Heat resistance
- High impact/almost unbreakable
- Flame-retardant availability
- Improved heat aging properties



AGING STABILITY: LEXAN LUX21X0T RESIN VS. STANDARD PC W UV ADDITIVE

FIGURE 1 - 2.5 MM COLORSHIFT HEAT AGING AT 130 °C

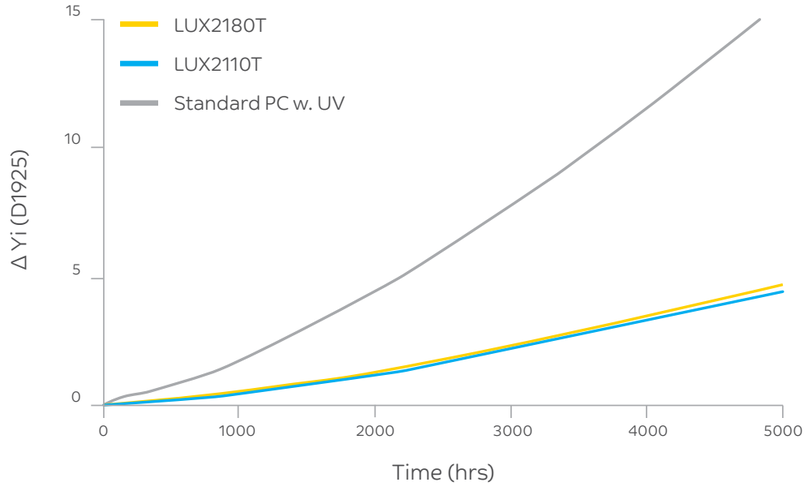


FIGURE 2 - TRANSMISSION SHIFT HEAT AGING AT 130 °C

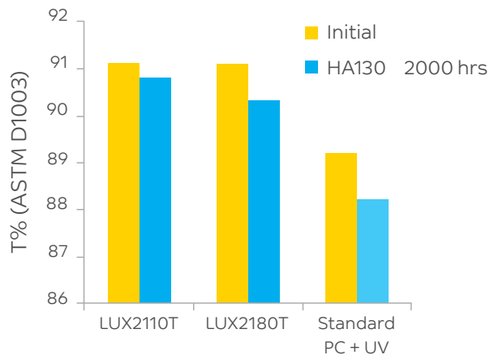
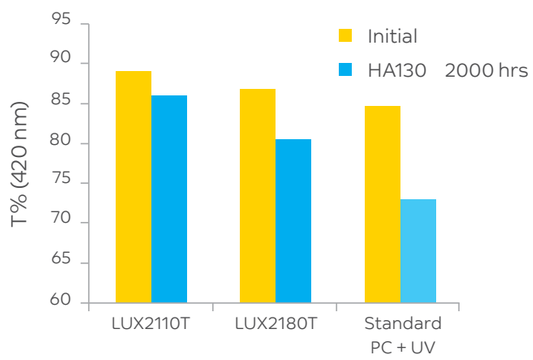


FIGURE 3 - TRANSMISSION 420 NM SHIFT HEAT AGING AT 130 °C



New LEXAN LUX resin grades show superior color stability

FLAME-RESISTANT SOLUTIONS FOR TRANSPARENT AND DIFFUSE LED APPLICATIONS

Flame-retardant (FR) materials are one of the main requirements for LED designs, and SABIC offers a broad range of solutions for both transparent and diffuse lighting applications. Select globally available grades deliver flame resistance meeting UL 94 up to 5VA standards in thin wall configurations, as GWFI (IEC) up to 960 °C. Plus, designers can expect additional performance characteristics, including excellent processability, low weight, high impact strength, strong heat resistance and compliance with environmental protocols governing non-brominated, non-chlorinated and non-phosphorus FR systems.

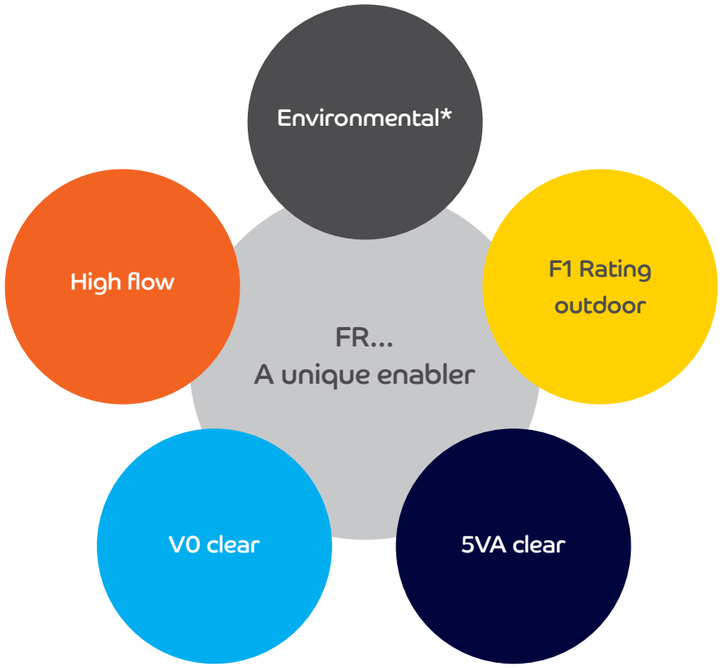
Our wide portfolio of engineering resins encompasses potential solutions for virtually any shape and standard required for retrofit light bulb designs and other LED luminaire applications.

