HUNTSMAN

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Advanced Materials

Matrimid® 5292 A-2 Resin
Matrimid® 5292 B Hardener

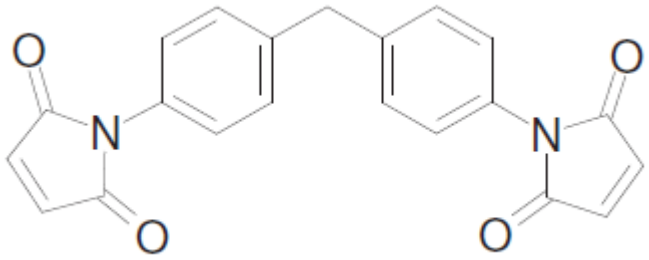
BISMALEIMIDE

General

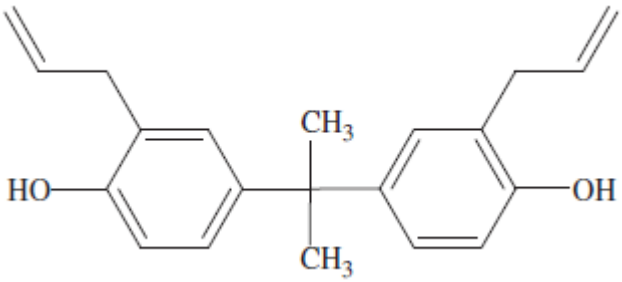
Matrimid® 5292 A-2 bismaleimide is a two-component system which, when combined and cured, is suitable for high-temperature advanced composites and adhesives applications.

Chemical Structure

Matrimid® 5292A-2
4,4'-Bismaleimidodiphenylmethane



Matrimid® 5292B
o,o'-Diallyl Bisphenol A



Patent

The technology described in this data sheet, with the use of component A and B, is covered by the Huntsman Patent No. 4,100,140.

Advantages

High heat performance
Maintains mechanical properties at ambient and elevated temperatures
Good toughness
Very good humidity resistance
Can be hot-melt processed
Good handling

Applications

Advanced composites structures
High-performance structural adhesives
Laminating (including printed circuit boards)
Casting applications
Filament winding
Coatings

Typical Properties*

Component A

Visual Appearance	Yellow, crystalline powder
Melting Point, °C (°F)	155 - 165 (311 - 329)
Maleimide Double Bond Content	>85% of theoretical
Particle size, microns	< 100 microns

Component B

Visual Appearance	Amber liquid
Viscosity @ 25°C (77°F), cPs	12,000 - 20,000

* Typical properties are based on Huntsman's test methods. Copies are available upon request.

Formulations

The Matrimid® 5292 A-2 system can be used by itself as described below (see formulations 1 and 2) or can be formulated with various chemical components which react with the double bonds of bismaleimides, allyl groups, or phenol groups. Additional formulating may improve some properties of the system.

Formulations	System 1*	System 2
Matrimid® 5292 A-2, pbw	100	113
Matrimid® 5292 B, pbw	85	85

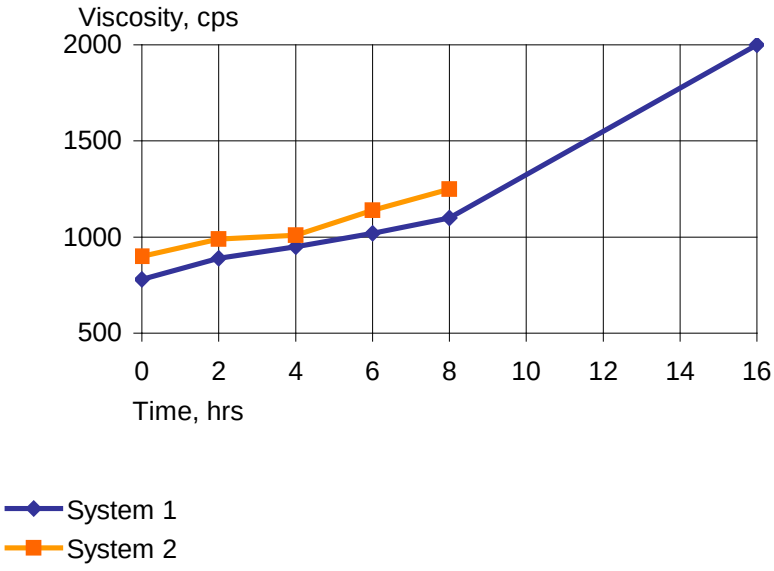
* Although formulation 2 shows some better performance properties our packaging size is equivalent to the pbw of formulation 1. This ratio provides more flexibility to formulate for the prepregger.

