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# Improved Output, Surface Effects & Physicals

# Choosing the Right Wax

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Waxes for Plastics

Clariant Plastics & Coatings USA, LLC

## SPE Olefins 2017

Houston, TX - Feb. 26 – Mar. 1, 2017

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# Contents:

# Clariant at a glance – An introduction

## A GLOBALLY LEADING COMPANY IN SPECIALTY CHEMICALS

**5807**
Sales 2015 (CHF m) from continuing operations

**227**
Net result 2015 (CHF m) from continuing operations

**4**
Business Areas

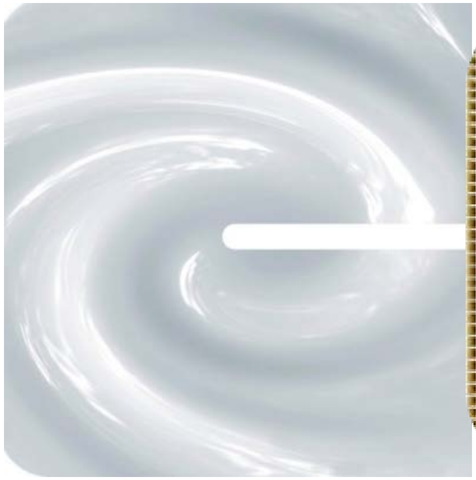
**853**
EBITDA 2015 (CHF m) before exceptionals

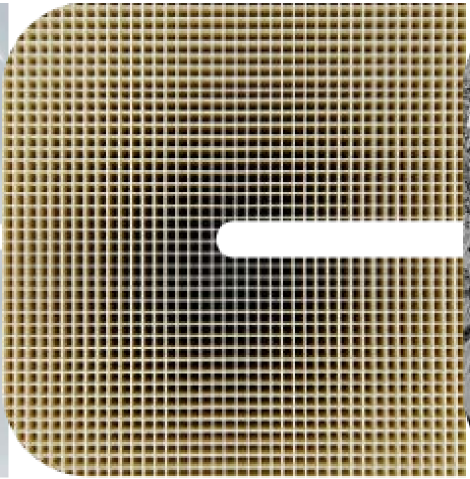
**14.7%**
EBITDA margin 2015 before exceptionals

**110** companies in **53** countries

**17213**
Employees 2015

# Four Business Areas -the right portfolio for growth





**Care Chemicals**

**Catalysis**

**Natural Resources**

**Plastics & Coatings**

# BU Additives, of Clariant Plastics & Coatings – 3 Busines Lines: FR’s, Additives and Waxes

**Flame Retardants:**
**Innovative products such as patented non-halogenated flame retardants provide environmentally compatible protection for electrical and electronic equipment.**

**Polymer Additives:**
**Polymer additives prevent oxidation, dissipate electric charge accumulation and improve heat, light and weather resistance**

**Waxes:**
**Waxes optimized for plastic applications, hot melt adhesives, polishes and protective coatings.**

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# BL Waxes – Specialty Performance Waxes

**Licolub™ & Licowax™ Montan waxes**

**Licowax™ & Licomont™ Saponified Montan Ester Waxes**

**Licocene™ Metallocene Olefin Waxes**

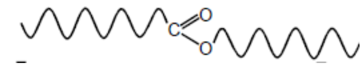
**Ceridust™ Micronized Olefins (PE&PP), Oxidized Olefins, Montans and Amides**

**Licocene™ Maleic Anhydride-Grafted Metallocene Olefins**

**Licowax™ Amide Wax – EBS**

# Waxes Defined

– Chemical definition: A lipid made up of a chain of alkanes or esters made from fatty acids and alcohols. Source: *Oxford Dictionary of Chemistry*



($C_{20}$ to $C_{70}$)

– Engineering definition: A semi -solid or smooth solid featuring a low melting point and thermoplastic qualities; which may be of animal, plant or mineral origins. Source: *Dictionary of Engineering*.

– Common English definition: A solid substance that becomes soft when warm and melts easily; often used to make candles. Source: *Cambridge Learner's Dictionary*

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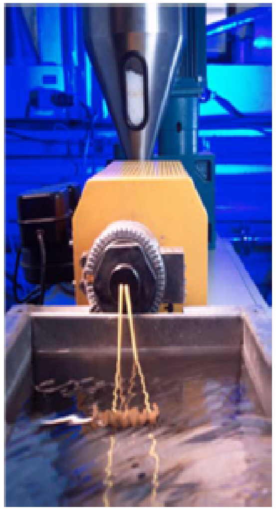
# What Should Waxes Achieve in Polymers ?

**During Mixing**

- Homogenizing
- Compatibilizing
- Dispersion

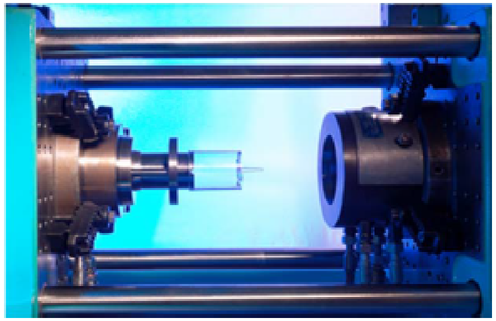


**During Processing**

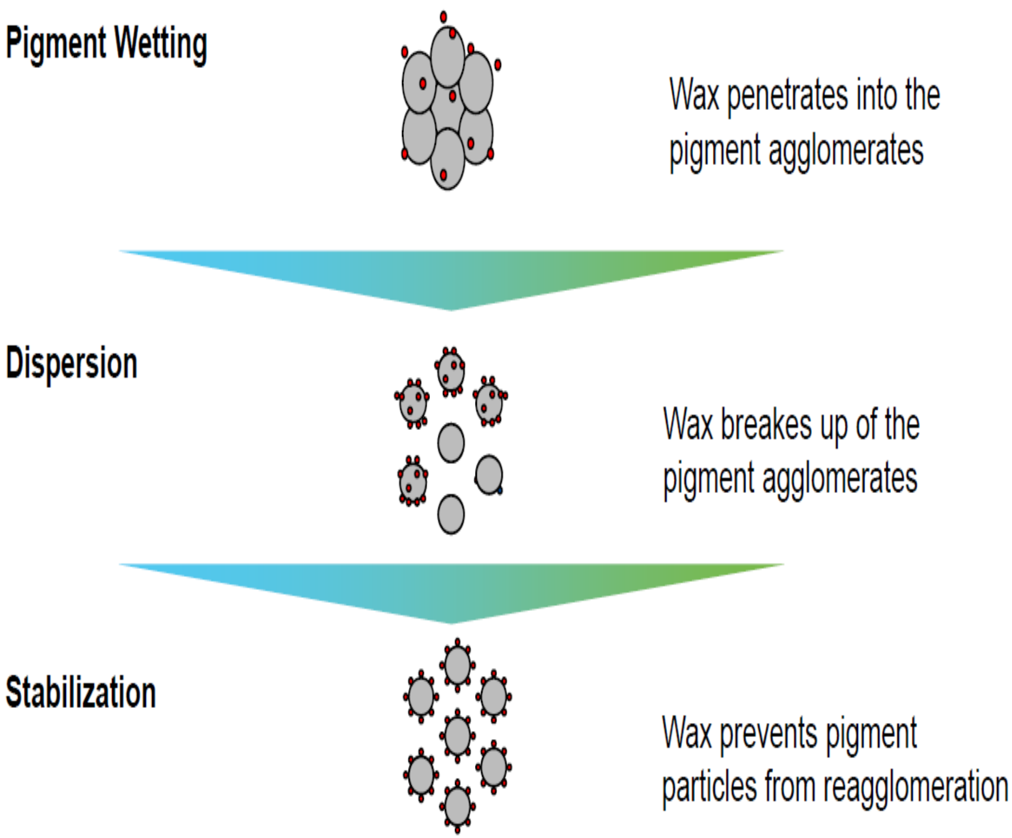
- Flow Improvement
- Decrease pressure
- Release effect
- Smoothen surface
- Pigment dispersion
- Avoid over-shearing of the polymer
- Increase color yield
- Reduce filter pressure

**Article properties**

- Provide antiblock effect
- Maintain printability
- Provide gloss
- Provide transparency
- Smooth surface