Optically clear flame-resistant solutions

For LED light bulb, spotlight and tube designs targeting the lighting market, SABIC offers select flame-resistant LEXAN resin grades that:

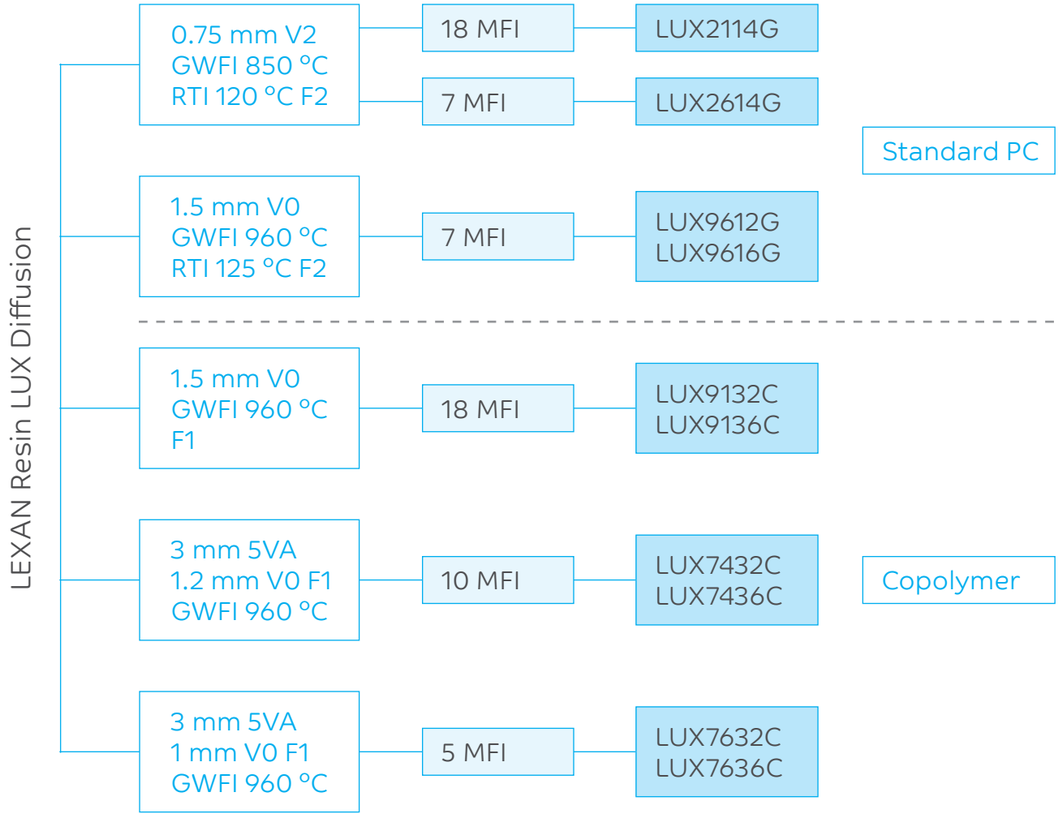
- Are listed UL 94 V0 up to 1 mm, 5VA at 3 mm for NAFTA and according to IEC standards (Europe) for GWFI up to 960 °C with BPT 125 °C (Europe)
- Enable high transmission across the visible spectrum
- Offer moldability and flow for open or directed beam designs
- Offer extrusion grades for flame-resistant tube designs
- Include FR grades for diffuse/transparent applications

Additionally, we provide some grades with UL746C, F1 rating for outdoor applications (see product tree, page 15).



