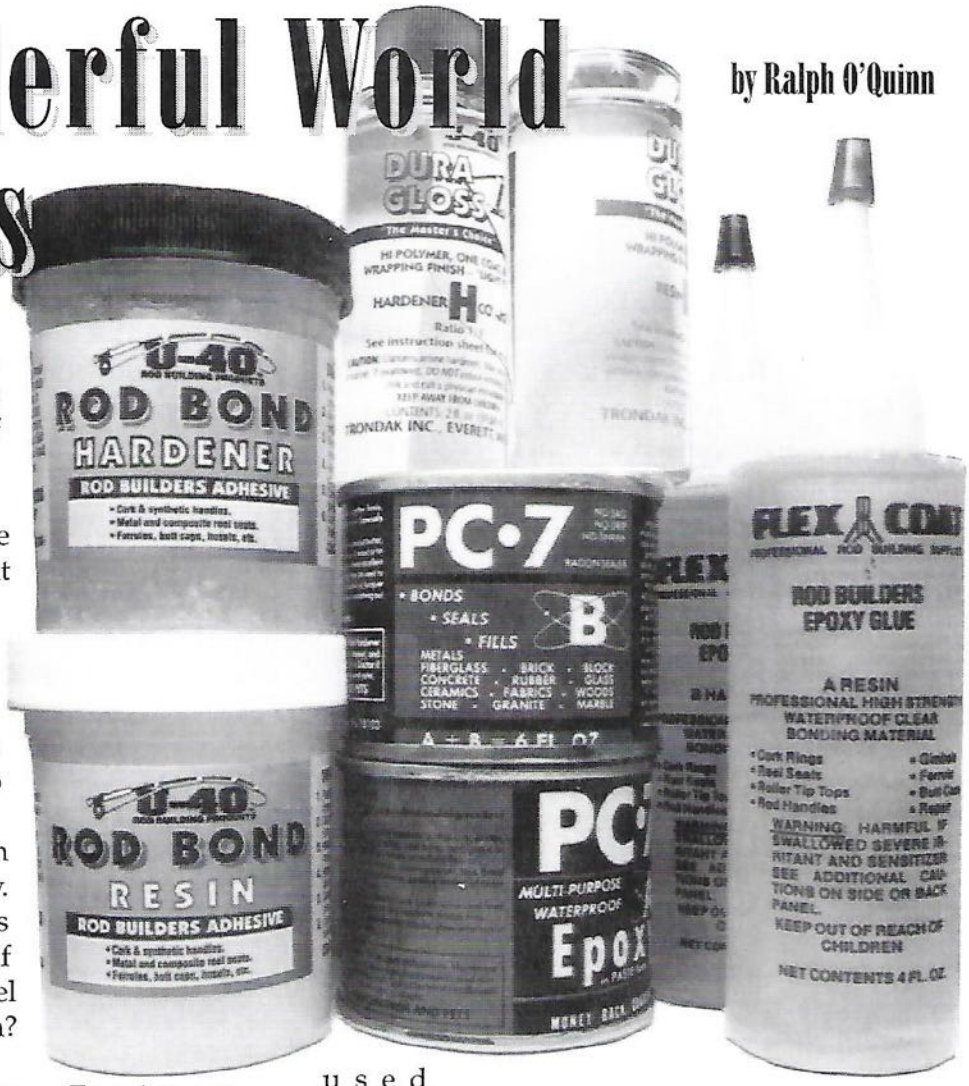
The Wonderful World Of Epoxies

by Ralph O'Quinn



Epoxy. A word that spreads terror in the hearts of many, exasperation in the minds of some, and puzzled confusion throughout our hobby/industry. The world of Rod Building as we know it, would be entirely different without epoxies. How many of you out there were building rods before the mid 1960s ? Remember the odd ball case in glues, the lacquers and varnishes for thread coating? Would you like to go back to those days?

