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News about

EPOXY CHEMISTRY

COMPOSITE PROCESSES

FABRICATORS

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Introducing Epoxy Tooling Paste

The new PRO-SET® 195/295 Epoxy Tooling Paste is now available. This product is formulated to create a hard, machinable surface for plug and mold building. The high-density, filled paste will machine with a carbide or diamond tool in a multi-axis router or machining center. The finished surface is very smooth and resists tear out or chipping. When being machined with a sharp tool bit, the paste machines into flakes, creating very little dust. The fillers used to thicken the paste were chosen with the goal of minimizing tool wear.

PRO-SET 195/295 is designed specifically for robotic application onto the mold or plug mandrel/substrate. The shear thinning nature of the mixed resin and hardener allow metering and mixing with a high-quality dispensing system. Pro-Set Inc. has partnered with Dispense Technologies Inc. (www.dispenstech.com) to create a dispensing system that can apply up to 1.25 gallons (5 liters) per minute through a static mixer creating a 1.5" wide by ⅝" thick bead. The beads can be applied parallel to one another, covering the entire surface quickly. This dispensing system can be attached to the machining center head to apply the material in a uniform thickness of ⅜" to ¾"over the surface of the mold or plug. This type of equipment will apply a drum of mixed tooling paste onto the surface every hour. Once the machining center tool path software is programmed, the operator can just keep changing drums until the surface is covered with the paste. Once that operation is complete, the cutting tool bit can be inserted into the router, and the surface can be machined within 6 to 8 hours after the paste is applied.

Paste being applied onto male mold shape with dispensing equipment.

Close-up of extruded bead of tooling paste as dispensed.

Because the resin and hardener are manufactured under vacuum, there is no entrained air in the cured material when dispensed with the Dispense Technologies equipment. The lack of air creates a very smooth surface once machined with very little porosity. In many cases, this surface can be polished to allow fabrication of the part directly on the tooling paste surface once mold release is applied.

PRO-SET 195/295 can also be batch mixed by hand, but there is more potential to get entrained air in the mixture when mixing and applying by hand. If hand mixing, you must allow a 10-minute induction time for thixotropy recovery before application to the substrate. Because hand application imparts more viscous shear into the mixture during application, maximum application thickness is ½".

The cured 195/295 has very low shrinkage (less than 0.5%) and a low Coefficient of Thermal Expansion (CTE). The CTE of 26.6 ppm/degree F provides very good dimensional stability during an elevated temperature cure or post cure. This is particularly important for building molds for pre-preg or wet-preg fabrication methods that require cure temperatures of 125° to 200°F.

The mix ratio is 2 parts resin to 1 part hardener. The materials are packaged in 1 gallon, 5 gallon and 55 gallon containers. Resin and hardener containers are sold separately, so 2 containers of resin are required to react with 1 container of hardener.

To arrange for a sample of the PRO-SET 195/295 Tooling Paste or to speak with a technical advisor, call toll free at 888-377-6738. See the complete data sheet online at www.prosetepoxy.com. ■

Shop Mixer for Filled Epoxy Systems

A common method for mixing filled epoxy systems is to use a palette made of glass, metal, rigid plastic, or even cardboard. The appropriate ratio of materials is measured and then folded together on the palette with a trowel or squeegee. Using a circular palette mixer takes this technique to a new level of efficiency. It makes quick work of blending filled epoxy systems. We recommend using a circular palette mixer to mix PRO-SET® 185/285 Fairing Compound or 195/295 Tooling Paste.

Machines like this are used regularly in New Zealand to mix fairing putties or compounds, but we have only recently discovered them. The idea is simple. The palette spins in a circle, and a pair of fences on top of the moving palette folds the components together. This method minimizes the amount of air swept into the material as it is being mixed. This is important for tooling pastes and fairing compounds because any air inclusions will need to be refilled after they are exposed by sanding or machining.

Palette mixers can be assembled out of readily available parts. We made the machine shown here in the shop at Gougeon Brothers, Inc. It has a small variable speed motor driving a belt which spins the turntable. Previously, the base and turntable had been used to apply finish in a cabinet shop. The turntable and fences are made from UHMW-PE (ultra high molecular weight polyethylene). The fences are adjustable and are supported on brackets attached to the base of the mixer. Adjusting the fences correctly causes the epoxy components to be rolled together to complete the mixing. A foot switch turns the machine on and off, so the operator has hands free to use a squeegee to ensure the materials are blending together properly.

To mix fillers into liquid epoxy, pour a small amount of the resin/hardener mixture onto the turntable and add a portion of the filler. Keep adding liquid epoxy and filler until the mixture reaches the consistency desired. Once you've made the first batch, you will have your recipe for additional batches of repeatable consistency.

