SUMITOMO BAKELITE North America

LONG GLASS EPOXY/DAP/SILICONE MOLDING COMPOUNDS
Processing Guide

Chemistry and Features: EPOXY

Epoxy molding compounds were commercialized in the early 1950"s. A variety of Long Glass epoxy resin based compounds were subsequently developed and have become widely used for aerospace and high performance applications. Long Glass Epoxy molding compounds are desirable in high performance applications for the following reasons:

- Excellent mechanical properties
- Excellent adhesion to a wide variety of materials
- Low Shrinkage
- Good electrical properties
- Resistance to moisture and chemicals
- Good compatibilty with a variety of other materials.
- Non-corrosive

Novolac epoxies, particularly the epoxy cresol and epoxy phenol novolac resin with o-cresol or phenol and formaldehyde with epichlorohydrin. This material is used where good thermal properties, high resistance to solvents and chemicals are required. (Figure 1) This is the typical type of epoxy that SBNA manufactures.

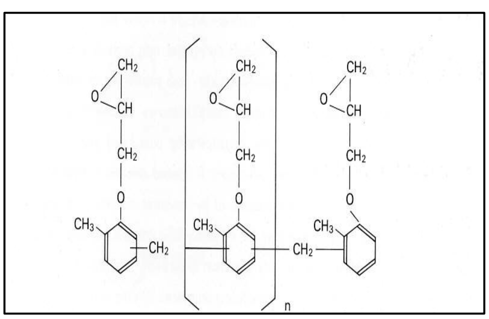

Figure 1: Epoxidizied Cresol Novolac Resin

Most epoxy molding compounds exhibit low dielectric loss. A high insulation value along with low part shrinkage and high mechanical strength are maintained under severe moisture and high temperature conditions. Epoxies range from slow burning to self extinguishing. These benefits have made epoxies one of the most popular plastics used in electrical/electronic field. Epoxies are highly chemically resistant, being affected only by strong acids and ketones. They are non-outgassing, flame resistant and have ease of flow with relatively low molding pressure.

Storage

Compounds based on Epoxy resin possess greater reactivity, and therefore cold storage of these materials is recommended. Normal storage life is about 6 months when kept at or below 40°F (4°C). The material should be brought to room temperature before containers are opened to prevent the introduction of condensed moisture from the atmosphere.

Chemistry and Features: DAP

Allylic resins are noted for good molding characteristics and the ability to retain electrical and mechanical properties under adverse environmental conditions. In large part, both the processing and final properties are derived from the structures of the polymers on which the molding compounds are based.

The polymers derived from diallyl phthalate consist of polycyclic structures. The polymer of diallyl ortho-phthalate (DAP) exemplifies this structure. All evidence indicates a uniformly cyclized structure with pendant allylic unsaturation spaced at regular intervals along the chain as shown in Figure 2.

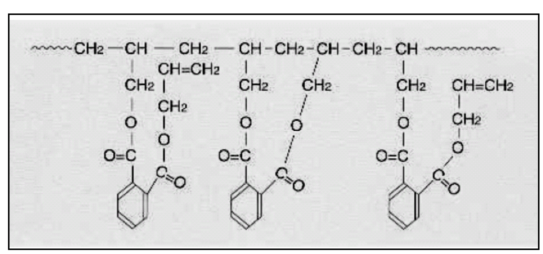

Figure 2: Molecular Structure of DAP Resin

The consequences of this structure are:

1. Solid polymers melting rather sharply at about 70°C.
2. High melt viscosity despite relatively low molecular weight (ca. 10,000) arising from the rigid, densely packed cyclic units.
3. Near equivalency of all crosslinking groups provides simple curing kinetics.
4. A cured structure which is thermally stable and resistant to a variety of chemicals.

The polymer of diallyl meta-phthalate ("iso-DAP") is similar in structure, differing only in that cyclization does not occur quite as regularly as in the ortho-phthalate resin. Crosslink density achievable in cured iso-DAP resin is thus higher with an attendant increase in the ultimate glass transition temperature (T_g). Fully cured DAP resin exhibits an ultimate Tg of about 165°C, while a Tg approaching 250°C is attainable with iso-DAP resin. Both of these polymers are important commercially.