Pick up a rod, any rod –hold it in front of you and look at it in entirety. Start with the butt cap. What holds it onto the handle? Epoxies. If you're holding a fly rod then the reel seat comes first . What holds it on? You get one guess. Look at the handle, reel seat and components. Epoxies are involved all the way. Now take a look at the guides. They are wrapped on with a nylon thread. What protects the threads? Another Epoxy of course. A lot of rods will have the tip top installed with a quick set epoxy instead of the usual hot melt. So from tip top to butt cap the normal fishing rod of today is loaded with Epoxies. If the rod is a Graphite rod, then the blank itself is held together with another Epoxy, although this one is a heat curing system. For the purpose of this discussion, we will limit ourselves to "room temperature curing, two part epoxy systems." Maybe we can clear up a few misconceptions along the way.

The word Epoxy Resin is actually a generic term applied to about 25 distinct types of resins that are commercially available. The resin that is the basis for our little rod building world is technically "the diglycidol ether of bisphenyl A" (DGEBA). These glycidol groups react with the amine hydrogen atoms on hardeners to produce the cured epoxy resin. Hardeners used with room temperature cured epoxy resins are "polyamines." Amine groups are very similar to ammonia in structure except that they are attached to organic molecules. Like ammonia, amines are strongly alkaline. Because of this similarity, epoxy hardeners often have an ammonia-like odor, most notable right after the container is opened. Epoxy hardeners are not catalysts. Catalysts promote reactions but do not chemically become a part of the finished product. Epoxy hardeners mate with the epoxy resin, greatly contributing to the ultimate properties of the cured system. A compounder can take one epoxy resin and a dozen or more amine hardeners and come up with a dozen or more different properties. He then can blend the hardeners and come up with even more interesting properties when they are mixed with the resin. This is the challenge of the compounder. Determine what properties are required for the job in hand; then combine the appropriate resins and hardeners to do the job. A compounder is really a bit like a first class chef! A cup of flour, a couple of

eggs — separate the yolks from the white – a dash of bitters, maybe a bat wing or two, stir under heat, add some frog eyes, and Voila — throw it out and try ----!!!

The epoxy curing reaction is decidedly exothermic. This means that it gives off heat as it cures. The rate at which the resin system cures is dependent upon the curing temperature. The warmer it is, the faster it goes. The curing rate will double or vary by about half with each 18F (10C) change in temperature. For example, if your rod takes 6 hours to become tack free at 72F, it will be tack free in 3 -hours at 88F, or tack free in 12-hours at 52F. The epoxy resins are probably the most versatile of the contemporary plastics. The basic properties may be modified in many ways - by blending of resin types by the selection of curing agents, and by the use of modifiers and fillers. There are other liquid resins – phenolics, polyesters, acrylics, etc.— which cure in a similar fashion, but only the epoxies are so versatile and possess a rather unique combination of properties. The flip side of the coin is that unprotected epoxy resins are not very sunlight resistant. After about six months' exposure to intense sunlight they begin to decay. Additional exposure will induce chalking, and eventually the epoxy will disintegrate, losing its mechanical properties. The solution to this is to protect the epoxy with a coating which contains an ultraviolet light shield. Fortunately for us, most rods will not see six months of exposure to the intense sun in an entire lifetime. Some epoxy kits sold for rod building advertise right on the bottle "ultra-violet protected polymer". Don't believe it. The polymer cannot be protected with an additive. It can only be protected with a cover coating. There are second generation amine hardeners on the market which do not discolor to an offensive brown, but even these will decay in intense sunlight.

Because it is exothermic, a mixed batch of resin and hardener if left in the mixing bowl will become warmer and warmer. This increased heat is reducing the pot life of the mixture correspondingly. If the same batch is spread out in a wide area, the exothermic heat is dissipated into the surrounding atmosphere and the pot life is greatly lengthened. This is why you should always pour your mixed batch into a container that will allow it to spread out.

