Go Boldly into the New Space Age

Proven composite materials from orbit to beyond

'TORAY'

Innovation by Chemistry

Space, Satellite, & Launch

Introduction

Our Objectives

Connecting the planet	Furthering scientific understanding	Reducing weight	High reliability

Credit: Airbus Defence and Space

SPACE TRANSFORMED: THE NEW ERA OF PRIVATE LAUNCHES AND SATELLITES

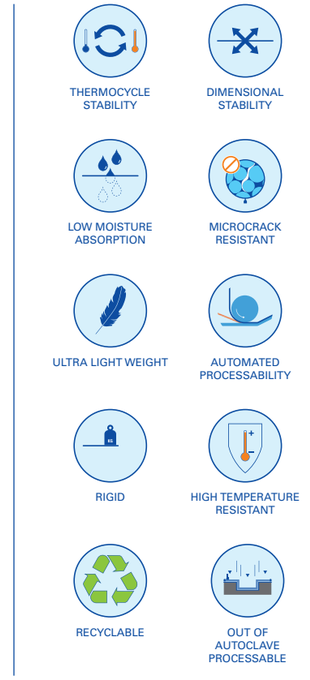
The space industry is experiencing a transformative evolution fueled by cutting-edge technological innovation and the commercialization of launch services. As humanity looks to space as the next frontier, falling launch costs are unlocking unprecedented access, paving the way for advancements ranging from satellite mega-constellations and high-bandwidth communications to next-generation space infrastructure such as space stations, orbital refueling depots, and space-based drones. In this dynamic environment, reliability is crucial, and technical solutions must be both cost-effective and capable of withstanding the extreme conditions of space.

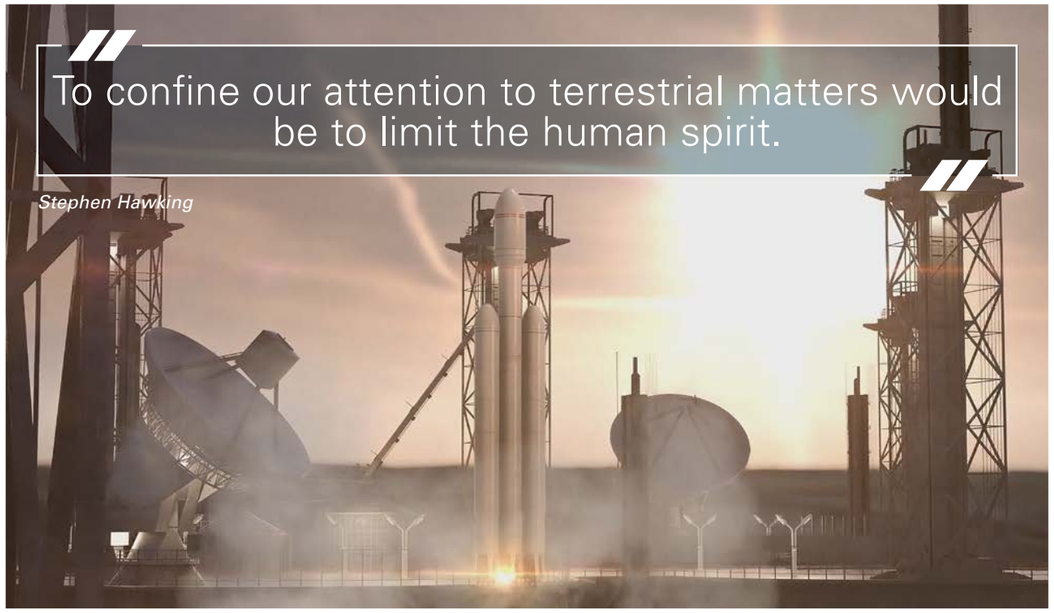
For over 30 years, Toray has been a trusted partner in the space and satellite sector, offering innovative resin and fiber solutions that meet rigorous spaceflight standards for outgassing, radiation resistance, and thermocycling. With our deep expertise, established heritage, and extensive database, we are equipped to tailor material solutions to your specific needs.