Procedure

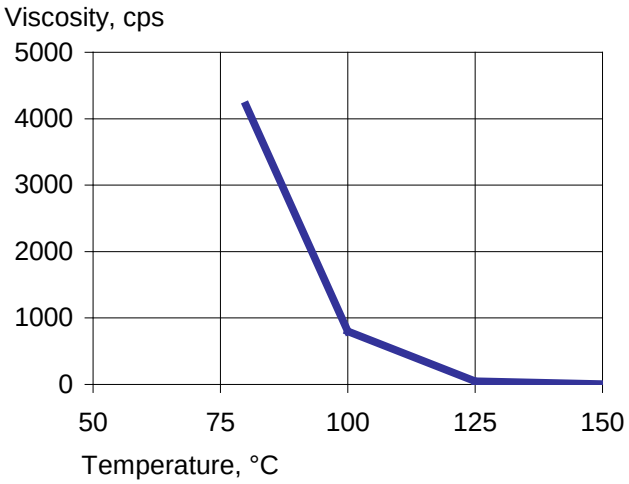
Combine both components A and B in proper proportions in an appropriate kettle equipped with heating capability, mechanical stirrer and temperature recording device. Heat both components with continuous stirring to 120-130°C (248-266°F) until a clear homogeneous solution is obtained. Additional heating dictates the pot life of the resultant prepolymer. For clear casting, degas the resultant mixture, while maintained at 130°C (266°F), at 26+ inches of vacuum for 5-10 minutes. For a 1000 gram mass of prepolymer, about 50-60 minutes time is available at 150°C (302°F). Hot degassed melt can be poured into preheated molds.

Formulations (continued)

Prepolymer Viscosity Profile @ 100°C (212°F)



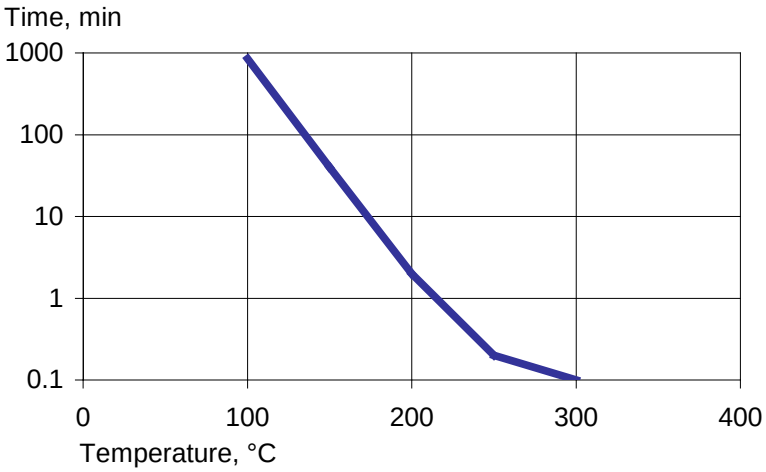
Viscosity Profile System 1



50°C=122°F; 75°C=167°F; 100°C=212°F; 125°C=257°F; 150°C=302°F.

Formulations (continued)