The photos show how the filled resin and hardener blend into a uniform mixture with no air. Some experimentation is necessary to determine the optimum fence location, but once that is identified, set up is very quick and a great deal of filled epoxy can be mixed rapidly. Clean up takes about 20 minutes, so you will need to mix enough material to make clean up worth the effort.

While we recommend using a circular palette mixer to mix PRO-SET 185/285 Fairing Compound or 195/295 Tooling Paste, the mixer can also be used to make other custom putties or pastes out of unfilled liquid epoxy resins and hardeners and any appropriate filler. ■

The circular pallette mixer.

Fairing compound on the mixer.

Beginning to mix on the spinning palette mixer.

Understanding the Thermal Properties of Thermoset Resins

This article summarizes a presentation given by Joe Parker in spring 2007 at the Society for the Advancement of Materials and Process Engineering (SAMPE) in Baltimore.

One of the most frequently asked questions about the various properties of a thermoset resin is how the thermal properties compare from one formulation to the next. The thermal properties are generally stated on the technical data sheet. The common properties described are the HDT (Heat Distortion Temperature) also known as DTUL (Distortion Temperature Under Load) and Tg (Glass Transition temperature). Both types of tests are ASTM certified, but already you can see that there is confusion because some of the monikers are describing the same information. As you will see below, other issues complicate the data even further. Multiple methods can be used to perform the HDT/DTUL or the Tg tests, and even test results can be interpreted differently by the formulator. The important thing to remember as you read this is that it is imperative that the materials being compared receive exactly the same cure profile and that the method does not include an elevated temperature conditioning cycle. What follows is a description of each of the methods, along with some typical data for comparative use.

HDT/DTUL

The HDT or DTUL is measured by casting a sample of the material being defined. The sample is machined into a test specimen that is 1" wide and ⅒" thick. A load is applied by using a three-point bend test. The sample is submerged in a fluid which efficiently transfers heat into the sample while the load is applied. Heat is added to the fluid. The reported result is simply a number indicating the temperature at which the sample deflects an additional amount equal to its thickness.

The deflection temperature is a measure of a polymer's resistance to distortion under a given load at elevated temperatures. The two common loads used are 66 psi and 264 psi. A complicating factor is that most material suppliers do not indicate the test load applied, nor is there an indication if the test specimen is fiber reinforced or just a casting of the polymer being evaluated.

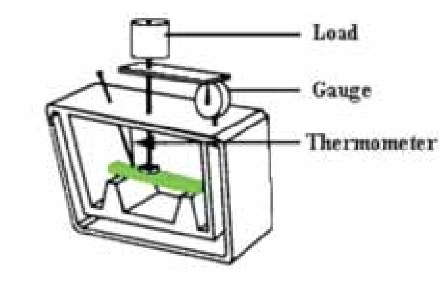

Figure 1—ASTM D648 test geometry.

The most common method used is ASTM D 648. The illustration in *Figure 1*, from www.quadrantepp.com, shows the test geometry.

Tg

Any polymer will have a region above its Glass Transition (Tg) that is described as the material's rubbery state and a region below its Tg that is described as its glassy state. The degree of rubbery or glassy is different for all materials based on the strength and modulus of the polymer, but that is irrelevant to understand the phenomena. The concept of a polymer's Tg temperature is easy to understand when you consider this analogy. When you enjoy chewing gum, you know that when it is at body temperature (in your mouth), it is very rubbery and chewy. But when you take a drink of a cold liquid while chewing, the gum gets much harder and may become glassy until your mouth warms it again. In the case of thermoset polymers, the use temperature is normally below the Tg because the polymer has good structural properties below that temperature.

Again, the comparison of the Tg of multiple resins gets complicated by the fact that there are several ways to measure the Tg and for each measurement method, there are several results that can be reported. So, before comparing, it is imperative to know how the material was tested and what is being reported.

A common method of measuring Tg is with the Differential Scanning Calorimeter (DSC) (*Figure 2*). This machine contains a small oven with sensors that record heat flow both in to and out of the polymer. The point where heat flow makes the transition from heat absorption to heat release coincides with the transition from glassy to rubbery is known as the Tg. A complicating factor is that the resin formulator can choose to report the onset of this region, the midpoint, or the end point of the region. Also, the ASTM standard allows for a 1st heat cycle to remove the effects of the specimen's cure profile before the test is run. We believe that the fabricator really needs to know the Tg based on the onset of the transition curve as recorded during the 1st heat cycle to best understand how the intended cure time and temperature will affect the thermal properties of the part. After all, when in use, the part is unlikely to be cured as completely as the 2nd heat cycle data shows. *Figure 3* shows the result of both the 1st heat scan and the 2nd heat scan

Figure 2—The Differential Scanning Calorimeter (DSC), used to measure Tg.

