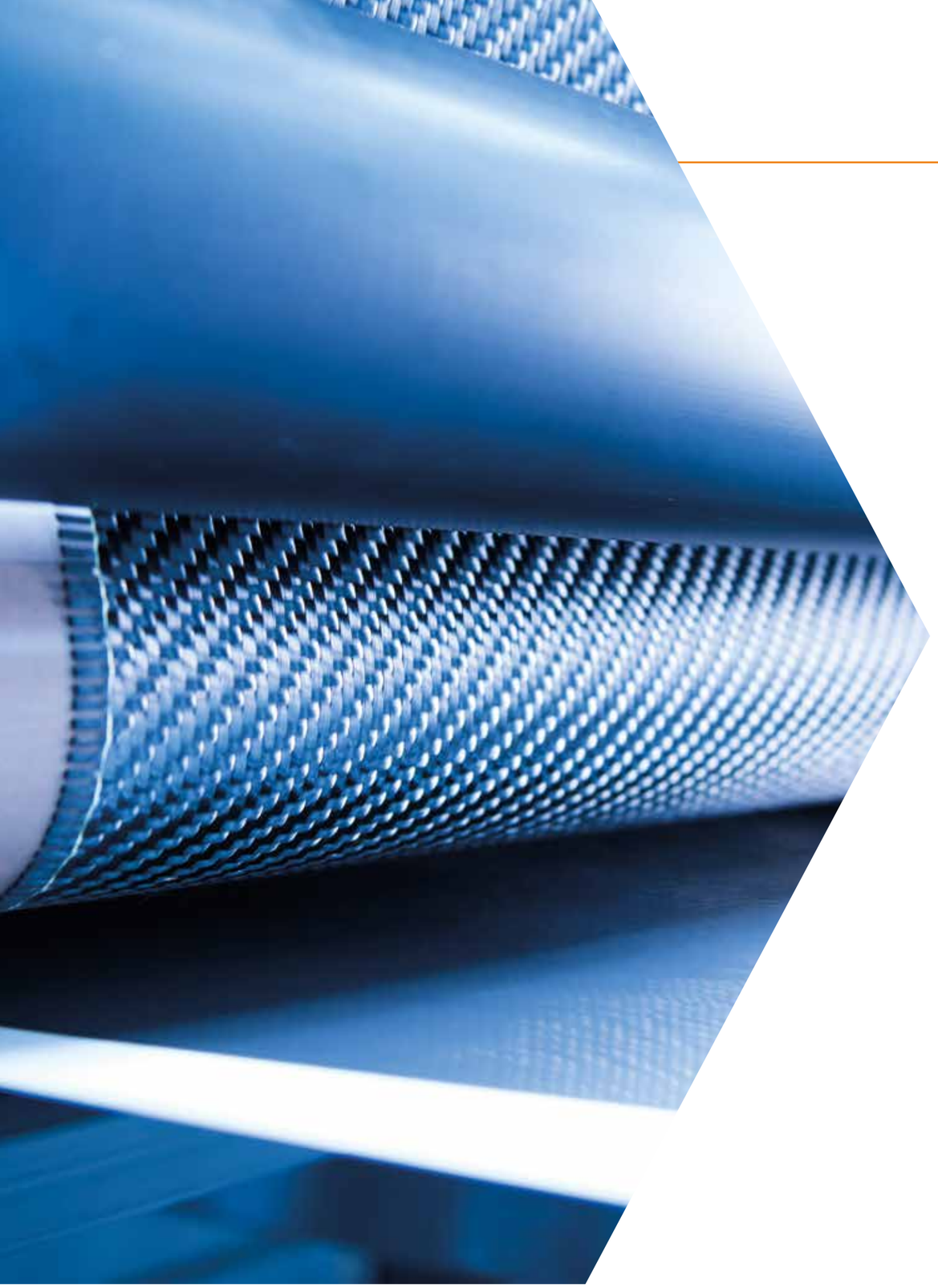
# AEROSPACE

Advanced Composite Materials Selector Guide


## WE CONTRIBUTE TO SOCIETY THROUGH INNOVATIVE IDEAS, TECHNOLOGIES, AND PRODUCTS

'TORAY'

Toray Advanced Composites



*Photos courtesy of Airbus, AgustaWestland, Boeing, Cirrus, General Atomics, US Military, NASA and of the respective companies.*

# INTRODUCTION TO TORAY ADVANCED COMPOSITES

Materials Technology and Capabilities

## MATERIALS TECHNOLOGY AND CAPABILITIES

**Toray Advanced Composites is a global leader in the development and manufacture of a wide range of advanced composite material solutions for aerospace, satellite, communications, and high-performance industrial markets. Our goal is to increase our customers' advantage with our market-leading product portfolio, a world-class technical support team, and award-winning customer service.**

Toray Advanced Composites operates five prepreg manufacturing sites globally, with three facilities in North America and two in Europe. Three of our facilities offer true carbon-free areas to serve the sensitive radome and communication industries with low dielectric constant and low-loss materials. Our major production sites operate aerospace-quality systems and are certified to ISO9001:2015 and/or AS9100D.

Toray Advanced Composites is unique in the industry, offering a broad spectrum of thermoplastic and thermoset prepreg systems, with particular expertise in high-performance thermoplastic composites (under the brand name Toray Cetex®).

## COMPOSITE POLYMERS

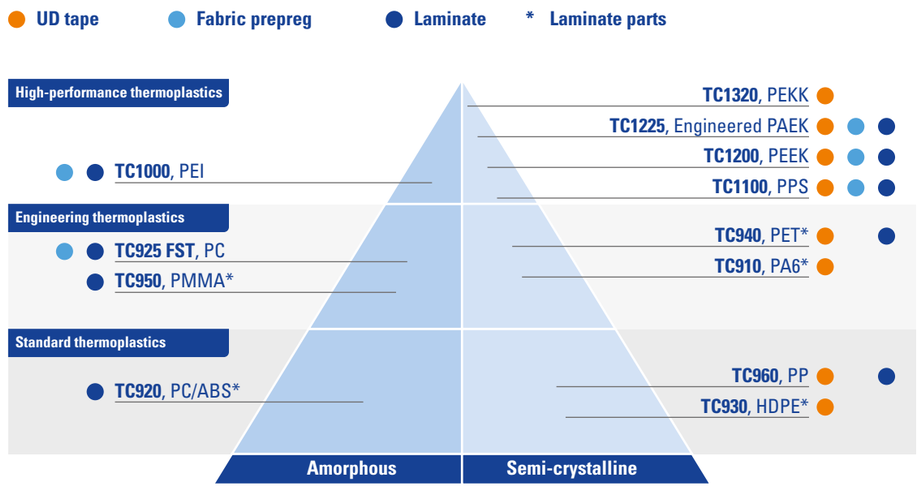
Thermoplastics are polymers that soften upon heating, becoming formable at an elevated processing temperature (often above 200°C/392°F) and return to their solid form upon cooling. Process cycles of only minutes can be achieved, facilitating high-volume manufacturing with heating only taking a matter of seconds. Rapid-closing presses utilizing metal tooling at low pressure are used to preform/form composite material parts.

## THERMOPLASTIC MATRICES

With more than 30 years of heritage, the Toray Cetex® family of thermoplastic composites, ranging through to the Polyaryletherketone (PAEK) family of polymers, are the materials of choice to take your project to new heights.

Cetex®

### OUR HIGH-PERFORMANCE THERMOPLASTIC POLYMERS AND PRODUCT FORMS



# INTRODUCTION TO TORAY ADVANCED COMPOSITES

Materials Technology and Capabilities

## THERMOSET MATRICES

Toray offers epoxy, cynate ester, bis-maleimide (BMI), and polyimide thermoset matrices. Thermosets offer room temperature part lay-up/forming followed by a cure cycle at an elevated temperature, typically 80-180ºC (176-356ºF). Curing is carried out by initiating a polymeric reaction under temperature and pressure through the cure cycle. Once thermosets are cured, they cannot be re-formed.

## INNOVATION

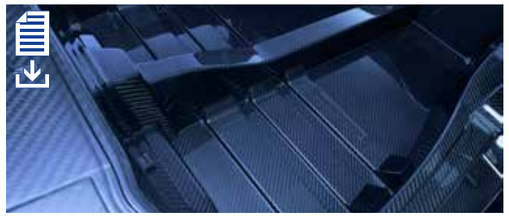
The aerospace industry depends on innovations in new materials and processes from suppliers. Our strong customer focus on tailored systems, combined with our comprehensive laboratory and testing capabilities, allows for rapid development, customization, and database development. Our experience in thermoset and thermoplastic resins, various composite fibers, and part design allows us to rapidly innovate to customer needs. Recognized in the industry for providing optimized fiber and resin solutions, we deliver advanced customer-oriented products to the market.

## YOUR GLOBAL PARTNER

Our state-of-the-art manufacturing facilities around the world allow Toray to efficiently supply composite materials to global customers.

Ongoing investments in facilities and personnel ensure production excellence to meet today's requirements and tomorrow's demand. Stop by and see for yourself. We welcome customer visits, and look forward to the opportunity to work with you on your next project.

Please visit our website to request a print copy of our technical and/or processing guides:
**www.toray**tac.com/processing-guides



Thermosets:
- **Toray Guide to Composites—Volume One**
- **Toray AmberTool® Tooling Prepreg Processing Guide**

Thermoplastics:
- **Toray Cetex® Engineering Guide for Interiors—Thermoplastic Composites**
- **Toray Cetex® Stamp Forming Processing Guide—Thermoplastic UD Tapes**

"TORAY"

Toray Advanced Composites

- 1972 — **the Netherlands** first thermoset prepregging begins
- 1982 — **Europe** first thermoplastic prepregs
- 1990 — **USA** first thermoset aerospace materials
- 1999 — **USA** acquisition of Bryte Technologies
- 2000 — **USA** Morgan Hill, new manufacturing facility
- 2007 — **USA** acquisition of Phoenixx TPC for thermoplastic UD tapes; **the Netherlands** upgrade of presses and capacity for thermoplastics
- 2008 — **USA** acquisition of YLA, Inc. & CCS Composites, LLC for space prepregs and compression molded parts
- 2010 — **USA** substantial increase in thermoplastic UD processing and capacity
- 2011 — **the Netherlands** major investment in thermoplastic processing capacity and technology; **USA** New manufacturing and major investment in new technology and capacity in Fairfield
- 2012 — **USA & Canada** acquisition of PMC/Baycomp for thermoplastics in industrial markets
- 2013 — **UK** acquisition of Amber Composites with leading positions in tooling, automotive, motorsport, and industrial markets; **the Netherlands** major investment in thermoplastic NDT
- 2015 — **USA** Morgan Hill, plant has doubled in size in < 10 years; **UK** following major plant upgrade and expansion by 50%, now Europe´s first carbon-free prepreg facility
- 2016 — **the Netherlands** thermoplastic UD processing capability
- 2018 — Toray Industries Inc. acquires TenCate Advanced Composites

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Aerospace Composite Materials Selector Guide

# AEROSTRUCTURES
Introduction

## OUR OBJECTIVES

| Optimize manufacturing supply chain | Maximize life-cycle performance | Minimize project risk |
|---|---|---|

## AEROSPACE HERITAGE

**Toray Advanced Composites is a leading provider of both thermoset and thermoplastic advanced composite materials to the aerospace industry. The world's leading aerospace programs rely on Toray's advanced composite materials.**

Recognized for partnering in aerospace on emerging programs, and providing optimized fiber and resin solutions, we deliver more than materials. We're dedicated to outstanding customer service and technical support, helping you meet your timelines to ensure program success.

As your partner, we help navigate complex qualifications, provide a selection of optimized material forms, and can perform all necessary qualification and acceptance testing in-house.

Cetex®

Toray Cetex® 1988 30 YEARS 2018

## WHY TORAY

- **Optimize manufacturing shop floor processes** with out-of-autoclave/vacuum-bag-only (OOA/VBO) thermoset prepregs
- **Maximize life-cycle performance** of composite structures through improved part durability with Toray Cetex® thermoplastic prepregs, and toughened thermoset prepregs
- **Minimize project risk** with Toray's tailored technical and customer support

CUSTOMER SERVICE & TECHNICAL SUPPORT

Toray provides complete composite material solutions for your structural applications. Our prepregs are available in uni-directional (UD) tape, slit tape, woven prepreg, and bulk molding compound (BMC) forms. Our Toray Cetex® thermoplastics are also available in ready to use reinforced thermoplastic laminates (RTL), custom oriented to the ply lay-up requested. Along with prepregs, the Toray MicroPly™ product line offers a complete set of compatible film adhesives, composite surfacing films, syntactics, and resins, as well as a full line of tooling prepregs.

For more product information, please use the following resources:

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App Store Google play

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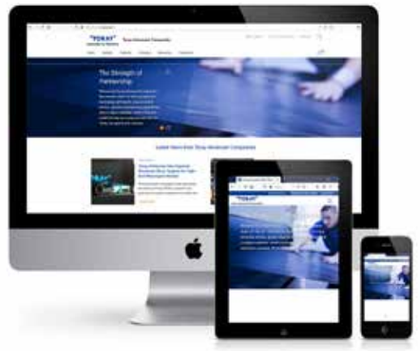
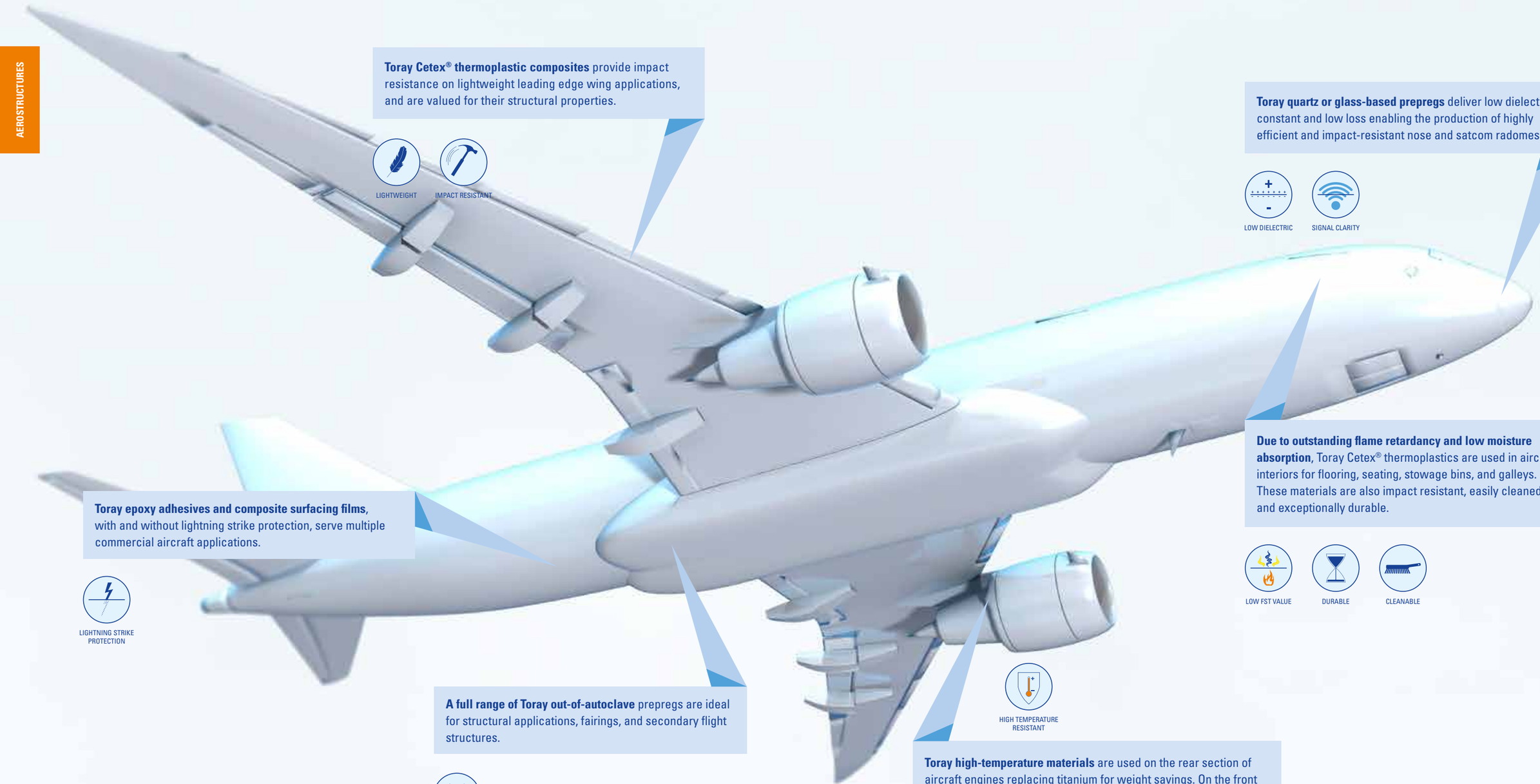


> To invent an airplane is nothing. To build one is something. To fly is everything.

