HEXION™

Technical Data Sheet

Re-issued September 2002

EPON™ Resin 164 (a.k.a. EPIKOTE™ Resin 180)

Product Description

EPON™ Resin 164 is a solid multifunctional epichlorohydrin/cresol novolac epoxy resin (see molecular structure). It combines the high thermal stability of the novolac backbone with the versatility, reactivity, and chemical resistance of epoxy resins. It is used where improved properties of cured epoxy resin systems are needed, particularly at elevated temperature and where stability of electrical properties under humid conditions are required. It finds application in electrical laminates, molding compounds, high performance aerospace composites, high temperature adhesives, powder coatings, and tooling.

Benefits

- An average of five reactive epoxide groups per molecule
- Low ionic contaminants
- Low saponifiable chloride
- Easily ground into uniform particle size
- Low melt viscosity
- Stability on storage

Sales Specification

Property	Units	Value	Test Method/Standard
Epoxide Equivalent Weight	g/eq	200 – 240	ASTM D1652
Viscosity at 25°C	cP	35 – 50 [1]	ASTM D445
Color	Gardner	6 max.	ASTM D1544

[1] 60% weight solution in MEK

Typical Properties

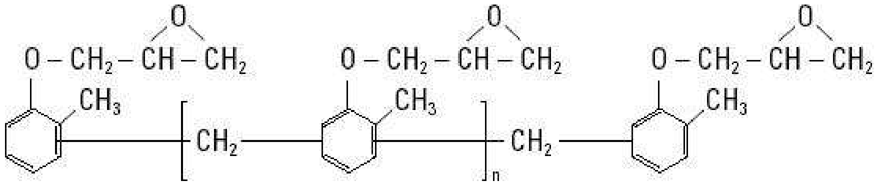
Property	Units	Value	Test Method/Standard
Vapor Pressure, at 25 °C		Negligible	
Solubility in Wwater		Negligible	
Melt Viscosity at 150°C	cSt	600 – 1200	ASTM D445, Cannon-Fenske
Melt Viscosity at 150°C	P	9 – 14	ICI Cone & Plate
Weight per Gallon, at 20 °C	lb/gal	10.2	

Flash Point, Setaflash	°F	>200	ASTM D3278
Bulk Density	lb/ft^3	35 – 40	
Saponifiable Chloride	% wt.	<0.005	
Total Chloride	% wt.	<0.15	
Free Chloride	ppm	<1	
Sodium	ppm	<5	
Tg by DSC	°C	37 – 39	
Melting Point, at 1°C/min.	°C	82	ASTM D3461
Water, (as manufactured)	% wt.	0.3 max.	

General Information

Chemical Abstract Service Registry Number: 29690-82-2
Chemical Designation: Polyglycidyl ether of ortho cresol novolac

Structural formula base resin:



Where n = an average of 3

Benefits

The use of EPON Resin 164 in epoxy resin formulations increases resistance to attack by moisture, solvents, and environment. In addition, it brings higher glass transition temperature (Tg) and crosslink density to cured systems which provides improved retention of strength, rigidity, electrical, and other properties at elevated temperatures. EPON Resin 164 is commonly used in formulations for making structural laminates, electrical printed circuit boards, and electronic molding powders which require higher performance temperatures and greater dimensional stability.

EPON Resin 164 is easily ground into powders or blended with other epoxy resins. It is compatible with most materials used with BPA-based epoxies and its low melt viscosity provides ease of handling and good flow characteristics. Its low ionic contamination plus ultra low saponifiable chloride reduces the potential of device failure in sensitive electronic devices. Because of this, EPON Resin 164 is the resin of choice for transfer molding compounds in semi-conductors, relays or other active or passive components in the electronic field.

The high functionality of EPON Resin 164 shortens cure times and improves handling and speed of production. The resin has excellent adhesive properties needed for bonding both metal and non-metal structural components. Typically, it maintains low weight loss in heat aging of cured systems. For these reasons, EPON Resin 164 is preferred for high temperature adhesives, structural composites, and other high performance products in the aircraft and aerospace industry.

Because most cured resin systems retain a significant proportion of properties up to their glass transition temperature (Tg), frequently the needed performance properties can be predicted based upon the Tg for the system selected. Hence, this bulletin provides a large amount of glass transition temperature data on a variety of systems to provide the reader with starting point compositions plus a guide for optimizing these systems.

