# ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

## Summary:

Water based pressure sensitive adhesives (PSA's) are used for a variety of products which include tapes, labels and protective films. The functionalized acrylic resins in many of these adhesives require use of cross linkers in order to control tack and adhesion. While Polyfunctional Aziridine's (PFAZ) are more common, epoxies can also be utilized to cross link resins containing pendant acid functionality. In particular, Erisys GA-240 (Tetra-glycidyl m-Xylene Diamine) has been shown to be an effective alternative to polyfunctional aziridines for these applications.

## Background:

The properties of water based acrylic PSA's are controlled through careful selection of monomers used to produce these polymeric substances. Hydroxyl and acid functional monomers help to make the polymers hydrophilic, thereby increasing water solubility, and also function to help increase adhesion. In addition, the acid functionality provides sites for cross linking reactions to occur. Monomers containing longer alkyl chains help to decrease the Tg of the polymer, thereby increasing the tack of the adhesive. Lower Tg gives better tack, and higher peel adhesion. Higher Tg results in less tack, lower peel adhesion, and increased shear adhesion. Some of the more common monomers used in making acrylic polymers for PSA's are shown in Figure 1 along with their typical use levels and Tg.

*Polymer chain of water-soluble acrylic PSAs*

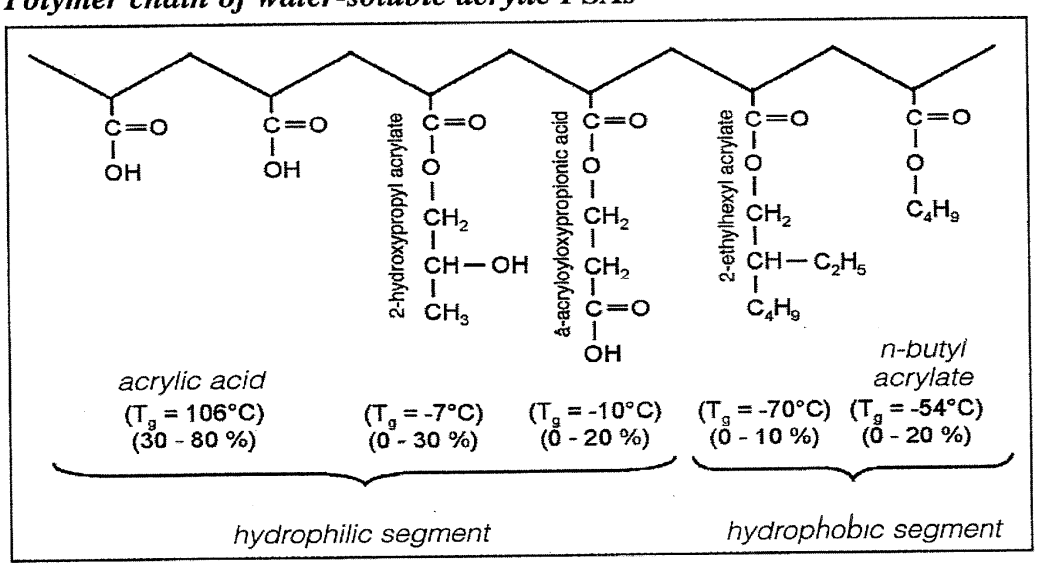



Figure 1

# ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

The molecular weight of the polymers used in PSA's is also of prime importance. Figure 2 illustrates the effect of molecular weight on cohesive strength, peel adhesion and tack. Increasing molecular weight will result in improved cohesive strength and shear adhesion along with decreased peel adhesion and tack.

