Sunk with a paintbrush

Protecting surfaces under the water sounds challenging, but Paul Oman reveals the secrets of third generation paints that can be used underwater.

Underwater painting sounds like some sort of parlour trick, but there are actually a number of epoxy coatings and repair products that can be applied to damp, wet, saturated, or submerged surfaces as well as used in environments of high humidity. Typical work sites can include pits, sumps, underwater supports, boats, piers and pilings and all sorts of below grade structures. The ability to patch, seal, encapsulate, reinforce, and protect objects, in place and in wet environments, is a much more attractive option than the alternative which is usually demolish and rebuild from scratch.

Despite the obvious advantages of moisture tolerant coating/repair products, such epoxies are not widely known or understood. The concept of underwater painting remains out of the belief of most industrial and marine maintenance professionals. However, with a slowing economy and fewer replacement dollars available, in situ rehabilitation or repair of existing structures, be they docks, yachts, ships, or dams, is becoming more of a more likely option.

In some cases the object might not be exactly underwater, just water saturated. An example would be an empty cement pit, manhole or sump that has contained water for many years. The cement is completely water saturated and will remain so for a very long time.

**EPOXY BASICS**

First formulated in the late 1930s in the US and Switzerland, epoxies can be considered a two-part, thermoset plastic. Mix two liquid components together, and an exothermic (heat producing) reaction takes place, and a hard, cured product results.

Basic and general characteristics of epoxies are:
- **easy cure temperatures, generally from 5-150°C**
- **low shrinkage**
- **high adhesive strengths**
- **high mechanical properties**
- **high electrical insulation, and**
- **good chemical resistance**

With so much going for it, epoxies were produced as commercial adhesives in 1946 and as commercial coatings by 1947. The versatility of epoxies was further advanced with the early formulations of epoxies that could be applied in an uncured state to wet surfaces.

These special epoxies have evolved from rather crude, unfriendly products into high performance, applicator friendly coatings.

**EPOXY CURING AGENTS**

The curing agent selection plays the major role in determining many of the properties of the final cured epoxy. These properties include pot life, dry time, penetration and wetting ability. Curing agents come in many different chemical flavors, generally based upon amines or amides.

Amine based curing agents are considered to be more durable and chemical resistant than amide based curing agents but most have a tendency to "blush" in moist conditions. Blushing produces a waxy surface film on actively curing epoxy, the result a reaction with the curing agent and moisture in the air. Other potentially toxic chemicals within the curing agent can also be released in the same manner, so amines are often viewed in light of these potential shortcomings.

Amides, on the other hand, are more surface tolerant and less troubled by moisture. Fortunately for epoxy end-users involved with underwater applications, there is a small subgroup of non-benzene ring structured amines that maintain all the benefits of amines while removing the toxic leachability and moisture attracting properties of typical amines. These special polyamines form the basis for today's cutting edge underwater epoxies.

**HOW EPOXIES WORK**

The well known adhesion of epoxies is due to the strong polar bonds it forms with the surfaces it comes in contact with. On dry surfaces the bond between the surface and the epoxy displaces the air, which is a fluid. The same is true underwater. As on dry surfaces, the polar bond attraction is strong enough to displace the fluid, in this case the water, and produce a strong bond even underwater.

Therefore, painting underwater is, in theory, no different that painting above the water. The cross-linking reaction of epoxies should be independent of the surrounding environment.

Still, most curing agents will react with water molecules rather than the epoxy base, resulting in a waxy film, mentioned above, known as amine blush. This makes them unsuitable for underwater application.

Creative colouring with underwater paints causes confusion for the squid population... Image: Graeme Howard
Underwater epoxies in action – a case study

Paul, remember me?, Joy Smith and her sunk boat in Papua New Guinea around Christmas time last year?

By the time I finally left my boat and got off the island, made it to civilization and then found your website in my desperate search for an air-shippable underwater epoxy, we had been marooned on remote Hermit Island, Papua New Guinea (PNG) for two months. Banshee sank in three minutes, on October 21, 2002, after hitting a coral head and was completely underwater for three days. There was a six foot crack through the hull and a punched in hole about a foot in diameter. The damage was massive.

Leslie patched the hull with old 2-Spar Splash Zone and a piece of wood a villager shaped with an axe. We kicked it off the rear, winched it upright, and then the villagers built an underwater cradle of lashed together logs to support Banshee. We bailed with buckets during a very low tide at night. She floated. The inside of the boat was trashed, the electric/electronics destroyed, the engine unusable, lots of things stolen, diesel oil, sandy sea water and ocean bottom rubble and mold covered everything. But the sailing rig survived.

However, it soon became apparent that the old 2-Spar patch would never hold for a 300 mile open sea voyage to Madang, PNG and dry dock for hull repair. As I told you when I wrote in December, the hull was steadily leaking, and we knew the temporary repair would not last long. I was desperate to save my boat that has been my life for 32 years.

