TECHNOLOGY INTRODUCTION

Lubrizol Surface Modifiers

Lubrizol surface modifiers are additives used to achieve specific surface effects in paints, coatings and inks. The technology enables formulators to enhance and protect appearance, feel, slip, abrasion resistance and overall durability of paints, coatings and inks. Products are available in powder and liquid form including micronized powder, aqueous and solvent-based dispersions and emulsified forms. In addition to wax based surface modifiers, Lubrizol also offers wax treated silica, along with other specialty products. A broad range of polymer chemistries and particle sizes are available to control performance properties. Lubrizol’s world class manufacturing and quality control procedures ensure consistent batch-to-batch performance.

SURFACE MODIFIER CHARACTERISTICS

Definition of a Surface Modifier

Many surface modifiers are formulated using combinations of waxy polymers. The main properties of wax are described below:

- A wax is a low melting organic material or compound which is solid at 40°C.
- Chemically, waxes may be hydrocarbons, alcohols, amides or esters of fatty acids.
- Waxy polymers are insoluble in water.
- Waxy polymers may be soluble in organic solvents. Solubility is dependent on polymer chemistry, solvent choice and may require elevated temperatures (~50-100°C).
- Waxy polymers have a sharp melting point and reach the minimum melt viscosity a few degrees above the melt temperature.

ORIGINS OF SURFACE MODIFIERS

Natural
- Living Organism
- Animal-based
- Vegetable-based
- Bees Wax
- Carnauba Wax
- Candelilla Wax
- Sunflower Wax
- Sugar Cane Wax
- Rice Bran Wax

Synthetic
- Homo-polymers
- Co-polymers
- Polyethylene
- Polypropylene
- Fischer-Tropsch
- Ethylene Vinyl Acetate
- Ethylene Acrylic Acid

Semi-Synthetic
- Amides
- Montan Wax
- Olin Wax
- Distillates
- Deposits
- Paraffin
- Microcrystalline

*PTFE is not a wax

APPLICATIONS

Choosing the right surface modifier for a formulation is dependent on the performance requirements of the coating or ink application. Typical applications and the properties surface modifiers can impact are outlined below.

Wood Coatings

Surface modifiers provide improvements in scratch and abrasion resistance, anti-blocking properties, matting and soft feel. Additionally, they can reduce the sedimentation of silica matting agents and improve sandability.

Coil Coatings

Properties achieved with surface modifiers include slip, anti-blocking, scratch and abrasion resistance. Addition of surface modifiers influences durability and matte appearance. During the metal forming process, surface modifiers aid in preventing damage to the coating surface.

Industrial Coatings

There are many types of industrial applications such as plastics, metal, film and foil with various performance requirements. The choice of surface modifier will depend on the properties desired during processing and use.

Can Coatings

Surface modifiers aid in protecting metal containers from abrasion damage in conditions such as high-speed production or during transportation. They can improve overprintability, promote heat-sealing stability and provide release properties without influencing porosity.

Architectural Coatings

The main properties needed in architectural coatings are metal marking resistance and anti-blocking, especially for doors and windows. Surface modifiers can also provide smooth surface feel and matting.

Inks and Overprint Varnishes

Surface modifiers are used to improve rub resistance and anti-blocking properties with minimal influence on gloss at low film weights. They are also used to control slip and mobility during production and handling.
Polypropylene (PP)
(Melt Point: 160-165°C)
Polymerization of propylene produces polypropylene wax. PP wax has a higher molecular weight and melting point than most other waxes. Plastic-like properties of polypropylene, such as high elasticity and toughness, are used in combination with PE waxes to optimize properties.

Carnauba
(Melt Point: 83-86°C)
Carnauba wax is extracted from the leaves of the carnauba palm tree and is available in refined and virgin grades. Carnauba wax is a hard, brittle wax with the color ranging in refined and virgin grades. Carnauba wax is hard, brittle and the most commonly used wax. It is commonly formulated with PE.

Fischer-Tropsch (F-T)
The reaction of carbon monoxide and hydrogen produces Fischer-Tropsch wax, also known as hard paraffin. FT is chemically inert and produces a very low coefficient of friction in coatings and inks. It can be expressed as the static or dynamic coefficient of friction (COF) and measured using instruments such as the Altek Mobility Tester.

PTFE
(Melt Point: 315-330°C)
Tetrafluoroethylene is polymerized to produce PTFE. PTFE is a wax, and it does not dissolve or melt, but functions like one. PTFE is chemically inert and produces a very low coefficient of friction in coatings and inks. It is commonly formulated with PE.

Microcrystalline (MC)
(Melt Point: 60–90°C)
Microcrystalline wax is refined from petroleum. Microcrystalline wax is a high molecular weight, highly branched hydrocarbon with low crystallinity. The melting point varies based on the structure.