*Otto Lilienthal*

# AEROSTRUCTURES
## Product Applications



**Toray Cetex® thermoplastic composites** provide impact resistance on lightweight leading edge wing applications, and are valued for their structural properties.

LIGHTWEIGHT

IMPACT RESISTANT

**Toray quartz or glass-based prepregs** deliver low dielectric constant and low loss enabling the production of highly efficient and impact-resistant nose and satcom radomes.

LOW DIELECTRIC

SIGNAL CLARITY

**Due to outstanding flame retardancy and low moisture absorption**, Toray Cetex® thermoplastics are used in aircraft interiors for flooring, seating, stowage bins, and galleys. These materials are also impact resistant, easily cleaned, and exceptionally durable.

LOW FST VALUE

DURABLE

CLEANABLE

**Toray epoxy adhesives and composite surfacing films**, with and without lightning strike protection, serve multiple commercial aircraft applications.

LIGHTNING STRIKE PROTECTION

**A full range of Toray out-of-autoclave** prepregs are ideal for structural applications, fairings, and secondary flight structures.

OUT-OF-AUTOCLAVE PROCESSABLE

HIGH TEMPERATURE RESISTANT

**Toray high-temperature materials** are used on the rear section of aircraft engines replacing titanium for weight savings. On the front of the jet engine, Toray Cetex® laminates with micro perforations absorb high-pitched turbine engine sounds.

On the engine nacelle, Toray TC350-1 and high-temperature thermosets are ideal solutions for thrust reversers, engine pylons, and nacelle cowlings.

# AEROSTRUCTURES
Product Overview

## THERMOSET

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | OOA/VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|---|
| BT250E-1 | Epoxy | 125°C (257°F) | 60 minutes at 121°C (250°F) | ▸ MIL-R-9300 qualified<br>▸ Self-adhesive to core | 30 | 12 | ○ | |
| BT250E-6 | Epoxy | 131°C (268°F) | 2 hours at 127°C (260°F) | ▸ FAA conformed database<br>▸ High-modulus system for rotor blades | 30 | 12 | ○ | |
| EX-1522 | Modified Epoxy | 180°C (356°F) | 2 hours at 177°C (350°F) | ▸ Low moisture absorption<br>▸ Excellent mechanical properties | 21 | 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) Optional post cure of 60 minutes at 177°C (350°F) for higher $T_g$ | ▸ NCAMP database on fabric version<br>▸ Good surfacing qualities<br>▸ Self-adhesive to core capability | 30 | 12 | ○ | ○ |
| TC275-1 | Epoxy | 164°C (327°F) or 183°C (362°F) with post cure | 6 hours at 135°C (275°F) Optional post cure of 2 hours at 177°C (350°F) | ▸ Low moisture uptake<br>▸ Hot/wet $T_g$ 136°C (277°F)<br>▸ Ideal system for large structures | 14 | 12 | ○ | ○ |
| TC275-1E **NEW** | Epoxy | 164°C (327°F) or 183°C (362°F) with post cure | 6 hours at 135°C (275°F) Optional post cure of 2 hours at 177°C (350°F) | ▸ Low moisture uptake<br>▸ Hot/wet $T_g$ 136°C (277°F)<br>▸ Ideal system for large structures | 21 | 12 | ○ | ○ |
| TC350-1 | Epoxy | 191°C (376°F) | 2 hours at 177°C (350°F) | ▸ Industry standard 177°C (350°F) epoxy<br>▸ Hot/wet $T_g$ 160°C (320°F)<br>▸ Good CAI 32 ksi (221 MPa) | 45 | 12 | ○ | ○ |
| TC380 **NEW** | Epoxy | 201°C (394°F) | 2 hours at 177°C (350°F) | ▸ High CAI 42 ksi (289 MPa)<br>▸ Excellent open-hole compressive strength 45 ksi (310 MPa)<br>▸ Excellent hot/wet strength retention | 28 | 12 | ○ | ○ |
| 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 high-temperature thermal stability<br>▸ Good moisture resistance<br>▸ Also available as an RTM resin | 30 | 6 | | ○ |
| TC420 | Cyanate Ester | 177°C (350°F) or 348°C (658°F) with post cure | 3 hours at 177°C (350°F). Optional post cure at 260°C (500°F) | ▸ Excellent thermal stability for use on heatshields and supersonic leading edges<br>▸ Epoxy-like processing with $T_g$ of BMI | 21 | 6 | ○ | ○ |
| RS-51 | Polyimide AFRPE-4 | 366°C (690°F) | Call for cure details | ▸ Ultra-high service temperature for jet engine applications | 10 | 6 | | |

## TORAY CETEX® THERMOPLASTIC

| | RESIN MATRIX | PEAK $T_g$ | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | WELDABLE/ JOINTING | TOUGHENED |
|---|---|---|---|---|---|---|
| TC1000 Premium | PEI | 215°C (419°F) | 315°C (600°F) | ▸ OEM qualified<br>▸ Industry-leading mechanical performance<br>▸ Good chemical resistance | ○ | ○ |
| TC1225 | Engineered PAEK | 147°C (297°F)<br>$T_m$ 305°C (581°F) | 325-350°C (615-662°F) | ▸ NCAMP qualification in process<br>▸ Outstanding structural performance<br>▸ Compatible with PEEK for overmolding and welding | ○ | |
| TC1100 | PPS | 90°C (194°F)<br>$T_m$ 280°C (536°F) | 330°C (625°F) | ▸ OEM qualified<br>▸ Microcrack free<br>▸ Low moisture absorption<br>▸ Ideal for leading edges, beams, clips, and floor panels | ○ | ○ |
| TC1320 | PEKK | 159°C (318°F)<br>$T_m$ 337°C (639°F) | 371°C (700°F) | ▸ OEM qualified<br>▸ Outstanding solvent and impact resistance<br>▸ Lower processing temperature material | ○ | ○ |
| TC1200 | PEEK | 143°C (290°F)<br>$T_m$ 343°C (649°F) | 385°C (725°F) | ▸ Continuous processing temperature<br>▸ Good high-temperature properties | ○ | ○ |

## TORAY MICROPLY™ FILM ADHESIVES & COMPOSITE SURFACING FILMS

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | OOA/VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|
| TC263 | Epoxy | 110°C (230°F) | 2 hours at 121°C (250°F) | ▸ High peel strength<br>▸ Ideal for metal or composite bonding | 14 | ○ | ○ |
| TC235SF-1 | Epoxy | 119°C (246°F) | 60 minutes at 121°C (250°F) | ▸ Excellent protective surface finishing film<br>▸ Available with embedded lightning strike foils<br>▸ Reduces shop floor finishing for productivity savings | 14 | ○ | ○ |
| TC310 | Epoxy | 157°C (315°F) | 2 hours at 177°C (350°F) | ▸ Ideal composite bonding film adhesive | 21 | ○ | ○ |
| TC4015 | Cyanate Ester | 177°C (350°F) or 321°C (610°F) with post cure | 2 hours at 177°C (350°F) | ▸ Excellent high-temperature properties<br>▸ Compatible with TC420 | 7 | ○ | ○ |

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

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**www.toray**tac.com
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# AEROSTRUCTURES
Product Overview

## TORAY MICROPLY™ SYNTACTICS AND CORE SPLICES

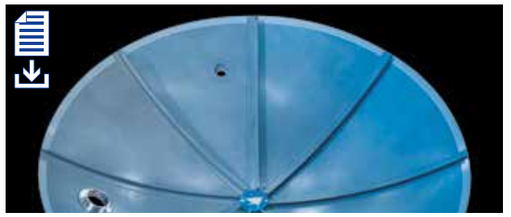
| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | OOA/VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|
| EM-3 | Epoxy | ~116°C (240°F) | 60 minutes at 121°C (250°F) | ▸ High-expansion film (8-10 x)<br>▸ 0.64 g/cc (40 pcf) density<br>▸ $T_g$ estimated from base resin data | 14 | ○ | ○ |
| TCF4035 | Epoxy | 140°C (284°F) | 3 hours at 130°C (265°F) | ▸ Low-density film 0.64 g/cc (40 pcf)<br>▸ Compatible with TC250, may be post cured for higher $T_g$ | 21 | ○ | ○ |
| TCF4045 | Epoxy | 180°C (356°F) | 3 hours at 179°C (355°F) | ▸ Density of 0.61 g/cc (38.5 pcf)<br>▸ Excellent low-dielectric syntactic film | 14 | ○ | ○ |
| TCF4001 | Cyanate Ester | 177°C (350°F) | 2 hours at 177°C (350°F) Optional post cure of 60-90 minutes at 232°C (450°F) | ▸ Low-density paste 0.38 g/cc (24 pcf) | 14 | ○ | |
| 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<br>▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ Compatible with TC420 prepreg system | 7 | ○ | ○ |
| SF-4 | BMI | 295°C (563°F) | 2 hours at 204°C (400°F), then 6 hours post cure at 250°C (452°F) | ▸ Low-density expanding film 0.62 g/cc (39 pcf)<br>▸ Compatible with RS-8HT and other BMI systems | 14 | ○ | |

## RTM RESINS

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | POT LIFE | OOA/VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|
| EX-1510 | Cyanate Ester | 193°C (380°F) | 2 hours at 177°C (350°F) | ▸ Low viscosity of 150 cPs at 25°C (77°F)<br>▸ 2-part system with 4-hour pot life | 4 hrs | | |
| RS-50 | Epoxy | 203°C (397°F) | 2 hours at 177°C (350°F) | ▸ Low minimum viscosity of 23 cPs<br>▸ 1-part system with 4-hour pot life | 4 hrs | | ○ |

## LEARN MORE ABOUT THE USE OF OUR PRODUCTS IN AEROSTRUCTURES

Find these case studies and more at **www.toray**tac.com/success-stories



**World's First Thermoplastic Rear Pressure Bulkhead**
Featured products: ▸ **Toray Cetex® TC1100/PPS**

**Structural Thermoset Prepregs for Kopter Group**
Featured products: ▸ **Toray TC275-1**
▸ **Toray BT250E-6**

**Cure Capable Mandrel for Aerospace Structures**
Featured products: ▸ **Toray AmberTool® HX42**

**Airbus A400M Thermoplastic Ice Protection Plate**
Featured products: ▸ **Toray Cetex® TC1100/PPS**

**Thermoplastic Upper Spar for an Aircraft Engine Pylon**
Featured products: ▸ **Toray Cetex® TC1320/PEKK**


**Hybrid Thermoplastic Tail Rudder Technology Demonstrator**
Featured products: ▸ **Toray Cetex® TC1100/PPS reinforced thermoplastic laminates (RTLs)**
▸ **MC1000 bulk molding compounds (BMCs)**

## READ OUR RECENTLY PUBLISHED ARTICLES ON PARTNERSHIPS AND PROJECTS

Find these articles and more at **www.toray**tac.com/literature

**Thermoplastic Affordable Primary Structures (TAPAS) 2 Consortium** *(published in Composites World)*

**Thermoplastic Composites Technology: A View from Europe**
*(published in Composites World)*
Bringing thermoplastic manufacturability to maturity is the goal of the ThermoPlastic composites Research Center (TPRC)





AEROSTRUCTURES

# SPACE, SATELLITE, & LAUNCH
Introduction

Credit: Airbus Defence and Space

## OUR OBJECTIVES

| Connecting the planet | Furthering scientific understanding | Reducing weight | High reliability |
|---|---|---|---|
| ▲ | ▲ | ▼ | ▲ |

## SPACE FLIGHT HERITAGE

**With more than 25 years of space flight heritage, Toray Advanced Composites is the undisputed leader in developing and manufacturing cutting-edge, high-reliability materials for the space market. Our products are found on most satellites, spacecraft, and planetary rovers launched from the Western world. No other materials company offers the pedigree, experience, or breadth of product knowledge to meet the demanding needs of the space, launch, and satellite industry.**

In partnership with our customers and with a close eye to evolving market needs, we have developed a comprehensive product portfolio of industry-leading resin systems for use on high-modulus PAN and pitch carbon fiber and specialty fabrics, as well as standard reinforcements.

## COMMERCIAL SATELLITES AND LAUNCH VEHICLES

We continue to develop and serve our long-standing customers, who are building ever larger telecommunications satellites to accommodate more powerful and sophisticated payloads - offering higher resolution, more deployable structures, and larger, more accurate reflectors.

Toray also offers a full range of products to meet the demands of today's heavy-lift commercial launch vehicles being utilized today to send high-value missions reliably into space.

## SCIENCE AND EXPLORATION

Our next generation materials support science missions, going further than ever before to unlock the secrets of the universe. Tomorrow's spacecraft will journey to more aggressive, hotter, and colder environments, and with greater numbers of planetary rovers and landers. Toray's materials are also playing a key role in sending humans to Mars.

## NEW SPACE

Today's rapidly emerging New Space market is bringing new opportunities to meet material demands for mass-produced satellite constellations, small launch-on-demand vehicles, and swarms of high-flying pseudo-satellite drones. New Space will bring internet connectivity, new science, and big data to billions more people.

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> To confine our attention to terrestrial matters would be to limit the human spirit.
>
> *Stephen Hawking*





SPACE, SATELLITE, & LAUNCH

# SATELLITE
Product Applications



**HEAT SINKS** Composite plates and tubes are manufactured with Toray highly conductive pitch-based carbon fiber prepregs. These unique materials provide superior thermal conductivity to channel heat from electrical components. Toray prepreg systems for these applications are designed to withstand high temperatures while providing exceptional resistance to the effects of thermocycling.

HIGH TEMPERATURE RESISTANT

THERMOCYCLE STABILITY

**REFLECTORS AND ANTENNAS** Toray space flight-approved cyanate ester and epoxy systems utilize high-modulus carbon fiber and specialized weaves. These materials are designed to deliver low CTE on reflectors, antennas, and deployable structures over space temperature extremes.

LIGHTWEIGHT

HIGH TEMPERATURE RESISTANT

THERMOCYCLE STABILITY

**SOLAR ARRAY, BOOMS, AND TRUSSES** These satellite applications utilize Toray high-modulus carbon fibers with resins that provide low coefficients of thermal expansion (CTE), low coefficients of moisture expansion (CME), low outgassing, and radiation resistance.