# What Should Waxes Achieve with Pigments ?

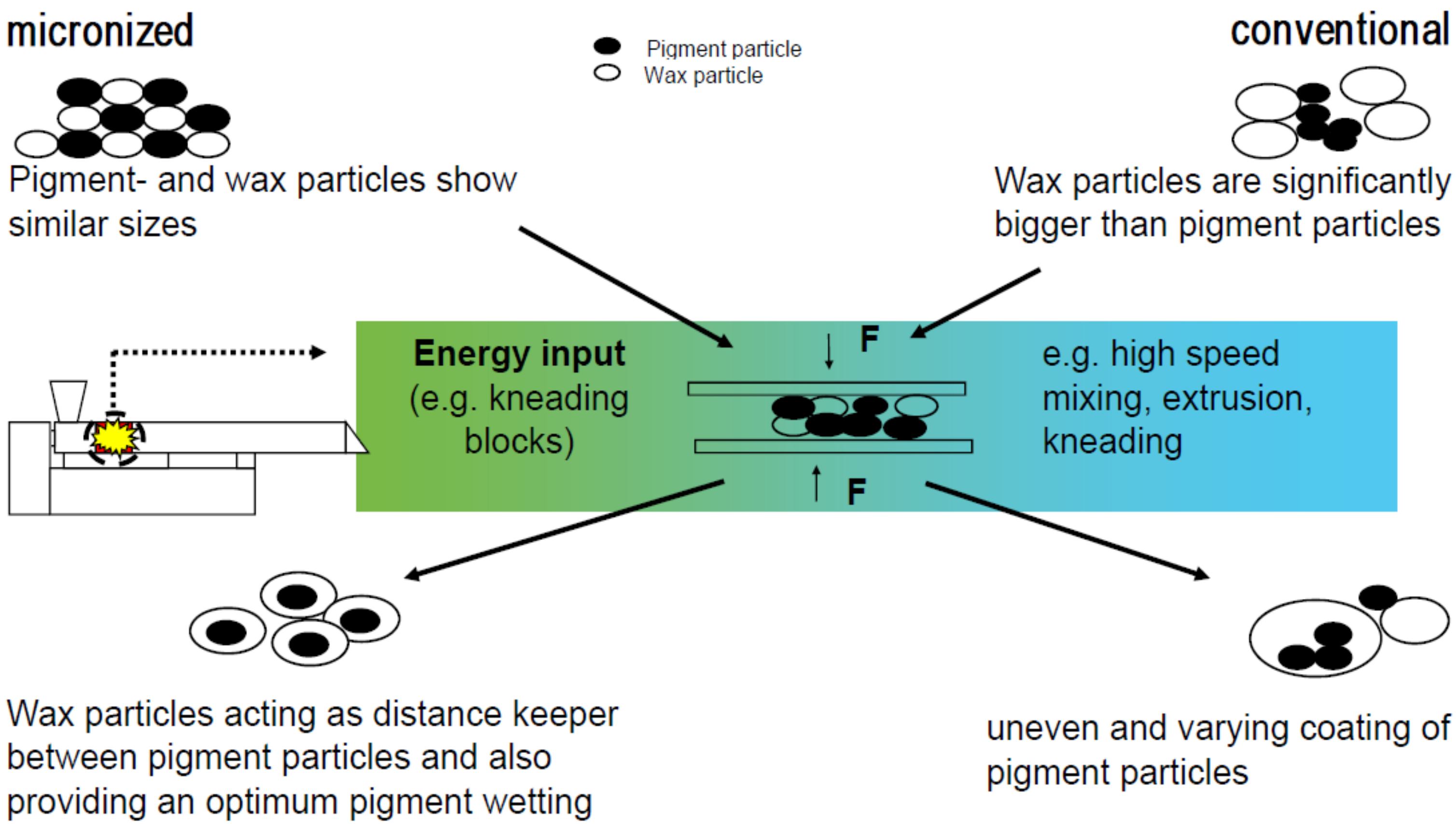



Criteria for Choosing Wax(es):

- Viscosity
- Polarity
- Volatility
- Color Stability
- Particle Size
- Interactions

# Particle Size Influences Dispersion

## - Influence of Particle Size



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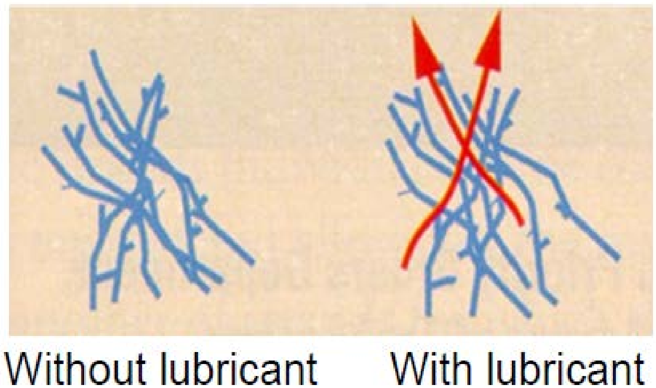
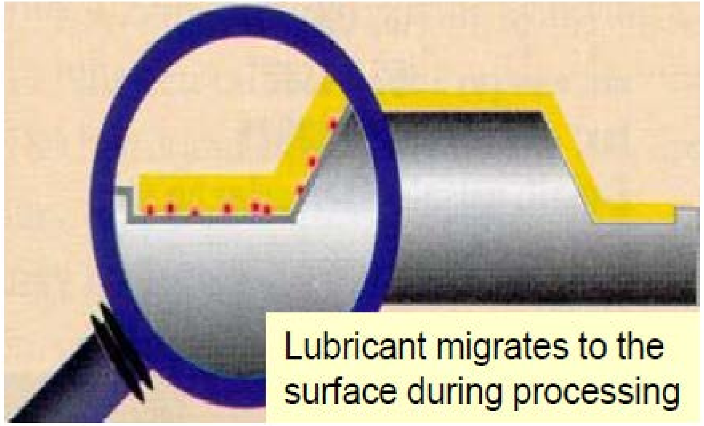
# Lubricant Mechanism's
*How they work in polymers.*

**Internal lubrication between polymer chains**




Reduced viscosity
Improved flow properties

**External lubrication on the surface**




Improved release effect

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# Internal and External Lubrication – Further Explained

## Internal Lubrication:

- promotes flow
- promotes weld line fusion
- improved die fill
- reduces die swell
- reduces die drool
- reduces head pressure
- can help keep clarity
- reduces HDT

## External Lubrication:

- metal release; i.e. “slip”
- reduces process temp
- can plate out [exusion]
- can slow recrystallization (Hc)
- can reduce weld line strength
- can “pool” in extruders; cause surge
- can interfere with printing
- can discolor; especially over long runs

*In reality, and depending on the concentration, many waxes or lubricants act as both.*

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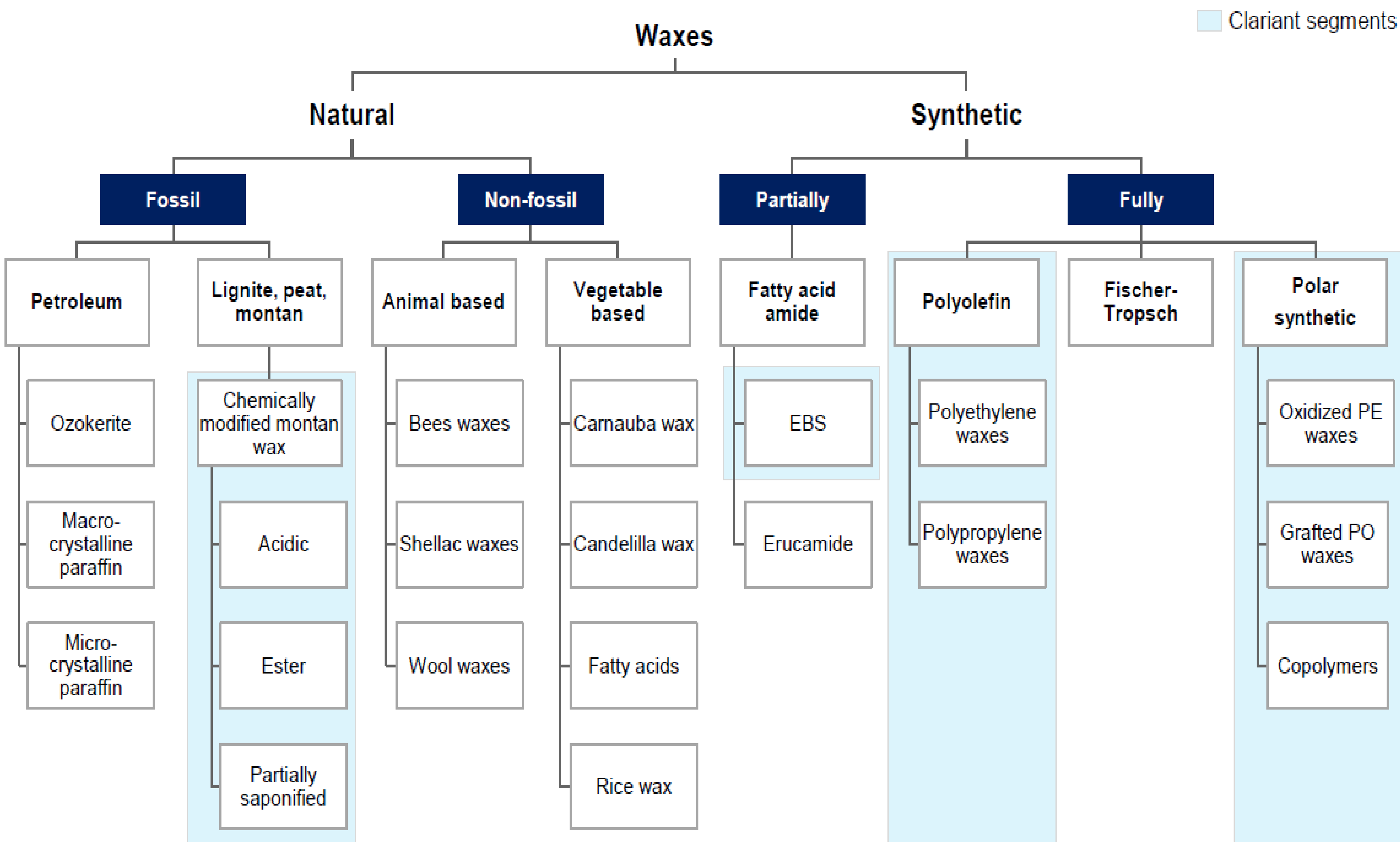
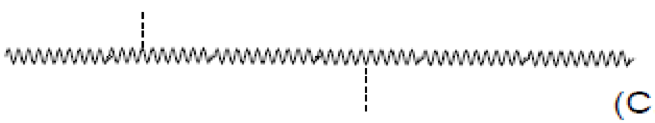
# Differing Chemistries– Depending on Usage
# *So, for Olefins, what is used?*



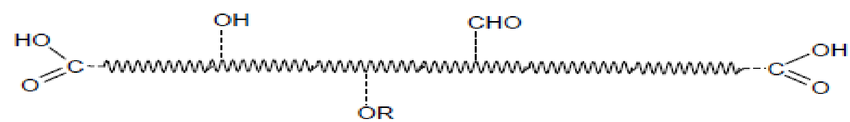
# Waxes Commonly Used in Olefins:

**Olefin waxes; both polar and non-polar** (i.e. PE, PP, Copolymer olefins)

- non-polar (i.e. PE, PP) more miscible in olefins, so mostly stay as an internal lube
- polar (oxidized, grafted or acid-copolymer) not as miscible in olefins, so it exudes to be more like an external lube. Best for functional polymers.

