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WATER-BASED COATING TECHNOLOGY

OVERVIEW

Coatings, paints, and finishings have been used for thousands of years for adornment, protection, and combinations of the two. During CPC's early years, our research team focused on the application of water-based/aqueous paints and their relevance to the study of Colloidal Science.

Since World War II, the most significant advancement in the field of protective coatings has been the explosive expansion of water-based paints. This was made possible during this time period by the invention of novel synthetic latices. Due to their ease of application and other desirable features, water base latex paints became popular. They are virtually odorless and quickly dry after application. Additionally, the finish is resistant to wear and tear, low VOC and washable. With soap and water, spills were simply wiped up. Water-based paints were later introduced to industrial manufacturing applications due to their lower VOC, reduced fire hazards and lower solvent leakage into the environment.

HISTORY

Water-based paints were the first type of paint and date all the way back to the beginning of time. From the caveman through the Egyptians, and subsequently to the colonial era, water base paintings were employed to decorate walls and other surfaces.

Companies such as CPC helped improve paint quality over time, but it wasn't until the 1940's and 1950's, with the introduction of latex, that significant improvements in water base paints were achieved to increase their quality and ease of application. Semigloss latex paints were introduced in the 1970s. These paints used latices with lower particle sizes and solvents that coalesced more readily. Over the last three decades, subsequent paints have been enhanced by the addition of epoxies and acrylics to latex base paints. Paint specialists evolved and assessed old paints for improvement in the late 1970's and early 1980's. Technological innovation enabled the development of sophisticated instruments and processes for determining the components of ancient paints, including field sampling, cross-section analysis, and fluorescence and chemical staining.

Additionally, they incorporated field observations with written documentation, oral research, and visual information regarding paints. Numerous chemicals in water paints have been discovered to be environmentally toxic, including lead and other heavy metal compounds. Such harmful materials have been removed from modern water-based paint formulas.

THE COLLOIDS SIGNIFICANCE

Colloids is a mixture in which one substance consisting of microscopically dispersed insoluble particles is suspended throughout another substance

The water-based paints CPC employed in the past are certainly a part of history, both technologically and commercially. Colors in paint are a direct reflection of the time period. Water-based or "aqueous coatings" are broadly classified as water-soluble, water-dispersible, or water-reducible. These can be further classified into solution and dispersion types. Because the terms colloids and suspensions are deemed arbitrary, we can include them in the term solution. These are the factors to consider: Solutions have a diameter of less than 0.001 micron, Colloids have a diameter of between 0.001 and 0.2 micron, and Suspensions have a diameter higher than 0.2 micron. 3 Colloids are two-phase systems, and their interfaces are of interest. Numerous contact combinations occur between solids, liquids, and gases. The vehicle or binder is dissolved in water for water-soluble coatings/paintings. Because the binder is water soluble, it will remain so until it is transformed to an insoluble state via a process such as polymerization.

Water-soluble coatings exhibit a variety of characteristics, both positive and negative.

Certain benefits include the following:

1. Simple formulations-pigment, vehicle, and water-that do not require catalysts or defoamers.

2. Ease of manufacture—can be produced in the same manner as conventional solvent-based paints, with pigment ground directly into the carrier.

3. Consistent film thickness—consistent film thickness comparable to that produced by conventional solvent systems

The high pigment binding and gloss-achieved by this method are comparable to those found in traditional systems. With a pigment/binder ratio of 1:1 or above, a high gloss can be achieved. Coatings based on water-soluble systems exhibit excellent stability and may be pumped via a variety of different types of equipment. After prolonged usage, the dip tank or spray equipment has a low proclivity for peeling or clogging. Paints can be repeatedly frozen and thawed without causing damage to the liquid paint.

Certain drawbacks include the following:

1. Materials in limited supply—there are only a few materials of this type accessible.

2. Water resistance is a problem for many air-drying water-soluble materials.

3. Heat is required to transform many water-soluble systems to their water-soluble state

Water-dispersible paints, the second category of water/aqueous paints, likewise have their advantages and disadvantages. The vehicle in this sort of coating is made up of tiny particles suspended in water. Particles with a diameter of 0.1 to 10 microns are used.

The following are some of the benefits.