Collaborating closely with our customers and staying attuned to shifting market demands, we have built a comprehensive portfolio of advanced material technologies designed for the evolving space industry, including:

- Standard Modulus (SM), Intermediate Modulus (IM), Intermediate Modulus Plus (IM+), and High Modulus (HM) TORAYCA™ carbon fibers
- Toughened thermoset prepregs available in fabric, uni-directional, and slit tape formats
- Epoxy, cyanate ester, bismaleimide, and polyimide resins
- Toray Cetex® thermoplastic composite materials
- Bulk molding compounds and compression molded components

In space, pedigree matters. Failure in deployment is not an option. Our proven track record ensures that we can help you meet the challenges of space with confidence.





Satellite
Product Applications

SUPPORTING EQUIPMENT
Structural panels, deployable booms, struts and tubes hold cameras and antennas. Tight dimensional tolerance requirements enable accurate pointing, clear spacecraft communications and delivery of ultra high definition images of Earth and space.

STIFF | LOW OUTGASSING | DIMENSIONAL STABILITY

ANTENNAS AND REFLECTORS
From small sandwich panel sub reflectors to huge deployable spinning structures, and flat phased arrays meters across, Toray materials meet satellite communication needs. Reflectors demand tight dimensional tolerances for accurate operation.

STIFF | LOW OUTGASSING | THERMAL CYCLE STABILITY

SATELLITE BUS STRUCTURE
Highly stiff and lightweight carbon fiber skinned sandwich panels support and protect the payload inside the satellite through launch, ensuring reliability of operation throughout the lifetime of the mission.

STIFF | LOW OUTGASSING

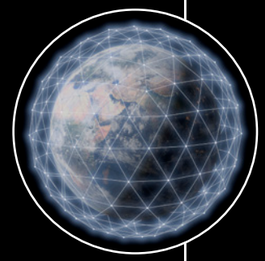
HEAT SINKS
All electronics equipment can generate heat and the satellite payload is no different. There's no convection of heat in the hard vacuum of space, so heat is "dumped" to the outside of the satellite by heat pipes, or sometimes composite plates with highly thermally conductive fibers.

HIGH TEMPERATURE RESISTANT | THERMOCYCLE STABILITY

SOLAR ARRAY PANEL SUBSTRATES
Thin skin sandwich panel structures supporting the solar cells, which provide all of the satellite's power requirements – there are no power sockets in space! For a satellite which maneuvers to generate Earth images, the stiffness of these panels is critical to the timing of how quickly it can take its next picture.

STIFF | LOW OUTGASSING

NEW SPACE, SMALL SATELLITES, AND CONSTELLATIONS IN LEO
As we progress towards smaller satellites and the rise of constellation networks, composite materials remain indispensable. The lightweight yet stiff properties of carbon fiber composite materials enable the creation of smaller, lighter structures, which reduce the load on the satellite supporting structure. This leads to significant mass savings and, in turn, a higher mass capacity and lower launch costs!



Launch Vehicle

Product Applications

PAYLOAD ADAPTORS, INTERSTAGE, SKIRTS, STRUTS, TUBES, LATTICES, STRUCTURAL PANELS
Toray exceptionally durable and microcrack resistant thermosets delivery a lightweight, high-strength structure for landing leg assemblies, secondary tubes, and struts and conduits.

MICROCRACK RESISTANT
LIGHTWEIGHT
STRONG

FAIRINGS, SATELLITE DISPENSERS
The latest generation of launch vehicles utilize TORAYCA™ SM, IM, IM+, HM carbon fibers and out-of-autoclave (OOA) processable prepreg systems for cost-competitive vehicle barrel assemblies, inner and outer stages, satellite dispenser units, and fairings for weight and cost savings.

STIFF
LOW OUTGASSING
THERMAL CYCLE STABILITY

HIGH TEMPERATURE CAPABILITIES, INCLUDING HEATSHIELDS AND OTHER HOT AREAS
Toray's high temperature cyanate ester prepregs create lightweight, thermally stable structures. The high char yield of these materials acts as an ablative, protecting the structure from excessive heat.

THERMAL CYCLE STABILITY
LIGHTWEIGHT
HIGH TEMPERATURE RESISTANT

CRYOGENIC TANKS
Toray high-quality toughened epoxy prepreg systems are ideally suited for high strength, low weight tanks. Retaining toughness at a low temperature, coupled with a low coefficient of thermal expansion (CTE), results in a tank that can perform in the harsh environment of space.

STIFF
LOW OUTGASSING

BACK TO EARTH
Reusability is key to a sustainable future in spaceflight. Toray's toughened and durable materials have a proven track record in the production of reusable components, including landing legs and fins, ensuring reliability and efficiency in every mission.