Handling Properties

EPON Resin 164 can be handled as a hot melt (melting point ca. 80 °C), as a blend with EPON Resin 828 [liquid bisphenol A/epichlorohydrin (BPA/ECH) epoxy resin] or other resins, as a powder, or from solution.

Figure 1 shows the viscosity-temperature profile for the neat resin. It has a low melt viscosity of ca. 10 poise at 150 °C (302 °F). It can be readily blended with other resins, fillers, curing agents and additives for formulating needs.

Figure 1 also shows viscosities for blends of EPON Resin 164 with EPON Resin 828. Typically, blends provide reductions in viscosity and cost while maintaining a useful balance of Tg and other performance properties.

Figure 1 / **Melt Viscosity for EPON™ Resin 164 and Blends with EPON Resin 828**

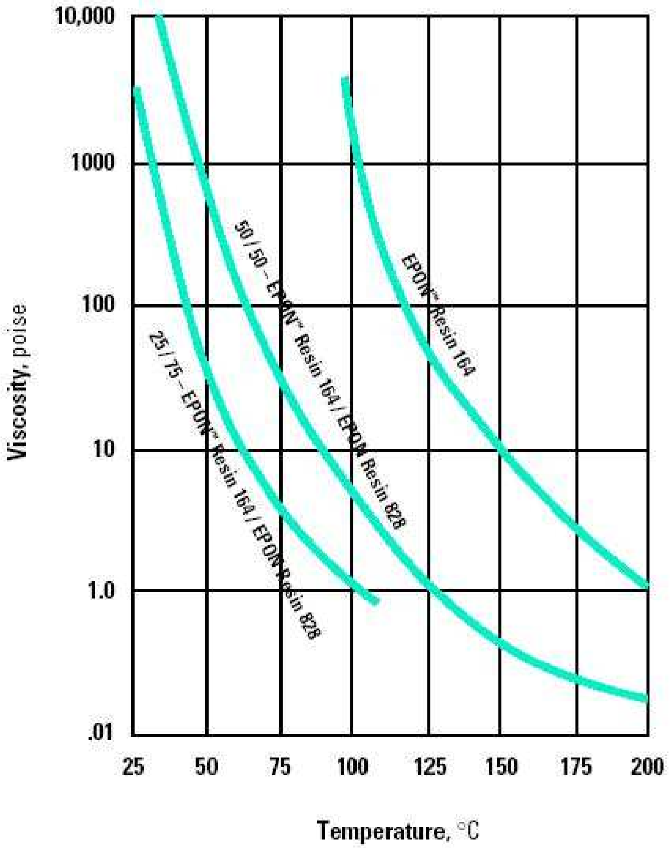


Figure 2 shows solution viscosities for EPON Resin 164 with a variety of solvents. Generally, ketones provide lower viscosities at higher resin solids than other solvents. For example, up to 75%w resin may be cut into MEK for 10-20 poise solution viscosity at room temperature, while only 65%w resin can be added to glycol ethers for the same viscosity.

Figure 2 / **Viscosities for solutions of EPON Resin 164 (at 25 °C)**

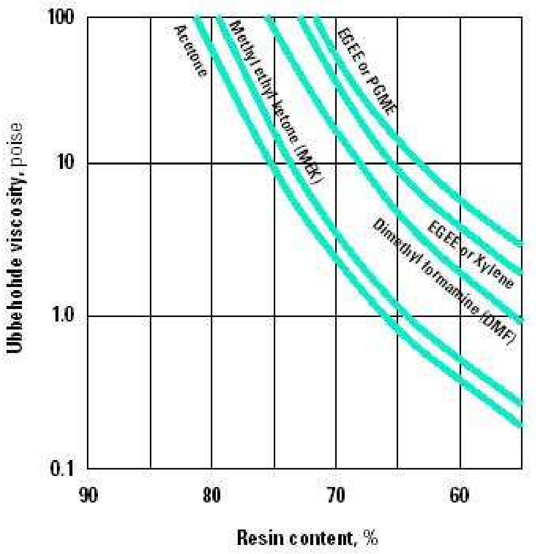


Table 1 / **Specific Gravity**

Solvent	Percent wt. resinC		
	60	70	80
Acetone	1.00	1.05	1.11
MEK	1.01	1.05	1.10
DMF	1.09	1.11	---
Xylene	1.04	1.08	---
Ethylene glycol methyl ether (EGME)	1.09	1.12	---
Ethylene glycol ethyl ether (EGEE)	1.085	1.115	---
Propylene glycol methyl ether (PGME)	1.08	1.11	---

