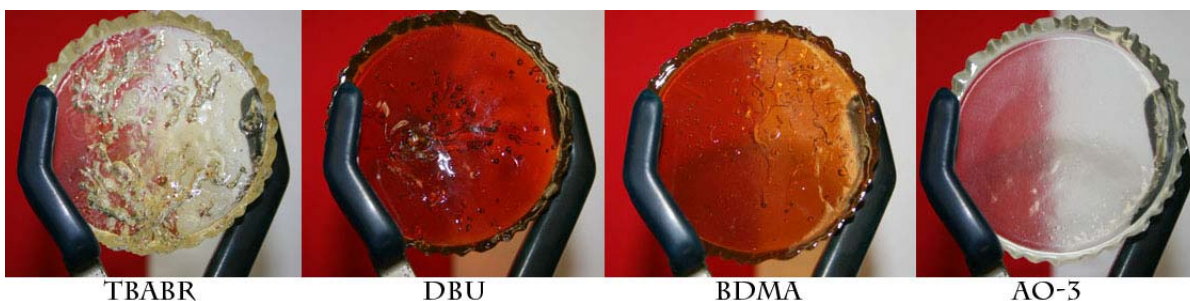




A Latent Catalyst for Fast and Colorless Epoxy Cures

Hycat™ AO-3

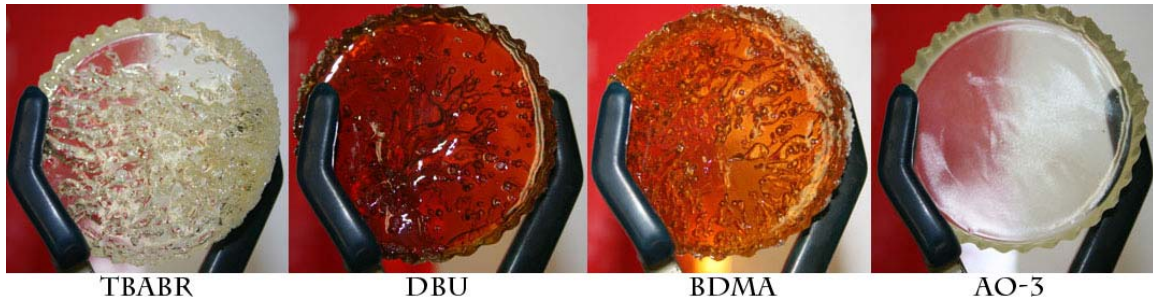
A common problem with various epoxy cures is the tendency for the cured products to be colored due to the components in the formulation, sensitivity to elevated cure temperatures and the chemical interaction of the catalyst during the cure. Combine with this the requirements for catalytic latency and ease of use for component blending only adds to the quest for the ideal cure system. *Hycat™ AO-3*, produced by Dimension Technology Chemical Systems, Inc., achieves these goals of clear and colorless and fast cures when reacting anhydrides with diglycidyl ether of bisphenol A, diglycidyl ether bisphenol F and cycloaliphatic diepoxides. Other epoxides are expected to behave favorably in similar formulations. Commonly used catalysts do not give these desired results. For example, a large difference in color was observed comparing the use of different cure catalysts. In a typical formulation of diglycidyl ether of bisphenol F (DER 354) and methylhexahydrophthalic anhydride (Lindride 52D) with 2.0 % catalyst loading at 120°C there is a noticeable change in color or uniformity of cure when comparing Hycat™ AO-3 to tetrabutylammonium bromide (TBABr) or 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) and benzyldimethylamine (BDMA).



Additionally, Hycat™ AO-3 gave good cure time and hardness values.

