

ORGANOPHOSPHOROUS HYCAT™ CATALYST

Hycat™ AO-1 is a liquid DTCS proprietary accelerator based on a complex organic phosphate with latent catalyst and **low VOC** properties. This catalyst is unique in that it provides the advantage of giving **none to low color** formation during the cure. Depending on the color of the starting materials, clear, colorless cures have been achieved with low to **no light distortion** properties. Hycat™ AO-1 was found to be a superior catalyst for use in fiber-optic formulation and for the manufacture of LED (Light Emitting Diode). Laboratory work with Hycat™ AO-1 shows that it is a unique catalyst to make “designer” prepolymers (via chain extension reaction) that have excellent stability and shelf-life (at least 9 – 12 days). These prepolymers can be cured with other formulation ingredients (e.g., cycloaliphatic epoxides) without having the need of adding more catalyst at relatively low temperatures (**95 to 120° C**). Depending on the color of the starting raw materials, little coloration of the cured formulation with excellent light transmission properties is obtained.

Hycat™ AO-1 will promote the reaction of Bisphenol-A Diglycidyl Ether type epoxides with phthalic acid or succinic acid based anhydrides such as methyl tetra-hydrophthalic anhydride (MTHPA), methyl hexahydrophthalic anhydride (MHHPA) and dodecenyl succinic anhydride. Other anhydride systems are expected to work as well.

HYCAT™ AO-1 PHYSICAL PROPERTIES

Appearance	Clear, colorless, liquid
Density	1.08 at 20° C
Boiling point	Decomposes at about 240° C at 10 torr
Pour point	Less than -25° C when super cooled
Acid Content	Less than 1 meq/g

HYCAT™ AO-1 CATALYST PERFORMANCE

Table 8 provides data related to the reaction of an epoxide (EPON 828) and an anhydride (MHHPA). This table is designed to convey information not only about cure times but also pot life at ambient and elevated temperatures. Graphs of this data follow on the next page.

Table 8

Epoxide	Anhydride	Temp, °C	Hycat™ AO-1 Loading, Wt. %	Pot Life Hours	Cure Time, Min.	Observations
EPON 828	MHHPA	22°	0.5 %	48	N/A	Mobile up to 48hrs @ ~ 22° C
EPON 828	MHHPA	80°	0.5 %	3 to 3.5	N/A	Mobile up to 3.0 – 3.5 hours @ 80° C
EPON 828	MHHPA	130°	0.5 %	N/A	6 to 9	Hard, non-tacky, clear, colorless solid
EPON 828	MHHPA	150°	0.5 %	N/A	2 to 3	Hard, non-tacky, clear, colorless solid
EPON 828	MHHPA	22°	0.25%	100	N/A	Mobile up to 100 hrs @ ~ 22° C
EPON 828	MHHPA	80°	0.25%	4 to 5	N/A	Mobile up to 4 – 5 hours @ 80° C
EPON 828	MHHPA	130°	0.25%	N/A	~ 16	Hard, non-tacky, clear, colorless solid
EPON 828	MHHPA	150°	0.25%	N/A	~ 8	Hard, non-tacky, clear, colorless solid

HYCAT™ AO-1 CATALYST PERFORMANCE – GRAPHICAL DATA

Figures 5 & 6 are graphical representations of the data in Table 8. These graphs show the latency characteristics of Hycat™ AO-1 coupled with its potent reaction to elevated temperatures.