Performance Properties

Performance of Catalyzed Systems

Unfilled Casings – Table 2 shows typical properties for EPON Resin 164 cured with NADIC Methyl Anhydride (NMA) and diaminodiphenylsulfone (DDS) which are commonly used curing agents in high performance applications. These properties demonstrate superiority of performance over more conventional BPA/ECH epoxies. EPON Resin 164 systems exhibit high Tg’s and heat deflection temperatures (HDT's) and better retention of properties at elevated temperatures (see Table 2). They display superior strength and modulus which translates to greater stiffness and rigidity and an ability to withstand higher loadings. They have lower coefficient of linear thermal expansion and excellent electrical properties which make them an excellent choice for encapsulation use. By contrast, EPON Resin 164 systems are less flexible than BPA/ECH epoxies and have relatively lower tensile strength and elongation.

Table 2 / **Physical Properties for Unfilled Castings of EPON Resin 164**

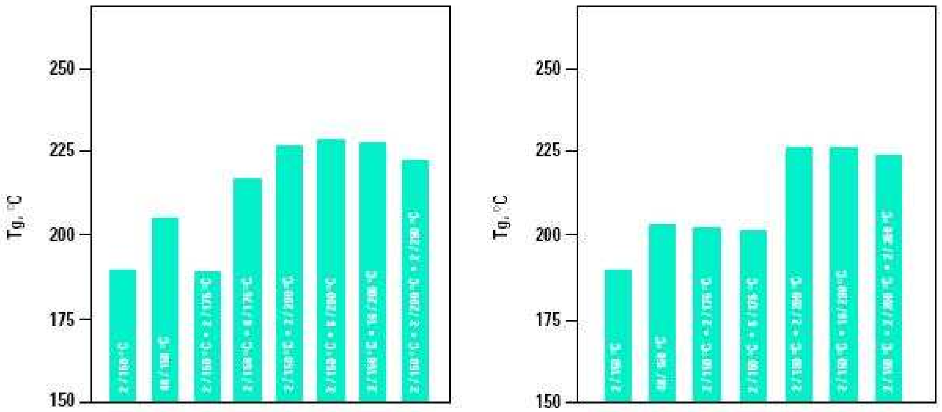
	Method	Units	A	B
EPON Resin 164		pbw	100	100
NMA, plus 1 pbw EMI catalyst		pbw	70	
DDS		pbw		25
Cure Schedule		hrs/°C	2/120 + 4/150 + 16/200	4/150 + 16/200
Cured State Properties				
Heat Deflection Temperature	ASTM D648	°C	225	225
Tg by DSC [1]	ASTM D3418	°C	230	236
Tensile Strength at break	ASTM D638	psi	8,200	10,300
Tensile Elongation at break		%	2.0	2.3
Tensile Modulus		ksi	510	540
Flexural Strength at break	ASTM D790	psi	18,500	23,000
Flexural Modulus		ksi	490	530
Compressive Strength				
0.2 % Offset		psi	14,000	14,600
Yield		psi	24,200	28,400
Compressive Deformation				
0.2 % Offset		psi	4.5	4.2
Yield		psi	15	17
Compressive Modulus		ksi	500	520
Coefficient of Thermal Expansion				
-10 °C to 130 °C			22	17
130 °C to 230 °C			35	30
230 °C to 260 °C			67	61
Density @ 25°C	ASTM D792	g/ml	1.256	1.198

Chemical Resistance				
Water absorption, 24 hr boil		% wt. gain	0.94	1.43
Acetone absorption, 3 hr boil		% wt. gain	-0.03	-0.08
Electrical Properties				
Dielectric constant	ASTM D150			
1 Hz			3.47	4.46
1 MHz			3.21	3.75
50 MHz			3.12	3.60
Dissipation factor				
1 Hz			0.007	0.014
1 MHz			0.019	0.021
50 MHz			0.015	0.031
Dielectric Strength, 1/8”	ASTM D149	Volts/mil	430	560
Volume Resistivity		ohm•cm	6×10^{16}	3×10^{16}

[1] Heating rate 40°C/minute.