	TBABr	DBU	BDMA	Hycat™ AO-3
Cure Time (min.)	8-12	8-12	4-8	12-16
Hardness Test, Durometer Type D	86	88	86	89

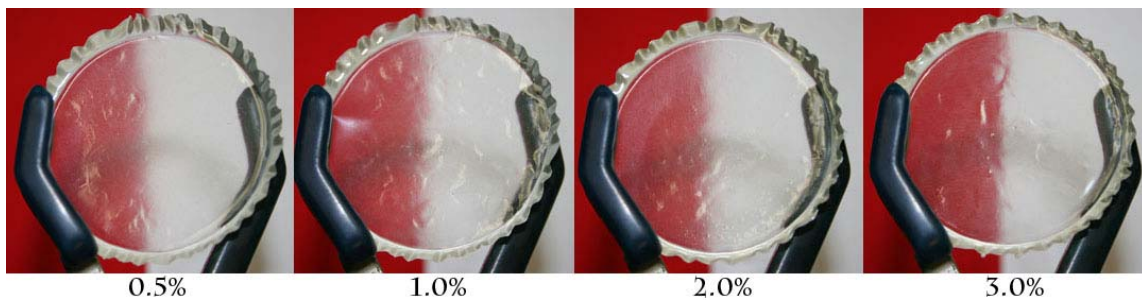
Again, when diglycidyl ether of bisphenol A (DER 332) was reacted with MHHPA (Lindride 52D) with 2.0 % Hycat™ AO-3 catalyst loading at 120°C, a clear and colorless cure resulted. By contrast, using the catalysts TBABr, DBU, and BDMA resulted in highly colored cures or considerable voids throughout the cure.



And as before, the cure time and hardness was favorable.

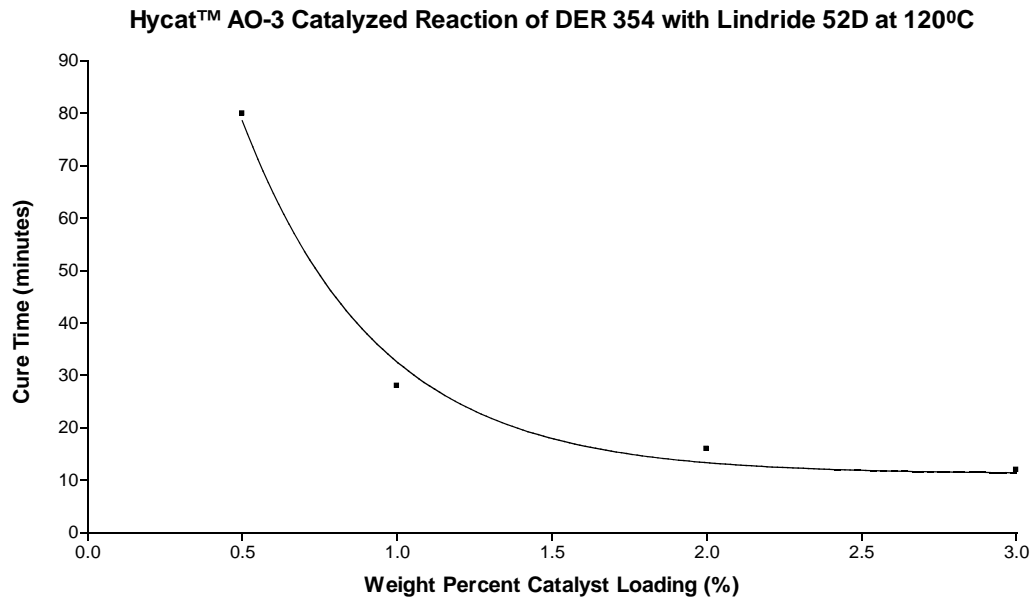
	TBABr	DBU	BDMA	Hycat™ AO-3
Cure Time (min.)	8-12	8-12	8-12	12-16
Hardness Test, Durometer Type D	86	87	86	89

In cure studies at 120 °C with DER 354 and MHHPA (wt. ratio 1:1) the variation in color was only slight when the concentration of Hycat™ AO-3 was increased from 0.5% to 3%.



As expected, the cure time was shorter at higher catalyst concentration.

