Vinyl Ester Resins

Process Description: Vinyl ester resins are high performance unsaturated resins chosen for their outstanding corrosion resistance and other physical properties. They can be applied through a wide array of techniques, but react differently to initiators than other unsaturated polyester systems.

General Composition: 30-100 wt% VE or Hybrid resin
70-0 wt% Glass & Filler (sand, CaCO3, ATH etc.)

Main Applications: Corrosion resistant pipes, tanks, & other structural components. Used as GC liner, barrier coat, laminating resin, and in other systems.

Cure Temperature: Ambient:: 20-40°C
Elevated 40-90°C

Cure System Design

Selection of the initiator should be dependent upon the resin reactivity, filler & glass loading, part mass, cure temperatures, and part geometry. Higher resin reactivity, lower filler loadings, and thicker parts contribute to higher exotherms & faster cure, but potentially higher shrinkage.

Cadox L-50a, an Methyl Ethyl Ketone Peroxide (MEKP), is the most common initiator used. Due to the different functionality of VE resins, they respond to the type 3 dimer form of MEKP and accelerated CHP initiators. They may generate foaming with H_2O_2 containing peroxides such as MEKP's in certain resins. Cadox LPT is a special purpose MEKP which can be used to minimize this effect and is highly reactive with bishphenol A epichlorohydrin and epoxy novalac resins.

An alternate cure system based on Trigonox K-90 (Cumyl hydroperoxide or CHP) can also be used to eliminate gassing, but slower cure or high promotion levels are typically required. Trigonox K-90 is used more commonly at elevated temperatures where good cure rates can be obtained.

Trigonox 239a, a pre-accelerated CHP solution with no amine, can eliminate all gassing while maintaining a fast cure speed and provide the lowest porosity. Depending upon the VE resin chemistry, promotion levels may need adjustment to deliver the same processing properties and cure times. Newer, more reactive resin technologies such as Dow's Momentum, need little if any adjustment. Though less common, Benzoyl peroxide accelerated with DMA or similar amines can also be used for special purposes. Typical initiator dosing rates are 1-3 phr (per hundred resin) peroxide. Below is a list of commonly used initiators used for ambient cure systems.

Typical Initiators for Ambient Cure VE Resins

Trade Name	Chemical Name	Physical Form	Peroxide Content	% Active Oxygen	Ts, max °F (°C)	SADT °F (°C)	NFPA Class	Standard Packages
Cadox L-50a	Methyl ethyl ketone peroxide in TXIB	Solution	35%	8.9%	86 (30)	≥140 (>60)	III**	4x8# Carton, 40# Hedpak
Cadox L-30a	Low Concentration Methyl ethyl ketone peroxide in TXIB for Summer	Solution	20%	5.3%	86 (30)	≥140 (>60)	IV**	4x7# Carton
Trigonox 263	Ketone Peroxide/CHP Mixture in TXIB for Lower Exotherm	Solution	48%	9.2%	86 (30)	140 (60)		4x8# Carton
Cadox BFF-50	Dibenzoyl peroxide in DCHP	Granules	50%	3.3%	77 (25)	131 (55)	III**	50# Carton
Trigonox 239A	Pre-accelerated Cumyl hydroperoxide solution for fast cure & lower porosity	Solution	45%	4.6%	77 (25)	131 (55)		4x7# Carton
Trigonox K-90	Cumyl hydroperoxide	Solution	88%	9.4%	104 (40)	158 (70)	III	35# Hedpak, 450# Drum

**** Estimated from NFPA 432 based on similar formulations**

Performance in bishphenol-A epichlorohydrin Resins Systems

These highly reactive resin systems can be cured with a wide variety of initiators. The following chart and exotherm graph shows the range of cure speeds and temperatures which can be obtained by choosing various initiators. Cadox LPT provides the fastest cure and highest exotherm with little gassing. Cadox L-50a is slightly slower, but exhibits slight gassing more typical of traditional low H_2O_2 MEKP's. Trigonox 239a shows a similar cure rate to Cadox L-50a, but has a drastically reduced exotherm, no gassing, and provides the best final cure. Trigonox 263 typically exhibits the slowest cure rate and lowest exotherm for temperature sensitive applications such as vacuum bagging.

