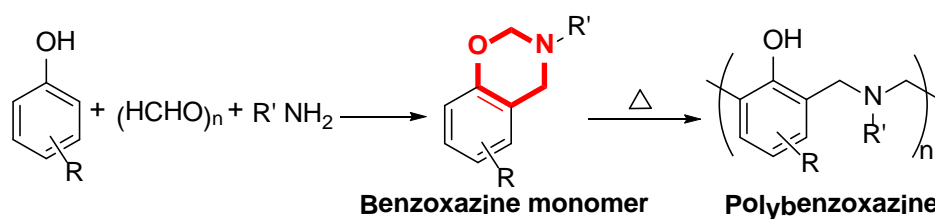


Benzoxazine Resins

1. INTRODUCTION

Benzoxazine resins are prepared from the reaction of 1:1:2 (molar ratio) of amine, phenol and formaldehyde. When heated, they homopolymerize readily to form rigid polymers that can be widely used as high-temperature composites, high performance copper clad laminates and plastic packaging materials. Improved properties can be obtained by combining with epoxy or phenolic resins, catalysts or toughening agents.



Benzoxazine resins and corresponding polybenzoxazines possess excellent performances.

- Room temperature storage and shipping stability
- No volatile release during cure
- Low cure shrinkage and exotherm
- Good dimensional stability
- Low water absorptivity
- Low dielectric constant
- Excellent flame resistance
- High temperature resistance
- Good mechanical property
- Good chemical resistance

Based on these advantages, the halogen-free benzoxazines are widely applied as composites, coatings, adhesives and encapsulants in a wide range of demanding applications. A simple comparison between benzoxazine resin and other classical resins is shown as follows.

Benzoxazine resin vs. epoxy:

- › Higher retention of hot/wet properties
- › Lower cure shrinkage and heat release
- › Better flame resistance and inherent Flame-Smoke-Toxicity (FST) characteristic

Benzoxazine resin vs. phenolics:

- › Lower porosity
- › No external acid or base catalysts needed for curing
- › Better mechanical properties

Benzoxazine resin vs. BMI:

- › Lower cure temperature and shorter curing time
- › Lower cost
- › Higher toughness

ACO PHARM CO.,LTD. has developed a series of benzoxazine resins (benzoxazine) and the corresponding formulations, which can meet the various requirements of different application scenarios. The following superiorities of benzoxazines are suggested to be considered when making a choice.

- * Reactivity and stability of the resin
- * Heat resistance
- * Toughness and damage tolerance
- * Processing method

2. BENZOXAZINE PRODUCT PORTFOLIO

2.1 Benzoxazine Resins

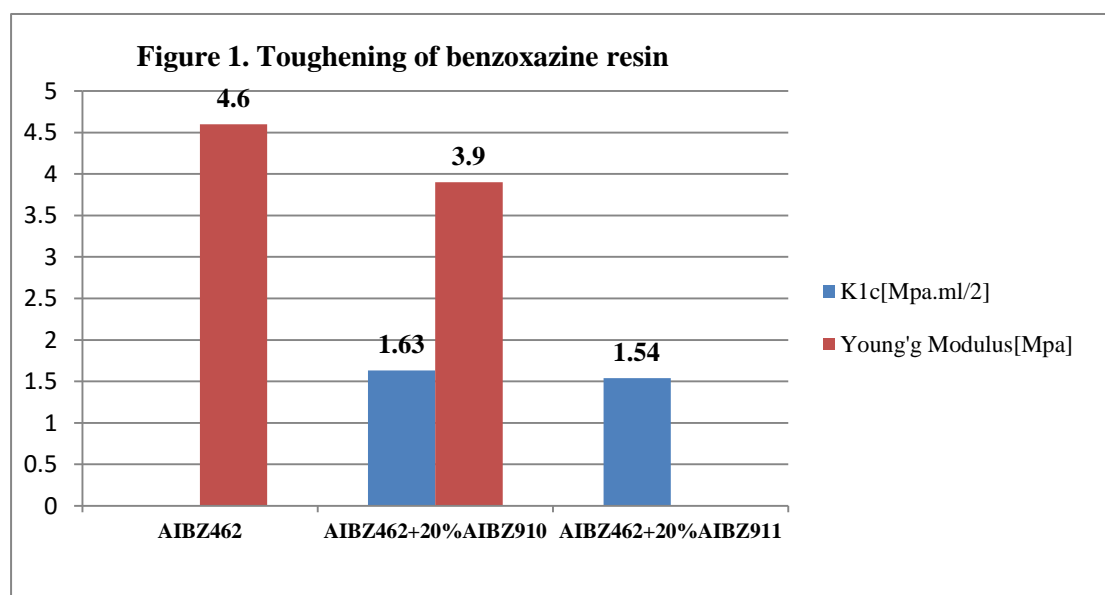
Benzoxazine resins	Melting Point [°C]	Viscosity [Pa·s]	Gel time @ 190°C [min]	Tg(DSC) [°C]	Toughness	Comments
AIBZ430	53-63	0.6-0.9 ^a	16.3-24.7	~175	--	<ul style="list-style-type: none"> • High-temperature resistance • Good flammability resistance
AIBZ682	50-60	0.4-1.0 ^a	9.2-13.8	~160	--	<ul style="list-style-type: none"> • High modulus • Low water absorption
AIBZ483	65-85	1.6-3.7 ^a	4.3-6.3	~200	Medium	<ul style="list-style-type: none"> • High dimensional stability • Co-polymerizable with epoxy or phenolic resins.
AIBZ462	--	0.2-0.4 ^b	9.2-13.8	~160	Medium	<ul style="list-style-type: none"> • Ambient storage and shipping
AIBZ8300	--	0.7-1.0 ^b	15.7-23.7	~245	Medium	<ul style="list-style-type: none"> • One-part system and easy processing • Good toughness and microcrack resistant
AIBZ8301	--	0.02-0.08 ^b	17.2-25.8	~200	Medium	<ul style="list-style-type: none"> • Lower cure shrinkage and cure exotherm • Ambient storage and shipping
AIBZ8302	--	0.10-0.16 ^b	11.7-17.3	~175	High	<ul style="list-style-type: none"> • Improved UV resistance • High hot/wet performance • Good flame, smoke and toxicity • Suitable for RTM or VARTM

