MASTERBOND®
TECH SPOTLIGHT

UV Curing Adhesives Shine

Adhesives that cure under a UV light source are user friendly and versatile — if you know how to apply them

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Adhesives that cure under a UV light source are user friendly and versatile—if you know how to apply them

Adhesive products have different ease-of-use characteristics. Some must be precisely weighed and mixed prior to use. Some need a carefully controlled heat cycle to cure properly. Some have a precarious pot life. Some offer a narrow window of open time. And then there are the UV curable compounds.

This diverse group of adhesives, sealants and encapsulants cures only when activated by a suitable UV light source. As one-component materials, they don't require labor intensive weighing or mixing steps. With the exception of special dual-cure systems, UV curable compounds require no heat cycle. These adhesives also remain stable for long periods of time, with shelf life of six months or more if kept away from UV light. And because they cure on demand when users turn on the UV light, they offer an unlimited open time.

The UV cure mechanism provides a couple of other practical benefits as well. For one, UV curables among the most environmentally friendly adhesives because they emit no volatile compounds as they harden *(see sidebar)*. For another, the light-initiated cure takes place both quickly and at low temperatures. So substrates experience little or no noticeable temperature change. This "cool cure" makes these adhesive products a natural fit for a wide range of heat-sensitive substrates and components.

Taken together, these characteristics put UV curables among the most user-friendly adhesive products on the market today. Here's a closer look at the capabilities of UV curable formulations, the requirements for an optimal cure, and the best applications for these beneficial adhesives:

UV Curable Capabilities

UV curable products come in many different formulations, for use in a wide range of bonding, sealing and encapsulation applications, but they tend to share many features and capabilities.

After exposure to UV light, these compounds form rugged thermoset materials with excellent durability, strength, hardness, impact resistance, adhesion and electrical properties *(see Table One)*. These compounds cover a service temperature range from -80 to 350°F and offer good chemical resistance even in the presence of moisture or heat.

Today's second generation UV curables also exhibit a particularly low shrinkage rate, which improves dimensional stability and can even help prevent substrates from warping. It's also an advantage when applying UV compounds in thick cross sections. With today's formulations, thicknesses up to 1/2-inch are far easier to attain than with first-generation products.

EASY ON THE ENVIRONMENT

Many organic adhesive products contain solvents and various diluents, and heat is generally used to drive off these volatiles during the cure process.

UV-cure compounds avoid this issue entirely. They cure when radiant energy from a UV light source is absorbed and converted to chemical energy. This conversion process is 100 percent reactive in that it produces no volatile losses. It is essentially a non-polluting cure.

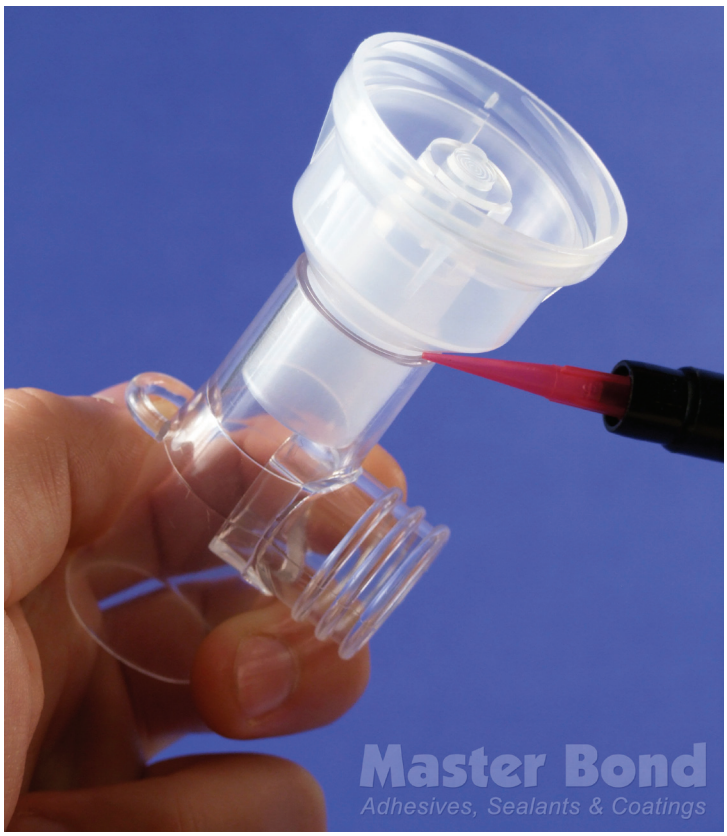
UV-cure compounds also save energy on the factory floor. They do away with the need for ovens or other thermal curing equipment. And they enable a more efficient production process thanks to their fast cure and minimal post-cure requirements.

