Secrets of the art: Formulating architectural coatings

From *JAC*, March/April 2010

More items for **Coatings Technology**

The best recipe demands good ingredients and a talented chef

By Vincent Genova
Kalcor Coatings

A PAINTSQUARE EXTRA from jacjournal.com

A cookbook is only as good as its worst recipe.

–Julia Child

Each week, the Food Network program, "Chopped," pits four professional chefs against each other by challenging them to create menus from the same basket of ingredients. Invariably, one chef prepares a spectacular dish while others fail to impress the judges.

A good cook knows just what ingredients combine for a perfect meal.

What seems to set the victor apart from the also-rans is not technique, or experience, but vision, and a talent for understanding subtle way that one ingredient affects another.

So it is with paint and coatings formulators. From the same laboratory shelf of pigments, resins and additives, one chemist often creates a coating with beautiful cosmetics and durability while another formulation misses the mark.

And a good paint formulator achieves the same feat with the right selection of resins, pigments and additives.

Taking the analogy a bit farther, on the show Top Chef, yet another twist is added to the cook-off as chefs are given only a paltry budget to shop for their own ingredients. This same constraint on cost is often a reality for paint formulators as well. Not only do the customers require affordable coatings to remain competitive in their own industry, but the paint company needs to also make a profit to stay in business. So the trick is to optimize the coating for the application; to not fall short of the specification but not to over-engineer the material either.

In our view as coatings formulators and manufacturers, the best results are achieved by combining the right ingredients for each coating application. In this article we examine a process of selecting the right resin, the right pigment, and the right additives to create the right paint. These approaches apply to both factory- and shop-applied architectural coatings and field-applied coatings, and many of the same principles and concepts also are relevant to protective coatings.

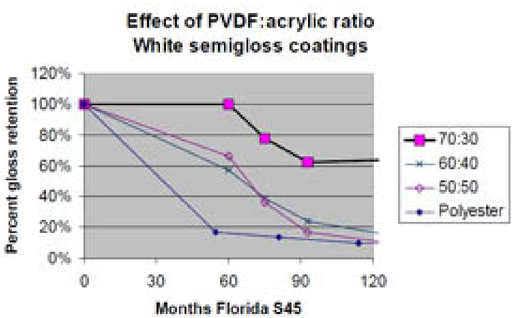
The right resin

The major criterion that sets architectural paints and coatings apart from many other applications is the requirement for exterior durability. The warranties offered by manufacturers to their customers can range from five, to 10, to 20 or more years. These expectations require a selection not only of resin systems, but of other ingredients such as pigments, which provide incredible long-term stability.

The choice of resin chemistry is fundamental to performance of architectural coatings. The right answer is frequently a custom blend of materials.

While fluoropolymer resin systems are often associated with coatings that demonstrate extreme durability, formulators have a number of options to consider. For example, urethane or urethane/acrylic dispersions might also be selected for architectural coatings needing five or 10 years of performance. But unlike their intrinsically more expensive fluoropolymer counterparts, these chemistries can be prepared in a very broad range of dispersions. One variety might be suitable for less demanding low-end materials, while another material might offer near space-age properties. The challenge facing the chemist is to formulate paint without over-engineering the coating by creating a product heavily weighted with a super-durable material when a more cost-efficient blend can meet the specification.

Once again, as in a food recipe, customers cannot expect champagne coatings on a beer budget. Frequently the right recipe calls for a resin, or system of resins that balance cost and performance by incorporating a primary resin and one or more co-resins. The primary resin is often selected chiefly for its weatherability or UV stability, while a co-resin may help the coating achieve some of the other required properties such as surface hardness or adhesion. Achieving the optimum balance of resin and co-resins is often the key to a coatings performance and its cost.



Getting the right blend is critical since it can have significant impact on performance and on price.

Resin selection can also have a direct impact on how easily the coating can be manufactured, since the resin system can have a significant impact on paint processing. Oil-free polyester and epoxy systems, for example, are notoriously difficult for the incorporation of pigments.

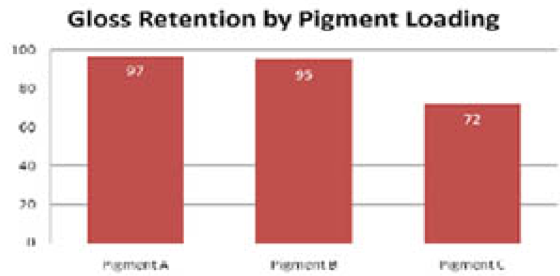
The right pigment

Since the human eye can detect even a slight variation in color—some say as slight as less than one "delta-E"—the uniform dispersion of the correct color pigments is essential to appearance. But "adding a little green" to the meal doesn't mean we are indifferent to the variation between mint and basil. Pigment chemistry can play havoc with coating chemistry if not selected correctly. To make this matter more complicated, pigments are frequently added not in isolation, but are commonly dispersed into binders so that even the right selection of pigment can be subverted by the interaction of the binder chemistry with other constituents.