LIGHTWEIGHT

RIGID

**PRECISION STRUCTURES** Toray materials protect the payload during launch and resist moisture to prevent outgassing in orbit. Toray high-modulus PAN or pitch-based carbon fiber prepregs are utilized for strength, stiffness, and light weight. Structures made from Toray products, including benches for optics and instrumentation, withstand extreme conditions in space, including thermal cycling, atomic oxygen, and radiation.

LOW MOISTURE ABSORPTION

THERMOCYCLE STABILITY

# LAUNCH VEHICLE
Product Applications

**BARREL FUSELAGE ASSEMBLIES, PAYLOAD SHROUDS, AND FAIRINGS**
The latest generation of launch vehicles utilize Toray out-of-autoclave (OOA) processable prepreg systems for cost-competitive vehicle barrel assemblies, inner and outer stages, payload shrouds, and fairings for weight and cost savings.

OUT-OF-AUTOCLAVE PROCESSABLE

LIGHTWEIGHT

**CRYOTANKS** Launch vehicle cryotanks utilize Toray toughened epoxies to provide high strength, low weight tanks.

STRONG

**STRUTS AND TUBES** Toray exceptionally durable and microcrack-resistant thermosets deliver a lightweight, high-strength structure for landing leg assemblies, secondary tubes, and struts and conduits.

MICROCRACK RESISTANT

LIGHTWEIGHT

HIGH TEMPERATURE RESISTANT

THERMOCYCLE STABILITY

LIGHTWEIGHT

HIGH TEMPERATURE RESISTANT

**HEATSHIELDS** Toray high-temperature cyanate ester prepregs create lightweight, thermally stable structures.



# SPACE, SATELLITE, & LAUNCH
Product Overview



## THERMOSET PREPREGS EPOXY

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUTGASSING, CTE/ CME OR HOT/WET DATA | OOA/VBO | TOUGHENED | LOW MOSITURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|
| EX-1522 | Modified Epoxy | 180°C (356°F) | 2 hours at 177°C (350°F) | ▸ Excellent mechanical properties<br>▸ Good balance of properties between cyanate ester and epoxy<br>▸ Low $D_k$ and $D_L$ | TML 0.28 %<br>CVCM 0.01 %<br>WVR 0.16 %<br>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<br>▸ Long out life of 60 days and the ability to post cure makes it ideal for large structures | Wet $T_g$<br>125°C (257°F)<br>Cured at 130°C (265°F) | ○ | ○ | | | ○ |
| RS-36 / RS-36-1 | Epoxy | 181°C (358°F)<br>190°C (374°F) | 90 minutes at 177°C (350°F) | ▸ ESA qualified for solar array<br>▸ High toughness<br>▸ Low moisture absorption | TML 0.4 %<br>CVCM 0.01 %<br>WVR 0.17 %<br>TML-WVR 0.12 % | ○ | ○ | ○ | ○ | |
| TC275-1 | Epoxy | 164°C (327°F) or 183°C (362°F) with 177°C (350°F) post cure | 6 hours at 135°C (275°F) Optional post cure of 2 hours at 177°C (350°F) | ▸ Ideal for large structure fabrication<br>▸ Low density<br>▸ Excellent toughness for impact resistance | Wet $T_g$<br>136°C (277°F) | ○ | ○ | ○ | ○ | ○ |
| TC275-1E **NEW** | 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<br>▸ Allows construction of thick or larger composites structures<br>▸ OOA/VBO processable | | ○ | ○ | ○ | ○ | ○ |
| TC350-1 | Epoxy | 191°C (376°F) | 2 hours at 177°C (350°F) | ▸ OOA/VBO processable<br>▸ Good hot/wet properties | Wet $T_g$<br>160°C (320°F) | ○ | ○ | ○ | | ○ |
| TC380 **NEW** | Epoxy | 204°C (399°F) | 2 hours at 177°C (350°F) | ▸ Extreme toughness for structural and cryogenic applications<br>▸ Excellent balance of CAI, OHC, and hot/wet properties | TML 0.83 %<br>CVCM 0.01 %<br>WVR 0.75 % | ○ | ○ | ○ | | ○ |

## THERMOSET PREPREGS BMI

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | TOUGHENED | LOW MOSITURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ Good moisture resistance | | | ○ | | ○ |

# SPACE, SATELLITE, & LAUNCH
Product Overview

## THERMOSET PREPREGS CYANATE ESTER

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUTGASSING, CTE/ CME OR HOT/WET DATA | OOA/VBO | TOUGHENED | LOW MOSITURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ Resistant to microcracking<br>▸ Low residual stress with 121°C (250°F) cure | TML 0.18 %<br>CVCM 0.01 %<br>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<br>▸ Extremely low CME 1205 µm/m/%<br>▸ Ideal system for stable structures | TML 0.29 %<br>CVCM < 0.01 %<br>WVR 0.17 %<br>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<br>▸ High $T_g$ | 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<br>▸ Low CTE, CME<br>▸ High stability<br>▸ RS-3C is controlled-flow version | TML 0.22 %<br>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<br>▸ Capable of high-temperature service<br>▸ Ideal for heat shield and ablative applications | TML 0.41 %<br>CVCM < 0.01%<br>WVR 0.28%<br>CTE 55 ppm/°C | ○ | ○ | ○ | ○ | ○ |

## RTM RESINS

| | RESIN | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | TOUGHENED | LOW MOSITURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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)<br>▸ Long pot life for complex parts | | | | ○ | |
| RS-16 | Cyanate Ester | 167°C (332°F) or 231°C (448°F) with post cure | 2 hours at 135°C (275°F) followed by 2 hours at 150°C (300°F) | ▸ Low-temperature cure resin system<br>▸ 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<br>▸ 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 | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ Ideal for metal or composite bonding | ○ | ○ | | ○ | ○ |
| TC310 | Epoxy | 157°C (315°F) | 2 hours 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 | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ Low shrinkage<br>▸ 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<br>▸ 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 | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| EM-3 | Epoxy | ~116°C (240°F) | 60 minutes at 121°C (250°F) | ▸ High expansion (8-10 x)<br>▸ 0.64 g/cc (40 pcf) density<br>▸ $T_g$ 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)<br>▸ Compatible with TC250, may be post cured for higher $T_g$ | ○ | ○ | | | ○ |

SPACE, SATELLITE, & LAUNCH

# SPACE, SATELLITE, & LAUNCH
Product Overview

## TORAY MICROPLY™ SYNTACTICS CYANATE ESTER

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | TOUGHENED | LOW MOISTURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ 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 | ○ | | | ○ | |

## TORAY MICROPLY™ SYNTACTICS OTHER THERMOSET MATRICES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | TOUGHENED | LOW MOISTURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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)<br>▸ 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 MOISTURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| 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 $T_g$ ONSET | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | DURABILITY/ TOUGHNESS | LOW MOISTURE ABSORPTION | SPACE/ SATELLITE | LAUNCH |
|---|---|---|---|---|---|---|---|---|---|
| MC1100 | PPS | 90°C(194°F) | 330°C (625°F) | ▸ PPS based BMC<br>▸ Fire retardant | | ○ | ○ | ○ | ○ |
| MC1200 | PEEK | 143°C (290°F) | 385°C(725°F) | ▸ PEEK based BMC<br>▸ Fire retardant | | ○ | ○ | ○ | ○ |

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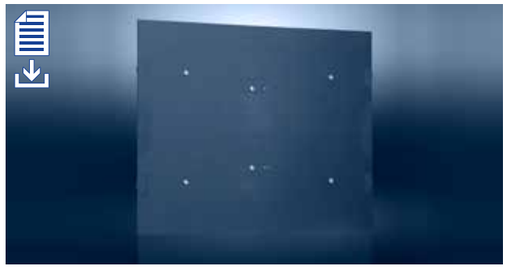

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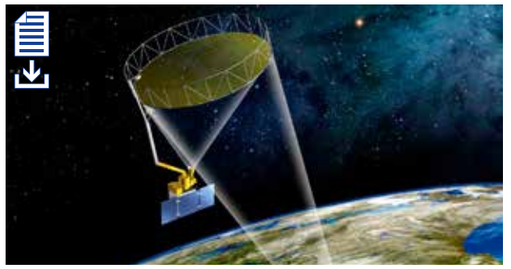

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# RADOME ANTENNA SYSTEMS
Introduction



## OUR OBJECTIVES

- Highly reliable system performance
- The right materials for complex communication systems
- Connecting and protecting people

## WORLD-LEADING RADOME COMPOSITE MATERIALS

**Toray Advanced Composites is the world's leading supplier of advanced composite materials for the high-performance radome and antenna industry. Our advanced composite radome materials are made in clean, controlled facilities, isolated from carbon and conductive particles, using state-of-the-art processing technology.**

Toray's advanced composite materials are used with confidence in military and commercial aircraft, ship, rail, and ground-based systems, including conformal or "patch" antennas, satellite RF components, microwave transparent, and radar absorbing structures.

Popular reinforcements such as E-glass, S-glass, quartz, aramid, and HDPE are fully compatible with Toray's advanced resin systems and can be supplied as prepregs, adhesive, and syntactics to satisfy the most demanding electrical, mechanical, and high-temperature applications.

## TORAY OFFERS:

- **Low dielectric constant and low-loss materials** for industry leading electromagnetic performance
- An **extensive materials database** of mechanical and electrical properties (0-60 GHz)
- **Carbon-free production** facilities in both the USA and the UK
- A **strong commitment to innovation** and technical support for the demands of this unique sector

*Carbon-free production line (Langley Mill - UK)*


LOW DIELECTRIC


HIGH PERFORMANCE

Clear satcom and ground to air communication are essential to commercial and military aircraft operations. In flight, it is not uncommon for a military aircraft to operate more than fifteen antennas with multiple functions including weather detection, satcom, ground communication, ground imagery, target acquisition, fire control, jammer pods, altitude monitoring, etc. With the largest database from 10-60 GHz, Toray materials possess the necessary attributes for the fabrication of the lightweight, most effective radome design.

## TREND TOWARD HIGHER FREQUENCIES

Increasingly, antenna systems are multifunctional, operating "broadband" over a number of different frequencies, with a trend toward the higher frequency bands. Not only are the lower frequency bands simply filling up, but operating at a higher frequency or over multiple frequencies allows high-speed transmission of "big data." Airlines can send and transmit data enabling the "connected aircraft" in real time. Passenger streaming of video onboard is now feasible with Ku, K, and Ka-band communications.

Increased antenna system sophistication drives complexity in the radome design, requiring C-sandwich and B-sandwich constructions for Wi-Fi radomes, necessitating higher-performance advanced composite materials. Toray materials are widely used in these sophisticated high-energy applications delivering both electrical effectiveness and protection of sensitive electronics.

To learn more about the fabrication of the General Dynamics LiveTV multiband satcom radome used by commercial airlines to bring Wi-Fi to passengers, read the online article titled "Composites aid connectivity for commercial aircraft" at **www.toray**tac.com/literature

> "What is sure is that the satellite view of our world and its evolution is now a common reality."

*Olivier Theyskens*

# RADOME ANTENNA SYSTEMS
## Product Applications



**SATCOM ANTENNA RADOME SYSTEM** Toray materials in satcom deliver high bandwidth clarity while providing excellent impact resistance to bird strike events. These material systems are utilized in almost all commercial aircraft broadband satcom applications and are relied upon in military aircraft and UAVs to deliver high-frequency signals for real-time high bandwidth communication.

**NOSE RADOME** Toray products meet the cost targets and impact resistance necessary in protection of ground to air communications for commercial aircraft navigation.

LOW DIELECTRIC

LOW LOSS


SIGNAL CLARITY

LOW DIELECTRIC

HIGH PERFORMANCE

**RADOME ANTENNA SYSTEMS** Toray materials are available in several configurations from epoxy/glass to cyanate/quartz to optimize the needs specific to various antennas positioned over several parts of an aircraft body including conformal and patch antenna systems.

**A Radome (radar dome) is a cover designed to protect an antenna system from the environment, while providing aerodynamics, lightning strike protection, and stealthy attributes. Selecting the right composite materials are crucial to maintaining the symbiotic performance of the radome antenna system that Toray products deliver.**

**NOSE RADOME** of the military aircraft; high frequency for fire control; electronic jamming systems, providing supersonic aerodynamics; stealthy attributes; lightning strike protection.



LOW DIELECTRIC


SIGNAL CLARITY

# RADOME ANTENNA SYSTEMS
Product Overview



## TORAY MICROPLY™ SYNTACTIC FILMS

| | RESIN TYPE | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | Material at 10 GHz: DIELECTRIC CONSTANT ($D_k$) | Material at 10 GHz: LOSS TANGENT (DF) | OOA /VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|---|
| SF-5 | Cyanate Ester | 193°C (380°F) or 254°C (490°F) with post cure | 2 hours at 177°C (350°F) Optional post cure of 2 hours at 232°C (450°F) | ▸ Density of 0.61 g/cc (38 pcf)<br>▸ Low dielectric constant and loss<br>▸ Compatible with Toray RS-3 | 1.70* | 0.004 | | |
| TCF4045 | Epoxy | 180°C (356°F) | 3 hours at 179°C (355°F) | ▸ Density of 0.61 g/cc (38.5 pcf)<br>▸ Good high-temperature properties | 1.57 | 0.008 | ○ | ○ |
| TCF4035 | Epoxy | 140°C (284°F) | 3 hours at 130°C (265°F) | ▸ Low density 0.64 g/cc (40 pcf)<br>▸ Compatible with TC250, may be post cured for higher $T_g$ | 1.94 | 0.018 | ○ | ○ |
| 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) | ▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ Expanding 2-4 x<br>▸ Compatible with TC420 prepreg system | N/A | N/A | ○ | ○ |

* SF-5 tested at 18 GHz

## TORAY MICROPLY™ FILM ADHESIVES

| | RESIN TYPE | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | Material at 10 GHz: DIELECTRIC CONSTANT ($D_k$) | Material at 10 GHz: LOSS TANGENT (DF) | OOA /VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|---|
| EX-1516 | Cyanate Ester | 126°C (258°F) | 5 hours at 121°C (250°F) | ▸ Compatible with Toray EX-1515 prepreg | 2.6 - 2.7 | 0.005 - 0.006 | ○ | ○ |
| 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) | ▸ Low-shrinkage cyanate ester film adhesive<br>▸ Low outgassing | 2.72 | 0.009 | ○ | ○ |
| TC310 | Epoxy | 157°C (315°F) | 2 hours at 177°C (350°F) | ▸ Ideal composite bonding film adhesive | 3.06 | 0.013 | ○ | ○ |
| TC263 | Epoxy | 110-115°C (230-239°F) | 2 hours at 121°C (250°F) | ▸ High peel strength<br>▸ Ideal for metal or composite bonding | 2.97 | 0.017 | ○ | ○ |
| 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 cyanate ester film adhesive | N/A | N/A | ○ | ○ |
| 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 for > 60 minutes at 232°C (450°F) | ▸ Excellent high-temperature properties<br>▸ Service temperature of 232°C (450°F) after post cure<br>▸ Compatible with TC420 | N/A | N/A | ○ | ○ |

## TORAY MICROPLY™ SYNTACTIC PASTES

| | RESIN TYPE | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | Material at 10 GHz: DIELECTRIC CONSTANT ($D_k$) | Material at 10 GHz: LOSS TANGENT (DF) | OOA /VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|---|
| EX-1541 | Cyanate Ester | 227°C (441°F) or 240°C (464°F) with post cure | 2 hours at 177°C (350°F) Optional post cure of 2 hours at 232°C (450°F) | ▸ Density of 0.16-0.38 g/cc (10-24 pcf)<br>▸ Good structural properties<br>▸ Low dielectric constant and loss | 1.32 | 0.009 | | |
| 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 0.35-0.42 g/cc (22-26 pcf)<br>▸ Mechanical properties achieved through OOA/VBO processing | 1.55 | 0.012 | ○ | |

