Wax Emulsions - Formulation and Properties of Wax Emulsions for Coatings and Industrial Applications by Michelman

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Background

Michelman products that add value--and support that helps you win—are close at hand, wherever you're growing. Our products enhance the surface qualities of coatings and inks, make composites tougher, and expand the possibilities of paper and film with barrier, functional, and aesthetic features. Our extraordinary technical support helps ensure those products deliver all they can to your bottom line.

Michelman is a global manufacturer of performance-enhancing barrier, functional, and decorative coatings for flexible film packaging, paperboard, and corrugated boxes; and additives and modifiers for many industries including coatings, inks, composites, and construction products.

Michelman's Range of Wax Products

Michelman's range of wax dispersion and wax emulsion products include :

- Michem® Lube
- Michem® Emulsion
- Michem® Glide
- Michem® Guard

Understanding the Properties Waxes Impart to an Ink or Coating

Among the numerous additives available today for coatings and inks, waxes have a significant impact on many formulations or processes. Even if used in relatively small quantities - typically below 3% solids content of the total composition - waxes impart or improve attributes such as slip and lubrication, abrasion resistance, anti-blocking, matting and water repellency - all critical properties in the coating and ink arenas. Waxes are often classified as surface conditioner additives

Classification of Different Types of Waxes

The term wax encompasses a broad range of naturally occurring and synthetic compounds constituted from high fatty acid esters (typically C36 - C50) or from polymers (700 < Molecular weight < 10,000). They differ from fats in that they are generally harder and less greasy. It is important to realize that chemical composition alone does not define a wax. Rather, the term "wax" should be used as a generic term for materials that are or have the following properties:

- solid at 20°C, varying in consistency from soft and plastic to brittle and hard;
- melting point of at least 40°C without decomposing, (this characteristic uniquely distinguishes waxes from oils and natural resins);
- relatively low viscosity at temperatures slightly above the melting point and non-stringing (i.e., producing droplets--a characteristic that excludes most resins and plastics).

Today, there are a large variety of waxes available, often classified according to their origin. Table 1 provides a summary of the waxes used most often in industrial applications.

Table 1. Waxes used most in industrial applications

Naturally occurring waxes			Synthetic Waxes
Animal	Vegetable	Mineal (*)	
Beeswax	Carnauba	Montan	PP, PE and PTFE (**)
Lanolin	Candellila	Paraffin (***)	Fischer - Tropsch
Lanocerin	Jojoba	Microcrystalline (***)	Fatty acid amide
Shellac	Ouricouri	Intermediate (***)	PTFE
Ozokerite			Polyamide

* Also called semi-synthetic waxes

** Polypropylene (PP), polyethylene (PE) and polytetrafluoroethylene (PTFE), although not technically waxes, are often associated with this class of surface conditioner additive because of the similar effects and performances they provide.

*** Oil derived

Mechanisms of Wax Action

To have a significant impact on the coating or ink properties, the wax must migrate to the surface and be present in sufficient quantity to impart the desired characteristic. Several migration mechanisms are generally proposed. These are outlined in the following sections.

Blooming Mechanism Molten

Molten wax particles float (or bloom) to the surface. The coating cools and re-crystallization of wax particles takes place, forming a thin but continuous wax-enriched surface layer. Generally, the softer the wax or lower the melting point, the more predominant is the blooming mechanism. The compatibility between the wax emulsion and other formulation components determines the wax migration rate (See Ill. A).

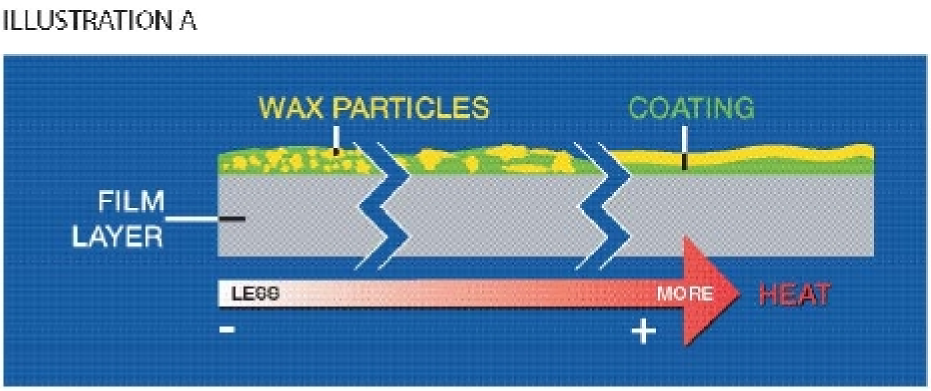

Illustration A. The compatibility between the wax emulsion and other formulation components determines the wax migration rate