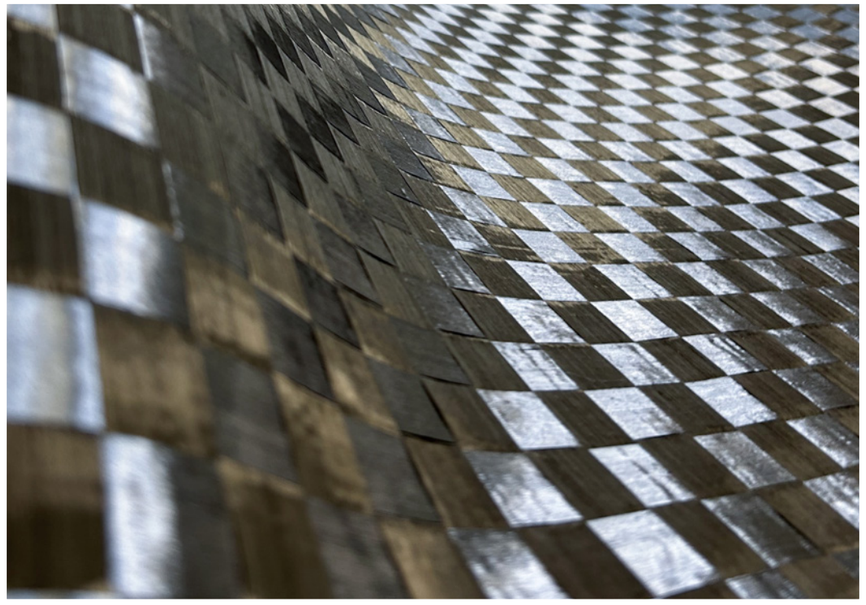
Space, Satellite, & Launch

Product Overview

TORAYCA™ Carbon Fiber

Fiber Type	Tensile Strength ksi (MPa) "	Tensile Modulus Msi (GPa)	Tensile Elongation (%)	Yield (g/1000 m)*	Density (g/cm³)	Number of Filaments					Twist			Sizing Type							Manufacturing Process				Market Segments			
						1K	3K	6K	12K	24K	Twisted	Untwisted	Never Twisted	1	3	4	5	6	7	F	Filament Winding	Pultrusion	Weaving/Braiding	Prepreg	Aerospace & Defense	Automotive	Industrial	Sports & Recreation
T300	512 (3,530)	33.4 (230)	1.50	66 / 198 / 396	1.76	●	●	●			●	●				●	●						●	●	●	●		●
T700S	711 (4,900)	33.4 (230)	2.10	396 / 800 / 1,650	1.80			●	●	●			●				●	●		●	●	●	●	●	●	●	●	●
T700G	711 (4,900)	34.8 (240)	2.00	800	1.80				●				●		●	●	●				●		●	●	●			
T800H	796 (5,490)	42.7 (294)	1.90	223 / 445	1.81			●	●		●	●				●	●						●	●	●		●	
T800S	853 (5,880)	42.7 (294)	2.00	515 / 1,030	1.80				●	●			●	●			●				●	●	●	●	●	●	●	●
T1100S	1,017 (7,000)	47.0 (324)	2.00	505 / 1,010	1.79				●	●			●				●				●				●	●	●	
T1100GC	1,017 (7,000)	47.0 (324)	2.00	505 / 1,010	1.79				●	●			●						●				●	●	●			●
M40J	640 (4,400)	54.7 (377)	1.20	225 / 450	1.77			●	●		●	●					●						●	●	●		●	●
M46J	609 (4,200)	63.3 (436)	1.00	223	1.84			●			●	●					●						●	●	●			●
	583 (4,020)	63.3 (436)	0.90	445	1.84				●		●	●					●						●	●	●		●	●
M55J	583 (4,020)	78.2 (540)	0.80	218	1.91			●				●					●						●	●	●			●
M60J	554 (3,820)	85.3 (588)	0.70	103 / 206	1.93		●	●			●	●					●						●	●	●			●

