Multi-Functional Dispersants for UV inks

Elliot Coulbeck

Mike Collinge

Lubrizol Performance Coatings

Role of Hyperdispersants:

Much can be achieved with surface coatings, materials can be protected, information displayed, and surfaces made more attractive to the eye. As such it should come as no surprise that there is a vast array of materials sold for use in coatings systems. These component materials can bring many beneficial properties to a final coating, including good color strengths, abrasion resistance, shine or gloss. For these components to do this however, they first need to form a stable colloidal suspension, the fundamental basis of most ink and paint systems. If these components cannot be combined to form a stable colloidal suspension, then their properties and the desired properties of the final coating will be greatly inferior. As such, pigment dispersants, sometimes referred to as Hyperdispersants, often play a key role in coatings systems, supporting the formation and stability of the colloidal suspension to allow the other components to perform to the best of their ability.

Intriguingly, the role of the Hyperdispersant is more critical in UV inks than traditional solvent borne inks, due to the nature of the other components in the ink. Traditional solvent born inks always contain some form of resin or binder, which has a primary role of forming the final film when the ink is printed. These resins or binders are normally of reasonable size, with molecular weights in tens of thousands, and as such they can to some extent help with the formation and stabilization of colloidal suspension. When you compare this to a UV based ink the molecular weights of the components are much smaller, with the biggest oligomers normally only being one or two thousand, and as such they offer very little to no help in the formation and stabilization of the colloidal suspension.

This critical role of providing a stable colloidal suspension is purely down to the Hyperdispersants in UV ink systems. Below is described the ways in which Lubrizol have improved our Hyperdispersants for UV ink application areas, to ensure that our Solsperse™ product range offers even more advantages to ink formulators than ever before.

Solubility of Hyperdispersants:

The solubility of any additive in an ink formulation is vitally important, if the additive cannot dissolve in the medium there is little chance it will perform its required function. This is of course true for Hyperdispersants, but is perhaps more critical than one might think, to understand this we need to think a little about how a Hyperdispersant works. Firstly, part of the Hyperdispersant must adhere to the surface of the particle being dispersed (often a pigment) and secondly, the remainder of the Hyperdispersant must extend into the solvent medium to form a steric barrier around the particle. It is the size of this steric barrier that is critical, if the barrier is too short the particles will get very close to each other and the attraction forces between the two particles will be too great, resulting in flocculation. However, if the barrier is long enough the particles can be held at greater distance, reducing attractive forces, and a stable colloidal suspension formed.

For an effective steric barrier of the correct size to be formed around the particle then part of the Hyperdispersant, often referred to as the steric stabilization chain, must be fully extended into the medium. If this part of the Hyperdispersant is not fully soluble then this chain will contract, and the steric barrier will not be of sufficient length to keep the particles in a stable colloidal suspension, as shown in Figure 1.