Note: All the above benzoxazine resins can be supplied as a solution in a solvent as required. ^a @ 120°C. ^b @ 100°C.

2.2 Toughening of Benzoxazine Formulations

The benzoxazine resins are usually brittle without toughening, showing poor impact resistance. Therefore the toughening is extremely important in practical application. Nevertheless, how to keep both the modulus and the glass transition temperature (T_g) while increasing the toughness of the resin is a big challenge. The toughening of the resin can be realized through the addition of some traditional reagents such as thermoplastic rubber and nanoparticles. However, in most cases, they will obviously reduce the T_g and the modulus of the cured thermosets simultaneously. We have developed a series of excellent toughening agents which can significantly improve the toughness of the corresponding cured benzoxazine without obviously reducing the T_g and the modulus.

Figure 1 shows the representative results of the mechanical tests (fracture toughness and tensile test) after 20% of toughening agent AIBZ910 or AIBZ911 is used with benzoxazine resin AIBZ462.



2.3 Cure Catalysts for Benzoxazine Formulations

Generally, pure benzoxazine is not very reactive. High temperature is often needed to obtain the corresponding polybenzoxazines. DSC analysis showed that typically the onset exothermic temperature is $>180^{\circ}\text{C}$ and the peak temperature $>200^{\circ}\text{C}$. Such a high curing temperature will limit its application in some cases. We have developed several efficient catalysts which can accelerate the curing process at lower temperature to meet the demands of different applications. The catalyst loading and the choice of catalyst are dependent on the required curing time/temperature, the processing method and epoxy component, etc.. The representative results for AIBZ950, one of the highly active catalysts, are shown in Figure 2.

On the other hand, as for resin transfer molding (RTM) or vacuum-assisted resin transfer molding (VARTM), the matrix resin should have the following properties: 1) it should have lower viscosity and longer pot life at a relatively higher temperature in order to conveniently cast bigger parts. 2) It should be able to fast cure at elevated temperatures in order to decrease production time and save cost. To this end, a latent catalyst is commonly needed. Catalyst AIBZ951 demonstrates excellent stability on benzoxazine resin at as high as 120°C (shown by the isothermal viscosity test), and has good catalytic effect as well (shown by DSC analysis). These properties are very beneficial to RTM or VARTM processing. (Figure 3).