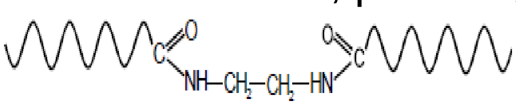


($C_{120}$ to $C_{700}$)

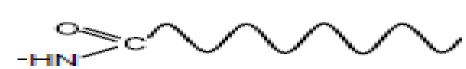



**Amides** (i.e. oleamide, erucamide, EBS)

- The materials have an aliphatic tail that prefers the polymer. However,…..
- Their amide (polar) end exudes to lubricate between the olefin and metal, providing the “slip” effect, from which they get their nickname.




- Amides can also act as anti-stats; especially with GMS



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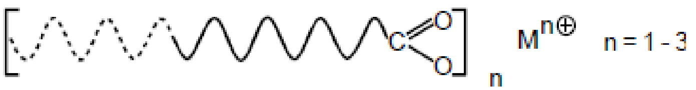
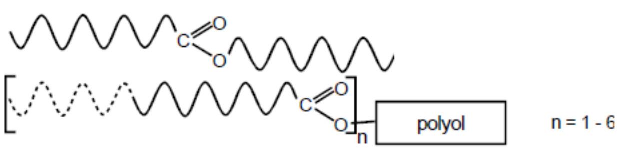
# Waxes Commonly Used in Olefins (cont.):

**Soaps** (i.e. saponified metal carboxylates)

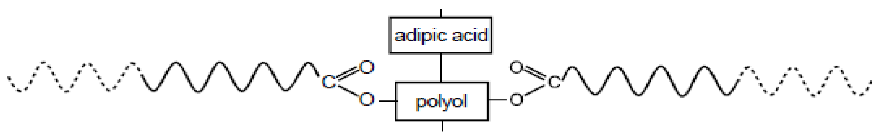



- lower m.w. types like zinc stearate, calcium stearate (more volatile, char sooner)
- higher m.w. types like sodium and calcium montanates (less volatile, resist char)

**Esters** (i.e. GMS, FACE, MACE)




- mono-esters of polyols (i.e. GMS) work as anti-stat too; especially with amides
- fatty acid polyesters of polyols reduce volatility and discoloration
- complex esters further reduce volatility; especially when higher m.w., montan waxes



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# Masterbatchers' Needs from Wax

- **Best Dispersion possible**
- **Highest concentration possible (for their clients' economies)**
- **Lowest influence on Color**
- **Color Consistency over a long run**
- **Minimal die drool or release of oxidized material (black specks)**
- **Lowest dosages possible**
- **Low organo-leptic contributions (smell, taste)**

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# Molders' Needs from Waxes

- Flow Improvement; i.e. Longer flow for hard-to-fill, thin-walled parts
  - reduced surface drag (i.e. external, surface lubrication)
  - less molded-in stress (internal lubrication)
  - melt strength retention [read mol. wt. retention] when lubricating
- Faster hardening; i.e. quicker crystallization/nucleation, improved physicals
- Easier mold release = Reduced sticking; without affecting labelling/adhesives
- Resin-rich [smooth] surface and complete "wetting"; with filled polymers
- Improved color development and consistency or transparency when needed

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# Extruders' Needs from Waxes

**Faster output, while maintaining the following:**

**- Surface smoothness**

**- Surface release (both metal "slip" and polymer "anti-block")**

**- Above release without excess wax inhibiting printing**

**- Low volatiles to reduce build-up of additives on rollers**

**- Reduced "die drool" at die lip (pressure drop & shear; low m.w. mat'l)**

**- Improved compatibility / binding of dissimilar material; i.e. WPC**

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# How do **you** know if all needs are met?

- Processing as rapidly as the machinery allows

- Aggressive processing (i.e. high heat) does not discolor the polymer or cause char (specks and streaking)

- Wax does not hinder print adhesion
- Minimal die drool (extrusion)

- Minimal vent plugging and gate blush (injection)

- Color consistency and development

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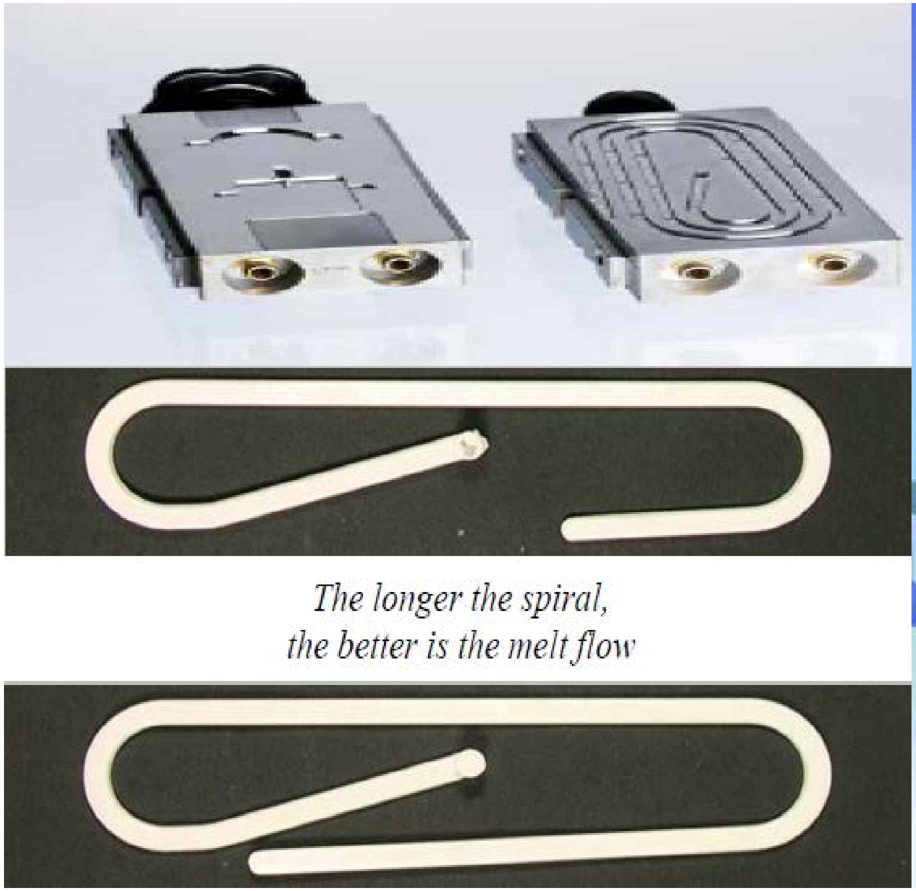
# How do **we** know if we are designing waxes properly? *Testing to Theory*.

– **Mold flow rate Improvement**
– **Mold release force reduction**
– **Reduced surface roughness**
– **Reduced extruder pressures**
– **Reduced volatility, vs. standard waxes**
– **Reduced charring in heated ovens, vs. standard waxes**
– **Improved pigment dispersion; less specking**

# Mold Flow Improvement Measured - *While Keeping Polymer Integrity*




**Spiral Melt Flow Testing**

**Haake Kneader – Viscosity Testing**

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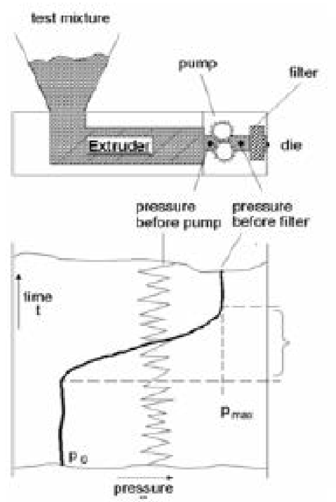
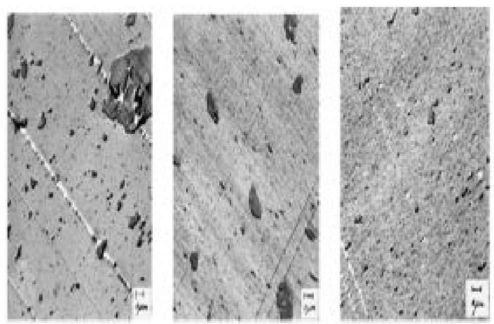
# Easier Mold Release - Quantified

Molding and Integrated Release Quantifying Force (N) Unit


Molded Cylinders >

# Pressure Rise & Color Development Testing



| Without wax | 3 % Licowax E | 2 % Licowax E<br>1 % Ceridust 5551 |
|---|---|---|
| (colour yield = 100 %) | (colour yield =117 %) | (colour yield = 131 %) |

$$FPV = (p_{max} - p_s) / m_c$$

FPV filter pressure value in [bar/g]

$p_s$ initial pressure in [bar]

$p_{max}$ maximum pressure in [bar]

$m_c$ inserted amount of pigment in [g]


production of the color yield plates

measurement of the color yield, (X,Y,Z values, or L*a*b* values DIN 53 235 )

$$F = m_B/m_P * 100$$

F rel. color yield in [%]

$m_B$ amount of color pigment (base) in [g]

$m_P$ amount of color pigment (test sample) in [g]

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# Testing Volatility by TGA & Air Draft Oven

**What TGA Can Tell You**

- Thermal Stability of Materials
- Oxidative Stability of Materials
- Composition of Multi-component Systems
- Estimated Lifetime of a Product
- Decomposition Kinetics of Materials
- The Effect of Reactive or Corrosive Atmospheres on Materials
- Moisture and Volatiles Content of Materials

TGA for small lab samples.

Air Draft for larger samples to show color development, Charring, etc.