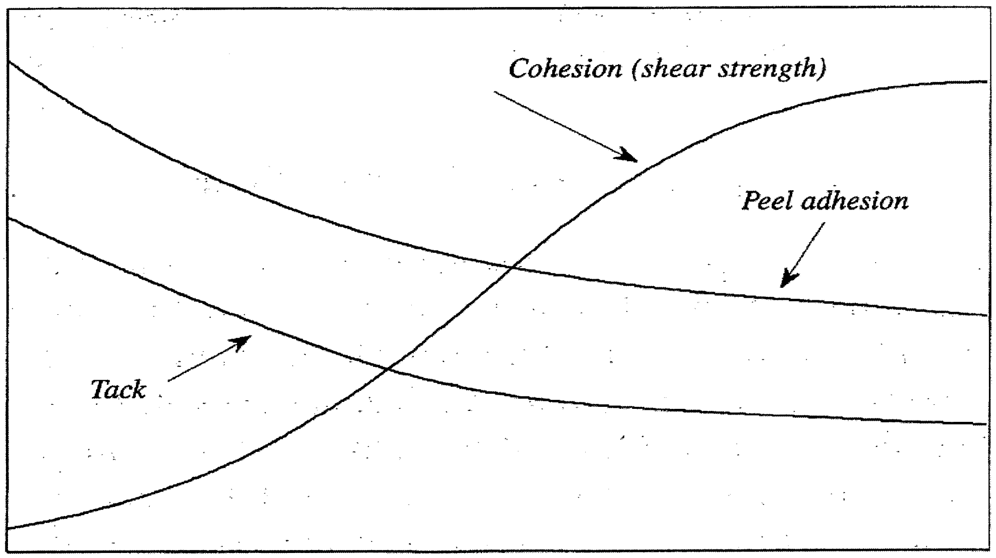



Figure 2

Good cohesive strength in a PSA is important in order to prevent adhesive transfer to the substrate when removing the film, tape or label. Figure 3 illustrates the difference we see in adhesive with poor cohesive strength (on the left) vs. good cohesive strength (on the right).

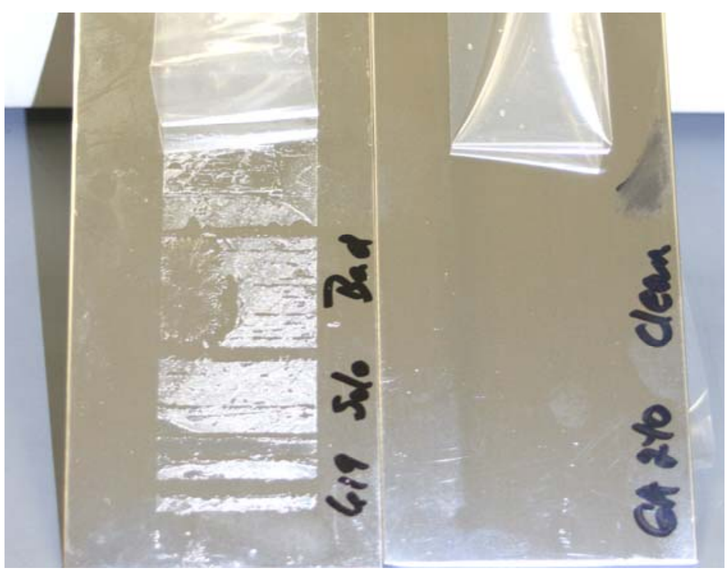



Figure 3

## ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

Polymers of higher molecular weight are normally more difficult to process. Cross linking of adhesive polymers is a useful tool to build molecular weight in situ and still be able to enjoy the benefits of lower molecular weight polymers for processing. Cross linkers are normally added to PSA's just prior to coating the substrates. Heat applied to drive off water during processing of the coated films helps activate the cross linker. The cross linking, in essence, increases the molecular weight of the polymer, leading to improved cohesion, higher shear strength, lower peel adhesion, less tack, higher temperature performance and improved chemical resistance. Use of some amount of cross linker is required in almost all PSA applications because the polymers used in these adhesives normally operate at temperatures above their glass transitions and would otherwise tend to cold flow at relatively low temperatures. Minimal amounts of crosslinker will prevent this from occurring.

Peel adhesion is normally measured by adhering a 1 inch wide tape sample to a piece of polished stainless steel, and then measuring the force required to pull the tape off in an Instron machine at a controlled rate of speed. The tape is pulled at an angle of 180° and force requirements from a few ounces to a few pounds are typical. Values are reported in units of "pli" or pounds per linear inch, meaning per 1 inch of width. (International units are Newtons per 10 mm of width) Figure 4 shows a typical configuration for a peel test.

