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Architectural Applications for Liquid and Powder Fluoropolymer Coatings: *A Comparative Review*

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In North America, liquid fluoropolymer coatings have long been the product of choice among architects for curtain walls, commercial windows, building panels and other architectural elements. This is due largely to their superior custom-color and small-batching capability.

These advantages have prevented powder fluoropolymer coatings from gaining significant market share for architectural applications in North America. That may be about to change. A new generation of powder fluoropolymer coatings is emerging that may give architects the small-batch, custom-color capability of liquid coatings together with the ultra-low VOC application benefits of powder.

The following pages review the merits of three major coating types – liquid, conventional powder and next-generation powder – so that architects and building owners can gain a full understanding of their respective protective, decorative and application properties.

KEY FINDINGS:

There are unique benefits associated with liquid and powder coatings for architectural metal. This paper identifies the aesthetic, performance and environmental attributes of current liquid and powder coatings and the next generation of fluoropolymer powder coatings.

The Role of Metal Coatings in Green Building Construction

In the United States, green building, led by the U.S. Green Building Council (USGBC) and its *Leadership in Energy and Environmental Design* (LEED) Rating System, has transformed the construction industry.

Governmental mandates, combined with other incentives offered by economic development agencies, utilities and other related entities, is motivating near-universal acceptance of green building practices and products, not just in new construction, but for major renovation and renewal projects as well.

Obviously, metal coatings play an integral role in contemporary building design and construction. Understanding their enviromental impact involves a wide array of factors related to their formulation, and where and how they are applied.

Consider volatile organic compounds (VOCs). Because powder coatings lack solvents, they emit zero VOCs. Liquid coatings are made with solvents that contain VOCs, but their VOC content is off-gassed and cured at the factory before arrival on the building site.

Where coatings are applied also is important. Metal coatings are typically applied to the exterior surface of a building, outside the weatherproofing membrane. Because exterior coatings are not directly exposed to building occupants, there is no associated health or environmental impact. As a result, they are not considered in LEED ratings except for possible *Innovation in Design* (ID) credit, as noted below in the *Credit Interpretations and Rulings* (CIRs) section of the USGBC web site:

- *There are no LEED VOC limits for factory- or shop-applied paints and coatings. A project that requires shop-applied paints and coatings to also meet* Green Seal *requirements could apply for an* Innovative Design *(ID) credit for Exceptional Efforts regarding Environmental Quality. Otherwise, anti-corrosive paints that meet the requirement of 250 g/L will satisfy the LEED requirement.*

The following link on the USGBC web site identifies CIRs as they apply to factory-applied metal coatings: http://www.usgbc.org/LEED/Credit/CIRDetails.aspx?RequirementID=57. For more information, contact the USGBC or your coatings manufacturer.

Comparing Liquid and Powder Coatings: Other Environmental Considerations

As mentioned earlier, powder coatings are made without solvents. Consequently, they emit ultra-low levels of VOCs when they are manufactured and factory-applied to a metal substrate.

Liquid coatings, on the other hand, do contain solvents and, consequently, emit VOCs. In North America, some applicators have overcome VOC emission challenges by incinerating the VOCs emitted in production. While this process is efficient, it does emit carbon.

Powder coatings have other environmental advantages. For instance, there is less waste in the application and recovery of powder coatings, which may make powder coating production lines more efficient.

Powder coatings also require less manufacturing and transportation energy. Liquid coatings are manufactured and shipped in solvents (liquid), which adds 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 on to the finished metal.

For these reasons, powder coatings, when used in the right applications, are generally perceived to be more environmentally progressive than liquid coatings.

For some applications, however, the answer is not so definitive. The best way to determine the most sustainable coating choice for a particular project is to solicit recommendations from coatings manufacturers who sell both liquid and next-generation powder coatings.

Next-Generation Powder Coatings Meet AAMA Standards

In North America, the prevailing performance standards for aluminum extrusions are defined by the American Architectural Manufacturers Association (AAMA). Three voluntary specifications apply: AAMA 2603-02, AAMA 2604-05 and AAMA 2605-05.

Each establishes minimum performance criteria for chalk resistance, fade resistance, color fastness, color retention, gloss retention, erosion and other factors. AAMA 2605-05, the highest of these standards, is the most specified for monumental and commercial construction applications in North America.

In North America, specifiers face little risk when specifying PVDF-fluoropolymer, high-performance liquid coatings, particularly when they are manufactured by a company with a long tenure of formulating coatings with durable pigments. Products from these companies consistently meet the AAMA 2605-05 standard and have a proven track record of durability and performance in the world's harsh, UV-intense climates.