1. High molecular weight polymers- It is feasible to employ high molecular weight polymers that exhibit exceptional features such as color retention, water resistance, chemical resistance, and mechanical strength.

2. Air drying—aerosol drying produces excellent coatings.

3. Excellent holdout—on a variety of surfaces, including porous ones

Following are some disadvantages:

1. Complicated- due to the heterogeneous nature of dispersion systems, they are complicated in makeup since they comprise pigment, latex, thickeners, defoamers, and a variety of other components.

2. Special Manufacturing - more conventional than regular coatings manufacturing

3. Stability- emulsions have a moderate mechanical stability. Excessive handling might result in the disintegration of an emulsion. Alternating freezing and thawing create a pause.

4. Heterogeneous- since an emulsion coating comprises water-soluble thickeners and surfactants, the emulsion film is not truly continuous and is permeable to a certain amount.

Water-reducible coatings comprise the third class of aqueous coatings. These materials can be synthesized by combining ordinary solvents and a surfactant. These can then be diluted with water before to application. The properties of this paint are in between solvent-based and water-based. Even though it includes some flammable solvents, provided sufficient water is present, the liquid paint will not burn when exposed to a flame.

While all three types of water-based coatings are widely utilized, water-soluble paints are the most prevalent. Water-based coatings are quite popular due to the remarkable physical qualities of water and a variety of other benefits such as low cost, low VOC, nonflammability, odor reduction, and nontoxicity. Along with these benefits, there are a few drawbacks, including the difficulty of adjusting wetting, flow, and drying.

WATER-BASED APPLICATION METHODS:

BRUSH

By and large, all brush-applied coatings are air-drying, with the most prevalent application areas in the residential and commercial construction industries. Brush application is one of the oldest methods of applying paint and, despite today's demand for better production rates with the least amount of work, a sizable number of paints are still applied using a brush.

Brushes are made with larger air spaces between the bristles at the tip than at the stock, which allows for a greater amount of paint to be held in the brush's lower half. They are often made of horsehair and, more recently, specific nylon fibers, albeit the finest are made of Chinese hog bristles. These brushes feature splayed or split ends, which allows the brush to make a much larger contact with the surface and spread the paint more evenly.

One significant advantage of brushing on a protective primer when painting structural steel is that any little surface contamination by oil or rust will be removed by brushing spray-applied coatings over these surfaces.

The primary benefits of applying with a brush are as follows:

1. Versatility
2. Suitability for variable-environment use
3. The operator maintains complete control over the amount of paint used;
4. Reduced paint waste

The primary disadvantages are that it is slower and more labor intensive than a number of other wet-paint application techniques.

SPRAY

Around 1907, furniture producers introduced the coatings spray gun, which was quickly adopted by the automobile sector. With the introduction of nitrocellulose lacquers in the early 1920s, spray application was broadened.

Spray application's fundamental premise is to atomize the paint and direct it onto the surface to be coated. Additionally, pressurized air, flow control valves, filter systems for removing dirt, oil, and water from the air supply, and containers for the paint supply are required. Containers for paint supply range in size from 250ml cups linked to the gun to remote 500-liter pressure pots located some distance away from the spray guns.

The following are the primary advantages of traditional spray guns:

APPLICATION SPEED

The degree to which operators have control over the thickness of the deposited coating and the character of the finish. This is seen in industrial production finishing, where expert spray operators can accommodate differences in the color and texture of the metal substrate by adjusting the amount of coating applied to it.

When the trigger is pulled back, the air valve is opened to allow "dusting" air to enter. As the trigger is retracted farther, it disengages the needle valve in the fluid nozzle, allowing paint to exit the gun and be combined with compressed air in a tubular stream. This process is referred to as first-stage atomization and occurs directly outside the nozzle.

Within 10mm of travel, a second stage of atomization occurs, in which the paint is changed from a tubular stream to a flat spray pattern via a burst of compressed air from each side of the air nozzle horns.