Amide waxes
(Melt Point: 73-140°C)
Mono- and bis-amides are semi-synthetic waxes. The reaction of fatty acids with amines and diamines produce mono- and bis-amides respectively. Mono-amides have a lower melt point and bis-amides have a higher melting range. Both types have low penetration and are brittle.

Silica
(Melt Point: 300-350°C)
Silica is available from several different manufacturers including precipitated silica, fused silica and silica gel. Unlike all other surface modifiers discussed in this document, silica is a crystalline material and does not melt.

Silica
Soft Feel
Scratch & Rub Resistance
Gloss Retention
Matting
Soft Surface Feel
Metal Marking Resistance
Scratch/Mar Resistance
Metal Marking Resistance
Soft Surface Feel
Silica
Soft Feel
Scratch & Rub Resistance
Gloss Retention
Carnauba
Soft Surface Feel
Polyethylene
Soft Feel
Polyethylene
Release
Polyethylene
Scratch & Rub Resistance
Gloss Retention
Microcrystalline
Release
Microcrystalline
Gloss Retention
Microcrystalline
Re-coatability
Polyethylene
Scratch, Rub & Abrasion Res.
Anti-Stick/Anti-Block
COF Reduction
Polypropylene
Matting
Polypropylene
Re-coatability
Polypropylene
COF Increase
Polypropylene
Surface Hardness
Amide
Matting
Soft Feel
Release
Air Release
Sandability
Baking Systems
Air Dry Systems

Functions of a Surface Modifier
Many factors must be considered when selecting the best surface modifier:
1. Surface modifier chemistry and particle size
2. Coating properties such as film thickness and resin chemistry
3. Application and cure methods

Additive performance is evaluated using a variety of quantitative and qualitative test methods.
Small Particle Surface Modifier Production

Why is particle size distribution so important?

Choosing the right particle size surface modifier is essential to develop the targeted performance in the coating or ink. Particle size distribution is typically reported at the Dv50, Dv90 and Dv98 levels. The Dv (value) is defined as the percentage by volume or population of particles less than the reported value. For example, Dv50 ≤ 6.0 µm means that 50% of the particles in the sample are less than or equal to 6.0 µm. Various instruments are available to measure the particle size using volume of particles or population of particle algorithms to calculate particle size.

Typically, surface modifiers with a Dv50 particle size less than 6 microns are required to protect thin film applications such as rigid metal can coatings, coil coatings, inks and other thin films used in printing and packaging without impacting appearance properties. Selection of products with Dv50 > 6 microns for these same applications can negatively impact aesthetics. Conversely, larger particle size surface modifiers are required for thicker film applications such as industrial clear wood coatings or powder coatings so that the polymer particles are at the air-coating interface to affect target properties, e.g. abrasion resistance or gloss reduction.

Waxy polymers used for surface modification are typically supplied in prilled or flaked forms. The particle size for surface modification is optimized to balance ease of incorporation, compatibility and performance without compromising secondary properties. The particle size can be controlled using micronization, dispersion and emulsification techniques. The chart below illustrates the average particle size range using these techniques.

The graphs below demonstrate performance trends based on a surface modifier at varying particle sizes. The performance trends below are based on an industrial coating containing an equivalent amount of a specific surface modifier applied to a common substrate at the same dry film thickness (dft).

Micronization

Fluidized bed jet mills and melt spraying are the two most commonly used methods to produce micronized powder. Particle-to-particle collisions occur when polymers pass through opposing jets of high pressure air in fluidized bed jet mills producing fine powdered wax polymers. Controlling the flow rate through the milling chamber and the pressure of the opposing jets enables micronization of a wide range of waxy polymers. In-line classifiers are used to adjust and control the resultant particle size distribution into the targeted range. Melt spraying techniques generate fine, spherical wax particles when molten waxy polymers are sprayed into a cooling chamber. Particles are separated from the gas stream in a cyclone chamber or filter bag house. Polymers and polymer blends with broad melting range typically process more efficiently, yielding a narrower particle size distribution when micronized with a fluidized bed jet mill compared to melt spray methods.

Air jet micronized wax

150x magnified

Spray micronized wax

150x magnified
Dispersions and Emulsions
Wax dispersions are a combination of natural and/or synthetic polymers that are mechanically dispersed in organic solvents, water or other liquid carriers using a variety of media mills or high-speed Cowles dispersion techniques. Dispersion of polymers into water typically requires the use of wetting agents to stabilize the organic polymers into water.

Wax emulsions are a stable mixture of one or more natural or synthetic waxes in water. Emulsions always contain a wetting agent package adjusted to the appropriate HLB value depending on the wax being emulsified. Processing is performed at temperatures above the melt point of the wax. If the wax melt point is above the boiling point of water, the emulsion must be processed under pressure to prevent the water from boiling.

Ease of incorporation, efficiency, cost, stability, bulk coating chemistry and compatibility must all be considered when selecting the surface modifier form.

