Mechanism & properties of wax additives in coatings & printing inks
Wax is a technological collective term for a range of naturally or synthetically derived substances which have the following properties:

- At 20°C solid, consistency from soft and plastic to brittle and hard
- Coarse to fine crystalline structure, transparent to opaque – but not glass like
- Melting point above 40°C without decomposition
- Low viscosity at temperatures slightly above the melting point
- Vary greatly in consistency and solubility with changing temperature
- May be polished by rubbing under moderate pressure

If more than one of these properties is not fulfilled by a material then it is not a wax in the meaning of this definition.
Wax Overview by Origin

WAXES

NATURAL WAXES

FOSSIL WAXES
- Montan waxes
  - Montan acid waxes
  - Montan ester waxes
  - Montan waxes partially saponified
- Petroleum derived waxes
- Animal waxes
  - Bees wax
  - Candelilla wax
  - Shellac wax
  - Camanuba wax
  - Wool wax
  - Sunflower wax
  - Sugarcane wax
  - Rice bran wax

RECENT WAXES
- Vegetable Waxes
- Primary amid waxes
- Secondary amid waxes

PARTIALLY SYNTHETIC WAXES
- Polyolefin waxes
- Fischer-Tropsch waxes
- Fully synthetic waxes

SYNTHETIC WAXES
- Polar synthetic waxes
Examples of waxes

- Bees wax
- Carnauba wax
- Paraffin wax
- Amorphous PP-wax
- Wool wax
- Polyethylene wax
Thermal cured coatings (stoving enamels)

Drying temperature >> Melting point of Wax
Mechanism of wax: Bloom/Floating Theory

- In **thermal cured coating systems** the melting point of the wax is usually exceeded by the drying temperature which causes the wax to melt. While curing, the concentration of liquid wax on the surface of the coating increases due to its lower density compared to the binder matrix. This migration through the coating is also supported by the evaporation of the solvent.

- After the curing process the accumulated wax solidifies at the surface leaving a thin and continuous layer of pure wax at the top of the coating. This mechanism is virtually independent from the wet layer thickness.

- Particel size is very important at low film thicknesses as large particles can cause pinholes or craters when they melt and suppress the coating film matter due to the phase transformation. Typical waxes have little to no impact on gloss if the formulation shows a good compatible with the type of wax.
Physically dried coatings / inks

Drying temperature << Melting point of Wax
In *physically dried coating systems* the melting point of the wax is usually not exceeded by the drying temperature (room temperature or forced drying). Particle size and shape of the wax is preserved in the fully dried coating and is chosen according to the dried layer thickness, application parameters and desired effect.

To achieve efficient improvement of e.g. scratch resistance, the wax particles need to emerge slightly from the surface of the coating. Compared to the Bloom/Floating Theory the system shows reduced gloss due to diffuse reflection at the surface of every single wax particle, better scratch and abrasion resistance.

The impact on hydrophobicity is not highly developed as the wax is simply locally distributed in the coating film and not a continuous wax layer like in thermally cured applications.
Impact of particle shape, size & distribution of wax particles

Drying temperature $<<$ Melting point of Wax

Too small

Insufficient surface protection

Too big

Non-lasting protection

IDEAL

IDEAL SURFACE PROTECTION
Impact of particle shape, size & distribution of wax particles

Drying temperature << Melting point of Wax

Broad particle size distribution

Inadequate protection

NARROW PARTICLE SIZE DISTRIBUTION

BETTER PROTECTION
Porous substrate

Total film thickness wax has to migrate

Inadequate protection

ADEQUATE PROTECTION
Impact of particle shape, size & distribution of wax particles

1. Stoving enamels ➔ WAX MELTS

Broad particle size distribution

2a. Physically drying lacquer ➔ WAX MIGRATION

Wax particles distributed in coating matrix

2b. Increased concentration of wax ➔ STACKING THEORY

Wax particles stack on each other
Drying temperature << Melting point of Wax

Typical coating formulation

Wax particles migrate to the surface during air drying

Highly filled coating

Wax particles stuck & cannot reach the surface

Wax particles migrate to the surface during air drying
CERETAN & LUBA-print Portfolio

CERETAN
Micronized powders
4-30µm (D50) (100% material)

LUBA-print
Liquid Dispersions
4-30 µm (D50) in water or solvents

LUBA-print
Precipitated Dispersions
1-6µm (D50) in solvents

LUBA-print
Liquid Emulsions
20nm-5µm (D50) in water
Slip / Coefficient of friction (CoF)

- Under Slip/CoF (coefficient of friction) we understand the force which is needed to slide two surfaces past each other. The lower the needed force - the higher the slip.