The Ball Bearing Mechanism

In this case, solid wax particles migrate individually or protrude through to the surface. By protruding slightly above the coating surface like ping-pong balls floating on a pool of water, they act as a physical spacer and prevent another surface from coming into close contact. Hard and high melting point waxes like HDPE, as well as PTFE which exhibits wax like characteristics, operate using this mechanism under certain conditions. Both the particle density and the extent of protrusion influence the magnitude of the effect (See Ill. B).

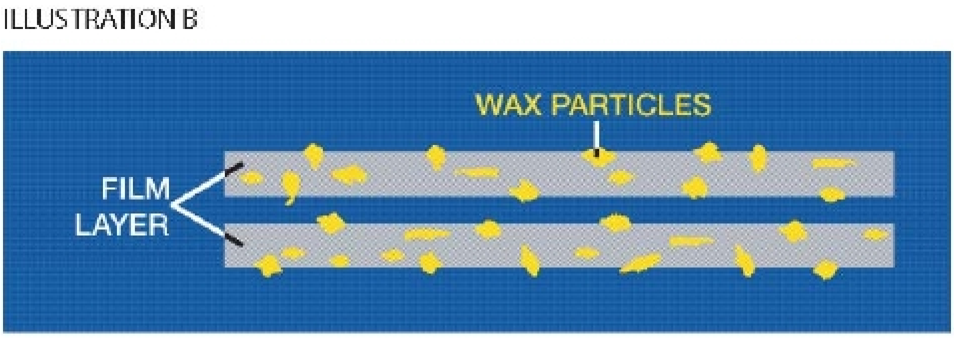

Illustration B. Both the particle density and the extent of protrusion influence the magnitude of the effect

Once at the surface, the layer of wax particles has the ability to modify the Coefficient of

Friction (CoF) of the substrate, imparting the desired characteristics. This explains why waxes are often classified as "Surface Conditioner Additives."

Functional Attributes Wax Imparts

Anti–blocking Between Two Surfaces

Anti-blocking is a term defining a non-stick condition between two surfaces or the resistance to adhesion between two surfaces under the influence of temperature, relative humidity or even pressure. A very well known example of a blocking condition is when a freshly painted window frame is closed too soon. Sometimes, it can be very difficult to open the window again. Factors affecting blocking include the coating surface free energy, topography of the coatings, hardness, and Tg of the polymer. HDPE, paraffin and carnauba waxes are typically used to counteract blocking. Anti-blocking agents are used extensively for items that are coated, dried and immediately stacked or rolled up for storage or shipment.

Slip Properties of Waxes

Slip represents the ability of two surfaces to glide over each other without causing any mechanical damage. Good slip properties require that the slip additive concentrate to the surface during and immediately after application and curing. The harder the wax, the better the slip properties. This is explained by the fact that wax crystals in the solid state are the main factor responsible for the characteristic of slip. Softer waxes tend to be more easily liquefied and, as a result, exhibit a lower proportion of solid crystals. Harder waxes resist liquefying and have a relatively higher proportion of crystals in the solid state to impart slip.

Abrasion Resistance in Waxes

Abrasion is a phenomenon caused by the mechanical action of rubbing, scraping or erosion. Since it is intimately related to scratching and slip, it is not surprising that many slip aids also function as mar and abrasion resistance additives. Abrasion resistance is produced by a combination of basic characteristics such as elasticity, hardness, strength, toughness, lubricity, particle size and, in some cases, thickness.

Water Resistance Properties of Waxes

Water repellency or water resistance is another important property obtained with waxes.

As the name implies, this characteristic is the protection of a surface against water penetration. The magnitude of protection can be temporary or limited (water resistance or repellency) up to a nearly infinite period of time or unlimited based upon the kind of exposure (waterproof). Water resistance generally implies resistance to water in the liquid state, whereas moisture resistance refers to protection against water in a gaseous or vapor state. Usually, paraffin waxes, including scale waxes (a lower refined paraffin grade containing up to 5 % oil), perform very well, particularly on porous surfaces. The oil penetrates easily and quickly into the pores and fissures of the substrate, imparting a very hydrophobic character to the treated surface.