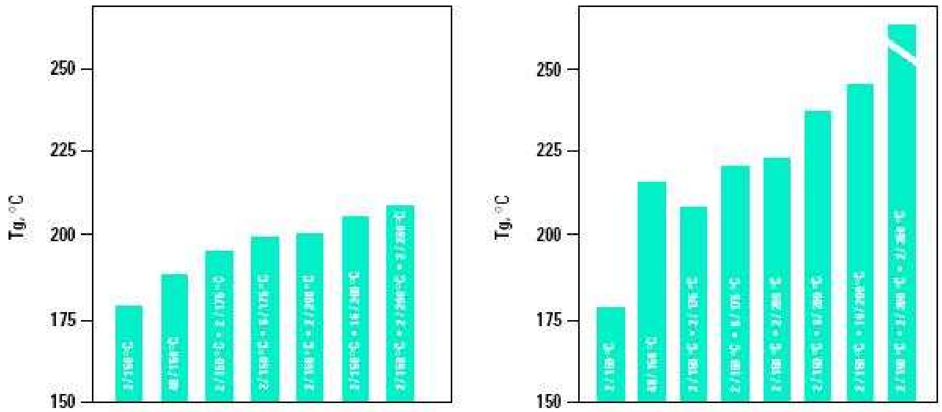
Cure CyclesVersus Tg **–** Figure 3 provides guidelines for selecting and optimizing cure cycle requirements. Data generally show that higher cure temperatures of 175-200 °C are required to achieve a higher Tg. Also, when higher cure temperatures are used, relatively short cure cycles provide full cure to the resin. When low temperature cures are used, Tg’s are lower, although still above 150 °C, and may be adequate for many uses. High Tg’s with short cures can be obtained by adding auxiliary catalysts such as boron trifluoride monoethylamine complex (BF3 MEA) and 2-methylimidazole (2-MI) to selected systems. Higher Tg’s can also be obtained using longer low temperature cures (e.g., 48 hours at 150 °C) without added auxiliary catalysts.

Figure 3 / **Effect of Cure Temperature and Time1 on Tg2 for EPON™ Resin 164 and Selected Curing Agents**



2-Ethyl, 4-Methylimidazole, 3 phr

EPON™ Curing Agent Y, 21.5 phr



CRJ 406[3], 54 phr

Nadic methyl anhydride / EMI, 67/1 phr

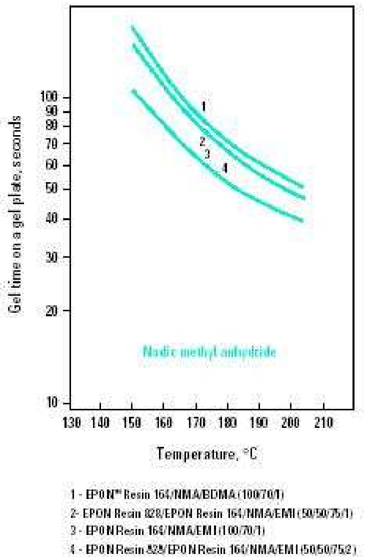
[1] The cure temperature and time (hours) are noted in each bar of the graphs.

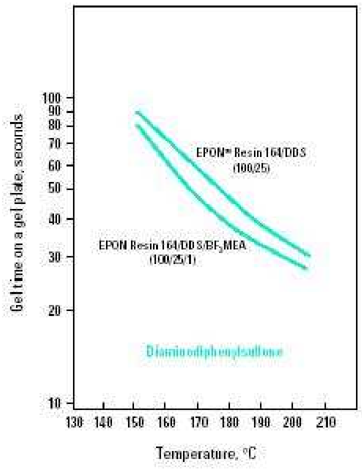
[2] The Tg in °C is determined by differential scanning calorimetry, heating rate 40°C/minute.

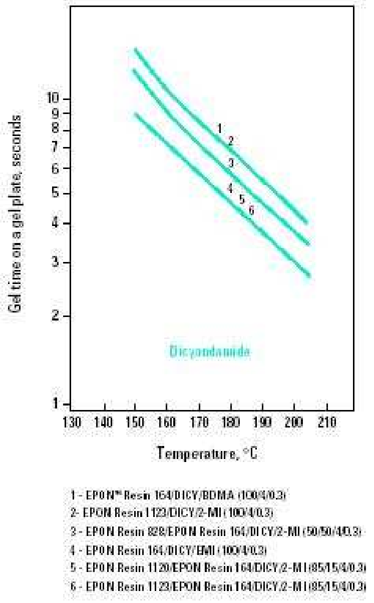
[3] CRJ 406 is a cresylic novolac produced by Schenectady Chemicals Inc. This system is further catalyzed by 0.2 phr 2 methylimidazole.

