PURE INDOOR AIR:
LOW-EMISSION FLOOR COATINGS WITH TEGO® ADDITIVES
DEAR READERS,

We have welcomed a new member to our family! In taking over Air Products’ Performance Materials Division, we added an array of creative new products, services and technologies to our portfolio for the coatings industry and thereby strengthened our position as leading specialist supplier for the industry.

For our customers, this means more innovation, more product know-how, and more solution competence – all in line with our claim of “One partner. Many experts.” This edition of The Coatings Expert journal aims to provide you with an idea of what this means in daily business, focusing once more on sustainability. Low-emitting floor coatings, innovative solutions for coatings with direct food contact, or an article on the new processes for sustainably improving the antifouling effect in maritime environments are just some examples.

We’re sure you’ll be keenly interested in the exciting news coming from the world of paints and coatings!

Yours,

Dr. Claus Rettig
Chairman of the Board of Management
Evonik Resource Efficiency GmbH

The TEGO® product offerings for floor coatings and the comprehensive technical know-how make Evonik an expert in low-emission floor coatings and allow formulators to adapt to changing conditions.

Floor coatings have transformed over the years. Initially, floor coatings were used mainly in trade and industry, where the requirements on the coatings are clear: The floor must be robust and capable of withstanding a wide range of external influences. Mechanical and chemical strength as well as easy cleanability are basic prerequisites.

Besides trade and industrial floor coating applications, floor coatings are now established in many other areas – public buildings, showrooms, gymnasiums, and private premises, to name a few. As a result, the requirements for floor coatings have changed. Whereas the floor coatings of the past had to meet specifications of a more technical nature, the requirements today are often supplemented by criteria benefiting the user, such as the color scheme of the floor coating or the ergonomic properties.

The changing conditions of use have naturally increased the demand for floor coatings with no negative impact on indoor air quality. With the development of VOC-free additives, such as TEGO® Airex 944 deaerator for low-emission floor coatings, Evonik is addressing this requirement.

Other products complement the range of VOC-free additives for low-emission floor coatings: TEGO® Dispers 652, for example, allows good pigment and filler dispersion and stabilization, thus preventing flooding of pigments during application. The use of TEGO® Wet 260 specifically improves substrate wetting and flow behavior.

TEGO® additives allow formulation of advanced floor coatings that keep air pure.

POLYURETHANE POWDER COATINGS FOR DIRECT FOOD CONTACT

The latest Evonik development, VESTAGON® EP-B 1190, is a crosslinker designed to formulate polyurethane powder coatings for direct food contact. The highly functional blocked PU crosslinker exhibits excellent chemical and sterilization resistance due to its chemical composition. VESTAGON® EP-B 1190 combines the characteristics of PU crosslinkers and delivers optimal performance for applications with direct food contact if proper polyester polyols are used (accord. to the Food Contact Notification No. 1268).

With the development of VESTAGON® EP-B 1190, Evonik follows its path to deliver environmentally-friendly systems and offers new solutions for a variety of new markets and applications.

CONTACT

Jürgen Kirchner
juergen.kirchner@evonik.com

André Raukamp
andre.raukamp@evonik.com
Evonik initiated the development of the blocking agent-free polyurethane (PUR) powder coating hardener VESTAGON® EP-BF 1328 as a reaction to market demand for low-temperature powder coating curing systems.

Current PUR systems available in the market need high curing temperatures starting at 180°C. The new VESTAGON® EP-BF 1328 enables design of powder coating formulations that can be processed within a hardening temperature down to 145°C. The applicators will benefit from more flexible handling options: it allows the possibility to either apply the coating at 180°C, which will lead to a reduction of cure time and an increase of line speed (increasing productivity), or to carry out the curing process at 145°C generating a saving of energy consumption and costs. It also enables the cure of PUR powder coating formulations on temperature-sensitive substrates due to the improved temperature frame.

VESTAGON® EP-BF 1328 can be used in many applications with special mentioning regarding the ACE-market (Agriculture Construction and Equipment), which is typical for the coating of heavy and large-scale pieces on a single process belt. VESTAGON® EP-BF 1328 will increase productivity at the applicator as more surface/pieces per time unit can be coated as before. Furthermore, it is expected to serve additional applications based on a wider temperature curing range.

Due to the versatility of a broader curing range, processes can be achieved at which the coater cures multiple coating layers at one temperature instead of partially applying liquid coating or adapting the curing conditions. Widening the curing temperature range using VESTAGON® EP-BF 1328 results in additional application opportunities for polyurethane powder coatings.

We see in VESTAGON® EP-BF 1328 a premium alternative to other crosslinking chemistries for exterior, low-temperature-cure powder coating applications.

Evonik addresses global market needs with this product development and positions itself as innovative and ideal partner for the powder coating industry. VESTAGON® EP-BF 1328 is still in the experimental phase, in which the concept is optimized with selected partners. The upcoming European Coatings Show in April 2017 will be used to introduce this product development. The official product launch will probably take place around mid of 2017.

**CONTACT**

Vincent Fritzemeier  
v Vincent.fritzemeier@evonik.com

Silane/polyurethane-hybrid crosslinkers are especially used, if highest technical performance concerning mechanical resilience and chemical resistance is needed, e.g. for scratch resistant wood or metal coatings. VESTANAT® EP-MF 203 and VESTANAT® EP-MF 204 are solvent free, ready-to-use silane/polyurethane-hybrid crosslinkers, which can be used as a moisture-curable binder or in combination with appropriate co-binders (e.g. acrylic resins).

