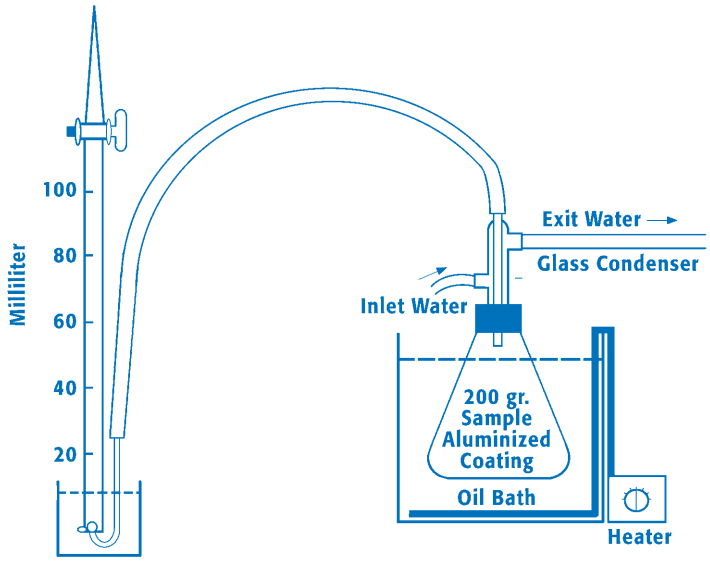
Surface-Treated Aluminum Pigments for Environmental Compliance

The coatings industry, as with most industries today, is continually challenged by many influencing drivers to change, modify and satisfy the continually evolving environment in which we live. Whether the change is driven by environmental requirements, performance, quality, or lower cost, we know one thing for certain — these changes will continue, and only those who are innovative will survive. Of course these challenges always have a "trickle down" effect, and raw material suppliers are not only impacted, but are expected to anticipate future needs, supplying new products well in advance of market requirements. The aluminum pigment industry recognizes many of these challenges and has responded very favorably in providing new products to support the changing face of the coatings industry.

Probably the most critical challenge for our industry has been the need to meet environmental regulations. Almost considered a survival need, many research hours and dollars have been spent in an effort to develop new and improved products to address local, regional and global needs. Not only are these efforts based on research leading to product improvement, but also countless improvements in pigment processing and production, which have been necessary to meet environmental objectives. Generally, the goal for environmental compliance is reduction of VOCs, either through the use of higher-solids systems, compliant solvents or water.

Figure 1/Gassing bath depiction.



Compliance Through Science

The aluminum pigment industry has addressed compliance through a science-based approach of understanding the chemistry of aluminum flakes and their interactions with various inhibiting agents. While the chemistry of these interactions is well known, there is still much to learn and understand about the effects when formulating into a waterborne coating system. One of the most well-known, but unwritten, laws involving aluminum pigment inhibition is that one technology is not universally acceptable for all systems. What works well in one system can sometimes be a very poor performer in another. It is for this reason that so many inhibition systems are currently in use.

Before discussing some of the current technologies, let's examine some basic compliance coating needs. The most basic of all needs is to maintain the aesthetic performance of the aluminum flake. In essence, the pigment must perform by offering a metallic effect very close, if not identical to, the parent grade. Another fundamental requirement for

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metallic waterborne coatings is low hydrogen gas generation. A typical accelerated gassing test (168 h @ 40 °C), which uses 200 cc of paint formulated with 8.0 g of aluminum metal, must yield well less than 10 mL of hydrogen gas. Figure 1 depicts a typical gassing bath test.

Additionally, the pigment must not affect the rheology, adhesion or any other performance parameter associated with the coating system. These can sometimes be very difficult goals to meet, depending on the inhibition chemistry in use. Beyond these performance goals, it is imperative that we meet system safety and health requirements. And finally, the technology must be cost effective!

Powder coatings-compliant systems are just as demanding, but with emphasis on different goals. Perhaps the two most important considerations for metallic powder coating performance are appearance and safety in use. Figure 2 illustrates a typical powder coated finish. Metallic flake orientation in solvent-borne systems is largely dependant upon solvent evaporation and film shrinkage. Additionally, traditional air-spray application assists in proper flake orientation of the flake. The lack of solvents in powder coating systems, coupled with their electrostatic spray application, create a double negative effect on how the flake orients. The second issue with metallic powder systems is one of safety. If properly handled and formulated, a metallic powder coating is no more explosive than a non-metallic powder coating. The concern is more with the handling and incorporation of the dry metallic flake. Finally, as with any other market, the compliance technology must be cost effective.

