ЖАРАТЫЛЫСТАНУ ҒЫЛЫМДАР / ЕСТЕСТВЕННЫЕ НАУКИ / NATURAL SCIENCES

DOI 10.54596/2958-0048-2024-2-9-14
UDK 667.637.233
IRSTI 67.09.51

STATE, PROBLEMS AND MODERN DIRECTIONS OF MODIFICATION OF WATER-DISPERSION PAINT AND VARNISH MATERIALS

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Abstract

This article is devoted to the analysis of the state, problems and prospective directions of application of water-dispersion paint and varnish materials. Providing reliable and durable protection of coating remains the main task of water-dispersion paint and varnish materials technology. In this connection, modern technical solutions to improve the protective characteristics of paint and varnish compositions based on aqueous film-forming agents and, accordingly, the search for effective components in the direction of modification of paints and coatings acting as universal additives, in particular, dispersants and anticorrosive agents are considered.

Key words: water-dispersion paints, lignosulfonate, surfactant, anticorrosive agents.

СУ-ДИСПЕРСИЯЛЫҚ ЛАК-БОЯУ МАТЕРИАЛДАРЫН ӨЗГЕРТУДІҢ ЖАЙ-КҮЙІ, МӘСЕЛЕЛЕРІ ЖӘНЕ ҚАЗІРГІ ЗАМАНҒЫ БАҒЫТТАРЫ

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Аңдатпа

Бұл мақала сулы-дисперсиялық лак-бояу материалдарын қолданудың жай-күйін, проблемаларын және перспективалық бағыттарын талдауға арналған, жабынның сенімді және ұзақ мерзімді қорғалуын қамтамасыз ету сулы-дисперсиялық лак-бояу материалдары технологиясының басты міндеті болып қала береді. Осыған байланысты, Сулы пленка түзуші негізінде лак-бояу композицияларының қорғаныш сипаттамаларын түзету және тиісінше әмбебап қоспалар, атап айтқанда диспергаторлар мен коррозияға қарсы агенттер ретінде әрекет ететін бояулар мен жабындарды өзгерту бағытында тиімді компоненттерді іздеу бойынша заманауи техникалық шешімдер қарастырылды.

Түйін сөздер: су-дисперсиялық лак-бояу материалдары, лигносульфонат, беттік-белсенді зат, коррозияға қарсы агенттер.

СОСТОЯНИЕ, ПРОБЛЕМЫ И СОВРЕМЕННЫЕ НАПРАВЛЕНИЯ МОДИФИЦИРОВАНИЯ ВОДНО-ДИСПЕРСИОННЫХ ЛАКОКРАСОЧНЫХ МАТЕРИАЛОВ

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Аннотация

Данная статья посвящена анализу состояния, проблем и перспективных направлений применения водно-дисперсионных лакокрасочных материалов. Обеспечение надежной и долговечной защиты покрытия остается главной задачей технологии водно-дисперсионных лакокрасочных материалов. В этой связи, рассмотрены современные технические решения по корригированию защитных характеристик лакокрасочных композиций на основе водного пленкообразующего и соответственно поиск эффективных составляющих в направлении модификации красок и покрытий выступающих в качестве универсальных добавок, в частности, диспергаторов и антикоррозионных агентов.

Ключевые слова: водно-дисперсионные лакокрасочные материалы, лигносульфонат, поверхностно-активное вещество, антикоррозионные агенты.

Introduction

Nowadays, environmental considerations are increasingly emphasized in the use of paint and coating materials (PCMs), leading to a widespread shift from solvent-based paints to water-soluble alternatives. Aqueous dispersions of copolymers of acrylic, acryl styrene and vinyl acetate are frequently used in paint formulations worldwide. Although vinyl acetate is more economical than styrene and polyacrylate, it offers a number of significant advantages. Vinyl acetate paints incorporating the PVAc polymer have excellent adhesion to various substrates, flexibility, excellent water resistance and less odor compared to their solvent-based counterparts. They are also known for their ease of application, fast drying time and low volatile organic compound (VOC) content, making them environmentally friendly. However, like most water-based paints, vinyl acetate paints lag behind their organic solvent-based counterparts in corrosion protection. Providing reliable and durable coating protection remains the main task of waterborne despersion paint technology. Modern technical solutions synchronize the phases of contact (air, steel substrate, pigment) and dispersion, allowing to create dense insulating films impermeable to aggressive agents. High adhesion strength plays a key role in preventing the occurrence and spread of corrosion under the film of water dispersion coating materials. This property significantly improves the protective characteristics of the coating, making it more durable and effective. However, when it comes to multifunctional modifiers, the issue of choosing the right solution becomes more complicated due to the lack of a universal option. The search for effective surfactants and water-dispersion paint-and-lacquer compositions requires complex physicochemical studies and technical evaluations.