The new crosslinkers are in comparison to VESTANAT® EP-MF 201 and VESTANAT® EP-MF 202 characterized by faster drying times, improved scratch resistance and a lower viscosity. The aliphatic basis of the polymeric product ensures the possibility to obtain easily light- and yellowing stable coatings. VESTANAT® EP-MF 203 and VESTANAT® EP-MF 204 are the isocyanate-free silane/polyurethane-hybrid crosslinkers for the formulation of high performance coatings.

VESTANAT® EP-MF 201 vs. VESTANAT® EP-MF 203

VESTANAT® EP-MF 202 vs. VESTANAT® EP-MF 204

Contact:
Tobias Unkelhäußer
tobias.unkelhaeusser@evonik.com

Your secret weapon…
DYNOL™ Superwetting Surfactants

Evonik gives formulators the advantage over their toughest opponent – difficult to wet surfaces. Applying water-based coatings on wood, plastic or oily metal substrates can be a battle and you can feel as though your surfaces are waging war on you. Our portfolio of DYNOL™ Superwetters have been strategically designed to provide a variety of options to lower the equilibrium and dynamic surface tensions of formulations.

In addition, many of these products are No foam or Low foam and some can aid coalescence of films by reducing the minimum film formation temperature (MFFT). Evonik is proud to offer four different classes of superwetters, the DYNOL™ 300, 600, 800 and 900 series. Each of these products has different attributes based on the nature of the superwetting surfactant molecules employed, resulting in a portfolio that can solve almost any difficult-to-wet surface challenge formulators may face.
The use of an innovative polymerization technique allows manufacturers to produce acrylic resins in solid form to meet even the highest standards of quality. The new CDP™ continuous production method gives our customers significant advantages when it comes to the handling and production of paints and coatings, as well as a notable enhancement of the application characteristics of the coatings produced.

The granulated product – DEGALAN® P 28 N – flows well, which significantly reduces dust formation when handling the material. The very narrow particle-size distribution of the product is partly what influences this.

The continuous production process improves batch conformity, resulting in clear-coat films that are far more transparent than those produced using the suspension process. The process also yields notable improvements in the characteristics of pigmented films, such as gloss, hardness development, pigment loading, compatibility with other binders, and adhesion to an exceptionally wide variety of substrates. These are clear advantages of using DEGALAN® P 28 N for development work in many types of applications.

Thanks to the broad compatibility of the bulk polymerization product, the polymer can be combined with a wide variety of other binders.

One application lies in the field of alkyd resin modification. Adding 10% to 20% of the polymer to alkyd resins (calculated as solids) achieves the desired degree of dust free time more quickly. Combining binders also allows manufacturers to significantly improve the weather resistance of the alkyd resin.

The product is also suitable for use in printing inks, as it is broadly compatible with other polymers, such as PVC copolymers, cellulose nitrates, polyamide resins, and plasticizers. Reasons for using DEGALAN® P 28 N include improvements in the adhesion and degree of gloss of applied printing films. The option of dissolving the product in aliphatic solvents makes it suitable for use in flexographic printing inks, and the bulk polymerization product can also be used for metalization applications and in rotogravure inks for coating plastic substrates.

UV-curing paints, known as 100% systems, are ideal for coating plastic films as well as paper, wood, and metallic substrates. Combining DEGALAN® P 28 N with a UV-curing coating reduces the overall formulation cost of a UV paint system, improves adhesion on metal and plastic substrates, and – important to keep in mind – increases flexibility and reduces shrinkage of the resulting coating films.

The solubility of the polymer in aliphatic solvents opens up even more applications for this product, including its use in aerosol applications for finishing a wide variety of substrates, as well as the possibility of developing correction pens.

DEGALAN® P 28 N FOR A VARIETY OF APPLICATIONS

Around the world, governments are lowering emission limits for volatile organic compounds (VOCs). Various upper limits for VOCs have been in place in the European Union for several years now, such as 420 g/L for the refinishing paints used in the automotive industry. China enacted this limit for spray paints last year as well, which is why taxes are now levied on VOC-containing paints in some parts of the country. Countries that do not yet have any threshold values for VOCs will follow suit, and laws are expected to become even more stringent over the coming years in important markets such as the EU and the US.

This poses major challenges for paints and coatings formulators. If they want to meet legal requirements, they will have to drastically reduce the amount of solvent in their products and limit themselves to only certain raw materials.

Until now, most of the manufacturers that produce raw materials for paints and coatings have concentrated on developing solutions for the VOC component of the base coat. Evonik, however, is focusing its development work on pigment concentrates, whose typically high VOC content determines the final VOC content of a paint. Until now, the addition of a pigment concentrate to a base coating has coincided with an increase in the percentage by weight of VOCs in the paint. Evonik has now managed to reverse that relationship: adding the pigment concentrate now actually reduces the VOC content of the paint. TEGO® VariPlus LK, a new liquid grinding resin, makes this effect possible by reducing the VOC content in the finished paint by an average of 20% relative to the standard solvent-containing industrial coatings on the market.

CONTACT
Andreas Olschewski
andreas.olschewski@evonik.com
Maximizing viscosity reduction gives developers new freedom

The new grinding resin reduces viscosity in two ways: First, it is itself a liquid; second, it makes the manufactured pigment concentrate less viscous. For example, if the VOC content is limited to 310 g/L, then the viscosity of the standard product on the market (plus a standard additive) would be greater than 15,000 mPas, making it unusable. But the viscosity of TEGO® VariPlus LK combined with a standard additive is only 600 mPas at the same VOC level. The effect is even more dramatic at a VOC content of just 110 g/L, even given these extreme requirements, the viscosity of this liquid grinding resin combined with a suitably adjusted additive is a mere 1,000 mPas.

