Coil coatings

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Coil coaters increasingly need to produce short runs of specific colours. Ideally, this needs colour pastes that are compatible with all binder systems. Resin-Free Pigment Concentrates (RFPC) meet this need but may require high dispersant levels. A dispersant produced by CRFP improves economy by giving low viscosity and high colour strength RFPCs at lower dispersant levels.

Table 1: Conflicting requirements of paint producers and users

<table>
<thead>
<tr>
<th>Paint manufacturers’ wish list</th>
<th>Paint users’ wish list</th>
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<tbody>
<tr>
<td>Limited number of colours</td>
<td>Full range of colours available</td>
</tr>
<tr>
<td>Minimum number of products and product changes</td>
<td>New products and shades continuously introduced</td>
</tr>
<tr>
<td>Large batch sizes, minimal colour changes and long production runs</td>
<td>just-in-time delivery</td>
</tr>
<tr>
<td>Regular predictable demand and stockage of final product at paint user</td>
<td>Nil/negligible stock of paint</td>
</tr>
<tr>
<td>Highest possible price</td>
<td>Lowest possible price</td>
</tr>
</tbody>
</table>

Figure 1: Formulation principles for CFRP dispersants

Changing patterns in colour production and demand

Today’s coatings, as in the past, serve the dual purpose of providing colour and protection. If this were all the paint manufacturer was expected to do, life would be very simple indeed and traditional methods of paint manufacture would, for the most part, be quite satisfactory.

However, we all know that this is far from being the case. Long gone are the days when a car manufacturer could sell the whole of his output in “any colour so long as it’s black”. This also holds true for the producers of the coatings for the pre-painted metal industry – coil coatings.

In the coil industry, many different resin systems are used to meet all the required end properties, such as durability, flexibility, chemical resistance etc. According to the European Coil Coating Association (ECCA) the main resin systems that are used in the pre-painted metal coating industry are:
- Polyester (69 %)
- Polyurethane (11 %)
- Polyvinylidene fluoride (PVdF) (3 %)
- PVC (plastisols) (16 %)

In the coil industry a strong trend is developing to move to more durable systems – so resins, pigments and colours are becoming more and more important. Alongside that there is also a trend to move to more colours and smaller coating batches.
are ground together. The advantage of such an approach is that low stock levels are achievable. However, there are also significant disadvantages. The whole process is time-consuming and is inefficient with small batch sizes. It is also very difficult to stabilise the pigments, which in many cases results in flooding, floating and rub-out problems – not to mention colour matching issues.

More advanced methods focus on working with pigment pastes. Paint companies who are already using pigment pastes in their production usually work with 20-25 different pigments. These pigment pastes have to be compatible with at least 5-7 different binders, often resulting in at least 100 different pigment pastes to be stocked. Again this creates significant complexity. The advantages are faster supply and improved pigment stabilisation compared to the co-grind method already outlined.

**Resin-free concentrates improve compatibility**

The most advanced, efficient and economical method of producing paint is through the Resin Minimal Pigment Concentrate (RMPC) or Resin Free Pigment Concentrate (RFPC) concepts by making use of high molecular weight polymeric dispersants (HMWD). With only one series of pigment concentrates, compatible with a very wide range of resin binders, it is possible to significantly reduce complexity and to improve consistency of quality. These are the essential advantages of the RMPC /RFPC concept over alternative approaches.

**Results at a glance**

- Coil coating producers face growing demands for relatively short runs of specific colours, often required at short notice. Producing colours in small batches can be uneconomic, and traditional colour mixing systems require large numbers of tinting pastes to suit different binder systems.

- One solution is to produce colours as Resin-Free Pigment Concentrates (RFPC), without using dispersing resins. However, high levels of expensive dispersant may be required to produce flowable pastes.

- Controlled Free Radical Polymer (CFRP) technology can produce polyacrylate block copolymer dispersants with very high efficiency, reducing dispersant requirements in pigment concentrates. One such product was evaluated in RFPCs based on three different pigments. In all cases it showed lower viscosity and higher colour strength than two competitive products and thus offers an efficient solution to the need for flexible production of colours.