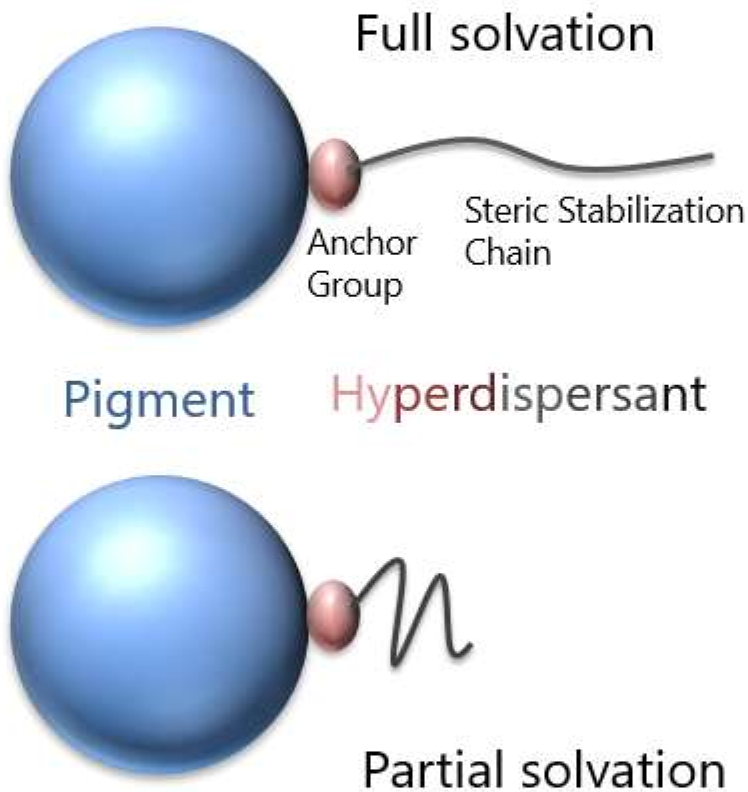

Figure 1: Effect of solubility on steric stabilization chain length

As such Lubrizol have developed two new Hyperdispersants with novel steric stabilization chains which have greater solubility than the market standard products, one designed to stabilize organic pigments and another for inorganic pigments and mineral fillers. The increased solubility of these products over the market standard offers mean that the products work in a broader range of UV monomers and oligomers. However, it also means that we can obtain better performance in monomer/oligomer mixture were the steric chains are now more solvated than market standard products. This can be seen in Figure 2 where we have milled the listed pigments in DPGDA with glass beads for one hour using a market standard product and separately using our novel Hyperdispersant and then measured the viscosity of the resulting millbases obtained. This clearly shows that the increased solvation of the novel

Hyperdispersants steric stabilization chain gives lower millbase viscosity for a range of pigments due to increased solvation of the chains in the monomer/oligomer mixture.

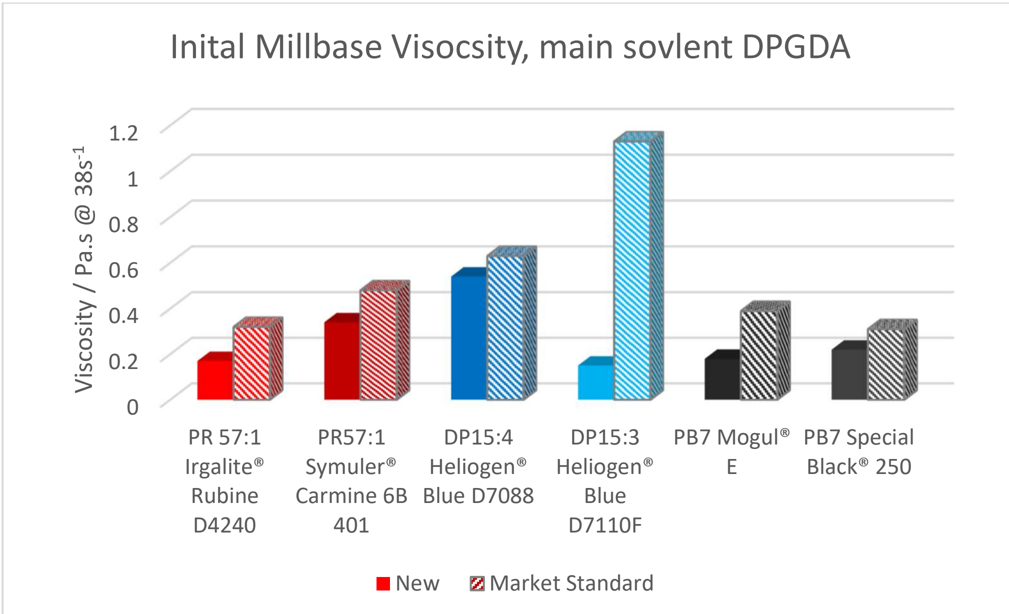

Figure 2: Impact of improved Hyperdispersant solubility dispersant on organic pigments

Challenging Pigments:

By increasing the solubility of our Hyperdispersants we have managed to improve the performance across a range of pigments, however there are some pigments that offer additional challenges. One such example of this is Pigment Yellow 13, a widely used and very useful pigment but one that is often challenging to disperse and keep stable. One of the reasons for this difficulty is that Pigment Yellow 13 is often surface treated with rosin and this can be at a high weight percent, so in fact the surface of the pigment is dominated by the rosin. Dispersants can struggle to adhere to this surface and this in turn leads to poor colloidal stability.

