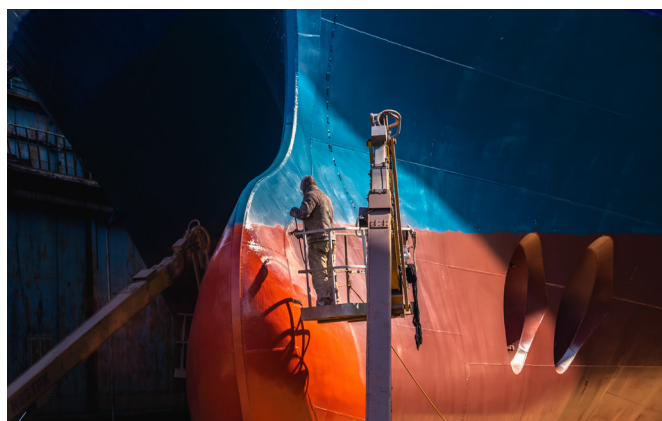


ANCAMINE® 2871 & 2872

ULTRA-LOW EMISSION EPOXY HARDENERS

WITH IMPROVED EHS PROFILE



ABSTRACT

The development of high-performing, safe, and sustainable epoxy systems is critical for modern industrial applications, particularly in sectors where labeling, safety, and regulatory compliance are essential. This study presents two novel ultra-low emission epoxy hardeners designed to minimize volatile organic compound emissions and offer a beneficial safety profile, while maintaining excellent adhesion, fast Shore D hardness development and high carbamation resistance. The hardener formulations were optimized using modified polyamine components, resulting in a system with significantly reduced emissions compared to conventional alternatives. Comprehensive analytical techniques and coating performance tests according to established standards were employed to assess the curing behavior and mechanical performance. The results demonstrate that the developed hardeners show excellent coating properties without compromising good labeling, offering a practical solution for industrial epoxy applications meeting required ultra-low emission properties.

INTRODUCTION

Epoxy systems cured with amine hardeners are an established technology in various industrial end markets due to their exceptional durability even under adverse conditions such as temperature fluctuations or exposure to sea water or chemicals. For instance, coatings based on epoxy technology protect industrial floorings, parking decks, industrial facilities, pipes and ships from abrasion, corrosion, and degradation by chemicals. Their robust performance during the service life provides reliable and persistent protection, thus enabling end users to reduce maintenance work and lower downtime costs. This does not only help to save costs and resources but also improves sustainability of the assets.

Besides high durability, a second sustainability aspect of critical importance in the coatings industry is low emissions. Especially when applied by spraying or in poorly ventilated areas, volatile organic compounds (VOC) in the coating formulation reduce the air quality, leading to more stringent safety equipment to protect the health of the applicators. Ultra-low VOC emissions are also substantial for achieving beneficial

emission ratings (e.g. EMICODE®) and meeting several indoor air regulations, such as the criteria set by the Committee for Health-related Evaluation of Building Products (AgBB).

A third major driver in the area of sustainability, is a strong demand for EHS-friendly (Environment, Health & Safety) labeling of products which is challenged by increasingly stringent regulatory requirements. Particularly, substances of very high concern (SVHC) are to be avoided. This category includes carcinogenic, mutagenic or reprotoxic (CMR) substances which pose serious risks to human health.

Evonik's proprietary ultra-low emission technology helps formulators to meet the described requirements of high performance and durability, combined with ultra-low to zero emissions. Whereas conventional hardeners contain benzyl alcohol which is considered as VOC since its boiling point is below 250 °C at atmospheric pressure of 101.3 kPa [1], these ultra-low emission hardeners do not require any additional non-reactive plasticizer. Thus, the

proprietary technology allows for very low viscosity and good through cure without vitrification in the absence of any VOC substances. [2]

Existing ultra-low emission curing agents in Evonik's portfolio contain the substance diethylaminopropylamine (DEAPA) which has recently been relabeled as reproductive toxic (category 2). Consequently, two new epoxy hardeners have been specifically designed as safer substitutes to the established curing agents. While providing comparable properties at a high-performance level and equivalent ultra-low VOC emissions at low viscosities, the new products offer beneficial labeling. This makes the two new amine curing agents ideal candidates for future-proof sustainable epoxy formulations.