Figure 2/Powder-coated parts.

Aluminum pigment manufacturers have met these challenges, developing products to meet, and in many cases, exceed customer requirements. Let's examine where the technology has taken us.

Three Technologies

Early waterborne technologies were based on simple chemistry — usually involving addition of a special solvent or surfactant, with the primary goal of reducing gas generation. Effective only if the coating was formulated and applied quickly, they very soon gave rise to more effective agents based on phosphate chemistry. The level of gassing stability was enhanced, but often created other performance-related issues. As waterborne popularity grew, so did the effort to improve performance. Within the last decade, three technologies and their variants have come to the forefront. All are based on chemically altering the surface of the aluminum pigment. All have minimal if no effect on aesthetics, and offer excellent system performance.

Phosphosilicate chemistry (US Patent: 5,348,579) has become a pillar of inhibition technology for both general industrial and automotive waterborne application. This inorganic chemistry effectively inhibits the gassing reaction while having little or no effect on coating performance issues. Adhesion, whether inter- or intra- coat, is excellent as is system rheology. This inhibition technology is easily applicable to all grades manufactured and offers excellent dispersion properties in waterborne systems. The only potential negative associated with this technology is the possibility of slightly reduced metallic travel associated with high inhibitor levels used for finer grades. In most cases, this is almost imperceptible and of little consequence.

A very recent chemistry based on a modification of phosphonic acid is showing excellent overall performance for metallic systems. While phosphates and phosphites (defined as organic esters of phosphorous or phosphoric acid) have had some limitations due to gassing or adhesion, phosphonic acids (organic moiety is directly bound to the phosphorus by a C-P bond) have shown interesting improvements. Modification of this chemistry to avoid the aggressive potential for agglomeration has resulted in a technology that is very effective in reducing the gassing reaction while at the same time

Figure 3/Aquavet pellets.

maintaining waterborne system performance. One of the key elements in this chemical enhancement is the phosphonic acid neutralization chemistry employed. This inhibition technology has been combined with a low-VOC technology to form a solvent-free, pelletized pigment with excellent performance properties. Trade named Aquavet™, this pigment offers the essential elements desired by metallic waterborne coatings formulators. In addition to performance, this pigment contains no solvents, and the pelletized form is very easy and clean to handle and dispense, as shown in Figure 3. The utility of Aquavet is further enhanced by its quick and easy dispersion in water. The two innovations that have made this product a reality are the inhibition technology, which provides the inhibition performance, and the resin carrier (portion of the pellet), which substitutes for solvent, providing low VOCs, pellet integrity and easy dispersion in water.

The third inhibition chemistry evolved from the idea of "encapsulating" the metal flake, and thus protecting it from the environment. Among the biggest hurdles challenging the development of this technology is the potential for multiple flake encapsulation or agglomeration. Protecting metal flakes from the environment through a coating is a challenge; meanwhile, protecting discrete flakes from the environment is a considerably larger challenge. However, ensuring that discrete flakes are coated is critical for maintaining pigment appearance and performance. Utilizing pigment dispersion technology and highly controlled reaction chemistry, a unique pigment has been developed through the deposition of Silica onto the flake surface. This chemical reaction, bonding silica to the aluminum flake surface, results in a brand new generation of products that offer vastly improved performance properties.

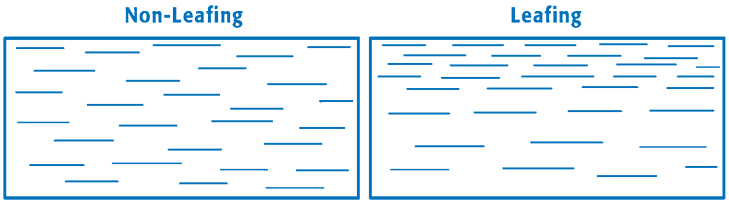
It may be presumptuous to assume that each individual flake is coated separately, however, from a performance standpoint, it is clearly seen that gassing reactivity is reduced to a level consistent with complete protection. Initial laboratory versions of this product were so promising in their performance that significant research time and effort has been dedicated to the development of further enhancements. Today, this product is being formulated into both industrial and automotive applications. Research on this technology continues in an effort to continually improve performance and cost features to meet and exceed customer expectations.