At Lubrizol we have investigating the absorption and adhesion of different functionalities onto Pigment Yellow 13, by formulating inks using an array of Hyperdispersants with different pigment affinity groups and comparing their initial viscosity and their storage stability. During this work we found that the functionalities of the market standard products such as amines and carboxylic acids can adhere to these surfaces, but only if they are in the correct ratios to each other. Accordingly, we have focused upon fine tuning the relative ratios of the pigment affinity groups of new Hyperdispersants for Pigment Yellow 13 and have managed to synthesis a product that can give great colloidal stability, as shown in Figure 3. Here we have milled a pigment yellow 13 in DPGDA with glass beads for one hour using a market standard product and separately using our novel Hyperdispersant, this millbase has then be stored at 50°C and the viscosity measured at set intervals.

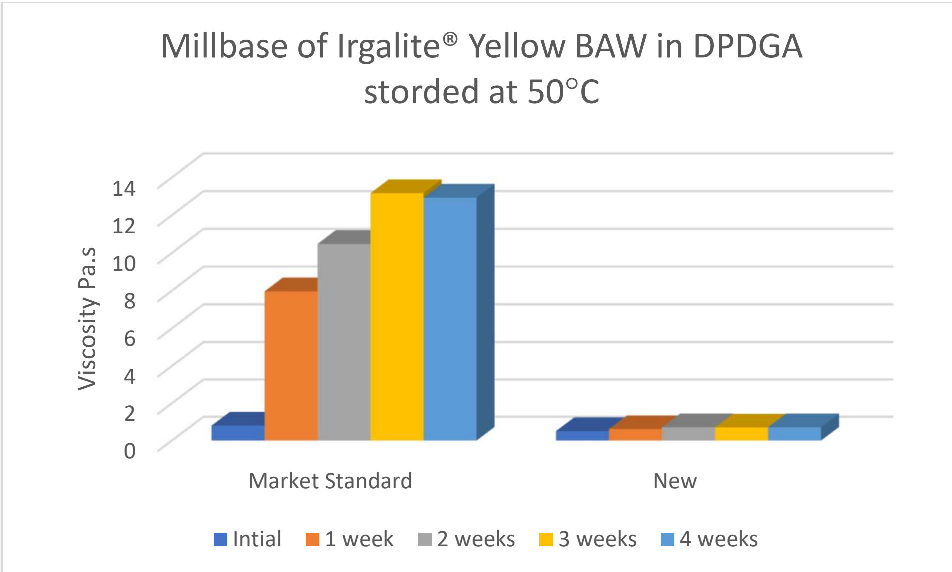

Figure 3: Millbase stability of Pigment Yellow 13

Recently we have received feedback that inks using Pigment Red 57:1 were much harder to stabilize than inks using different pigments, this appeared to be a general problem facing the industry, rather than a couple of ink manufacture struggling with one grade of Pigment Red 57:1. As such we started to investigate this problem and found that we could make low viscosity millbases using a variety of conventional Hyperdispersants. However, when these inks and millbases were stored at 50˚C they quickly started to thicken up, with many becoming gel like in less than one week.

When we started to investigate this problem, we envisaged that the main cause must be that the Hyperdispersant was not adhering to this pigment strongly enough. A simple screen test was derived, where we have milled the pigment red 57:1 in DPGDA at a 25% loading of pigment with glass beads for one hour using, the millbases where then stored at 50°C and the viscosity measured at set intervals, and numerous experimental samples were examined. Some of these experimental samples started to show some promise, with one sample remaining stable beyond the one-week mark. Again, like the Pigment Yellow 13 work this sample did not have vastly different functionality than the other Hyperdispersants tested but the relative ratios of its functionalities were rather different. This sample continued to show great storage stability, even at 3 weeks at 50˚C (see Figure 4) and showed similar performance over a range of different grades of Pigment Red 57:1.