Historically, powder coatings formulated in Europe have been unable to meet these more exacting AAMA 2605-05 standards, which encompass the rigorous "South Florida" test for UV exposure. Although, many coatings manufacturers claim to have products that meet AAMA 2605-05 specifications, not all are able to produce the mandated 10-year "South Florida" exposure panels.

With the next-generation of powder coatings, that problem has been solved. These products incorporate the proven pigmentation and resin technologies of existing PVDF-based fluoropolymer liquid coatings. As a result, architects and building owners who want the advantages of powder coatings can reduce risk and uncertainty by specifying powder products manufactured to meet AAMA 2605-05 performance criteria, and by sourcing them from manufacturers with long-term pigment and resin exposure data.

Corrosion Performance 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. The current AAMA 2605-05 standard addresses finish properties as they relate to weathering, but they do not address seacoast performance considerations.

As the U.S. population migrates to coastal areas, the coatings industry will increasingly confront the corrosive effects of salt on aluminum. Pretreatments are an important part of this equation.

Thus far, traditional pretreatments have provided the most effective long-term protection of aluminum in seacoast environments. Until proven new pretreatments are developed, they remain the best option to limit the high cost and environmental impacts associated with repeated field application of (failed) coatings caused by inadequate pretreatment.

Film permeability is another critical difference between liquid and powder coatings. As a general rule, liquid coatings are made with thinner film builds. That makes them less vulnerable to seacoast corrosion than traditional powder coatings because moisture is less likely to become trapped under the finish and contribute to corrosion. For that reason, next-generation powder coatings, like their liquid counterparts, are applied as part of a multi-coat system that features an extremely corrosion-resistant base coat and allows for a much more consistent film build.

Corrosion resistance is particularly important for metal curtain wall and window systems. Their components are typically fabricated from pre-coated extrusions. As a result, when these products are installed, their edges often are cut, which exposes the underlying aluminum and makes it susceptible to salt-related corrosion.

Next-generation powder coatings have corrosion resistance equal to conventional multi-layer liquid coatings. Traditional single-coat powder coatings, especially when combined with non-proven pretreatments, are more susceptible to failure in seacoast applications.

European vs. North America Coating Practices

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

In Europe, architectural powder coatings are typically not formulated to meet AAMA 2605-05 requirements. Polyester formulations made there meet a local 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 2604-05 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 coating infrastructure is dedicated to powder coatings. In North America, most finishing capacity in the construction market is dedicated to liquid coatings, although many North American finishing companies have added powder capabilities.

Next-generation powder coatings complement existing liquid coating technologies and are formulated to reduce risk and meet market demands in North America.

Next-Generation Powder Coatings: Expanded Appearance Options for Color and Pearlescent Effects

Color restrictions have always been a major drawback for traditional powder coatings. This is due mainly to their manufacturing limitations.

Traditional powder coatings are made by melting raw materials (resins, pigments and additives) together, then cooling and extruding the mixture into chips. The chips are then ground into a fine finished powder coating that is sprayed on to a metal substrate. Unfortunately, until that entire process is complete, it is impossible for a powder coatings manufacturer to determine the exact color of the coating it has just created.

If the specifying architect determines that 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.

Next-generation powder coatings overcome these limitations with new processes that allow manufacturers to produce color at the speed of design. They also make it easier and more affordable to generate small batches of custom colors.

One advantage liquid coatings retain over powder coatings is the ability to achieve bright metallic finishes. While architectural powder coatings can be formulated with mica to produce a pearlescent effect, they are not yet available with the brightest aluminum flake, which demands a particular kind of clear coat not currently compatible with architectural-grade powder coatings.

This is significant in North America, where architects have a strong affinity for shiny metallic effects. Nevertheless, innovative powder coatings manufacturers in North America are effectively addressing these perceived color limitations.

Hardness

Powder coatings have a well-deserved reputation for hardness and durability. They 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.

For this reason, powder coatings are preferred for metal coatings that will be in direct contact with the public. Window and door frames, storefronts, railings and fencing are common architectural applications where the hardness of powder coatings is beneficial.

Next-generation powder coatings combine the hardness of conventional powder with the long-term durability of PVDF coatings.

Cost

Cost considerations are critical to any material selection decision. A final cost comparison of installed powder and liquid fluoropolymer coatings must weigh several factors. While there are potential manufacturing, production, transfer efficiency and shipping cost benefits for powder coatings, they can sometimes be overridden by application, color and other cost advantages associated with liquid coatings.

