Skimming the surface:
High performing additives
Trends in the architectural market are strongly driven by two sources. The first driver is legislation, where compliance to Volatile Organic Compound (VOC) regulations is non-negotiable and is forcing formulators to look carefully at all their ingredients (including additives) to reduce VOCs to low levels (<50g/l). The second driver, and arguably the most important, is the end-consumer in the Do-It-Yourself market, who are asking for longer lasting, easier to use products that are ‘less harmful’ to themselves and their families – this could mean lower odour, less solvent or quicker drying for example. Of course they also want these products at the lowest price possible.

Experts at Dow Corning strive to help the formulator meet these two goals by producing water resistant and foam control additives with low VOCs that can be used at low levels to improve the durability of architectural paints at an affordable cost, whilst meeting the necessary regulations.

Improving the Durability of Architectural Paints

Traditionally improved water resistance has been a request of the consumer for exterior applications in order to protect the underlying substrate from water penetration.

Less obvious to the consumer perhaps is the need for the paint film to be permeable to any water coming from within the substrate to prevent cracking and blistering.

Silicone resin emulsions have been used for water resistance for a number of years in the industry, where the formulator replaces a proportion of the acrylic resin emulsion by the silicone. The amount of silicone used is of course dependent on the performance required but typically replacement is at levels way beyond those considered to be ‘additive levels’ and certainly at >5% of the total formulation by weight. Whilst this improves performance, it can also add significant cost. To achieve water beading typically another additive is also required.

Dow Corning has developed two silicone-based materials that can be used at additive addition levels (typically <2% of the total formulation) to give improved water resistance, one such material also gives water beading without the need for an additional additive. Improvements in architectural paints when using these additives using standard industry tests such as $S_d$ (Water Vapour Transmission in accordance with ASTM 7783-1:2000) and $W_{24}$ (Water absorption through a paint film in accordance with DIN 52617) are demonstrated in figure 2.
ADDING TO WATERBORNE

Dow Corning 87 Additive is a solvent and APEO-surfactant-free silicone emulsion. When added to a waterborne paint at typical use levels of 2-5% by weight of the total formulation, this additive contributes <4-10g/l VOC. In the in-house waterborne acrylic resin emulsion based architectural paint formulations, this additive has shown improved water repellency and excellent water beading.

**Figures 1 and 2 demonstrate the performance of this additive at 2% by weight addition to the total formulation of a waterborne paint, added in the let down phase. Dow Corning 87 Additive gives reduced water absorption at only 2% addition by weight to an acrylic based emulsion paint compared to current silicone resin technology at 5% by weight. In addition, this has increased the contact angle of water on the surface of the paint from 75° to >110°.**

Evaluation of the performance of this additive in an acrylic waterborne paint with high Pigment Volume Concentration (PVC) showed the same excellent level of performance. **Figure 3** lists the paint formulation used; **Figure 4** shows water absorption ($W_{24}$) and water beading (contact angle) of the paint are improved with addition of Dow Corning 87 Additive, beyond the competitor performance at the same addition level. A contact angle of >120°C is achieved here.

As previously mentioned, less obvious to the consumer perhaps is the need for the paint film to be permeable to any water coming from the substrate to prevent cracking and blistering. Paints with ‘excellent’ water vapour permeability are generally considered to have an Sd value of <0.14 (the lower the Sd value the better the film can ‘breathe’ and therefore blistering and cracking is reduced). The Sd value of the paint formulation shown in **figure 3** is very low without the addition of silicone and remains so even with the addition of Dow Corning 87 additive at its highest use level (5%). See also **figure 5**.

**Fig. 3. High PVC paint formulation used to assess Dow Corning water resistant additives**

<table>
<thead>
<tr>
<th>Component</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvent</td>
<td>Water</td>
</tr>
<tr>
<td>Thickener</td>
<td>Natrosol 250</td>
</tr>
<tr>
<td>pH modifier</td>
<td>Sodium Hydroxide (20% w/w solution)</td>
</tr>
<tr>
<td>Dispersant</td>
<td>Dispiex GA40</td>
</tr>
<tr>
<td>Antifoam</td>
<td>DC 68 Additive</td>
</tr>
<tr>
<td>Pigment</td>
<td>TiO₂ - TR92</td>
</tr>
<tr>
<td>Filler</td>
<td>Kaolin - Optimat 2550</td>
</tr>
<tr>
<td>Filler</td>
<td>Mica - Mica Mkt</td>
</tr>
<tr>
<td>Filler</td>
<td>Carbital 115 - CaCO₃</td>
</tr>
<tr>
<td>Thickener</td>
<td>Polyurethane thickener</td>
</tr>
<tr>
<td>Resin</td>
<td>Acrylic emulsion</td>
</tr>
<tr>
<td>Coalescing solvent</td>
<td>Dipropylene glycol n-butyl ether</td>
</tr>
<tr>
<td>Biocide</td>
<td>Acticide MBS</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**Fig 4. Left: $W_{24}$ and contact angle of water on an acrylic-based emulsion paint with and without Dow Corning 87 Additive and vs a competitor Si resin emulsion**