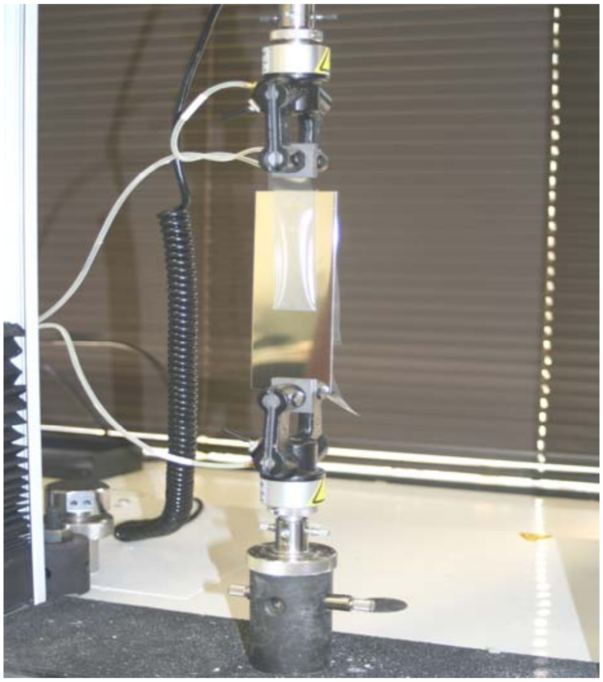


Figure 4

Shear adhesion, on the other hand, is a static test where a 0.25 $in^2$ (1/2" x 1/2" or 12.5 mm x 12.5 mm) piece of tape is adhered to a stainless steel plate. A typical set up is shown in Figure 5. A 500 gram weight is hung from the tape and the time it takes for that piece of tape to pull off the substrate is measured. Longer time to failure is indicative of greater cohesive strength. Most PSA's, even with a small amount of cross linker, show times to failure in excess of 3100 minutes (with a 500 gram weight).

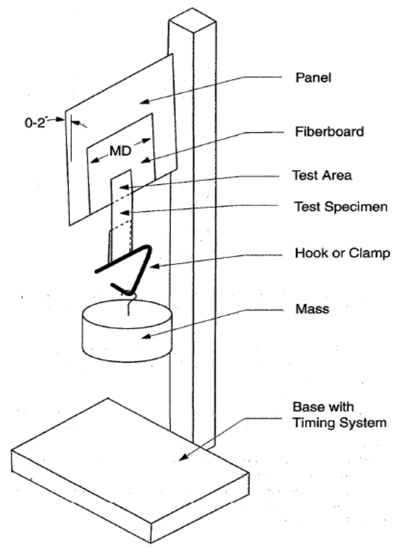
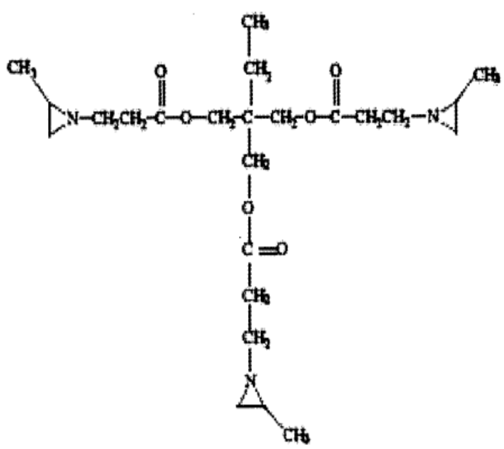
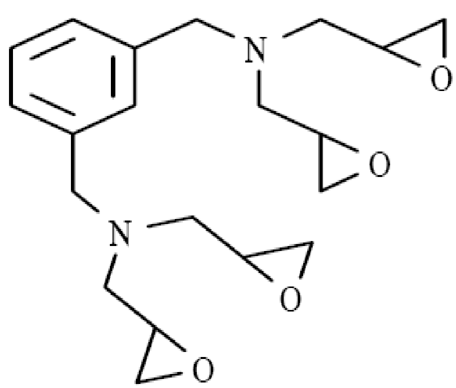



Figure 5

While several different chemistries can be used to crosslink polymers in PSA's, one of the most common class of compounds are polyfunctional aziridines (PFAZ). While very useful and employed widely, aziridines have some undesirable characteristics including reduced efficacy over relatively short dwell times in water, and significant health/safety concerns. CVC has found that Erisys GA-240 shows excellent cross linking capabilities when used in PSA's and can be used to replace aziridine in these applications. Figure 6 shows structures of a typical PFAZ and Erisys GA-240.