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Seeking improved solutions

Colourants for coil coatings are often formulated using the specific binder of the system that it is used in. Some more advanced systems use dispersing resins that have compatibility with a series of resin systems. However, the dispersing resin in general does not have optimal compatibility in all systems. Due to this limitation a variety of colourant systems has to be used to cover all let-down systems.

The RFPC approach removes the influence of the resin. However, the relatively high level of dispersant can make this option less economically attractive due to the fact that additional dispersing agents would be required to compensate for the absence of resin.

Here, the use of highly efficient dispersing agents based on block copolymers can reduce the required amount of a dispersing agent in the RFPC formulation by providing extra stabilisation against flocculation without having to compensate for the absence of resin. The requirements for such a concentrate are:

» Consistent colour development;
» Excellent compatibility with various resin systems;
» No adverse effect on properties of the base paint;
» Stability to settling, syneresis and drying out over time;
» No flooding, floating, flocculation or seeding;
» Low viscosity, even at high pigment content; free-flowing (pumpable) - ease of incorporation;
» Capacity for reproducible production batches;
» Compliance with all relevant regulations and cost efficiency.

So far, RFPC formulations for solvent-based systems have not been generally accepted in the market. The usual requirement to use large amounts of dispersant does make them more expensive compared to the resin minimal pigment concentrate (RMPC) technology. This higher cost can be accepted when specific demands are set for the system, for example in terms of pigment loading.

Efficient dispersant improves RFPC economics

In order to be able to formulate RFPC systems with a lower dispersant demand, novel efficient dispersing agents were needed. Our CFRP technology is ideally suited to deliver the required properties. This technology is used to synthesise highly defined polyacrylate block copolymers. By sequential polymerisation of different monomers, well defined amphiphilic block copolymers can be made (Figure 1). The number of available acrylate and vinyl monomers with different polarity and

<table>
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<th>Table 2: RFPC formulations used for coil coating evaluation</th>
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<tbody>
<tr>
<td>Pigment</td>
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<tr>
<td>Dispersant on DBP</td>
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<tr>
<td>Dispersant on oil-absorption</td>
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<tr>
<td>Dispersant on BET</td>
</tr>
<tr>
<td>Dispersant*</td>
</tr>
<tr>
<td>Butyl glycol**</td>
</tr>
<tr>
<td>Solvent from dispersant</td>
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</tbody>
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* "Efka 4310" and Competitor 1, 52 % actives in solvent, Competitor 2: 70 % actives in solvent
** Due to the higher actives content for the Competitor 2 product, more butyl glycol than shown above had to be added to the formulations

Figure 2: Test results for "Special Black 4" RFPCs formulated with different dispersants, comparing high and low shear viscosity, colour strength and rub-out (in a 90/10 white reduction)
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functionality opens up many possibilities for building AB-block copolymers.

A special monomer mix is chosen in order to secure wide compatibility with the different resin and solvent systems (using the A-block) as well as an excellent affinity for pigments (using the B-block).

This CFRP technology was first commercially introduced in 2003 and has since led to a whole family of products. One of the latest additions to the CFRP dispersing agent family is “Efka 4310”. This product satisfies the latest requirements needed to formulate RFPCs for polyester coil coating systems. As a benefit, the lack of grinding resin does not need to be compensated for by high levels of the pigment dispersant.

Performance of dispersants compared in RFPCs

Comparisons are made below between three different dispersants:

- “Efka 4310”: made by the CFRP process;
- “Competitor 1”: made by conventional polymerisation and recommended for coil coatings;
- “Competitor 2”: made by controlled radical polymerisation and recommended for coil coatings.

All products function via steric stabilisation and have amine-based anchoring groups.

Resin free pigment concentrates (RFPC) were formulated with all these dispersing agents (see Table 2). These pigment concentrates were then tested in several different let-down systems based on different polyester binders, one with a linear polyester, two with weakly branched polyesters and one with a highly branched polyester. The results with the let-down based on the binder “Dy-nopol LH832” (polyester resin) are shown as typical and representative for the results achieved in all the other let-down systems. The RFPCs were tested in a 90/10 white reduction and in masstone in the different let-down systems.