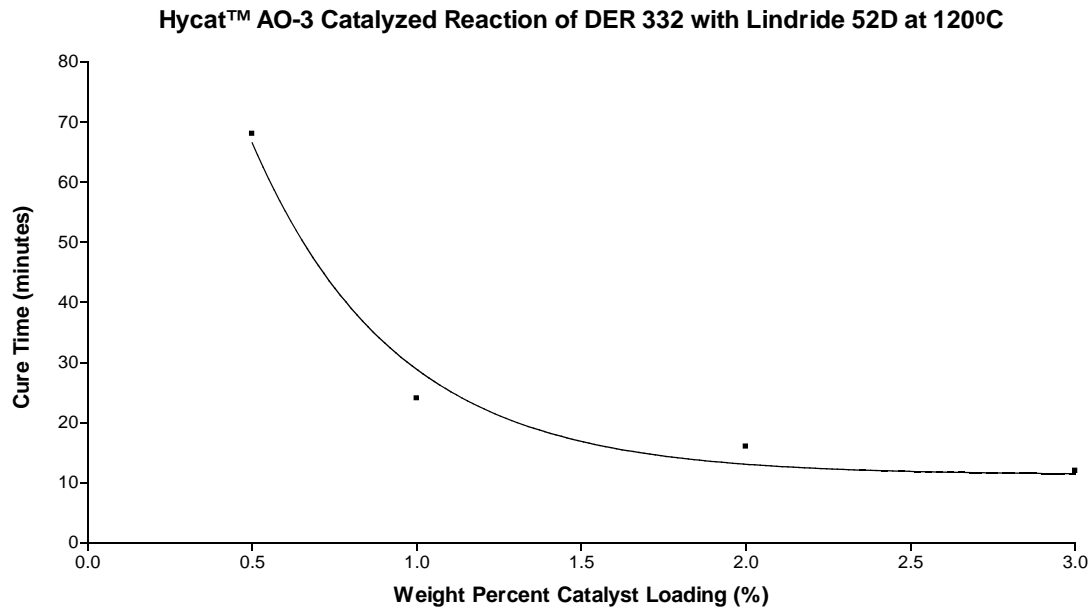
	Hycat™ AO-3 Reaction of DER354 with Lindride 52D at 120°C			
Wt. % Catalyst Loading	0.5%	1.0%	2.0%	3.0%
Cure Time (min.)	76-80	24-28	12-16	8-12



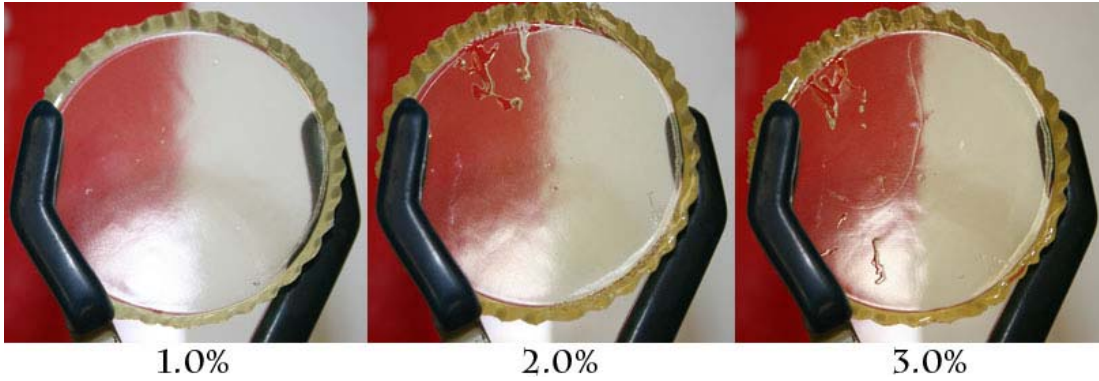
Similar results were observed in a formulation of diglycidyl ether of bisphenol A (DER 332) and MHHPA (Lindride 52D) at 120°C with Hycat™ AO-3 at various loading concentrations ranging from 0.5% to 3%.