The marked decrease in viscosity is possible because the resin has an exceptional affinity for pigments and can better stabilize them for optimal pigment loading. To achieve this, Evonik developers formulated the resin in such a way that would counteract the tendency of the pigment particles to flocculate. In order to stop van der Waals forces from causing flocculation, the space between particles must be great enough for them to move past each other easily. TEGO® VariPlus LK contains groups with an affinity for pigments, and it is this chemical structure that gives the resin a wetting effect – even without an additive – making it particularly suitable for spraying, for example. Due to its elasticity, the liquid resin can also be used as a co-binder for binding intermediate coats onto steel, galvanized steel, or PVC. TEGO® VariPlus LK can also be used for extending pot life.

By wetting pigment particles well – especially in conjunction with a suitable additive – TEGO® VariPlus LK yields greater color intensity than other grinding resins. On a test surface made of light-gray polyurethane, TEGO® VariPlus LK (with a corresponding additive) was superior to the market standard at the same level of pigment – a difference that was clear even to the naked eye. Low viscosity also decreases the amount of solvent required in the pigment concentrate, allowing formulators to increase the concentration of pigment particles. The result is more intense color in the finished paint using the same amount of concentrate. If the target viscosity is 2,000 mPas, the new grinding resin combined with an appropriate additive can accommodate roughly 30 % more pigment than comparable competitive products. In addition, to achieve the same color development as they previously had, paint formulators now need less pigment concentrate. As a result, formulators can do their part to make high-solid systems more economical.

The hardness of the finished coating is not compromised by the resin’s liquid form: Developers were able to optimize the manufacturing process to the point where the low viscosity of the grinding resin has very little effect on the hardness of the paint. The team managed to adjust the glass transition temperature by varying the monomer composition, such that the impact of the former was minimal when it came to hardness, yet major in terms of reducing VOCs. Roughly two years of intense development work went into the molecular structure of TEGO® VariPlus LK.

In addition to this, however, it also meets all of the standard requirements for a grinding resin. Tests have shown that TEGO® VariPlus LK has a minimal influence on coating properties such as gloss (DIN EN ISO 2813), weather resistance (DIN EN ISO 9227, DIN EN ISO 6270-2), adhesion (DIN EN ISO 2409), drying time (ASTM D 5895), chemical resistance (DIN EN ISO 2812-4), and elasticity (DIN EN ISO 1520). The rub-out effect of paints and coatings based on this new grinding resin is much smaller than that of standard products on the market under the same conditions, regardless of whether polar or non-polar solvents are used.

TEGO® VariPlus LK is a ketone resin and, as such, tests have shown it exhibits exceptional compatibility with all common binders and resins, including alkyd resins, polyethers, epoxide resins, and nitrocellulose.

Another advantage: The new opportunities afford by TEGO® VariPlus LK allow formulators to increase pigment concentration while significantly reducing the amount of concentrate needed. Evonik has also developed a specially tailored additive to make the best possible use of the viscosity benefits of the grinding resin: TEGO® Dispers 676 supports the decrease in viscosity, thus reinforcing the positive individual effects of the resin. Developers did this by...
keeping the core of the molecule highly compact and incorporating a large number of anchor groups, with the result of excellent pigment wetting. The stabilizing side chains were selected in a way that makes the additive effective across a broad range of polarities.

**Conclusion**

TEGO® VariPlus LK is a grinding resin that, when used in combination with TEGO® Dispers 676, minimizes the VOC content of solvent-containing industrial paints and coatings. The result is a product unparalleled on the current market. The new grinding resin even allows formulators to reconsider the use of binders that once had to be rejected (despite their other advantages) due to VOC thresholds. Given long product cycles for pigment concentrates and potentially tighter VOC thresholds, the new combination promises planning reliability for years to come.

In addition, this innovation will also give formulators more freedom to vary viscosities, pigment concentrations, and formulations as a way of further optimizing their existing systems.
Food packaging is an ever-growing segment within the printing inks market. A general growth trend is observed all over the world, with more specific trends observed within the various regions. For example, the European food packaging market experiences a trend toward smaller packaging sizes; in Asia, there is a higher demand for packaged food due to expansion of the population and changes in consumer behavior. In the food packaging market, the preferred printing technologies are flexo and gravure printing, with regional preferences for either technique. Nevertheless, the market development toward smaller lot sizes and the marketing trend toward customization pushes the industry to develop offers for fully or partially digitally produced food packaging.

Depending on the end applications, different ink technologies are utilized. For example:

- Solventborne inks are used for flexible packaging on film substrates.
- Waterborne inks are used for corrugated boxes and paper bags.
- Radiation-curing inks are used for aluminum foil packaging (like dairy lids) or narrow web labels.

There are three main drivers for the food packaging market:

- Regulatory topics such as the Swiss Ordinance, the VOC regulation in China, and low migration potential.
- Performance topics such as printability, retort ability, and lamination bond strength.
- Commercial topics such as price-performance ratio and total cost of formulation.

In order to overcome the industry’s challenges, Evonik is constantly working to strengthen its portfolio for inks for food packaging applications. Besides the well-known TEGO® additives, the portfolio also includes the TEGO® VariPlus and TEGO® AddBond co-binders.

Evonik’s latest developments for this market are the new, patented high molecular weight wetting additives, TEGO® Wet 550 and TEGO® Wet 285. These products were designed to meet the market needs for wetting additives with distinct performance, excellent regulatory status, and low migration potential. In order to achieve this, our R&D and Applied Technology departments developed these fully Swiss Ordinance A compliant wetting additives that exhibit a low migration potential due to their molecular weight being well above the level of 1000 Dalton.

In combination with other Swiss Ordinance A additives (like TEGO® Foamex 830 and TEGO® Dispers 761 W), these new wetting additives allow ink developers to formulate state-of-the-art food packaging inks and to meet the aforementioned market needs and trends.