## THERMOSET PREPREGS**

| | Resin type | DRY $T_g$ ONSET | Cure time and temperature | KEY PRODUCT CHARACTERISTICS | Quartz laminate at 10 GHz: DIELECTRIC CONSTANT ($D_k$) | Quartz laminate at 10 GHz: LOSS TANGENT (DF) | OOA /VBO | TOUGHENED |
|---|---|---|---|---|---|---|---|---|
| BTCy-2 | Cyanate Ester | 191°C (375°F) | 1.5 hours at 177°C (350°F) | ▸ Toray's lowest dielectric loss prepreg<br>▸ Ideal for high-energy radomes | 3.28 | < 0.001 | | |
| 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) | ▸ Toughened version of BTCy-1<br>▸ Low-void content with lower pressure cures<br>▸ Ideal for radome applications | 3.33 | 0.001 | | ○ |
| BTCy-1 | Cyanate Ester | 190°C (374°F) or 238°C (461°F) with post cure | 90 minutes at 177°C (350°F) Optional post cure of 2 hours at 232°C ( 450°F) | ▸ Low moisture absorption<br>▸ Low dielectric constant and loss | 2.7-2.8 at 18 GHz | 0.003 | | |
| 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) | ▸ Epoxy-like processing and handling<br>▸ 121°C (250°F) cure for low residual stresses<br>▸ Post curable for higher $T_g$ | 3.20 | 0.004 | | ○ |
| BT250E-1 | Epoxy | 125°C (257°F) | 60 minutes at 121°C (250°F) | ▸ MIL-R-9300 qualified<br>▸ BT250E-1FR is the flame retardant version | 3.26 | 0.008 | ○ | |
| 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) | ▸ Low dielectric constant and loss<br>▸ Toray RS-3C is a flow modified version | 3.19 | 0.009 | ○ | ○ |
| TC420 | Cyanate Ester | 177°C (350°F) or 348°C (658°F) with post cure | 3 hours at 177°C (350°F) Optional post cure at 260°C (500°F) | ▸ Excellent thermal stability<br>▸ Epoxy-like processing with $T_g$ of BMI | 3.39 | 0.009 | ○ | ○ |
| EX-1522 | Modified Epoxy | 180°C (356°F) | 2 hours at 177°C (350°F) | ▸ Low moisture absorption<br>▸ Low dielectric constant and loss | 3.36 | 0.011 | | ○ |
| 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) Optional post cure of 60 minutes at 177°C (350°F) for higher $T_g$ | ▸ Highly toughened system<br>▸ Post curable for higher $T_g$ | 3.49 | 0.012 | ○ | ○ |
| 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 high-temperature thermal stability<br>▸ Good moisture resistance | 3.49 | 0.014 | | |
| TC522 **NEW** | Modified Epoxy | 189°C (372°F) | 2 hours at 180°C (356°F) | ▸ Outstanding compression after impact<br>▸ Low dielectric constant and loss<br>▸ Outstanding hot/wet properties | 3.33 | 0.004 | ○ | ○ |

** In order of laminate loss tangent at 10 GHz using ASTM D2520 Method A.

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the **Toray TAC Product Selector**

**www.toray**tac.com/radomes
Go to our online resource center for case studies and technical papers





RADOME ANTENNA SYSTEMS

## OUR OBJECTIVES

| Reduce weight | Good durability | Excellent FST performance | Improve cost-effectiveness |
|---|---|---|---|



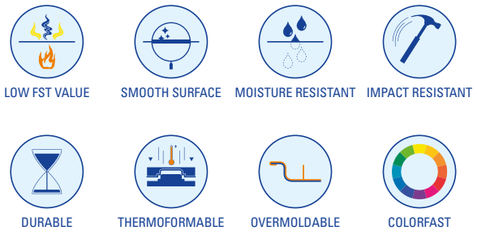
Cetex®

## SHAPING THE FUTURE OF COMMERCIAL AND CORPORATE AIRCRAFT INTERIOR COMPOSITES

**Toray Advanced Composites offers market-leading fire-retardant advanced composites for the aircraft interiors industry. Across the industry, experts use Toray lightweight composite materials in a wide variety of aerospace interior applications to maximize mechanical durability, eliminate secondary operations, and deliver optimal FST safety.**

The Toray Cetex® brand of differentiated reinforced thermoplastic laminates (RTL) and uni-directional (UD) tapes are used in a wide variety of aircraft interior applications, ranging from flooring and cabin seating, to stowage bins and galleys. Thermoplastic composites, reinforced with glass or carbon fibers provide:

- Extremely low FST and OSU properties (OSU < 25/25)
- High-quality surface finishes, substantially reducing the need for filling and sanding before application of decorative trims or sublimation printing
- Excellent moisture resistance leading to improved durability
- Very tough surfaces for improved impact and wear performance, enabling long-term durability
- Fast manufacturing cycles, providing press forming in minutes
- Part count reduction: Overmolding thermoplastics enables consolidation of parts and integration of mechanical fixtures
- Component coloring: An option to deliver “base color” for applications




Tailored to your application needs, Toray Cetex® laminates are consolidated as a single or multi-ply construction to maximize functionality. The RTL semi-finished product incorporates tailored fiber lay-ups, color, and a surface finish ready for service.

**Toray Cetex® TC925 FST** – Polycarbonate (PC) resins provide a cost-effective solution that combines strong FST and OSU results with excellent impact performance.

**Toray Cetex® TC1000** – Polyetherimide (PEI) resins provide optimum FST and OSU performance, coupled with superior chemical resistance and ideal secondary operation compatibility (welding, jointing, and painting).

**Toray Cetex® TC1100** – Polyphenylene Sulfide (PPS) provides outstanding solvent resistance for structural applications and ideal FST performance.

**Toray Cetex® TC1225** – Polyaryletherketone (PAEK) resin, (part of PEEK family) offers outstanding structural and thermal performance and compatibility to PEEK for injection overmolding and welding.

Materials can be provided as prepreg rolls or consolidated laminates (RTL) with a format of 3.66 m x 1.22 m (12’ x 4’)

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the Toray TAC Product Selector
Available on the App Store · Google play

**www.toray**tac.com/interiors
Go to our online resource center for product data sheets and technical resources.

> “...it’s an important seat – because you’re in it.”
>
> *Donald Burr*

AIRCRAFT INTERIORS

# AIRCRAFT INTERIORS
## Product Applications



**STORAGE BINS** In an industry where weight and impact performance is paramount, Toray Cetex® is the ultimate solution. Exceptionally durable and lightweight for hardwearing bin surfaces and linings, we also offer an embedded color, eliminating secondary painting and finishing requirements.

DURABLE COLORFAST

**CABIN LININGS** Offering high impact resistance and exceptional durability, Toray Cetex® offers near perfect demold performance, maximizing efficiency for trim by minimizing post-processing (sand/sweep) operations.

SMOOTH SURFACE IMPACT RESISTANT

**DUCTING** For ultimate flow rate performance, Toray Cetex® thermoplastics offer the lowest porosity levels in the lightest materials available. Used in low-pressure systems across the world, our laminates are rolled and seam welded for maximum efficiency.

LIGHTWEIGHT WELDABLE

**CEILING LININGS** Lightweight and stiff, Toray Cetex® thermoplastics offer near-perfect demold performance, maximizing efficiency for large surfaces by minimizing post-processing (sand/sweep) operations.

LIGHTWEIGHT STIFF

**GALLEYS** High-volume and wear applications such as galleys and dividers demand resilient low-maintenance performance. With Toray Cetex® thermoplastics in-color and high moisture barrier technology, your workspace now has new possibilities.

LOW FST VALUE COLORFAST

**CARGO LININGS** With excellent FST performance and exceptional durability, Toray Cetex® thermoplastics offer near-perfect demold performance, maximizing efficiency for large surfaces by minimizing post-processing (sand/sweep) operations.

LOW FST VALUE IMPACT RESISTANT

**SERVICE CARTS** Toray Cetex® thermoplastics are the ultimate solution in an industry where weight and impact performance are paramount. Exceptionally durable and lightweight for hard-wearing cart surfaces, graphics can also be sublimated into the surface, eliminating secondary painting and finishing requirements.

IMPACT RESISTANT COLOR DECORATION

**SEAT STRUCTURES** Capable of fast manufacturing cycles, Toray Cetex® thermoplastics are ideal for high-volume parts such as seat pans, back panels, and arm rests. Materials can also be overmolded with features for process improvement and design integrity. Braided thermoplastic slit tapes are ideal for seat frames and tubular structures.

THERMOFORMING OVERMOLDABLE

**FLOORING** Manufactured in high volumes and prone to abuse, aircraft flooring demands exceptional resilience. Our hybrid system combines the best of lightweight thermoplastic and thermoset technology to deliver exceptional durability and longer service life, withstanding carpet changes without surface degradation.

CHEMICAL RESISTANT IMPACT RESISTANT

AIRCRAFT INTERIORS

# AIRCRAFT INTERIORS
Product Overview

## THERMOSET

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | DURABILITY/ TOUGHNESS | CHEMICAL RESISTANT | OEM QUALIFICATION |
|---|---|---|---|---|---|---|---|---|
| E721-FR | Epoxy | 120°C (248°F) | 60 minutes at 120°C (248°F) | ▸ Fire retardant under FAR 25.853 Appendix F - vertical burn material test criteria (ii)<br>▸ Core bondable | ○ | | ○ | |
| TC264-1 | Epoxy | 124°C (255°F) | 90 minutes at 118-127°C (245-260°F) | ▸ Flame retardancy applications e.g., ducting, decorative enclosures, and composite panel assemblies | ○ | ○ | ○ | |
| BT250E-1FR | Epoxy | 125°C (257°F) | 60 minutes at 121°C (250°F) | ▸ Self-adhesive to honeycomb and foam core<br>▸ Outstanding surface finish with OOA | ○ | ○ | | MIL-R-9300 (BT250E-1) |

## TORAY CETEX® THERMOPLASTIC

| | RESIN MATRIX | PEAK $T_g$ | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | SECONDARY OPERATIONS | DURABILITY/ TOUGHNESS | CHEMICAL RESISTANT | OEM QUALIFICATION |
|---|---|---|---|---|---|---|---|---|
| TC925 FST | PC | 153°C (307°F) | 260°C (500°F) | ▸ Good FST performance, OSU (< 25/25)<br>▸ White color option for visual aspect<br>▸ Value based solution | ○ | +<br>+ | + | |
| TC1000 Premium | PEI | 215°C (419°F) | 315°C (600°F) | ▸ Excellent FST performance, OSU (< 15/15)<br>▸ Qualified to OEM specifications | ○ | +<br>+ | +<br>+ | ABS 5036<br>ABS 5814 |
| TC1000 Design | PEI | 215°C (419°F) | 315°C (600°F) | ▸ Excellent FST performance, OSU (< 15/15)<br>▸ Ideal for customer qualified design programs | ○ | +<br>+ | +<br>+ | |
| TC1100 | PPS | 90°C (194°F) $T_m$ 280°C (536°F) | 320°C (608°F) | ▸ Achieves 35/35 for OSU performance<br>▸ Outstanding solvent resistance for structural applications<br>▸ High impact resistance<br>▸ Ideal for beams and floor panels | | +<br>+ | +<br>+<br>+ | ABS 5045<br>ABS 5222<br>MEP 15-052 |
| TC1225 | PAEK | 147°C (297°F) $T_m$ 305°C (581°F) | 325-350°C (615-662°F) | ▸ Outstanding structural and thermal performance<br>▸ Compatibility to PEEK for injection overmolding and welding | ○ | +<br>+<br>+ | +<br>+ | |

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the **Toray TAC Product Selector**

**www.toray**tac.com/interiors
Go to our online resource center for case studies and technical papers

## TORAY MICROPLY™ FILM ADHESIVES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OOA/VBO | DURABILITY/ TOUGHNESS | CHEMICAL RESISTANT | OEM QUALIFICATION |
|---|---|---|---|---|---|---|---|---|
| TC263 | Epoxy | 110°C (230°F) | 2 hours at 121°C (250°F) | ▸ High peel strength<br>▸ Ideal for metal or composite bonding | ○ | ○ | ○ | |

## NOMEX® HONEYCOMB* AEROSPACE GRADE

| | CONFIGURATIONS CELL SIZE & DENSITY | SHEET SIZE | KEY PRODUCT CHARACTERISTICS |
|---|---|---|---|
| ANA-3.2-29 | 3.2 mm 29 kg/m³ | 1250 x 2500 mm | ▸ Fire resistant and self-extinguishing to FAR 25.853<br>▸ High-temperature strength up to 180°C (356°F)<br>▸ High strength-to-weight ratio and easily formable to shape<br>▸ Nomex® paper sheets are coated and bonded together with a high-modulus phenolic resin |
| ANA-3.2-48 | 3.2 mm 48 kg/m³ | 1250 x 2500 mm | |
| ANA-3.2-64 | 3.2 mm 64 kg/m³ | 1220 x 2440 mm | |
| ANA-4.8-48(OX) | 4.8 mm 48 kg/m³ | 1250 x 2500 mm | |

*Nomex® is a registered trademark of E.I du Pont de Nemours and Company.*

* Cut to customer thickness specifications +/- 0.125 mm.
Offered from Langley Mill, UK. Additional grades can be sourced upon request, subject to minimum order quantities.

For additional honeycomb core grades please refer to our core materials on page 53 of our Aerospace Advanced Composite Materials Selector Guide.

### HYBRID PANEL SOLUTION

Toray Cetex® TC1000 can also be supplied as part of a patented hybrid panel solution, benefiting from the surface properties of the Reinforced Thermoplastic Laminate (RTL) capping a traditional Toray thermoset epoxy prepreg/Nomex® honeycomb core structure.






AIRCRAFT INTERIORS



# AmberTool®

## TOOLING REINVENTED

**The increased use of composites materials is driving the need for more advanced composite tooling solutions. Part manufacturers are demanding tools with longer life and tighter tolerances while pushing for more efficient production methods. The market demands a trusted technology partner that can provide world-class innovation, manufacturing, and service.**

With more than 20 years of pedigree in demanding tooling applications, the Toray AmberTool® collection of prepregs comprised of the HX, HXR, and TC series, is sold globally by a proven team of tooling experts. Our comprehensive range of prepregs for aerospace applications cure from 50°C (122°F) while delivering $T_g$ properties up to 213°C (415°F). These materials are available on a wide range of reinforcements, allowing our customers to have complete tool design freedom and flexibility.

## COMPLETE TOOL DESIGN FREEDOM

Toray AmberTool® composite tooling prepregs allow high precision for molded and machined tooling applications with a superior degree of accuracy. We support our products globally, offering customers a complete technical support service including tailored training courses.