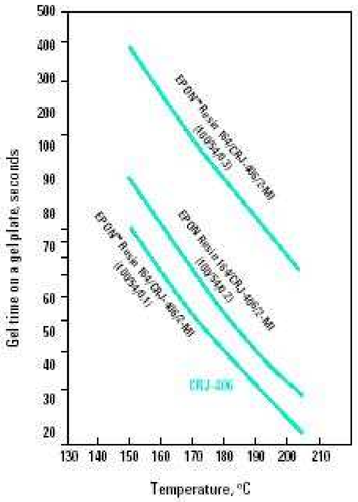
Reactivity – Figure 4 shows gel times for EPON Resin 164 and its blends with EPON Resin 828 for several curing agents. This information may be useful in adjusting reactivities for resin systems to meet process needs. Generally, gel times are similar to those obtained with BPA/ECH resins. They show a linear decrease with increasing temperature. Adding EPON Resin 164 to EPON Resin 828 shortens gel times slightly. Gel time can also be shortened by adding an auxiliary catalyst. Among these catalysts 2-methylimidazole is more effective than benzyldimethylamine on an equal weight basis.

Figure 4 / **Effect of Gel Temperature on Gel Time of EPON Resin 164 Systems**



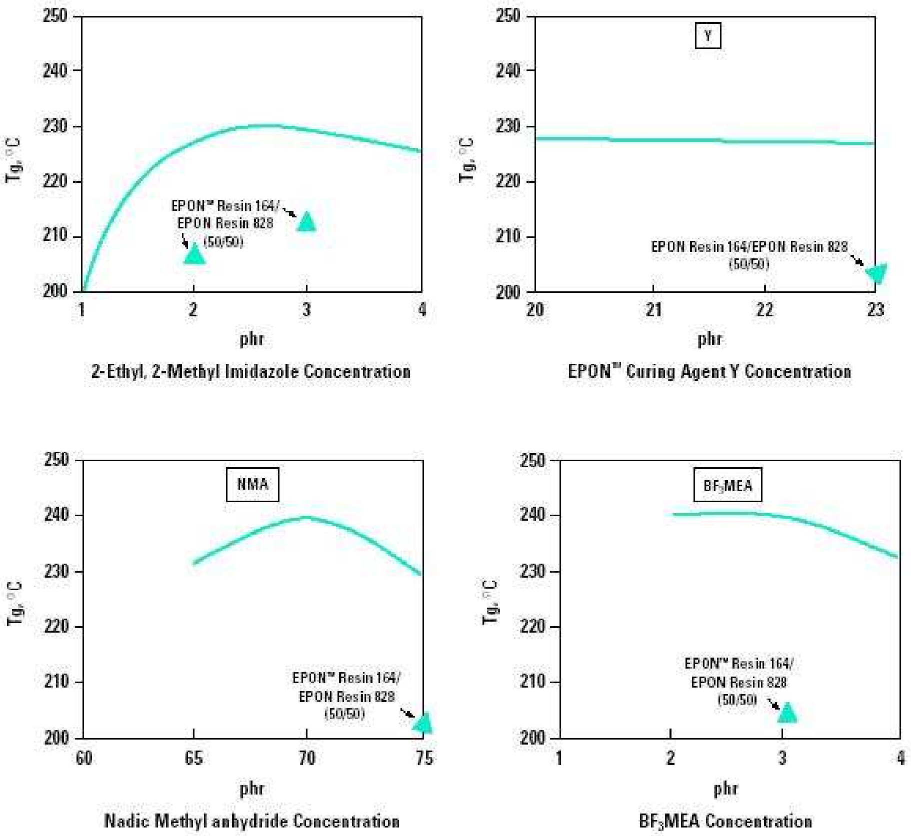






Effect of Curing Agent Stoichiometry on Tg – Figure 5 shows that only slight changes occur in Tg with varying stoichiometry (or concentration) of the curative in most systems, except with DDS which shows a slightly larger effect. The effect is very small or negligible with catalytic curatives such as 2-ethyl-4-methylimidazole and BF3 MEA in the 2-4 phr range and small (although measurable) with curatives which react with the resin such as NMA and CRJ 406 phenolic resin. Overall, the data suggest that EPON Resin 164 is less sensitive to variations in curing agent stoichiometry and weighing errors for metering and mixing equipment. However, we recommend careful optimization of both curative concentration and cure cycle for particular application because this will provide maximum physical and electrical properties and retention of these properties in the end use conditions. For convenience in preparing cost/benefit estimates, point values are also shown for 50/50 blends of EPON Resin 164 with EPON Resin 828.