THEORETIC APPLICATIONS TO WATER-BASED INDUSTRIAL COATINGS

The creation of films from dispersions is more complicated than that of solutions. By contrast, polymer dispersion consists of a distinct polymer phase spread in a liquid media in the form of individual spheres. On a macular level, such a system is not homogeneous. As water evaporates or is absorbed into the porous substrate, the spherical polymer particles become increasingly near until they contact. Then, deformation of the spheres is required to generate a continuous polymer film devoid of voids. This requires the presence of a driving force of sufficient magnitude to overcome the polymer spheres' resistance to the shape change. Under induced stress, hard polymers will resist deformation extremely well, but rubbery polymers will deform more rapidly. The ability of a dispersed polymer to form films is related to its deformability. If the polymer is too hard to deform, no film forms and a powdery or spongy structure remains when the water evaporates. Water's capillary pressure exerts forces on the dispersed particles, drawing them closer. This pressure is comparable to that created when two glass plates are separated by a small layer of water. When two or more spheres are wetted by the intervening aqueous phase, comparable forces exist. This pressure builds when the water evaporates, and the spheres collide. When the spheres come into contact, the evaporation of the water exerts pressure on the spheres, deforming them. This results in the formation of a film.

The film development process is influenced by a variety of elements, some of which are environmental, some of which are physical, and some of which are compositional. Another such component that affects the development of films is time. A sufficient length of time is essential for the film to properly form. Controlling water evaporation will affect the coalescence of the emulsion film. The relative humidity regulates the evaporation rate, and the porosity of the substrate also influences how quickly the water evaporates off the film. Temperature is one of the environmental (physical) conditions that affect the creation of the film. The temperature at which the coating is applied is critical for film formation. Temperature influences the hardness of the polymer, which has an effect on its fusibility. The temperature cannot go below the freezing point of water as the ultimate limit. For the physical influence on film formation, the physical state of the emulsion is critical. Generally, the smaller the particle size, the easier it is to make a nice film. For instance, emulsions have a tendency to hold water under particular flocculated conditions, resulting in cavities in the film. The chemical composition and molecular weight of the polymer have an effect on the fusion temperature and, consequently, on the creation of films. If the polymer is too stiff to fuse at the application temperature, plasticizers or solvents may be added to help soften the resin and facilitate fusion.

A surfactant is a chemical molecule that alters the forces exerted on a liquid or solid by other liquids, gases, or solids. Generally, a surfactant is composed of two molecules, one of which is hydrophilic and the other of which is hydrophobic. Surfactants, which include wetting agents, detergents, dispersants, foaming agents, penetrating agents, and spreaders, have a wide variety of applications in aqueous coatings. To begin, a surfactant is employed to disperse the pigment during grinding. It allows for a more complete wetting of the pigment particles. It is used as a dispersant to aid in the dispersion of tiny solid particles in liquids. Second, surfactants are required as emulsifiers, either during the emulsion polymerization process or after the vehicle has been emulsified. Emulsifiers create a stable contact between oil or another substance and water. For emulsifiers, the connection is a liquid, liquid one. The surfactant's third role is to impart particular physical features to the aqueous coating, such as improved wetting to the surface to which it is applied and improved flow.

Hydrophilic colloids soluble in water include starch, sodium alginate, and methyl cellulose, among others. These materials form solutions with a high viscosity at low concentrations. Typically, as little as a tenth to one percent of the protective colloids is required. A significant fraction of the protective colloids in the grind aid in the dispersion process. By thickening the mixture, we achieve a high shearing action, which ensures proper mixing. The pigment particle is entirely coated in a protective colloid, which enhances the paint's durability. During the manufacturing process, a protective colloid is applied to an emulsion vehicle or latex. Due to the enhanced viscosity imparted to the water phase by the protective colloid, the pigment settling propensity of the dispersed particles to clump together is reduced when mechanical, freezing, or other stresses are applied. When employed as a thickener, the water-soluble resin creates the proper viscosity for application. The type of protective colloid utilized will influence the coating's flow and leveling. It is advantageous to limit the amount of protective colloid to a minimum for a variety of reasons, including economy. Protective colloids are relatively expensive in comparison to other paint components. Once the film has been placed and dried, the protective colloid serves no use and may even detract from the coating's effectiveness. Due to their water-soluble nature, these components increase the coating's water sensitivity. Typically, the protective colloids are incompatible with the vehicle or latex, resulting in a microscopic network of water-sensitive resin throughout the film after it dries.