derakane™ signia™ resins
unchanged polymer backbone

introduction

Introduced in 1965 to combat corrosion in hot, wet chlorine environments, Derakane™ epoxy vinyl ester resins have become the industry standard for corrosion-resistant fiber reinforced polymer (FRP) equipment. High performing derivatives have been introduced over the years to allow vinyl ester solutions for expanded chemical environments, high temperature performance and areas requiring improved toughness. With the introduction of Derakane™ Signia™, Ashland has leveraged new production capabilities to modernize resin features including improved environmental performance, better workability and increased worker satisfaction.

features

Derakane™ Signia™ resins provide significant advantages for fabricators, design engineers and asset owners/end users of corrosion-resistant FRP equipment.

In the shop

- low styrene emission
- improved shop efficiency
- longer shelf life

In the field

- unchanged polymer backbone
- identifiable resin system

In this paper, we will expand on the unchanged polymer backbone of Derakane™ Signia™ resins. The polymer backbone of Derakane™ Signia™ 411 bisphenol-A epoxy vinyl ester resin is unchanged compared to previous generations of Derakane™. It provides resistance to a wide range of acids, alkalis, bleaches, and organic compounds used in chemical processing industry applications.

Assurance of corrosion performance is critical to users and specifiers of FRP equipment. Since the Derakane™ Signia™ polymer backbone is the same compared to previous Derakane™ products, asset owners and engineers can be assured that all previous Derakane™ corrosion studies, historical data and field case histories are relevant and demonstrate performance for their design requirements. This assurance, combined with improvements for the fabricator, leads to the availability of better, more efficiently produced and more environmentally friendly FRP equipment.

unchanged polymer backbone

Through direct chemical structure evaluation, Ashland verifies the Derakane™ Signia™ polymer backbone is unchanged compared to previous versions of Derakane™ resins. The structure of the resin polymer backbone is proprietary; however, several properties of the Derakane™ Signia™ resin have been evaluated to validate the polymer backbone has not changed. The first step towards this is comparing thermal and mechanical properties and validating they are the same for Derakane™, Derakane™ Momentum™, and Derakane™ Signia™ bisphenol-A epoxy vinyl ester resins. Properties such as tensile and flexural strength, modulus and heat distortion temperature measure directly the characteristic of the cured polymer matrix crosslinking.

Table 1 presents thermal and mechanical properties for cured clear castings of Derakane™ Signia™ 411, Derakane™ 411-350, and Derakane™ Momentum™ 411-350 resins. Taking standard deviation into account for each of the test methods, the thermal and mechanical properties of the three resins are the same[1,2].

property of casting	derakane™ signia™ 411	derakane™ 411-350	derakane™ momentum 411-350	unit (SI)	method
tensile strength	**85.6**	81.3	83.6	MPa	ASTM D638
tensile modulus	**3.1**	3.0	3.0	GPa	ASTM D638
tensile elongation	**5.1**	5.1	5.2	%	ASTM D638
flexural strength	**147.9**	138.6	144.8	MPa	ASTM D790
flexural modulus	**3.3**	3.2	3.3	GPa	ASTM D790
heat distortion temperature	**105**	105	105	°C	ASTM D648

Table 1. Typical mechanical properties of Derakane™ Signia™ 411, Derakane™ 411, and Derakane™ Momentum™ 411 clear castings. All properties were calculated on a clear casting that was cured for 24 hours at ambient conditions then post-cured.

Resin viscosity and density are largely governed by polymer chain length and the percent of monomer (styrene) present. In Table 2, the viscosity, styrene content and density of Derakane™ Signia™, Derakane™ Momentum™, and Derakane™ 411 resins are presented. The data shows the viscosity, styrene content and density are the same for all of the resins. If there was a difference in polymer chain construction for these resins, more styrene would be needed for longer average chain lengths, or less styrene for shorter average chain lengths to achieve the same viscosity. Variations in polymer chain construction would create differences in mechanical properties – which is not seen in Table 1 data.

property at 25°C (77°F)	derakane™ signia™ 411	derakane™ 411-350	derakane™ momentum™ 411-350	unit (SI)	method
Brookfield viscosity	**350**	350	350	cps	ASTM D2196
styrene content	**44**	44	44	%	ASTM D638
density	**1.046**	1.046	1.046	g/ml	ASTM D1475

Table 2. Typical liquid properties of Derakane™ Signia™ 411, Derakane™ 411, and Derakane™ Momentum™ 411 resins.