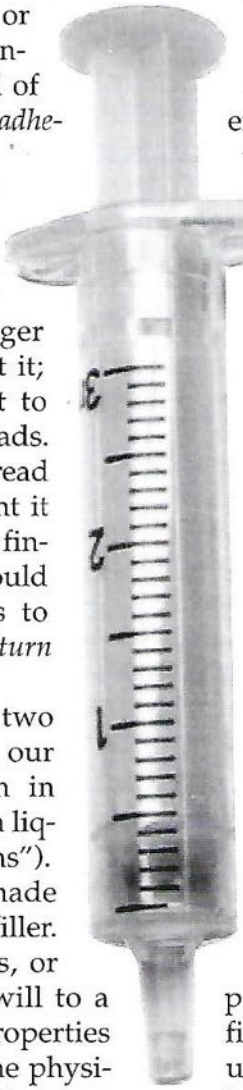
Epoxies that are available on the retail market were first modified to fit a particular niche or perform a definitive task. Many of the problems confronting rod makers are due to some epoxies that were not compounded for rodmaking in the first place. They were compounded for another purpose, then some local entrepreneur discovered the product, figured it would make a good rod making goop, put it into little bottles, labeled it for rodbuilding and sold it to you. Now you are plagued with properties that were intended for another industry, like furniture, or boat building, etc. Before you purchase your next epoxy, do a little research and see if the product you have in mind was actually compounded for rod building. What do we as rod builders want in an epoxy? Let's analyze our needs and wanties. Its always nice to be able to separate your needies from your wanties! Personally I have a lot more wanties than needies – but that's another story .

In building a rod we use epoxies in two separate distinct fashions. One, as a glue (bond is a better word) to hold things together, things like reel seats, handles, fore grips, butt caps, etc. Second, as a coating, to protect threads, coat decals, lettering, etc. Can we really expect one product to perform two distinct and widely divergent tasks? Sometimes yes, but more often a resounding NO!

When building a light spin rod, fly rod or any rod where you are using cork rings for the handle, it is okay to use your thread finish epoxy to bond on the cork rings. (personally I always use a paste , even on tight fitting cork rings. I like the properties of the paste better than the possibility of a brittle, thin bond which some liquid finishes will give you.) Just make sure that your rings are reamed for a good tight fit, there is plenty of epoxy between the rings and you use a clamp to hold things tight while the epoxy is curing. Also remember to wipe off any excess epoxy that squeezes out when the rings are put under pressure from the clamp. Then the handle is formed in place. Some of the premium rod manufacturers (especially premium fly rods) make their handles in this manner. If you are using a preformed cork handle – it's another story. Good bonds can be obtained with liquid adhesives when using tight fitting foam handles, but you cannot get a reliable bond with liquid adhesives on preformed cork handles, reel seats or any other loose fitting components where the tolerances may be measured in 32nds or 16ths of an inch rather than in a few thousands. The entire handle assembly is best assembled with a paste epoxy. And not just any paste. Some pastes are sticky – viscous – hard to mix and hard to assimilate into the bond area. The epoxy paste for rod builders is more like the consistency of Vaseline. It can easily be mixed (blended). It will contain a slip agent, in order that tight fitting handles may be readily moved into the proper position. It will spread like a good margarine (I can't afford butter) at room temperature, and most impor-

tant – it will stay where it is put. Meaning there is no tendency to run or sag or slump. You put it there and it stays there. If you must fill up a quarter inch gap in order to get a good bond, then it will build up a quarter inch gap and bond with only contact pressure. It will be tough enough to bear the load required on a rod, even with that quarter inch thick bond line. In the cured state it will always remain tough and *flexible*. Some pastes cure out rock hard and tend to crack and delaminate (lose their bond) in service.

Also if you are into *repair* of rods, you will be asked to do some exotic jobs sometimes. Like replacing a broken fly rod reel seat, or splicing a broken rod just above the handle and many other fun jobs. This kind of work demands a good *paste type epoxy adhesive!*



Can we use this neat paste adhesive on our thread work? Obviously not! Here is where our wanties can really run rampant. Our physical requirements are now practically reversed. We no longer want the material to stay where we put it; we now want it to flow. We want it to spread out evenly and penetrate the threads. This, a paste will not do. After it has spread out and penetrated the threads, we want it to coat the threads with a good looking finish. It would be nice if the materiel would do this unassisted, but since it tends to slump to one side, we have learned to *turn* the rod until the finish gels.

So we have a legitimate *needy* for two distinctly different types of epoxies in our rod building world. A paste (known in industry as "Potting Compounds") and a liquid(known in industry as "Casting Resins").