* Non brominated & non chlorinated & non-PTFE used FR System

LEXAN LUX RESIN DIFFUSION SOLUTIONS



Potential Benefits of LEXAN Copolymers

- Improved flame resistance - thinner wall V0 performance over standard clear FR PC resins
- New flame resistance capability - 5VA performance over clear FR PC resins
- Non-brominated, non-chlorinated, non-phosphorus and no PTFE added
- UL746C f1 rating
- Standard PC type optical properties
- Improved melt flow and process capability over existing clear FR PC resins

FROM CLEAR TO DIFFUSION

Products with broad optical properties to cover LED many applications

LEXAN LUX_G grades

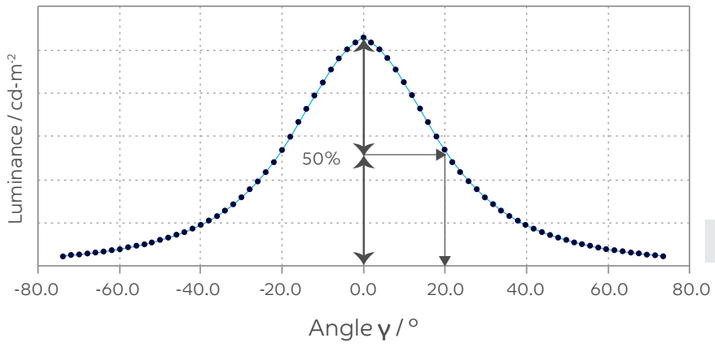
MFR 18 300 °C; 1.2 kg	UL94 V2 0.75 mm		LUX2114G WH8B508X	LUX2114G WH8B490X	LUX2114G WH8B491X	LUX2114G WH8B492X	LUX2114G WH5B140X
MFR 7 300 °C; 1.2 kg	UL94 V2 0.75 mm		LUX2614G WH8B508X	LUX2614G WH8B490X	LUX2614G WH8B491X	LUX2614G WH8B492X	LUX2614G WH5B140X
MFR 7 300 °C; 1.2 kg	UL94 V0 1.5 mm	LUX9610 - 11204 NA9G155T	LUX9612G WH8A508X	LUX9612G WH8A490X	LUX9616G WH8A491X	LUX9616G WH8A492X	LUX9616G WH5A140X
Thick	Item						
3 mm	%T *	88.8	75	70	52	50	46
	DLD (deg.)	—	29	32	54	56	60
2 mm	%T *	89.7	84	81	64	61	54
	DLD (deg.)	—	22	26	46	50	59
1 mm	%T *	90.6	89	89	80	78	66
	DLD (deg.)		8	11	25	30	50

LEXAN LUX Copolymers

MFI 18 300 °C; 1.2 kg	UL94 V0 1.5 mm UL746C f1	LUX9130C NAT	LUX9130C NA8G002T	LUX9132C WH8A013X	LUX9132C WH7A317X	LUX9132C WH6A305X	LUX9136C WH5A143X	LUX9136C WH4A202X
MFI 10 300 °C; 1.2 kg	UL94 V0 1.2 mm 5VA 3 mm UL746C f1	LUX7430C NAT	LUX7430C NA8E061T	LUX7432C WH8F013X	LUX7432C WH7E317X	LUX7432C WH6E305X	LUX7436C WH5E143X	LUX7436C WH4E202X
MFR 5 300 °C; 1.2 kg	UL94 V0 1.0 mm 5VA 3 mm UL746C f1	LUX7630C NAT	LUX7630C NA8E061T	LUX7632C WH8F013X	LUX7632C WH7E317X	LUX7632C WH6E305X	LUX7636C WH5E143X	LUX7636C WH4E202X
Thick	Item							
3.0 mm	%T *	91	89.1	77.7	68.1	52.3	47.8	42.2
	DLD (deg.)			25.6	33.2	50	57.2	59.8
2.0 mm	%T *	91.3	90	84.7	79	64.6	58.8	50.5
	DLD (deg.)			18.1	25.1	42.3	52.1	58.8
1.5 mm	%T *	91.4	90.2	87.7	83.5	73	67.5	56
	DLD (deg.)			12.4	17.9	32.8	47.1	57.3
1.0 mm	%T *	91.5	90.8	89.4	87.6	81.3	76.5	63.7
	DLD (deg.)			7.1	12.7	19.8	30.5	53

* **Transmission**: percentage of the incident light that is transmitted
* **Degree of light dispersion (DLD)**: angle at which half of the luminance of the incident light is observed

FIGURE 4 - DEGREE OF LIGHT DISPERSION (DLD)



Degree of Light Dispersion = $\gamma_{L = 50\%}$

Diffuse flame-resistant solutions

Diffusive lighting applications signify a large potential market opportunity for LED lighting applications, and SABIC can support lighting design solutions. We are the first resin supplier to offer FR diffusion materials with UL-rating in all colors, including RTI (long-term) grades. We provide almost limitless aesthetic and light management design options for LED retrofit light bulbs and tubes.