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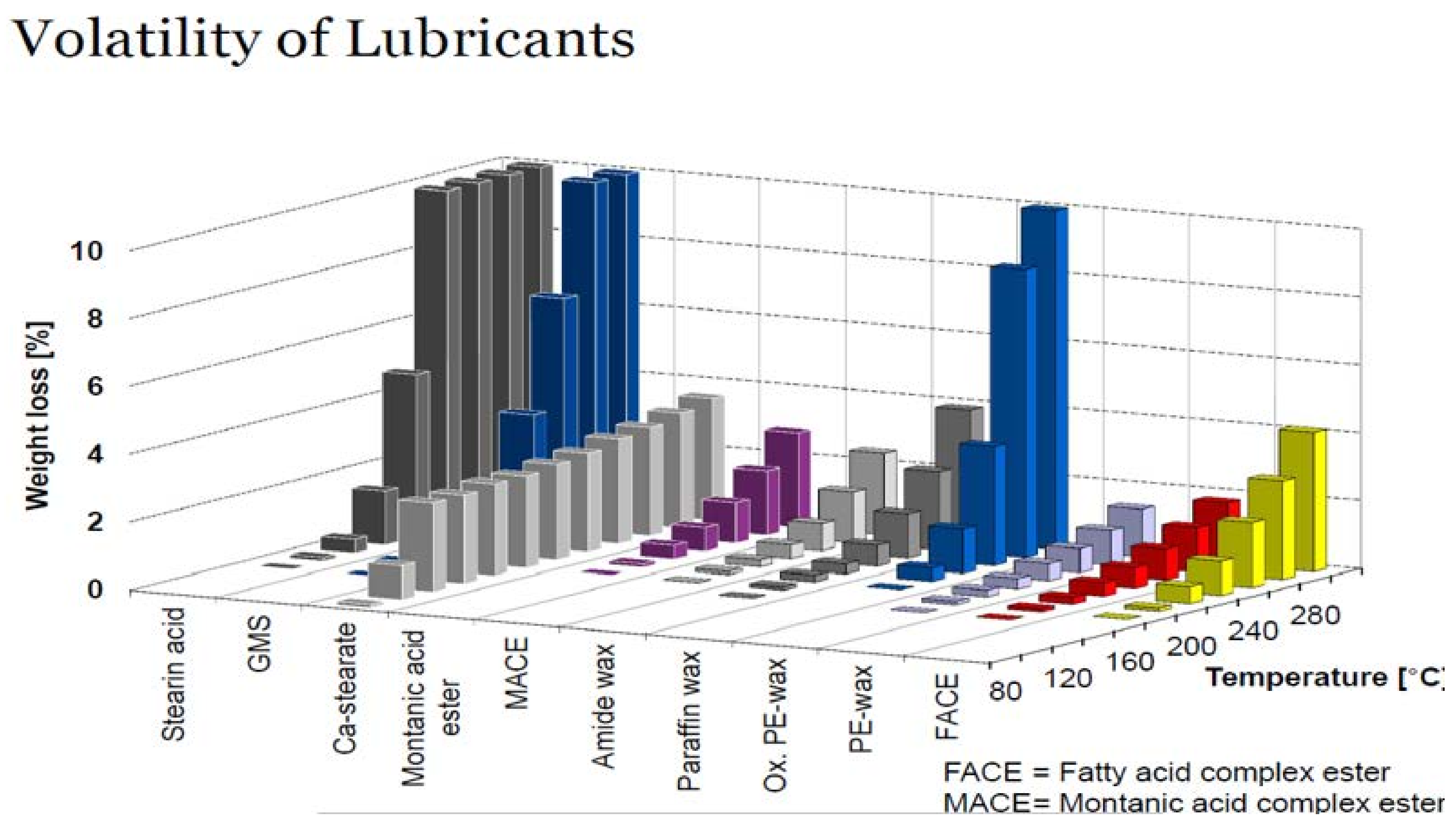
# What do These Tests Show?
# *Volatility Results of Various Waxes*




TGA results from Clariant – Gersthofen Lab

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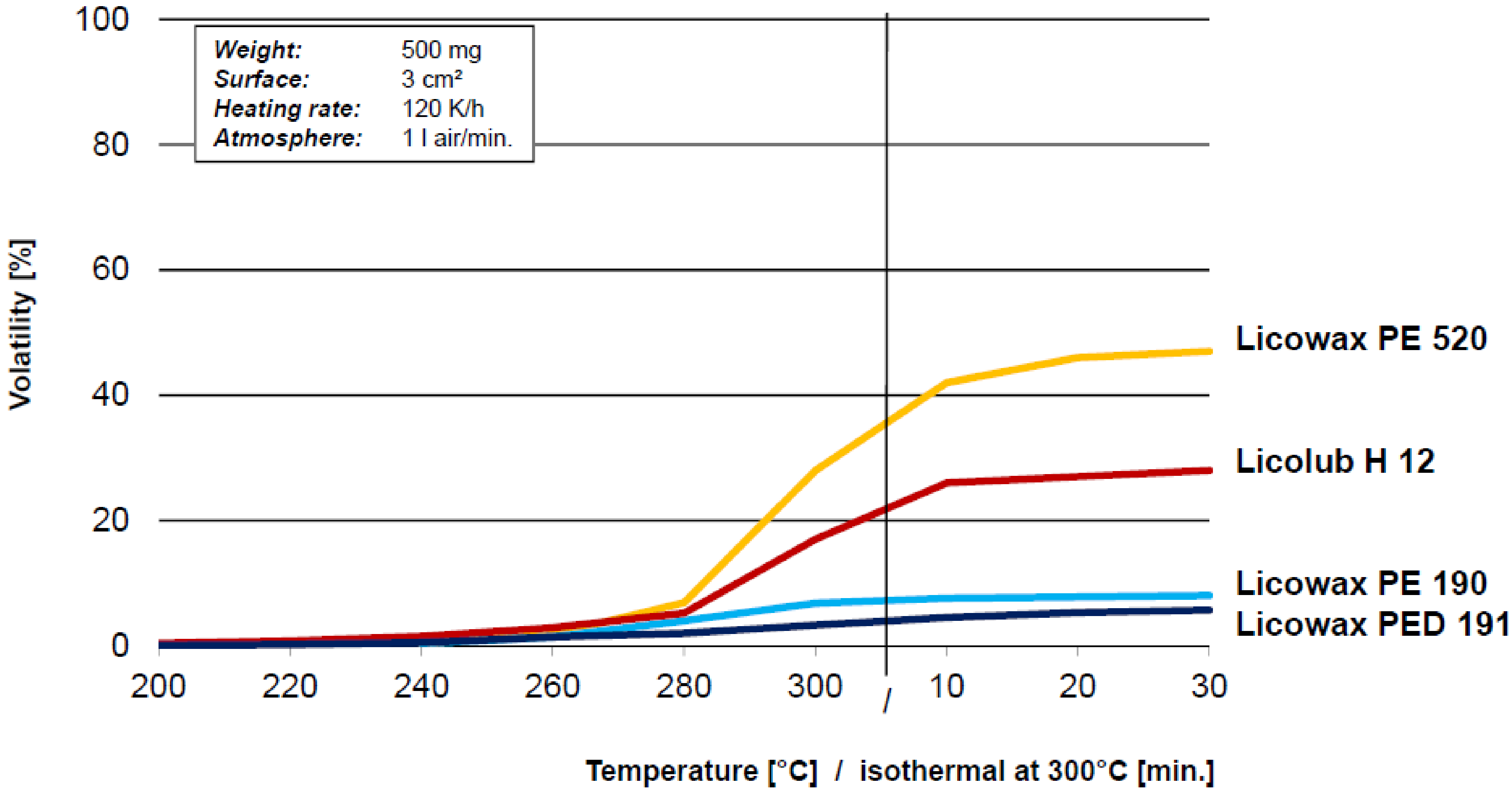
# Volatility (TGA) of Polyolefin Waxes



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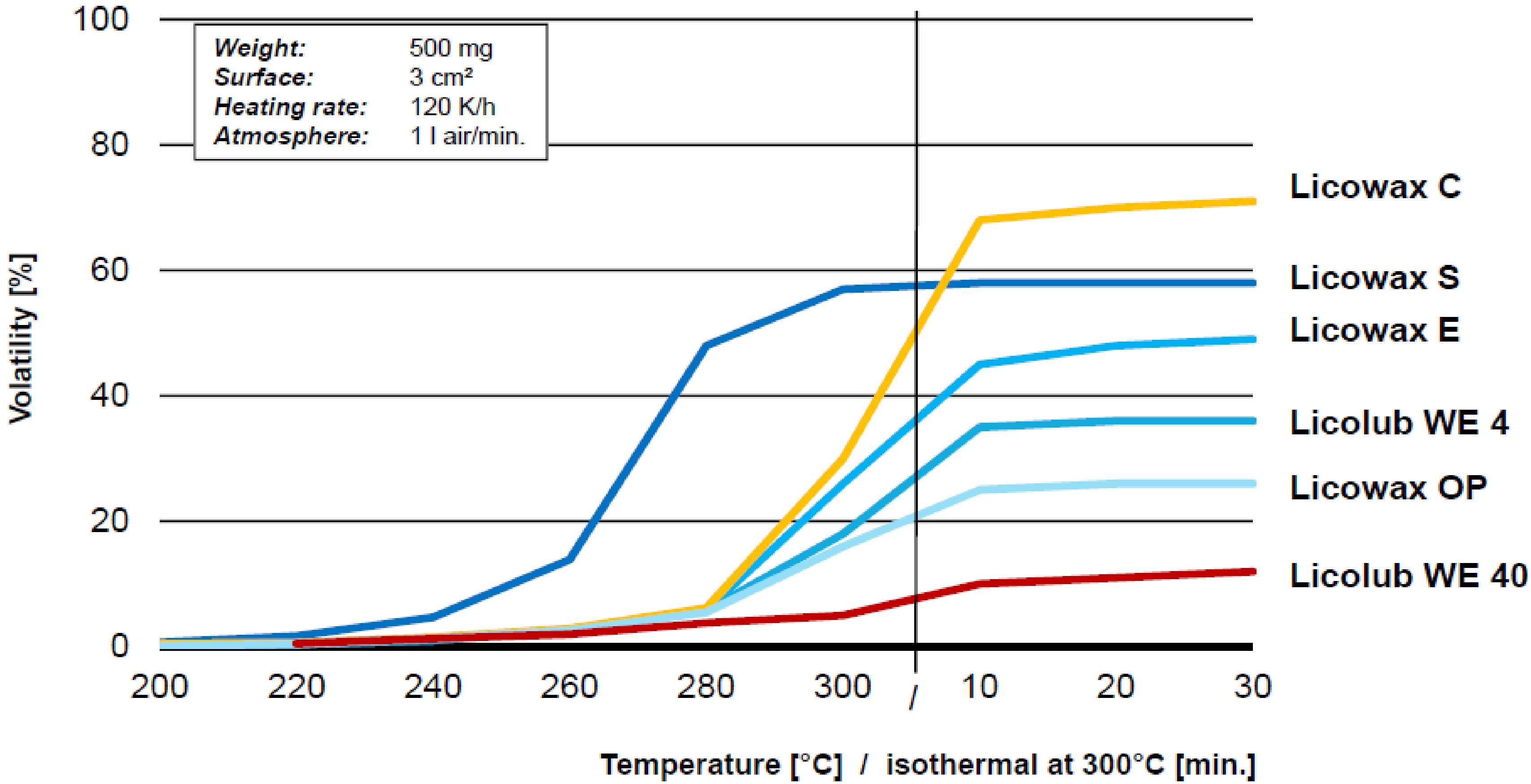
# Volatility (TGA) of Ester and Amide Waxes