PFAZ



GA240

Figure 6

# ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

## Testing and Results:

Tests were run using Erisys GA-240 and Neocryl CX-100 as crosslinkers for Rhoplex N-619 acrylic emulsion for pressure sensitive adhesives. For peel adhesion testing, crosslinkers at levels from 1 to 5% (dry basis), were added to the N-619 emulsion under agitation. For shear testing, levels of 0.25 to 3.0% (dry) were used. Erisys GA-240 was added in the form of a 65% solution in Ethyl Acetate. Neocryl CX-100 was added "as is". Draw-downs were made on polyester film using a #50 wire wound rod. Films were oven dried for 5 minutes at 150°F, then held at RT and tested for peel adhesion initially and periodically thereafter up to 35 days later. Shear adhesion was tested after 1, 3 and 5 days at RT.

Results for peel adhesion using GA-240 and CX 100 from 1 to 5% as cross linker are shown in Figure 7 and Figure 8.

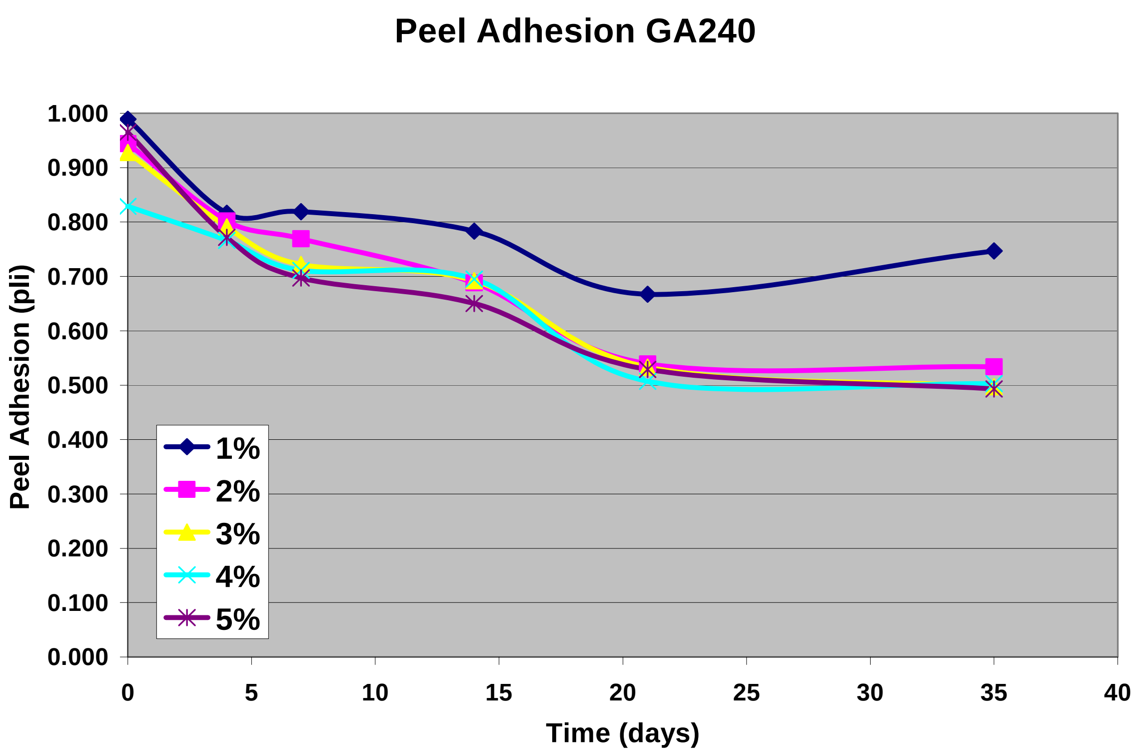