Diffuse LED light bulbs/luminaries

- Flame-retardant: Listed for UL 94 up to V0 1.0 mm and 5VA up to 3 mm (NAFTA), and according to IEC standards (Europe) for GWFI up to 960 °C/BPT 125 °C (Europe)
- RTI listed up to 125/115/125 °C
- Excellent light management enables high transmission with hiding power
- UV/thermal stability for light fastness

Diffuse LED retrofit tubes

- Flame-retardant: Listed for UL 94 up to V0 1.0 mm and 5VA up to 3 mm (NAFTA), and according to IEC standards (Europe) for GWFI up to 960 °C/BPT 125 °C (Europe)
- RTI listed up to 125/115/125 °C
- Excellent light management enables high transmission with hiding power
- UV/Thermal stability for light fastness
- Extrusion grades for flame-resistant tube designs

SABIC has both diffuse and transparent flame-retardant grades – excellent candidate materials for your application needs.

HIGH-REFLECTIVE GRADES

SABIC delivers high-reflective material for LED lighting reflectors. The reflectivity goes up to ~97%, depending on wall thickness and wavelength. (see graph example of LEXAN LUX2489D resin in color WH9G012 below). Option also available with anti-dust properties if needed.

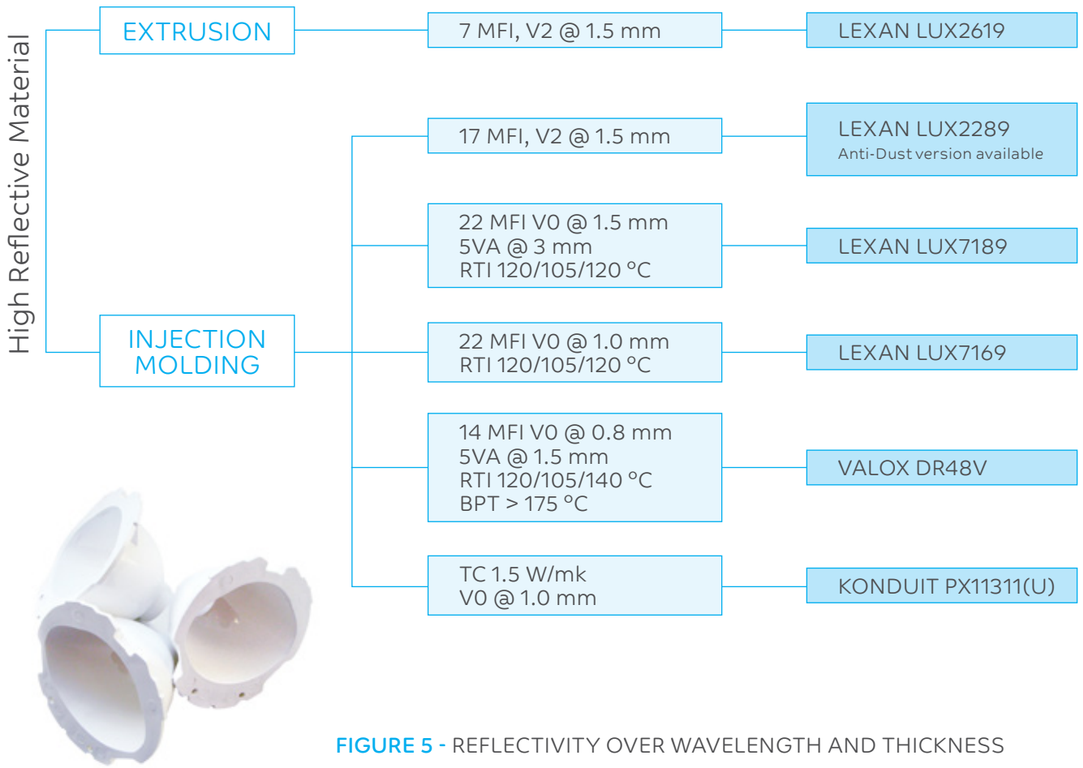
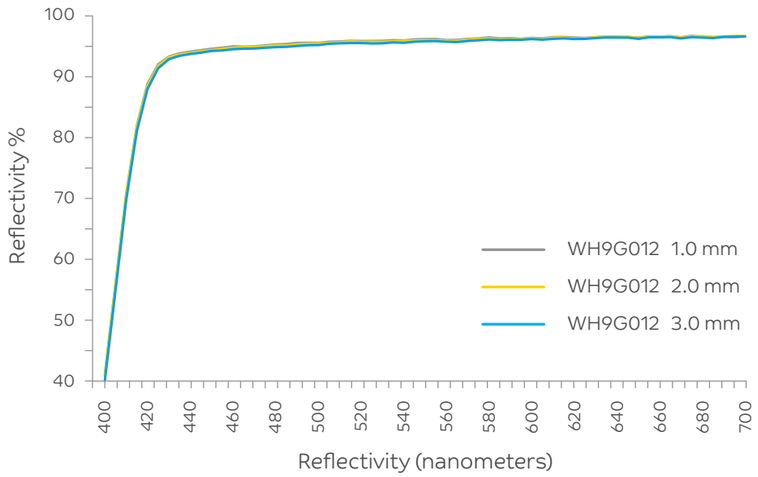


FIGURE 5 - REFLECTIVITY OVER WAVELENGTH AND THICKNESS

The reflectivity reported is the reflectivity over 420-700 nm, as measured with a Perkin Elmer LAMBDA 950 spectrophotometer with 150 mm reflective sphere, Spectralon coated.



