MEETING TOMORROW’S DEMANDS TODAY

VAE-Based Emulsions for the Indian Paints and Coatings Market
Meeting tomorrow’s demands today: VAE-based emulsions for the Indian paints and coatings market

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VINYL acetate-ethylene copolymer emulsions (VAEs) were introduced into the commercial market more than 50 years ago. However, it was not until early in the last decade that VAE emulsions gained a growing importance in the market for architectural coatings and paints – especially for formulations with a good cost performance balance and low environmental impact.

Today, high-quality binders based on vinyl acetate-ethylene copolymers are becoming more and more important in the paint and coatings industry. Although the benefits of polymerizing a hard monomer (vinyl acetate, VA) and a soft, hydrophobic monomer (ethylene, E) have long been recognized, until relatively recently, the costs of VAE copolymer emulsions were often too high to be widely utilized in the coatings market.

However, improved production processes, higher productivity, as well as changes in raw material availability and prices have resulted in increased popularity of VAE copolymer emulsions over the last ten to fifteen years. Nowadays, VAE-based products are used as high-quality binders in construction chemicals, adhesives, plasters, engineered fabrics and, increasingly, in the field of paints and coatings.

VAE emulsions are the result of the polymerization of vinyl acetate and ethylene monomers via a high pressure polymerization process. Polyvinyl acetate is a rather stiff material due to its relatively high Tg (glass transition temperature*); it is often copolymerized with ethylene to provide greater flexibility. The resulting vinyl acetate-ethylene copolymer emulsions feature all the benefits of the homopolymer in strength and heat resistance, yet also offer better adhesion and coalescence properties.

VAE emulsions typically come as a white liquid where the solid particles are dispersed in an aqueous medium. To prevent the solid particles from sticking together and agglomerating, protective substances are arranged around the polymer particles. The most common types of protectives are surfactants and protective colloids. Their purpose is not only to protect the polymer particles, but to control viscosity and additional properties such as water resistance.

(see Fig. 1)

Emulsions protected by colloids typically show strong wet tack, good machine workability and rapid setting speed, so they are mainly used in adhesives. For paints and coatings, surfactant-protected VAE emulsions have greater advantages, such as fine particle size, good sprayability, thixotropic rheology and water-resistance, as well as glossy film properties (see Fig. 2).

The fundamental properties of the polymer backbone determine the suitability of a given type of emulsion for a particular end use application. One of the main advantages of VAE emulsions for coatings applications is that ethylene is directly incorporated into the polymer backbone. These ethylene units in the polymer chains act as internal, tightly integrated plasticizers, thus minimizing the risk of migration.

Having ethylene incorporated into the polymer backbone allows VAE copolymers to exhibit increased flexibility, as well as making it easier for queries and responses: author.paintindia@gmail.com

OOO

CH₃

CH₃

OOO

(H ₃ C)

CH₃

Fig. 1: Vinyl acetate-ethylene copolymer structure
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The fundamentals of VAE technology

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The fundamental properties of the polymer backbone determine the suitability of a given type of emulsion for a particular end use application. One of the main advantages of VAE emulsions for coatings applications is that ethylene is directly incorporated into the polymer backbone. These ethylene units in the polymer chains act as internal, tightly integrated plasticizers, thus minimizing the risk of migration.

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them to entangle and coalesce. Moreover, when polymerized with vinyl acetate, ethylene is more efficient than other co-monomers at reducing the glass transition temperature and minimum film formation temperature (MFFT*). Figure 3 shows the impact of different co-monomers polymerized with vinyl acetate and the effect on the glass transition temperature. Interpreting the figure, it becomes clear that ethylene is a much more effective plasticizing monomer for vinyl acetate than, for instance, butyl acrylate (BA). Furthermore, the backbone flexibility of the ethylene co-monomer appears to provide enhanced film formation properties beyond a simple Tg reduction.

**Improved performance**

In paints and coatings, VAE emulsions serve as binders: They impart adhesion, cohesion, and enhance important properties such as gloss potential, flexibility, and toughness.

An advantage of VAE copolymer formulations is that they can be designed to exhibit superior scrub resistance in systems with or without coalescing solvents. Furthermore, they can provide significant improvements in key coating properties such as low-temperature coalescence and mudcracking while reducing the overall formulated cost of the paint.