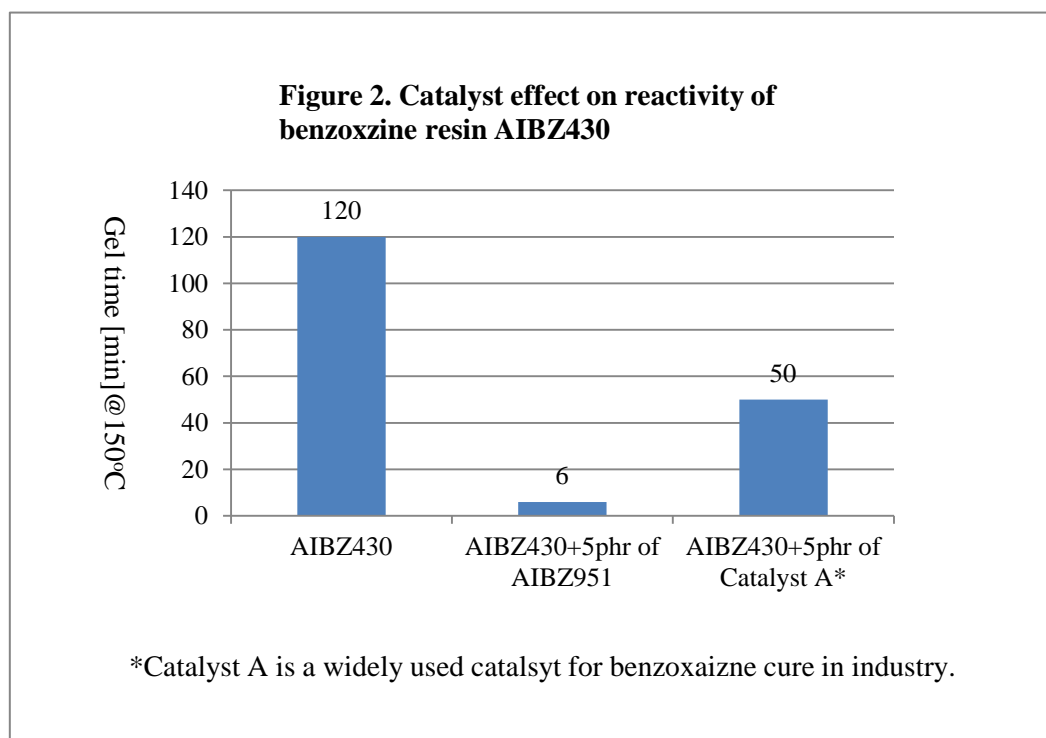
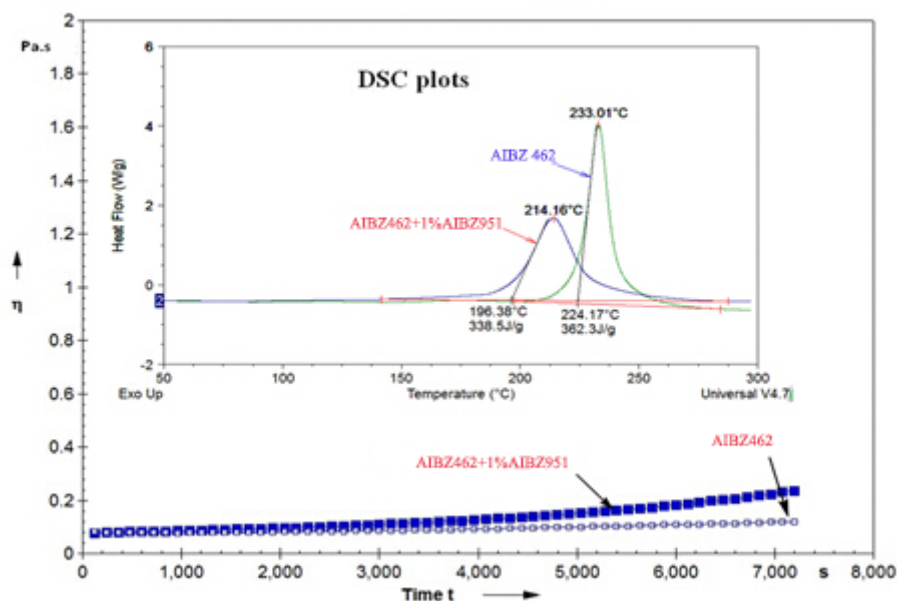


Figure 3. Isothermal Viscosity at 120 °C and DSC plots of AIBZ 462 w/o and w/ AIBZ 951



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ACO Pharm Co., LTD is a research-based manufacturer and world-wide supplier of various novel advanced intermediates for drug discovery and new **Benzoxazine Resin for new material**. We have a good working experience in the Chemistry industry. Our company mainly produces **Benzoxazine Resin** and intermediates using for the new material industry and pharmaceuticals industry.

Most of our catalog products are available in sizes from gram-scale to semi-bulk quantity. We can deliver them from 3-5 days domestically and 3-7 days internationally for the in stock items. Product quality is of paramount importance. We offer customers the highest quality and the purity in our fine chemicals.

Our services:

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- Manufacture of **Benzoxazine Resin** for the new material industry
- Carbon fiber reinforced **Benzoxazine resins** composites
- Customer chemical synthesis and contract research services to the pharmaceutical and fine chemical industries.

- Benzoxazine Resin Technology

We can make various organic chemicals from the kilogram to tons scale at competitive price.

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