Discussion

The range of waterborne paint and varnish compositions is extensive, and most of them belong to three main types: styrene-butadiene, polyvinyl acetate and acrylic compositions [1]. These coatings, despite their relative resistance to oxidative aging and UV radiation, are prone to microbial degradation, especially during storage and painting. In Europe, more than 600,000 tons of water-based polymer dispersions are used annually for architectural coatings and varnishes in a variety of applications, including high humidity environments. Low-shrinkage wood primers have been prepared based on vinyl acetate dispersions, which are superior to primers based on traditional binders. [2]. The use of vinyl acetate copolymers in the manufacture of hot melt adhesives for polyolefin pipelines is known [3]. Dispersions of vinyl acetate copolymers are also used in the production of industrial coatings for metal substrates. These coatings are applied to metal surfaces for protection against corrosion, abrasion and environmental degradation.

The promise of vinyl acetate film formers is due to their cost-effectiveness, adhesive properties, flexibility, water resistance, ease of application, low VOC content and versatility, making them a favorable choice for a wide range of coatings and adhesives. It is common to include corrosion inhibitors and passivators in coating formulations or to use pigments with similar effects. The use of lignosulfonates to produce anti-corrosion coatings is effective [4]. The increasing consumption of high quality paints based on aqueous dispersions places higher demands on the protective properties of paints. Most manufacturers try to solve product quality problems by changing equipment, which usually does not bring the expected results and only increases the cost of production. Advances in polymer modification have led to the development of hydrolysis-resistant film formers capable of forming coatings with excellent physical-mechanical, adhesion and insulating properties. However, the presence of hydrophilic additives in paints requires optimization to improve water and corrosion resistance as well as adhesion strength, especially in high humidity environments. This review discusses the main strategies for optimizing these properties of waterborne film-forming coatings.

Protective characteristics of materials, such as moisture resistance, ability to absorb moisture, resistance to atmospheric conditions and aggressive media, are largely determined by the quality of dispersion of pigments and fillers. An important role here is played by adhesion - a complex indicator depending on the properties of the polymer and the substrate surface, as well as the conditions of coating application [5]. Coatings consisting of monomeric or oligomeric film formers that transition directly into the polymer state on the substrate have the highest adhesion strength [6]. Aqueous dispersions of vinyl acetate polymers with the addition of lignosulfonates as dispersing agents are known to improve corrosion resistance [7]. The use of polyisocyanate (PIC) as additives - adhesion promoters is known [8]. Protective polymer colloids include polyvinyl alcohol, polyvinylpyrrolidone, copolymers of maleic anhydride and styrene, and cellulose derivatives [9]. Although these compounds exhibit limited surface activity, they create a viscoelastic structural-mechanical layer upon adsorption at the interface. Depending on the circumstances, interfacial protective colloidal molecules can adopt different conformations [10] and their surface serves as a structural barrier during the melting process. The protective layer can look like a multilayer coating, creating a strong framework and reinforcing the protective barrier. Mineral stabilizers in combination with low molecular weight surfactants can make the particle surface hydrophobic, thereby increasing its stability. Future protective coatings may rely less on anti-corrosion pigments and inhibitors, emphasizing superior barrier properties. The introduction of modifiers into waterborne paint formulations improves their process and performance characteristics, reduces raw material consumption and production costs, and contributes to environmental sustainability.

Understanding polymer chemistry, surface phenomena, and colloidal chemistry at a theoretical level is essential for effectively utilizing additives and conducting practical tests to assess their efficacy [11]. The use of additives such as surfactants offers a promising approach to improve the quality of paints, reduce production costs and increase usability. The effectiveness of a modifier in a particular formulation depends on several factors including proper selection based on the desired function, its optimum concentration and its location in the formulation phases ensuring its presence where it is needed. The task of surfactants is to ensure optimal interaction between pigments and fillers on the one hand and the polymer medium on the other, forming a thin but incredibly important adsorption layer. Inside, the layer is formed by the interaction of the polar groups of the surfactant with active centers on the surface, facilitating several key processes such as: dispersion: the surfactants prevent the formation of aggregates by "knocking" the pigment and filler particles into smaller units. This results in brighter color and a smoother finish. Cohesion: Surfactants help the particles "stick" to each other, forming a stable internal structure of the pigment. Stability: Surfactants prevent the pigment from settling to the bottom, ensuring a uniform paint consistency. In the external structure, the interaction between the surfactant and the polymer medium determines the adhesion of the pigment to the substrate. The hydrocarbon chains of the surfactant "protrude" outward, creating a lyophilic layer that "attracts" the polymer. Surfactants with elongated hydrocarbon chains (hydrophobizers) are used in non-polar hydrocarbon environments. These include marginal carboxylic acids, acrylates, salts, quaternary ammonium compounds. Polar media utilize surfactants with polar groups in the hydrocarbon structure that exhibit a lyophilic tendency to polymeric dispersion media. This principle applies to a wide range of paints and coatings, including formulations with polymer solutions in certain solvents or water-soluble polymers in aqueous solutions, as well as water-dispersible adhesives used as binders. Recently, polymeric surfactants have been recognized as probably more effective than low molecular weight surfactants because of their higher affinity for film forming polymeric substances. Adsorption phenomena occurring under the action of surfactants promote physical and sometimes chemical interactions between dispersed particles, film former molecules, surface and substrate, affecting properties such as stability, deformation strength, and insulating properties. In addition, the molecular properties and polymer concentration can both decrease and increase the stability of the colloidal system.