**Fig 5. Left: Sd of water on an acrylic-based emulsion paint shown in fig 3 with and without Dow Corning 87 Additive**

**Fig 6. Above: $W_{24}$ of an acrylic based emulsion paint with and without Dow Corning 88 Additive and vs a competitor Si resin emulsion**

**Fig 7. Below: $W_{24}$ of the acrylic based emulsion paint shown in fig 3 with and without Dow Corning 88 Additive and vs a competitor Si resin emulsion**

**Fig 8. Above: $W_{24}$ of an acrylic based emulsion paint with and without Dow Corning 88 Additive and vs a competitor Si resin emulsion**

**Fig 9. Below: $W_{24}$ of the acrylic based emulsion paint shown in fig 3 with and without Dow Corning 87 Additive**

**Fig 10. Above: $W_{24}$ of an acrylic based emulsion paint with and without Dow Corning 87 Additive and vs a competitor Si resin emulsion**

**Fig 11. Below: $W_{24}$ of the acrylic based emulsion paint shown in fig 3 with and without Dow Corning 87 Additive**

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**Fig 23. Below: $W_{24}$ of the acrylic based emulsion paint shown in fig 3 with and without Dow Corning 87 Additive**

**DECORATIVE APPLICATIONS

Dow Corning 88 Additive is a 100% silane/siloxane blend. This is suitable for use in waterborne decorative paints that contain polar solvents but is also suitable for use in non-aqueous, solvent-based decorative paints. In our in-house formulations this additive has shown excellent water repellency at low addition levels of 2%. At this level the total contribution to the VOC of the paint is 1.5g/l.**

In **figure 6** it can be seen that Dow Corning 88 Additive vastly reduces water absorption at only 2% addition by weight to an acrylic based emulsion paint. At 5% addition by weight an additional improvement can be seen. No such improvement is seen with the competitive product, even when the addition level is doubled to 10% by weight.

In the high PVC paint formulation listed in **figure 3** it can
be seen that W24 values of <0.1 at only 2% addition of Dow Corning 88 Additive by weight, while the water permeability (Sd) is not significantly impacted by the addition of Dow Corning 88 Additive even at high addition levels (5%).

So how do these materials work? Dow Corning 87 and 88 additives react to create a hydrophobic silicone network in the paint to repel water but allow the paint to retain an open structure sufficient to allow water to permeate through the film to allow it to breathe.

CONTROLLING FOAM IN WATERBORNE ARCHITECTURAL PAINTS

Antifoams are a critical component in the formulation of architectural paints to control foam. Traditionally low actives silicone antifoams or mineral oil antifoams are used to control foam in architectural paints. This is often because these materials are considered cost effective due to low price/kg. There are however more choices available to the formulator. A high solids silicone antifoam can often be used at much lower levels in the formulation to achieve good cost-in-use performance.

Dow Corning offers three specific silicone antifoam emulsions to the architectural market to control foam in waterborne formulations – all are low-VOC and are free from APEO surfactants. Dow Corning 62 and 68 additives are approximately 50-60% actives silicone emulsions that give good foam control at low addition levels. In figure 9 better foam control performance of these antifoams versus mineral oil based antifoams on the market today, can be seen, by evaluating the density of the paint after high shear mixing – the higher the density, the better the foam control.

Of course the formulator may wish to use a lower actives antifoam to allow for greater formulation flexibility. Dow Corning Antifoam 2210 is a 10% actives silicone emulsion that has been shown to give comparable or better performance to a leading competitor low solids silicone emulsion antifoam in the market today.

In figure 10 Dow Corning Antifoam 2210 is evaluated in a 45% solids acrylic polymer dispersion (BASF Acronal LR 9014). Good foam control is seen (compared to the control with no antifoam) on immediate addition (one day) and after in-can storage (two months).

On an actives basis all three antifoams give the same good foam control. The level of compatibility may, however, also influence the choice of the formulator.

It is hoped that Dow Corning has demonstrated suitable offerings to the formulator to improve the durability of their paint formulations as well as solve the issues foam brings and in a cost-effective way. Other additives to help flow and levelling, substrate wetting, slip and scratch resistance are also available from the company’s website.

Fig. 8. Above: Sd of the acrylic based emulsion paint shown in fig 3 with and without Dow Corning 88 Additive and vs a competitor Si resin emulsion

Fig. 9. Above: Dow Corning 62 and 68 Additives are compared to mineral oil-based antifoams. 0.1% solids addition is used for all products

Fig. 10. Below: Dow Corning 62 and 68 Additives are compared to mineral oil-based antifoams. 0.1% solids addition is used for all products

Fig. 11. Below: Dow Corning 62, 68 Additives and Antifoam 2210 are compared directly at the same actives level in an acrylic emulsion. This means approx 0.2% by wt of the 62 and 68 Additives and 1% by wt of the Antifoam 2210. Density is measured after high shear mixing (3150rpm for 10min)