The pastes were dispersed in a glass jar with 2 mm glass beads that were put in a shaker in accordance with DIN 53238-13. Rheology measurements were performed using a Haake “Rheostress” rheometer. Applications were made and cured in an oven; before curing the sample a rub-out was made.

Stability of carbon black RFPC is improved

Paste formulations were made with the carbon black pigment and the three dispersants. Results are shown in Figure 2. Under some addition and shear conditions the competitive products can match the low paste viscosity of the CFRP product “Efka 4310”, but the colour strength is higher for the CFRP product. As can be seen from the rub-out values all pastes show a rub-out colour shift; however, the rub-out for the CFRP dispersant is a “white rub” whereas the rub for the competitive products are “dark rubs”. Closer examination showed that the pastes made with the competitive products showed flocculation when used in the let-down system thus indicating the better stability and suitability of the CFRP dispersant for the carbon black pigment.
Another test was carried out by storing the ready-made paint, including the paste, for a number of days at elevated temperatures (one week at 40 °C). After storage the colour strength of the paint is compared to a freshly made paint. The RFPCs formulated with the CFRP dispersant showed very good results not only for the black but also for the other pigments tested.

**Organic and inorganic red pastes also improved**

The results for a PR101 iron oxide are shown in Figure 3. The two controlled polymers show the lowest paste viscosity. The colour strength of the pastes with the new CFRP dispersant is again the highest of the three products tested. This product also shows the lowest rub-out colour shift, indicating excellent compatibility. With the CFRP product a paste can be formulated with 65 % pigment loading, excellent compatibility and still very low viscosity. The low paste viscosity indicates a potential for using even higher pigment loadings, thus allowing for more efficient use of the milling equipment. Here too the CFRP for coil again shows the best performance.

The results for a PV19 pigment are shown in Figure 4. The paste viscosity in the low shear range is more or less the same compared to the competition, but at higher shear it is significantly lower. This makes the paste more free-flowing and easily pumpable. Colour strength is highest for the CFRP dispersant and the compatibility is at a similar level for all pastes.

In this scientific study several other pigments were also evaluated in different coil coating systems. All results support the finding that CFRP-based dispersants for coil coatings have the best performance when compared to other market technologies.

This CFRP dispersant for coil coatings allows RFPC pastes to be formulated at dispersant levels that are normally used for RMPC formulations without compensating for the lack of dispersing resins. Stable pastes with good performance were formulated, and for carbon black and iron oxide red in particular the new CFRP for coil can outperform established market standards.

**Production flexibility matched with economy**

The latest generation of highly efficient Controlled Free Radical Polymer (CFRP) pigment dispersing agents based on polyacrylate block copolymers thus provides high quality Resin Free Pigment Concentrates (RFPC) to improve the economics and meet market demands in producing polyester coil coating systems. CFRP dispersing agents for coil coatings will give the formulator and producer the possibility of producing pigment pastes with:

- Wide compatibility in many different resin systems;
- One pigment concentrate system needed, thus less stock of premixes;
- Excellent colour development and colour stability in the final coating;
- Maximum colour strength obtained from the pigment;
- A low viscosity profile allows increased pigment loading in the grinding stage;

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**Figure 3:** Test results for “Bayferrox 140M” RFPCS formulated with different dispersants, comparing high and low shear viscosity and colour strength (in a 90/10 white reduction)

**Figure 4:** Test results for RFPCS using “Cinquasia Red Y RT-759-D” formulated with different dispersants, comparing high and low shear viscosity and colour strength (in a 90/10 white reduction)
Higher efficiency in grinding;
High flexibility in producing different let-down systems;
Quick response when new coating systems are required.
Overall our CFRP dispersing agents not only bring technical advantages but also true economic value to the whole production chain of pre-coated metal.

**REFERENCE**


**BIBLIOGRAPHY**


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