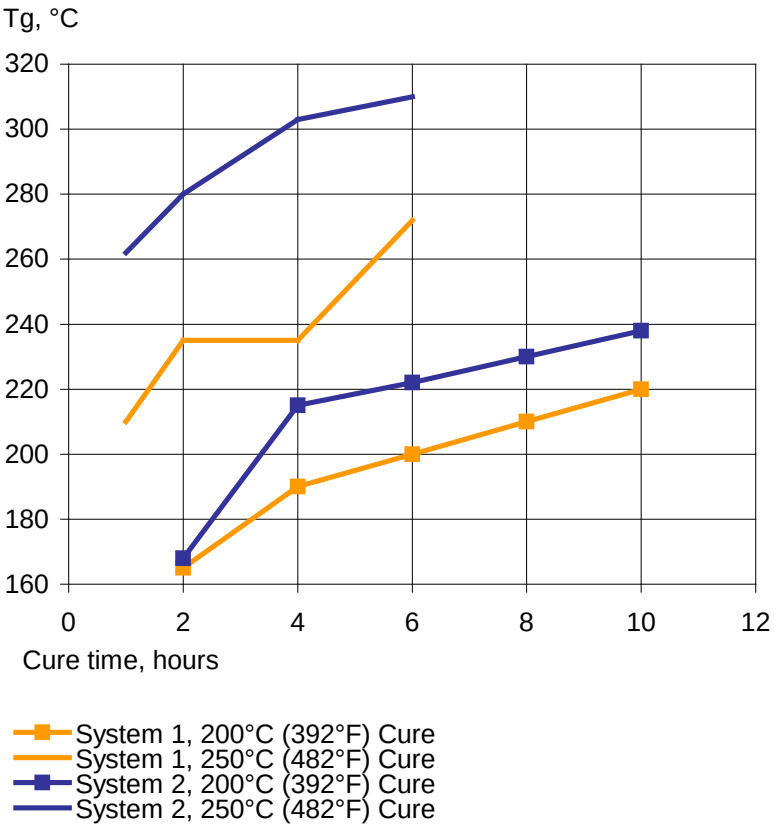
Gel Time versus Temperature
(For both systems)



50°C=122°F; 100°C=212°F; 150°C=302°F; 200°C=392°F; 250°C=484°F; 300°C=572°F; 350°C=662°F.

Cure Schedule versus Glass Transition Temperature, final cure is dictated by the end use properties desired. The following graph shows the effect of different cure schedules on the glass transition temperature:

Glass transition temperature



Formulations

(continued)

Cured Properties of Neat Resin Casting

The following cure cycle was used for both formulations to develop neat resin properties below:
1 hour at 180°C (356°F)
2 hours at 200°C (392°F)
6 hours at 250°C (482°F)

Formulations	**System 1**	**System 2**
R.T. Tensile:		
Strength, ksi (MPa)	11.9 (82)	13.6 (93.8)
Modulus, ksi (MPa)	620 (4,276)	564 (3,990)
Elongation, %	2.3	3.0
R.T. Flex.		
Strength, ksi (MPa)	24.2 (167)	26.8 (185)
Modulus, ksi (MPa)	589 (4,062)	580 (4,000)
R.T. Compression:		
Yield Strength, ksi (MPa)	29.9 (206)	30.4 (210)
Ultimate Strength, ksi (MPa)	30.9 (213)	-
Modulus, ksi (MPa)	348 (2,400)	360 (2,483)
Compression at yield, ksi (MPa)	16.8 (116)	13.6 (93.8)
Compression at failure, %	33.5	-
149°C (300°F) Tensile:		
Strength, ksi (MPa)	7.4 (51)	10.1 (69.6)
Modulus, ksi (MPa)	354 (2,441)	412 (2,841)
Elongation,%	2.6	3.05
204°C (400°F) Tensile:		
Strength, ksi (MPa)	5.8 (40)	10.4 (72)
Modulus, ksi (MPa)	294 (2,027)	394 (2,717)
Elongation, %	2.3	4.6
HDT, °C (°F)	273 (523)	285 (545)
Tg (By TMA-Penetration mode) °C (°F)	273 (523)	282 (540)
Tg (By DMA) °C (°F) Dry	295 (563)	310 (590)
Tg (By DMA) °C (°F) Wet*	305 (581)	297 (567)
Specific Gravity of cured System at 25°C (77°F)	1.2319	1.2328
Fracture Toughness (Compact Tension): G_{IC} Values, in. lb/in^2	0.97	1.2

* Two weeks @ 38°C (100°F), relative humidity.

Formulations

(continued)

Mechanical Properties After Humidity Exposure (Neat Resin)

Below are mechanical properties of the Matrimid® 5292 A/B neat resin cured per the previously described cure cycle. These systems were tested at R.T. and 149°C (300°F) after exposure to 100% relative humidity at 38°C (100°F) for 2 weeks

Formulations	**System 1**	**System 2**
R.T. Tensile:		
Strength, ksi (MPa)	9.6 (66)	12.8 (88)
Modulus, ksi (MPa)	548 (3,779)	549 (3,786)
Elongation, %	2.1	3.4
149°C (300°F) Tensile:		
Strength, ksi (MPa)	4.3 (30)	6.9 (47.6)
Modulus, ksi (MPa)	270 (1,862)	312 (2,151)
Elongation, %	1.95	3.2
Water Pick-up, %	1.40	1.5

Cured Properties After Lower Temperature Cure (Neat Resin)

To demonstrate the effect of lower cure temperatures on mechanical properties, castings were prepared as described above with the exception of the cure cycle which is:
1 hour @ 177°C (350°F) + 10 hours @ 200°C (392°F).

