

BISMALEIMIDE OF DAIWA

1. PRODUCTS

Name	Chemical name	Appearance	melting point ()	Gel Time (sec)	Notes
BMI - 1000	4,4' - diphenylmethane bismaleimide	Brown to Light Yellow Crystal	147 ~ 168	120 ~ 150 ^{*1}	Cas. No. 13676 - 54 - 5 TSCA Registered EINECS No.237-163-4
BMI - 1000H		Brown to Light Yellow Powder			
BMI - 1100		Brown to Light Yellow Crystal		80 ~ 120 ^{*1}	
BMI - 1100H		Brown to Light Yellow Powder			
BMI - 2000	phenylmethane maleimide	Light yellow to Light Brown Crystal	125 ~ 160	180 ~ 240 ^{*1}	Cas. No. 67784 - 74 - 1 TSCA Registered
BMI - 2300				344 ^{*1}	
BMI - 3000	m - phenylenebismaleimide	Light Yellow Crystal	199 ~ 204	30 ^{*2}	Cas. No. 3006 - 93 - 7 TSCA Registered EINECS No.221-112-8
BMI - 3000H		Light Yellow Powder			
BMI - 4000	bisphenol A diphenyl ether bismaleimide	Light Yellow Crystal	134 ~ 163	60 ~ 90 ^{*2}	Cas. No. 79922 - 55 - 7
BMI - 5100	3,3' - dimethyl - 5,5' - diethyl - 4,4' - diphenylmethane bismaleimide	Light Yellow Crystal	160 ~ 170	110 ^{*2}	Cas. No. 105391 - 33 - 1 TSCA Registered
BMI - 7000	4 - methyl - 1,3 - phenylene bismaleimide	Light Yellow Crystal	167 ~ 171	80 ^{*2}	Cas. No. 6422 - 83 - 9 TSCA Registered EINECS No.229-175-3
BMI - 7000H		Light Yellow Powder			
BMI - TMH	1,6 - bismaleimide - (2,2,4 - trimethyl) hexane	Brown Crystal	73 ~ 110	126 ^{*2}	Cas. No. 39979 - 46 - 9 TSCA Registered EINECS No.254-730-1

*1 : Gel Time at 200

*2 : Gel Time at 250

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BISMALEIMIDE OF DAIWA

2 . SOLUBILITIES OF BISMALEIMIDE

Name Temp. Solvent	B M I - 1 0 0 0		B M I - 2 0 0 0		B M I - 2 3 0 0		B M I - 3 0 0 0		B M I - 4 0 0 0		B M I - 5 1 0 0		B M I - 7 0 0 0		B M I - T M H	
	2 5	5 0	2 5	5 0	2 5	5 0	2 5	5 0	2 5	5 0	2 5	5 0	2 5	5 0	2 5	5 0
DMF (N,N-dimethylformamide)	3 5	5 3	4 3	7 4	7 9	1 4 0	1 5	2 4	6 1	8 8	5 7	9 8	2 4	3 7	2 3	6 5
DMAc (N,N-dimethylacetamide)	3 0	4 4	3 9	6 3	6 4	1 2 7	1 3	2 0	5 9	8 3	4 5	8 0	1 6	2 8	2 8	6 5
NMP (N-methyl-2-pyrrolidone)	3 7	5 1	4 5	7 5	5 4	1 0 0	1 7	2 4	7 2	9 3	2 0	7 4	1 6	3 1	3 0	5 5
1,4-Dioxane	9	2 5	1 8	3 9	2 8	9 0	4	8	2	8	2 1	5 7	4	6	-	-
Cresol(Mixture)	7	2 7	2 5	6 9	2 0	6 5	1 5	2 7	8	3 0	-	-	-	-	-	-
Acetonitril	9	2 3	1 2	3 7	3 7-7 6	3 7-1 1 0	6	1 2	4	1 3	4 5	9 2	9	2 3	-	-
Acetone	6	1 1	7	1 8	5 0-8 0	5 0-1 3 0	3	5	1 0	2 4	2 9	6 5	7	1 4	1 9	5 1
MEK (Methylethylketone)	3	6	5	1 0	6 8-8 3 ^{* 1}	6 8-1 1 0 ^{* 1}	2	3	8	1 9	2 4	4 5	3	7	1 3	3 2
THF (Tetrahydrofuran)	6	1 4	9	2 1	2 9-1 0 0	2 9-1 2 0	2	4	4 5	6 8	2 7	5 4	3	4	-	-
Toluene	< 1	< 1	< 1	< 1	-	-	< 1	< 1	2	5 ^{* 1}	2	1 0	< 1	< 1	1 0	2 8

Solubility (g/100g solvent)

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* 1 : There may be unsolved part left in solvent occasionally.