LIMIT LED HEAT – NOT LED DESIGN

KONDUIT™ compounds for thermal management

Although LEDs generate light five times more efficiently than conventional incandescent lamps, much of their input energy still converts into heat that – if not managed – can detract from an LED's optimal useful lifetime. As demand rises for LEDs with higher efficiencies and longer life spans, thermal heat management will be more and more critical to competitive designs.

This poses a potential problem for conventional heat sink materials, such as die-cast aluminum, since they can impose limitations on LED design and require costly secondary operations. Thermal conductive compounds, such as SABIC's KONDUIT material, offer a valuable alternative.

KONDUIT compounds are based on thermoplastics loaded with special fillers to enable thermal conductivity. They deliver lower weight than aluminum or other conventional metal solutions, and a higher mechanical impact resistance than ceramic solutions. Our materials offer ease of processability and need no secondary operations. Plus, they provide tremendous design freedom when balancing form and function.

KONDUIT compounds offer thermal conductivity up to 15 W/mK in combination with electrical isolation to pass industry electrical standard-6KV breakdown tests. The materials are available with UL 94 listing up to V0 @ 0.8 mm with a non-halogenated flame-retardant system. Available in white, gray and black, they also offer a range of aesthetic options.

In plane / through plane

KONDUIT Compounds Light Color	ELECTRICAL ISOLATIVE	UL94 V0	PX11311U	K = 1.5 W/mK*, 0.8 W/mK UL94-V0 @ 1.0 mm, based on PA6
			PX13322	K = 3.3 W/mK*, 1 W/mK UL94-V0 @ 0.8 mm, based on PA6
			OX11314	K = 1.9 W/mK*, 0.9 W/mK UL94-V0 @ 0.7 mm, based on PPS
			PX11313	K = 1.9 W/mK*, 0.9 W/mK UL94-V0 @ 0.8 mm, RTI = 105 °C, based on PA6
	ELECTRICAL ISOLATIVE NOT FLAME RETARDANT	UL94 HB	DTK22	K = 2.0 W/mK*, 0.6 W/mK UL94-HB @ 1.0 mm, based on PC
KONDUIT Compounds Dark Color	ELECTRICAL ISOLATIVE	UL94 V0	PX13012	K = 5.5 W/mK*, 1.2 W/mK UL94-V0 @ 0.8 mm, based on PA6
		UL94 V0	OX11315	K = 13 W/mK*, 0.8 W/mK UL94-V0 @ 0.8 mm, based on PPS
	ELECTRICAL CONDUCTIVE	UL94 HB	PX10323	K = 18 W/mK*, 1.5 W/mK UL94-HB @ 1.0 mm, based on PA6
		UL94 V0	OX10324	K = 18 W/mK*, 1.3 W/mK UL94-V0 @ 1.2 mm, RTI = 130 °C, based on PPS

* Thermal conductivity measured with Hotdisk TPS2500 In-plane with a 3 mm plate (60 by 60 mm, film-gated).

HIGH HEAT, HIGH PERFORMANCE

Heat-resistant LEXAN XHT and LEXAN CXT resins for high-temperature performance

Many LED components and applications – including spotlights, flashlights, light-guides, lenses and reflectors – often demand an extra degree of heat resistance. This can be driven by high temperatures during peak exposure of during prolonged times, not only during part operation but potentially also during demanding secondary operations or assembly processes. Formulated from a unique high-heat polycarbonate copolymer, LEXAN XHT resins retain their clarity and mechanical properties far longer than comparable polycarbonate materials. The recently introduced LEXAN CXT resins offer similar benefits with a significantly extended processing window versus existing LEXAN XHT resins and also extend the heat resistance for UV-stabilized resins to even higher levels. These resins can potentially offer the following key advantages to your LED design:

PROCESSABILITY

LEXAN XHT resin deliver an excellent flow profile compared to other high-heat resins, expanding design freedom and increasing production efficiencies. LEXAN CXT resins have a significantly extended processing window compared to LEXAN XHT resins and allow higher melt temperatures without affecting color or mechanical properties to fill more complex, larger and/or thinner tools.