I bought your underwater epoxy, and you shipped it to Manus Island, PNG. I picked it up and returned to the remote island of Hermit; what a name! Almost didn’t make it back as a storm came up while we were in the open 26 foot boat making it back to the island. 36 hours in an open boat with heavy seas with local bush people and me! BUT I HAD THE EPOXY AND KNEW WE WOULD NOW SAIL BANSHEE OFF HERMIT.

The whole saga is a very very long story of an incredible three month ordeal for two women alone. I got back to Hermit in mid January, and Les and I applied your stuff according to your directions. We patched the hull inside and out as you said. By then, the leakage from the 10 year old 2-Spar Splash Zone was getting worse. However, your stuff stopped all the leaks.

After 3 weeks of working on the boat, we left Hermit for the voyage to Madang, PNG. Sailing the 300 miles with no engine, no electronics, no autopilot, no functioning life-ralt, and very little food or water. There were very high winds and rough seas and then dead calms, and we only had wind and sails alone to get us across that ocean. YOUR REPAIR STUFF HELD! The hull had a fierce pounding—but no leaks. WE MADE IT! We were towed in at the entrance to Madang Harbour and collapsed in exhaustion.

If we had not had your epoxy, our boat which is our life would still be under water at Hermit. We owe a debt of gratitude to you. The boat was put up in a primitive dry dock, and we literally cut out the repaired hull with a diamond tipped saw. Your stuff eats sanding grinders! We are good at epoxy repair of hulls—thank goodness, because no one here knew anything. Before we had properly repaired big holes where thru-hulls had been removed by building up larger and larger layers of mat and roving with epoxy resin. Leslie is very good at that—having worked in a fiberglass repair shop. This was just a bigger job. Ghostly work.

We are now safely sitting in an anchorage in Madang rebuilding, and rewiring with our very limited funds. We plan to leave Madang for Guam and employment in December....

Very thankfully,
Joy S. and Leslie B.,
US Yacht Banshee
Madang, Papua New Guinea
specific and related to electrical cells formed in a conductive medium (seawater) on a conductive surface. Always test in the actual marine environment before committing to any underwater coating project.

If there is a problem, the epoxy will simple refuse to 'stick' to the surface. It is very obvious (and embarrassing). It often will not transfer off the brush, roller, or paint pad/glove.

**WARNING – Additives in Concrete**

Concrete structures, often commercial in nature, can sometimes have adhesion problems too. Commercial aquariums and swimming pools are examples. In some cases chemicals were added to the concrete to speed curing, reduce air bubbles, and so on. These chemicals, some perhaps silicon based, prevent bonding of the epoxies to the concrete. It is also possible that some pool/aquarium paints also contain stain or slime ‘no-stick’ chemicals that make underwater coating impossible. For example, when applying to commercial aquariums there are some where the underwater epoxies work fine and others where they don’t work at all. The only safe thing to do is test before taking on such a project.

**EPOXY EVOLUTION**

Three generations of apply underwater epoxies have emerged over the years. Each has pushed the technology window forward. The success of first generation epoxies was in their ability to be applied and cured underwater. The next generation moved these epoxies into true coating status, albeit with issues of user friendliness and chemical safety issues still to be addressed. The third generation epoxies have addressed those issues successfully.

**First Generation Underwater Epoxy Coatings:**
- Sticky, like Bubble Gum
- Knead the two parts together in hand-sized amounts and push on to the surface
- Potentially difficult to ship - may require haz-mat shipping (Corrosive Liquid - N.O.S.)
- May have short shelf life.

**Second Generation Underwater Epoxy Coatings**
- Good underwater adhesion
- True bonding instead of sticking
- Poor storage stability (heating required) - products tended to crystallize over time
- Toxic - MDA and possible solvents
- Haz-mat shipping required
- Problem bonding to cathodically protected surfaces

**Third Generation Underwater Epoxy Coatings**
- Stable storage - will not crystallize over time
- Non-toxic, 100% solids (0% VOC), no MDA
- Non haz-mat - unregulated shipping
- Improved application on cathodically protected surfaces
- Easy application results in productivity increase

**CLOSING**

The underwater applied coating market remains a small niche within the much larger industrial and marine maintenance marketplace. Both first and second generation underwater coatings are still widely in use, primarily because of the conservative nature of the industry and the acceptance of less than user friendly underwater products.

Too few users and potential users/applicators of underwater coatings are aware of the advances made in recent years. This is changing because the shift toward environmentally friendlier, and easier to use coatings are slowly causing the re-evaluation of old familiar products and the introduction of new companies with new products that better meet today’s expectations.

The ability of a single product to be effectively used on dry surfaces, underwater, or on saturated or dripping metal/concrete surfaces, while being both environmentally and user friendly, represents a technology that will continue to gain acceptance.

The savings associated with in-situ underwater repairs and coating projects is often easy to document, as are the potential benefits from even more ambitious applications of this maturing coating technology.