## INDUSTRY-LEADING COMPOSITE TOOLING EXPERIENCE

**Master and surface coat application**

- Compatible with high-performance epoxy paste and block master patterns
- Specialized sealing and release agent recommendations
- Excellent surface finish generation

**Full tooling delivery solutions**

- Custom cutting solutions within Europe
- Fast delivery solutions for standard materials
- Wide range of carbon and glass reinforcements with curing temperatures as low as 40°C (104°F) and $T_g$'s up to 213°C (415°F) (after post cure)
- Surface machinable for final accuracy
- Carbon and glass backing structures

Courtesy of The National Composites Centre, UK

**Experienced technical support**

- Proven processing procedures and full tooling processing guide available
- Tailored training courses offered
- Specialized tooling knowledge on surface treatments and advanced experience in mold heating applications
- Mold life-cycle maintenance solutions
- New materials research, assuring health and safety compliance

# COMPOSITE TOOLING PREPREGS
Product Overview

## TORAY AMBERTOOL® COMPOSITE TOOLING PREPREGS

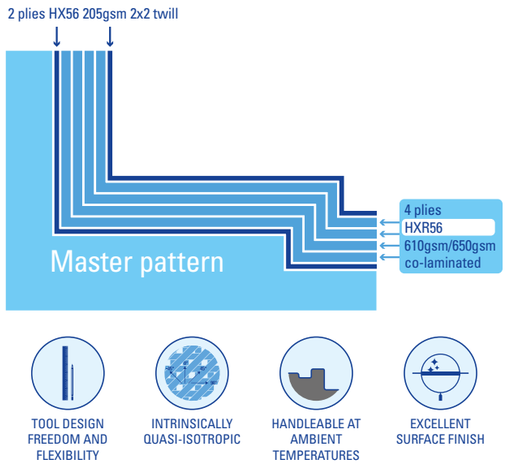
| | RESIN | $T_g$ (ONSET)*1 | MIN CURE TEMP | TYPICAL CURE TIME AND TEMPERATURE*2 | OUT LIFE | KEY PRODUCT CHARACTERISTICS | AEROSPACE | INDUSTRIAL | MOTORSPORT | AUTOMOTIVE | ENERGY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HX32-1*3 **NEW** | Epoxy | 162°C (323°F) | 65°C (149°F) | 12 hours at 70°C (158°F) | 30 days | ▸ Long out life for large applications | | ○ | | | ○ |
| HXR56*3 **NEW** | Epoxy | 185°C (365°F) | 40°C (104°F) | 8.5 hours at 50°C (122°F) | 50 hours | ▸ Quasi-isotropic two-layer product for rapid lamination | | ○ | ○ | ○ | ○ |
| HX56*3 | Epoxy | 185°C (365°F) | 40°C (104°F) | 8.5 hours at 50°C (122°F) | 60 hours | ▸ Improved handleability | | ○ | ○ | ○ | ○ |
| HX50*3 | Epoxy | 190°C (374°F) | 40°C (104°F) | 8.5 hours at 50°C (122°F) | 60 hours | ▸ Excellent surface finish | | ○ | ○ | ○ | |
| HX42 | Epoxy | 200°C (392°F) | 50°C (122°F) | 8 hours at 60°C (140°F) | 5 days | ▸ Proven system for aerospace | ○ | ○ | ○ | ○ | |
| HX40 | Epoxy | 203°C (397°F) | 50°C (122°F) | 12 hours at 65°C (149°F) | 8 days | ▸ Large tooling applications | ○ | ○ | | | ○ |
| TC40*4 | BMI | 213°C (415°F) | 182°C (360°F) | 6 hours at 182°C (360°F) | 14 days | ▸ High service temperature | ○ | | | | |

*1 after post cure *2 followed by post cure | Sourced from: *3 Europe *4 North America

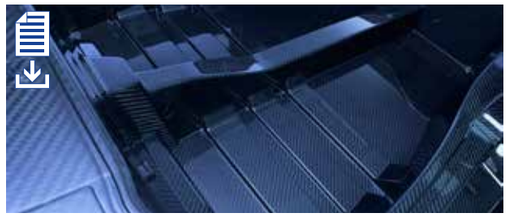
### NEW PRODUCTS

Toray AmberTool® HXR56 is the latest innovation from our heritage range of composite tooling prepregs. The new Toray AmberTool® HXR series is a multi-axial format, specifically designed for when complexity and speed are required, ultimately reducing overall tooling costs.

**Example of HXR lay-up:**




Please visit our website to request a print copy of our processing guide:
**www.toray**tac.com/processing-guides



**Toray AmberTool® Tooling Prepreg Processing Guide**

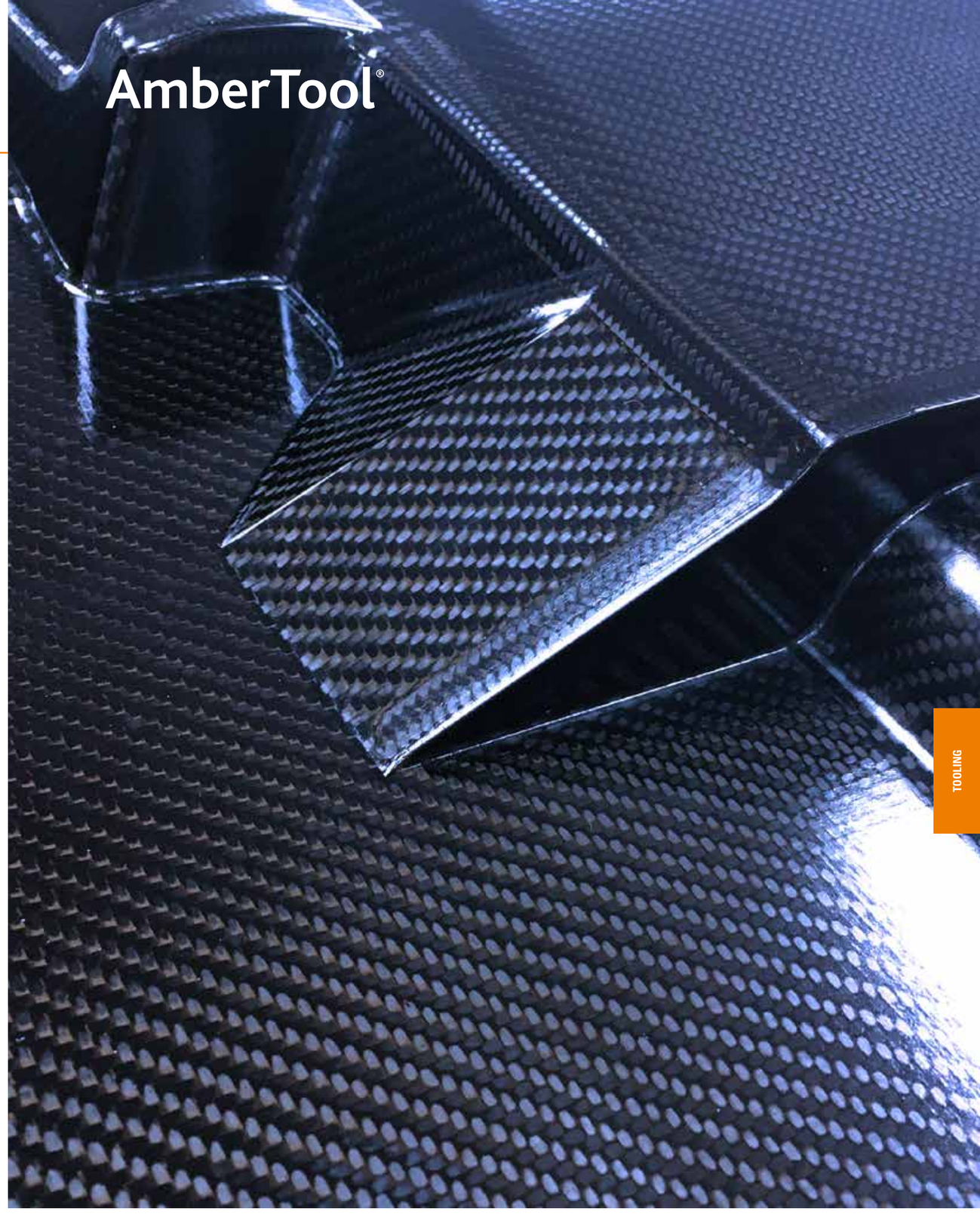
Find this case study and more at
**www.toray**tac.com/success-stories

**Cure Capable Mandrel for Aerospace Structures**
Featured products: ▸ **Toray AmberTool® HX42**

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the **Toray TAC Product Selector**

**www.toray**tac.com/tooling



# COMPRESSION MOLDING & BULK MOLDING COMPOUNDS

Introduction

## LIGHTWEIGHT

Chopped fiber compression molded composite parts are lighter in weight than aluminum or titanium.

## COMPLEX PART FABRICATION

Compression molding allows design and fabrication of complex shapes in single-shot molding.

## OPTIMIZED LOAD PATHS

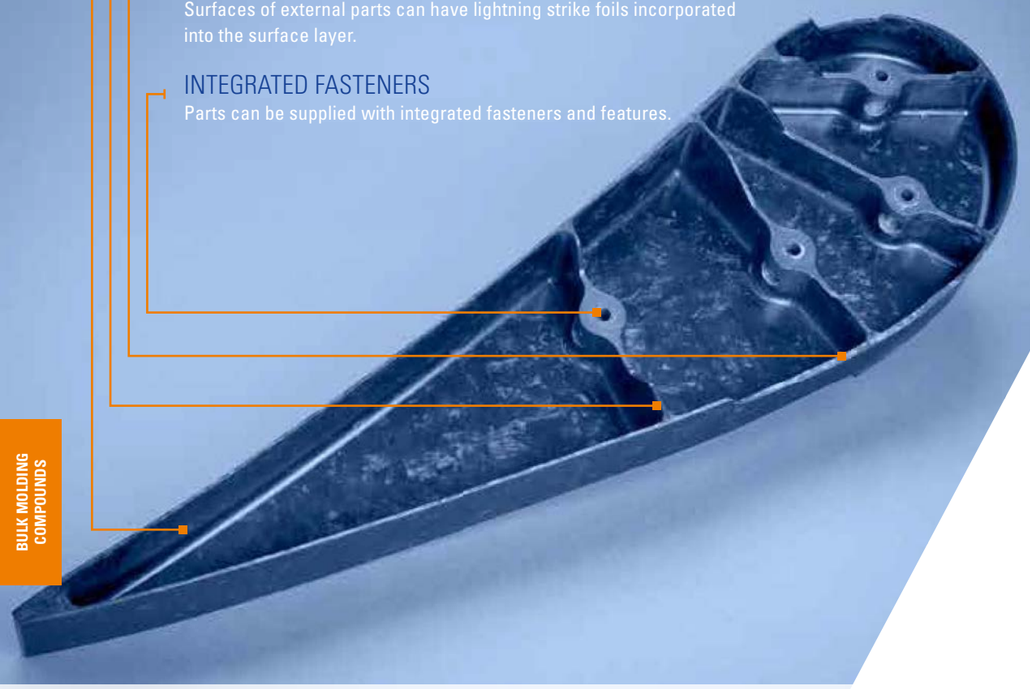
Parts can be optimized with ribs and stiffened assemblies to strengthen high-load areas.

## LIGHTNING PROTECTION

Surfaces of external parts can have lightning strike foils incorporated into the surface layer.

## INTEGRATED FASTENERS

Parts can be supplied with integrated fasteners and features.



## OUR OBJECTIVES

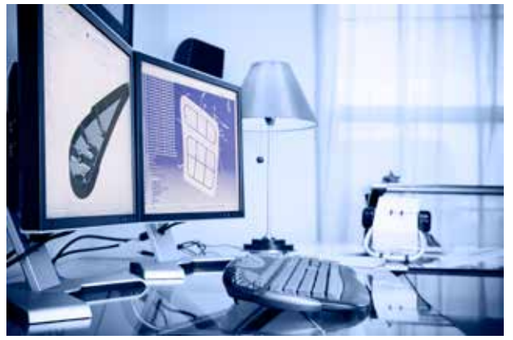
| Lightweight complex parts | High-strength structure | Rapid part forming |
|---|---|---|



## COMPRESSION MOLDING AND BULK MOLDING COMPOUNDS (BMC)

**Toray manufactures and sells chopped thermoset and thermoplastic chopped carbon fiber bulk molding compounds (BMC) for compression molding. Compression molding is an enabling technology for the fabrication of complex composite parts for aerostructures, space, and satellites using bulk molding compounds (BMC). Resin matrices utilized include both thermosets and thermoplastics. Toray supplies chopped standard, intermediate, or high-modulus carbon fiber reinforcements.**

In a highly controlled process, our bulk molding compounds are manufactured by using precise resin-infused carbon uni-directional (UD) tapes. The UD is chopped into fiber lengths ranging from 12 to 50 mm (1/2" to 2"). Longer fiber lengths generally provide higher strengths, while smaller length fibers allow more complex structural details to be molded into the part.



## COMPRESSING MOLDING PART, DESIGN AND FABRICATION

The Toray CCS group specializes in the design, tooling, and fabrication of complex compression molded composite parts using BMC.

Compression molding offers an alternative to machining and hand lay-up for intricate geometry components. The process also delivers cost and weight savings by allowing the fabrication of composite parts in high volumes with short cycle times.

Special features such as lightning strike foils and integrated fasteners can be designed into the part. The utilization of chopped fiber BMC in compression molded parts often delivers higher strength and lighter weight than the metal parts they replace.

Toray CCS's compression molded parts are found in a wide range of applications and industries, including satellites, launch vehicles, military and commercial aircraft, thermal management, and high-performance industrial applications.

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the Toray TAC Product Selector

**www.toray**tac.com/compressionmoldedparts
Go to our online resource center for product data sheets and technical resources.

> "Aeronautics was neither an industry nor a science. It was a miracle."
>
> *Igor Sikorsky*

BULK MOLDING COMPOUNDS

# BULK MOLDING COMPOUNDS
Product Overview

## BMC THERMOSET EPOXY

| | RESIN | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCHERS | RADOMES | AIRCRAFT INTERIORS | ENGINES/ HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|
| 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 | ○ | ○ | ○ | | ○ | |

## BMC TORAY CETEX® THERMOPLASTIC

| | RESIN | PEAK $T_g$ | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCHERS | RADOMES | AIRCRAFT INTERIORS | ENGINES/ HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|
| MC1100 | PPS | 90°C (194°F) | 330°C (625°F) | ▸ PPS based BMC with high-strength (standard-modulus) fiber<br>▸ Fire retardant | ○ | ○ | ○ | | ○ | |
| MC1322 | PEKK | 162°C (324°F) | 380°C (715°F) | ▸ PEKK based BMC with high-strength (standard-modulus) fiber<br>▸ Excellent chemical and solvent resistance | ○ | | | | ○ | |
| MC1200 | PEEK | 143°C (290°F) | 385°C (725°F) | ▸ PEEK based BMC with high-strength (standard-modulus) fiber<br>▸ Fire retardant | ○ | ○ | ○ | | ○ | |

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**www.toray**tac.com
Go to our online resource center for case studies and technical papers

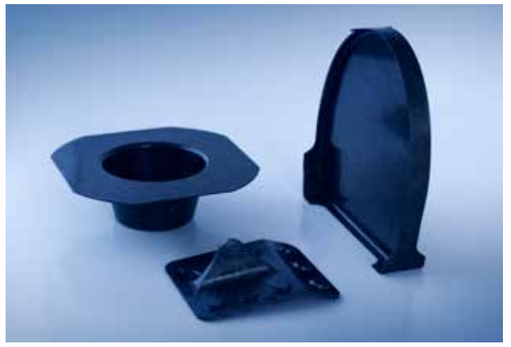
## COMPRESSION MOLDING APPLICATIONS

Toray chopped fiber bulk molding compounds (BMC) enable the cost-effective production of complex, extremely high-tolerance composite parts, typically to replace machined aluminum or titanium components for weight or cost reduction.

For instance, in the Bell-Boeing V-22 Osprey, compression molded parts have replaced honeycomb stiffened composite parts providing cost and productivity savings.