**Multiple Yield values are for each tow size (number of filaments per tow)*



Space, Satellite, & Launch
Product Overview

Thermoset Prepregs Epoxy

	Resin matrix	Dry Tg onset	Cure time and temperature	Key product characteristics	Outgassing, CTE/ CME or hot/wet data	Public Database	OoA/VBO	Toughened	Low Mositure Absorption	Impact Resistant	High Temperature Performance
2510	Epoxy	131°C (294°F)	132°C (270°F) 2 hours	• Qualified to AMS 3960, 3914, and 3915 • Long freezer life	Wet Tg 131°C (267°F) TML 0.46 % CVCM 0.02 % WVR 0.12 %	AGATE	●				
2511	Epoxy	162°C (324°F)	132°C (270°F) 2 hours	• Qualified to AMS 3962 • Low void content with OOA/VBO • Long freezer life	Wet Tg 118°C (244°F) TML 0.33 % CVCM 0.02 % WVR 0.07 %	CMH-17	●	●	●	●	
2700	Epoxy	163°C (326°F) 200°C (392°F) with post cure	160°C (320°F) 5 minutes (press) 132°C (270°F) 2 hours	• Multi-process flexible system for high volume • Short cure cycles < 5 min • Low void content and optimized tack	Wet Tg 146°C (294°F) TML 0.32 % CVCM <0.01 % WVR 0.06 %		●	●	●	●	●
3900	Epoxy	204°C (400°F)	177°C (350°F) 2 hours	• Qualified to AMS 6891 • Long out life • Legacy commercial aerospace material • 121°C (250°F) hot/wet service • Outstanding toughness"	Wet Tg 166°C (330°F) TML 0.38 % CVCM 0.04 % WVR 0.07 %	CMH-17		●	●	●	●
3960	Epoxy	204°C (400°F)	177°C (350°F) 2 hours	• Long out life, extremely long freezer life • Excellent balance of CAI and OHC properties • 121°C (250°F) hot/wet service • Outstanding toughness	Wet Tg 166°C (330°F) TML 0.38 % CVCM 0.04 % WVR 0.07 %	NCAMP *in progress*	●	●	●	●	●
EX-1522	Modified Epoxy	180°C (356°F)	2 hours at 177°C (350°F)	• Excellent mechanical properties • Good balance of properties between cyanate ester and epoxy • Low D_k and D_L	TML 0.28 % CVCM 0.01 % WVR 0.16 % TML-WVR 0.12 %			●	●		
TC250	Epoxy	140°C (285°F) or 180°C (356°F) with post cure	60 minutes at 88°C (190°F), followed by 2 hours at 130°C (265°F)	• NCAMP qualified • Long out life of 60 days and the ability to post cure makes it ideal for large structures	Wet T_g 125°C (257°F) Cured at 130°C (265°F) TML 0.27 % CVCM 0.01 % WVR 0.32 %		●	●			
RS-36 / RS-36-1	Epoxy	181°C (358°F) 190°C (374°F)	90 minutes at 177°C (350°F)	• ESA qualified for solar array • High toughness • Low moisture absorption	TML 0.4 % CVCM 0.01 % WVR 0.17 % TML-WVR 0.12 %		●	●	●		
TC275-1E	Epoxy	168°C (334°F)	6 hours at 135°C (275°F) Optional post cure of 2 hours at 177°C (350°F	• Long out time version of TC275-1 • Allows construction of thick or larger composites structures • OOA/VBO processable	Wet T_g 136°C (277°F) TML 0.44 % CVCM 0.01 % WVR 0.22 %		●	●	●		
TC350-1	Epoxy	191°C (376°F)	2 hours at 177°C (350°F)	• OOA/VBO processable • Good hot/wet properties	Wet T_g 160°C (320°F) TML 0.55 % CVCM 0.01 % WVR 0.27 %		●	●	●		
TC380	Epoxy	204°C (399°F)	2 hours at 177°C (350°F)	• Extreme toughness for structural and cryogenic applications • Excellent balance of CAI, OHC, and hot/wet properties	TML 0.83 % CVCM 0.01 % WVR 0.75 %		●	●	●		

High Temperature Polyimide and BMI

	Resin matrix	Dry Tg onset	Cure time and temperature	Key product characteristics	Public Database	OoA/VBO	Toughened	Low Mositure Absorption	Impact Resistant	High Temperature Performance
RS-8HT	BMI	203°C (397°F) or 285°C (545°F) with post cure	2 hours at 204°C (400°F) followed by 6 hours at 250°C (482°F)	• Excellent elevated temperature performance • Good moisture resistance				●		
TC890	Polyimide 900HT	454°C (850°F)	Call for cure details	• Non-MDA PMR-15 replacement • Short-term service temperature capability of 538°C (1000°F)						●

