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Technical Bulletin

JEFFSOL® CARBONATES IN EPOXY FORMULATIONS

DESCRIPTION

The JEFFSOL® carbonates are useful solvents in a variety of applications. The JEFFSOL® EC, PC, and EC-50 members of this series are ethylene carbonate, propylene carbonate, and a 50/50 blend of the two. At room temperature EC is a solid, while PC and EC-50 are liquids. These solvents possess low toxicity, high polarity, and relatively low vapour pressure and a miscible with many other solvents. Some materials which dissolve in few if any other solvents will dissolve in the JEFFSOL® carbonates. They can be used as reactants as well as solvents, since the cyclic carbonate group is opened by functional groups such as alcohols and amines. Because of their reactivity and the dilution effect, the carbonates have a considerable effect on the bahavior of certain amine-cured epoxy resin systems.

FEATURES

The effects of the carbonates in the epoxy formulation will depend on the carbonate concentration and on the reactivity of the amine curing agent. With relatively reactive unhindered aliphatic amine curing agents such as ethyleneamines and XTJ-504 the effects are more significant. In general the following features are noted:

- Lower viscosity
- Shorter gel time
- Improved cured resin properties
- Greater elongation

BENEFITS

The JEFFSOL® carbonate-modified epoxy systems are good candidates for use in any application where reactive curing agents are used and where reduced viscosity, faster cure, and improved strength and modulus would be desirable. Suggested applications would include flooring, potting, and coatings. The reduced viscosities that are possible can be useful in formulating highly filled systems that retain good mechanical properties.

DISCUSSION

Addition of carbonates results in a decrease in resin viscosity. The 10,000-12,000 cP viscosity of the typical liquid epoxy resin can be reduced to around 1,000 cP by addition of 20 phr of a JEFFSOL® carbonate (Figure 1). Although the carbonates are thus not as effective in viscosity reduction as conventional glycidyl ether diluents, in some cases (with reactive amines) they enhance the formulation properties in other ways besides viscosity reduction. Some properties are shown in Tables 1 and 2. Tables 1 and 2 give an overview of curing and cured resin properties for some heat-cured amine/epoxy/carbonate systems, and Table 3 shows comparisons of some ambient cure and heat cure data.

The focus in the tables is on cures with relatively reactive amines, because they are representative of the curing agents which give enhanced properties in the carbonate-diluted systems.

Unlike other reactive diluents, the JEFFSOL® carbonates (used with the more reactive curing agents) give a reduction in the gel time that is roughly proportional to their concentration, at least up through about 20 phr. his decrease in gel time is accompanied by little if any change in the exotherm temperature. The typical XTJ-504 gel time of about 70 minutes, for example, can be reduced to 20 minutes or less with JEFFSOL® EC. The consumption of some amine through reaction with the carbonates results in some increase in the mix ratio that gives the optimum glass transition temperature.

In general the strength, modulus and elongation values with either room temperature or elevated temperature cures are increased by the presence of low levels of the carbonate. In a room temperature cure, better properties are attained in a given period of time. Thermal properties and solvent resistance, on the other hand, are reduced somewhat.

JEFFSOL® Carbonate Properties

	EC	PC
Density, lb/gal	10.9[1]	10.0[2]
Boiling point, °C	248	242
Freezing point, °C	-49	
Flash point, PMCC, °F	305	275

[1] 40°C [2] 20°C

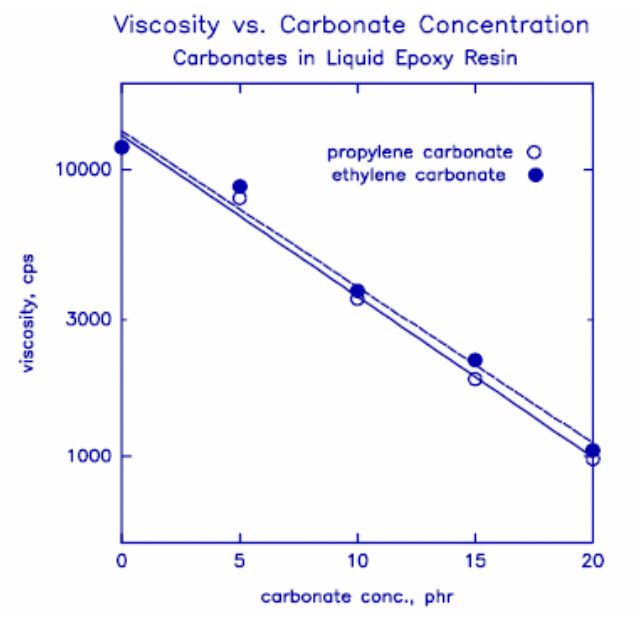

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Table 1. Properties of Carbonate-Modified Systems
TETA Cure