Toray can design the part, fabricate the tooling, and then move into full production to support your needs. For prototype parts or parts with limited production volumes, consider compression molded billet stock, which can be machined to shape.

A technical paper titled **"Billet stock: Advantages and usages"** offers valuable information. It can be found on our website under Compression Molded Parts. **www.toray**tac.com/compressionmoldedparts



To learn more, search for the following articles and case studies at **www.toray**tac.com

**Top Five Questions Asked about Compression Molding**
Hear answers from an expert on the most asked questions about compression molding at **www.toray**tac.com/literature (Articles section)

**Toray Compression Molding Design Guide**
To request a printed copy of this design guide, go to **www.toray**tac.com/processing-guides

**BMC Billet Stock**
Available products for cost-effective fabrication of a thick composite structure. **www.toray**tac/selector-guides (Product Highlights section)

**Redesigning for Simplicity and Economy**
Read about the compression molded access door for the Bell-Boeing V-22 Osprey at **www.toray**tac.com/literature (Articles section)

## OUR OBJECTIVES

- High thermal stability
- Replacement for titanium structures
- Lightweight and thermally resistant





## MATERIALS FOR ULTRA-HIGH TEMPERATURE PERFORMANCE

**Operating in temperature extremes of 260-371°C (500-700°F), Toray's line of cyanate esters, polyimides, and BMIs are available on a variety of carbon and ceramic reinforcements. These specialized materials replace titanium and other metals, offering design flexibility and significant weight savings.**

Toray Advanced Composites through its partnership with Proof Research ACD are developing next generation, high-temperature prepregs for aerospace, defense, and structural applications. Under exclusive license, Toray is the supplier of prepregs made with PROOF® polyimide resins. PROOF® has additional resins including NRPE and variants of AFRPE polyimides that Toray can offer as prepregs.

## TORAY'S HIGH-TEMPERATURE ADVANCED COMPOSITES ARE COMMONLY USED FOR:

- Jet engines, ducts, and stators
- Leading edges on hypersonic vehicles
- Heat shields and heat protection systems
- Rocket engine nozzles, thrusters, and powerplants
- Titanium replacement in aircraft and launch vehicles
- High-temperature composite tooling

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the Toray TAC Product Selector

**www.toray**tac.com
Go to our online resource center for product data sheets and technical resources.

> "To most people, the sky is the limit. To those who love aviation, the sky is home."
>
> *Anon*

# ULTRA-HIGH TEMPERATURE
Product Applications

**TORAY HIGH-TEMPERATURE EPOXY AND BMI MATERIALS** have excellent long-term thermal resistance and are ideal for nacelle structures.

THERMOCYCLE STABILITY

**TORAY CYANATE ESTERS** achieve high $T_g$ with low moisture absorption, and are ideal for leading edges and heat shields on supersonic vehicles.

LOW MOISTURE ABSORPTION

**TORAY POLYIMIDE-BASED PREPREGS** provide excellent thermal stability and can replace titanium for weight savings. The latest generation of military jet engines use Toray high-temperature materials to achieve weight savings.

HIGH TEMPERATURE RESISTANT

LIGHTWEIGHT



ULTRA-HIGH TEMPERATURE

# ULTRA-HIGH TEMPERATURE
Product Overview

## THERMOSET PREPREGS

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS |
|---|---|---|---|---|
| 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 high-temperature thermal stability<br>▸ Good moisture resistance<br>▸ Available in RTM resin form |
| 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 of 90 minutes at 260°C (500°F) | ▸ Excellent thermal stability<br>▸ Epoxy-like processing with $T_g$ of BMI<br>▸ Used on heatshields and supersonic leading edges |
| RS-51 | Polyimide AFRPE-4 | 366°C (690°F) | Call for cure details | ▸ Ultra-high service temperature for jet engine applications<br>▸ Based on PROOF's AFRPE-4 |
| TC890 | Polyimide 900HT | 454°C (850°F) | 2 hours at 371°C (700°F) | ▸ Non MDA PMR-15 replacement<br>▸ Service temperature capability of 538°C (1000°F)<br>▸ Used in heat shields and ablatives<br>▸ Based on PROOF's 900HT |

## TORAY MICROPLY™ FILM ADHESIVES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS |
|---|---|---|---|---|
| TC310 | Epoxy | 157°C (315°F) | 2 hours at 177°C (350°F) | ▸ Ideal composite bonding film adhesive |
| 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<br>▸ Service temperature of 232°C (450°F) after post cure<br>▸ Compatible with TC420 |

## TORAY MICROPLY™ SYNTACTICS

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS |
|---|---|---|---|---|
| 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 foam 0.35-0.42 g/cc (22-26 pcf)<br>▸ Mechanical properties achieved through OOA/VBO processing |
| 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<br>▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ Tensile strength up to 260°C (500°F)<br>▸ Compatible with TC420 prepreg system |
| SF-4 | BMI | 295°C (563°F) | 2 hours at 204°C (400°F), then 6 hours post cure at 250°C (452°F) | ▸ Low-density syntactic film 0.62 g/cc (39 pcf)<br>▸ Compatible with RS-8HT and other BMI systems |

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

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**www.toray**tac.com/hightemp
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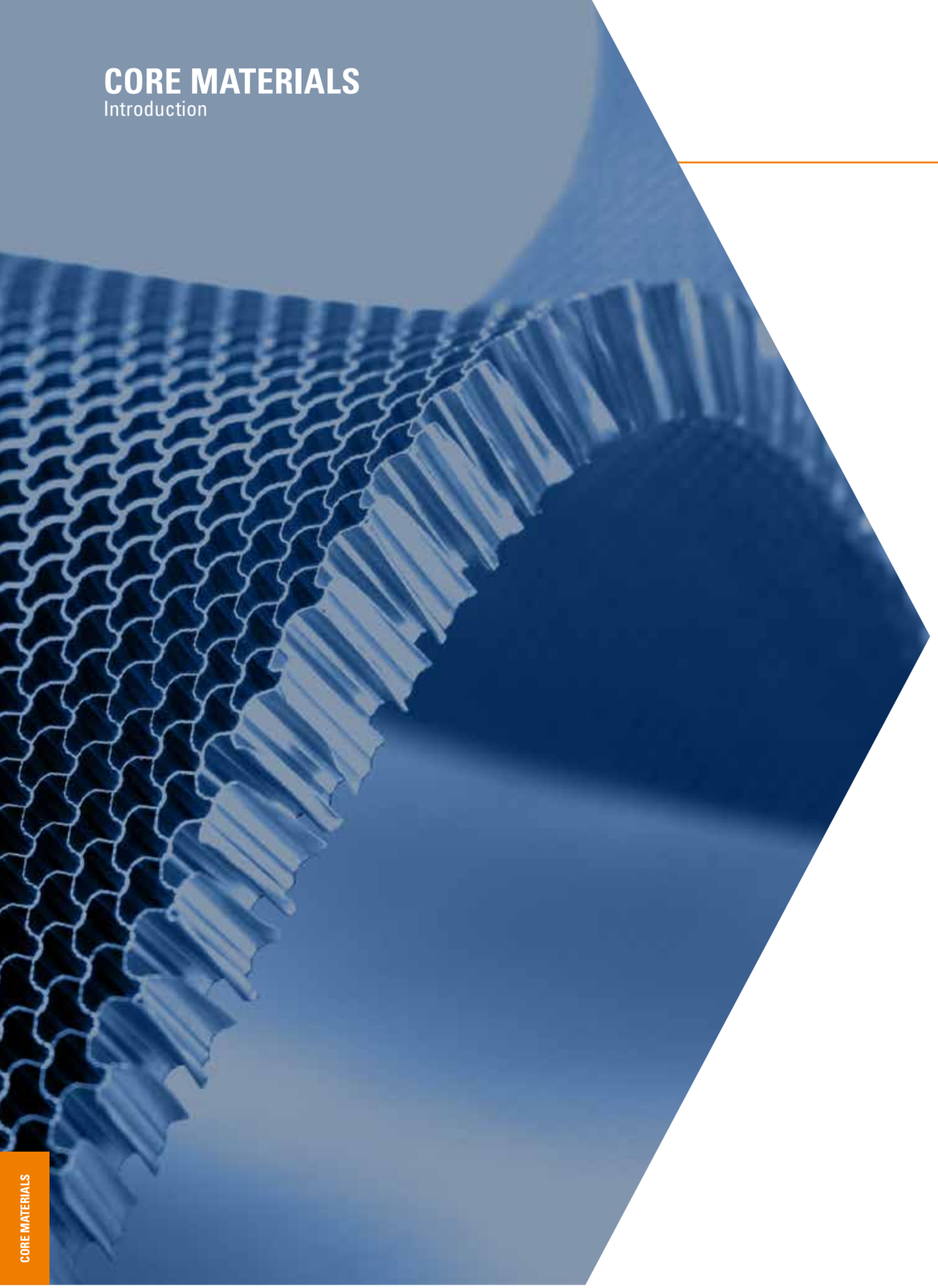

# HONEYCOMB CORE
## Product Overview

Toray Advanced Composites, UK (Langley Mill), has the largest independent core processing operation in Europe. Aluminum and Nomex® honeycomb are available in addition to Flex-Core® honeycomb. We hold extensive stock in-house for quick ordering. All orders are cut to customer's thickness specification and available with fast turnaround times.

### HONEYCOMB CORE*

| | CONFIGURATIONS | | KEY PRODUCT CHARACTERISTICS |
|---|---|---|---|
| Aluminum Honeycomb - Aerospace Grade | 4.5-1/8-10N-5052<br>8.1-1/8-20N-5052 | 4.5-1/8-10N-**5056**<br>6.1-1/8-15N-**5056****<br>8.1-1/8-20N-**5056** | ▸ High strength-to-weight properties at relatively low cost<br>▸ Improved mechanical properties in comparison to commercial grades<br>▸ Broader selection of densities than commercial grades<br>▸ Sheet size 1250 x 2500 mm except **1220 x 2440 mm |
| Aluminum Honeycomb - Commercial Grade | 1.8-3/4-25N-3003<br>5.2-1/4-25N-3003 | | ▸ High strength-to-weight properties at relatively low cost<br>▸ Easily machined and formed for applications such as air or fluid control, light collimation, heat exchangers |
| Nomex® Honeycomb Aerospace Grade | ANA-3.2-29 3.2 mm 29 kg/m$^3$<br>ANA-3.2-48 3.2 mm 48 kg/m$^3$<br>ANA-3.2-64 3.2 mm 64 kg/m$^3$**<br>ANA-4.8-48(OX) 4.8 mm 48 kg/m$^3$ | | ▸ Fire resistant and self-extinguishing to FAR 25.583<br>▸ High-temperature strength up to 180°C (356°F)<br>▸ Good dielectric properties<br>▸ Nomex® paper sheets are coated and bonded together with a high-modulus phenolic resin<br>▸ Sheet size 1250 x 2500 mm except **1220 x 2440 mm |
| Nomex® Honeycomb - Commercial Grade | ANC-3.2-48 3.2 mm 48 kg/m$^3$<br>ANC-4.8-32 4.8 mm 32 kg/m$^3$<br>ANC-4.8-48 4.8 mm 48 kg/m$^3$<br>ANC-4.8-48(OX) 4.8 mm 48 kg/m$^3$ | | ▸ Fire resistant and self-extinguishing<br>▸ Good thermal and electrical insulating properties<br>▸ High strength-to-weight ratio and easily formable to shape<br>▸ Sheet size 1250 x 2500 mm |
| Aluminum Flex-Core® | 5052/F80 - .0013N Density 4.3<br>5052/F80 - .0024N Density 8.0<br>**5056**/F80 - .0014N Density 4.3 | | ▸ Unique cell configurations that permit small radii of curvature without deformation of the cell walls or loss of mechanical properties<br>▸ For parabolic, spherical, and cylindrical shapes<br>▸ Sheet size 915 x 1220 mm |

Flex-Core® is a registered trademark of Hexcel. Nomex® is a registered trademark of E.I du Pont de Nemours and Company.
*Offered from Langley Mill, UK. Additional grades can be sourced upon request, subject to minimum order quantities and extended lead times.

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

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CORE MATERIALS

# TORAY MICROPLY™ SYNTACTICS AND CORE SPLICES
Product Overview

## FILMS AND PASTES

Valued in the industry for their lightweight, low-density, and high-compressive strength, Toray MicroPly syntactic core materials are high-performance resin films or pastes filled with hollow glass microspheres. Syntactic materials are used to fill honeycomb core or hollow spaces. They provide strength for fasteners and prevent moisture/fluid ingress. Core splices or foams represent syntactic materials that contain a blowing agent. Core splices expand to transfer load between two discrete honeycomb core pieces.

## AEROSPACE SYNTACTICS

Toray MicroPly syntactic materials are produced in carbon-free environments, thus assuring electrically-pure products. They feature low dielectric loss and constant properties, and are compatible with Toray's award-winning line of radome prepregs. Toray MicroPly syntactics are valued for their low-density, high-strength, and low outgassing characteristics.

### TORAY MICROPLY™ SYNTACTICS AND CORE SPLICES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | PRODUCT FORMATS: FILM | PASTE | EXPANDING | MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM-3 | Epoxy | N/A | 60 minutes at 121°C (250°F) | ▸ High expansion (8-10 x)<br>▸ 0.64 g/cc (40 pcf) density | ○ | | ○ | ○ | ○ | | ○ | | |
| TCF4035 | Epoxy | 140°C (284°F) | 3 hours at 130°C (265°F) | ▸ Low density 0.64 g/cc (40 pcf)<br>▸ Compatible with TC250, may be post cured for higher $T_g$ | ○ | | | ○ | | ○ | ○ | | |
| TCF4001 | Cyanate Ester | 176°C (349°F) optional post cure | 2 hours at 177°C (350°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) | ▸ Expanding syntactic film/core splice<br>▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ Compatible with TC420 prepreg system | ○ | | ○ | ○ | ○ | | ○ | | ○ |
| TCF4045 | Epoxy | 180°C (356°F) | 3 hours at 179°C (355°F) | ▸ Excellent low dielectric loss and constant<br>▸ Density of 0.61 g/cc (38.5 pcf) | ○ | | | ○ | | | ○ | | |
| EM-5A | Cyanate Ester | 204°C (400°F) optional post cure | 2 hours at 177°C (350°F) | ▸ Expansion ratio of 4 x | ○ | | ○ | | ○ | | ○ | | |
| EX-1541 | Cyanate Ester | 227°C (441°F) or 240°C (464°F) with post cure | 2 hours at 177°C (350°F), post cure of 2 hours at 232°C (450°F) | ▸ Density of 0.16-0.38 g/cc (10-24 pcf)<br>▸ Good structural properties<br>▸ Low dielectric constant and loss | | ○ | | | ○ | | ○ | ○ | ○ |

CORE MATERIALS



MicroPly™

### TORAY MICROPLY™ SYNTACTICS AND CORE SPLICES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | PRODUCT FORMATS: FILM | PASTE | EXPANDING | MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF-5 | Cyanate Ester | 193°C (379°F) or 254°C (490°F) with post cure | 149°C (300°F) to 177°C (350°F), post cure of 2 hours at 249°C (480°F) | ▸ Density of 0.61 g/cc (38 pcf)<br>▸ Low dielectric constant and loss<br>▸ Compatible with Toray RS-3 | ○ | | | ○ | ○ | | ○ | | ○ |
| SF-4 | BMI | 295°C (563°F) | 2 hours at 204°C (400°F), then 6 hours post cure at 250°C (452°F) | ▸ Low density 0.62 g/cc (39 pcf)<br>▸ Compatible with RS-8HT and other BMI systems | ○ | | ○ | ○ | ○ | | ○ | | ○ |