MECHANICAL PROPERTIES

Like all LEXAN resin grades, LEXAN XHT and LEXAN CXT resins offer excellent practical impact resistance, but also retain its mechanical properties longer than comparable polycarbonate grades after prolonged exposures at elevated temperatures.

DIRECT METALLIZATION

LEXAN XHT resins' high heat resistance expands options for direct metallization of lightweight plastic LED components, such as lens reflectors. In addition to improving performance, this can also help reduce cost and cycle-time related to secondary operations.

HEAT AGING

Compared to other high-heat polymers, LEXAN XHT and LEXAN CXT resins offer color and transmission retention after prolonged exposure to high temperatures. This may make these resins excellent candidates for LED lighting applications with demanding temperatures conditions.

LEXAN XHT and CXT Resins

Vicat 120	MFI	Standard	UV Stabilized	Improved processing UV-stabilized
190°C	15	XHT5141		CXT19UV
180°C	26	XHT4141	XHT4143	
170°C	33	XHT3141	XHT3143 (T)	CXT17UV
160°C	48	XHT2141	XHT2143 (T)	
150°C	70	XHT1141	XHT1143	

OUTSTANDING PERFORMANCE UNDER THE SUN

UV-resistant LEXAN SLX resin stands up under extreme weather

LEXAN SLX RESIN

As molded

After exposure‡

STANDARD PC + UV

As molded

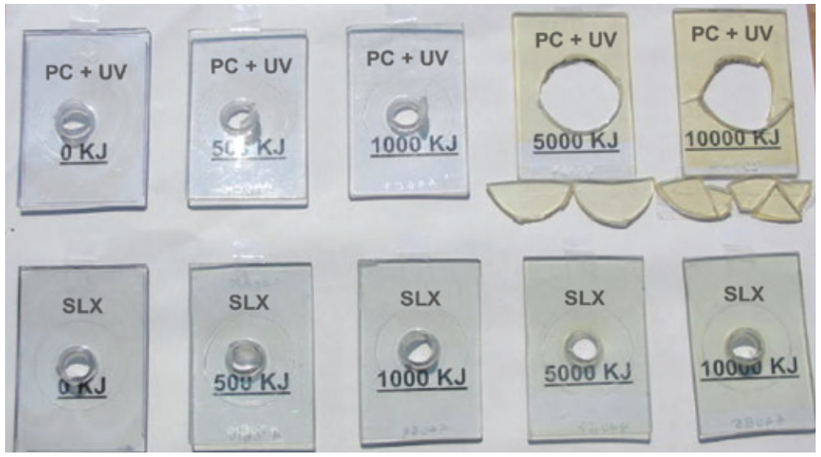
After exposure‡

‡In hot chamber, 175W MH lamp for 2900 hours @ 120 °C on refractor – 55 °C ambient

Specially formulated to deliver improved long-term weatherability, LEXAN SLX polycarbonate (PC) resin resists yellowing due to ultraviolet (UV) exposure and retains its excellent gloss, color stability and mechanical properties more than five times longer than standard PC. Plus, these same qualities mean using LEXAN SLX PC resin can help reduce or eliminate costly secondary operations to apply UV coating. Available in either transparent or diffuse color options, it is a superb candidate for LEDs designed for outdoor and street-lighting applications. Available in natural, with limited white diffuse colors also available.