All the figures above are representative ones of each product, and not the guaranteed ones.

BISMALEIMIDE OF DAIWA

3. PROPERTIES OF BISMALEIMIDE RESIN

Property	Units	Test Method	Test condition	BMI - 1000	BMI - 2000	BMI - 4000	BMI - 5100 *1
Gel Time	min.	-		12	8	15	150 *2
Mechanical Properties							
Flexural Strength	MPa	JIS K6911	Room Temp.	140.5	124.6	139.3	105.9
			200	107.4	88.7	63.4	55.4
Flexural Modulus	GPa	JIS K6911	Room Temp.	3.80	3.68	3.29	3.35
			200	2.90	2.47	1.92	1.79
Charpy Impact Strength	KJ/m ²	JIS K7111	Notched	1.4	1.3	3.2	1.3
				24.3	20.0	31.9	17.8
Barcol Hardness	- - -	JIS K6911	Room Temp.	50	50	44	49
Thermal Properties							
Grass Transition Temp.		DMA	2 /min.	> 300	> 300	277	264
Coefficient of Linear Expansion	- ¹	JIS K7197	40 ~ 100	3.94×10^{-5}	2.12×10^{-5}	7.38×10^{-5}	6.02×10^{-5}
			100 ~ 200	5.47×10^{-5}	5.72×10^{-5}	8.18×10^{-5}	8.40×10^{-5}
			200 ~ 300	20.12×10^{-5}	11.16×10^{-5}	20.81×10^{-5}	20.11×10^{-5}
Temperature of 5% Weight Loss (Td ₅)		- - -	10 /min.	397	394	407	433
Water Absorption	%	JIS K6911	- - -	0.55	0.54	0.51	0.63
Electrical Properties							
Dielectric Constant (0.1MHz)	- - -	- - -	Room Temp.	3.45	3.42	3.07	2.87
			200	3.32	3.33	3.16	-
Dielectric Loss Tangent (0.1MHz)	- - -	- - -	Room Temp.	0.027	0.018	0.017	0.020
			200	0.020	0.013	0.027	-

Hardening agent : DDM (Diamino Diphenyl Methane)

Blend Ratios (mol) : Maleimide / DDM = 2 / 1

Curing Condition : 150 × 1.5hrs 175 × 1.5hrs 200 × 1.5hrs 230 × 4hrs

*1 Curing Condition : 200 × 1.5hrs 200 × 0.5hr 200 × 1hr 230 × 4hrs

Gel Time : After synthesizing a vanish from Bismaleimide and DDM with 2 to 1 ratio, the molar ratio, the gelation time of the vanish at the temperature of 170 was measured.

*2 gelation time of the vanish at the temperature of 200 was measured.

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BISMALEIMIDE OF DAIWA

4 . PROPERTIES OF BISMALEIMIDE RESIN

Property	Units	Test Method	Test condition	BMI - 1000	BMI - 2300	BMI - TMH
Gel Time	seconds	-		136	94	* 575 *1
Mechanical Properties						
Flexural Strength	MPa	JIS K6911	Room Temp.	140.5	125.0	118.0
			200	107.4	101.8	2.0
Flexural Modulus	GPa	JIS K6911	Room Temp.	3.80	4.10	3.68
			200	2.90	3.10	0.25
Charpy Impact Strength	KJ/m ²	JIS K7111	Notched	1.4	1.3	1.7
				24.3	21.9	14.8
Barcol Hardness	- - -	JIS K6911	Room Temp.	50	50	50
Thermal Properties						
Grass Transition Temp.		DMA	2 /min.	> 300	> 300	197.8
Coefficient of Linear Expansion	- 1	JIS K7197	40 ~ 100	3.94×10^{-5}	4.60×10^{-5}	-
			100 ~ 200	5.47×10^{-5}	4.63×10^{-5}	-
			200 ~ 300	20.12×10^{-5}	14.37×10^{-5}	-
Temperature of 5% Weight Loss (Td ₅)		- - -	10 /min.	397	401	405
Water Absorption	%	JIS K6911	- - -	0.55	0.56	0.29
Electrical Properties						
Dielectric Constant	(1G Hz)		Room Temp.	3.29	3.07	2.81
	(3G Hz)	- - -	Room Temp.	3.25	3.04	2.80
	(5G Hz)		Room Temp.	3.16	3.01	2.78
Dielectric Loss Tangent	(1G Hz)		Room Temp.	0.012	0.013	0.005
	(3G Hz)	- - -	Room Temp.	0.013	0.014	0.005
	(5G Hz)		Room Temp.	0.015	0.015	0.005

Hardening agent : DDM (Diamino Diphenyl Methane)

Blend Ratios (mol) : Maleimide / DDM = 2 / 1

Curing Condition : 150 × 1.5hrs 175 × 1.5hrs 200 × 1.5hrs 230 × 4hrs

Gel time : Mixture of Maleimide / DDM (= 2 / 1 mol ratios) was measured on the iron board at 200 .