Further, VAE emulsions feature high binding power and good rheological behavior as well as excellent applicability and workability. For this reason, VAE emulsions are able to fulfill higher application and performance demands.

**Low-odor paints and coatings**

Increasing technological demands require today’s paints and coatings to be reliable, high-quality, and high-performance products. Additionally, more attention is being paid to the materials’ environmental compatibility. Globally, the coatings market is increasingly looking for solutions with minimal volatile organic compounds (VOC). Thus, the paints of the future must have a low environmental impact with a high efficiency while still complying with increasingly stringent requirements, labels and legislation.

What makes VAE copolymers inherently low VOC-capable is that the ethylene monomer is directly incorporated into the polymer backbone, making ethylene the ideal internal plasticizer for vinyl acetate polymer dispersions. As mentioned, ethylene polymerized with vinyl acetate is more efficient than other co-monomers at reducing the Tg and the MFFT. Consequently, reducing the solvent demand of the polymer enables the formulation of a low VOC or even odorless paint.

Ethylene reacts more readily with vinyl acetate than, for instance, butyl acrylate does. As a result, VAE copolymers have a more random distribution of monomer throughout the polymer chain. In a typical coatings-
grade vinyl acrylic (VA/BA) system, each monomer seeks to react with "itself," creating a "blockier" copolymer with long chains of both vinyl acetate and butyl acrylate. This phenomenon makes vinyl acrylates more susceptible to hydrolysis, or "unzipping," in the presence of an alkaline solution.

In a structural comparison of VAE copolymers to VA/BA copolymers, ethylene is incorporated into the polymer backbone and provides main chain flexibility (Fig. 4). This is advantageous for VAE copolymers because it allows the polymer chains to be more flexible, making it easier for them to entangle and coalesce. Butyl acrylate, on the other hand, is attached to the polymer backbone as a pendant group, which makes the chain less flexible, hindering entanglement and coalescence.

VAE copolymers exhibit inherently good coalescing properties (Fig. 5). The graph clearly illustrates the inherently better coalescing properties of VAE-based emulsions compared to styrene-acrylic (SA) emulsions. That's one reason these dispersions are becoming the industry standard in low-odor interior paints - minimizing coalescing solvents for reduced odor and lower formulation cost. VAE copolymers also offer improved coalescence at low temperatures. This provides better low-temperature touch-up properties, a factor critical to the contractor paint market.

**Benefits in applications and industry**

VAE copolymer dispersions are ideal to use for architectural coatings with reduced environmental impact. With a variety of benefits including low solvent demand, low residual monomer (<200 ppm), and developed without the use of APEO (alkylphenol ethoxylate) containing raw materials or formaldehyde donors, newer VAE copolymers are well suited to meet even the strictest environmental regulations.

Characterized by high rotation freedom, low spatial hindrance, high backbone flexibility and stable structure, VAE copolymers provide a certain degree of water resistance and a desirable degree of resistance to acids and alkalis. The molecular chains of these copolymers are capable of maintaining stable properties in dilute acid and alkali conditions through adjustment of the polymer structure's copolymer component - for example, the ratio of vinyl acetate to ethylene or special functional monomers - to develop high-performance copolymer dispersions.

**Conclusion**

Today's natural gas-based VAE copolymers have been developed for a variety of applications to meet specific end uses. Customized solutions take into consideration the unique circumstances and needs of each customer, in the coatings industry and beyond. Moreover, VAE copolymer dispersions are able to fulfill higher application and performance demands while eliminating co-solvents in a formulation. Technological advances continue to address ecological and sustainability issues of vinyl acetate and ethylene monomers, as they enable low VOC-capable water-based VAE copolymer produced with raw materials that do not contain APEO. Latest VAE copolymer dispersion developments are allowing formulators to incorporate new raw materials while still offering full performance and, in many cases, cost advantages.

**Notes**

* Tg (glass transition temperature) indicates the hardness of the dry polymer; it is the temperature where the polymer transitions from a smooth, glassy substance to a softer, rubbery substance. The lower the number, the softer the polymer.

** MFFT (minimum film formation temperature) indicates the temperature where the polymer forms a film. The lower the temperature, the easier the polymer forms a film at room temperature.
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