In the field of high-performance solventborne printing inks for lamination applications, the use of PU-resins is quite common due to their positive influence on lamination bond strength. However, some shortcomings stem from the use of these resins. The most prominent one is the negative effect the resins have on the viscosity of pigment bases, when used as grinding medium.

TEGO® Dispers 690 was specifically developed to overcome this challenge. It yields excellent viscosity reduction and pigment stabilization in combination with typical PU-resin qualities and is highly compatible with other binders like NC-resins. The performance is
especially good in combination with TEGO® VariPlus 1201 TF co-binders. Additionally, it fulfills high regulatory demands by consisting of 100 % Swiss Ordinance A materials.

Other TEGO® additives, such as the TEGO® Glide surface control additives, are used to fine-tune ink performance and ink film properties, and they play an important role in modern ink formulations.

This leads to another example of a dedicated development for food-packaging ink. The new surface control additive TEGO® Glide A 116 was developed to meet the needs of surface print food-packaging applications.

Here, in many cases, a well-defined slip level is crucial for the process ability and manageability of the packaging, because filling lines and further handling need well-defined surface properties. TEGO® Glide A 116 fulfills those needs because it combines defined slip with full Swiss Ordinance A status and shows excellent compatibility with the typical binder systems (such as NC).

Evonik experts can help you optimize your formulation via recommendations, lab work, and joint development projects.

### CONTACT

Dr. Thorsten Brand
thorsten.brand@evonik.com

**DYNAPOL® – HIGH PERFORMANCE POLYESTERS FOR INTERNAL COATING OF FOOD CANS**

Cans are a brilliant invention, preventing deterioration of all kinds of food over long periods. This long shelf-life is usually achieved today by coating the inside of the can with materials based on epoxy resins based on the chemical bisphenol A (BPA). Due to the continuing strong suspicion that this ingredient can cause health problems, the EU Parliament is demanding a ban on BPA in all food-contact materials.

Evonik anticipated this development early on, and offers high molecular weight polyester resins under the DYNAPOL® brand name. With the development of a new generation of binders specifically for food contact applications, Evonik is now systematically pursuing the trend towards epoxy-resin-free internal coatings for cans: In DYNAPOL® L 907 and DYNAPOL® L 914 Evonik, the leading global supplier of polyesters for applications in metal coating and reactive hot melt adhesives, is offering the coatings industry suitable alternatives to the current BPA-containing systems. Both products are main binders for internal can coatings in the “BPA non-intent” (BPA-NI) category, and are excellently suited for the formulation of high-end coatings for food cans.

In the packaging of beverages in particular, alcohol-containing filling goods account for a major market share, but they place specific requirements on the internal coating. The new developments Polyester VP 2010-38 and Polyester VP 4406 are tailor-made for this purpose, and with these Evonik offers BPA-NI options for an expanded range of canned products.

To be able to meet growing market demand for BPA-free food packaging, Evonik is currently building at its Witten site in Germany’s Ruhr region a new production plant for specialty copolyesters, including those of the DYNAPOL® brand. The plant is expected to be complete in 2018.

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<th>Product Group</th>
<th>Brand</th>
<th>Typical use</th>
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| Defoamer/Deaerator    | TEGO® Foamex  
TEGO® Airex | Defoaming and deaerating of printing inks and lacquers                        |
| Dispersing Additive    | TEGO® Dispers | Pigment wetting and stabilization in bases; viscosity reduction; color-strength enhancement; grinding efficiency enhancement |
| Substrate Wetting Additives | TEGO® Wet | Influence the static and/or dynamic surface tension of printing inks and lacquers and wet critical substrates |
| Radiation-Curing Additives | TEGO® Rad | Control leveling and/or slip and release properties in radiation-curing printing inks and lacquers |
| Rheology Additives     | TEGO® ViscoPlus | Stabilization of viscosity and transfer enhancement in water-based printing inks |
| Co-Binders             | TEGO® VariPlus  
TEGO® AddBond | Enhance properties like adhesion, gloss and chemical resistance; grinding resists to lower viscosity and enhance pigment stabilization |
| Matting Agents         | SIPERNAT®  
ACEMATT® | Silica-based fillers to influence matting of printing inks and lacquers |
Innovative adhesive resins TEGO® AddBond LP 1600 and LP 1611
Attractive flow additives TEGO® Flow 375 and 460 N

Demands made upon can and coil coatings are on the rise. Increasingly stringent global laws, complexity reduction, and substrate innovation present coating formulato rs with new challenges in their search to find smart, long-lasting solutions for their customers. To meet these challenges, Evonik has expanded its raw materials portfolio, adding four new innovative products:

- TEGO® AddBond LP 1600 and TEGO® AddBond LP 1611: VOC-free adhesion resins
- TEGO® Flow 375 and TEGO® Flow 460 N: silicone-free flow additives

Better adhesion on difficult substrates
The new adhesion resins TEGO® AddBond LP 1600 and LP 1611 allow coatings formulators to improve adhesion of coil and can coatings on difficult substrates such as aluminum or cold rolled steel. With the use of a patented innovative binder technology, TEGO® AddBond LP 1600 and 1611 provide the freedom to formulate low viscosity systems without the need for additional solvents — unlike other products. They reduce viscosity without increasing the volatile organic compounds (VOC) content of the coating. The 100 % liquid adhesion resins are not classified as hazardous goods and are solvent-free, making them safe to handle during transportation.

In addition to being listed in the usual country registers, both TEGO® AddBond LP 1600 and TEGO® AddBond LP 1611 are approved for coatings in contact with food, in accordance with FDA Regulation 21 CFR 175.300. For example, this means that they can be used in can coatings. The two TEGO® AddBond grades also meet the requirements for printing inks used in packaging stipulated by the Swiss Consumer Goods Ordinance (Swiss A).