Figure 5 / **Effect of Curing Agent Stoichiometry on Glass Transition Temperature (**Tg**) of EPON Resin 164 Systems**

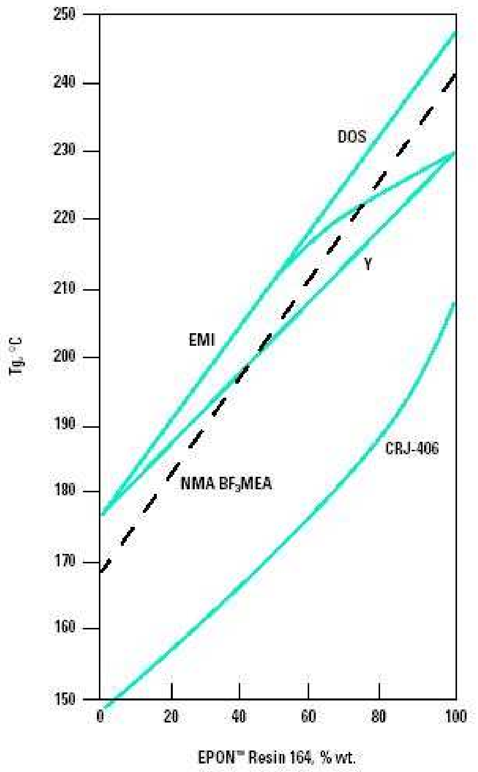


[1] Tg's determined by DSC. All systems cured 2 hours @ 150 °C plus 2 hours at 200 °C.

Applications

Effect of Resin Blends on Tg**–** Figure 6 shows Tg's for blends of EPON Resin 164 with EPON Resin 828. Generally, Tg's increase linearly with EPON Resin 164 content because of its higher functionality. Systems cured with catalysts, aromatic amines, and NMA have similarly high Tg's, indicating usefulness for high temperature adhesives and composites. The system with CRJ-406 phenolic curative has relatively lower Tg (but still >200 °C) but appears to be a tougher system that should be especially useful for molding compounds.

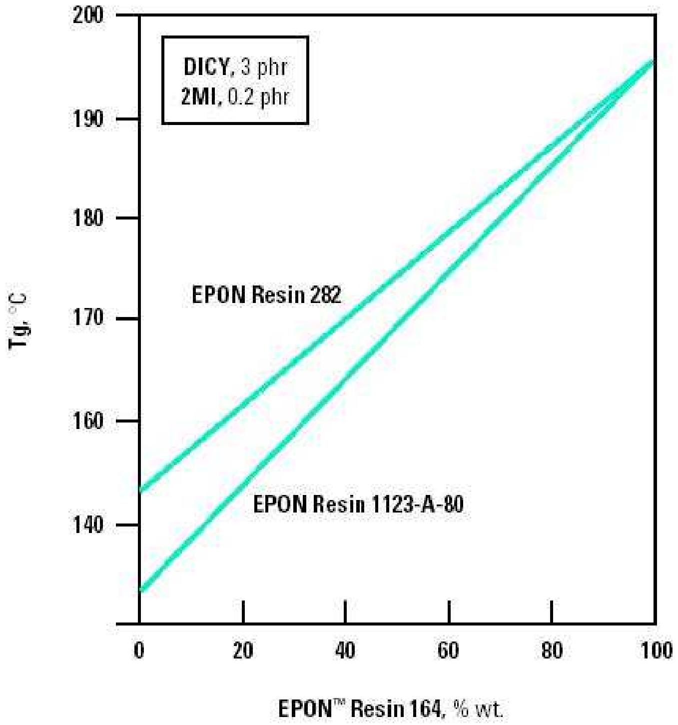
Figure 6 / **Tg's[1] for Blends of EPON Resin 164 with EPON Resin 828 with Several Curing Agents**



[1] Tg's by DSC. Cure, Hrs/°C = 2/150 = 2/200

Figure 7 gives the Tg's of blends of EPON Resin 164 with EPON Resin 1123-A-80 (solution of a solid brominated laminating resin) or 828. In either case Tg can be raised ca. 10 °C with 20%w addition of EPON Resin 164. Chemical resistance is also improved and hence there is utility in high performance electrical laminate applications. It is noteworthy that the Tg for 100 percent EPON Resin 164 cured with dicyandiamide (Figure 7) is high (195 °C). This system has potential for adhesives, prepeg, and other structural uses.