Figure 7

# ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

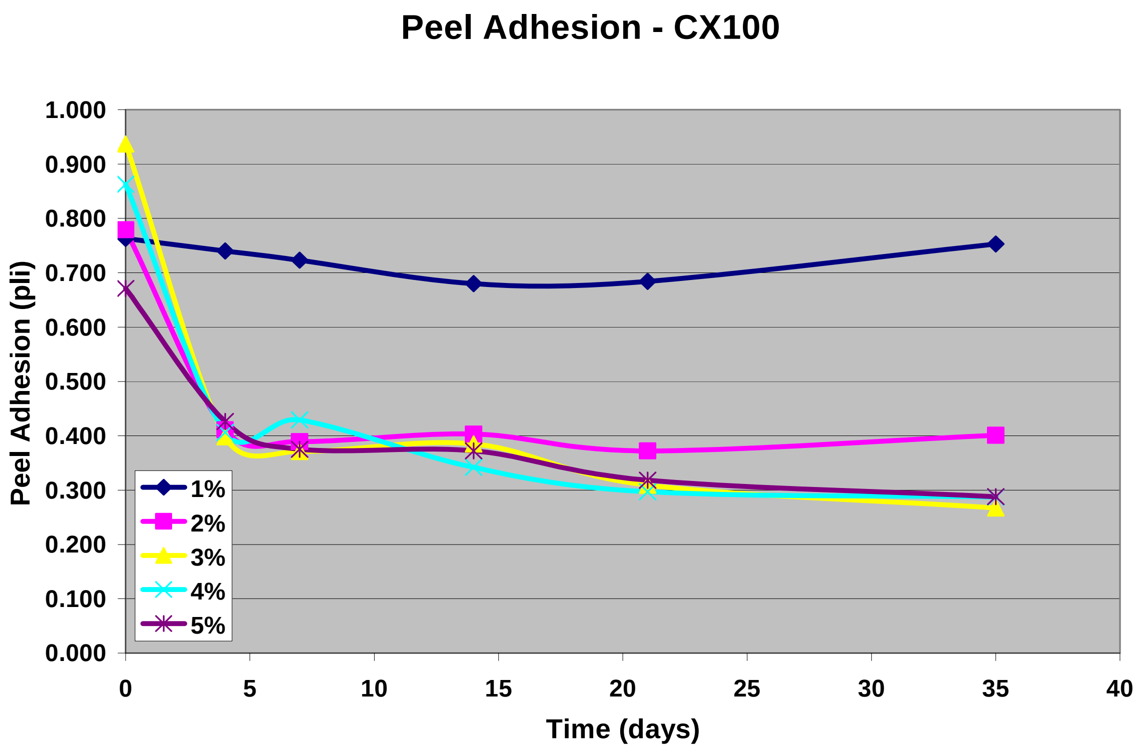



Figure 8

The peel adhesion when no crosslinker is used is approximately 1.5 pli (2.63N/10 mm). Samples made without crosslinker all show adhesive transfer to the stainless steel adherend.

The results indicate that, while each crosslinker works well to decrease peel adhesion, values achieved with CX100 are somewhat lower. Further work as shown in Table 1 below indicates that equivalent levels of adhesion can be achieved with somewhat higher levels of GA-240 as long as the adhesive film receives a force cure.

| Peel Adhesion in pli | 1% GA240 | 2% GA240 | 1% CX100 | 2% CX100 |
|---|---|---|---|---|
| Cure 5'@150F + 24 hr @ RT | 1.84 | 1.73 | 0.83 | 0.76 |
| Postcure 24 hr.@150F | 0.87 | 0.73 | 0.79 | 0.62 |

## ERISYS™ GA-240 as Cross Linker for Pressure Sensitive Adhesives

Results for Shear Adhesion testing are shown in Figures 9, 10, & 11.