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# Reduced Charring of Montan Waxes vs. Stearates
## *Air Draft Oven at 250C, for 30 min.*

Licolub WE 40

Licolub WE 4

Calciumstearate SP

Calciumstearate Liga 860

Licowax E

Licowax OP

Magnesiumstearate SP

Zinkstearate SM 101

# Reduced charring of Licolub PE Waxes

**Tempering of PE-Waxes (Oven test 200 °C, Air)**

**High pressure, radicalic polymerized**

GL 6

GL 7

**Low pressure, Ziegler-Natter polymerized**

Licowax PE 520

0 h (melt) | 2 h | 4 h | 8 h

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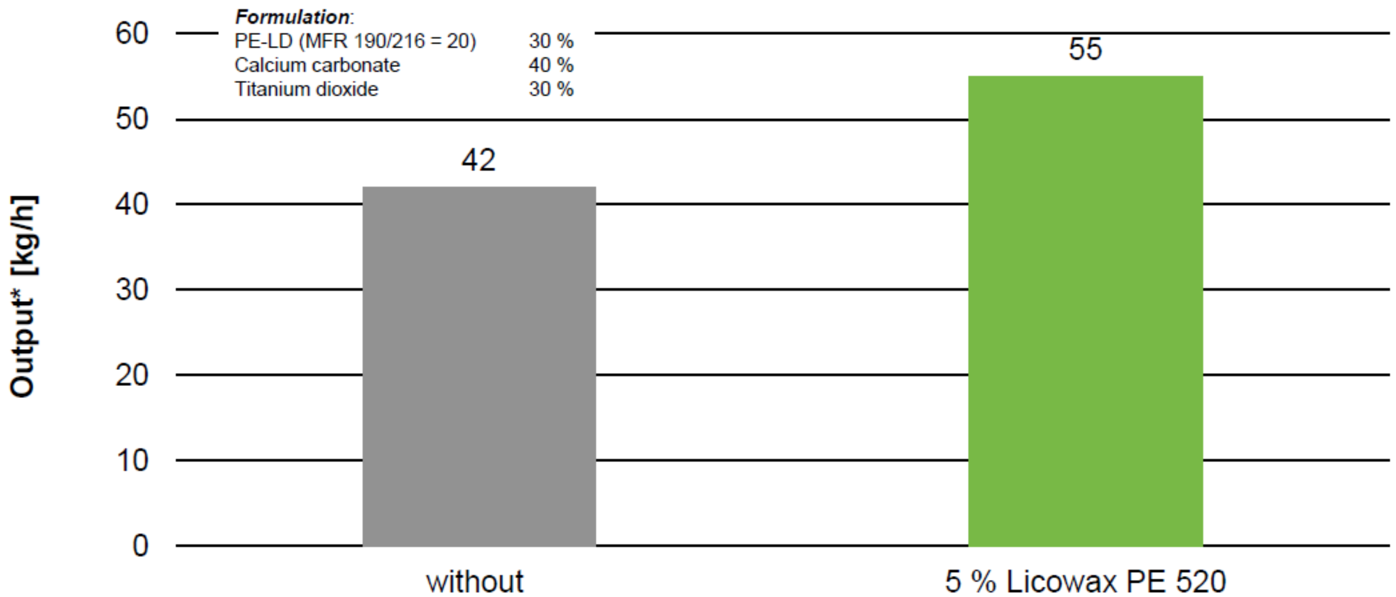
# Melt Flow Data with PE Wax

## Licowax PE 520 in Polyethylene
## Flow Improvement

***Influence on output rate***




* determined at 90 % power uptake of extruder

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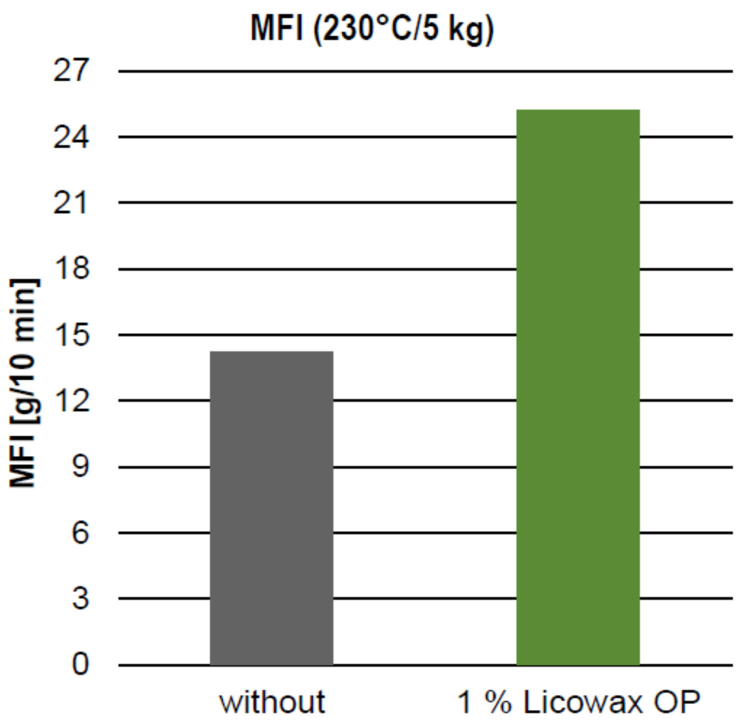
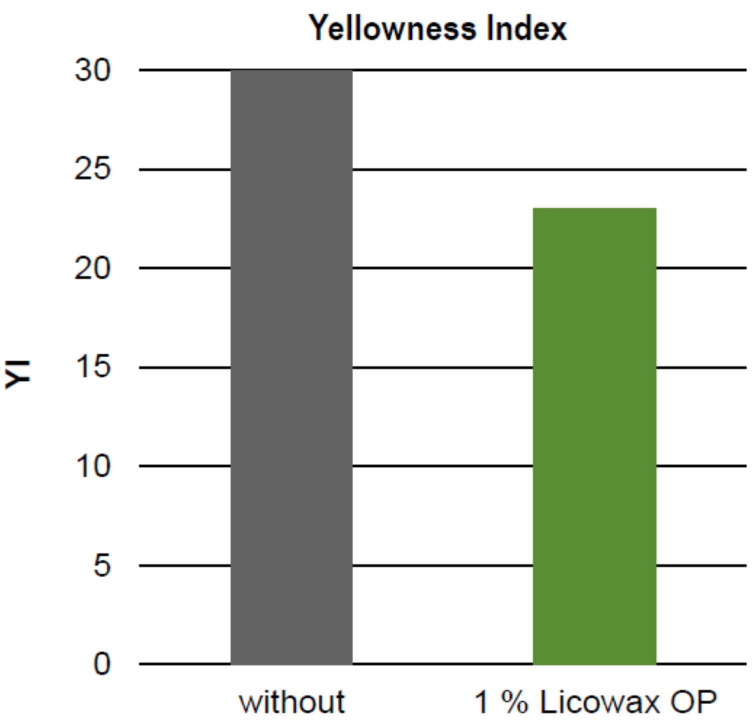
# Flow Data with Partially Saponified Montan Wax

## Licowax OP for
## Talc-Filled Polypropylene Compounds (30 wt.-%)
## - Flow Improvement and Color Behavior



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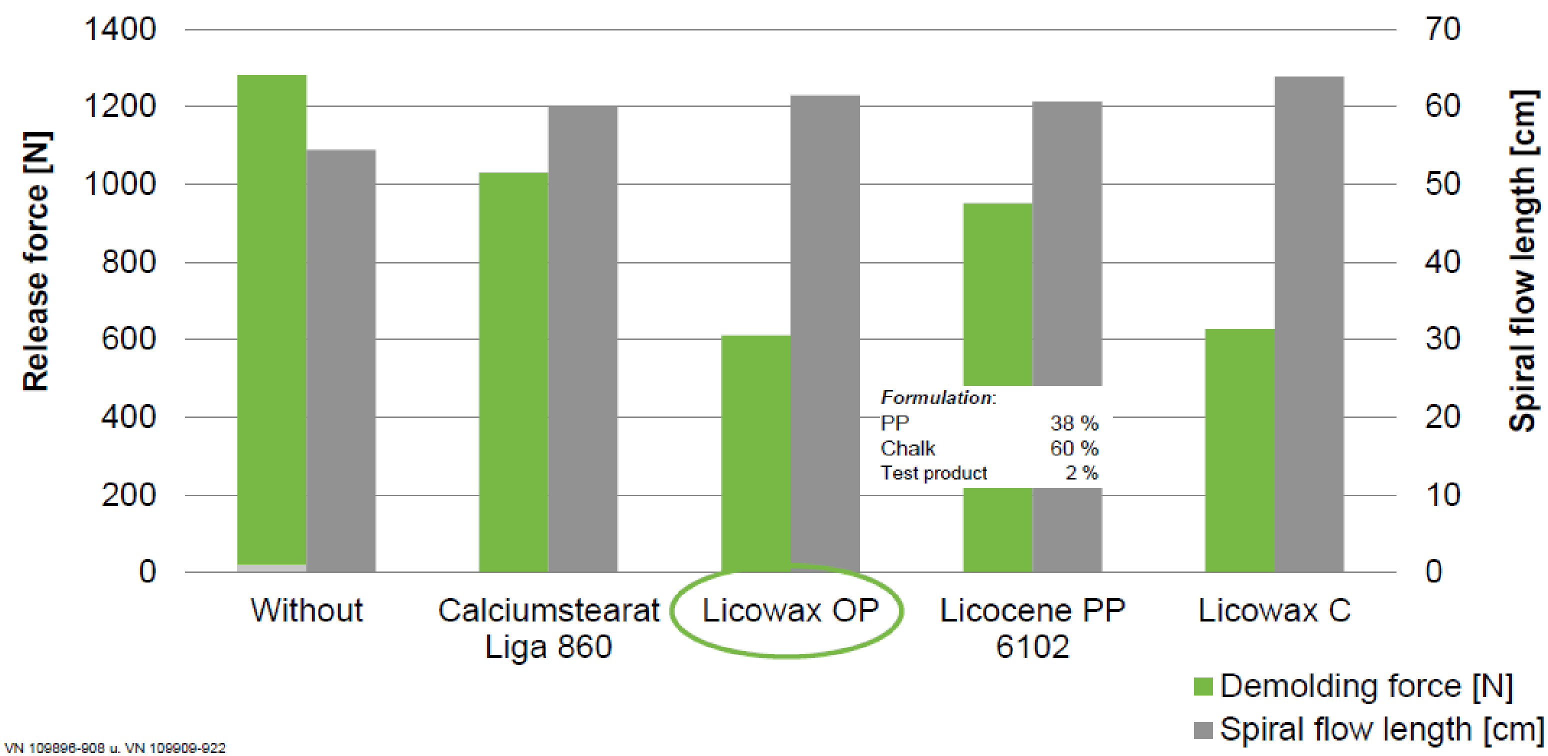
# Flow & Mold Release Data – Various waxes