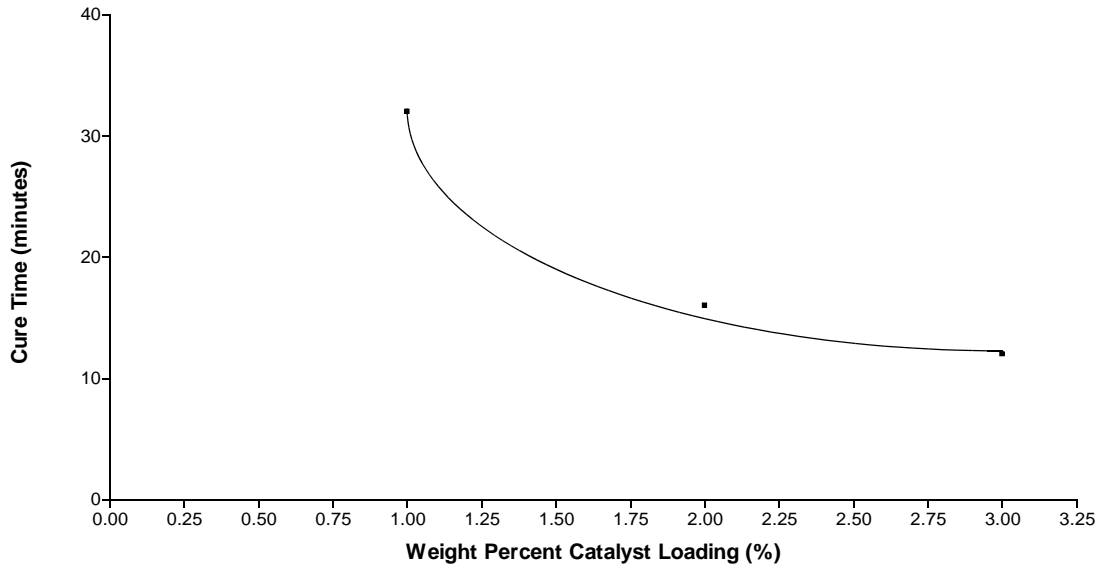
Hycat™ AO-3 Reaction of DER332 with Lindride 52D 120°C				
Wt. % Catalyst Loading	0.5%	1.0%	2.0%	3.0%
Cure Time (min.)	64-68	20-24	12-16	8-12



Favorable results were also experienced when Hycat™ AO-3 was used with a cycloaliphatic diepoxide (Lindoxy 190) and MHPA (Lindride 52D) at 120°C. Although slight coloration did occur at higher catalyst loading, fast cure time was experienced.

