Two trends are evident in architectural paints today. Waterborne, or latex, paints continue to grow in use, and today’s homes are increasingly being painted with deep, vibrant colors, both inside and out. While experience has shown that the best overall balance of rheology in waterborne coatings is achieved by using non-ionic associative rheology modifiers, when such coatings are tinted with high levels of colorants they often exhibit a significant decrease in viscosity. This decreased viscosity can manifest itself in a number of ways, including low sag resistance, poor brush loading and a “thin” appearance in the can. Although a number of approaches to formulating around these issues exist, there continues to be a need for viscosity-stable rheology modifiers. A new development in HEUR thickening offers significant improvements in these performance parameters.

**Associative Thickening**

Associative rheology modifiers consist of a water-soluble polymer backbone that contains two or more hydrophobic groups. This general structure is shown in more detail in Figure 1 for the specific case of the HEUR (hydrophobically modified ethylene oxide-based polyurethane) composition. The function of the hydrophobes is to associate with hydrophobes from other rheology modifier polymers as well as with the surface of the binder latex particles. Figure 2 illustrates how such associations can result in the formation of a network structure that links together individual latex particles, thereby restricting their motion and thus increasing the viscosity.

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**FIGURE 1 |** Structure of HEUR non-ionic associative rheology modifier.

**FIGURE 2 |** Mechanism of associative thickening. Hydrophobic groups associate with the latex surfaces to form a network structure.

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**Effect of Colorant Addition**

Colorants, especially the universal type, contain high surfactant concentrations. The hydrophobes from these surfactants compete for adsorption sites on the latex surface and will thereby displace some of the rheology modifier from that surface. The net effect of this competition is that there will be fewer thickener hydrophobes adsorbed, resulting in a weaker network and lower viscosity. The surfactant will also decrease the association between rheology modifier chains themselves, also contributing to a decrease in viscosity.

Various approaches exist to mitigate these effects of colorant addition. The simplest approach is to minimize the use of associative thickeners, and in their place use non-associative thickeners. This approach tends to result in poor flow, a direct consequence of the volume-depletion flocculation mechanism by which non-associative thickeners work. This phenomenon is shown in the transmission electron microscope (TEM) images shown in Figure 3, where the left side shows uniformly distributed latex particles in a mixture containing only latex and water. However, when a non-associative thickener is added, there is flocculation of the latex particles, resulting in regions of high latex concentration and regions of low concentration. This flocculation creates high viscosity at low shear rates, which leads to poor flow and leveling of the coating.

A second approach to mitigating the viscosity loss problem is to overthicken the untinted base paint, so that after tinting, the viscosity drops to the desired final viscosity. This approach adds cost to the formulation, can make handling of the unthickened paint during manufacturing and filling more difficult, and gives a wide range of final, tinted viscosities that depend on the color formula.

In summary, as the colored paint market continues to grow, the currently available approaches to mitigating viscosity drop all have weaknesses. Thus the need continues to exist for a rheology modifier that provides significantly better viscosity stability upon colorant addition.

**New Viscosity-Building Mechanism**

A new rheology modifier technology has now been developed that significantly reduces the viscosity loss upon tinting. This new type of thickener is of the HEUR, non-ionic type and in addition to viscosity stability, it delivers the excellent flow and leveling and other properties for which non-ionic rheology modifiers are well known. It is also free of solvent for compliance with current and future regulations.

The improved viscosity stability is achieved through a new viscosity-building mechanism. To understand this new mechanism, one needs a slightly more
detailed model of how associative thickeners build the networks that develop their viscosity. Figure 4 shows the surface of two latex particles and a number of interactions that contribute to the network. There are high-shear building (HS) (also called ICI-building) and mid-shear building (MS) (also called KU-building) thickeners adsorbed on the surface of the latex particles. Since there is typically a higher level of HS than MS in a coating, the figure shows more HS adsorbed than MS. Note the existence of both looped and single-ended adsorption of the MS thickener.

The new technology has been designed to have a lower molecular weight than the high-shear thickener. This difference in molecular weight leads to the two components occupying different volumes of space when adsorbed on the latex surface (shown schematically in Figure 5), thus hindering access to the lower-molecular-weight, new-technology component. This steric crowding makes some of the hydrophobes on the new technology polymer inaccessible for network building and, in effect, inactivates a fraction of these thickener polymers.

When colorant is added, its surfactants will displace both HS and MS chains from the latex surface. This change results in a decrease of the steric crowding at the surface, and allows some of the previously inaccessible mid-shear chains to now participate in network building. Furthermore, the displaced chains can participate in building the multi-link connections necessary for effective network building. This effect is illustrated by comparing the schematic prior to the addition of the colorant (Figure 4) to the situation after colorant addition (Figure 6).

In summary, with the new technology, the colorant activates a new mechanism that increases viscosity upon the addition of surfactant. The result is significantly less viscosity loss upon the addition of colorant to the paint base.

**Benefits of New Technology**

The viscosity stability delivered by this new technology, embodied in Acrysol™ RM-895 rheology modifier, will be of greatest benefit in paints that exhibit the largest viscosity loss with colorant, i.e., medium to deeply tinted paints (4% or more tint). Thus, we compared the performance of the new technology to current HEUR products in a 100%-acrylic Rhoplex™ VSR-1050, semigloss neutral base formulated at 34% volume solids and 30 PVC of calcium carbonate.

The viscosities of each initial, untinted base paint were adjusted so that after tinting with 8 oz/gal of either phthalo blue or red iron oxide, the viscosities were approximately 95 KU. The viscosity losses exhibited by the three paints are shown in Figure 7. Clearly,
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the new technology gives a much lower viscosity drop on tinting. The new technology has sag resistance comparable to or better than the conventional HEUR products (left side of Figure 8). The right side of the figure shows the increased sag resistance obtained when the initial KU, and hence the tinted KU, of the new technology paint is deliberately higher. An unexpected result is that even the 120 KU Acrysol RM-895 paint has flow that is only slightly poorer than the 100 KU paint, thus giving an excellent flow/sag balance to the tinted paint. The improved sag resistance also translates into excellent brush and roller loading.

Because of the need to establish a wide array of associations between rheology modifiers, surfactants, dispersants, latex particles and other hydrophobic components of the formulation, it is common for viscosities to take several hours, and sometimes overnight, to reach their final values. This new technology typically achieves its final viscosity within approximately 1 hour, potentially spurring a significant increase in plant productivity.

Conclusion

The new technology for non-ionic thickeners described above acts through a new mechanism to provide three desired properties to tinted paints: 1) improved resistance to viscosity loss, 2) improved sag resistance, and 3) preservation of excellent flow.

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