The colorfastness, or long-term outdoor stability of pigments, is one of the chief concerns with formulating architectural coatings, but the formulation chemist must consider an extensive range of factors when selecting suitable pigments. These include:

- Lightfastness
- Heat stability
- Toxicity
- Staining
- Dispersability
- Opacity or transparency
- Resistance to alkalis and acids
- Reactions and interactions between other pigments, binders and additives

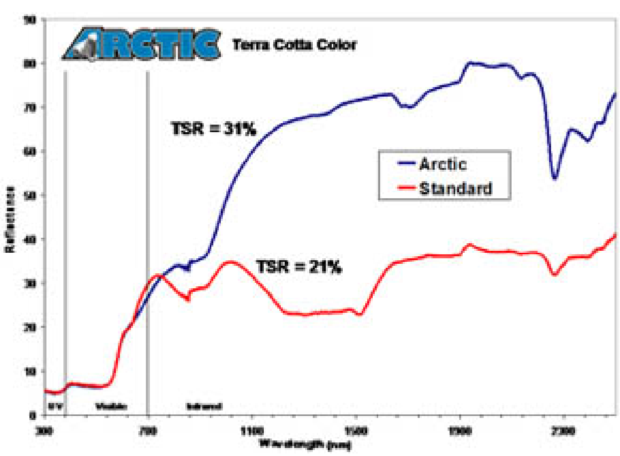
With pigments, as with other ingredients, the matter is complicated by the fact that the properties of the coating usually change with the amount of pigment added, or "loading." Pigment loading can cause a negative, unintended effect on characteristics such as gloss retention, surface hardness, and chip or scratch resistance. This makes finding pigments with enough color depth, opacity, and tinting power even more difficult when the loading must be constrained to low levels in order to achieve other physical properties.



While pigments are the key to color, too much pigment can have unintended effects on other coating properties such as gloss retention.

Formulated products can be metameric; that is, generate differences in appearance depending on the color, temperature, and nature of the light source. A perfect match under indoor lighting may appear off balance when viewed under sunlight. A good color match will hold up under a broad range of light sources.

Recently, the art and science of pigment selection has gone beyond the simply visible and into the unseen wavelengths of infrared light. With burgeoning interest in energy efficiency, a new breed of "cool coatings" that made their initial debut in the form of white, reflective roof coverings has expanded into "cool siding" and other building materials. In these applications, pigments are selected on the basis not only of appearance in the visible portion of the spectrum, but how they respond to invisible radiation from sunlight in the 1,000-2,000 nanometer portion of the spectra. Pigment materials such as carbon black and phthalo blue, longtime staples of pigment chemists, are characterized by poor solar reflectivity. In coatings where solar reflectivity is an important objective, these pigments are being replaced by newer mixed metal oxide materials that provide the same aesthetics but produce cooler surface temperatures as well.



More than meets the eye: new solar-reflective pigments provide cool surfaces by reflecting unseen IR wavelengths. This adds to color fastness and increases UV stability of the substrate itself.

Solar reflectivity is not just a matter of creature comfort, or even energy efficiency. Coatings commonly absorb energy that can be detrimental to the cured coating itself, resulting in fading and a loss of properties over time. Coatings designed with high solar reflectance provide longer service life and retain their appearance even when subjected to direct sun exposure. These highly relfective coatings also provide protection of the underlying substrate.

Today's pigments for are becoming increasingly sophisticated in other ways, such as producing special effects along with high performance. New-generation architectural coatings, for example, allow designers to achieve a weathered look. Controlling coating gloss, particularly on plastics, produces a less "plastic" look and increases curb appeal by conveying the appearance of a natural material such as wood or masonry.

Just as coatings allow plastic to look like chrome-plated metal in kitchen, bathroom, or automotive components, the coating of plastics to resemble a number of other natural materials opens up new markets while providing customers with the most cost-effective and durable technologies available.

The right additives

While two or three main ingredients make up more than 90% of the weight of most paint formulations, it is the choice of the remaining additives; "the secret ingredients," that frequently make the difference between coating success and failure. This is why the "starting formulae" provided by most raw-material suppliers is not threatening to a coating chemist's livelihood, since it is the selection and proper balance of these additives that can result in the best coatings.

Additives play a key role in tuning the properties of coatings in the areas of:

- Adhesion
- Hardness
- Ease of application (e.g. flow and leveling)
- Gloss control
- Processing/pigment dispersion
- Mar resistance
- Cleanability

Crosslinking agents are sometimes used to augment performance properties or shorten the handling and packing times of coated products. For enhanced exterior durability, a variety of additives can be incorporated, including UV absorbers and stabilizers, micronized titanium dioxide, and antioxidants for reducing the effects of thermal degradation.

While resins and pigments are the basic building blocks of any paint or coating, the choice of additives is often dictated by unique requirements of each specific application. For example, flow additives based on silicones, acrylics, and fluoropolymers help aid the wetting properties of the coating and provide surface-tension modification to help prevent craters and fisheyes in solvent-borne coatings. Thus, formulating a coating to be used for the complex extruded profiles common to window trim components requires the chemist to ensure easy and uniform flow in a vacuum coater. Improper rheology can prevent the application of an even coating film, and excessive foaming in the chamber can produce defects and interfere with production. Coatings for cement block, on the other hand, require superior penetration.