Thermoset Prepregs Cyanate Ester

	Resin matrix	Dry Tg onset	Cure time and temperature	Key product characteristics	Outgassing, CTE/CME or hot/wet data	OoA/VBO	Toughened	Low mositure absorption
EX-1515	Cyanate Ester	121°C (249°F) or 174°C (345°F) with post cure	3 hours at 121°C (250°F) Optional post cure of 2 hours at 177°C (350°F)	• Low density • Resistant to microcracking • Low residual stress with 121°C (250°F) cure	TML 0.18 % CVCM 0.01 % CTE 61 ppm/°C		●	●
TC410	Cyanate Ester	112°C (234°F) or 181°C (358°F) with post cure	3 hours at 121°C (250°F) Optional post cure at 177°C (350°F)	• Low CTE 58.4 µm/m/°C • Extremely low CME 1205 µm/m/% • Ideal system for stable structures	TML 0.29 % CVCM < 0.01 % WVR 0.17 % TML-WVR 0.12 %		●	●
BTCy-1A	Cyanate Ester	185°C (365°F) or 207°C (405°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 60 minutes at 204°C (400°F)	• Tough • High Tg	CTE 77 ppm/°C		●	●
RS-3/ RS-3C	Cyanate Ester	191°C (375°F) or 254°C (490°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 60 minutes at 232°C(450°F)	• Extensive qualification portfolio • Low CTE, CME • High stability • RS-3C is controlled-flow version	TML 0.22 % CVCM 0.01 %	●	●	●
TC420	Cyanate Ester	176°C (349°F) or 348°C (658°F) with post cure	3 hours at 177°C (350°F) Optional post cure at 260°C (500°F)	• Good resistance to microcracking • Capable of high-temperature service • Ideal for heat shield and ablative applications	TML 0.41 % CVCM < 0.01% WVR 0.28% CTE 55 ppm/°C	●	●	●

Space, Satellite, & Launch

Product Overview

Toray Cetex® Thermoplastic

	Resin matrix	Melting temperature T_m	Processing temperature T_p	Key product characteristics	Public Database	OoA/VBO	Durability/ Toughness	Low Mositure Absorption	Impact Resistant	High Temperature Performance
TC1225	LMPAEK™ Low-Melt Polyaryle-therketone	305°C (581°F)	340-385°C (644-725°F)	• Lower processing temperature with good high temperature performance • May be overmolded with PEEK for final part • Very good CAI properties 282 MPa (40.9 ksi) • Ideal for structural applications	NIAR NCAMP[1] CMH-17	●	●	●	●	●

[1] *Database is FAA accepted*

RTM Resins

	Resin	Dry T_g onset	Cure time and temperature	Key product characteristics	Toughened	Low Mositure Absorption
EX-1545	Cyanate Ester	173°C (345°F)	2 hours at 177°C (350°F)	• Toughened resin system with low viscosity of 140 cPs at 43°C (110°F) • Long pot life for complex parts		●
RS-16	Cyanate Ester	151°C (304°F) 252°C (486°F) with elevated post cure	2 hours at 135°C (275°F)	• Low-temperature cure resin system • Post curable for higher T_g	●	●
EX-1510	Cyanate Ester	193°C (380°F)	2 hours at 177°C (350°F)	• Low room temperature viscosity of 150 cPs • Post curable for higher T_g		●

Toray Microply™ Film Adhesives Epoxy

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
RS-15H	Epoxy	99°C (211°F)	6 hours at 93°C (200°F) Alternate cures are available	• Low-temperature curing adhesive	●	●	
TC263	Epoxy	110°C (230°F)	2 hours at 121°C (250°F)	• High peel strength • Ideal for metal or composite bonding	●	●	
TC310	Epoxy	157°C (315°F)	2 hours at 177°C (350°F) or 2 hours at 121°C (250°F), followed by 1 hour at 177°C (350°F)	• Ideal composite bonding film adhesive	●	●	

Toray Microply™ Film Adhesives Cyanate Ester

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
EX-1516	Cyanate Ester	126°C (258°F)	5 hours at 121°C (250°F)	• Compatible with Toray EX-1515 prepreg	●	●	●
RS-4A	Cyanate Ester	195°C (383°F) or 238°C (460°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 1.5-2 hours at 232°C (450°F)	• Moisture resistant	●	●	●
EX-1543	Cyanate Ester	191°C (376°F) or 211°C (412°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 2 hours at 204°C (400°F)	• Compatible with 177°C (350°F) curing cyanate ester prepregs • Low shrinkage • Low outgassing	●		●
TC4015	Cyanate Ester	176°C (349°F) or 321°C (610°F) with post cure	2 hours at 177°C (350°F) Optional post cure of > 60 minutes at 232°C (450°F)	• Excellent high-temperature properties • Compatible with TC420	●		●