Maintaining transparency in standard coatings and under baking conditions is possible with these binders. Their compatibility with conventional main binders and co-binders was a priority during development. Even though they were originally developed for baking enamel systems, TEGO® AddBond LP 1600 and TEGO® AddBond LP 1611 are also effective in other curing systems such as 2K epoxy resin coatings, alkyd resin coatings, and 2K polyurethane coatings. In addition to improving the adhesion of a coating to the substrate, the impact resistance and the flexibility are greatly increased. Chemical resistance of the coating film and weather resistance are not compromised.

TEGO® AddBond LP 1600 and TEGO® AddBond LP 1611 differ in their inherent viscosity: LP 1611 is slightly more viscous than LP 1600 but has a lower impact on the hardness of the final system and therefore on the mechanical properties of the surface.

TEGO® AddBond LP 1600 is less viscous and therefore reduces the VOC content of coatings even more than TEGO® AddBond LP 1611.

New flow additives reduce complexity
In addition to the two adhesion resins, Evonik has also developed two new flow additives for use in can and coil coatings. End-users’ decisions are strongly influenced by long-term quality considerations and appearance. TEGO® Flow 375 and TEGO® Flow 460 N contribute to meeting the increasing demands made upon the global production and marketing of can- and coil-coated products.

Both products are silicone-free and free of aromatics. The two polyacrylates are listed worldwide and are suitable for direct contact with food (FDA 175.300). Their wide range of properties reduces transportation complexity for coatings manufacturers and enables broad use. Instead of using many different products, formulators can now use the same additive for more diverse coating materials and end uses.
Struggling to find additives with food contact compliance? Our experts have some food for thought

Awareness of items such as bags, boxes, beverage cans, and kitchen furniture that come into contact with our food (and how safe they are to our health) has increased significantly over the past decade. These items are often printed, coated or held together by products (e.g., inks, coatings or adhesives) that Evonik is helping to make safe for contact with the food we eat.

The substances used must comply with certain regulations to ensure that they do not migrate into our food in quantities that could be a danger to human health or cause an unacceptable change in the composition of the food itself. It’s also important for us, as consumers, and for producers that any substances used do not cause any deterioration in the organoleptic characteristics (e.g., to the odor or the taste) of our food.

Evonik’s four new products fulfill the high expectations of can and coil coatings. They enable formulators to address customers’ specific requirements.

Former Air Products

Food contact regulations include a mix of regional and national legislations and/or recommendations; however, to date, there is no global harmonization of these regulations. These food contact protocols are extremely important, and it is crucial to look beyond the United States’ FDA and European guidelines because the rest of the world is continually adopting new measures. In fact, more recent regulations under consideration in markets such as China, India, Japan and South East Asia, can also impact imports into these regions.

Frequent updates in regulations make it challenging for formulators to stay up-to-date, so we are committed to developing new compliant high-performance additives that address the ongoing challenges faced by formulators.

Please check our website for more information: www.evonic.com/food-contact-status

Marco Heuer
marco.heuer@evonik.com
STRUCTURE MODIFIED HYDROPHILIC AEROSIL® (VP 4200) IMPROVES ANTIFOULING PERFORMANCE IN CUPROUS OXIDE BASED COATINGS

Structure modified AEROSIL® (SMS) was introduced more than a decade ago for improving scratch resistance and mechanical strength across coatings and adhesives/sealant industry fields. New developments now create novel design which offer environmentally sustainable improvement to antifouling performance in marine environments.

The use of hydrophilic structure modified AEROSIL® (VP 4200 = Experimental product, pilot plant) formulated at customer side synergistically with copper oxide (Cu₂O) improves the antifouling behavior and life-cycle performance of antifouling coatings.

A brief review of the model to explain the positive effects of VP 4200 in Cu₂O based antifouling coatings will be described. Specific performance enhancements of increased stability and a reduced leaching of copper ions will be addressed.

Background
Results show, structure modified hydrophilic fumed silica VP 4200 has demonstrated antifouling efficacy when used as an active extender with Cu₂O, thereby achieving antifouling function with lower levels of copper oxide.

Basic Formulation and Application Details
- 70 g Rosin (with co-biocide, w/o Cu₂O)
- 10 g VP 4200: structure modified hydrophilic AEROSIL®
- 20 g Xylene
- Dispensing conditions: bead mill 15 min, 2000 rpm
- Then addition of 6 g Cu₂O
- Dispensing conditions: bead mill 5 min, 2000 rpm

There are three reference formulations
- Blank (no coating, pure PVC substrate)
- Ref 1 (with co-biocide and no Cu₂O)
- Ref 2 (with co-biocide and 30 % Cu₂O)

Application:
- Coatings were applied to PVC panels by roller at 100 microns dry film thickness.
- The testing was according to ASTM 6990-03: Evaluating Biofouling Resistance and Physical Performance in Marine Coating Systems.
- Testing was carried out in the North Sea (LimnoMar, Norderney), Germany.

When the coated panels are stored in the North Sea, over time, biomass accumulates and rating values represent percentage of panel surface covered by biomass. The fouling rating used in Graph 1 indicate the percentage of panels covered, after every review. The score of 100 indicates no fouling and the score 0 indicates the entire panel is covered with biomass.

Graph 1 depicts the performance of the Blank panel containing no coating shows full fouling by April 2016 (9 months). Reference 1 containing the coating with the co-biocide demonstrates a slightly better performance. However, almost 80 % of the panel shows biomass coverage in the same period. Reference 2 containing the co-biocide and 30 % by weight of copper oxide performs the best by far with only 3 % of its surface showing biomass attachment. When the coated panels are stored in the North Sea, over time, biomass accumulates and rating values represent percentage of panel surface covered by biomass. The fouling rating used in Graph 1 indicate the percentage of panels covered, after every review. The score of 100 indicates no fouling and the score 0 indicates the entire panel is covered with biomass.

