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EPOXY PLASTICS

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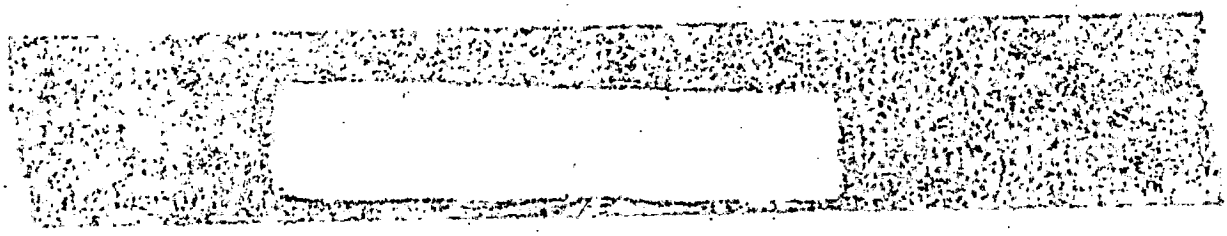

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ABSTRACT

This report deals with practical methods of handling and using some of the many epoxy plastics. Molds, mold-release agents, fillers, diluents, and modifiers are described. Mixing, pumping, bonding, equipment required, and toxicity are also covered.

A collection of formulae is given in table form. The table makes it possible to select the appropriate type of epoxy mixture for the specific job.

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INTRODUCTION

Although not a complete "how-to-do-it" course, this report is intended to serve as a guide to the selection of epoxy plastics for those who are not experienced in working with plastics. It is based on experiences in using epoxy resins for the plast eight years in the synchrotron shop. The materials mentioned are only a small part of available epoxy resins and their associated curing agents, fillers, etc. A number of successful formulae are shown in Table I, but many other combinations are possible for specific jobs.

Some of the epoxy resins and curing agents and diluents are supplied by Shell Chemical Corporation under the trade name Epon. Many other companies supply similar epoxy resins and the other materials used in these formulae. More specific information on the supply of these materials and the uses can be obtained from Mr. James O. Turner or Mr. Joseph W. Bryan.

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HANDLING EPOXY PLASTICS

All the epoxy resins and their associated curing agents, diluents, and modifiers are toxic to some extent. The degree of toxicity depends on the individual who is handling the material. Some individuals have a high allergic sensitivity to these materials and will break out in a rash similar to poison ivy or have a swelling about the eyes upon direct contact with these materials or inhaling the vapors given off. Trouble of this sort can be avoided by practicing good common-sense methods of handling the epoxy. A good hooded exhaust system should be used for mixing. Do not breathe the fumes. Avoid contact of the epoxy mixture with the skin, either by using care in handling or by the use of rubber gloves and protective clothing. Should contact be made with the skin, clean the area with acetone or alcohol followed by a thorough soap and water wash. Generally, the more volatile or lighter diluents and curing agents are the most irritating.

A list of materials follows in order of decreasing toxicity:

Allyl glycidal ether (AGE)
Phenyl glycidal ether (PGE)
Resins containing ethers as above
Duomeen S
Amino acids (DTA)
D curing agent
U curing agent
D 40 curing agent
Mod-epox
Epon resins
Thiokol
Versamid

TOOLS AND EQUIPMENT

The following tools and equipment are of value in handling epoxy resins:

Paper cups, beakers, or polyethylene containers
Spatulas and tongue depressors
Acid brushes
Kim wipes and paper towels
Weighing scales
Pump and tank capable of creating a vacuum of about 28 in. Hg.
Temperature-controlled oven
Infra-red heat lamps.

Simple ovens made from aluminum foil-lined cardboard boxes are often useful for curing plastics on large or odd-shaped jobs. Heat lamps placed inside the box or directed through a hole in the box will allow moderate temperatures in the 60° to 80°C range.

MOLD RELEASE

Many things can be used for mold release, however, the most common are the silicone greases and fluids. Dow-Corning high-vacuum grease or Ram Mold Release 225 are good. The Ram 225 is the easiest to use and is quite satisfactory for most mold surfaces. It can be applied by dipping, brushing, or spraying. Allow the excess to drain off and air-dry the mold; it is then ready for use. On porous molds, such as plaster of Paris, a coat of silicone grease or paste wax followed by Ram 225 is usually sufficient.

MOLDS

Molds are generally made of metal and should be tight with no air leaks. The mold surfaces should be smooth and polished with no undercuts. The surface of the plastic will be as good as the surface of the mold. Draft should be incorporated in molds where possible. Thin metal molds which can be peeled off the work and discarded are often useful. In some cases special molds can be made of other materials such as plaster of Paris, wood, and plastics. Very useful flexible molds can be made of Polyvinyl Geon 121 or Dow-Corning silicone rubbers. These liquids can be poured around a pattern and cured to yield a rubber-like material. They pick up fine detail quite well and have reasonable dimensional stability. Removing castings with undercuts presents no difficulty since the molds can be stretched.

MIXING

Once a formula is picked, the constituents should be carefully weighed and mixed together thoroughly. Some materials have a color indicator incorporated to show when complete mixing has been achieved. All formulae in this report are compounded by weight. Mechanical mixing can be used to advantage on the more viscous materials.

PUMPING

It is good practice to pump the entrapped air out of the mix before after, and (or) during pouring. This is determined by the type of casting. Use vacuum and air pressure to force the plastic into small spaces, such as between turns of small wire in a transformer coil. Heat, where it can be tolerated, will thin the mix and release air bubbles. Overheating should always be avoided.