To confirm corrosion performance is unchanged, Derakane™ Signia™ and classic Derakane™ resins were evaluated in two relatively aggressive chemical environments. Hydrochloric acid and sodium hydroxide are bookends of conditions found in many industrial applications such as chemical manufacturing and mineral processing – consistent performance in these environments is critical and is a key indicator of an unchanged polymer backbone.

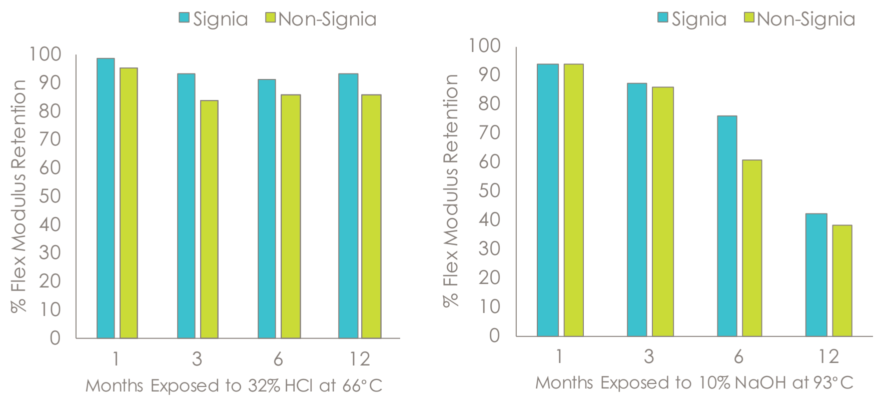

Figure 1. ASTM C-581 corrosion study data for 32% hydrochloric acid at 66°C (left) and 10% sodium hydroxide at 93°C (right).

The graphs of ASTM C581 corrosion data in Figure 1 show the percent retention of C581 coupon flex modulus after exposure to 32% hydrochloric acid at 66°C (150°F) (Figure 1, left) and after exposure to 10% sodium hydroxide at 93°C (200°F) (Figure 1, right). Laminate modulus is determined primarily by the reinforcement, not the resin. The retention of modulus relates directly to degradation of glass reinforcement and the ability for the resin to protect the glass from the chemical environment[2]. The data demonstrates that the performance of Derakane™ Signia™ and classic Derakane™ bisphenol-A epoxy vinyl ester resins is similar – taking variations inherent to C581 testing into account.

It should be noted 10% sodium hydroxide at 93°C (200°F) is relatively aggressive and the coupon construction chosen is not what would be recommended for this service in a real-world application. This construction was chosen to better evaluate how each resin protects glass reinforcement from chemical attack[3].

summary

The chemistry of epoxy vinyl ester resins makes them highly reactive; when first invented, they were unstable and difficult to use. Introduction of better production capabilities improved their stability and allowed them to become a material of choice for corrosion applications where alloys could not perform. In Derakane™ Signia™ resins, Ashland has combined the best technological features of the Derakane™ and Hetron™ lineage with additional new learnings to introduce a leap forward in stability and usability compared to previous generations of epoxy vinyl ester resins. Liquid, thermo-mechanical, and corrosion performance data presented in this paper supports that Signia™ resins have an unchanged polymer backbone – assuring customers the vast library of Derakane™ corrosion and case history data collected over the past 50 plus years applies to Signia™ resins.

[1] Clear castings of 3.2 mm (1/8") thickness were prepared between glass plates using standard preparation methods. The castings were cured at room temperature for 24 hours then post-cured. Thermal and mechanical properties were determined using ASTM methods and Instron mechanical testing equipment.

[2] Properties are typical values, based on material tested in our laboratories. Results may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specification items.

[3] Derakane™ epoxy vinyl ester resins chemical resistance guide, pp. 8, 65, Spring 2017, Ashland LLC., Dublin, Ohio, 43017

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