Formulations	**System 1**	**System 2**
R.T. Tensile:		
Strength, ksi (MPa)	15.1 (104)	14.5 (100)
Modulus, ksi (MPa)	622 (4,290)	595 (4,103)
Elongation, %	2.9	2.9
149°C (300°F) Tensile:		
Strength, ksi (MPa)	10.7 (73.8)	11.4 (78.6)
Modulus, ksi (MPa)	466 (3,213)	484 (3,338)
Elongation%	4.2	3.1
204°C (400°F) Tensile:		
Strength, ksi (MPa)	7.5 (51.7)	10.6 (73.1)
Modulus, ksi (MPa)	264 (1,821)	505 (3,483)
Elongation, %	5.3	2.7
Tg °C (°F) (By TMA-Penetration Mode)	218 (424)	234 (453)

Prepregging/Laminating

Impregnating/Prepregging

Hot-melt impregnation techniques are easily utilized with this bismaleimide system. Although impregnation by the use of solvents is also possible.

For the composite properties presented below, unidirectional prepreg was prepared using the drum winding technique. The polymer used here was prepared as described for neat resin casting and was kept at 150°C (302°F) during the winding process. Hexcel graphite fiber, Magnamite AS-4-12K was used. The resultant prepreg had good tack and drape characteristics. Tack and drape can be controlled by varying the prepolymerization time. In this case no further staging was required prior to molding.

Molding and Curing of Prepreg

Both formulations described above are conducive to standard autoclave or compression molding techniques. A 177° C (350°F) cure for 1-2 hours is recommended followed by a free standing post cure for up to 6 hours @ 250°C (482°F). Other post cure schedules are possible depending on the required end properties. Composites prepared for this testing were compression molded as follows:

Prepreg plies with appropriate release and bleeder cloth were laid up in a mold.

The mold was put in a press under contact pressure and the temperature raised to 177°C (350°F) @ 5°F/min.

When prepreg reached 177°C (350°F) it was held 10-15 minutes under contact pressure, then 100-psi pressure was applied and held for 1 hour at these conditions.

At the end of one-hour cure, the mold was cooled to R.T. under pressure.

The laminate was demolded and post-cured in an air circulating oven as follows:

2 hours at 200°C (392°F)
6 hours at 250°C (482°F)

Composite Properties

Temp. °C (°F) (Condition)	System 1	System 2
Short Beam Shear Strength, ksi (MPa)		
25 (77)	16.4 (113)	17.8 (123)
177 (350) (Dry)	11.0 (75.9)	11.9 (82)
232 (450) (Dry)	8.6 (59.3)	11.4 (78.6)
177 (350) (Wet*)	7.5 (51.7)	7.7 (53.1)
25 (77) (Aged**)	-	15.2 (105)
177 (350) (Aged**)	-	8.1 (55.9)
Flexural Strength, ksi (MPa)		
25 (77)	-	270 (1,862)
177 (350) (Dry)	-	219 (1,510)
177 (350) (Wet*)	-	162.5 (1,121)
Flexural Modulus, ksi (MPa)		
25 (77)	-	21,000 (144,828)
177 (350) (Dry)	-	21,000 (144,828)
177 (350) (Wet*)	-	21,800 (150,345)

Reinforcement, Graphite Fiber, Magnamite AS-3-12K, 65 V/O

* 2 weeks @ 71°C (160°F), 95% R.H.
** 1000 hrs @ 232°C (450°F)

STORAGE STATEMENT

Matrimid® 5292 Component A is supplied in a 100 pound package and Component B is supplied in a 110 pound package. Matrimid 5292A-2 and Matrimid 5292B should be stored in a dry place, in the sealed original container, at temperatures between 2^{O}C and 40^{O}C (36^{O}F and 104^{O}F). The product should not be exposed to direct sunlight. Under these storage conditions, and when supplied under Huntsman standard certification, both of these products have a shelf life of 5 years. (Expiration date may differ based on customer specification).

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First Aid!
Refer to MSDS as mentioned above.

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