- At first the static friction has to be overcome afterwards the dynamic friction. A high friction (low slip) generally correlates with a higher abrasion.
Surface properties of wax additives
Slip / Coefficient of Friction (CoF)

Blank sample – without wax

Sample with 3% micronized wax
Scratch /rub & abrasion resistance

- Scratch resistance: = *punctual surface area stress*. The resistance ability of a surface against damage caused by sharp objects moving over the surface causing micro cuts.

- Under rub or abrasion resistance we understand the resistance of a coatings surface against wear of the layer through repeated rubbing over a larger surface area with a blunt or rough object.

- Wax particles protruding the coating film act as spacers and prevent damage of the coating layer itself.
Rub resistance

**Without wax**
Flexo-Ink
*(200 rub cycles)*
- Obvious surface damage
- Significant pigment transfer

**With 1% PE-Wax**
Flexo-Ink
*(2,000 rub cycles)*
- No surface damage
- No visible pigment transfer
Surface properties of wax additives
Scratch /rub & abrasion resistance

Scratch resistance

- Polyester based, white basecoat with and without wax additives
- Coating resists a 10x higher weight load

Sheen Hardness Test
Surface properties of wax additives
Matting effects of waxes

- Matting is caused by scattering of light at the surface as a result of a defined micro surface roughness.
- Defined wax particles (average size: 6-15μm) reduce gloss in physically drying coating formulations. It is very important to select a wax additive with a particle size distribution that suits perfectly to the dry film thickness of the coating film.
- In stoved/baked coating systems the wax particles melt and create a homogenous, very thin layer on the top of the coating. Under ideal conditions the gloss will remain the same. Such formulations are difficult to matt with a wax in the meaning of the wax definition.
Surface properties of wax additives
Matting effects of waxes
The hydrophobicity is the ability of the surface to repel water.

Non polar waxes (e.g. paraffins) reduce the surface tension of the coating - the lower the surface tension is the better the water repellence.

A good hydrophobicity delays or avoids the water absorption of the coating significantly. A bad hydrophobicity leads to an immediate water absorption or to a soaking of the surface.

Waxes provide excellent hydrophobicity but due to their chemical nature they do not provide lipophobic effects.
Surface properties of wax additives
Hydrophobicity
Blocking is the tendency of coated materials to stick together when compressed. Blocking can cause serious surface damages when the blocked surfaces will be separated.

Low molecular waxes like paraffin or fatty acid amides form a thin release film between the coated layers and prevent blocking thereby. Defined, larger wax particles of e.g. PE, PP, PTFE act as spacers between the coated layers and prevent reflow.
Surface properties of wax additives
Blocking / Antiblocking

Wood coating

**Film thickness:**
120µm (dry film)

**Weight load:**
200 g/cm²;
24 h/50 °C
Variation of particle size distribution

- The emulsification technology MÜNZING applies is very versatile. This enables us to adjust the particle size distribution to customer specific requirements.
- The picture above shows a defined increase of the particle size distribution starting from 20 nm ($D_{50}$) on the left to 4 µm ($D_{50}$) on the right – based on the same wax type.
Wax Qualities of Micronized Powders
Sprayed Waxes vs Milled Waxes

Milled wax

Sprayed wax
Spherical & Smooth particles:
- Easier to incorporate/disperse
- Less influence on gloss
- Less influence on viscosity due to lower surface area and lower particle interaction.
- Perfect particle orientation inside coating matrix = better surface protection.
- Higher efficiency due to narrow particle size distribution (= less dosage required)
- Low dust formation

Irregular & Rough particles:
- Difficult to incorporate
- Higher matting potential
- Increase in viscosity due to higher surface area and interlocking of particles
- Imperfect particle orientation due to irregular shape
- Less efficient due to broader particle size distribution (=higher dosage required)
- Creates more dust
Spherical & Smooth particles:
- Wax blends: = homogenous particles of constant composition due to melting step prior to spray micronization.

Irregular & Rough particles:
- Wax blends: Mixture of particles of different composition. Particles standing side by side.
# Comparison of wax additives with other technologies

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<th>Matting Flattening</th>
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*Images represent the properties: Scratches, Mar Resistance, Slip Mobility, Rub + Abrasion Resistance, Matting Flattening, Gloss, Texture, Haptic Soft Feel, and Repellency.*