Storage

DAP compounds exhibit excellent shelf life under normal factory storage conditions, and no special precautions are necessary beyond keeping them in closed containers and avoiding exposure to temperatures over 90°F (32°C). Moldability and molded properties are generally not significantly affected for at least 1 year provided that the material is stored at or below 70°F (21°C).

Compounds based on iso-DAP resin possess greater reactivity, and therefore cold storage of these materials is recommended. Normal storage life is about 6 months when kept at or below 50°F (10°C). The material should be brought to room temperature before containers are opened to prevent the introduction of condensed moisture from the atmosphere.

Chemistry and Features: SILICONE

Silicones are best known for their extreme temperature properties. Silicone resins usually are formulated to contain a three-dimensional network of sioxane linkages. They have good chemical and electrical properties. They find their largest use in electrical applications. Silicone molding compounds have high arc resistance, high dielectric strength, low dielectric constant and dissipation factor, good resistance to corona and electric breakdown. These properties are retained after exposure to moisture and elevated temperature. Some silicones are used in 600 °F service temperature.

Storage

Compounds based on Silicone resin possess greater reactivity, and therefore cold storage of these materials is recommended. Normal storage life is about 6 months when kept at or below 40°F (4°C). The material should be brought to room temperature before containers are opened to prevent the introduction of condensed moisture from the atmosphere.

Flow Rheology

Long Glass Compounds based on Epoxy/DAP/Silicone resins are designed to process well in both compression and transfer molding equipment. Compounds are available in a range of flows, from stiff for compression molding to softer grades for transfer molding. Their plasticities are normally measured by a special transfer molding procedure known as Mesa Spiral Flow (Figure 3) and Cup Close Flow (Figure 4). These tests provide an indication of the relative ability of the compound to flow and fill molds.

Figure 3: Mesa Spiral

Figure 4: Cup Close

Preforming

Long Glass Epoxy/DAP/Silicone compounds can be charged directly into the mold cavity in loose form. This practice may be desirable in the case of single cavity compression molds for large components, additionally, oven preheating should be considered. The compound should be accurately weighed for each molding cycle.

For the production of small and medium-sized parts with multi-cavity compression molds or transfer molds, preforms are generally preferred. Preforms can be made into a variety shapes and sizes by compaction of the molding material in a die. Preforms are easier to handle and can be more readily preheated than loosely packed bulk material.

Long Glass Epoxy/DAP/Silicone compounds can be preformed by any of the usual types of hydraulic or mechanical preforming presses.

Automatic preformers require free-flowing granular compounds in order to maintain weight consistency and rapid cycles. Materials with the lowest bulk densities, such as those containing long glass fibers, cannot usually be preformed automatically in conventional equipment. These often require auxiliary feeding equipment or a manual weighing and pressing operation.

Preheating

The molding compounds should be heated before being loaded into the mold. This reduces the time required to bring the material to a plastic state and allows shorter molding cycles than are possible with cold material. Preheating can increase productivity by 20 to 40% depending on the geometry of the part and the material being molded. The preheated material also flows more easily and uniformly and generally requires less pressure. Other benefits of preheating include smoother molded surfaces and enhanced physical properties.

The most commonly used preheating methods are dielectric (HF) heating of a densely packed preforms for DAP based compounds. Oven preheating is not recommended for DAP materials. Air circulating oven heating is the most common method of preheating for both epoxy and silicone based long glass materials. See figures 6 and 7 for recommended conditions.

Preheat temperature is one of the most critical molding parameters. The temperature should be optimized to provide the easiest flow. This usually means raising the temperature of the compound until obvious precure or short shots occur in molding, and then dropping back 10 to 15°F.

Molding Methods

In general, Long Glass molding compounds are best processed by either of two conventional thermoset molding methods; compression or transfer molding. Most thermoset molding machines are suitable for these materials without the need for special equipment.

Compression molding is a predominant method used with Long Glass compounds. This method is particularly useful for larger parts. Higher molded part strength and overall lower shrinkage rates may be somewhat lower than that of parts molded by transfer method. The magnitudes of these differences are dependent on sprue, runner and gate design plus the flow pattern in the mold cavity.

In transfer molding, an optimally molded part requires complete cavity filling and adequate packing before gelation. Mold filling time should neither be too short to avoid trapping air nor overheating material through friction, nor too long, to avoid gelation before the cavity is completely packed. If molding conditions do not allow sufficient packing pressure, part strength will be compromised. Other properties including dimensions are affected by cavity packing pressure as well. The curing time should be long enough for the part to be ejected from the mold without distortion.