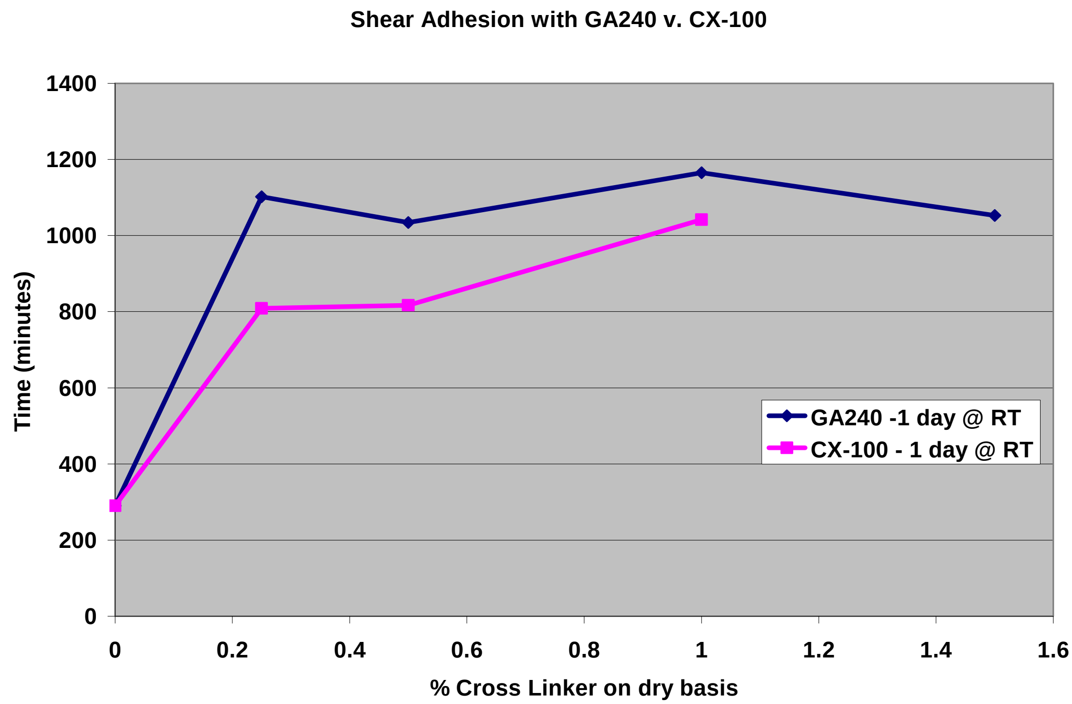



Figure 9 Shear Adhesion – 1 Day Cure @ RT
(at higher cross linker levels results exceed 3100 minutes)

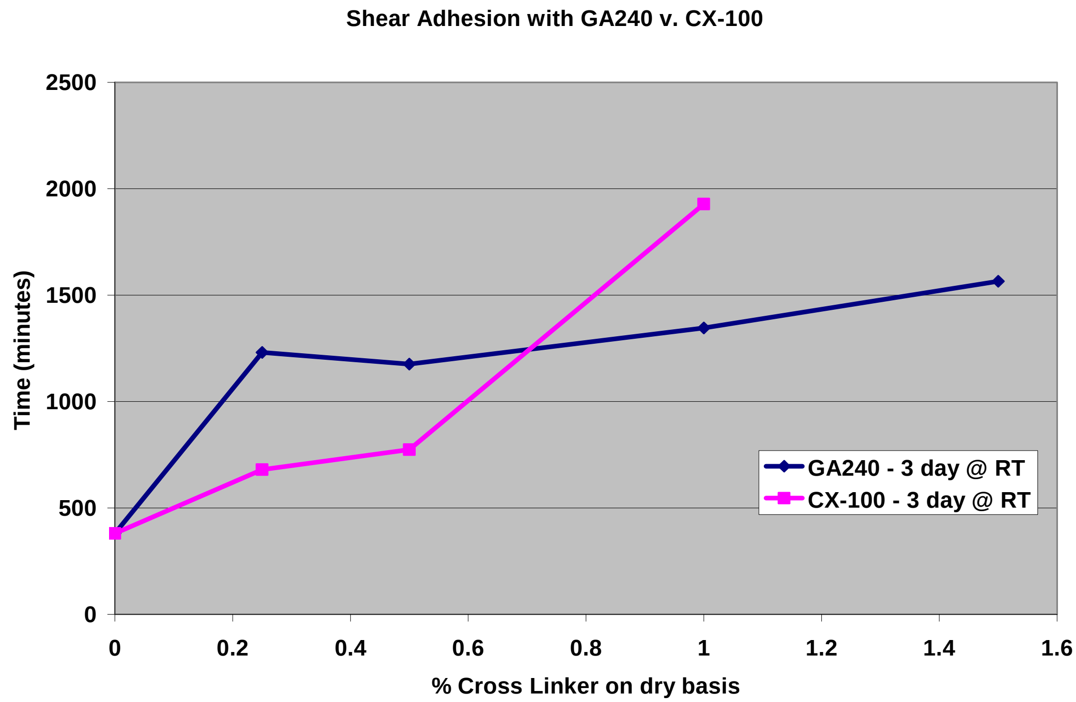


Figure 10 Shear Adhesion – 3 Day Cure @ RT
(at higher cross linker levels results exceed 3100 minutes)