Coating Formulation for Obtaining Tactile Properties

Although coatings are usually applied to provide optical effects (color, gloss or matting etc.), or to protect a substrate, some applications also require the surface to have tactile properties. By employing a coating that incorporates coarse wax particles, a rough and uneven surface is created at the microscopic level that is very similar to that observed with matting agents. Because tactile properties are largely dependent on the coating formulation, it is important that the wax particles protrude through the coating layer and this requires a particle size larger than the film thickness.

Formulating with Wax Emulsions

Wax emulsions are now well established and extensively used in aqueous formulations such as paints, coatings, inks and OPVs, textile and leather treatments, polishes, paper and corrugated coatings, etc. These ready-to-use wax emulsions can be easily incorporated into a formula by simple mixing. Their very fine particle size ensures thorough, homogeneous incorporation with other ingredients of the formulation, maximizing the required effects. And because of their inherent smaller particle size are less likely to detract from gloss.

Mechanism for Stabilizing Wax Emulsions

Wax emulsions can be stabilized by either a steric mechanism (using nonionic emulsifiers) or by an electrostatic mechanism (using ionic emulsifiers, most often anionics). Combining anionic and nonionic emulsifiers provides the emulsion the optimum stability because wax particles are protected through both stabilization mechanisms. This is referred to as the electro-steric stabilization mechanism.

In addition, each stabilization mechanism not only has its own advantages and limitations but also significantly impacts the overall formulation giving added flexibility in formulating. The advantages and limitations of both surfactant families are presented in Table 2.

Table 2. Advantages and limitations of surfactant types.

Nonionics/ Steric Stabilization	Anionics / Electrostatic Stabilization
Compatible with ionics	Good wetting and emulsifying properties
Impart good freeze-thaw stability	Compatible with nonionics
Less deleterious to mechanical properties (i.e., better emulsion stability)	Best performance in alkaline systems
Perform well over a large pH range	Lower water-sensitivity
Less foaming than anionics	Very effective in polar media
Better stability in hard water	Good adhesion and anti-corrosion properties
Less solubility at hight temperature (Cloud point)	Better interaction with pigments
Work for all types of emulsions	More snesitive to freeze-thaw cycling
Lower reduction of itnerfacial tension	More foaming than nonionics

Impact of Wax Properties on Formulation Performance

The wax properties that have the greatest impact on formulation performance include the chemical composition, the molecular weight, the melting point, the hardness and, in the case of emulsions and dispersions, the particle size.

Factors to Consider for Selecting Type of Wax for End Application and Coating

The end application and the coating process (including the curing) also substantially influence selection of the most appropriate wax. When selecting a wax, it is important to consider:

- Melting point of the wax should be lower than the curing temperature when curing is required. This allows the wax to melt, migrate to the surface of the coating, re-crystallize as the coating cools and, eventually, form a continuous film that encourages blooming.
- Particle size and particle size distribution should be chosen to allow particles to migrate to the film surface. This is particularly important if a hard wax is selected as it will produce the ball bearing mechanism. Sometimes a wax emulsion with a smaller particle size performs equally well, provided that the concentration is correctly adapted. The particle size range can be controlled during the emulsification process in order to meet precise specifications.
- pH of the wax emulsion should be within approximately one unit of the system to which it is added. If necessary, the pH of the emulsion can usually be adjusted using aqueous ammonia or acetic acid.
- Type of surfactant can also influence compatibility with the other components, as well as the overall formula stability. Matching the emulsion charge with the coating charge enhances stability.
- Order of component addition in water-based formulations can be a critical factor in maintaining stability. Agglomeration can be prevented and overall stability maximized by adding the wax emulsion last. A further dilution of the emulsion with soft or demineralized water before incorporation can also reduce the shock.
- Regulatory aspects of waxes, if the emulsion is intended for food contact use (in a coating or in a package), must be in compliance with applicable regulations (FDA, BfR, European Directives, etc.). Many waxes are available in various grades, may be chemically modified, or may consist of any number of different chemical compounds; therefore, a confirmation of the product's regulatory status should be provided by the manufacturer or supplier.

Source: Michelman

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Primary Activity

Surface Modifiers