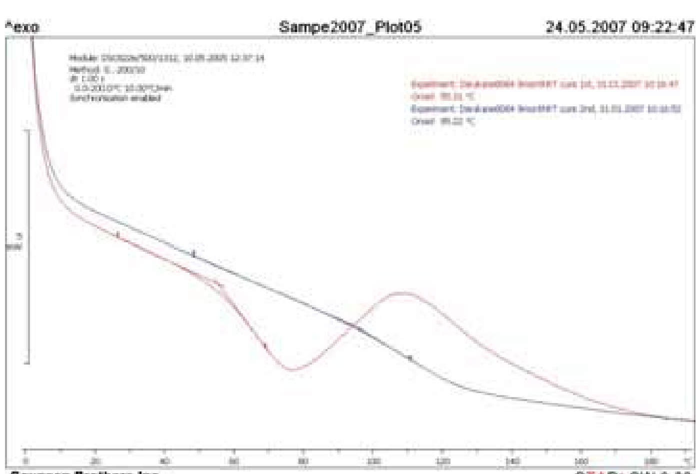

Figure 3—DSC report showing the results of both the 1st heat scan and the 2nd heat scan for Derakane 8084 vinylester resin.

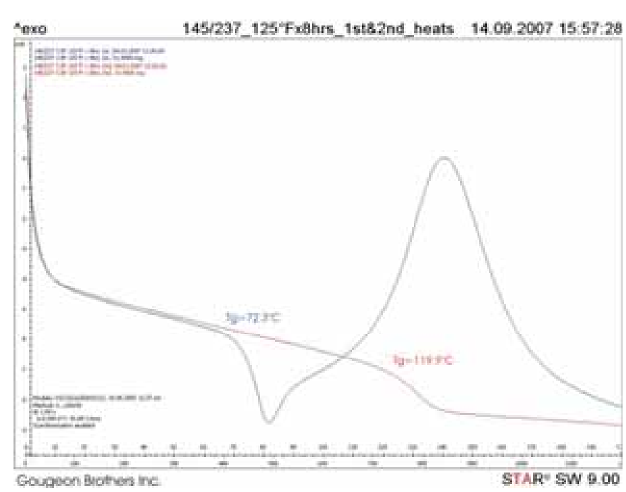

Figure 4—DSC report showing the result of the 1st and 2nd heat scans of PRO-SET 145/237.

for Derakane 8084 vinylester resin. *Figure 4* shows the result of the 1st and 2nd heat scans of PRO-SET 145/237. A limitation of using DSC to determine the Tg is that any fiber reinforcement (or filler) will skew the result, so the most accurate information is obtained with a neat resin sample.

Another method for measuring Tg is with Dynamic Mechanical Analysis (DMA)(*Figure 5*). This machine subjects a specimen, either neat resin or fiber reinforced to a three-point deflection test. The test is run with a repeating load applied at about 1 Hertz (1 cycle per second). The load vs. deflection test generates the information necessary to calculate the modulus of the material. The entire test region of the machine is enclosed with a chamber that can be either heated or cooled. As the sample is heated, the modulus will decrease when the specimen reaches the Tg of the resin. This method is not affected by fiber reinforcement because it is measuring a change in the stiffness contribution of the resin.

Figure 5—The Dynamic Mechanical Analysis (DMA), used for measuring Tg.

Each of these methods will provide usable information. However, it is not wise to compare the HDT of one polymer with the Tg determined by DMA of another polymer formulation even though both tests are similar in that they use a three-point bend test and increase the temperature during the test. Testing the same casting of cured epoxy with each of the methods will provide a range of results that may extend more than 30°F from one method to another.

HDT generally provides the lowest result; DSC provides a result 5 to 15° F higher, while Tg by DMA indicates a result about 10 to 15° F higher than the DSC method.

To really understand how one polymer formulation will compare to another, you must use the same method and test them against one another in the same lab. The data provided on a technical data sheet is intended to be a comparative guide to the different formulations produced by a single manufacturer, not a comparison between products of different manufacturers. It is imperative that the materials being compared receive exactly the same cure profile and that the method does not include an elevated temperature conditioning cycle. If you have questions or would like additional information about the thermal properties of any of our PRO-SET Epoxy formulations, refer to the data sheets available on the PRO-SET web site at www.prosetepoxy.com or call our chemistry staff at 888-377-6738. ■

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