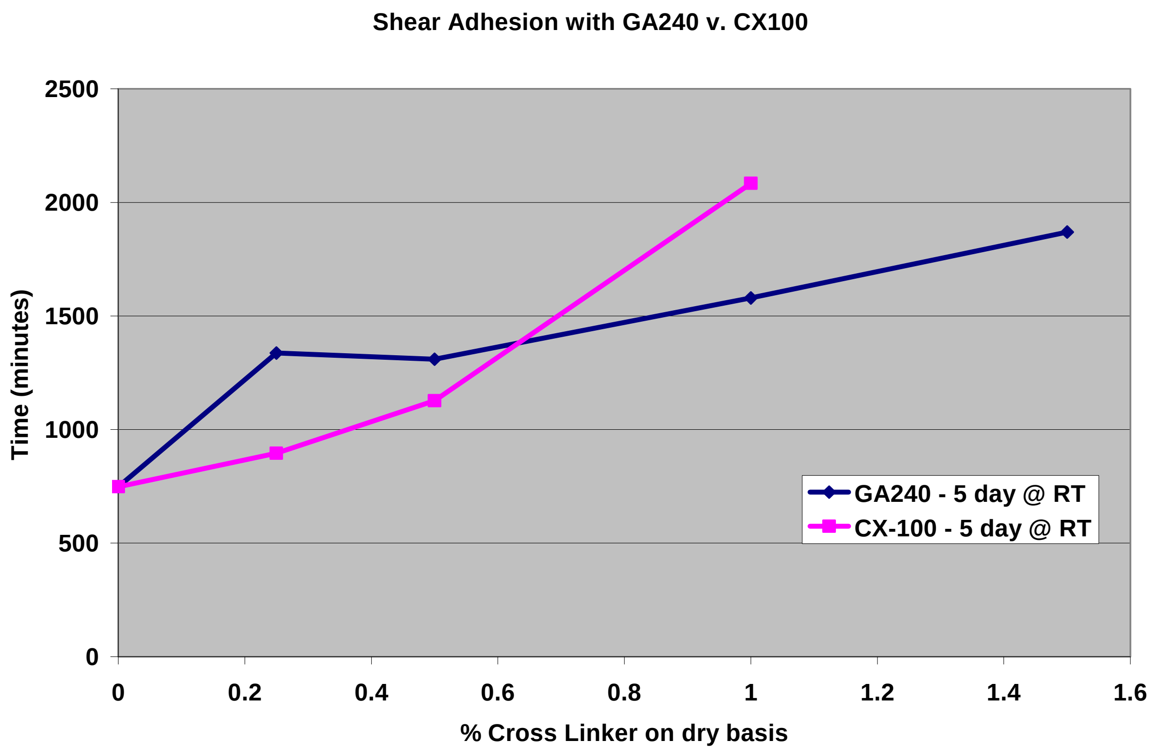



Figure 11 Shear Adhesion – 5 Day Cure @ RT
(at higher cross linker levels results exceed 3100 minutes)

Shear testing indicates that GA240 is more effective than CX-100 at lower use levels. It is important to understand that at crosslinker levels in excess of those shown on graphs, the shear adhesion values were in excess of 3100 minutes.

## Conclusion:

These results illustrate that GA-240 can be used as an effective cross linker in pressure sensitive adhesives to decrease peel adhesion, increase shear strength, and eliminate any problems with adhesive transfer to substrates by increasing the cohesive strength of the treated adhesives. GA-240 demonstrates equivalent performance to the polyfunctional aziridine cross linker (CX-100) in terms of shear adhesion and increased cohesive strength. While the decrease in peel adhesion with GA-240 is not as great as with CX100, GA-240 does cause substantial and entirely acceptable reductions in peel adhesion in pressure sensitive adhesives. In addition, GA-240 will remain active in formulated adhesives for several days while those systems treated with CX100 will require re-inoculation of the adhesive due to decomposition of the aziridine due to hydrolysis. Finally, GA-240 does not carry with it the types of safety and health concerns that are inherent in the aziridine systems.