Figure 7 / Tg's[1] **for Blends of EPON Resin 164 with EPON Resin 1123-A-80 (Brominated Electrical Laminating Resin) and EPON Resin 828**



[1]Tg's by DSC. Cure, Hrs/°C = 2/150 = 2/200

Molding Powder – Table 3 shows typical properties for molding powders made from EPON Resin 164 using CRJ-406 phenolic curative plus high (silica) filler loading. These filled EPON Resin 164 molding powders also display high Tg, flexural strength, and excellent electrical properties.

Table 3 / **Effect of EPON Resin 164 Content on HDT and** Tg **of an Electrical Molding Powder**[1]

	Units	A	B	C	D
EPON Resin 164	pbw	100	70	30	0
EPON Resin 1002F	pbw	0	30	70	100
HDT	°C	190	177	133	108
Tg	°C	201	182	145	122

[1] These molding powders were 70%w silica flour and 30%w catalyzed resin. The catalyzed resin contained 100 parts EPON Resins 164 plus 1002F, 0.2 phr 2-methylimidazole accelerator, and varying amounts of CRJ-406 curative as follows 53, 43, 30, and 20 phr respectively.

Table 4 shows thermal properties for molding compounds like those in Table 3 using blends of EPON Resin 164 with EPON Resin 1002F. Tg can be varied from 122-201 °C depending upon needs, HDT varies between 108-190 °C and is always 5-15 °C lower than the Tg due to stress loading.

Table 4 / **Properties for EPON Resin 164 Molding** Powder[1]

	Method	Units	A

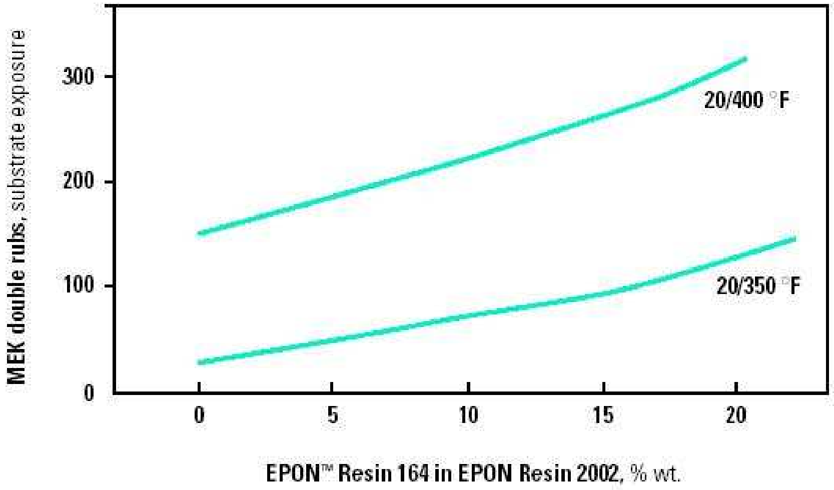
EPON Resin 164		pbw	19.60
CRJ-406		pbw	10.40
2-Methylimidazole		pbw	0.08
Silica Flour		pbw	70.00
Cured State Properties			
Tg by Rheometrics [2]	ASTM D3418	°C	201
Flexural Strength at break	ASTM D790	MPa(psi)	123 (17,800)
Flexural Modulus		MPa(psi)	13,200 (1,900,000)
Coefficient of Thermal Expansion			
50 °C to 201 °C		°C x 10^{-6} in/in	32
201 °C to 275 °C		°C x 10^{-6} in/in	79
Weight loss, 120 hrs at 200°C		% wt.	0.41
Electrical Properties			
Dielectric constant 1 MHz	ASTM D150		3.8
Dissipation factor, 1 MHz			.011
Dielectric Strength	ASTM D149	Volts/mil	520
Volume Resistivity		ohm•cm	3.9 x 10^{15}

[1] 1/8” molded plaques cured 5 minutes at 150 °C under 900 psi molding pressure, then postcured 16 hours at 177 °C.