Coating intricate extrusions like this window component, requires that paint be formulated for vacuum coating—providing the rheology needed for uniform coverage.

Particle-size control helps maintain the needed opacity required for good hiding at acceptable coverage rates. At the same time, the coating needs to be permeable, providing a moisture barrier while at the same time allowing the substrate to breathe.

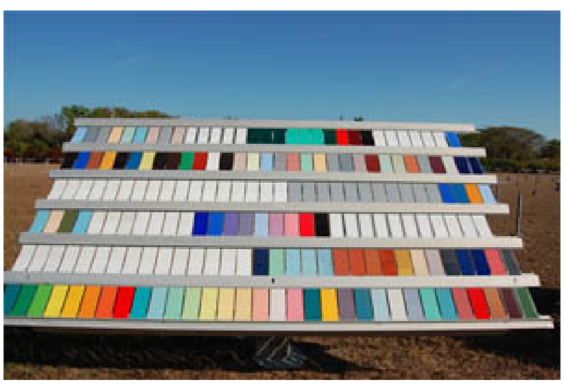
Other additives are intended to enhance product properties during building-component installation or to aid in coating application. These might include additives that provide chip resistance during siding installation, or a solvent combination that facilitates wetting and reduces premature drying are.

The role of proper solvent packages in water-borne coatings is particularly critical, since a coalescent solvent helps melt the resins together so they aggregate and form a continuous film. The proper mixture softens the resin as water evaporates, facilitating optimal film formation.

Siding coatings can be formulated for chip resistance—not for the product's use, but to reduce damage during the installation process.

Other additives are selfishly, though necessarily, chosen for their impact on making the paint easier to manufacture. Dispersants are commonly added to help in the effective dispersion of pigments in processing .Defoaming agents are important ingredients in the manufacture of water-borne materials. It does little good to formulate with additives that are shear-sensitive to the mixing apparatus needed to blend the paint. The laboratory technician must be capable of "scale up" in the same way a chef must take into account that creating a recipe that cannot be reproduced is not helpful. Often this requires a formulation that includes the preparation of intermediates. Master cuts, or intermediates, can provide a cost-effective means of making the large batches common in architectural-coatings production.

The seasoned formulator must keep in mind not only the performance specifications for each coating, but augment this with a realistic view of other customer expectations such as ease of application and "user friendliness." The final coating is not necessarily a masterpiece along the lines of a culinary creation, but a high-performance product designed for mass consumption. In addition, architectural coatings are subject to storage, application, and curing conditions that are far from ideal and often unpredictable. Formulating for flow and leveling, and anticipating spray characteristics in the development of rheology make the coating usable. Much attention is given to creating a broad viscosity profile; anticipating issues with shear during onsite preparation is well advised. Providing adequate wettability, along with a slow enough dry time to prevent drying of the paint on gun tips during application can serve as the final flourishes to an expertly devised and constructed architectural coating.



Trust, but verify. This holds true for coatings as well, since most architectural coatings carry a high risk of failure.

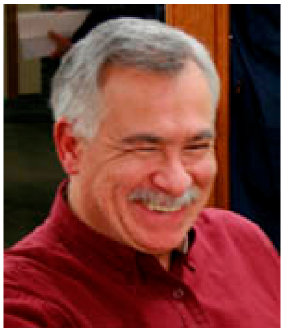
Finally, to quote an old saying, "never trust a skinny chef." Those involved in the high-stakes world of architectural coatings realize that the customer site is the wrong venue for evaluating their chemistry. Accelerated weathering, alongside actual outdoor weathering in harsh environments such as South Florida to obtain exposure data is a prerequisite for developing paints that must provide years of service under harsh environmental conditions. Of course, some of this evaluation is made easier by formulating with materials to which the resin and pigment suppliers have also committed resources to testing. But since the final composition may be affected by interactions that are impossible to predict, there is no shortcut to testing these fully formulated coatings.

As Julia Child observed...

A cookbook is only as good as its worst recipe.

A good formulator knows the limitations of his ingredients, and the failure modes to be on the lookout for. There is no substitute for expertise and experience.

About the author



Vince Genova is technical director at Kalcor Coatings Company, based in Willoughby, Ohio. He has 30 years of experience in the coatings industry and has previously held technical-management positions with NPA Coatings, Aexcel Corp., and Cansto Coatings. He has a BS degree in polymer engineering from Case Western Reserve University.

Kalcor is a manufacturer of custom coating products for the architectural, industrial, automotive, and graphic-arts industries. The company offers a range of solvent-borne, water-borne, and UV formulations for building products; meeting the rigorous demands of roof, siding, window, door, and concrete applications.

Acknowledgements

The author wishes to gratefully acknowledge the contributions of Jerry Petersheim of Arkema Inc., and Terry Sliwinski and Ken Looey of Ferro Corp., for their input and generous contributions to this article.

For more information about custom paint formulation contact Kalcor Coatings 440-946-4700

Of contact the author, Vince Genova at vgenova@jkalcor.com