Weathering material behavior simulation

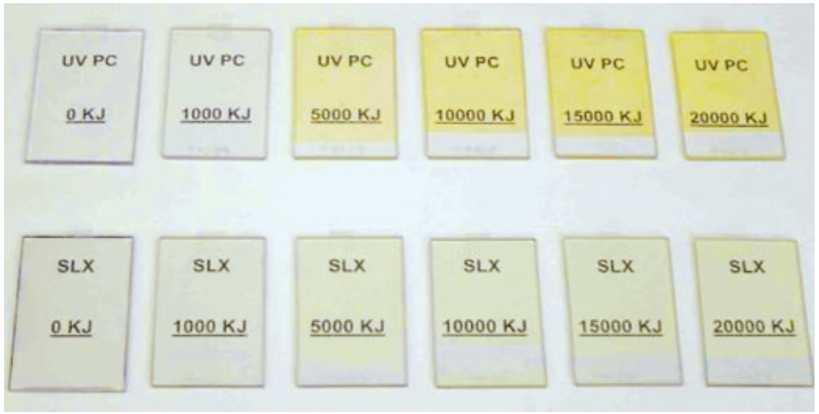
3 years simulated weathering



< PC + UV RESIN

< LEXAN SLX RESIN

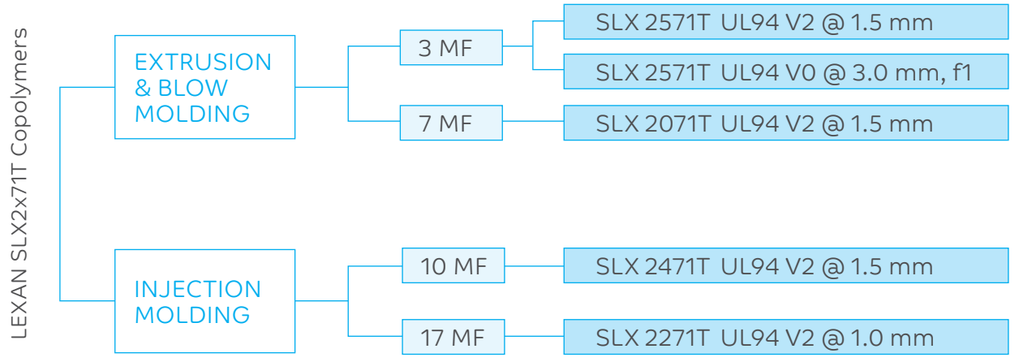
6 years simulated weathering



< PC + UV RESIN

< LEXAN SLX resin

LEXAN SLX Copolymer preferred product tree



A WIDE SPECTRUM OF MATERIALS SOLUTIONS

SABIC is your one-stop shop for engineering thermoplastics. In addition to the high-performance resins already outlined, we offer a broad range of additional materials platforms that are excellent candidates for just about any application need. Plus, we continue to push the boundaries of performance by innovating new materials technologies every day.

ULTEM™ RESINS

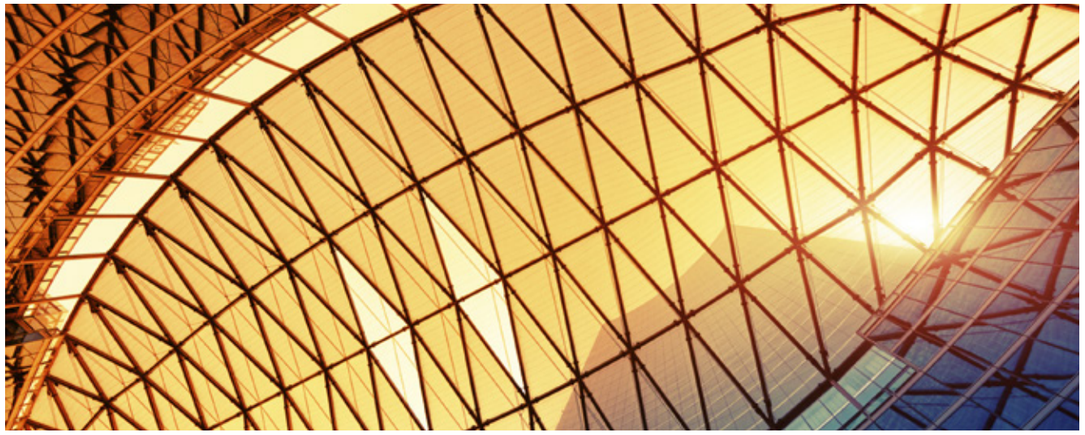
Many LED applications require housings or reflectors that must deliver durable performance under high temperatures. ULTEM amorphous thermoplastic resins, polyetherimide (PEI) materials, are an excellent candidate.

Their outstanding resistance to extremely elevated temperatures means ULTEM resins deliver long-lasting strength and stiffness, as well as broad chemical resistance under the most demanding conditions.

Select ULTEM copolymers can meet even higher heat, chemical and elasticity needs. Available in transparent and opaque custom colors as well as glass-filled grades, ULTEM resins balance mechanical properties and processability, offering design engineers exceptional flexibility and freedom.

KEY PROPERTIES OF THE ULTEM RESINS BASE POLYMER:

- High long-term heat resistance exhibiting a glass transition temperature of 217 °C (422 °F), HDT/Ae of 190 °C (374 °F) and relative thermal index (RTI) of 170 °C (338 °F)
- Inherent flame retardancy with low smoke evolution, meeting ABD, FAR and NBS requirements
- Excellent dimensional stability (low creep sensitivity and low, uniform coefficient of thermal expansion)
- Exceptional strength and modulus at elevated temperatures
- Good resistance to a broad range of chemicals such as automotive fluids, fully halogenated hydrocarbons, alcohols and aqueous solutions
- Stable dielectric constant and dissipation factor over a wide range of temperatures and frequencies
- Transparency to visible light, infrared light and microwave radiation



VALOX™ RESINS

A versatile materials solution, VALOX resins, a polyester material, include performance-matched grades designed to provide application-specific property profiles. VALOX resins combine heat and chemical resistance as well as outstanding electrical properties with exceptionally good processability and surface appearance. Select grades offer non-brominated and non-chlorinated flame retardant properties.