[2] This glass transition value was from tan delta max as measured by the Rheometrics Mechanical Spectrometer.

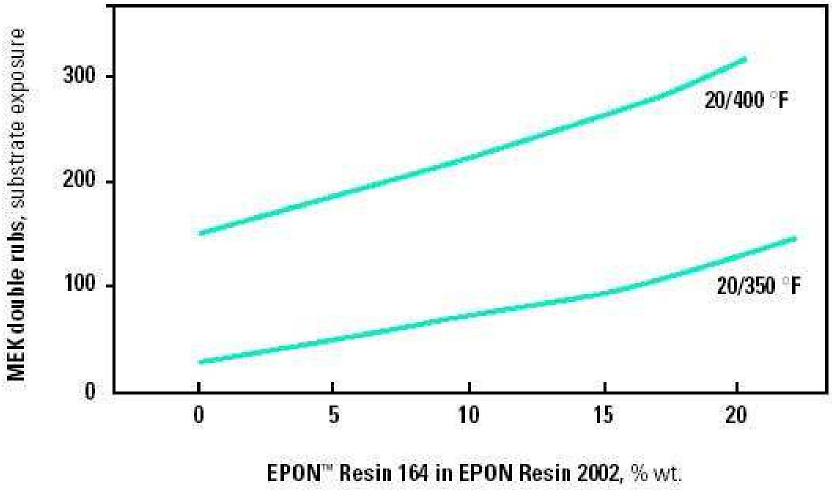
Figure 8 demonstrates the low moisture absorption and superiority of EPON Resin 164 in steam processing relative to a typical BPA/ECH epoxy molding compound. It is yet another reason for using EPON Resin 164 in harsh environments and electronic applications.

Figure 8 / **Moisture absorption in 15 PSIG steam for EPON Resin 164**



Thin Film Powder Coatings – Figure 9 shows the increase in solvent resistance for powder coatings when EPON Resin 164 is added to the typical EPON Resin 2002 system. Solvent resistance as measured by MEK double rubs can be more than doubled by the addition of up to 17%w EPON Resin 164.

Figure 9 / **Increase in Solvent Resistance with Added EPON Resin 164 in a Thin FilmPowder Coating**



Strength Retention at High Temperature for Glass Cloth Laminates – Table 5 shows excellent high flexural strength properties for glass cloth reinforced laminates based upon EPON Resin 164 cured using DDS plus BF3 MEA auxiliary catalyst. Also, evident are a very high retention of strength (47%) and modulus (77%) at temperatures up to 225 °C. This high retention of strength, electrical, and other properties at elevated temperature is due to high crosslink densities obtained with EPON Resin 164 systems.

Table 5 / Flexural Properties of 8-Ply Glass Cloth Laminates [1]

Composition	Units	Value
EPON Resin 164	pbw	100
DDS	pbw	27
BF_3MEA	pbw	1

Temperature°C	Flexural Strength, MPa (PSI)	Flexural Modulus, MPa (psi)	Flexural Strain at break, %
23	570 (83,000)	24,000 (3,500,000)	2.4
150	500 (75,000)	22,000 (3,200,000)	2.4
200	340 (49,000)	19,500 (2,800,000)	2.2
225	270 (39,000)	19,000 (2,700,000)	2.2

[1] Dry layup laminates, 35%w resin, cured 8 hours at 175 °C.

Safety, Storage & Handling

Please refer to the MSDS for the most current Safety and Handling information.

Please refer to the Hexion web site for Shelf Life and recommended Storage information.

This product is prone to "blocking" or "sintering", i.e., softening of the particles and agglomeration to a semi-solid mass, when stored at slightly elevated temperatures. Blocking does not affect the performance of the resin. This product should be stored in a cool dry place to minimize handling problems due to blocking.

Exposure to these materials should be minimized and avoided, if feasible, through the observance of proper precautions, use of appropriate engineering controls and proper personal protective clothing and equipment, and adherence to proper handling procedures. None of these materials should be used, stored, or transported until the handling precautions and recommendations as stated in the Material Safety Data Sheet (MSDS) for these and all other products being used are understood by all persons who will work with them. Questions and requests for information on Hexion Inc. ("Hexion") products should be directed to your Hexion sales representative, or the nearest Hexion sales office. Information and MSDSs on non-Hexion products should be obtained from the respective manufacturer.

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Contact Information

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For literature and technical assistance, visit our website at: www.hexion.com

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