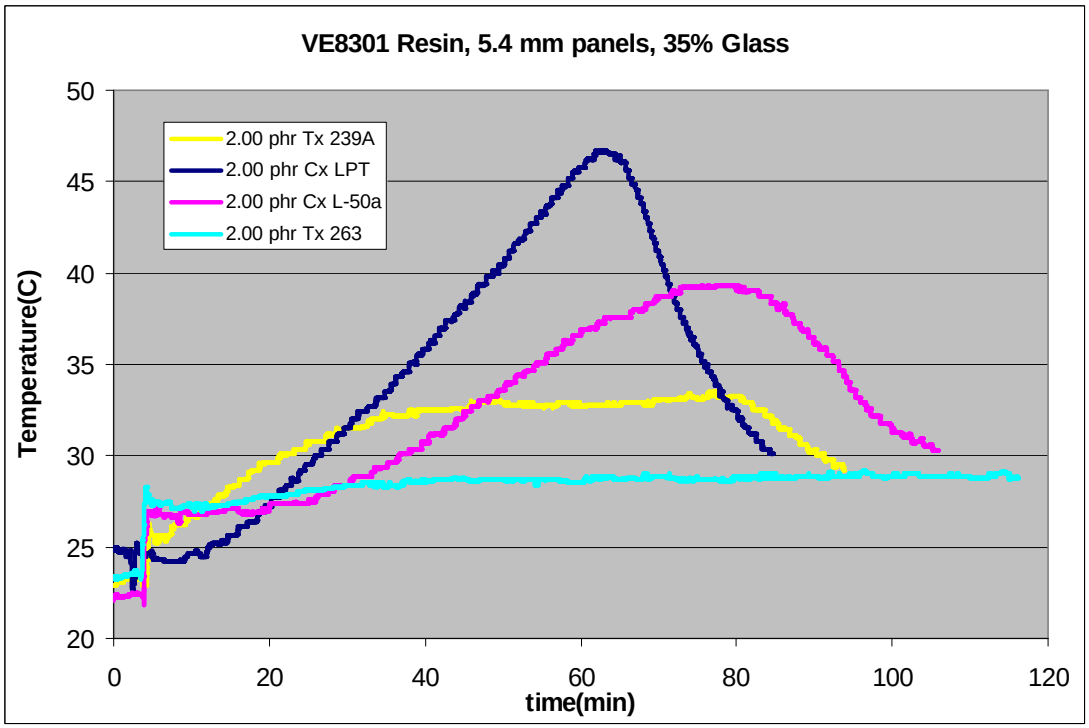
5.4 mm Panels, 35% Glass, 25°C

Initiator	Gassing	Gel time(min)	Peak Temp(C)	Time to Peak(min)	Gel To Peak(min)	Residual Styrene(%)
2.0 phr Trigonox 239A	None	17.3	33.5	76.4	59.1	4.43
2.0 phr Cadox LPT	Slight	23.7	46.7	61.9	38.2	5.23
2.0 phr Cadox L-50a	Yes	33.2	39.3	75.5	42.4	5.85
2.0 phr Trigonox 263	Slight	NA	29.2	96.2	NA	5.71

Barcol Development

Initiator	60 min	75 min	95 min	120 min	72 hours
2.0 phr Cadox LPT	0	5	15	20	45
2.0 phr Cadox L-50a	0	0	10	15	44
2.0 phr Trigonox 239A	0	0	10	15	43
2.0 phr Trigonox 263	0	0	0	0	42

The exotherm traces below show the rates of reaction and exotherms. The initial spike in exotherm stems from the reaction of the hydrogen peroxide component in MEKP's with the cobalt promoter and causes the gassing seen with typical MEKP's. It is minimized by Cadox LPT and eliminated by Trigonox 239a. The significantly lower exotherm of Tx 239a does not mean a lower degree of final cure.



Performance in Epoxy Novalax Resins Systems

Epoxy Novalax resins are much more reactive and have much faster gel times than bisphenol-A based resins. This type of resin is also very responsive to the type 3 dimer form of MEKP and responds well to both Cadox LPT and Trigonox 239a. Trigonox 239a was too fast in gel time in this pre-accelerated resin system to allow laboratory panel preparation at the promotion levels contained in this resin, but a comparison of 100 gram mass tests below confirms it to be the fast gel and cure speed. Gassing still occurs in this resin system with conventional MEKP.

100g Cup Gel Test, 25°C Water Bath

Initiator	Gel time(min)	Peak Temp(C)	Time to Peak(min)	Gel To Peak(min)	Gassing
2.0 phr Trigonox 239A	4.7	194.0	10.1	5.4	None
1.5 phr Trigonox 239A	6.0	189.2	10.9	4.9	None
2.0 phr Cadox LPT	12.1	202.7	17.8	5.7	Slight
1.5 phr Cadox LPT	15.2	193.1	21.9	6.7	Slight
1.5 phr Cadox L-50a	20.8	173.8	26.8	5.9	Yes
2.0 phr Trigonox 263	19.5	167.3	38.7	19.2	Slight

Panels prepared show Cadox LPT to provide the fastest cure and the highest exotherm since Trigonox 239a was not included. The most commonly used Cadox L-50a shows a slower gel time, but fast cure and slightly higher residuals. Trigonox 263 exhibits a reduced exotherm and good final cure for temperature sensitive applications.

5.4 mm Panels, 35% Glass, 25°C

Initiator	Gel time(min)	Peak Temp(C)	Time to Peak(min)	Gel To Peak(min)	Residual Styrene(%)
1.5 phr Cadox LPT	22.3	118.3	33.1	10.8	0.86
2.0 phr Trigonox 263	24.2	35.0	87.1	62.9	1.47
1.5 phr Cadox L-50a	35.0	48.9	50.1	15.1	2.28

The resin chemistry and reactivity of these resins varies more widely that ortho or iso-PE's so a thorough evaluation of initiators is recommended for each resin. Promoter and accelerator levels also vary widely adding to the need to work with resin suppliers in choosing the best resin for each application. Resin supplier's recommendations are the best starting point, but additional guidance can be obtained through your Akzo Nobel account manager.