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the co-biocide demonstrates a slightly better performance. However, almost 80% of the panel shows biomass coverage in the same period. Reference 2 containing the co-biocide and 30% by weight of copper oxide performs the best by far with only 3% of its surface showing biomass attachment.

The combination of 12% by weight SMS (VP 4200) combined with a dramatically reduced loading of 6% copper oxide is also shown. This combination performs similar to the formulation containing 30% copper oxide and co-biocide.

Figure 2 captures biomass accumulation of select formulations at the end of the test period. Panels containing dramatically reduced loadings of copper oxide show significant antifouling efficacy with higher addition levels of SMS (Structured Modified fumed Silica). The best performing formulation has a significantly reduced loading of copper oxide (6% + co-biocide) and 12% by weight Structured Modified AEROSIL®, VP 4200.

Schematic 2 conceptualizes the improved durability allowing the copper oxide to persist longer in the coating due to the reinforcing contribution with the higher loading of the SMS.

Schematic 3 depicts a molecular model demonstrating the availability of “free” silanol groups (SiOH-groups) in hydrophilic fumed silica. “Free” means the silanol groups do not have a direct neighboring SiOH for bridging and are therefore active for adsorption of Cu-ions. The protons of the silanol groups are substituted by copper ions; so at the end Si-O-Cu-ion pairs can be discussed. Schindler et al. published 1976 the 100% adsorption of copper ions at pH > 7 on hydroxylated silica surface (North Sea has pH > 8). The active ionic interaction is based on the SMS’s silanol groups containing surface interacting and anchoring the copper ions. The higher loading of the SMS supports not only anchoring of the copper oxide but significant film reinforcement and film toughness helps keep copper oxide available longer. Lower thickening performance of the SMS makes possible the higher loading, which is creating the target functionality. Furthermore, spray application is still possible.

Summary and Conclusion

Structure modified fumed silica (SMS), like VP 4200, can improve the efficacy of Cu$_2$O based antifouling coatings. With loading levels above 10% (by weight, based on total) of SMS, dramatically lower loadings of Cu$_2$O (approx. 6% by weight, based on total) are found to give effective antifouling protection. Novel particle design based on hydrophilic structure modified AEROSIL® performed better than hydrophobic modified option.
The influence of surfactants on colorant acceptance in paints and coatings

The introduction of Point-of-Sale Tinting systems in the 1950s changed forever the way that decorative paints are sold. Previously, paints were supplied in a limited range of colors and retailers had to stock a large range of ready-made colors to meet demand. Tinting systems led to dramatic changes; all retailers needed were base paints and a tinting machine to supply an immense range of colors, while inventory and production for both the supplier and paint store was reduced.

Tinting systems are designed to deliver color to a paint to achieve the exact shade desired, and include colorants, dispersing and mixing equipment, software and a color formula database matched to the color marketing tools. The selected colors are prepared by accurately dosing the colorants into a base paint, followed by mixing to produce the finished color. In order to achieve the maximum operational efficiency, producers will use universal colorants to tint a wide range of different base paint chemistries, carriers and formulations.

Most universal colorants are traditionally based on glycols to ensure compatibility with different carriers, and contain the appropriate pigments, fillers, dispersants, thickeners and other additives. However, recent changes in the regulation of Volatile Organic Compounds (VOC) in paints has led to many colorants being reformulated with much lower levels of glycol and co-solvent. While these may be identical in terms of color, these low VOC colorants may give different performance in both dispensing machines and the base paints. Additionally, many paint producers buy their colorants, rather than manufacture their own, so colorant changes will often require formulation changes in the base paint.

**Color development**

The term “color development” describes the degree of color quality and color uniformity of a tinted paint. Good color development implies that the color appears uniform and of the expected strength and is dependent on the stability of the pigments, and fillers dispersed in both the base paint and colorant. When the colorant and paint are mixed, the additives present in both can re-equilibrate among all the pigments and fillers. Because many base paints are under-stabilized, this often means that some of the additives needed to stabilize the colorant pigment are redistributed away from the color pigment to pigments and fillers in the base paint.

The formulation of pigment dispersions, in base paints and colorants can be enhanced by the use of surface active agents to wet, disperse and stabilize solid particles or pigments and to provide application performance. Typically, formulations contain at least two, and often three or more, surface active components that are combined to provide the optimal properties. These materials include classical polymeric and oligomeric dispersants and lower molecular weight surfactants. These surfactants can also help to improve the compatibility of the dispersion for letdown into other systems and minimize shock and color acceptance when tinted. These surfactants work by migrating to the surfaces created when the dispersing additives re-distribute upon mixing, thus preventing the destabilization of the pigments (see figure 1).

**Nonionic surfactants as compatibilizers**

A series of nonionic surfactants was tested to see if they could enhance the color acceptance of different colorants when let down into a water-based acrylic base paint and a solvent-based alkyd paint. The surfactants were post-added to the paints at 1.0% (w/w) dosage and tested with the most challenging colorants. Based on customer feedback, colorants with the color indexes PV 23, PBk 7 and PB 15:3 are among the most difficult in terms of color acceptance when used to tint water-based or solvent-based paints. The influence of the additives on color compatibility and color strength was measured by applying the tinted paints by drawdown onto Leneta Chart after 2 and 10 minutes of shaking. A rub-out was performed, and the color difference between the rubbed and un-rubbed parts was measured. The color was measured using an X-Rite 939 Spectrodensitometer D65/10 and recorded as a Delta E value. The formulation without post-added surfactants was used as the reference and its color strength was set as 100%.