EPOXY CURING AGENT DEVELOPMENT: PROPERTIES AND POSITIONING

Ancamine® 2871 and Ancamine® 2872, have been developed to meet sustainability attributes of high performance and durability, ultra-low VOC emission and improved labeling. Both handling and end properties were adjusted to meet the performance level of the established products Ancamine® 2712M and Ancamine® 2739 which have been recently relabeled as reprotoxic. Both new products are modified polyamines which can be used as ambient curing agents in two-component standard liquid epoxy systems. Recommended end applications include industrial flooring and protective coatings in industrial or marine applications. Both curing agents exhibit low viscosities of ~ 600 mPas and an amine hydroquin equivalent weight (AHEW) of 95.

Ancamine® 2871 is designed for highly reactive systems that cure even under adverse conditions such as lower temperatures or high humidities. Providing low viscosity and high adhesion to different materials such as metal and concrete, it is ideally suited for primer applications. However, its limited UV stability prevents broader use in topcoat formulations.

Table 1: Table of basic hardener properties

Result Type	Ancamine® 2871	Ancamine® 2872
AH-EW	96	95
Use level, phr	50	50
Viscosity 25 °C, mPas	350–650	300–700
Amine value, mg KOH/g	520–580	530–580

Ancamine® 2872 exhibits improved color (Gardner color max. 3) and UV stability compared to Ancamine® 2871 with equally high adhesion which makes it a good choice for both primer and topcoat applications. It has been designed for longer working time and offers a good balance between pot life and cure speed at ambient temperatures.

METHODS & RESULTS

Both curing agents have been mixed with a standard liquid epoxy resin (LER) in a 1:2 ratio, i.e. 50 parts per hundred parts of epoxy resin (50 phr), mixed with a speed mixer at 1700 rpm for 2 minutes. A low formulation viscosity can be achieved without the need for solvents or plasticizers (mix viscosities with LER 50 phr after 5 min at 23 °C: Ancamine® 2871 3880 mPas and Ancamine® 2872 4800 mPas). As reference, Ancamine® 2712M and Ancamine® 2739, were tested under the same conditions.

The pot life was measured by gelation time on a gel tester (Techne Gelation Timer, 150 g mix), and obtained 35 min and 53 min for Ancamine® 2871, Ancamine® 2872, respectively.

The resulting formulation was applied in thin films of 75 µm wet film thickness (WFT). Cure speed was determined with a Beck&Koller Drying Time Recorder at both 23 °C and 10 °C, according to ASTM 5895. The results for Ancamine® 2871 at phase 3 show high reactivity even at low temperatures: 4.2 h (23 °C) and 8.8 h (10 °C). The phase 3 results for Ancamine® 2872 are slightly longer but still show a good curing profile: 5 h (23 °C) and 9.5 h (10 °C).

The carbamation resistance test was conducted on black Leneta charts according

to ISO 2812 method (**Figure 1**). The coating was applied at 150 µm thickness. Either a water saturated cotton patch was placed on the cured coating or water dropped on the film then covered with a watch glass to prevent evaporation. The appearance of the coating was judged after given testing time in a scale of 1 to 5, with 5 being the best showing no effect, and 1 being the worst with a white surface. Both products show very good carbamation resistance at 23 °C (**Table 2**).

Cross-cut tests according to ASTM D3359 resulted in grade 0 (best) for both products (**Figure 2**), confirming excellent adhesion properties. UV resistance was tested for 7 d under UVA light (351 nm, 0.89 W/m²/nm). Both products exhibit good stability, especially Ancamine® 2872, making it suitable for transparent coatings, identical to Ancamine® 2739 (**Figure 3**).