Potting Compounds are usually made by taking a casting resin and adding a filler. The type of filler used, i.e. glass fibers, or micro-balloons, or talc, or whatever, will to a large degree determine the **physical** properties of the potting compound. It's mostly the physical properties of your paste epoxy (potting compound) that you are interested in for your rod building. That is why it is important to select a product that was compounded for rod building

Of the two basic types of epoxies that we use in rod building (casting resins, and potting compounds) the casting resins are by far the more controversial. The casting resins are what we call our thread finishes. In rod building, we use them mostly for a finish, only secondary as an adhesive. It is this finish for our threads that commands our attention, and wherein lies so many fables, old wives tales, sacred beliefs and disbeliefs. This is the area of more "witch hunts" than medieval England ever saw! Let's examine a few of them.

1. My epoxy finishes had not been used for two years; obviously this is too old so I threw it out and bought a new kit for my latest rod.

Fact: Epoxies simply do not – repeat — do not age. If the resin and the hardener are stored in a proper container – [glass or metal preferred] at approximately room temperature, their properties do not deteriorate within your lifetime. The hardener will turn brown if in a glass or clear plastic container because ultra violet does that to it. But this does not effect any of the properties that it originally carried. I have tested systems that had been stored in an unheated warehouse and forgotten for twenty years. After thawing out the crystallized resin, the resin and hardener were subjected to a grueling examination wherein all original criteria were met or exceeded. Do not throw out your old epoxies, they are just as good as the day that you acquired them.

2. I can't get two consecutive mixes to come out the same, so I must have a bad batch.

Fact: Forget it. A bad batch simply does not happen. Of all the witches that we hunt, this one is the easiest to find. I have been involved with epoxies for forty some years, in several different capacities. Research engineer, parts development, compounder, you name it. Along the way you meet others who are also involved, and they have contacts here and there. Some are suppliers, some are competitors, some are manufacturers, some are distributors. All have one thing in common— a day to day contact with epoxies and the epoxy industry. I have never been able to find a single person involved in the epoxy industry who has any first hand knowledge of a bad batch. However all of us hear about bad batches all the time. Of all the bad batches that have been presented to me over the years, I have always been able to prove that there is nothing wrong with the batch. The problem is always with the user of the batch. There is never anything wrong with the batcher, it is always the batchee who is at fault.

3. My resin has turned hazy; some of it is actually white and cruddy looking; it must be spoiled.

Fact: Epoxy resins (but not the amine hardeners) will crystallize at low temperature. The temperature depends upon the resin. Some resins will crystallize at about 60-degrees F. With others, it takes a much lower temperature. Most will crystallize considerably above freezing temperatures. This crystallizing does not harm the resin in any way. To thaw it out, zap the bottle of resin in your microwave oven for 10-seconds and take a look. If it isn't entirely clear and isn't too warm, give it another 10-seconds. Repeat this procedure until it is entirely clear. Be careful that you don't melt the plastic bottle. An alternative is to submerge the bottle in a container of warm water until it is clear. The resin is as good as new. The newer resins just coming onto the market are relatively much more resistant to crystallizing than those that we have been accustomed to.

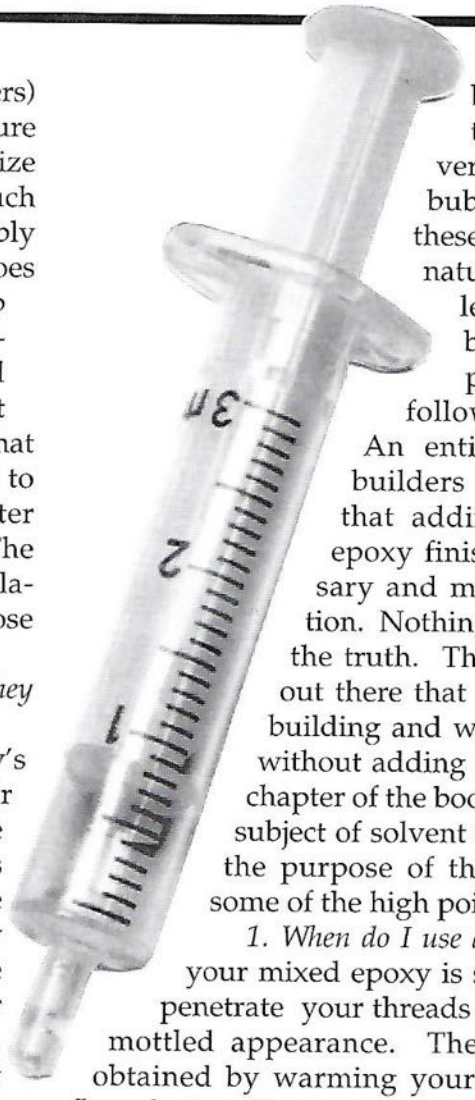
4. Never use the quick set, '5-minute epoxies' as they are too brittle.