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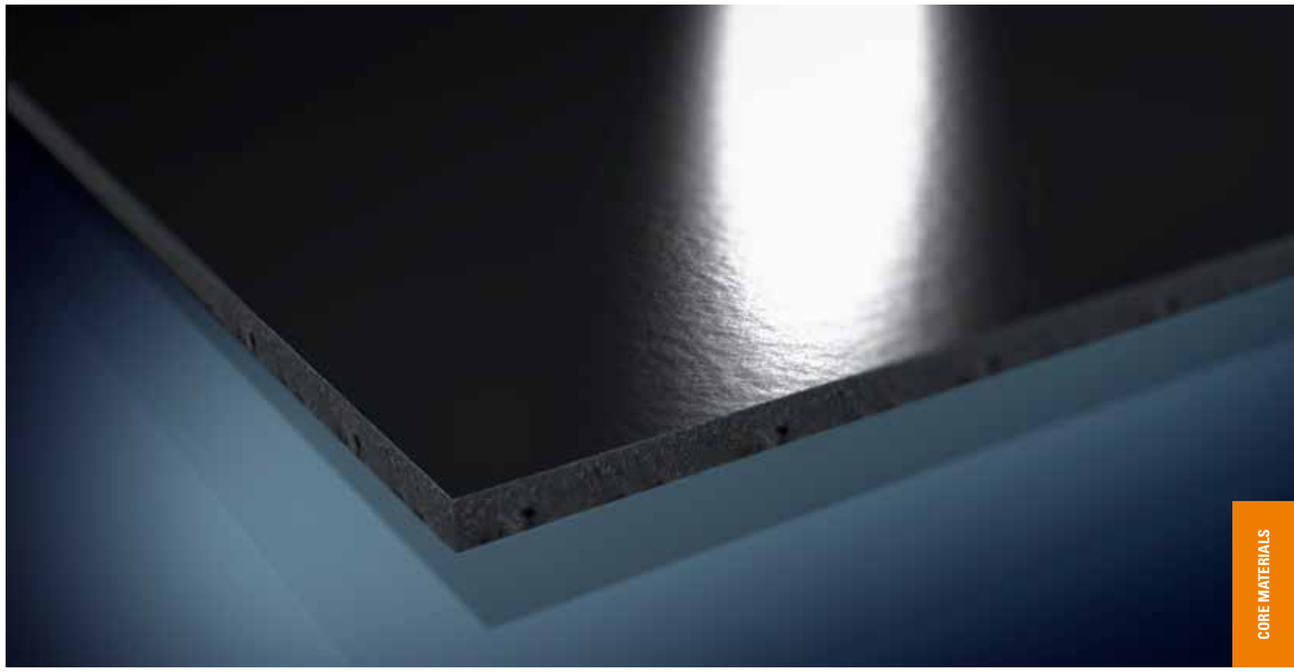
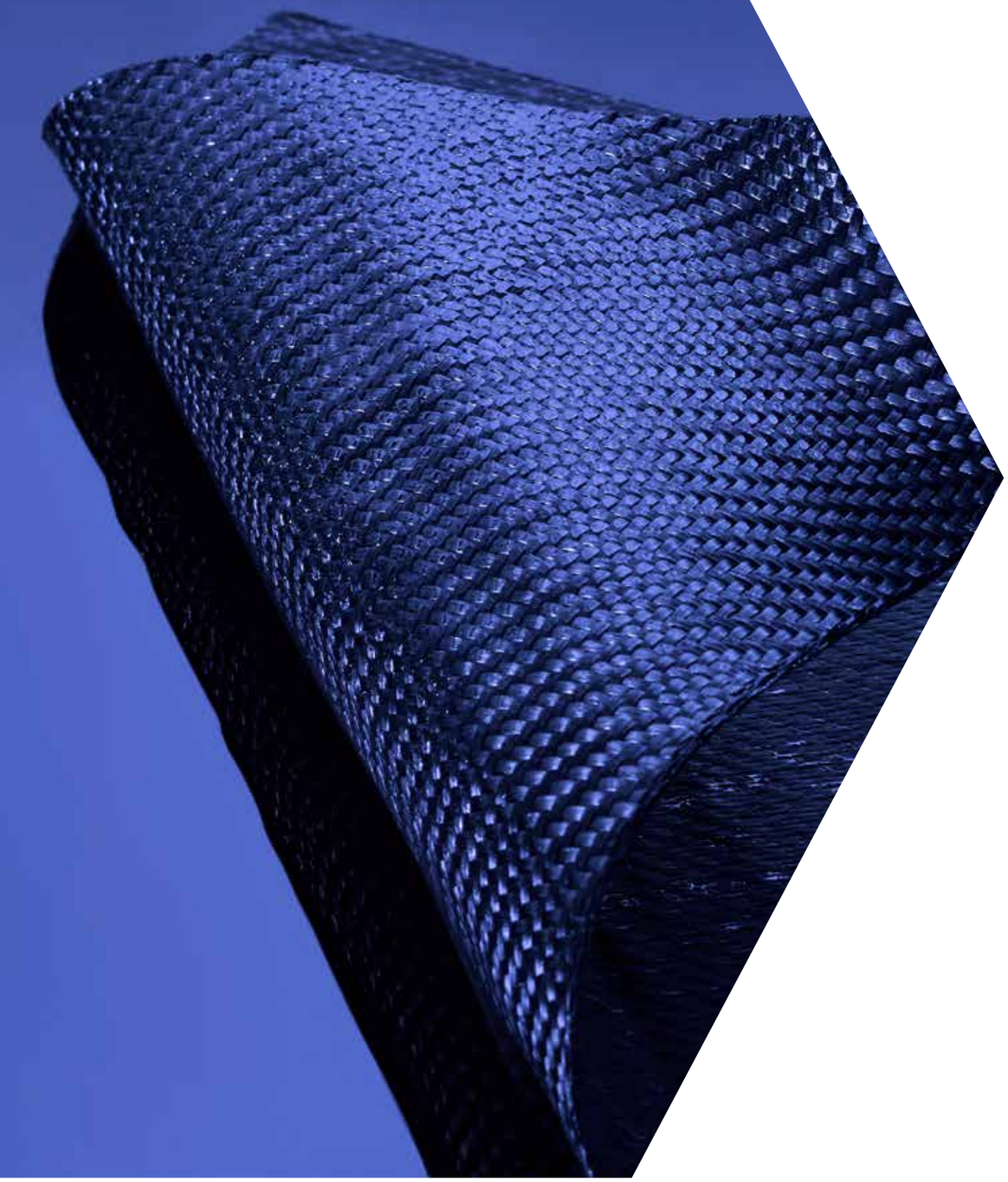


CORE MATERIALS

# AEROSPACE PRODUCT SELECTOR
Introduction



## ADVANCED COMPOSITE MATERIALS FOR AEROSPACE

**The aerospace industry depends on supply chain innovation for new materials and processes. At Toray Advanced Composites, our focus on tailored systems, combined with our comprehensive laboratory and testing capabilities, allows rapid development, customization, and database development for our customers.**

We add to that customer value with our broad experience in thermoset and thermoplastic matrices, various composite fibers, and part design.

Recognized in the industry for providing optimized fiber and resin solutions, we deliver innovative customer-oriented products to the market.

Our recognized brands include:

**Cetex®**

Toray Cetex for our thermoplastic composite materials

**AmberTool®**

Toray AmberTool for our composite tooling prepregs

**MicroPly™**

Toray MicroPly for our thermoset film and paste adhesives, syntactics and core splices, surfacing films, and peel plies

Overleaf are details of Toray's extensive advanced composite materials product range including:

- Thermoset UD tape and prepregs
- Thermoplastic UD tape, prepregs, and laminates
- Film adhesives
- Syntactics
- Resin transfer molding (RTM) resins
- Bulk molding compounds (BMC)
- Toray AmberTool® prepregs

# AEROSPACE PRODUCT SELECTOR
Thermoset Prepregs Epoxy

## THERMOSET EPOXY

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OOA/VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | LOW DIELECTRIC LOSS & CONSTANT | UD TAPE | FABRIC PREPREG | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| BT250E-1 | Epoxy | 125°C (257°F) | 60 minutes at 121°C (250°F) | ▸ MIL-R-9300 qualified<br>▸ BT250E-1FR is the flame retardant version | 30 | 12 | ○ | ○ | ○ | | | | | ○ | ○ | | | | | ○ | ○ | ○ | | ○ | | | ○ | | |
| BT250E-6 | Epoxy | 131°C (268°F) | 2 hours at 127°C (260°F) | ▸ High-modulus system for rotor blades<br>▸ Complete FAA-conformed database on four product forms | 30 | 12 | ○ | ○ | ○ | | | | | ○ | ○ | | | | | | ○ | ○ | | ○ | | | | | |
| E721-FR | FR Epoxy | 120°C (248°F) | 60 minutes at 120°C (248°F) | ▸ Direct lamination to honeycomb without the use of resin film<br>▸ Fire resistant under FAR 25.853 Appendix F material test criteria (ii) | 60 | 12 | ○ | ○ | ○ | | | | ○ | ○ | ○ | | | | | | | ○ | | | | | | ○ | |
| EX-1522 | Modified Epoxy | 180°C (356°F) | 2 hours at 177°C (350°F) | ▸ Fire retardant, V-0 level<br>▸ Low moisture absorption<br>▸ Low outgassing, low dielectric constant and loss | 21 | 12 | | ○ | ○ | | | ○ | ○ | ○ | ○ | | | ○ | | ○ | ○ | ○ | | ○ | ○ | | ○ | | |
| RS-17B | Epoxy | 171°C (340°F) | 2 hours at 177°C (350°F) | ▸ Flexible cure system (135°C-177°C)<br>▸ Extensive space flight heritage<br>▸ More cost-effective versus cyanate ester systems | 30 | 12 | | ○ | ○ | | ○ | ○ | | ○ | ○ | | | ○ | | | ○ | ○ | | | ○ | | | | |
| RS-36 & RS-36-1 | Epoxy | 181°C (358°F) | 90 minutes at 177°C (350°F) | ▸ Lower cost resin system compared to cyanate esters<br>▸ RS-36-1 is the higher $T_g$ version | 30 | 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). | ▸ Toughened system<br>▸ Post curable for higher $T_g$<br>▸ NCAMP database on fabric version | 30 | 12 | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | | | | ○ | ○ | ○ | | ○ | | ○ | ○ | | |
| TC264-1 | Epoxy | 124°C (255°F) | 90 minutes at 118-127°C (245-260°F) | ▸ Ideal for flame retardancy applications<br>▸ Ideal for ducting and composite panels | 30 | 12 | ○ | ○ | ○ | | | ○ | ○ | ○ | ○ | | | | | | ○ | ○ | | | | | | ○ | |
| TC275-1 | Epoxy | 164°C (327°F) or 183°C (362°F) with 177°C (350°F) post cure | 6 hours at 135°C (275°F) Optional post cure of 2 hours at 177°C (350°F) | ▸ Low moisture uptake, high $T_g$ retention<br>▸ Ideal system for large structure<br>▸ OOA/VBO processable | 14 | 12 | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | | ○ | | | ○ | ○ | | ○ | ○ | ○ | | | |
| TC275-1E **NEW** | Epoxy | 168°C (334°F) | 6 hours at 135°C (275°F) optional post cure of 2 hours at 177°C (350°F) | ▸ Longer out time version of TC275-1<br>▸ Allows construction of thick or larger composites structures<br>▸ OOA/VBO processable | 21 | 12 | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | | ○ | | | ○ | ○ | | ○ | ○ | ○ | | | |
| TC350-1 | Epoxy | 191°C (376°F) | 2 hours at 177°C (350°F) | ▸ Industry standard 177°C epoxy<br>▸ Good hot/wet properties<br>▸ Good CAI properties 221 MPa (32 ksi) | 45 | 12 | ○ | ○ | ○ | ○ | | ○ | | ○ | ○ | ○ | ○ | ○ | | | ○ | ○ | | ○ | | ○ | | | |
| TC380 **NEW** | Epoxy | 201°C (394°F) | 2 hours at 177°C (350°F) | ▸ Excellent open-hole compressive strength<br>▸ High CAI strength 289 MPa (42 ksi)<br>▸ Excellent hot/wet strength retention | 28 | 12 | ○ | ○ | | ○ | | ○ | | ○ | ○ | ○ | ○ | ○ | | | ○ | ○ | | ○ | | ○ | | | |
| TC522 **NEW** | Modified Epoxy | 189°C (372°F) | 2 hours at 180°C (356°F) | ▸ Outstanding compression after impact<br>▸ Low dielectric constant and loss<br>▸ Outstanding hot/wet properties | 21 | 12 | ○ | ○ | | | | ○ | | ○ | ○ | ○ | | ○ | | ○ | ○ | ○ | | | | ○ | | | |

# AEROSPACE PRODUCT SELECTOR

Thermoset Prepregs Cyanate Ester and Other Matrices

## THERMOSET CYANATE ESTER

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OOA/VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | LOW DIELECTRIC LOSS & CONSTANT | UD TAPE | FABRIC PREPREG | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| BTCy-1 | Cyanate Ester | 190°C (374°F) or 238°C (461°F) with post cure | 90 minutes at 177°C (350°F) Optional post cure of 2 hours at 232°C ( 450°F) | ▸ Low moisture absorption<br>▸ Low dielectric constant and loss | 14 | 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) | ▸ Toughened version of BTCy-1<br>▸ Low void content with lower pressure cures<br>▸ Ideal for satellite or radome applications | 30 | 6 | | ○ | | | ○ | ○ | | ○ | ○ | | | ○ | | ○ | ○ | ○ | | | ○ | | ○ | | |
| BTCy-2 | Cyanate Ester | 191°C (375°F) | 90 minutes at 177°C (350°F) | ▸ Toray lowest dielectric loss prepreg<br>▸ Ideal for high-energy radomes | 14 | 6 | | ○ | | | | | | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | | | | | ○ | | |
| 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) | ▸ 121°C (250°F) curing cyanate ester system for low-residual cure stresses<br>▸ Post curable for higher $T_g$ | 21 | 12 | | ○ | | | ○ | ○ | | ○ | ○ | | | ○ | | ○ | ○ | ○ | | | ○ | | ○ | | |
| 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) | ▸ Industry standard prepreg system for satellite structure<br>▸ Low dielectric constant and loss | 30 | 12 | ○ | ○ | | | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | | | ○ | | ○ | | |
| 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) | ▸ Lowest CTE, CME, outgassing<br>▸ Ideal system for stable structures | 7 | 6 | | ○ | | | ○ | ○ | | ○ | ○ | | | ○ | | ○ | ○ | ○ | | | ○ | | | | |
| 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) | ▸ Excellent thermal stability<br>▸ Epoxy-like processing with $T_g$ of BMI<br>▸ Used on heatshields and supersonic leading edges | 21 | 6 | ○ | ○ | | | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | | ○ |