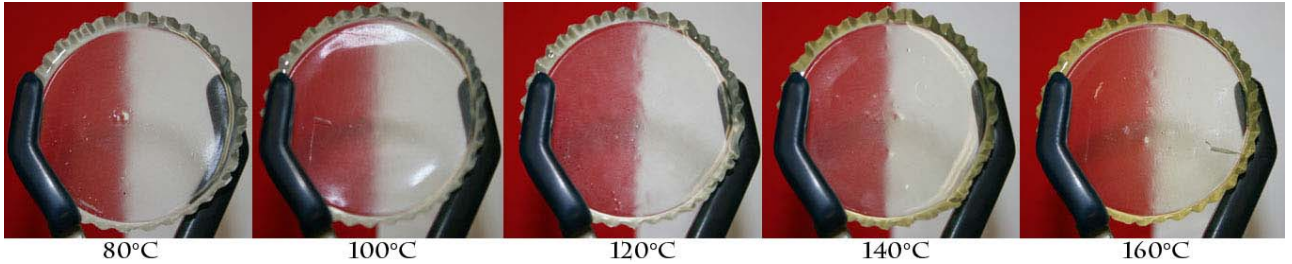


Hycat™ AO-3 Catalyzed Reaction of Lindoxy 190 with Lindride 52D at 120°C

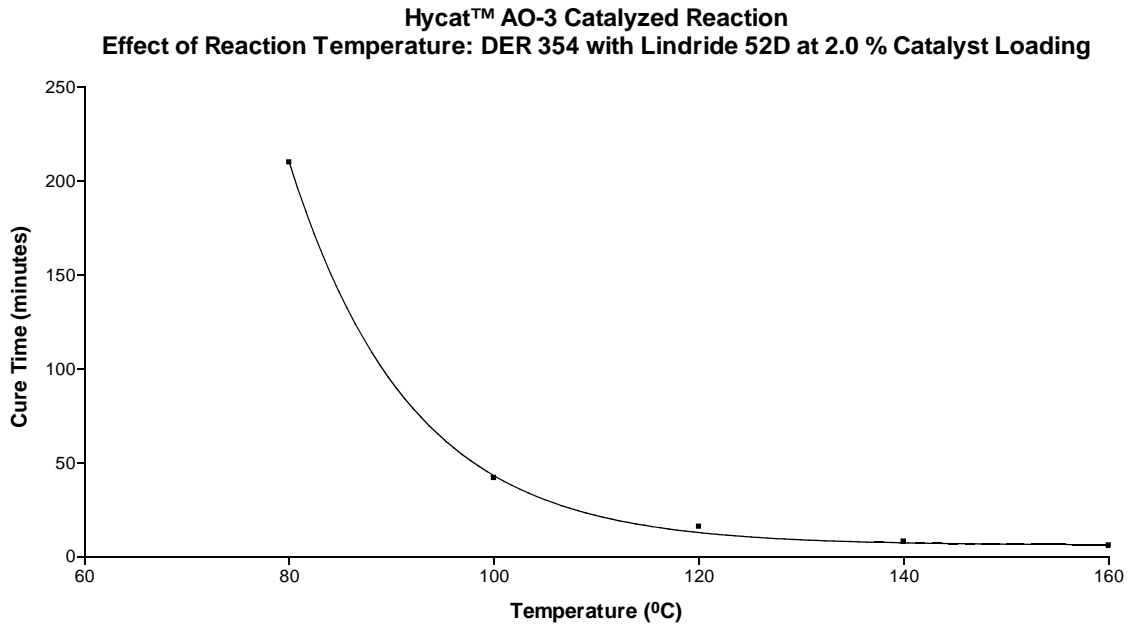


Hycat™ AO-3 Reaction of Lindoxy 190 with Lindride 52D 120°C			
Wt. % Catalyst Loading	1.0%	2.0%	3.0%
Cure Time (min.)	28-32	12-16	8-12
Hardness Test, Durometer Type D	91	88	89

The reaction diglycidyl ether of bisphenol F (DER 354) and MHPA (Lindride 52D) with 2.0 weight percent Hycat™ AO-3 loading does become slightly colored if the cure temperature is increased above 140°C. As expected, there is also a decrease in cure time as the temperature is increased.