FILLERS

Many materials can be used to fill plastics. They are used to cut the cost of the finished plastic or to modify various properties. Generally the plastic takes on the properties of the filler. The percentage of filler used in a given mix is dependent on the desired properties of the finished plastic and on the handling properties of the mix, i. e., viscosity, thixotropy, etc. For instance, fillers are often used to bring the coefficient of expansion of the plastic closer to that of metal parts embedded in the plastic. Glass cloth is used in laminates to improve strength. Santocel is used for thixotropic properties.

Some typical fillers are:

Aluminum oxide
Glass beads (pavement-marking type)
Glass cloth
Glass fibers and roving
Metal powders
Carbon
Aluminum silicate
Asbestos floats

DILUENTS AND MODIFIERS

Diluents are usually of a 100% reactive type that enter into the final product. They are used to lower viscosity for easy handling. Typical diluents are allyl glycidal ether, phenyl glycidal ether, and Mod-Epox.

Modifiers are used to change specific properties of the plastics. Mod-Epox, Versamid, and Thiokol are used to improve impact resistance. Duomeen S gives better thermal shock and vibration resistance.

BONDING

One of the most important factors in getting a good bond between epoxies and other materials is cleanliness. Washing in detergent and water followed by an alcohol rinse or in degreasing solvents is suitable treatment. Avoid films left by some solvents. Be careful not to get finger marks on the surfaces to be bonded. All bonding surfaces should be roughened by sanding, etching, or sandblasting.

Table I

Epoxy resins, additives, and conditions for preparation

Application	Resin	Modifiers, diluents, and fillers	Curing agent	Curing time and temp. (°C)	Remarks
Adhesive	100 parts Epon 820		8-10 parts DTA	Room temp. for 24 hr	General purpose adhesive
Adhesive	100 parts Epon 820		100 parts Versamid 125		Excellent for Mylar, metal, ceramic, or glass joints. More flexible than above and good at low temperatures such as that of liquid hydrogen.
Adhesive	100 parts Epon 901		23 parts Shell B-1	Room temp. for 24 hr, or 1 hr at 75°	Thixotropic paste-type adhesive for structural bending. Good for use on vertical surfaces where run-off might be a problem.
Adhesive	100 parts Armstrong A2		4 parts Armstrong A	Room temp. sets in 30 min. cures in 24 hr	Filled adhesive good in electrical applications and for most structural bonding
Adhesive	100 parts Armstrong A4		4 parts Armstrong A	Room temp., sets in 30 min, cures in 24 hr	Filled adhesive good for use on vertical surfaces where run-off might be a problem. Possible use as heat-conducting coil embedment.

Continued

Table I (continued)

Epoxy resins, additives, and conditions for preparation

Application	Resin	Modifiers, diluents, and fillers	Curing agent	Curing time and temp. (°C)	Remarks
Adhesive	100 parts Epon 820	75 parts aluminum powder	10 parts DTA	4 hr at 60°	Good heat-conducting embedment for electrical coils. Good electrical insulation.
Adhesive and small castings	100 parts Epon 820		25 parts U	Sets in 4-8 hr cures in 24 hr at room temp.	Low toxicity. Good adhesive; good for small casting or potting jobs and laminating.
Adhesive	100 parts Epon 901		23 parts Shell B-1	Sets in 6 hr; cures in 24 hr at room temp. or 1 hr at 75°	Paste adhesive good for vertical surfaces because of thixotropic properties. Produces rigid structural bonds on metals, glass, and rigid plastics
Casting; clear to 200 grams	100 parts Epon 820		9.5 parts Shell D	4 hr at 60°C	Good for quick cure small castings Easily machined

Table I (continued)

Epoxy resins, additives, and conditions for preparation

Application	Resin	Modifiers, diluents, and fillers	Curing agent	Curing time and temp. (°C)	Remarks
Casting; clear to 40 pounds	100 parts Epon 820		15 parts D-40	16 hr at 60°C	Excellent for large castings of low shrinkage. Easily machined.
Casting; filled	100 parts Epon 820	200 parts glass beads	100 parts Versamid 125	4 hr at 60°C	For large castings and those with metal inclusions. Machinable but hard on tools.
Casting; clear	100 parts Epon 820	25 parts Mod-Epox	9.5 parts Shell D or 15 parts Furane D-40	4 hr at 60° or 16 hr at 60°	Thins mixture for better penetration while maintaining or improving electrical properties.
Casting; clear, flexible	100 parts Epon 820	50 parts Thiokol LP-3	13 parts Shell D	2 hr at 80° plus 2 hr at 120°	Improved impact resistance. Good for electrical purposes and at low temperatures

Table I (continued)

Epoxy resins, additives, and conditions for preparation

Application	Resin	Modifiers, diluents, and fillers	Curing agent	Curing time and temp. (°C)	Remarks
Casting; clear and flexible	30 parts Epon 820 or 70 parts Epon 820		70 parts Versamid 125 or 30 parts Versamid 125	4 hr at 60°	This material can be modified over the range shown in the Resin and Curing-agent columns to get different amounts of flexibility. The more Versamid, the greater the flexibility.
Casting; flexible	100 parts Epon 820 heat to 50°		69 parts Duomeen S heat to 50°	2 hr at 75° plus 2 hr at 100°	Greater thermal shock and mechanical-vibration resistance. Good electrical properties.
Conducting plastic	100 parts Epon 820	15 parts AGE 125 parts graphite	10 parts DTA	1 hr at Room temp.	Resistance of a 1-in. cube of this is about 100 ohms between opposing faces. Mixes to a heavy paste.
Laminates	100 parts Epon 820	Volan-treated glass cloth	8 parts DTA	Room temp. for 24 hr	Good for building up structural members, patching, etc. Unlimited possibilities for building up new equipment.