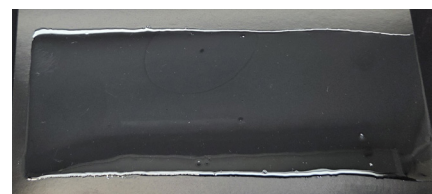


Figure 1: Ancamine® 2871 Carbamation test at 23 °C, Ancamine® 2872 is comparable

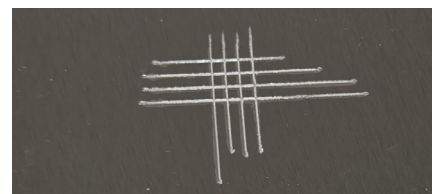


Figure 2: Ancamine® 2871 Cross-cut test result on clear coat, Ancamine® 2872 is comparable



Figure 3: UV stability comparison of Ancamine® 2739 and Ancamine® 2872

The Shore D hardness is typically tested for flooring applications to define walkability and back-to-service time. The tests were performed according to ASTM D2240. 18.5 g of epoxy resin and curing agent were poured in 5 cm diameter circular metal lids to get 1 cm thick clear casts. A Shore D hardness of 40-50 is targeted for walkability, full cure corresponds to a final shore D hardness level of 80. Both products show a fast hardness development, comparable to Ancamine® 2712M and Ancamine® 2739 (Graph 1). Especially Ancamine® 2871 exhibits a fast curing at ambient and low temperatures.

Through cure was tested via DSC measurement with 10 K/min heating, from the exothermic peak area difference of right away and curing after 7 days measurements. Conversions $\geq 95\%$ after 7 days indicate good through cure in the absence of additional plasticizers in the coating formulation.

Tested with Bisphenol A/F epoxy resin, diluted with 20 % C12-C14 glycidyl ether, EEW=190, $\eta=900$ mPas, cured at room temperature resulted in a conversion of 95 % for Ancamine® 2871 and of 98 % for Ancamine® 2872.

CONCLUSION

Ultra-low emission products with excellent performance combined with good labeling properties are key market drivers for the coatings industry. Increasingly stringent regulatory requirements often lead to re-classification of existing systems. The new

Table 2: Basic clear coat properties with a Bisphenol A epoxy resin
(marked with *: Bisphenol A/F epoxy resin with 20 % C12-C14-glycidyl ether)

Result Type	Method	Ancamine® 2871	Ancamine® 2872
Gel time		35	53
TFST Phase I	23 °C	02:15	02:45
TFST Phase II	23 °C	03:30	04:00
TFST Phase III	23 °C	04:15	05:00
TFST Phase I	10 °C	03:30	04:00
TFST Phase II	10 °C	06:30	07:15
TFST Phase III	10 °C	09:00	09:30
Carbamation water drop	1 h 23 °C	5	5
Carbamation wet patch	1 h 23 °C	5	5
Carbamation water drop	24 h 23 °C	5	4
Carbamation water drop	1 h 10 °C	2	2
Carbamation wet patch	1 h 10 °C	2	2
Carbamation water drop	24 h 10 °C	1	1
MEK-RUB		195	184
Crosscut adhesion	Scale 0-5: best 0	0	0
Pendulum hardness	day 7	416	393
Conversion ratio, % *	7 days	95	98
Tg, °C	2nd Heat	76	68

products Ancamine® 2871 and Ancamine® 2872 were developed as safer substitutes for the recently relabeled products Ancamine® 2712M and Ancamine® 2739, offering an improved labeling compared to the existing products while maintaining performance and mechanical properties at the same high level.

The new curing agents feature ultra-low VOC emissions, low viscosity, and high conversion rates. Furthermore, fast hardness development makes both products an ideal candidate for ready-to-service flooring applications within 24 hours.

Ancamine® 2871 is specifically designed for use in primer applications with fast cure whereas Ancamine® 2872 can be used for both primer and topcoat applications, demonstrating good UV stability.

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- [1] The Paint Directive, 2004/42/EC
- [2] Z. Tuncay, "Ultra low emission coatings", European Coatings Journal, May 2021

Graph 1: Shore D hardness development at different temperatures

