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Architectural Applications for Liquid and Powder Fluoropolymer Coatings: *An Objective Review*

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In the United States, liquid fluoropolymer coatings have long been the product of choice among architects for curtain walls, commercial windows, building panels and other architectural elements. In recent years, however, an increasing number of practitioners have begun to consider the merits of powder coatings for these types of applications, thanks mostly to their inherent environmental advantages.

The following pages review the advantages of liquid and powder coatings by comparing their respective protective and decorative properties, as well as their environmental attributes.

KEY FINDINGS:

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Environmental Considerations

Powder coatings are made without solvents. As a result, they emit virtually zero volatile organic compounds (VOCs) when they are manufactured or factory-applied to a metal substrate.

Liquid coatings, on the other hand, do contain solvents and, consequently, emit VOCs. In North America, applicators have overcome VOC emission challenges by incinerating the VOCs emitted in production, using the emitted solvents to fuel production. While this process is efficient, it still requires the consumption of natural gas and emits CO_2.

Powder coatings have other environmental advantages. For instance, there is less waste in the application and recovery of powder coatings, which helps to make them more efficient and sustainable.

Powder coatings require less transportation energy than liquid coatings, which are manufactured and shipped in liquid (solvents), adding to their mass and weight. This has obvious implications for packaging and shipping, and adds to the amount of energy needed to get liquid coatings from the factory onto the finished metal.

For these reasons, powder coatings, when used in the right applications, are generally considered to be a better environmental choice than liquid coatings.

For some applications, however, the answer is not quite so definitive, particularly when issues such as long-term durability and corrosion are factored in. As a result, the best way to determine the most sustainable coating choice for a particular project is to solicit information and recommendations from coatings manufacturers' architectural specialists.

Performance Requirements

In the United States, the prevailing performance standards for aluminum extrusions are defined by the American Architectural Manufacturers Association (AAMA). Three voluntary specifications apply: AAMA 2603, AAMA 2604 and AAMA 2605. Each establishes minimum performance criteria for chalk resistance, fade resistance, color fastness, color retention, gloss retention, erosion and other factors. AAMA 2605, the highest of these standards, is the most specified and installed standard for monumental and commercial construction applications in North America.

In North America, specifiers face little risk when specifying fluoropolymer high-performance liquid coatings. Not only do these products consistently meet the AAMA 2605 standard, they also have a proven track record of durability and performance in the harsh, UV-intense climates of the southern and southwestern U.S.

Historically, powder coatings formulated in Europe have been unable to meet these more exacting AAMA 2605 standards, which encompass the famously rigorous "South Florida" test for UV exposure.

In recent years, however, a new generation of North American-manufactured powder coatings have been designed to meet the performance criteria of AAMA 2605. These coatings are based on the superior fluoropolymer resin technology and pigmentation of liquid coatings, which have delivered decades of proven performance in North America.

Despite these advances, the relative lack of AAMA 2605-rated performance, along with warranties that are less robust than those from liquid coatings manufacturers, has made North American architects reluctant to specify powder coatings for commercial construction projects.

Nevertheless, architects and building owners who want the sustainability advantages of powder coatings can largely reduce their perceived risk by specifying powder coatings certified to the AAMA 2605 standard and sourced from manufacturers with long-term pigment and resin exposure data.

Corrosion in Seacoast Environments

Performance requirements for coatings in seacoast environments are even more stringent than those for normal environments. This is due to the increased risk of corrosion from humidity, salt, wind and other factors. While current AAMA standards address finish properties as they relate to weathering, they do not adequately address seacoast performance considerations.

Commercial construction is booming along North American seacoasts as populations continue to migrate to those areas. This has forced specifiers and coatings manufacturers to develop more robust liquid and powder coatings technologies.

Pretreatments are another important part of the equation when specifying coatings systems. Thus far, chromium pretreatments have proven to provide the most effective protection of aluminum in seacoast environments. Unfortunately, these products have environmental drawbacks. As a result, the industry is working vigorously to develop alternative pretreatments that effectively protect metal.

Until these pretreatments are developed, chromium pretreatments remain the best option for seacoast environments because they help limit the high cost and negative environmental impacts associated with repeated field application of coatings.

European vs. North American Coating Practices

Powder coatings have been the preferred coating for aluminum substrates in Europe for decades. In North America, on the other hand, liquid coatings have been the norm, due to differing standards of quality, specification practices and supply chain infrastructure.

European architectural powder coatings are made from a chemistry that does not meet AAMA 2605 requirements. Polyester formulations made in Europe meet a European standard (Qualicoat) that is not recognized as a standard of quality in North America. In fact, powder coatings that meet the highest Qualicoat standard in Europe are similar in quality only to AAMA 2604 standards. The highest Qualicoat standard requires less exposure to the elements, and also calls for routine washing of all exterior metal building components, an expensive proposition for North American building owners.

