Clariant Waxes for PVC Processing

GENERAL

Ing. Contreras Plata Enrique
in representation of Clariant Division of Plastics additives

Public
BU Additives
Technical Marketing Waxes
22.07.2016

what is precious to you?
Clariant Waxes for PVC Processing

CONTENT

- PRODUCTS
- APPLICATIONS
- PERFORMANCE
Montan Waxes -
Unique Lubricants for PVC Processing

<table>
<thead>
<tr>
<th>Product</th>
<th>Drop point [°C]</th>
<th>Acid value [mg KOH/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licowax® E</td>
<td>~ 81</td>
<td>~ 18</td>
</tr>
<tr>
<td>Licowax OP</td>
<td>~ 99</td>
<td>~ 12</td>
</tr>
<tr>
<td>Licolub® WE 4</td>
<td>~ 80</td>
<td>~ 26</td>
</tr>
<tr>
<td>Licolub WM 31</td>
<td>~ 74</td>
<td>~ 12</td>
</tr>
<tr>
<td>Licolub WE 40</td>
<td>~ 76</td>
<td>~ 20</td>
</tr>
</tbody>
</table>

~ C<sub>30</sub> COOH = Montanic acid

~ C<sub>18</sub> COOH = Fatty acid

● = CO-function (polar)

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# Polar Lubricants for PVC Processing

<table>
<thead>
<tr>
<th></th>
<th>Drop point [°C]</th>
<th>Viscosity [mPa*s]</th>
<th>Acid value [mg KOH/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Licowax PED 191</strong></td>
<td>~123</td>
<td>~ 1800 (140 °C)</td>
<td>~ 17</td>
</tr>
<tr>
<td><strong>Licolub H 12 / Licowax PED 521</strong></td>
<td>~104</td>
<td>~ 350 (120 °C)</td>
<td>~ 17</td>
</tr>
<tr>
<td><strong>Licowax C / Licolub FA 1 veg. based</strong></td>
<td>~142</td>
<td>-</td>
<td>~ 8</td>
</tr>
</tbody>
</table>

_________ = Alkyl chain

* Softening point
Non-Polar Lubricants for PVC Processing

<table>
<thead>
<tr>
<th></th>
<th>Drop point [°C]</th>
<th>Viscosity [mPa*s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licowax PE 190</td>
<td>~135*</td>
<td>~25.000 (140 °C)</td>
</tr>
<tr>
<td>Licowax PE 520</td>
<td>~120</td>
<td>~ 650 (140 °C)</td>
</tr>
<tr>
<td>Licolub H 4</td>
<td>~111</td>
<td>&lt; 10 (120 °C)</td>
</tr>
<tr>
<td>Licocene® PE 4201</td>
<td>~ 128</td>
<td>~ 60 (140 °C)</td>
</tr>
<tr>
<td>Licocene PP 6102</td>
<td>~ 145</td>
<td>~ 60 (170 °C)</td>
</tr>
</tbody>
</table>

________ = Alkyl chain

* Softening point
Montan Waxes - Unique Lubricants for PVC Processing

**Effects**
- Broad lubricating (internal and external)
- High melt strength
- Low volatility
- High compatibility

**Benefits**
- Flow Promotion
- Release Effect
- Dimensional Stability
- No Condensed Precipitates/no mold deposits
- Surface Properties (smoothness, printability)
- High Transparency
- No plate out
- High Vicat Value /Heat Distortion Temperature
Clariant Waxes for PVC Processing

APPLICATIONS
# Application & Effects of Clariant Waxes in PVC

<table>
<thead>
<tr>
<th>Applications</th>
<th>Effects</th>
<th>Processing</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Shear dependent viscosity control</strong></td>
<td><strong>Antisticking</strong></td>
<td></td>
</tr>
<tr>
<td>1a) PVC Film Rigid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calender</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sn-stab.; Ca/Zn-stab.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extrusion / Calendrette</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sn-stab.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extruded / blown film</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sn-stab.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca/Zn-stab.</td>
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</tr>
<tr>
<td>1b) PVC Film Flexible</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2) Non Food Applications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Injection Molding</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Effects**

- **Shear dependent viscosity control**
- **Antisticking**
- **Slip**
- **Antiblock**
# Effects of Clariant Waxes in PVC Extrusion

<table>
<thead>
<tr>
<th>Applications</th>
<th>Effects</th>
<th>Processing</th>
<th>Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shear dependent viscosity control</td>
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<tr>
<td></td>
<td></td>
<td>Antisticking / Gelation / Machine load</td>
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<tr>
<td></td>
<td></td>
<td>Gloss</td>
<td></td>
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<tr>
<td>4) PVC Profile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca/Zn-stabilized</td>
<td>WE 40</td>
<td>H 12</td>
<td>PE 520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PED 191</td>
<td>PED 602 / PE 4201</td>
</tr>
<tr>
<td>OBS-stabilized</td>
<td>WE 40</td>
<td>H 12</td>
<td>PE 520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PED 191</td>
<td>PED 602 / PE 4201</td>
</tr>
<tr>
<td>5) PVC Pipe</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ca/Zn-stabilized</td>
<td></td>
<td>H 12</td>
<td>PE 520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PED 191</td>
<td>PED 602 / PE 4201</td>
</tr>
<tr>
<td>Organic based</td>
<td></td>
<td>H 12</td>
<td>PE 520</td>
</tr>
<tr>
<td>Stabilizer</td>
<td></td>
<td>PED 191</td>
<td>PED 602 / PE 4201</td>
</tr>
</tbody>
</table>
Clariant Waxes for PVC Processing