Fact: Cure time has nothing to do with an epoxy's structural properties. Some 5-minute epoxies are far stronger than 1 hour cure systems. Most 5- minute epoxies that you see were compounded for a mass market with minimum economics in mind. The compounder has to make a buck, and he definitely was not thinking of your rods. Look for 5-minute epoxies that advertise for plumbing repair or Marine repair. You will have a good strong product.

5. I always add my solvent after blending, so that it is mixed evenly with the resin and hardener.

Fact: Occasionally a witch hunt will uncover a Demon. Witches are very elusive, and usually non-existent. Demons are very real, very troublesome, and always controversial. Usually both sides of the demon debate have a point. Such a demon is solvent added to our epoxies. I have never heard of anyone adding solvent to a paste epoxy – in case there is anyone out there who is considering it I have only one thing to say to you at this point - *DON'T DO IT!*

What solvent to use, and how much, are the big issues that are debated on and on into the night. Seldom is there a dissenting voice or a question of WHY do I have to add a solvent to a perfectly good 100% solid casting compound. Before we answer this question let's regress to the part of this story where we stated that "not all epoxies are compounded for rod building". Therein lies our problem. When epoxies first hit the market for rod builders, the material was borrowed from another industry and repackaged for rod building. It was too thick to properly penetrate thread windings; it gave a mottled appearance because of uneven wetting; it did not level very well; and it produced bubbles galore. Thinning these heavy resins became a natural answer to the problem. Today it has become an accepted practice to be routinely followed with all epoxies. An entire generation of rod builders was raised to believe that adding a solvent to their epoxy finish is something necessary and merely a routine operation. Nothing could be further from the truth. There are epoxy systems out there that were designed for rod building and will perform very nicely without adding any thinner. An entire chapter of the book can be written on the subject of solvent in casting resins, so for the purpose of this article, lets just hit some of the high points.



1. When do I use a solvent? Only when your mixed epoxy is so thick that it will not penetrate your threads uniformly; i.e. leaves a mottled appearance. The same results can be obtained by warming your mixed epoxy until it flows better. You can warm it with a hair dryer right on the threads.

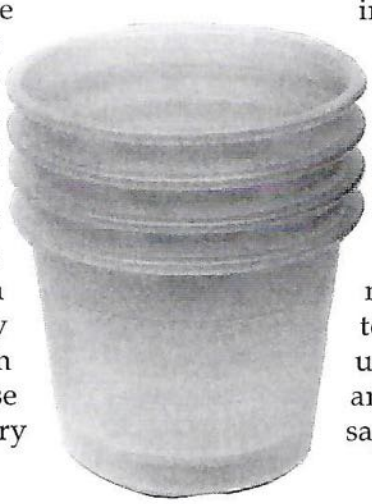
2. What solvent do I use? Never use any solvent other than Acetone. Why? Because it is the most volatile of all the permissible solvents. The big problem with using solvents is getting rid of the solvent. The more volatile the solvent the quicker it will escape. The quicker it escapes the less problems further down the line. Other Ketones, alcohols, etc., are not sufficiently volatile to escape from the resin before it hardens, at which point you have a real problem on your hands.