## Licowax OP for Chalk-Filled Polypropylene Compounds
## - Release Force and Spiral Flow Test

Lowest release force, good flow improvement with Licowax OP




VN 109896-908 u. VN 109909-922

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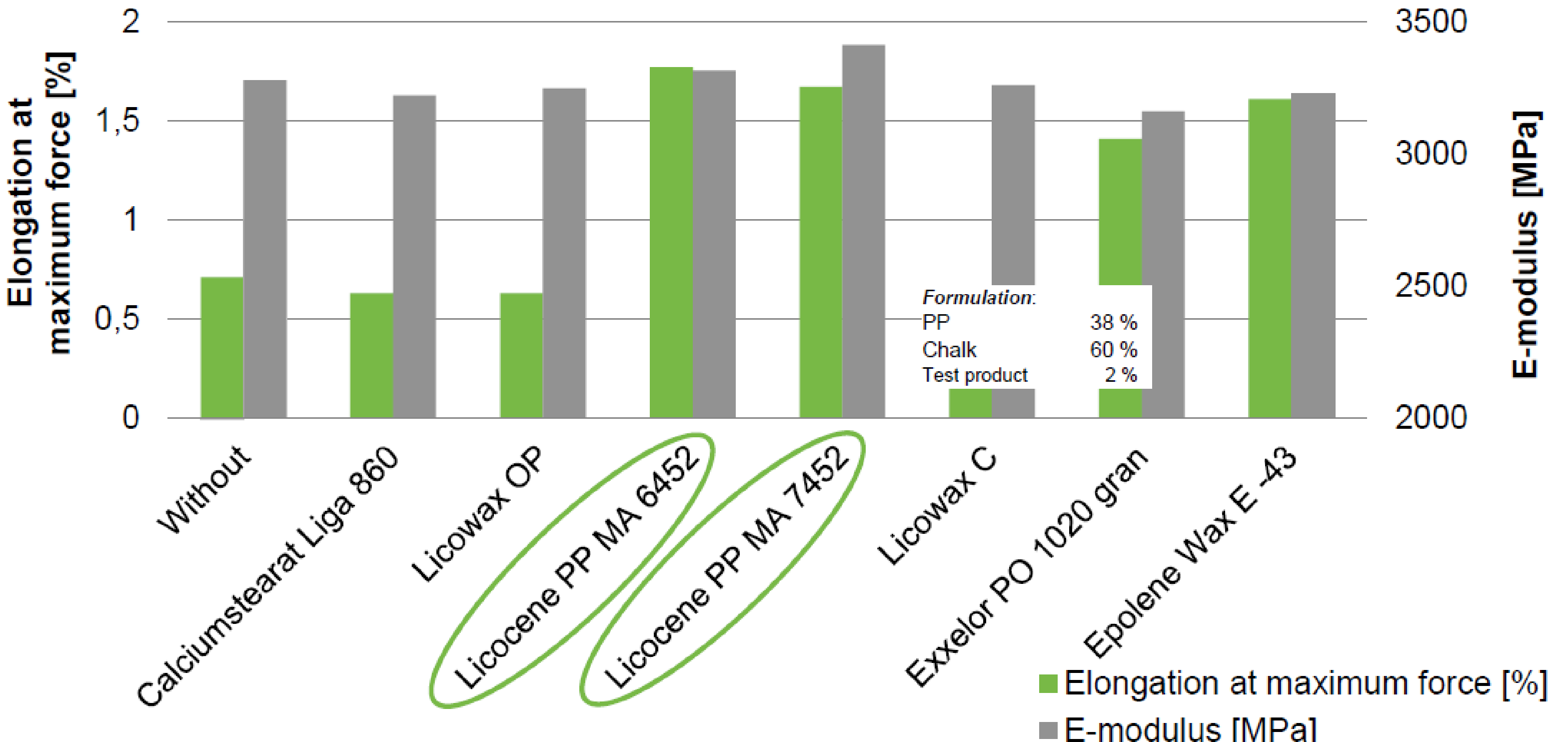
# Filled PP Physical Testing Data

## Grafted Licocene PP Grades for Chalk-Filled Polypropylene Compounds
## - E-Modulus and Elongation

Highest E-modulus and Elongation with grafted Licocene PP grades

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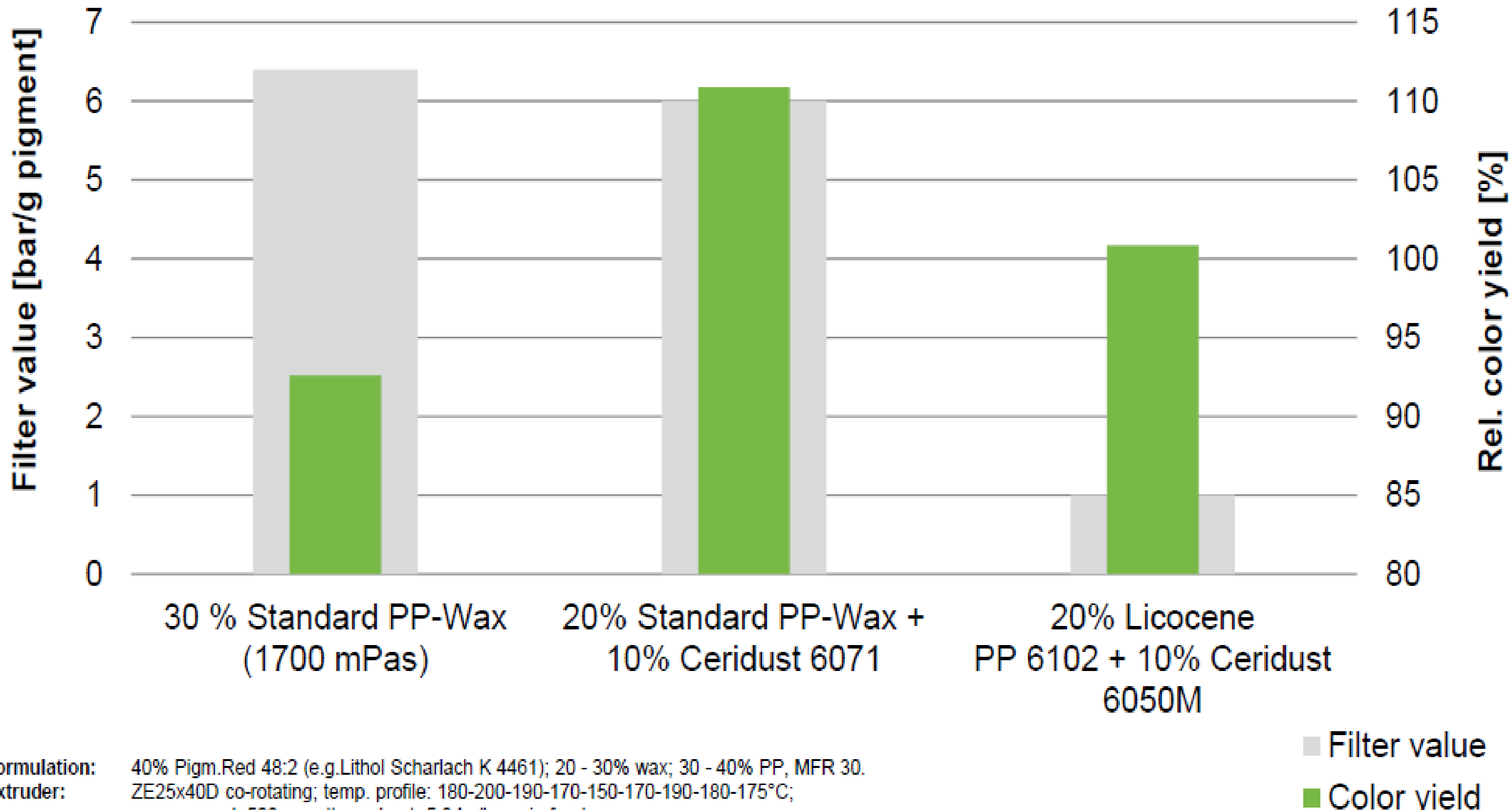
# PP Filter Test and Color Yield Data

– Highly crystalline, low melting, low viscous, micronized PP wax gives the best results regarding dispersion in contrast to other PP waxes




**Formulation:** 40% Pigm.Red 48:2 (e.g.Lithol Scharlach K 4461); 20 - 30% wax; 30 - 40% PP, MFR 30.
**Extruder:** ZE25x40D co-rotating; temp. profile: 180-200-190-170-150-170-190-180-175°C; screw speed: 500 rpm; throughput: 5.0 kg/h; main feed