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

The best way to obtain competitive bids without adding undue risk 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. Certified applicators generally deliver the highest quality because their training and standards minimize pre-treatment and application variability, a problem often associated with job shops unfamiliar with commercial construction projects.

Conclusion

This is an exciting time of change in the world of architecture. The explosion of green construction practices and globalization have increased demand for powder coatings as a viable metal coatings option.

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 inspired market leaders to develop a new generation of powder coatings that quench the thirst for greener products and reduce specifier risk through chemistry and pigmentation technologies proven in North America.

Due to the design preference for bright metallics and the existing coatings industry infrastructure, it is unlikely that powder coatings will ever gain the same level of market acceptance in North America that they enjoy in Europe.

However, thanks to their environmental advantages and their expanding color and small-batch capabilities, the next generation of powder coatings is likely to emerge as a popular complementary product to liquid coatings in North America.

General Coatings Selection Guidelines

Greater choice is good news for architects, specifiers and curtain wall consultants, but it also presents new product selection challenges. The two tables that follow outline general guidelines to consider when comparing coatings technologies. Even with these guidelines, the decision about which technology to employ for an individual building project can be difficult. Ultimately, the best solution is to engage a company that manufacturers both liquid and powder coatings, and that can offer expert advice based exclusively on your project.

Table 1: Advantages of Liquid and Powder Architectural Coatings Designed to Meet AAMA 2605-05 Performance Criteria

	Liquid	Standard Powder	Next-Gen Powder	Comments
Emissions	–	+	+	Powder coatings have ultra-low VOC. (~1% volatiles, ½ H_2O)
Waste	–	+	++	There is no booth sludge for next-generation or conventional powder coatings. However, coarse particles cannot be recycled and require non-hazardous disposal.
Energy Use	–	+	+	Can be 30% less than liquid.
Film Builds	+/–	+/–	++	Conventional and next-generation powder can be applied at higher film builds than liquid. Next-generation powder enables superior film build control.
Appearance	+	–	+	Liquid and next-generation powder can be smoother than conventional powder, which exhibits some fine "orange peel" effect. Although orange peel has been minimized in modern formulations, next-generation powder and liquid can still achieve a smoother finish.
Material Transfer/ Use	–	+	++	Liquid and powder coatings are applied electro-statically. Liquid coatings contain solvents that evaporate during application. New and conventional powders are solvent-free. Powder use can offer better than 95% transfer efficiency when overspray is recovered.
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)	++	–	++	Conventional single-coat powder on aluminum is susceptible to filiform corrosion in industrial or marine environments. Next-generation powder coatings are based on multi-layer systems and have corrosion resistance equal to conventional multi-layer liquid coatings.

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

	Liquid	Standard Powder	Next-Gen Powder	Comments
Curtain Wall - Commercial Buildings	++	+	++	For normal commercial applications, both liquid and powder coatings offer benefits.
Curtain Wall - Monumental Buildings	++	+	++	Liquid coatings have a proven track record in North America on monumental buildings and in seacoast performance. Next-generation powder is based on similar technology. Conventional powder may grow in this market as it becomes more proven in commercial applications.
Commercial Windows	+	+	+	Commercial windows are excellent for both liquid and powder applications. Liquid offers the ability for fast color change. Powder offers more mar resistance for projects with street-level windows or in high-touch environments like retail and institutional applications. Next-generation powder combines both.
Storefronts	+	++	++	Powder offers more mar resistance for storefront situations, where this is important. Liquid coatings offer brighter metallics when bright silvers are preferred.
Handrails, Railings, Fencing	–	+	++	Liquid coatings are ideal for small-batch custom work. Conventional powder has better efficiencies and wear, especially for large runs of standard colors. Next-generation powder combines both.
Seacoast and Industrial Environments	++	–	++	Multi-layer PVDF systems with traditional pretreatments offer the best seacoast performance. Conventional powder technology, applied by non-certified applicators using varying pre-treatments, are highly susceptible to corrosion in sea-coast environments.
Architectural Accents, Column Covers, Street Lamps, Lamps, Flag Poles, etc.	+	++	++	Powder edges out liquid in mar resistance and hardness, but liquid offers more design options. Next-generation powder offers the best combination of color options and durability.

PPG is a global supplier of liquid and powder architectural coatings that meet all quality standards and specifications. 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.

For more information on PPG coatings or to talk with a PPG architectural specialist, call **888-PPG-IDEA (774-4332)** or visit www.ppgideascapes.com

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