Surface Modifier Curing Mechanisms
The performance of a surface modifier is dependent on the ability of the particle to be present at the coating-to-air interface. The two mechanisms to accomplish this are described below:

1. Surface modifiers float to the surface due to density differences or incompatibility between the additive and the bulk coating. This is referred to as the floatation effect.
2. The average particle size of the additive is larger than the dry film thickness of the coating/ink or the concentration of particles is high enough to facilitate stacking near the coating-to-air interface. This is referred to as the ball bearing or overlay effect respectively.

Density differences between the wax and liquid enable the wax to migrate to the surface of air dried, solvent based or water based coatings or inks. Convection currents are generated during solvent evaporation, causing the additive to float to the coating-to-air interface. As solvent evaporates, the volume of coating or film decreases, causing film shrinkage which allows the formulator to take advantage of the ball bearing or the overlay effect.

In UV cured, high-solids or solvent-free systems, viscosity and degree of film shrinkage impact surface modifier performance. As a result, the mobility of the surface modifier and the ability to float to the coating-to-air interface is limited. Rapid cure cycles constrain the mobility of a surface modifier to migrate to the surface in UV cured systems. Due to these constraints, the floatation effect is limited in these systems, and the overlay/ball bearing effect has a greater influence on performance. Therefore, selecting the correct particle size surface modifier is critical to achieving the targeted performance characteristics.

The curing temperature is important because it influences the viscosity and the mobility of the additive particles. If it is above the melting point of the additive, it can lead to significantly different performance because a microscopic wax layer can be formed at the coating-to-air interface. This is known as the layering effect.
**HANDLING GUIDELINES**

**Incorporation**
Dispersed and emulsified surface modifiers can be easily incorporated into inks and coatings using low speed mixers. Occasionally, high-speed mixing is required. Caution should be taken if using high-speed mixing to avoid foam generation and overgrinding.

Micronized waxes can be easily dispersed using mixers or dissolvers. Formulation variables such as viscosity, solvent package, resin type, selection of dispersant and pigment surface treatment can influence the ease of incorporation. Processing temperatures should be maintained below 40°C to prevent particle swelling in solvent based systems.

A pre-dispersion of micronized wax can be prepared to simplify incorporation into coatings or inks. As a guide, 15-30% micronized wax could be pre-dispersed in a blend of resin and solvent consistent with the ratios in the coating. Pre-dispersion of micronized wax into an aqueous system will require the use of wetting agents. Temperature control is important in solvent based systems to prevent particle swelling and viscosity drift.

**Addition Rate**
Typically, surface modifiers are used between 1-5% to achieve targeted performance properties.

**Storage**
Surface modifiers are stable under standard conditions (5-40°C). Product data sheets should always be referenced for specific storage recommendations. It is important to protect wax preparations from extreme temperature conditions such as frost and high heat. Solvent based dispersions should not be stored above 40°C to prevent swelling and viscosity drift. Aqueous dispersions should be protected from freezing.

**Food Grade Applications**
Many surface modifiers comply with FDA regulation 21 CFR § 175.300, 175.105, 176.170 and 176.180 in addition to other food content regulations. Additional regulatory compliance information on Swiss Annex, Nestle, EU 10/2011 and other regional food compliance requirements can be obtained from the product manufacturer.

**PRODUCT LINES FOR PAINTS, COATINGS AND INKS**
Depending on the application, Lubrizol offers a variety of micronized and liquid wax preparations.

**Dry Powders**
Lanco™ and Pinnacle™ micronized waxes suitable for water-based, solvent-based and UV systems.
Lanco™ Matt micronized wax treated silica matting agents suitable for water-based, solvent-based and UV systems.
PowderAdd™ micronized waxes designed especially for use in powder coatings.

**Liquid Preparations**
Lanco™ Glidd, Liquitron™ wax dispersions available for water-based, solvent-based and UV systems.
Lanco™ LiquiMatt matting dispersions offered for solvent and water-based systems.
Fluotron™ and Duotron™ wax dispersions based on pure PTFE or PE/PTFE suitable for water-based systems.
Aquaslip™ and Liquilube™ wax emulsions for water-based systems.

- Appropriate for paint and coating applications
- Appropriate for ink and varnish applications

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![Dry Powders Diagram](image)

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- Appropriate for ink and varnish applications
WHAT WE ADD MAKES THE DIFFERENCE™

Lubrizol is a market-driven innovator of specialty chemicals that solve today’s challenges in the paints and coatings, printing and packaging, paper and textiles, plastics and composites and digital print markets. More than just a supplier, we are a collaborator with extensive experience in surface protection, dispersion, adhesion and barrier properties that enables us to enhance the performance, simplicity and sustainability benefits of our customers’ products. With a commitment to collaboration, applied science, and demonstrated value, our team of experts is dedicated to exceeding customer expectations for both the simplest and toughest requirements. Count on Lubrizol to make the difference.