Toray Microply™ Syntactics Epoxy

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
EM-3	Epoxy	~116°C (240°F)	60 minutes at 121°C (250°F)	• High expansion (8-10 x) • 0.64 g/cc (40 pcf) density • T_g estimated from base resin data			
TCF4035	Epoxy	140°C (284°F)	3 hours at 130°C (265°F)	• Low density 0.64 g/cc (40 pcf) • Compatible with TC250, may be post cured for higher T_g	●	●	

Toray Microply™ Syntactics Cyanate Ester

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
TCF4001	Cyanate Ester	176°C (349°F)	2 hours at 177°C (350°F) Optional post cure of 60-90 minutes at 232°C (450°F)	• Low density 0.38 g/cc (24 pcf)	●		●
TCF4050	Cyanate Ester	176°C (349°F) or 232°C (450°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 60-90 minutes at 232°C (450°F)	• Expanding syntactic film/core splice • Density of 0.28-0.55 g/cc (17-35 pcf) • Compatible with TC420 prepreg system	●	●	●
EM-5A	Cyanate Ester	204°C (400°F)	2 hours at 177°C (350°F) Optional post cure of 60-90 minutes at 232°C (450°F)	• Expansion ratio of 4 x	●		●
EX-1541	Cyanate Ester	227°C (441°F) 240°C (464°F) with post cure	177°C (350°F)—2 hours Optional post cure 232°C (450°F)—2 hours	• Density of 0.16–0.38 g/cc (10–24 pcf) • Good structural properties • Low dielectric constant and loss			●

Space, Satellite, & Launch

Product Overview

Toray Microply™ Syntactics Other Matrices

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
SF-4	BMI	295°C (563°F)	2 hours at 204°C (400°F), then 6 hour post cure at 250°C (452°F)	• Low density 0.62 g/cc (39 pcf) • Compatible with RS-8HT and other BMI systems	●		

BMC Thermoset Epoxy

	Resin Matrix	Dry T_g onset	Cure time and temperature	Key product characteristics	OoA/VBO	Toughened	Low Mositure Absorption
MS-1A	Epoxy	164°C (327°F)	15-30 minutes at 138°C (280°F) followed by post cure of 1-2 hours at 177°C (350°F)	• Chopped fiber epoxy BMC with high-modulus fiber			
MS-1H	Epoxy	191°C (375°F)	15-30 minutes at 138°C (280°F) followed by post cure of 1-2 hours at 177°C (350°F)	• Chopped fiber epoxy BMC with intermediate-modulus fiber			
MS-4H	Epoxy	191°C (375°F)	15-30 minutes at 138°C (280°F) followed by post cure of 1-2 hours at 177°C (350°F)	• Chopped fiber epoxy BMC with high- strength (standard-modulus) fiber			

Toray Cetex® BMC Thermoplastic

	Resin Matrix	Dry Tg onset	Processing temperature	Key product characteristics	OoA/VBO	Durability/ Toughness	Low Mositure Absorption
MC1100	PPS	90°C(194°F)	330°C (626°F)	• PPS based BMC • Fire retardant		●	●
MC1200	PEEK	143°C (290°F)	385°C(725°F)	• PEEK based BMC • Fire retardant		●	●

Toray AmberTool® Composite Tooling Prepregs

	Resin	Neat resin dry T_g onset	T_g PEAK	Typical cure temperature and time	Key product characteristics	Out life # days	Freezer live # months
HX40	Epoxy	203°C (397°F)	229°C (444°F)	65°C (149°F) 12 hours	• Extended out life for larger scale tooling applications • High temperature end use performance • Versatile curing options 50–75°C (122–167°F)	8	12
HX42	Epoxy	219°C (426°F)	234°C (453°F)	60°C (140°F) 8 hours	• Proven system for aerospace • Shorter cure schedule at lower temperatures • Available in carbon reinforcements from 205gsm to 990gsm • Excellent surface finish • 210°C (410°F) end use temperature	5	12

Notes

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