Poor colorant compatibility may become apparent through the slow development of color, or loss of color through flocculation of either the white pigment in the base paint or the colorant pigments. Flocculation can be detected quite easily by the rub-up test, as this action re-disperses the pigments leading to a change in color between the rubbed and unrubbed areas if flocculation has occurred.

The best result with the PV 23 colorant was obtained with the alkoxylated acryl ethylene based SURFYNOIL® 2502 surfactant (see figure 2).
This surfactant is known for its ability to quickly wet many different hydrophobic surfaces, such as organic pigments. It is also a low foam surfactant and relatively hydrophobic. Other hydrophobic acetylenic diol-based surfactants were also effective; however, most traditional alkyl phenol ethoxylates and alcohol ethoxylate-based surfactants were not effective with this colorant.

One of the most widely used colorants is PBk 7. Again, colorant acceptance could be improved by post-adding surfactants to the base paint. In general, the best results were achieved with high HLB (hydrophilic) surfactants such as ZETASPERSE® 179 and ZETASPERSE® 182 dispersants, in both water-based and solvent-based base paints. Similar results could be seen with other colorants and binder systems (see figure 3), where the addition of nonionic surfactants such as ZETASPERSE® 182 dispersant and CARBOWET® GA210 surfactant could improve the acceptance of different colorants.

Conclusions
The experiments show that nonionic surfactants can be used to improve the acceptance of colorants into different chemistries and types of base paint. These additives help the stabilization of the pigments by slowing down or compensating for the migration of dispersants and other stabilizing surfactants from the pigment in the colorant to pigments in the base paint, or vice versa. As a result, a product selector guide is available to paint formulators.

Text: Christine Louis, Mike Peck and Jim Reader

CONTACT
Christine Louis christine.louis@evonik.com
Mike Peck mike.peck@evonik.com

References
The global cost of corrosion is estimated to be $2.5 trillion per year, which is equivalent to 3.4% of the Global Gross Domestic Product (GDP, 2013) (NACE International) [1]. This enormous damage causes a major interest in new corrosion protection systems and the necessity to control and reduce metal corrosion. Chromate in various guises has been the preferred pre-treatment process for different metal substrates like aluminium and HDG steel for many years. Nonetheless, treatment with chromium (VI) is already prohibited in some application areas because chromate (CrVI) has been identified as a human carcinogen. Also other established surface processes like phosphate pre-treatment are under discussion, since aggressive media and chemicals with high environmental impact are used. Corrosion protection system containing organic solvents are discussed as environmentally harmful and should be replaced by water-borne systems. In some cases there are alternatives available and promising candidates are water-borne silane systems.

The first water-borne silane systems based on organofunctional silanes were introduced to the market by Evonik in 1997 [2]. Novel water-borne silane systems can also work at ambient temperatures [3]. They can react with the metal surface and can passivate the substrate. A hydrophobic protection layer can be formed to protect from corrosion and the adhesion of a subsequent coating can be improved. However, water-borne silane systems do not give an active but a passive corrosion protection. Novel water-borne silane systems already entered the market and are used as binder or component in corrosion protection formulations.

Blank corrosion protection of aluminium alloys and HDG steel with Dynasylan® SIVO 160 formulations

Aluminium is less corrosive compared to other metal substrates since the metal is protected against further corrosion by a dense aluminium oxide layer which is immediately formed at the atmosphere. Nevertheless, in some cases it is necessary to protect the blank aluminium surface against corrosion, which can happen in the presence of e.g. chloride. Water-borne silane systems based on SIVO 160 can be used in such applications. Very thin layers in the range of 100 – 200 nm can prevent the corrosion of aluminium. For exterior weathering SIVO 160 needs to be formulated with additives and stabilizers in order to bring the best performance.

If HDG steel is protected with a SIVO 160 based formulation a corrosion protection of 80 to several 100 hours is possible depending on the zinc alloy. Formulations of Dynasylan® SIVO 160 are environmentally friendly and advantageous for blank corrosion protection of aluminium and HDG steel.

Dynasylan® SIVO 140 – a water-borne silane system as binder for two pack zinc dust paints

As previously discussed water-borne silane systems form a film on the metal surface and this thin film can lead to a passive corrosion protection. However, depending on the layer thickness, hydrophobic properties of the layer and the network density, the passive corrosion protection is limited. The performance can be improved substantially when such systems are formulated with active corrosion protection systems.

The novel water-borne silane system Dynasylan® SIVO 140 was designed for better compatibility with additives and fillers. The system contains special organofunctional groups which can interact with the filler and stabilize the formulation. Formulations based on Dynasylan® SIVO 140 can cure at room temperature, are almost VOC-free and can be formulated with fillers and anticorrosive pigments. Such formulations can be applied with a different film thickness at the substrate. The curing time depends on the formulation (type and amount of fillers and additives used) and the applied wet film thickness. The film thickness of the water-borne Dynasylan® SIVO 140 has an impact on the curing time since water has to evaporate which depends not only on the film thickness but also on the temperature and humidity. The advantages of Dynasylan® SIVO 140 can be summarized as follows:

• almost zero VOC
• low temperature curing
• low or higher film thicknesses are possible
• improved heat resistance compared to organic binders
Reducing VOC is a main requirement from the market and in many countries there are also legislations restricting the use of VOC in coatings. Formulations based on Dynasylan® SIVO 140 can be used to formulate almost VOC-free zinc dust paints.

Figure 1 compares the VOC emission of a standard zinc dust paint based on silicic acid ester with a zinc dust paint formulated with Dynasylan® SIVO 140. The example was calculated for a steel construction coated with a zinc dust paint. The dry film thickness was 70 µm and the application area was around 20,000 m². The VOC emission can be reduced by more than 90%.

