ENVIRONMENTALLY FRIENDLY SOLUTIONS FOR WATERBORNE METALLIC PAINTS

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ABSTRACT

Within the Coatings industry, the clear trend towards waterborne paint systems for all kinds of applications remains unbroken.

This trend does not merely demand a stabilised metallic pigment, but an elaborate and complete product portfolio that, in the end, can contribute to the protection of our environment and to the health of human beings.

ECKART - with their long-term experience in the production of aluminium pigments - offer manifold products and services for water-based coatings: a wide range of different stabilisation technologies, superior processing treatments as well as sophisticated “easy to use” solutions, all causing less impact on the environment.
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1. Background

The global market for water-based paint systems has been on the upswing for quite some time now. Besides the field of architectural applications, there is also a clear international shift from solvent-borne to waterborne coatings, e.g., in the automotive, consumer electronics, domestic appliances, packaging and printing inks industries. Effect pigment manufacturers need to offer solutions covering two vast areas: new, fascinating colours and effects, combined with sophisticated, non-polluting technologies. These different requests and the high variety of possible applications do not only require the fulfilment of the technical and optical demands already mentioned but also products that are environmentally friendly, harmless to health, chemically stable and easy to use.

2. Production of aluminium pigments

In the first step, aluminium ingots are melted and atomized to granules.

In ball mills, the granulate material is rolled out to obtain effect pigment flakes.
3. Characteristics of aluminium pigments

In general, a difference can be made between two kinds of aluminium pigments:

**Leafing pigments** are aluminium pigments which float to the top and which orientate themselves at the surface due to the lubricant used for their production, thus creating a mirror-like effect.

![coating film](substrate)

- typical behaviour of leafing pigments

**Non-leafing pigments** are aluminium pigments which are wetted by the binder and therefore distribute themselves uniformly in the polymer matrix.

![coating film](substrate)

- typical behaviour of non-leafing pigments

Leafing pigments show the highest reflective values but the disadvantage is that they offer only poor intercoat adhesion and low rub resistance. For this reason, such pigments cannot be used for paints where a high rub-resistance, good intercoat adhesion and excellent wetting properties are required. Leafing pigments are used mainly for functional applications, like reflector coatings, marine coatings and in North America for the so-called "attic barrier coatings systems".

The use of non-leafing pigments is coercive for the most kind of paints in order to fulfil the criteria of intercoat adhesion, tinting, wetting and rub resistance.
4. Stabilisation of aluminium pigments

In order to guarantee sufficient stabilisation in waterborne and emulsion paints, it is necessary to passivate the aluminium pigments.

In principle, there are two basic concepts for the stabilisation of aluminium pigments.

First, the so-called “Additive Technology”, which means the absorption of corrosion inhibitors on the active surface of the aluminium pigment.

Additive Molecules

Second, the so-called “Encapsulation Technology”, which encapsulates the aluminium pigment with a transparent silica layer.

Optically Inactive Encapsulation

Encapsulation is the overall benchmark technology for stabilising metallic pigments and is based on sol-gel chemistry [1]. Usually, organic silica (SiO$_2$) precursors like tetraethoxysilanes (TEOS) are hydrolysed in a first step and condensed in a second step to produce a dense layer of SiO$_2$.

To promote the reaction between water and the organic (hydrophobic) precursor, watermiscible organic solvents like alcohols, glycol ethers, ketones are needed [2, 3]. Although the above reaction scheme looks quite simple, it must be stressed that the overall reaction is very complex. A large number of different chemical species is produced during the step-wise hydrolysis and condensation, both reactions taking place concurrently. Usually, an acid- or base-catalyst is used. Hydrolysis and condensation show different dependence on pH and this adds further complexity to the process.
5. APEO free organic stabilisation

APEO’s (Alkylphenol ethoxylates) or NPE’s (Nonylphenol ethoxylates), which is a subset of APEO’s, are well known in the chemical industry because of their excellent wetting and dispersing properties. Studies have determined that these products can be toxic to aquatic life and that these products or by-products are considered to be an endocrine disruptor due to their ability to mimic estrogen.

Therefore, products that are free of APEO stand for a new generation of water-stabilised aluminium pigments.

ECKART’s new product series Hydroxal E and Hydroxal DC form the new lines of stabilised aluminum pigments which do not contain APEO’s. These new water containing E and DC grades are the perfect environmentally friendly alternatives to the existing organically stabilised pigments in the market, which are used in automotive and general industrial applications. For many years, ECKART have already been offering variants free of APEO, especially for decorative paints and graphic arts applications. Now with this new generation of organic stabilisation, previous disadvantages like long dispersing times and weak wetting properties are eliminated. This specific feature comes along with an excellent gassing stability as well as ideal pigment orientation. Due to the absence of APEO’s, the products are, of course, completely harmless and eco-friendly.