Liquid epoxy resin, e.e.w. 188	100	100	100	100	100	100
JEFFSOL® EC		5	10	16		
JEFFSOL® PC					6	11
TETA	13	17	19	20	17	18
Brookfield visc. cP	2500	1220	680	460	790	500
Gel time, min (200 g mass)	39	18	10.5	7.5	23	18
Peak exotherm temp., °C	250	257	256	249	242	248
Initial temp, °C	23	23	24	24	24	24
Glass transition temp., °C	130	116	105	91	107	98
Shore D hardness, 0-10 sec	88-87	87-86	89-87	89-88	89-87	87-86
HDT, °C, 264 psi load	125	108	93	75	98	84
Izod impact strength, ft-lb/in	0.44	0.62	0.47	0.49	0.45	0.71
Tensile strength, psi	8,200	10,500	12,000	13,000	10,000	11,000
Tensile modulus, psi	446,000	456,000	510,000	541,000	530,000	600,000
Ultimate elongation, %	2.2	4.4	4.5	5.5	3.0	4.5
Flexural strength, psi	15,000	15,900	22,000	23,000	21,000	22,000
Flexural modulus, psi	388,000	449,000	497,000	527,000	498,000	520,000
% Wt. gain, 24 hr water boil	2.1	3.1	4.7	5.6	3.5	5.5
% Wt. gain, 3 hr acetone boil	0.20	0.62	1.2	2.3	0.6	1.7

Cure conditions: 2 hr 80°C. 3 hr 125°C
1 cP = 1mP·s
1 psi = 0.006895 MPa
1 ft-lb/in = 53.37 J/m

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Table 2. Properties of Carbonate-Modified Systems XTJ-504[a] Cure

Liquid epoxy resin, e.e.w. 188	100	100	100	100	100	100	100
JEFFSOL® EC		5	9	16			
JEFFSOL® EC-50					11		
JEFFSOL® PC						11	18
XTJ-504	20	23	26	28	25	21	23
Brookfield visc. cP	700	380	200	160	300	250	185
Gel time, min (200 g mass)	70	36	20	14	33	48	48
Peak exotherm temp., °C	242	225	235	215	230	210	200
Glass transition temp., °C	96	75	58	57	62	64	74
Shore D hardness, 0-10 sec	83-80	84-82	86-82	84-80	84-82	85-82	80-75
HDT, °C, 264 psi load	85	65	50	32	50	47	32
Izod impact strength, ft-lb/in	1.4	1.9	0.75	1.3	1.1	1.6	1.4
Tensile strength, psi * 0.001	8.7	9.60	10.2	5.25	8.46	9.63	3.20
Tensile modulus, psi * 0.001	365	427	485	320	453	495	197
Ultimate elongation, %	7	9	8	75	7	7	69
Flexural strength, psi * 0.001	14.4	17.0	18.0	9.80	18.2	16.8	4.80
Flexural modulus, psi * 0.001	350	431	474	288	472	461	167
% Wt. gain, 24 hr water boil	3.4	4.7	6	5.6	5.9	3.9	2.7
% Wt. gain, 3 hr acetone boil	2.2	4.4	9	16	9.7	9.5	13

Cure conditions: 2 hr 80°C, 3 hr 125°C
1 cP = 1mP·s
1 psi = 0.006895 MPa
1 ft-lb/in = 53.37 J/m

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Table 3. Cured Resin Properties with Carbonate Diluents

Ambient Cure vs. Heat Cure

Liquid epoxy resin, e.e.w. 188	100	100	100	100	100	100	100
DETA	21	21					
TETA			13	20	20		
TEPA						20	20
JEFFSOL® EC-50	10	10		10	10	10	10
cure conditions	heat	rt	rt	heat	rt	heat	rt
Tensile strength, psi	13,700	5,250	2,100	12,500	8,300	9,000	8,900
Tensile modulus, psi	615,000	599,000	640,000	565,000	581,000	541,000	554,000
Ultimate elongation, %	6.4	0.95	0.4	3.8	1.6	2.1	1.9
Flexural strength, psi	23,600	9,700	4,900	22,600	16,800	21,800	15,800
Flexural modulus, psi	555,000	541,000	470,000	521,000	550,000	509,000	547,000
HDT, °C, 264 psi	68	51	51	86	54	89	50
% Wt. gain, 24 hr water boil	9.3	9.8	1.8	5.4	5.4	4.4	4.5
% Wt. gain, 3 hr acetone boil	4.9	8.5	0.3	1.6	8.3	0.92	8.4

Cure conditions: heat: 2 hr 80°C, 3 hr 125°C; rt: 7days approx. 25°C

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