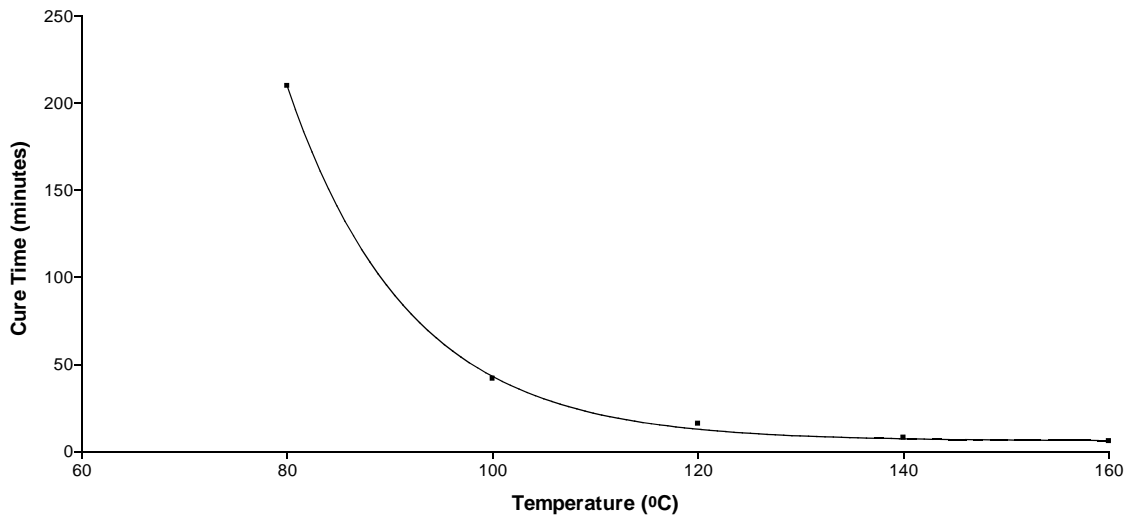
Hycat™ AO-3 Reaction of DER354 with Lindride 52D at 2.0 Weight Percent Catalyst Loading					
Temperature (°C)	80	100	120	140	160
Cure Time (min.)	180-210	38-42	12-16	4-8	4-6



Again, similar results were observed in a formulation of diglycidyl ether of bisphenol A (DER 332) and MHPA (Lindride 52D) at 2.0 weight percent catalyst loading of Hycat™ AO-3. Samples at 80°C display a clear, colorless cured product with slight color formation as the temperature was increased to 160°C. As expected, cure time is shorter at the elevated temperatures.



Hycat™ AO-3 Catalyzed Reaction
Effect of Reaction Temperature: DER 332 with Lindride 52D at 2.0 % Catalyst Loading