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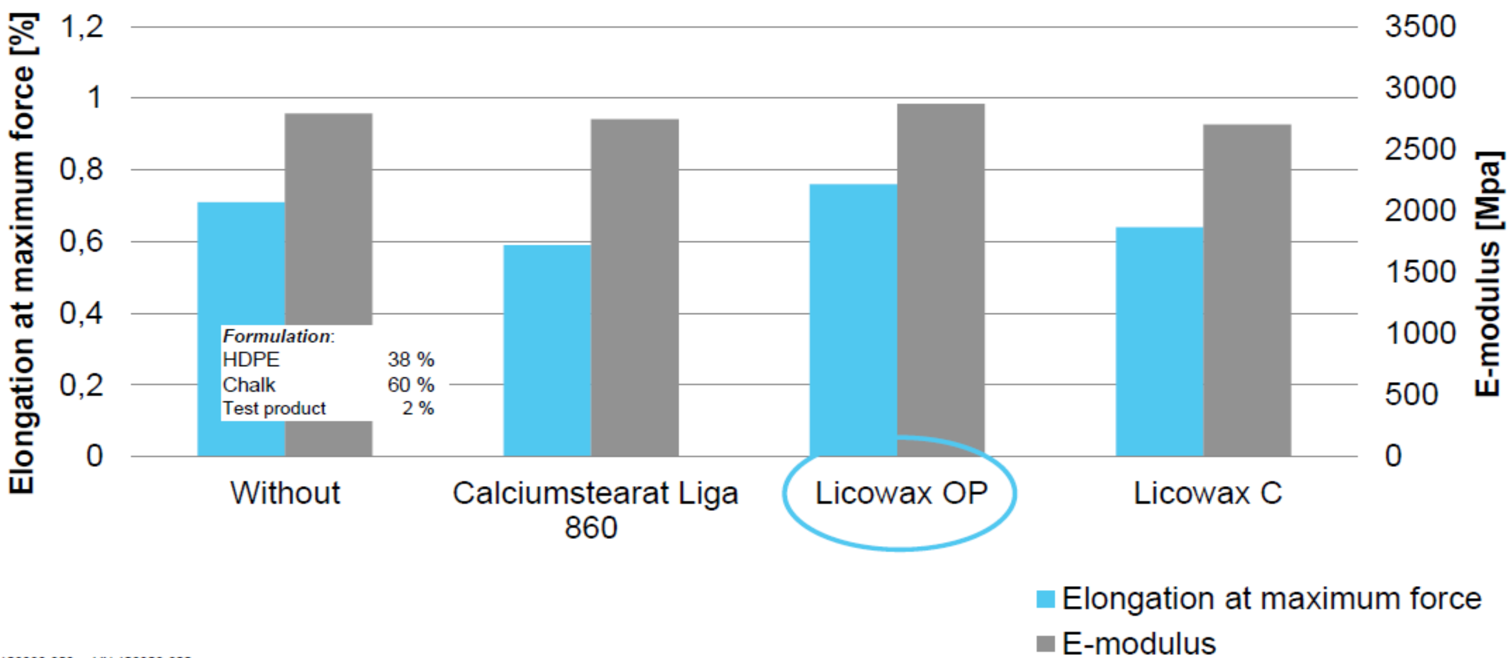
# Filled HDPE Physical Testing

## Licowax OP for Chalk-Filled HDPE Compounds
## - Elongation and E-Modulus

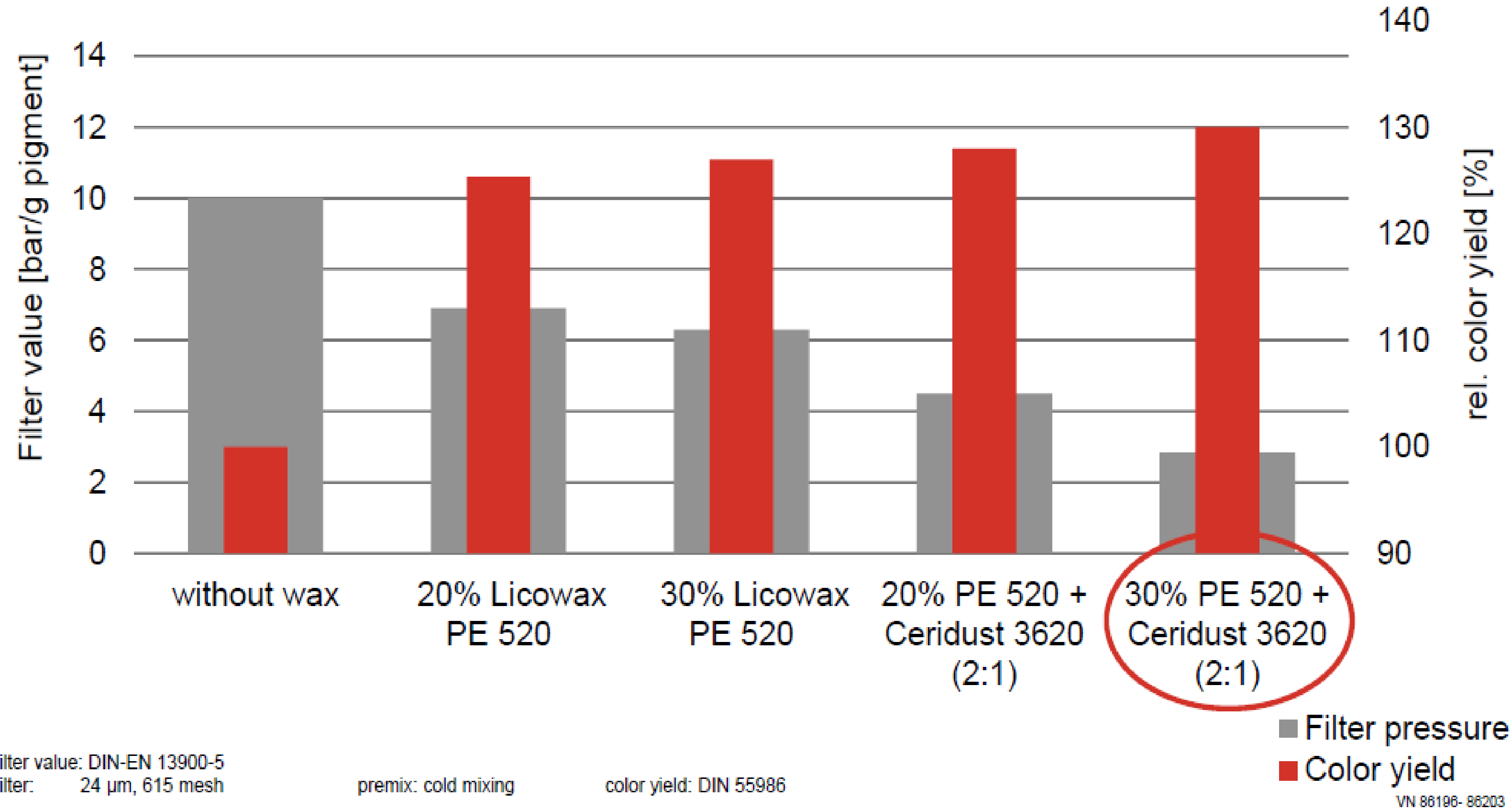
No negative influence of E-modulus and elongation




VN 109896-908 u. VN 109909-922

# LLDPE MB Filter Test and Color Yield

– 40 % Pigment Red 57:1 + 30 % LLDPE (MFR 25)




filter value: DIN-EN 13900-5
filter: 24 µm, 615 mesh
premix: cold mixing
color yield: DIN 55986

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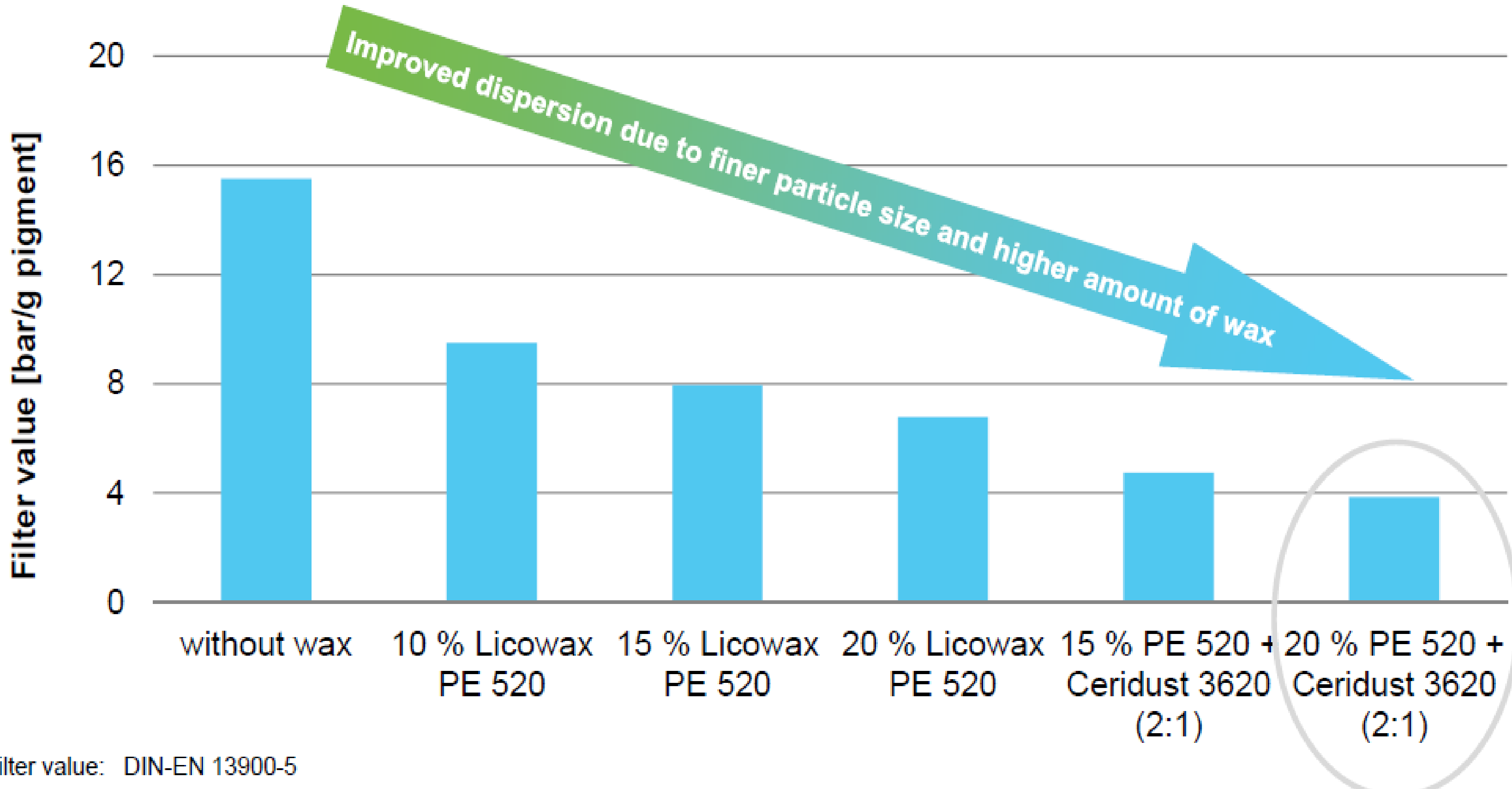
# Filter Test – Fast Blue A2R in LLDPE