Figure 5

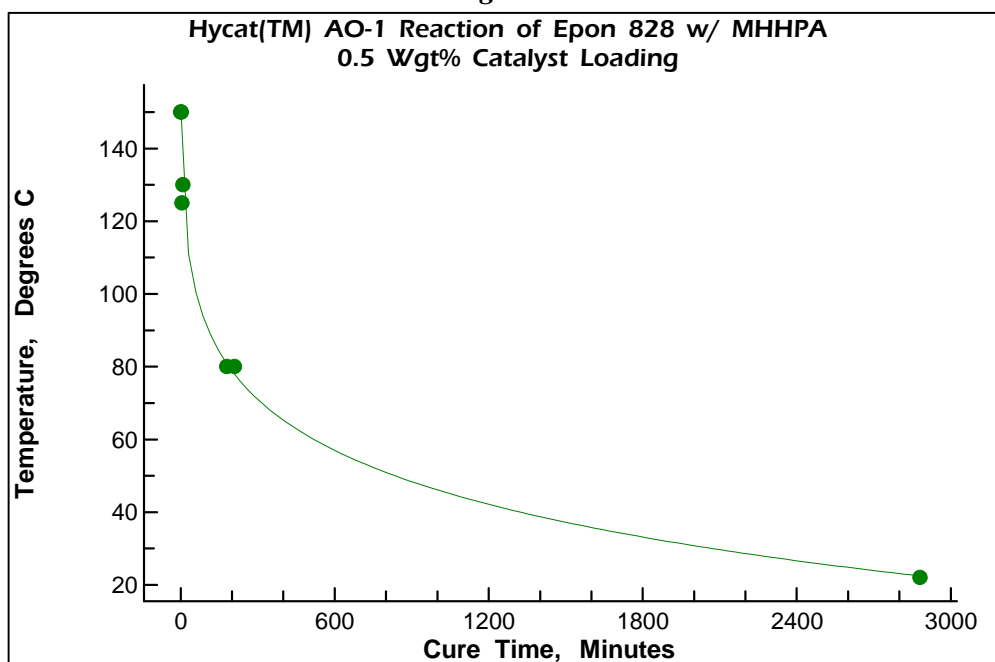
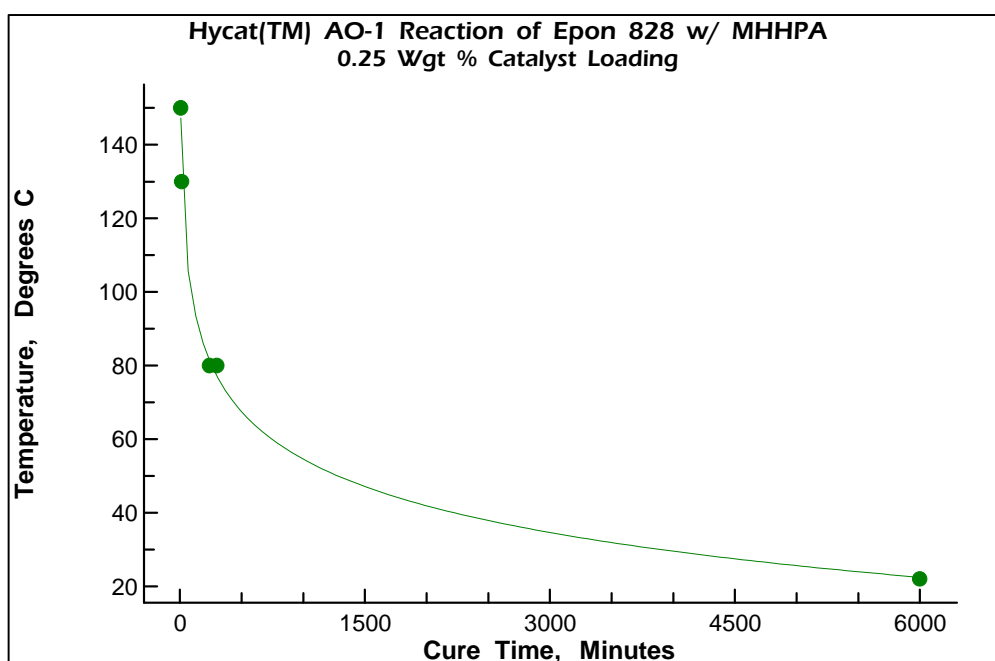


Figure 6



HYCAT™ AO-1 OPTICAL PERFORMANCE

Work done by *Dr. Sergey Geidur* at the *Saint Petersburg State Technological Institute* in Russia also showed the effectiveness of using **Hycat™ AO-1**, in comparison to other catalysts systems, to increase the brightness of LEDs. In Dr. Geidur's work, EPON 828 and an anhydride hardener was cured at 150°C. For the most part, a stoichiometric ratio of the epoxy to the hardener was generally used. The results of Dr. Sergey's work are shown below [Note: all hardeners had a Hazen color of *less than 50*].

COMPARISON OF COLOR FORMATION WITH DIFFERENT CATALYST SYSTEMS

Table 9 displays the resulting color observations in the reaction of EPON 828 with various hardeners at 150°C. **Hycat™ AO-1** demonstrated superior colorless and near colorless characteristics.

Hardeners Used:

- MTHPA
- HHPA
- EPICURE 1761 MTHPA
- MHHPA

Catalysts Used:

- **Hycat™ AO-1**
- Imidazole
- N,N-Dimethylbenzylamine (BDMA)
- Tetrabutylammonium Bromide (TBAB)

Table 9

HARDENER	IMIDAZOLE	BDMA	TBAB	HYCAT™ AO-1
MTHPA ¹	Yellow	Brown	Yellow	Almost Colorless
HHPA ²	Yellow	Brown	Light Yellow	Colorless
HHPA ³	Yellow	Brown	Light Yellow	Colorless
EPICURE 1761 ⁴	Yellow	Brown	Yellow	Almost Colorless
MTHPA ²	Light Yellow	Brown	Light Yellow	Colorless
MHHPA/SW ²	Yellow	Brown	Yellow	Colorless
MHHPA ³	Yellow	Brown	Yellow	Almost Colorless

1: Sterlytamaksky Petrochemical Factor, Russia

2: Lonza Group, Italy

3: Milliken Chemical, USA

4: Resolution Performance Products, Germany