3. How much solvent do I use? This depends upon the epoxy system that you are thinning. You will need more thinner for one system than for another. I often get into a hassle with experienced rod builders who are routinely into thinning, and it seems that there is no one good answer for 'how much solvent to use.' Most of them use something on the order of "one drop of acetone for each cc of resin mix." Some of them use a flat 1cc of solvent for a standard 6cc of resin mix. It becomes a matter of taste and personal preference.

Personally I never use any solvent except when I am experimenting. I have found that more problems are encountered when using too little rather than too much solvent. When using too little solvent, the resin mix is not thinned sufficiently to allow the solvent to readily escape before the mix is hardened. If the solvent is still in the mix after it has hardened, you will have shrinkage and all the horrors that shrinkage entails – checking, crazing, cracking, etc. In my experimenting I have found that a mix of equal parts resin, hardener and acetone have given me the best results and the least troubles down the road. This blend makes the resin mix very thin and the solvent readily escapes while the mix is hardening. Always use a warm environment to help the solvent escape, and never apply a second coat until it has dried for about 24 hours. This is a good mix to use on heavy threads for a first coat.

Another demon that plagues our little world of epoxies is the measuring and mixing of them. Our epoxies are formulated to be mixed on a ratio of 1:1. One part resin to one part hardener. Most epoxy kits that are supplied for rod building include a pair of syringes. Usually the syringes are 3cc in volume. The smallest unit that can be purchased is a 2-ounce kit. which includes 1-ounce of resin and 1-ounce of hardener. This means that there are 10 mixes of epoxy in the 2-ounce kit. 3cc of resin and 3cc of hardener = 6cc of blended epoxy, which is enough to complete two 9ft fly rods. The 2-ounce kit costs retail about 7 or 8 bucks, which translates to about 80 cents per 6cc of mixture, or about a nickel for each of the 18 guides on two fly rods. In spite of these figures, there are characters out there who insist on trying to mix 1cc each of resin and hardener (to save money yet) and wonder why the damn stuff never sets up correctly. I consider 3cc of each component to be the absolute minimum that can be consistently measured and mixed accurately, and only if you use a syringe for measuring. Even if I am going to coat just one guide, I will mix 3cc of each component and throw away the excess. Any epoxy kit intended for rod builders will contain syringes for measuring. Keep far away from those that do not contain a syringe. Chances are very good that it will be a troublesome system not really formulated for rod builders. Rod building suppliers furnish syringes that are especially packaged for measuring epoxies. They are plastic syringes with a synthetic rubber piston. In order to form a seal, the piston is larger than the ID of the cylinder. This creates so much friction that the piston cannot be activated. Therefore the piston is lubricated. The piston is normally lubricated at the factory with a silicone oil. If you obtain a pair of these, and you proceed to measure your epoxy therefrom, I can guarantee that you will experience the ultimate demon transgression into our rod building world. You will also have kinip-shin fits trying to figure out where did all the fish eyes come from and how do I get rid of them (you don't). Use only the syringes that came with your kit, or purchase a pair from a reliable rod building supplier. These syringes will have the piston lubricated with a non contaminating lubricant. There are also syringes out there that do not have a rubber piston. The piston is merely the same plastic that the cylinder and barrel are made from, it is molded in as part of the barrel. These syringes are two-piece instead of three-piece and are totally contaminate free as there is no piston to lubricate. You should never clean a syringe. Merely wipe them dry, then the hardener syringe should have the piston pulled back to the end and stored in a clean container until they are needed again. With proper care, these plastic syringes can be used over and over, again and again. A syringe is the *best* method of measurement that will guarantee that you will be within the allowable tolerance of your resin/hardener mixture. The only possible exception being the pumps used by many rod manufacturers, which are certainly accurate, but not necessary for the custom builder.