Because of this significant difference in standards, most European extrusion coatings infrastructure is dedicated to the application of powder coatings. In North America, most finishing capacity in the construction market is dedicated to the application of liquid coatings. However, the recent construction boom in North America has challenged the industry to expand capacity to meet growing demand in both residential and commercial construction. As manufacturers and outsourcers have expanded, they have continued to add liquid and powder coating capacity to meet both market and environmental demands.

Differences in climate, standards, and design practices complicate the simple argument that if powder coatings work in Europe, they can also be used in North America. Due to the factors outlined above, wholesale change is simply not likely. Instead, it appears that next-generation powder coatings, formulated to reduce risk and meet market demands in North America, will complement existing and new advanced liquid coating technologies.

Appearance-Color, Gloss and Metallic Effects

In terms of color, the manufacturing of powder coatings is more restrictive than the production of liquid coatings. This gives liquid coatings a distinct advantage in the North American market, where architects demand color customization, immediate sample production, faster delivery to applicators and the ability to order small, economical batches of customized coatings for their individual projects.

Unlike liquid coatings, whose colors can be adjusted easily and efficiently during the blending process, color formulation and matching with powder coatings is significantly more cumbersome. This is mainly due to the manufacturing process.

Powder coatings are made by melting raw materials (resins, pigments and additives) together, then cooling and extruding the mixture into chips. These chips are ultimately ground into a fine, finished powder coating. Until the powder coating reaches this final form, it is impossible for the manufacturer to determine the exact color of the coating it just created.

If the specifying architect determines the color is wrong or does not meet its intended match, the process has to be repeated, often several times, until the final, desired color is achieved.

Another advantage liquid coatings have over powder coatings is the ability to achieve bright metallic finishes using aluminum flakes. In North America, architects have a stronger affinity for bright, shiny metallic effects than their European counterparts.

While architectural powder coatings can be formulated with mica to produce a metallic effect, they are not currently available with the brightest aluminum flakes. Aluminum flake metallics also require a clear coat not currently available in architectural-grade powder coatings.

Powder coatings manufacturers in North America and around the world are moving aggressively to address the perceived color limitations associated with their products. In the meantime, they have adopted two strategies aimed at increasing the appeal of their products.

The first is to offer a limited range of standard colors, an option that remains less appealing to architects who are accustomed to specifying colors on a project-by-project basis.

The second, and most promising going forward, is the development of sophisticated custom-color and small-batching capabilities. In fact, several innovative multi-technology (liquid and powder) providers already match powder coatings colors to their liquid coatings color palette (sans metal flakes), offering architects instant access to a rainbow of color choices.

To meet the needs of accelerated construction calendars in North America, some progressive manufacturers also are allowing architects to use liquid coatings samples during the color selection phase; then producing powder coatings samples for use in the final color approval process. This gives North American architects even greater freedom in choosing between liquid and powder coatings.

While powder coatings are closing the gap, liquid coatings still retain a significant advantage when it comes to custom color, speed and bright metallic effects. Because design and customization remain paramount in North America, it is likely that the introduction of powder coatings for monumental and commercial architectural applications will complement, but not replace liquid coatings, in the foreseeable future.

Hardness

The reluctance of North American architects to specify powder coatings for large expanses of architectural metal belies their well deserved reputation for hardness and durability. Coatings of this type are widely used in the appliance and automotive industries, as well as on lawnmowers, mountain bikes, motorcycles, farm equipment, patio furniture and other well-worn items.

In residential applications, powder coatings are used for metal components such as window frames, door frames and railings.

The hardness of powder coatings is due to the raw materials used in their manufacture. Because they must be solid at room temperature, the resins used in powder coatings are simply heartier than those suspended in their liquid counterparts. As a result, powder coatings naturally produce thicker film builds that are harder and, therefore, more resistant to scratches, mars, erosion and other detriments associated with high-touch, high-traffic applications.

These characteristics are important for commercial architectural applications where the public is in direct contact with the finish. Storefronts, railings, hand-rails, fencing, door frames, crash bars, and commercial windows are all applications where the hardness of powder coatings can be advantageous. When coatings are used for monumental and commercial building applications above street level, however, these advantages are considered less important.

Cost

Cost considerations are critical to any material selection decision in construction. A final cost comparison of installed powder and liquid fluoropolymer coatings is a function of several factors. While there are potential manufacturing, production and shipping cost advantages for powder coatings, they can sometimes be offset by application and other cost advantages associated with liquid coatings.

In the end, actual installed cost is a function of variables such as job size, recyclability, geographic location and the dynamics of an ever-changing competitive bidding environment. Market conditions and pricing through the entire value chain is difficult to predict with accuracy.

The best way to obtain competitive bids without adding undue risk to a project is to work with a coatings manufacturer that produces both liquid and powder coatings and who has an established program to approve and certify coatings applicators.