Besides these two VOC- and APEO-free product lines, another product series with similar characteristics has been developed under the name of Stapa Hydromic. The difference is that this product line does contain VOC. Therefore, Stapa Hydromic can be airfreighted. The intention of this development was to achieve good intercoat adhesion and a highest level of humidity resistance for additive stabilised aluminium pigments.

6. Silica encapsulation

Silica encapsulation has evolved as standard technology for the protection of metallic effect pigments without the need to resort to heavy metals or other harmful substances. As the encapsulation layer consists of a highly cross-linked network, there is also much less chance that low-molecular compounds might be liberated and eventually migrate (opposite to simple additive stabilization).
Aluminium pigments, which are encapsulated through the sol-gel process with a homogeneous and transparent silicate layer, show the maximum possible mechanical and chemical stabilities. Especially the Hybrid-sol-gel layer and the surface functionalisation allow the development of customised solutions. These tailor-made products provide the best performance in terms of optical effects, stability and eco friendliness.

A novelty within these product series is ECKART’s Stapa HFG (Hydro Food Grade). It is the only silica encapsulated product to fulfil all requirements regarding direct food contact and is conform to European standards and FDA regulations, like FDA 175.300. Stapa HFG is therefore the first choice for all kinds of applications with potential food contact, such as packaging, coatings for cookware and can coatings.

7. Easy to use solutions

The overall handling of effect pigments can be quite delicate, labour-intensive and time consuming. In order to decrease complexity and to realize a higher productivity, easy to use solutions are particularly interesting for the manufacturers of metallic paints.

The ECKART development called “Hydro Pellet” is a new generation of aluminium pellets, which makes the dispersion process really easy. Thanks to its solid form, dosage is much easier compared to powders and pastes. Hydro Pellets contain only a small amount of binders and they are free of any solvent, water, biocides and formaldehyde. The aluminium pigments inside the pellets are stabilised, so that they can be used in waterborne as well as in conventional applications. Due to the absence of water, the Hydro Pellets can be airfreighted.

The benefits of Hydro Pellets - compared to pastes and powders - are the easy handling and dosage: without any dust evolution.

According to GHS (Globally Harmonized System of Classification, Labelling and Packaging of Chemicals), the Hydro Pellets are classified as not dangerous which allows a broad application field.
Hydro Pellets: Summary of Advantages

- High Pigment loading
- Easy to disperse
- Dust free
- Free of solvents
- Free of formaldehydes
- Free of water
- Free of biocides
- Product can be airfreighted

The major application fields are the areas of decorative coatings and printing inks, but it is also a good opportunity for tinting systems. Average dispersion time for finished paint systems is approx. 15 to 25 min., depending on wetting properties, viscosity and fineness of the pellet. The dispersion in distilled water is extremely fast and takes on average only 30 seconds.

8. Outstanding chemical performance products

Cost saving is one of the key targets - also within the coatings industry. A lot of effort is aimed at reducing one coatings layer. It would be perfect to develop a paint system showing the same chemical and optical performance – with or without a top-coat. In terms of metallic effect paints, this means that the protection of the effect pigment should not be achieved by a top-coat but should have to be fulfilled by the pigment itself.

To meet all these requirements, ECKART have developed a double coated aluminium pigment. Its first layer is a silica layer, followed by an additional polymer coating. The pigment provides a fascinating brilliance and light reflection as well as pronounced dark flop behaviour. Its key feature is its outstanding chemical resistance, which means it also accomplishes even the hardest chemical resistance tests for the automotive industry. It passes the test with 0.1 mol NaOH, 4 h at 55° C, whereat the maximum colour change has be to lower than 1.5 dE-units.

What counts a lot is that this pigment category has been designed for waterborne and solvent-borne systems alike – one pigment can be used for both systems. The product guarantees high gassing stability as well as resistance to hand-sweat and to similar stresses. Therefore, it is perfectly suited for one-coat applications such as consumer electronic products, automotive interior applications and all coatings systems that must withstand extreme chemical contamination.
9. Conclusion

Solvent-borne paints only request a few different aluminium pigments and surface modifications whereas the wide range of water-based coatings systems require multiple solutions. For this reason, there is a high demand for manifold stabilization methods in order to meet the customers’ specifications. It is not merely necessary to provide products with a high chemical resistance or which are free of APEO, but also products that guarantee perfect orientation and the desired brilliant metallic effect. Besides these pigment conditions, all requirements regarding productivity have to be fulfilled. That is the reason why it is a must to offer easy to use concepts as well.

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References