*1 Gel time at 250

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BISMALEIMIDE OF DAIWA

5. PROPERTIES OF BISMALEIMIDE RESIN

Curing agent	DDM (Diamino diphenyl methane)	DDE (Diamino diphenyl ether)	DDS* 1 (Diamino diphenyl sulfone)	BAPP (2,2-Bis[4-(4-aminophenoxy)phenyl]propane)	Bisaniline-M* 2	FUJICURE-6300* 3	
Mol ratios (BMI - 1000 / Curing agent)	2/1	2/1	2/1	2/1	2/1	2/1	
Gel Time (seconds)	170 200	292 136	583 162	3856 343	917 97	600 171	
pre-curing condition	150 (1.5hrs)	160 (0.5hr)	175 (1.0hr)	150 (1.0hr)	150 (1.0hr)	150 (1.5hrs)	
curing condition	175 (1.5hrs)+200 (1.5hrs)+230 (4hrs)	175 (3hrs) + 230 (4hrs)					
Resin density	1.27	1.28	1.31	1.25	1.23	1.26	
Mechanical Properties							
Flexural Strength (MPa)	Room Temp.	140.5	108.4	52.7	136.0	126.4	94.8
	200	107.4	104.9	38.8	75.0	72.6	53.1
Flexural Modulus (GPa)	Room Temp.	3.80	3.68	4.87	3.43	3.52	4.04
	200	2.90	2.78	3.27	1.79	2.10	2.61
Charpy Impact Strength (kJ/m ²) Notched		1.4	2.77	0.57	3.18	1.95	0.65
		24.3	21.89	3.61	19.17	21.62	14.88
Barcol Hardness	50	46.0	60.1	44.3	54	54.3	
Thermal Properties							
Grass Transition Temp. (°C)	>300	272.7	313.8	263.5	261.9	332.2	
Coefficient of Linear Expansion (× 10 ⁻⁵ / °C)	40 ~ T _g	-	5.143	-	4.482	7.752	2.236
	T _g ~ (T _g + 20)	-	22.668	-	19.540	23.816	5.072
Temperature of 5% Weight Loss (T _{d5}) from Room Temp.		393.0	390.0	404.4	395.9	379.9	372.8
	from 300	397.0	394.1	405.9	403.0	384.1	378.9
Water Absorption (%)	0.55	-	-	-	0.56	-	
Electrical Properties							
Dielectric Constant	(1G Hz)	3.29	3.07	3.23	3.03	2.94	3.20
	(3G Hz)	3.25	3.06	3.21	3.02	2.93	3.17
	(5G Hz)	3.16	2.96	3.28	2.99	2.89	3.15
Dielectric Loss Tangent	(1G Hz)	0.012	0.008	0.011	0.009	0.006	0.018
	(3G Hz)	0.013	0.009	0.012	0.010	0.007	0.018
	(5G Hz)	0.015	0.009	0.013	0.011	0.007	0.019

* 1 For fragility of a sample, some edge parts have broken.

* 2 4,4'-(m-phenylenediisopropiridene)dianiline (MITSUI CHEMICALS, Inc.)

* 3 Mixture of modified aliphatic polyamines and modified aromatic polyamines.
(FUJI KASEI KOGYO CO.,LTD.)

