

# Keeping Up Appearances

Understanding the differences between conventional paints, high-solids coatings and waterborne coatings. From easy application to high performance, liquid coatings have much to offer...

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Here's the good news: According to the Institute for Supply Management, economic activity in the U.S. manufacturing sector has continued to show uninterrupted growth for more than two years while the overall economy has grown for the last four. In addition, among the top industries experiencing growth are furniture, industrial and commercial equipment and computers, electrical components and equipment, and transportation equipment.

And more good news: Technology in liquid coatings that OEMs use in manufacturing these in-demand products has never been better. Recent developments have produced coatings made with lower solvent content, which in turn offers environmental advantages. In response to stricter air quality regulations, coatings manufacturers have also made advancements in technology to provide waterborne coatings that closely simulate the high-performance characteristics of solvent-thinned coatings while meeting clean-air standards.

But before any coatings are selected for the finishing line, it helps to have a solid understanding of coating capabilities and performance. A good place to start is with a close look at what actually goes into the composition of liquid coatings. Next, we'll examine the mechanics of film formation, and then overview today's most popular liquid coating types.

## Coating Composition

There are four basic ingredients found in all coatings: pigments, binders, resins and solvents. The combination of these components produces

a dried film that provides color and protection. Each ingredient plays an important role in forming a durable and protective film.

*Pigments.* Pigments are finely ground, solid particles that are dispersed in liquid to make paint. These non-volatile particles, packed tightly together, are what you see when you look at dried paint film. The selection and proper balancing of pigments contribute to color, hiding, chalking, tint retention, leveling, sheen uniformity, flexibility, gloss, and resistance to scrubbing, corrosion and blistering.

*Binders.* Binders are the non-volatile resins that bind pigment particles together. The adhesive quality of these resins also causes the pigment particles to stick to a substrate. The stronger they adhere to the surface and the higher the quality of the resin, the more durable the paint film will remain over time.

Commonly used binders that form the foundation for many coatings include emulsions (acrylic or vinyl), dispersions (acrylic, alkyd or polyurethane), or solutions (alkyds, polyesters, epoxies, acrylics and urethanes). There are also hybrids such as acrylic urethanes and polyester urethanes, which are common in all coating types. Alkyd resins are usually seen in solvent-borne and waterborne coatings.

*Resins.* Choosing any resin in a coating formulation involves a combination of performance and cost. For example, applications that require excellent resistance to corrosive environments require resins that are more costly, such as epoxies and urethanes. However, using these types of coatings in an interior residential application would be



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overkill to say the least. Most decorative finishes contain lower cost acrylic resins that are perfectly suitable for office and home settings. Depending on the job requirements, different resins can be combined into a hybrid mixture designed to deliver specific performance capabilities.

**Solvents.** The next building block of paint is solvent. The solvents in a liquid coating are what make a coating thin enough to apply easily. Solvents are the medium that carry the solid ingredients to the surface being painted. Without solvents, paint would have the consistency of mud.

Solvents work by dissolving a binder and reducing the viscosity of the coating, allowing it to be applied in a thin, even coat. They also help to control the rate of drying and the ability of the coating to flow and level. As the solvent evaporates, what's left behind is a hard, durable coating. In some paint formulations, co-solvents are used to help speed the drying process.

**Additives.** Additives are the final component of paint. They offer special performance

abilities such as rust inhibition or UV protection. In general, additives are just a small portion of the total coating formulation.

### Getting Left Behind: The Paint Film

How a coating forms a film is another part of understanding the differences in the performance of liquid coatings. Once a coating is applied, there are four basic mechanisms that allow the paint film to form. The first is coalescence.

**Coalescence.** When a waterborne coating is being applied, latex polymers are dispersed throughout the wet paint. As the water evaporates, the binder becomes more

tightly packed and the binders and polymers fuse together. Coatings that dry through the process of coalescence first go through a 10-minute evaporation stage. Then, they begin to form a film through the process of coalescence. This process can take from 30 minutes to one hour. But, to become fully cured, the paint film might need up to 30 days.

**Oxidation.** Oxidation is another method of film formation. First the coatings dry by solvent evaporation. Then the binder (usually an alkyd) reacts with oxygen from the air to cure and harden further. Coatings that dry through oxidation first go through a 10-minute evaporation stage. Then, they begin to form a film through oxidation. This chemical reaction takes four to six hours. However, the paint film will continue to oxidize for the life of the coating. (This explains why old alkyd paint films tend to be very brittle.)

**Chemical curing.** The third type of drying mechanism is chemical curing. Chemically cured coatings harden and attain their final resistance properties as a result of a chemical reaction that combines small molecules to



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create larger molecules. Epoxies and two-part urethanes are examples of this mechanism. As with the other means of forming a film, the first part of chemical curing is a 10-minute solvent evaporation. Then the film is formed through a chemical reaction that can take from 30 minutes to several hours, depending on the paint formulation.