What customers want is nothing new: to reduce the complexity of the dispersion process. Using a bead mill to create the perfect dispersion is the most technically challenging – and time-consuming – processing step in manufacturing paints and coatings. To prevent this, raw materials manufacturers offer dispersions, preparations, and pastes in which the dispersion of insoluble solids (silica, pigments, fillers, etc.) has been optimized. Dispersions such as these, however, may also contain undefined quantities of solvents, water, binders, or additives, and, while formulators have no control over this, the effects of these components may nevertheless be felt in the finished coating system.

It would be far simpler if manufacturers could use a dissolver to process the solid raw materials for the coating. Unfortunately, the particle sizes that can be achieved by dispersing materials in a dissolver lie significantly above the maximum particle size accepted for use in products such as varnishes.

Thanks to an innovation in the production process for AEROSIL® Fumed Oxide products, these fumed silicas can now undergo wetting and dispersion – processes that previously had to be carried out in two separate systems (dissolver, bead mill) – in a single dissolver step.

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[1] NACE International, 2016, 15835 Park Ten Place, Houston, Texas

CONTACT
Dr. Philipp Albert
philipp.albert@evonik.com
The challenge involved is not a trivial one. The formation of aggregates and agglomerates is an essential component of the flame hydrolysis process used for producing AEROSIL® – without them, AEROSIL® would not have its characteristic structure or, consequently, its effects. The resulting particle spectrum extends beyond 200μm (example: AEROSIL® R 972), but to achieve favorable optical and application characteristics, manufacturers aim for aggregate sizes of < 10μm.

The feasibility of the idea had already been confirmed two years ago when a laboratory-scale set-up produced the first product samples, which were named “easy-to-disperse” (or “E2D” for short), a term that describes the unique properties of these products (i.e., readily dispersible in a dissolver). A pilot plant constructed and commissioned at the Evonik Hanau site this year has now generated the first pilot-scale product samples.

The experimental program began with VP RS 92, an E2D version of AEROSIL® R 972. Measurements of the particle size distribution revealed the critical difference: whereas the particle spectrum of the standard version of AEROSIL® R 972 was split into two fractions, the new process yielded only one fine fraction. The elimination of coarse particles would allow paints and coatings manufacturers to avoid milling processes involving high shear forces (bead milling, for example).

In order to test its processing characteristics, rheological effects, and optical properties within a coating system, the standard product was processed using traditional milling procedures, while the experimental was processed exclusively in the dissolver. The results for viscosity, gloss, haze, and jetness (depth of color) were all correct within the accuracy of measurement. A significant, absolute reduction in processing time was observed as well, even as the degree of dispersion improved.

The viscosity curves at high and low shear rates were identical within the key range of rising viscosity. This showcases a key advantage of the E2D product: because it achieves the same level of efficiency and the same optical characteristics, manufacturers do not need to adjust existing formulations, and new formulations can be created according to the same rules as earlier coatings. Plus, easy-to-disperse versions of fumed silicas are chemically identical to the corresponding AEROSIL® products. An important point to highlight here is that no additives of any kind are used, making these products just as compatible with coating systems as familiar standard products are.

Now that VP RS 92 has been produced successfully (and is available for sampling), the pilot plant is being used for developing easy-to-disperse versions of other AEROSIL® products.

The use of easy-to-disperse silica decreases processing times, cleaning times, production losses, etc., while omitting the milling step reduces investment and maintenance costs especially in clear varnish production. Pigment manufacturers likewise offer products that can be dispersed in dissolvers, opening up the possibility of formulating colored coatings with no need for a bead mill.
Evonik’s Methacrylates Business Line offers its customers a wide product range, high supply security, and competent commercial and technical consulting based on decades of experience and a global production network. In addition to the bulk methacrylates, like MMA, GMAA, BMA, and hydroxy esters, the group of specialty monomers such as versatile functional methacrylate monomers, crosslinkers, and alkyl and ether methacrylates is continuously being supplemented by new developments. “We offer our customers everything from one source: more than 50 specialty products, along with technical consulting, all the way to joint development projects and exclusive business relationships with individual support,” states Dr. Hans-Peter Hauck, head of the Business Line.

The coatings industry in particular benefits from these advantages. Whether for methacrylate-based resins targeting a broad range of applications, or for niche applications like can or electronic coatings and reactive adhesives, Evonik offers the products and the expertise to impart the resin with special and tailored properties. Whenever a customer needs a completely new methacrylyc building block or a special product specification, it is on the innovation team of the Business Line to make the new development ready for production. And the methacrylates specialists are always proactively developing new solutions—such as VISIOMER® 6976, a light-curing product that has grown popular among producers of architectural paints and adhesives.

Silicone epoxy hybrid resins, like SILIKOPON® EF and SILIKOPON® ED, can be used to formulate high-quality paints that are weather-proof and resistant to chemicals. Such formulations may become brittle over time. The addition of flexibilizing components can counteract this effect and make these coatings less resistant. ALBIDUR® 1223 eliminates this dilemma entirely and combines long-term flexibility with chemical and weather resistance.

By using ALBIDUR® 1223 (an alpha-omega-terminated linear alkoxy cycloaliphatic urethane resin), formulators can set the elasticity of the paints in any mixing ratio without compromising the outstanding durability of the coating. This improves the results for flexibility tests such as Erichsen cupping or bending strengths by up to 500%. These significant improvements make ALBIDUR® 1223 a valuable tool for coating formulators. This co-binder enhances the properties of SILIKOPON® EF and SILIKOPON® ED, leading to the creation of new possible coating applications.
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