As if the measuring demon wasn't enough of a problem, we are also plagued with the mixing/blending demon. This demon is the master demon of all the demons. In fact I think that he is making a bid to be promoted to the rank of devil. This is where most of the Witch hunts are started. Here is where the "bad batches", the "too old resins", the contaminated cups, too high humidity, too low humidity, ad infinitum, usually begin right here. Over any designated period of time – say a month – I will mix/blend an



average of about 3 batches of resin per day, day in and day out. Some days none, some days about a dozen or so. Most mixes are what I call a standard batch, 3cc of resin and 3cc of hardener measured from a syringe. I normally use a 1oz polypropylene or polyethylene cup. Never use polystyrene as it is too fragile. I inject the hardener into the cup first (because it is the thinner liquid of the two) followed by the resin. For stirring, I have developed several sizes and shapes of stainless steel spatulas. Hold the cup of resin and hardener at about a 45-degree angle and twist it in one direction while moving the flat spatula in the opposite direction – you are now duplicating a cement mixer. Do not move your spatula any faster than you turn the mixing cup. In other words, avoid a rapid stirring motion as this induces bubbles. You are trying to create a folding action. You should continue this folding for about 2-minutes. Watch the material become cloudy as it mixes together, then it will slowly become clear. Continue to mix/fold for about another minute. Then wipe your spatula clean. Let the mixed materiel sit for about another minute or so, then pour the contents into a flat area where it can spread out. It is important that your spatula scrape the sides of the plastic cup. Physically scrape the sides to remove and blend all of the liquid material. This is the area where so many well intentioned, long time experienced rod builders get into trouble without knowing why. Many of you out there have been taught that aluminum cups - or aluminum foil pressed into a suitable dish make a good mixing bowl. Taint so! Look at the wrinkles in that aluminum cup or foil. Wrinkles that prevent you from scraping the sides. Without scraping the sides there will be unmixed materiel clinging there. Do you want unmixed material in your mixture when you apply it to your guides? If you enjoy watching a nice rod stay tacky for days on end, when you know good and well that you did everything absolutely correct, then go ahead and enjoy the witch hunt.

Many an article has been written on the horrors of plastic mixing cups. How they contaminate, how the mold release agent in the cup causes fish eyes in your mix, on and on. These well meaning authors are witch hunting and creating demons in the process. I'm not sure just how many different brands of plastic cups I have used over the years - certainly more than a dozen. In the past, every time I got into a different brand I would do a statistical experiment using 100 samples in an attempt to find a contaminate. I've never been able to prove statistically that any plastic

cup that I have ever used did anything to contaminate my mixture. Over the years, this statistical data has become Empirical data, so I accept plastic cups as a mixing medium for epoxies.

The best mixing container, and one that I occasionally use, is a bartender's shot cup. A one-ounce glass cup made for mixing liquors. This cup used with a steel spatula (about a 1/4-inch wide blade) is ideal. The glass cup is easily wiped clean with a paper towel - Bounty brand. I pour all the mixture out onto a flat container, scrape the cup with my spatula, wad up a paper towel, cram it into the cup and wipe it clean. Then repeat this procedure, except moisten the wadded up paper towel with Isopropyl Alcohol (IPA). I have made batch after batch in this manner with nary a problem.

I have a friend who uses a 1/4- inch round piece of solid rod blank instead of a spatula for his stirring. I have tried it and it works fine. You can scrape the sides of the cup with the round stirrer, and it is large enough to impart a cement mixer motion to the blending. I don't use it because I like my spatulas better and because I also use the spatulas for applying the epoxy to the rod. I never ever use a brush.

Here is a good experiment for you skeptics to try. Mix up a batch of your favorite casting resin in your usual manner. Pour it into a flat container at least 2-1/2-inch in diameter so you can later remove it. After pouring out the mixed resin, set the mixing bowl (with the remainder of the mix still intact) and the flat container aside for at least 24 hours. Now peel your biscuit from the flat container and feel it. It should feel solid with no stickiness. Now feel inside your mixing bowl. It will probably be sticky, which means unmixed material. If there is no stickiness, then you are a competent mixer/blender and please go to the head of the class. If you felt any stickiness on your flat biscuit, then you have undoubtedly participated in many a witch hunt.

We are now to the point where we are building the rod which is another topic entirely and will be covered in another story at another time. The moral of this story is very simple. Treat your epoxies with care and they will take care of you. Treat them with indifference or disdain and they have the ability to bite back.

Ralph O'Quinn founded the Trondak U-40 line of rod building products some years ago. Today he serves in an advisory role with the company.