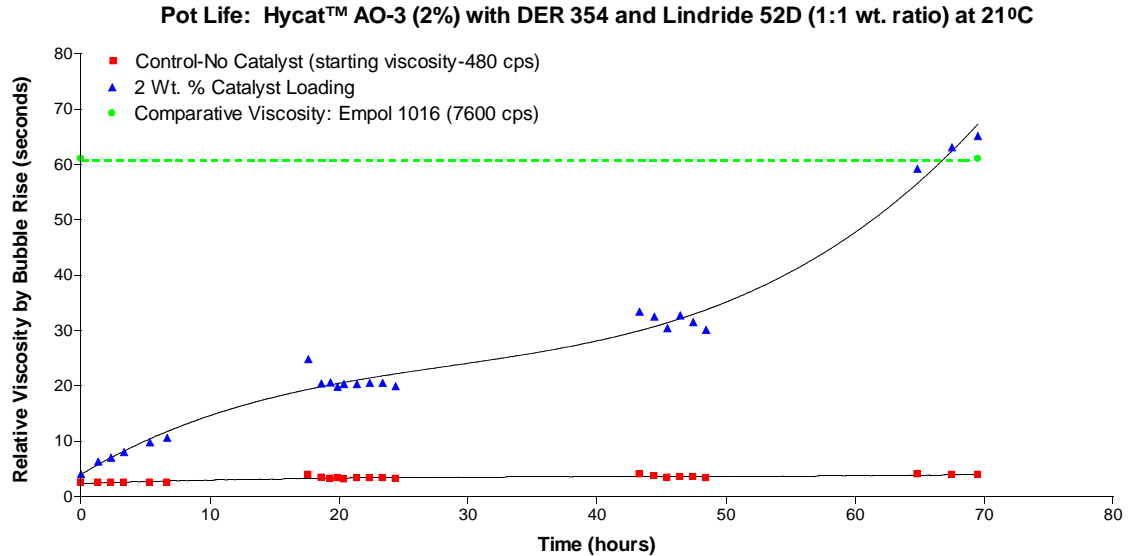


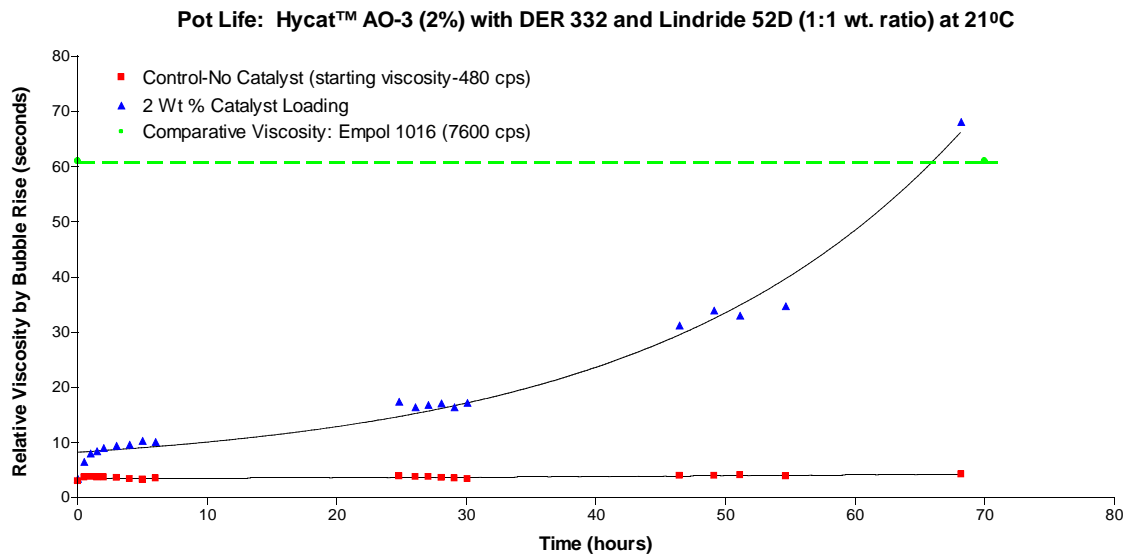
Hycat™ AO-3 Reaction of DER332 with Lindride 52D at 2.0 Weight Percent Catalyst Loading					
Temperature (°C)	80	100	120	140	160
Cure Time (min.)	180-210	38-42	12-16	4-8	4-6

Hycat™ AO-3 shows the following properties

- Appearance Clear and Colorless and essentially free of foreign matter
- Density at 20°C 1.044 g/mL
- Viscosity at 20°C 68.4 cps
- Freezing point, °C Less than -15 degrees
- Shelf life 2 years
- Limitations Not effective with carboxylic acids

The formulations with Hycat™ AO-3 show excellent pot life. At a 2% catalyst loading in formulations of diglycidyl ether of bisphenol A and F with MHHPA, the viscosity build up over a three-day period at room temperature (21°C) is below 8000 cps. These data are shown in the graphs below.





Hycat™ AO-3 does not promote significant homopolymerization of epoxy resins. When Hycat™ AO-3 was dissolved (2.0 % by wt.) in either the bisphenol A or F epoxy resins as well as the cycloaliphatic epoxy resin little homopolymerization occurred. After five days at room temperature (21°C), the resins had not started to gel or increase in viscosity. On day five, the samples were placed in a 120°C oven for an hour and the test samples showed no increase in viscosity and remained very fluid.

The activity of Hycat™ AO-3 appears to be limited to the reaction of epoxy resins with anhydrides. Hycat™ AO-3 does not appear to accelerate or promote the reaction of epoxy resins with carboxylic acids. The ability to cure dimer acids with epoxy resins catalyzed with Hycat™ AO-3 was examined. Three formulations were investigated with a 2.0 weight percent catalyst loading; a dimer acid (EMPOL 1016) with a cycloaliphatic epoxide (Lindoxy 190), a dimer acid (EMPOL 1016) with diglycidyl ether of bisphenol F (DER 354), and glutaric acid with a cycloaliphatic epoxide (Lindoxy 190). In all cases, Hycat™ AO-3 did not effect a suitable cure of these formulations.