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BISMALEIMIDE OF DAIWA

6 . PROPERTIES OF BISMALEIMIDE/DABPA(o,o'-diallyl bisphenol A) RESIN^{* 1}

BISMALEIMIDE	BMI-1000	6/3/1 ^{* 2}			
Mol ratios (BMI / DABPA)	1.14/1 ^{* 3}				
Gel Time (seconds)	170	1085	1883		
	200	406	618		
pre curing condition	150 (2.0hrs)	150 (3.0hrs)			
curing condition	175 (3hrs)+230 (4hrs)				
Resin density	1.19	1.22			
Mechanical Properties					
Flexural Strength (MPa)					
Room Temp.	163.4	169.0			
200	86.9	90.3			
Flexural Modulus (GPa)					
Room Temp.	3.72	4.18			
200	2.50	2.59			
Charpy Impact Strength (kJ/m ²)					
Notched	2.47	3.10			
	28.12	33.62			
Barcol Hardness	56.6	55.6			
Thermal Properties					
Grass Transition Temp.()	270.5	283.7			
Coeffeicient of Liner Expansion(× 10 ⁻⁵ /)					
40 ~ Tg	3.981	5.319			
Tg ~ (Tg + 20)	21.178	55.791			
Temperature of 5% Weight Loss (Td ₅)					
from Room Temp.	429.1	428.0			
from 300	430.3	428.9			
Water Absorption (%)	-	-			
Electrical Properties					
Dielectric Constant (1G Hz)	2.93	3.03			
(3G Hz)	2.91	3.00			
(5G Hz)	2.87	2.97			
Dielectric Loss Tangent (1G Hz)	0.010	0.014			
(3G Hz)	0.012	0.016			
(5G Hz)	0.012	0.016			

* 1 Method of molding : casting

* 2 BMI-1000/BMI-7000/BMI-TMH = 6/3/1

* 3 Blend ratio (pbw) : BMI / DABPA = 113 / 85

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BISMALEIMIDE OF DAIWA

7. PROPERTIES OF BISMALEIMIDE/Cyanate ester^{* 1} RESIN

BISMALEIMIDE	BMI-1000	BMI-1000	BMI-1000		
Blend ratios(BMI/Cyanate ester)	10/90	20/80	40/60		
Mol ratios(BMI / Cyanate ester)	1/11.59	1/5.15	1/1.93		
Gel Time (seconds)	170	-	832		
	200	1412	1113	286	
precurring condition	170 (2.5hrs)				
curing condition	170 (3hrs) + 230 (4hrs)				
Resin density	1.22	1.23	1.25		
Mechanical Properties					
Flexural Strength (MPa)					
Room Temp.	119.8	91.3	77.7		
200	76.0	66.1	63.9		
Flexural Modulus (GPa)					
Room Temp.	3.58	3.69	3.96		
200	2.38	2.54	2.68		
Charpy Impact Strength (kJ/m ²)					
Notched	1.72	1.43	1.28		
	18.88	8.76	8.11		
Barcol Hardness	49.8	50.6	52.6		
Thermal Properties					
Grass Transition Temp. ()	269.8	273.7	278.1		
Coeffeicient of Liner Expansion(× 10 ⁻⁵ /)					
40 ~ Tg	6.163	5.927	5.122		
Tg ~ (Tg + 20)	33.335	11.759	11.825		
Temperature of 5% Weight Loss (Td ₅)					
from Room Temp.	417.3	421.6	429.1		
from 300	421.6	424.7	430.9		
Water Absorption (%)	-	-	-		
Electrical Properties					
Dielectric Constant (1G Hz)	2.89	2.89	3.10		
(3G Hz)	2.87	2.87	3.08		
(5G Hz)	2.84	2.86	3.03		
Dielectric Loss Tangent (1G Hz)	0.010	0.010	0.012		
(3G Hz)	0.011	0.011	0.013		
(5G Hz)	0.011	0.011	0.013		

* 1 Bisphenol A cyanate ester

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BISMALEIMIDE OF DAIWA

8 . PROPERTIES OF BISMALEIMIDE/EPOXY/ACID ANHYDRIDE^{*1} RESIN

BISMALEIMIDE		Blank	BMI-1000P	BMI-4000			
Blend ratios(Epoxy/Acid anhydride ^{*1} /BMI)		100/90/0 ^{*2}	100/90/41.8 ^{*2}	100/90/41.8 ^{*2}			
Gel time(seconds)	150	147	170	152			
	170	76	65	62			
Curing condition		150 (4hrs) + 200 (10hrs)					
Termal Properties							
Tg ()	DMA法	141.4	186.0	175.0			
	TMA法	122.7	166.3	153.6			
Temperature of 5% Weight Loss(Td ₅)()							
from Room Temp.		347.9	360.0	352.2			
from 300		356.8	365.8	359.3			

* 1) Methyl tetrahydro phthalic anhydride

* 2) BDMA(Benzyl dimethyl amine) is used as epoxy promoter.

Blend ratios is 1phr for epoxy.

DCP(Dicumyl peroxide) is used as bismaleimide promoter.

Blend ratios is 0.5phr for bismaleimide.

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