Because the coatings industry is taking a multipronged approach to meet environmental regulations, the aluminum pigment industry is doing the same. A second approach to compliance is removal of all solvents, resulting in powder coating systems. This coatings technology is believed to be one of the fastest growing markets today. Traditionally designed and used in general industrial coatings markets, their use is rapidly expanding, and automotive applications are now a reality. The ultimate goal, of course, is acceptable topcoat appearance, and even this is getting very close to reality. As mentioned earlier, the challenge in developing an acceptable metallic powder coating system is flake orientation and safety. Let's examine what aluminum pigment manufacturers are doing.

Safety

Safety has always been at the vanguard of aluminum pigment technology. In fact, every facet of our process is governed by safety. As such, most all manufacturers belong to organizations that closely watch, disseminate and share information on safe practices involving production of flake pigments. Two of the more prominent organizations are the Aluminum Association, Washington, D.C., and the European Aluminium Particulate Association. Just as we are concerned about our in-plant safety practices, we are also concerned about the way in which our customers use our products. The crucial user safety issues involve the handling and processing of dry aluminum flake. We strongly encourage proper handling and processing procedures to ensure a safe operation. As we are all aware, dry aluminum flake will have the potential for explosion if suspended in air with an ignition source present. While the opportunity for explosion is possible, it can be managed in a very safe and usable fashion. Today, thousands of pounds of dry metallic flake are successfully used and formulated on a daily basis. All aluminum pigment manufacturers offer guidance and assistance in the storage, handling, and

Figure 4/Aluminum pigment overview.



use of aluminum pigments and powders.

A Good, Metallic Appearance

The second metallic powder coating challenge is the development of a good metallic appearance. Flake orientation governs appearance, and with no solvents present and an application method not really conducive to good orientation, many early powder coatings systems had poor appearance. Recognizing the importance of solving or at least improving this property, aluminum pigment manufacturers began work on the development of surface treatment technologies as a potential solution. One of the early observations was that standard, untreated aluminum flake performed very poorly when formulated into powder coating systems. With this realization, much effort was placed on modifying the flake surface to improve appearance and performance. The theory behind surface treatments was to modify the flake surface in such a way as to make it react in a similar fashion to the powder resin — or make it more polymer-like. Out of this research program, two distinct technologies were born: one organic and one inorganic.

Several organic technologies are currently available on the market today. Those manufactured by Silberline are the result of a polymerization reaction of monomers, acrylic and others onto the flake surface. This process results in a finished product that exhibits some very unique properties, but most of all demonstrates excellent flake orientation in powder coating systems. The sheath of polymer surrounding the flake also provides improved acid, alkali and chemical resistance, along with improved adhesion and electrical resistivity. While all of these improvements may not be terribly important to a powder coatings manufacturer, they are symptomatic of a pigment that has had a significant change made to its surface chemistry. The leafing and non-leafing pigment alignment is illustrated in Figure 4.

The second surface treatment technology is based on inorganic silica chemistry. Very similar to the chemistry designed for water, this product also demonstrates significant improvements in appearance and chemical resistance. However, unlike the organic treated grades, this technology also possesses the unique property of degradation stability. The silica chemistry adds a degree of protection to the malleable flake, thus increasing its resistance to shear forces.

The concept of creating this organic or inorganic coating on the flake surface greatly enhances the aesthetic performance of aluminum flake in powder coating systems, as well as offering significantly improved chemical resistance. In an effort to provide customers with a safe handling mechanism, Silberline has developed and introduced a unique packaging design. Rather than supplying the product in bulk form, which requires scooping and extra handling, Silberline patented a process for packaging metal pigment powders (EP 0 916 577 B1), which presents the customer with 2-kilo quantities in a dust containment package, thus minimizing handling and safety concerns.

Conclusion

Regulatory compliance is an issue that will continue to challenge all facets of the coatings industry, from raw material supplier to finished coatings manufacturer. We cannot afford to be complacent in our research and developmental programs because what works today, may not be the successful answer to future challenges. The aluminum pigment industry continues to dedicate resources to meet all challenges through new and unique products that are environmentally green.

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