KEY PROPERTIES OF VALOX RESINS:

- Highly tailorable mechanical, thermal and electrical properties combined with excellent dimensional stability
- Excellent resistance to a variety of chemicals, including hydrocarbons, dilute acids and bases, detergents and most aqueous salt solutions
- UV stable, F1 listing
- Available in a broad range of both filled and unfilled grades, with specified UL and other agency compliance ratings
- Flame-retardant grades offer a UL94 5VA rating and a glow wire test (GWT) pass at 960 °C (1760 °F)
- Relative temperature index (RTI) up to 140 °C (284 °F), yet provide good low-temperature performance to -40 °C (-40 °F)
- SMT, high reflectivity, good whiteness retention
- Up-cycled sustainable solution VALOX iQ™ resins

TYPICAL APPLICATIONS AND GRADES:

- Shell (socket): (iQ)ENH4550, (iQ)ENH4565
- Street LED lighting housing: (iQ)357U, V3900WX
- LED chip reflector

VALOX ENH4565 RESIN

A 33% GF PBT resin, non-brominated and non-chlorinated flame-retardant, injection molding grade for applications that demand low CTE, good thermal shock resistance and ductility.

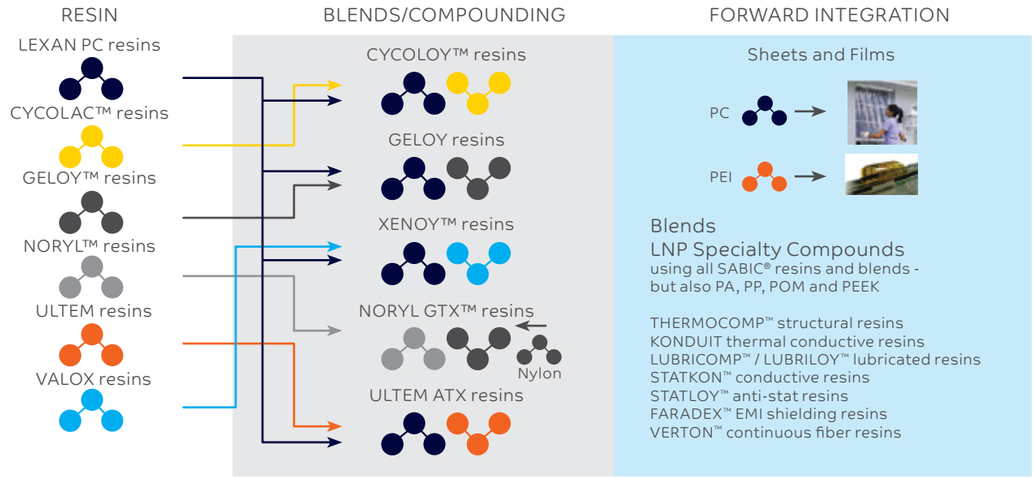
POTENTIAL BENEFITS

- Non-brominated and non-chlorinated, flame retardant
- Good thermal shock resistance
- Super weld line strength
- Low CTE: Narrow CTE gap between plastics and metal for over molding application
- Good tensile and impact strength, Thin wall FR and high RTI: V0@0.8 mm, RTI@130 °C

POTENTIAL APPLICATIONS

- Applications needing good thermal shock resistance, such as lighting socket and cooling fan
- Applications needing good weld line strength, such as cooling fan frame
- High tensile and impact strength applications, such as EV charging coupler

BROAD PORTFOLIO OF HIGH-PERFORMANCE RESINS



SUSTAINABLE INNOVATION

Sustainable practices are not just the right thing to do for the environment, they are also a smart business strategy. SABIC has a long history of positive contributions to the sustainable performance of our customers' products – and to our own. We continue to invest in materials, technologies and processes that help customers worldwide lower their carbon and energy footprints, eliminate waste and ensure strict compliance with global environmental regulations.

Specifically, for LED applications, our advanced flame-retardance systems can replace hazardous flame-retardant (FR) substances that face increasing restrictions around the world. The 2006 Restriction of Hazardous Substances (RoHS) Directive (2002/95/EC, as amended) banned the use of certain hazardous substances in electrical and electronic (E/E) equipment in the European Union (EU). The EU Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC, as amended) mandates separate disposal processes for products containing any RoHS substance, which adds costs and makes recycling more difficult. Similar legislation is being developed in other parts of the world, and the RoHS list of substances is expected to grow. Chlorinated and brominated flame retardants have also come under scrutiny due to concerns about by-products that may form during incineration.

For years, SABIC has offered non-brominated FR resins, such as the LEXAN 9x5 resin series, and halogen-free FR resins such as the LEXAN 9x9 resin series and ULTEM and Flexible NORYL resin grades. We continue to expand this portfolio with new functionality and improved technology to help our customers develop applications that will meet their entire list of quality criteria.

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