## THERMOSET HIGH TEMPERATURE POLYIMIDE AND BMI

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OOA/VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | UD TAPE | FABRIC PREPREG | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| 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 high-temperature thermal stability<br>▸ Good moisture resistance | 30 | 6 | | ○ | ○ | ○ | ○ | | | ○ | ○ | | ○ | | | ○ | ○ | | ○ | | ○ | ○ | | ○ |
| RS-51 | Polyimide AFRPE-4 | 366°C (690°F) | Call for cure details | ▸ Ultra-high service temperature for jet engine applications | 10 | 6 | | ○ | | | | | | ○ | ○ | | ○ | | | ○ | ○ | | ○ | | | ○ | | ○ |
| TC890 | Polyimide 900HT | 454°C (850°F) | Call for cure details | ▸ Non-MDA PMR-15 replacement<br>▸ Short-term service temperature capability of 538°C (1000°F) | 30 | 12 | | ○ | | | | | | ○ | ○ | | ○ | | | ○ | ○ | | ○ | | | ○ | | ○ |
| NRPE | Polyimide | 371°C (700°F) | Call for cure details | ▸ Better hot/wet properties versus AFR-PE-4E<br>▸ Lower pressure cure processing<br>▸ More robust processing of thick components verses AFR-PE-4E<br>▸ Post cure not required | 30 | 12 | | ○ | | | | | | ○ | ○ | | ○ | | | ○ | ○ | | ○ | | ○ | ○ | | ○ |

# AEROSPACE PRODUCT SELECTOR

Toray Cetex® Thermoplastic Prepregs and Laminates

Cetex®

## TORAY CETEX® THERMOPLASTIC

| | RESIN | PEAK $T_g$ | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | PROCESSING | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | WELDABLE/JOINTING | AUTOCLAVE | PRESS FORMING | AFP/ATL | DURABILITY/ TOUGHNESS | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | MECHANICAL PERFORMANCE | UD TAPE | FABRIC PREPREG | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | AERO ENGINES |
| TC925 FST | PC | 153°C (307°F) | 260°C (500°F) | ▸ Designed for interior applications with good FST properties (OSU < 25/25)<br>▸ Value-oriented solution<br>▸ Good chemical resistance | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | | | | | ○ | |
| TC1000 Design | PEI | 215°C (419°F) | 315°C (600°F) | ▸ Laminates are available to customer specifications<br>▸ Lower cost option than Premium where OEM specifications are not required | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | | | | | ○ | |
| TC1000 Premium | PEI | 215°C (419°F) | 315°C (600°F) | ▸ Excellent FST performance (OSU < 15/15)<br>▸ Moderate solvent resistance<br>▸ Widely used in aircraft interiors, qualified to OEM specifications | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | | | | ○ | ○ |
| TC1100 | PPS | 90°C (194°F)<br>$T_m$ 280°C (536°F) | 320°C (608°F) | ▸ Microcrack free<br>▸ Low flammability, achieves 35/35 for OSU performance<br>▸ Good CAI properties 229 MPa (33.2 ksi)<br>▸ Ideal for leading edges, beams, clips, and floor panels | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | | | | ○ | ○ |
| TC1200 | PEEK | 143°C (290°F)<br>$T_m$ 343°C (649°F) | 385°C (725°F) | ▸ Good high-temperature properties<br>▸ Very good CAI properties 265 MPa (38.4 ksi)<br>▸ Ideal for structural applications | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | ○ | ○ |
| TC1225 | Engineered PAEK | 147°C (297°F)<br>$T_m$ 305°C (581°F) | 325-350°C (615-662°F) | ▸ Lower processing temperature with good high-temperature performance<br>▸ May be overmolded with PEEK for final part<br>▸ Very good CAI properties 282 MPa (40.9 ksi)<br>▸ Ideal for structural applications | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | ○ | ○ |
| TC1320 | PEKK | 159°C (318°F)<br>$T_m$ 337°C (639°F) | 371°C (700°F) | ▸ Outstanding solvent and impact resistance<br>▸ Very high CAI properties 337 MPa (48.9 ksi)<br>▸ Ideal for structural applications<br>▸ Lower processing temperature material | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | ○ | | | | | ○ |

## TORAY MICROPLY™ FILM ADHESIVES EPOXY

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RS-15H | Epoxy | 99°C (211°F) | 6 hours at 93°C (200°F) Alternate cures are available | ▸ Low-temperature curing adhesive | 30 | 12 | ○ | ○ | ○ | | | ○ | | ○ | ○ | | | | | ○ | ○ | | ○ | | |
| TC263 | Epoxy | 110°C (230°F) | 2 hours at 121°C (250°F) | ▸ High peel strength<br>▸ Ideal for metal or composite bonding | 21 | 12 | ○ | ○ | ○ | | | ○ | | ○ | ○ | | | | | ○ | ○ | ○ | ○ | ○ | |
| TC310 | Epoxy | 157°C (315°F) | 2 hours at 177°C (350°F) | ▸ Ideal composite bonding film adhesive | 21 | 12 | ○ | ○ | ○ | | | ○ | | ○ | ○ | | | | | ○ | ○ | ○ | ○ | | ○ |

## TORAY MICROPLY™ FILM ADHESIVES CYANATE ESTER

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EX-1516 | Cyanate Ester | 126°C (258°F) | 5 hours at 121°C (250°F) | ▸ Compatible with Toray EX-1515 prepreg | 21 | 12 | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | | ○ | | | ○ | | ○ | | |
| 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) | ▸ Low-shrinkage cyanate ester film adhesive<br>▸ Low outgassing | 14 | 6 | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | | ○ | | | ○ | | ○ | | |
| 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 cyanate ester film adhesive<br>▸ Compatible with 177°C (350°F) curing cyanate ester prepregs | 14 | 6 | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | | ○ | | | ○ | | ○ | | |
| 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<br>▸ Compatible with TC420 | 14 | 6 | ○ | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | ○ | ○ | ○ | | ○ |

## TORAY MICROPLY™ SURFACING FILMS EPOXY

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | TACK LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOISTURE ABSORPTION | LIGHTNING STRIKE PROTECTION | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TC235SF-1 | Epoxy Surfacing Film | 119°C (246°F) | 60 minutes at 121°C (250°F) | ▸ Excellent protective surface finish<br>▸ Available with embedded lightning strike foils<br>▸ Reduces shop floor finishing for productivity savings | 30 | 12 | ○ | ○ | ○ | | | ○ | | ○ | ○ | | | | ○ | ○ | | | | | | |

## TORAY MICROPLY™ SYNTACTICS EPOXY

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | PRODUCT FORMATS: FILM | PASTE | EXPANDING | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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<br>▸ $T_g$ estimated from base resin data | 14 | 12 | | ○ | | | | ○ | | ○ | ○ | | | | | ○ | | ○ | ○ | ○ | | ○ | | |
| TCF4035 | Epoxy | 140°C (284°F) | 2 hours at 130°C (265°F) | ▸ Low density 0.64 g/cc (40 pcf)<br>▸ Compatible with TC250, may be post cured for higher $T_g$ | 21 | 12 | ○ | ○ | | | ○ | ○ | | ○ | ○ | | | | | ○ | | | ○ | | ○ | ○ | | |
| TCF4045 | Modified Epoxy | 180°C (356°F) | 3 hours at 179°C (355°F) | ▸ Excellent low dielectric loss and constant<br>▸ Density of 0.61 g/cc (38.5 pcf) | 14 | 6 | ○ | ○ | | | | ○ | | ○ | ○ | | | | | ○ | | | ○ | | | ○ | | |

## TORAY MICROPLY™ SYNTACTICS CYANATE ESTER

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | PRODUCT FORMATS: FILM | PASTE | EXPANDING | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EM-5A | Cyanate Ester | 204°C (400°F) optional post cure | 2 hours at 177°C (350°F) | ▸ Expansion ratio of 4 x | 28 | 12 | ○ | ○ | | | ○ | ○ | | ○ | ○ | | | | | ○ | | ○ | | ○ | | ○ | | |
| EX-1541 | Cyanate Ester | 227°C (441°F) or 240°C (464°F) with post cure | 2 hours at 177°C (350°F), post cure of 2 hours at 232°C (450°F) | ▸ Density of 0.16-038 g/cc (10-24 pcf)<br>▸ Good structural properties<br>▸ Low dielectric constant and loss | 14 | 6 | | ○ | ○ | | ○ | | | | | | ○ | ○ | | | ○ | | | ○ | | ○ | ○ | ○ |
| SF-5 | Cyanate Ester | 193°C (379°F) or 254°C (490°F) with post cure | 2 hours at 177°C (350°F), post cure of 2 hours at 249°C (480°F) | ▸ Density of 0.61 g/cc (38 pcf)<br>▸ Low dielectric constant and loss<br>▸ Compatible with Toray RS-3 | 14 | 6 | ○ | ○ | ○ | | ○ | ○ | | | | | ○ | ○ | | ○ | | | ○ | | ○ | | ○ |
| TCF4001 | Cyanate Ester | 176°C (349°F) optional post cure | 2 hours at 177°C (350°F) post cure of 60-90 minutes at 232°C (450°F) | ▸ Low density 0.38 g/cc (24 pcf)<br>▸ Compatible with TC420 prepregs | 14 | 6 | ○ | ○ | | | ○ | | | ○ | ○ | | ○ | ○ | | | ○ | | ○ | ○ | ○ | | ○ | | ○ |
| TCF4050 | Cyanate Ester | 176°C (349°F) or 232°C (450°F) with post cure | 2 hours at 177°C (350°F) post cure of 60 minutes at 232°C (450°F) | ▸ Expanding syntactic film/core splice<br>▸ Density of 0.28-0.55 g/cc (17-35 pcf)<br>▸ Compatible with TC420 prepregs | 7 | 6 | ○ | ○ | | | ○ | ○ | | ○ | ○ | | ○ | ○ | | ○ | | ○ | ○ | ○ | | ○ | | ○ |

## TORAY MICROPLY™ SYNTACTICS OTHER THERMOSET MATRICES

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING: OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | PRODUCT ATTRIBUTES: TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | PRODUCT FORMATS: FILM | PASTE | EXPANDING | AEROSPACE MARKET SEGMENTS: AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SF-4 | BMI | 295°C (563°F) | 2 hours at 204°C (400°F), then 6 hour post cure at 250°C (482°F) | ▸ Low density 0.62 g/cc (39 pcf)<br>▸ Compatible with RS-8HT and other BMI systems | 14 | 6 | ○ | ○ | | | ○ | | | ○ | ○ | | ○ | | | ○ | | ○ | ○ | ○ | | ○ | | ○ |

# AEROSPACE PRODUCT SELECTOR

Resin Transfer Molding and Bulk Molding Compounds

## **RTM** RESINS

| | RESIN | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | POT LIFE | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | 1 PART | 2 PART | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| EX-1510 | Cyanate Ester | 193°C (380°F) | 2 hours at 177°C (350°F) | ▸ Low viscosity at room temperature of 150 cPs<br>▸ Post curable | 4 hrs | | | ○ | | ○ | | | | | | ○ | ○ | | | ○ | | ○ | ○ | | | | ○ |
| 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)<br>▸ Long pot life for complex parts | 24 hrs | | | ○ | | | | | ○ | ○ | ○ | ○ | | | | ○ | | | ○ | | ○ | | | |
| RS-16 | Cyanate Ester | 167°C (332°F) or 231°C (448°F) with post cure | 2 hours at 135°C (275°F) | ▸ Low-temperature cure resin system<br>▸ Post curable for higher $T_g$ | 4 hrs | | | ○ | | ○ | ○ | | ○ | ○ | | ○ | | | | ○ | | | ○ | | ○ | | | |
| RS-50 | Epoxy | 203°C (397°F) | 2 hours at 177°C (350°F) | ▸ Toughened epoxy for structural applications<br>▸ Low minimum viscosity of 23 cPs | 4 hrs | | | ○ | | | ○ | | ○ | ○ | ○ | | | | ○ | | | ○ | | ○ | | | |

## **BMC** THERMOSET

| | RESIN MATRIX | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | HS | IM | HM | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| 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 (HM) fiber | 14 | 6 | | | ○ | | ○ | | | ○ | ○ | | | | ○ | | | ○ | ○ | ○ | ○ | | | |
| 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 high-modulus (HM) fiber | 14 | 6 | | | ○ | | ○ | | | ○ | ○ | | | | ○ | | ○ | | ○ | ○ | | | | |
| 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 (HS) fiber | 14 | 6 | | | ○ | | ○ | | | ○ | ○ | | | | ○ | ○ | | | ○ | ○ | ○ | | ○ | |

## **BMC** TORAY CETEX®

| | RESIN MATRIX | PEAK $T_g$ | PROCESSING TEMPERATURE | KEY PRODUCT CHARACTERISTICS | PROCESSING | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | HS | IM | HM | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| MC1100 | PPS | 90°C (194°F) | 330°C (625°F) | ▸ PPS based BMC with HS and IM fibers<br>▸ Fire retardant | | | ○ | | ○ | ○ | ○ | ○ | ○ | | ○ | ○ | ○ | | | ○ | ○ | ○ | | ○ | | |
| MC1200 | PEEK | 143°C (290°F) | 385°C (725°F) | ▸ PEEK based BMC with HS and IM fibers<br>▸ Fire retardant | | | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | ○ | ○ | ○ | | ○ | | |
| MC1322 **NEW** | PEKK | 162°C (324°F) | 380°C (715°F) | ▸ PEKK based BMC with HS fibers | | | ○ | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | ○ | | | ○ | | | | ○ | | |

# AEROSPACE PRODUCT SELECTOR
Toray AmberTool®

AmberTool®

## TORAY AMBERTOOL® COMPOSITE TOOLING PREPREGS

| | RESIN | DRY $T_g$ ONSET | CURE TIME AND TEMPERATURE | KEY PRODUCT CHARACTERISTICS | OUT LIFE # DAYS | FREEZER LIFE # MONTHS | PROCESSING | | | | | PRODUCT ATTRIBUTES | | | | | | | | PRODUCT FORMATS | | | AEROSPACE MARKET SEGMENTS | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | OOA / VBO | AUTOCLAVE | PRESS FORMING | AFP/ATL | POST CURABLE | TOUGHENED | FLAME RETARDANT | CHEMICAL RESISTANT | CORROSION RESISTANT | IMPACT RESISTANT | HIGH TEMPERATURE PERFORMANCE | LOW MOSITURE ABSORPTION | LIGHTNING STRIKE PROTECTION | UD TAPE | FABRIC PREPREG | RTL LAMINATE | AEROSTRUCTURES | SPACE AND SATELLITE | LAUNCH | RADOMES | AIRCRAFT INTERIORS | ENGINES/HIGH TEMP |
| HX40 | Epoxy | 203°C (397°F) | 12 hours at 65°C (149°F) | ▸ Large tooling applications<br>▸ High-temperature performance | 8 | 6 | | ○ | | | ○ | | | ○ | ○ | | | | | | ○ | | ○ | ○ | ○ | ○ | | |
| HX42 | Epoxy | 200°C (392°F) | 8 hours at 60°C (140°F) | ▸ Proven system for aerospace<br>▸ Shorter cure schedule at lower temperatures<br>▸ Excellent surface finish | 5 | 6 | | ○ | | | ○ | | | ○ | ○ | | | | | | ○ | | ○ | ○ | ○ | ○ | | |
| TC40 | BMI | 213°C (415°F) | 6 hours at 182°C (360°F), post cure 2 hours at 210°C (410°F) | ▸ High service temperature<br>▸ Excellent thermal stability | 14 | 6 | | ○ | | | ○ | | | ○ | ○ | | ○ | | | | ○ | | ○ | ○ | ○ | ○ | | |

For more product information such as product data sheets, case studies, or technical papers, please use the following resources:

Search for the **Toray TAC Product Selector**

**www.toray**tac.com
Go to our online resource center for case studies and technical papers

# LOCATIONS AND CAPABILITIES

**SOLUTIONS**
- Thermoplastic composites
- Thermoplastic laminates
- Thermoset composites
- Carbon-free manufacturing
- Parts manufacture
- Sales office

**CERTIFICATIONS**
- ISO 9001:2015
- AS9100D
- ISO 14001:2015
- ISO 45001:2018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