Current trends in the modification of vinyl acetate-based paints and coatings suggest the use of lignosulfonates as versatile additives, particularly dispersants and anticorrosive agents. Lignosulfonates derived from lignin, a natural polymer found in wood, are attracting increasing attention due to their environmental friendliness and multifunctional properties [12]. As dispersants, lignosulfonates promote the dispersion of pigments and fillers in the paint composition, resulting in increased stability and uniformity of the coating. Their amphiphilic nature allows them to adsorb on the surface of pigments, reducing particle agglomeration and improving rheological properties [13]. In addition, lignosulfonates act as stabilizers, preventing sedimentation and flocculation during storage and application. The mechanisms of interaction between lignosulfonate dispersants and pigments and fillers in vinyl acetate paints include several physicochemical processes that promote dispersion and stabilization of solids in a liquid medium. Lignosulfonate dispersants are adsorbed on the surface of pigments and fillers through interactions such as electrostatic attraction and hydrogen bonding. During the adsorption process, the lignosulfonate molecules attach to the surface of the particles, forming a protective layer that prevents particle aggregation. The adsorbed lignosulfonate molecules create a steric barrier around the pigment and filler particles, preventing their convergence and aggregation. The spatial arrangement of the lignosulfonate chains on the particle surface prevents the formation of strong interparticle forces, which promotes dispersion and prevents flocculation. Lignosulfonates contain charged groups, such as sulfonate molecules, which ionize in aqueous medium, creating electrostatic repulsion between particles, resulting in mutual repulsion and stabilization of the dispersion [14]. In addition, lignosulfonates can dissolve pigment and filler particles, improving their compatibility with the liquid medium and facilitating dispersion [13]. Lignosulfonate dispersants can exhibit a synergistic effect when combined with other dispersants or additives in a paint formulation, increasing dispersion efficiency and stability, resulting in improved paint performance and coating properties.

In addition, lignosulfonates show promising anti-corrosion properties. When incorporated into vinyl acetate-based coatings, they form a protective barrier on metal substrates, inhibiting corrosion by impeding the interaction between the substrate and corrosive agents. This protective mechanism is attributed to the adsorption of lignosulfonates on the metal surface, forming a passivation layer that prevents the diffusion of corrosion agents [15].

Lignosulfonates exhibit excellent dispersing ability comparable to synthetic surfactants, while having excellent compatibility with other components in the formulation. The capability to deliver both dispersion and anti-corrosion benefits within a single additive offers a cost-efficient and effective method to enhance the performance of paints and coatings based on vinyl acetate. Compared to synthetic surfactants, lignosulfonates offer several advantages. Although synthetic surfactants can provide similar dispersing properties, they often raise concerns regarding environmental impact and biodegradability. Lignosulfonates, on the other hand, are derived from renewable sources and can be sustainably obtained from the wood pulping process. Therefore, the current direction in enhancing vinyl acetate-based paints includes employing lignosulfonates as adaptable additives that leverage their dispersing and anti-corrosive characteristics to boost coating effectiveness while addressing environmental considerations. As renewable, biodegradable and multifunctional additives, lignosulfonates provide a sustainable and effective solution for creating high quality and environmentally friendly coatings.

Conclusions

In general, ensuring the protective properties of water-dispersion paint and varnish coatings is achieved by combining high insulating, adhesive ability. Developing water-dispersion paint and varnish compositions with specific properties is challenging due to several complexities associated with water-dispersion film-forming systems.

Modern technological advances aimed at improving the reliability and long-term protection of coatings imply modification of aqueous polymer dispersions with universal surfactants. The introduction of surfactant dispersants into paint and varnish compositions opens up additional opportunities for targeted changes in the physical and chemical properties of structural layers formed at the interphase boundaries "pigment-surface-active agent" and "pigment-dispersion medium". This process includes control of disaggregation and stabilization of dispersions in paint coatings.

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