In-depth curing greatly extends the range of applications—particularly to the potting and encapsulation of sensitive electronic components like integrated circuits, light emitting diodes, high voltage coils and optical fibers. Additionally, in-depth cure enables bonding and potting applications involving printed circuit boards, capacitor seals and electrical connectors.

The Right Light

Because they are 100 percent reactive and not inhibited by oxygen, Master Bond's UV cure reactions can take place at ambient temperatures and in the presence of air. When fully exposed to a suitable light source without any shadowing, they can cure in a minute or less. Even after the light source has been removed, the cure reaction will continue until all the UV reacting species have been consumed. This capability allows users to make the most economical use of UV energy.

The UV energy used to cure these formulations typically falls in the range of 10-40 mW/cm^2. A variety of lamps can generate this energy, providing their output includes UV light of 250-365 nm wavelengths. Cures can also be achieved with low intensity UV sources, but cure times will be significantly longer and may require several minutes or more.



Easy-to-use one component UV curable adhesives are environmentally friendly and offer high bond strengths to similar and dissimilar substrates.

UV CURING HARDWARE

UV curing systems employ special lamps as a radiative energy source. These UV lamps are controlled discharge devices that contain mercury and inert gas. At both ends of the tube are electrodes, which are joined to metal end caps to form the electrical connections to the lamp. The distance between the electrodes determines the amount of voltage needed to span the gap and strike an arc. The arc generates electromagnetic energy of varying wave lengths, giving off infrared and visible light as well as the desired ultraviolet radiation.

Lamp cooling by air or water is important because electrodes operate most efficiently at around 1,500°F. A power source or ballast is required to increase the input voltage and provide constant power to the mercury vapor lamps.

Considerable progress has been and continues to be made in the design and durability of UV lamp equipment. Lamps that can generate UV light at 365 nm, which is becoming the standard, can now give trouble free service for more than 2,000 hours. (Remember to take safety precautions when using any UV light source.)

In general, a thicker layer of UV curing material will require somewhat longer exposure to UV light than a thinner one, but the relationship is not directly proportional. Also, the rate of cure increases with the amount of UV intensity deposited on the surface—but again the relationship is not directly proportional. The rate of curing furthermore depends on the distance of the surface of the UV curing polymer system from the UV radiation source.

As with any adhesive, optimal adhesion requires clean substrates. Oils, greases, release agents, dirt and other contaminants should be removed before adhesive application. In cases involving metals or other inorganic substrates, the degree of cleanliness can be ascertained by a simple test which involves spreading a few drops of cool water on the surface. If the water spreads over the area with a continuous film, parts are sufficiently clean for further processing; if the water beads or stays in puddles, EPA acceptable solvents such as IPA or acetone should be used for degreasing. The water test should then be repeated before applying the UV-cure compound.

THE CURE FOR SPIN COATING JOBS

An increasingly important use for UV curing compound involves their use in spin coating, a method for coating substrates with a thin film. Often used in the semiconductor industry to create microlithography photoresists, spin coating has also been applied to the microfabrication of electro-optic, microfluidic and sensor components. Film thickness varies with the application but is usually a couple of microns or less.

UV curable epoxies are a particularly good fit for the spin coating process. These compounds offer a lower viscosity that's well-suited to uniform deposition by spinning. These compounds also cure quickly upon UV-light exposure and do so at room temperature, which helps protects delicate substrates and electrical structures from excessive heat. Once applied as films, the epoxies have exceptional performance properties, including high impact strength, strong bonds to a variety of electronic substrate materials, chemical resistance and electrical insulation properties.

Master Bond offers two UV-curable epoxies that are well-suited to spin coating applications: UV15 and UV15LV are both 100 percent reactive, ultra low viscosity compounds that produce tough, durable, chemically resistant films on a variety of substrates—including silica and selected polyester films, especially pre-treated varieties. Neither compound is oxygen inhibited, which speeds cure times in ambient conditions. Both typically cure in less than a minute under commercial UV lamps. With appropriate post cure, both epoxies exhibit a glass transition temperature of 125°C, an exceptionally high value for this class of materials.

For more information, visit **www.masterbond.com**.