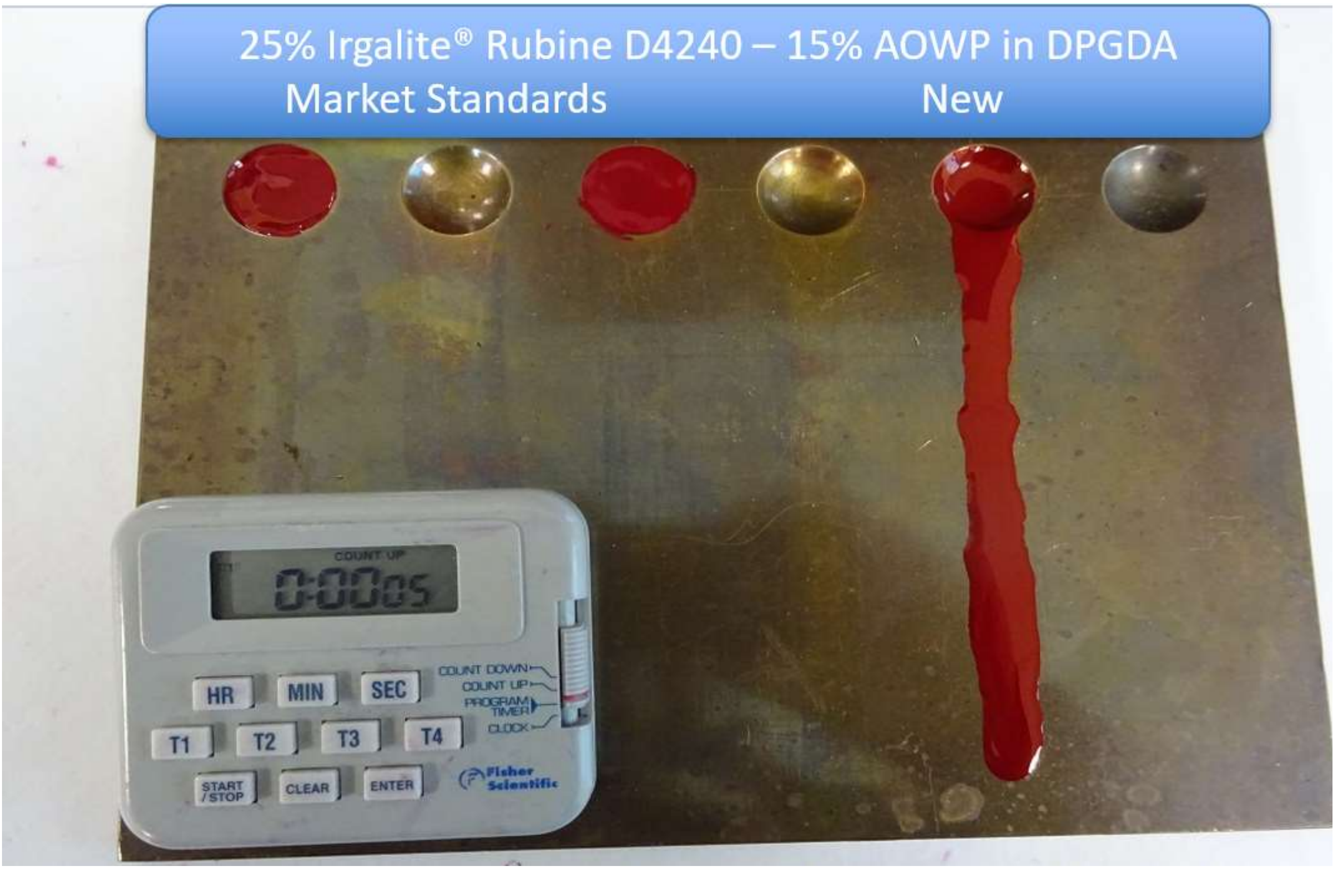

Figure 4: Stability of Pigment Red 57:1 millbases after three weeks storage at 50˚C

Viscosity of Hyperdispersants:

The physical form of many high performing Hyperdispersants can be somewhat non-desirable. Many are viscous liquids, and some can even be pastes, in many market sections this is not a major issue as it is perfectly acceptable to deliver these products in common solvents. However, in UV inks we cannot deliver these additives in a simple organic solvent, and as such the market standard tends to be 100% active products, which are usually viscous liquids. The arises as the parameters that normally make a Hyperdispersant perform well also tend to increase its viscosity, for example, higher molecular weight Hyperdispersants often give better long-term ink stability but simultaneously raise additive viscosity. Likewise, functional groups that adhere strongly to pigment surfaces, such as amines and acids also often make the polymer more "sticky" or "tacky" due to their inherent surface adhesion.