**Evaporation.** Some coatings form a film just by evaporating the solvent thinners in the formulation. Lacquers dry by this mechanism. As the solvent evaporates, it leaves behind a solid coating. In this case, the binder does not go through any chemical change while evaporation is taking place. Coatings that dry through evaporation usually take 10 to 30 minutes to fully cure.

How various types of liquid coatings achieve a coating film is an important aspect of their differences. The durability of the film that's left behind is largely dependent on the quality of the solid pigments, binders and additives that

are used in the composition of the coating. If the manufacturer uses too many filler materials in the coating, the film will deteriorate prematurely.

### Matching Needs to Performance

There are three basic types of liquid coatings: solvent-borne, high-solids and waterborne. To select the best type for the job requires a good understanding of all of them. The process comes down to matching coating performance with finishing-line needs and capabilities, and product end-use needs.

**Solvent-Borne.** Solvent-borne coatings are often referred to as the workhorses of the industry because of their reputation for providing long-lasting finishes that dry quickly and meet high-production schedules. Available as total coating systems, solvent-borne products encompass a whole range of uses including fillers, primers, sealers and topcoats. You can also get various formulations of solvent-borne coatings to meet specific demands for gloss, color retention and chemical resistance.

The durability and long-lasting good looks offered by solvent-borne coatings has made them a popular choice for metal finishes in the military, industrial, agricultural, construction equipment, office furnishing and consumer electronics industries. In fact, solvent-borne finishes that meet Federal standards dominate the finishing market.

Finishers who want very durable coatings for plastic substrates also have turned to solvent-borne coatings, since they offer exceptional film durability, long-term performance and

superior texturability. The plastics industry also values solvent-borne coatings for their ability to cure below 300°F, the deformation temperature for many plastics.

Recent advancements in the formulations of solvent-borne coatings have made them more eco-friendly, meeting strict federal standards for low HAPS and VOCs. For example, ultra-low VOC polyester baking enamels that emit less than one lb/gal of VOCs while offering excellent application and performance characteristics are available.

*High-Solids.* High-solids coatings, with their low solvent content, have their own advantages. Since these coatings contain less solvent, their impact on the environment is greatly diminished. The development of high-solids coatings was spurred by the Clean Air Act in the 1970s, followed by even tighter restrictions on HAPS and VOCs with the 1990 amendments to the federal regulations. High-solids coatings are available in single or two-component systems and in a variety of formulations including polyesters, alkyds, epoxies, urethanes and acrylics.

In general, high-solids coatings are defined as those that have at least 60% volume solids content. There are high-solids products on the market that offer volume solids higher than 90%. Of course, the challenge for manufacturers in the development of these coatings has been to deliver a product that can be applied easily with conventional equipment. Remember, solvents provide a means to thin the overall product. That explains why coatings with conventional low-solids content are very fluid at room temperature.

In order to obtain a product with a viscosity that allows easy spray application, manufacturers use a combination that includes polymers with lower molecular weight, more efficient solvents and low-viscosity crosslinking agents. By using environmentally acceptable solvents, manufacturers are able to develop high-solids coatings that are very low in VOCs as well as HAPS.

The one area that has greatly propelled the technology of high-solids coatings is advancements in polymer technology. Thanks to ongo-

ing research and development in this field, new polymers that act as both solvent and binder have been created. The presence of these polymers in high-solids formulations lowers the molecular weight and/ or viscosity. The result is better gloss retention, adhesion, flow and leveling. In fact, these new-generation high-solids coatings can offer the same performance characteristics as their high-quality, conventional low-solids counterparts.

Another major development that has impacted the manufacture of high-solids coatings is advancements in crosslinking technology. Since high-solids coatings are expected to cure under various conditions and offer top performance characteristics, crosslinking technologies have been developed to work with the new polymers to reduce initial viscosity, making application easier. A good example of this technology is the combination of high-solids melamine crosslinkers with high-solids polyesters to create attractive coatings for appliances, office furnishings and recreational equipment. In addition to creating highly durable, attractive finishes, manufacturers have used crosslinker/polymer combinations to create coatings that cure at room temperature or with UV/EB energy systems that are ideal for substrates such as wood and plastics.

As mentioned earlier, one of the benefits of high-solids coatings is their ability to be applied by conventional methods. However, manufacturers might recommend the use of high efficiency spray equipment to optimize application. The reason for this is simple: additives that prevent sagging or promote flow in high-solids coatings can slow the application process.

Another method for high-solids application is a high-speed rotary atomizer with turbo bells or discs. In some cases, application can be enhanced by adding an electrostatic charge to the coating particles leaving the atomizer. Finally, conventional hot-spray is another good application choice since the heat quickly reduces the viscosity without adding more solvents, making application easier.