Substrate Versatility

UV-cure compounds have been successfully applied on many different types of organic and inorganic substrates. Among them are difficult-to-bond materials such as pretreated polyester and polyimide films, sputtered metal films and high-purity alumina ceramics. Other common substrates include glass, silicon and other semiconductor materials, silica and acrylic optical fibers, paper products, sputtered and ion-plated coatings and printed circuit board materials.

UV-cure adhesives will also work with polyethylene, polypropylene and other polyolefins, though these substrates require special surface treatments to promote adhesion. The same goes for surface-treated fluorocarbon polymers such as polytetrafluoroethylene (PTFE) and chlorinated fluorocarbon resins. Whenever these difficult-to-bond substrates are involved, it's imperative that UV light exposure takes place without any shadowing or diminished intensity.

Successful assembly operations are today using UV-cure compounds on highly-automated continuous processing equipment. The fastest of these lines can reach speeds in 80 ft/min, which provides some indication of just how productive these fast-curing adhesives can be.

With their ability to address so many advanced material substrates and reach high volumes, UV-cure adhesive products have gained the most traction in "high tech" industries such as electronics, optics and medical devices. The cure-on-demand capability has opened up in applications that have complex assembly routines and need to control the open time.

Even more applications are likely over the coming years as more engineers recognize just how easy to use and versatile these adhesives can be.

For further information on this article, for answers to any adhesives applications questions, or for information on any Master Bond products, please contact our technical experts at Tel: +1 (201) 343-8983.

POPULAR MASTER BOND UV CURABLE PRODUCTS

Master Bond Grade	Mixed Viscosity RT, cps	Color Code	Hardness Shore D	Service Temp Range, °F	Applications
UV10MED	1,200-1,500	light amber clear	60-65	-60 to 250	Medical version of UV10. USP Class VI approved. Good electrical and physical strength properties. Resists sterilants well.
UV11-3	60	transparent	N/A	-60 to 250	Ultra-low viscosity, spin coatable, scratch resistant coating. Used with glass, acrylics, polycarbonates and other plastics.
UV14-3	8,000	transparent	30	-60 to 250	Flexible adhesive, sealant and encapsulant. Easily removable by conventional solvents. Has a low index of refraction (1.477).
UV15	120-150	slight amber clear	>75	-60 to 300	Very low viscosity. Features superb temperature stability, chemical resistance and low shrinkage. Post cure with heat raises Tg.
UV15-7	1,400-1,800	transparent	70	-60 to 300	Adhesive, sealant, coating and encapsulant. Cures over 1/8" deep. Superb adhesion and non-yellowing properties.
UV15-7DC	1,500-2,500	transparent	>70	-60 to 300	Dual cure version of UV15-7. Will cure in "shadowed out "areas by adding heat (250°F). Excellent physical and electrical properties.
UV15-LRI	6,000-10,000	transparent	50	-60 to 250	Low index of refraction (1.481). Adhesive, sealant and coating with good mechanical strength properties.
UV15-7SP4	800-1,500	transparent	35	-80 to 250	Highly flexibilized version of UV15-7. Outstanding thermal and impact resistance. Very good non-yellowing properties.
UV15-7TK1A	paste	translucent	65	-60 to 300	Paste version of UV15-7. Dimensionally stable. Low shrinkage. Used as an encapsulant and glob top in electronic and opto-electronics.
UV15X-2GT	paste	translucent	65	-80 to 250	Easily processable glob top. Excellent moisture resistance. Offers good heat resistance and superior thermal cycling properties.
UV15X-6MED	24,000	transparent	25-30	-80 to 250	Medical grade version of UV15X-5. USP Class VI approved. Excellent adhesion to metals, plastics, glass and rubber.
UV16	120-150	slight amber clear	>75	-60 to 300	Enhanced temperature. Very low shrinkage and good dimensional stability. Post cure with heat recommended.
UV18S	1,800-2,000	slight amber clear	55-60	-60 to 250	Adhesive, sealant and coating with excellent resistance to many acids, bases and solvents.
UV21	32,000-36,000	transparent	20-25	-60 to 250	Flexible adhesive, sealant and coating with excellent adhesion to acrylics, polycarbonates, glass and other optical-type substrates.
UV22	4,000	transparent	>85	-60 to 300	Highly filled, nanoparticle reinforced system. Greatly enhanced physical strength properties. Unsurpassed low shrinkage. Outstanding hardness and abrasion resistance.