Mold cavities should be well polished and plated with hard chrome to ensure easy release. A draft of ½ degree on cavity surfaces that are perpendicular to the mold parting line will facilitate easy part de-molding. All transfer molds must be properly vented at the parting line, and knock-out pins may need axial flat faces to provide more venting for deep recesses.

Suggested Start-Up Conditions

Molding conditions may vary depending on the shape of the part, mold design, and composition of the material. Suggested start-up conditions Long Glass Epoxy/DAP/Silicone compounds along with approximate curing times are provided in Figures 5, 6 and 7.

Postcuring and Degassing

Molded parts normally do not attain complete cure under standard process conditions. In most cases, conditions are established which produce an acceptable degree of cure and attendant physical properties when the parts are removed from the mold. It is not necessary to post-cure molded parts unless a specific application requires that resistance to high-temperature or chemical exposures be maximized or that the by-products of the curing initiators be driven off.

The retention of physical properties at elevated temperatures is governed by the T_g. For maximum thermal stability and retention of physical properties at high temperatures, molded parts can be postcured. This should be performed in a forced-draft oven having good temperature control and outside venting.

Optimum postcuring conditions are determined by the specific application requirements. When determining the oven temperature cycle, it is important to note that lower temperatures generally result in less thermal stress and less discoloration of the part. Most cycles begin at 275°F (135°C) and the temperature is gradually raised to avoid exceeding the T_g. The rate of temperature rise should be as fast as permissible without visual signs of degradation such as blistering or cracking. A final oven temperature of 175°C is usually sufficient to complete the crosslinking reactions without significant discoloration. For applications requiring minimum outgassing, the final oven temperature should be at least equal to the maximum service temperature and the parts should be baked from 4 to 6 hours at this final temperature or until the rate of weight loss is negligible.

Technical Assistance: Please contact your Sumitomo Bakelite representative if technical assistance is desired.

Figure 5: Suggested Start-Up Conditions – Long Fiber DAP

COMPRESSION/TRANSFER	PARAMETER SETTINGS
Mold Temperature	320-350°F (160-177°C)
Molding Pressure – Compression	3,500-6,000 psi (238-408 bar)
-Transfer	2,500-5,000 psi (170-340 bar)
Cure Time (1/8”)	45-70s (per 3.2 mm thickness)
Preheat (Preform)	Dielectric (HF)
Preheat Temperature	220-230°F (104-110°C)
Alternate Charging Method	Bulk Loading – No Preheat
Shelf Life (Ortho DAP)	1 year-70°F(21C°) from date of ship
Shelf Life (ISO DAP)	6 month-50°F(10C°) from date of ship

Figure 6: Suggested Start-Up Conditions – Long Fiber EPOXY

COMPRESSION/TRANSFER	PARAMETER SETTINGS
Mold Temperature	270-330°F (132-166°C)
Molding Pressure – Compression	1,000-8,000 psi (7-55 bar)
-Transfer	2,500-8,000 psi (17-55 bar)
Cure Time (1/8”)	150-300s (per 3.2 mm thickness)
Preheat (Bulk)	Oven – Air Circulating Type
Preheat Temperature	200-225°F (93-107°C)
Preheat Time	3-10 minutes (charge dependent)
Alternate Charging Methods	1) Bulk Loading – No Preheat 2) Preform after Preheat
Shelf Life	6 month-40°F(4°C) from date of ship

Figure 7: Suggested Start-Up Conditions – Long Fiber SILICONE

COMPRESSION/TRANSFER	PARAMETER SETTINGS
Mold Temperature	280-300°F (138-149°C)
Molding Pressure – Compression	2,000-6,000 psi (14-41 bar)
-Transfer	4,000-8,000 psi (28-55 bar)
Cure Time (1/8”)	300s (per 3.2 mm thickness)
Preheat (Bulk)	Oven – Air Circulating Type
Preheat Temperature	150-180°F (66-82°C)
Preheat Time	3-10 minutes (charge dependent)
Alternate Charging Methods	1) Bulk Loading – No Preheat 2) Preform after Preheat
Shelf Life	6 month-40°F(4°C) from date of ship