While the increased adoption and capacity for powder coatings in North America are clearly making them a more viable option in commercial construction applications, the only way to get a true installed cost comparison is to solicit competitive bids for a project.

Conclusion

This is an exciting time of change in the world of architecture. The explosion of green construction practices and globalization have increased awareness of powder coatings as a viable option to coat architectural aluminum in the North American market.

Although powder coatings have been used in Europe for decades, the construction practices, specifications and requirements, maintenance practices and litigious environment are significantly different in North America.

These differences have led some market leaders to seize the opportunity to develop a new generation of powder coatings that quench the thirst for greener products, while reducing specifiers' risk by offering chemistry and pigmentation technologies already proven in North America.

Due to the design preference for bright metallics, custom batch and color requirements, and the existing coatings application infrastructure, it is unlikely that powder coatings will replace liquid coatings in the North American architectural market. However, thanks to their environmental advantages and increasing manufacturing flexibility, they will continue to strengthen their position as a complementary product to liquid coatings, increasing the range of design and technology choices available to North American architects.

The expanded range of coatings choices presents new challenges to architects, specifiers and curtain wall consultants. The two tables that follow outline general guidelines to consider when comparing coatings technologies. Even with these guidelines, the decision about which technology to actually employ for an individual building project can be difficult. Ultimately, the best solution is to engage a coatings company that manufactures both liquid and powder coatings, and that can offer expert advice based exclusively on your critical project needs.

Table 1: Advantages of Liquid and Powder Architectural Coatings Designed to Meet AAMA 2605 Performance Criteria

	Liquid Coating	Powder Coating	Comments
Emissions	–	+	Powder coatings have no VOC. (~1% volatiles, ½ H_2O)
Waste	–	+	Powder coatings produce less waste during application.
Energy Use	–	+	Can be 30% less than liquid
Film Builds	+/–	+/–	Powder can be applied at higher film builds than liquid. Although this is a benefit from a surface protection standpoint, it needs to be considered in engineering and fabrication process.
Appearance	+	–	Liquid coatings can be smoother than powder coatings, which exhibit some fine "orange peel" effect. Although orange peel has been minimized in modern formulations, liquid can still achieve a smoother finish. Slight textures can minimize surface imperfections.
Material Transfer/Use	–	+	Both technologies use electrostatic application techniques. Powder coatings have no solvents that evaporate during application like liquid coatings. Powder use can offer over 95% transfer efficiency when powder overspray is recovered for re-use on large runs with standard colors.
Metallic Colors	++	–	Bright metallic color based on aluminum flake is better in liquid technology. Powder metallic looks are available using mica effect pigments.
Corrosion Resistance (seacoast environments)	+	–	Single coat powders on aluminum are susceptible to filiform corrosion in industrial or marine environments. Multi-coat powder or combination systems show promise, but need a track record as technology develops.

Table 2: Substrate and Environmental Recommendations for the Use of Architectural Liquid and Powder Coatings in North America

	Liquid Coating	Powder Coating	Comments
Curtain Wall - Commercial Buildings	+	+	For normal commercial applications both liquid and powder coatings offer benefits.
Curtain Wall - Monumental	++	+	Liquid coatings have a proven track record in North America on monumental buildings and proven seacoast performance.
Commercial Windows	+	+	Commercial windows are excellent for both liquid and powder applications. Liquid offers the ability for fast color change, while powder offers more mar resistance for projects with more street level windows, or in high-touch environments like retail and institutional applications.
Storefronts	+	++	Powder offers more mar resistance for storefront situations. Liquid offers brighter metallics.
Handrails, Railings, Fencing	–	+	Powder's limited palettes compared to liquid are outweighed by efficiencies and wear. Powder is better for this use when there are large runs of standard colors. For small batch custom work, consider liquid for quick turn-around (or standard powder colors).
Residential Windows	+	+	Some high end residential windows use AAMA 2605 coatings. Powder can offer environmental benefits, and efficiencies, while liquid offers more color options.
Seacoast and Industrial Environment	++	–	Liquid coatings with chromium pretreatment and chromium primers offer the best proven seacoast performance. Powder technology is not as advanced as liquid systems to date, but emerging technologies look promising.
Architectural Accents, Column Covers, Street Lamps, Flag Poles, etc.	+	++	Powder edges out in mar and hardness, but liquid offers more design options. Look for new looks and designs in the future for both liquid and powder technologies.

PPG is a global supplier of liquid and powder architectural coatings that meet all quality standards and specifications. For more information on PPG liquid and powder architectural coatings, call our architectural specialists. As a supplier of both technologies, PPG technical personnel are uniquely qualified to help you evaluate your individual project needs to make the best decision between liquid and powder technology based on design, environmental, performance, and supply chain considerations.

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