– 30 % Fast blue A2R in LLDPE




filter value: DIN-EN 13900-5
filter: 40 µm, 725 mesh
premix: cold mix

VN 86931 - 86941

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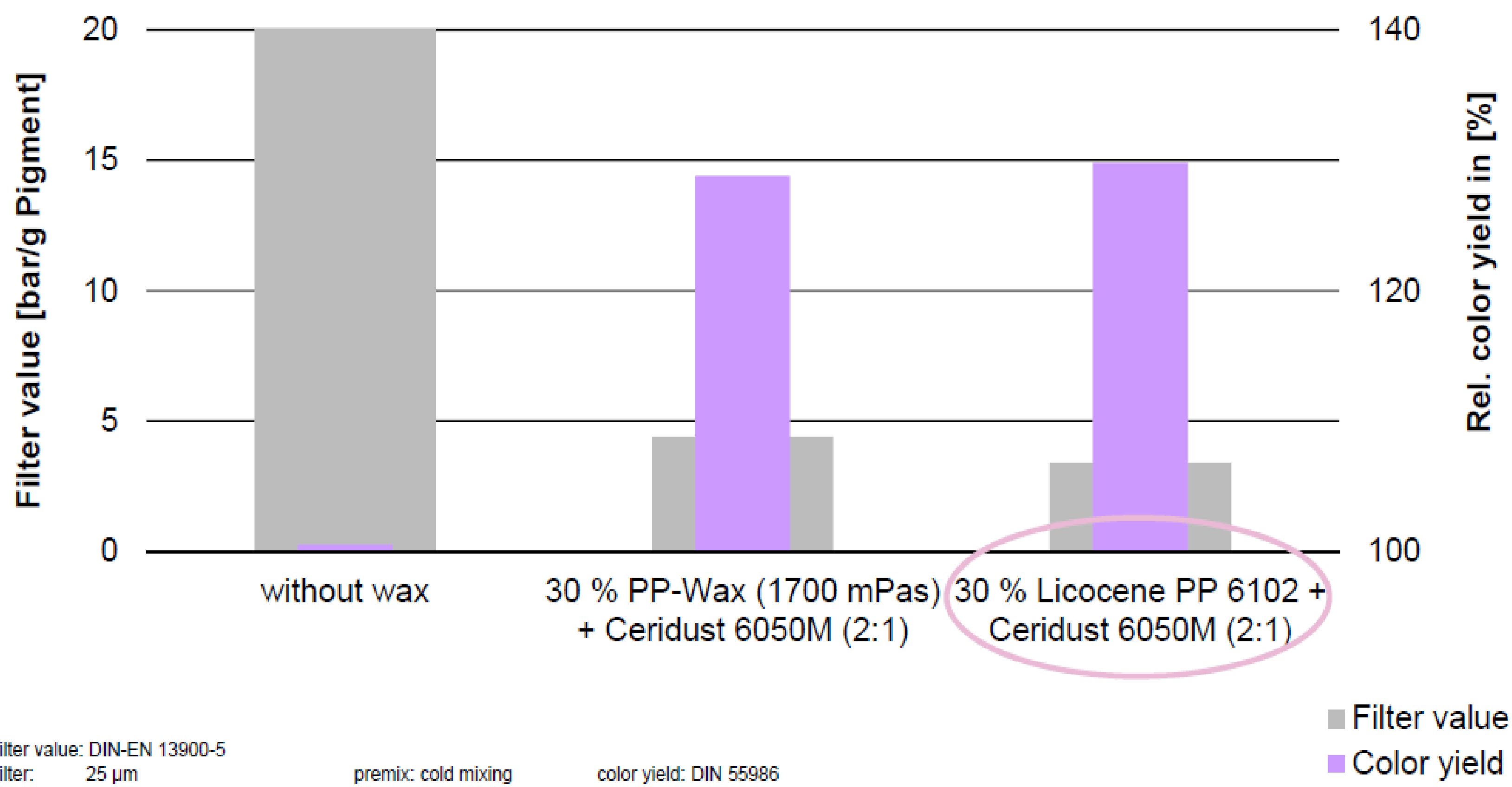
# Effects of Wax on Dispersion and Color yield

– 30 % Pigment Violett 19 + 40 % PP HG 245 (Borealis)




filter value: DIN-EN 13900-5
filter: 25 µm
premix: cold mixing
color yield: DIN 55986

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# Summary of Effects of Properly Chosen Waxes

- **Better mold release**
- **Maintains polymer integrity [read viscosity]**
- **Improved melt flow; easier mold fill**
- **Better color consistency; less charring**
- **Reduced volatiles; less mold / vent cleaning**
- **Quicker recrystallization (injection molded crystalline poymers); i.e short cycles**
- **Improved spherulite formation; i.e. better impact physicals**
- **Resin-rich surface with filled compounds; better appearance**
- **Maintains better clarity, where applicable**
- **Improve pigment dispersion and color consistency**

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# General Wax Recommendations for Olefins

| | | | |
|---|---|---|---|
| **PP fiber masterbach** | Fiber | Dispersion | Licocene PP 6102 |
| **PP-filled** | Extrusion<br>Injection molding | Dispersion, output, Surface quality, Hydrophobation | Licowax OP<br>Licowax C<br>Licolub FA 1 pwd. veg. based<br>Licocene PP MA 6452<br>Licocene PP MA 7452 |
| **PP-filled, rubber modified** | Injection molding | Release effect, Mechanical properties, Paintability | Licolub WE 40 |
| **PP-recyclate**<br>**Filled recylate** | | Flow properties | Licocene PP 6102<br>Licowax OP<br>Licocene PP MA 6452<br>Licocene PP MA 7452 |
| **HDPE** | Tapes | Slip agent | Licowax C<br>Licolub FA 1 pwd. veg. based |
| **PE-recyclate**<br>**Filled recylate** | | Flow properties | Licowax PE 520<br>Licowax OP<br>Licowax C<br>Licolub FA 1 pwd. veg. based |
| **PE-filled** | Extrusion<br>Injection molding | Dispersion, output, Surface quality, Release effect | Licowax OP<br>Licocene PE MA 4351 |

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# Troubleshooting – Correcting Common Wax Issues:

| Problem | Possible Causes | Remediation |
|---|---|---|
| Blacks specks in PE film, or PP extrudate | - excessive die or barrel heat, wax not thermally stable, or other additives not thermally stable and the lube is allowing co-exusion or release from the metal | Use a lube of higher thermal stability; i.e. Licowax OP, PE 520, Licolub WE 40. See Heated Oven results (slides 28,29) for examples. |
| Pigments chunks or flecks in PE film or film masterbatch | - poor dispersion | Improve masterbatch or compound dispersion with Licowax PE 520 or Licocene PE 4201. |
| Agglomerates in PP fiber masterbatch | - poor dispersion | Improve dispersion with Licocene PP 6102. |
| High amp or Torque in highly loaded MB | - melt flow too stiff, colorants not wetted out | Increase melt flow with Licocene PE 520 |
| High Amp or Torque in rubber modified PP | - melt too stiff, metal drag or friction | Increase flow & metal release with Licolub WE 40 |
| Poor adhesion/wetting/compatibility of wood filled olefins - both PP and HDPE | - excessive moisture, or insufficient functionality of olefins to bond to hydroxyl-rich surface of cellulosics | Improve wetting out and coupling to achieve better tensile and flex-mod with Licocenes PP MA6453, PP MA 7452 |
| Black streaks in extrudate or molded part | - additive or wax depositing in the die block or manifolds/runner and charring | Substitiute wax with greater thermal stability; i.e. Licowax PE 520, OP or WE 40. If the problem still persists, check other additives, or colorant dispersion. |
| Mold vents clogging, excessive mold residue, gate "blush" | - insufficient venting, excessive volatilization of wax or additives | Substitute with lower volatility waxes such as montan Licolub WE 40, OP waxes or PE Licowax PE 520 or 190, per chart on slides 25 - 27. |
| HDPE or PP parts sticking in mold | - insufficient metal | Reduce pull force / mold adhesion with a "slip" like Licowax C. If molding UHMWPE, use Licolube WE 40 for better thermal stability at high temp |

# QUESTIONS ?

CLARIANT

# Other Clariant Chemistries for Your Polymers:

Antioxidants (primary): e.g. Hostanox® O, and O 310

Antioxidants (secondary): e.g. Hostanox® P-EPQ

Antistatic Agents: e.g. Hostastat® HS1

Flame Retardants: e.g. Exolit® OP and APP (non-halo)

Llight Stabilizers (HALS): e.g. Hostavin® N30

Light Stabilizers (UV Abs'): e.g. Hostavin® VSU

CLARIANT

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