Although high-solids coatings have much



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to offer in performance and the ability to meet tough regulations, they do have some drawbacks associated with their low solvent content, such as sagging, streaking, orange peeling and poor edge coverage.

When working with high-solids coatings, finishers need to be vigilant to ensure excellent surface preparation. While good surface preparation is always important, high-solids coatings are less forgiving than their conventional low-solids counterparts, since the amount of solvent is reduced. To make sure all substrates are clean and dry, try to isolate contaminants on the finishing line such as dirty filters, lubricating fluids, dirt and dust.

**Waterbornes.** Waterborne coatings are another popular choice among liquid coatings. As the name suggests, these coatings employ water as their primary "solvent," in place of organic solvents. For many years, these coatings were considered inferior to solvent-borne coatings since they did not provide the same tough and long-lasting performance characteristics. But technological improvements along

with advancements encouraged by the need to comply with clean air standards have resulted in waterborne coatings that have properties equal to or even better than those of solvent-borne finishes.

To give waterborne coatings their performance characteristics, special resins such as synthetic polymers are used in their formulation along with additives that give these coatings fast dry times as well as excellent adhesion to plastic substrates. Waterborne coatings also can be applied to wood, metal, glass and masonry surfaces using most types of application equipment, including spray, dip or flow coating. Some waterborne coatings can be air-dried while others require baking to cure.

One of the most significant advantages offered by waterborne coatings is their low levels of VOCs. Most waterborne coatings offer VOC levels well below the 2.0 lb/gal levels and zero HAPS that meet even the toughest regulatory requirements. Other advantages offered by waterborne coatings are reductions of fire hazards and the costs associated with solvent

clean up and disposal. Waterborne coatings are also easy to use in inhabited spaces, since they have low odor.

As with other coating types, waterbornes have some disadvantages. For example, waterborne coatings work best when applied at up to 1.2 mils dry film thickness – a level not appropriate for all applications. Waterborne coatings also take longer to dry when exposed to high humidity, so additional costs for air circulation, exhaust or dehumidifying systems may be required. As with high-solids coatings, waterborne coatings are not as forgiving as solvent-borne finishes when applied to substrates that are not properly prepared. Finally, waterborne coatings can be more expensive than other types of coatings.

Waterborne coatings come in different types of formulations that contain one of three types of synthetic polymers, including water-reducible polymers, water-solubilized polymers and water-emulsion polymers (**see illustration**). Since these polymers have significant differences, each provides its own specific set of characteristics.

For example, water-emulsion coatings contain circular shaped particles that have a high molecular weight when dispersed in water. This increase in the molecular weight allows the coating to obtain improved performance without having an adverse affect on the viscosity. Of the three types of waterborne formulations, water-emulsion coatings offer the most durable coating properties, including good chemical and water resistance.

Advancements in water-emulsion technology along with the addition of modified resins and additives have produced coatings with excellent resistance to foaming during application as well as good corrosion resistance of the applied coating. These new water-emulsion coatings also offer faster cure times, longer pot life, improved resistance to yellowing and better gloss retention. With these capabilities, water-emulsions have been a popular choice for the automotive, plastic and business-machine industries.

Water-soluble coatings are different from water-emulsion coatings in that the spherical

shaped particles in these formulations (called colloidal dispersion polymers) are smaller and swell in water. As a result, the molecular weight of film formers in a water-soluble coating falls between those used in an emulsion polymer and those in a true solution. Colloidal-dispersion polymers have characteristics of both emulsions and solutions, resulting in a coating that is easy to apply and provides good gloss, durability, water and chemical resistance. Given these properties, it is most often specified for industrial product finishing applications.

The third type of waterborne coating is the water-reducible coating. Under the microscope, water-reducible coatings look quite different from water-soluble and water-emulsion coatings. With water-reducible coatings, copolymers are formed by polymerization reactions similar to those in organic solvents such as alcohols or esters. There are no discrete particle formations, and unlike water-emulsion polymers, the viscosity and properties of these coatings depend on the molecular weight of the film formers. These coatings are tough and durable, although chemical resistance is not as high as that produced by water-emulsion and water-soluble coatings.

### What the Future Holds

Research and development continues to offer finishers a wide range of coatings to meet a variety of needs on the production line, as well as customer demands. Advances in waterborne technology will continue to provide coatings that meet and exceed VOC compliance while providing improvements in application and performance. The same positive outlook is there for high-solids coatings.

The goal is to eventually obtain a 100% solids formulation with no VOCs. Although these formulations have been achieved by UV-cure products, manufacturers are working to achieve 100% solids coatings that can be cured by conventional baking systems. Finally, solvent-borne coatings have continued to evolve into ultra-low VOC baking enamels that emit less than one lb of VOCs and still provide excellent benefits.

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