At Lubrizol we would prefer that our products are easy to handle, so that warming of the additives was never required and that pumping was easy. To tackle this, we have started to explore the concept of very flowable high performance Hyperdispersants. To do this we have critically looked at every part of the product that can increase viscosity or add a tacky nature and tried to either replace it with a lower viscosity alternative or reduce its prevalence in our final product. This has been challenging, we have even had to design a new process for making this product, but we now have a prototype, a low viscosity high performance Hyperdispersant. Figure 5 shows the viscosity of this material in comparison to a market standard product for this area.

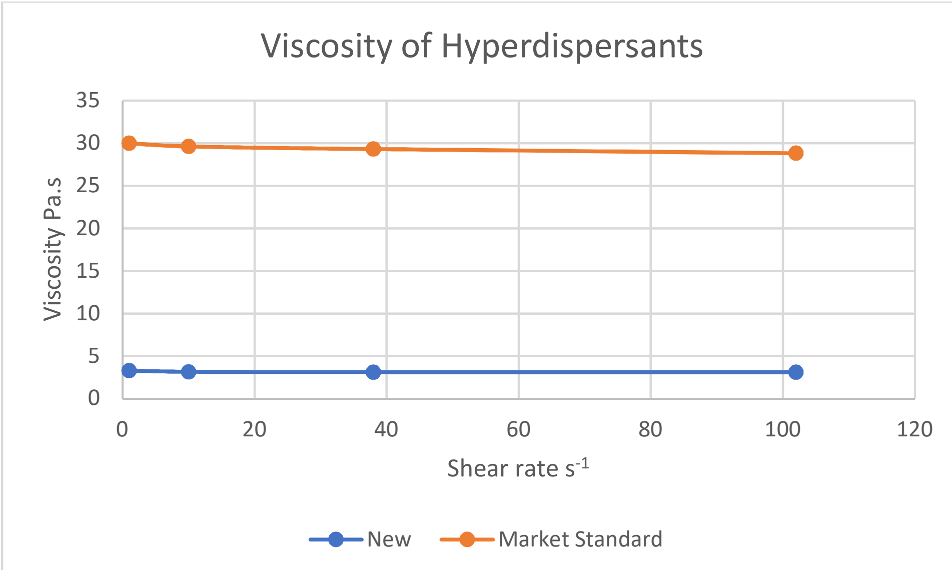

Figure 5: Viscosity of prototype chemistry

Although we are still in the development stage of this new Hyperdispersant we are currently getting very promising results when used to formulate cyan, magenta and yellow inks, so we are hopeful that our efforts to reduce the viscosity of the material have not had a detrimental effect on its primary function as a dispersant for pigments.

To Conclude:

This article covers how Lubrizol has developed new technology to complement our already well regarded Solsperse™ products for UV ink applications. We have tried to achieve this via three main methods. Firstly, improving the solubility range of our products, so that they can be used in a wider array of monomer and oligomer mixtures and give greater performance due to the increased solvation of the steric stabilization chain. Secondly, by targeting pigments that are sufficiently different enough from many other pigments that they benefit from having tailor-made Hyperdispersants, this includes products designed for Pigment Yellow 13 and Pigment Red 57:1. And finally, we are looking at making Hyperdispersants that are much easier to handle than many high performing pigment dispersants that are currently on the market, and we currently have a very promising prototype in this area.

Acknowledgement:

We would like to thank the following for companies for kindly suppling their pigments for these investigations: BASF; SunChemicals®; Cabot; Orion Engineered Carbons.

Trade Marks:

Irgalite® is a trademark of BASF

Symuler® is a trademark of SunChemicals

Heliogen® is a trademark of BASF

Mogul® is a trademark of Cabot

Special Black® is a trademark of Orion Engineered Carbons