PERFORMANCE
Volatility (TGA) of Lubricants for PVC

→ Lowest volatility with montanic esters compared to stearic esters

![Graph showing volatility vs. temperature for various lubricants.](image-url)

- **Weight:** 500 mg
- **Surface:** 3 cm²
- **Heating rate:** 120 K/h
- **Atmosphere:** 1 l air/min,
Influence of Lubricants on Melt Strength

→ Highest melt Strength with montanic esters compared to stearic esters

**Tensile Stress Capacity of a Ca/Zn-Stabilized PVC Melt**

**Basic formulation:**
- S-PVC, k value 60: 100.0 parts
- Ca-12-Hydroxy Stearate: 0.3 phr
- Zn-Stearate: 0.1 phr
- Epoxidized Soyabean Oil: 3.0 phr
- β-Diketone: 0.3 phr
- Lubricant: 0.5 phr

Göttfert® Rheotens
(screw Ø 30 mm; gradient 4:2; die Ø 5 mm
temperature: 140/160/175/190 °C
acceleration 6 cm/s²)
Vicat Softening Point of Different Lubricants

→ *Highest Vicat values with Licowax E*

Formulation:
- Vinnolit S 3160: 100 phr
- Octyl tin stabilizer: 1.5 phr
- Processing Aid (Arcylate): 1 phr
- Test product: 1 phr

Parameters:
- (according to DIN EN ISO 306)
- Initial temp.: 30 °C
- Heating rate: 50 K/h
- Method: B (50 N)

<table>
<thead>
<tr>
<th></th>
<th>without</th>
<th>Glycerol dioleate</th>
<th>Mixture of fatty acid complex esters (Gl 2)</th>
<th>Licowax E</th>
<th>Licolub WM 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vicat</td>
<td>79</td>
<td>78</td>
<td>77</td>
<td>77</td>
<td>76</td>
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<tr>
<td></td>
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</tbody>
</table>
Clariant Waxes for PVC Processing

FILM COMPOUNDS
Release Effect in Sn-Stabilized PVC Film Compound

→ Licolub WM 31 shows excellent external lubrication and anti-sticking

Formulation:
- S-PVC, k value 60: 100 phr
- Sn-Octyl mercaptide: 1.5 phr
- MBS Impact modifier: 5.0 phr
- PMMA Processing aid: 1.0 phr
- GDO: 0.3 phr
- Lubricant: 0.3 phr

Collin Two Roll Mill
220 g, 195 °C, 15/20 rpm
Release Effect in Sn-Stabilized PVC Film Compound

→ Licowax E show excellent anti-sticking

**Formulation:**

- S-PVC, k value 60: 100 phr
- Sn-Octyl mercaptide: 1.5 phr
- MBS Impact modifier: 5.0 phr
- PMMA Processing aid: 1.0 phr
- GDO: 0.3 phr
- Lubricant: 0.3 phr

Collin Two Roll Mill

220 g, 195 °C, 15/20 rpm
Transparency in Sn-Stabilized PVC Film Compound

→ Higher transparency with all montanic acid esters vs. fatty acid esters

Formulation:
- 100,0 parts M-PVC, k value 60
- 8,0 phr MBS Impact modifier
- 1,2 phr PMMA Processing aid
- 1,2 phr Sn-Octyl mercaptide
- 0,5 phr GDO
- 0,3 phr Lubricant

0,5 and 2 mm pressed plates
Release Effect and Gelation in Sn-Stab. PVC Film Compound

→ Better external release effect and fast gelation vs. fatty acid ester mix

**Basic formulation:**
- S-PVC, k value 60
- Sn-Octyl mercaptide
- MBS Impact modifier
- PMMA Processing aid
- GDO
- External lubricant

<table>
<thead>
<tr>
<th>Compound</th>
<th>Time to sticking [min.]</th>
<th>Fusion time [sec.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACE/FAE/Ca-Soap</td>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>Licowax OP</td>
<td>12</td>
<td>120</td>
</tr>
<tr>
<td>FACE/FAE/Ca-Soap</td>
<td>8</td>
<td>60</td>
</tr>
<tr>
<td>Licowax OP</td>
<td>16</td>
<td>90</td>
</tr>
<tr>
<td>FACE/FAE/Ca-Soap</td>
<td>12</td>
<td>120</td>
</tr>
<tr>
<td>Licowax OP</td>
<td>16</td>
<td>150</td>
</tr>
</tbody>
</table>

Two roll mill (190 °C, 16,7/20 rpm)

Haake kneader (40 rpm, 140°C, 63 g)
Release Effect in Ca/Zn-Stabilized PVC Film Compound

→ Better anti-sticking/external lubrication of montanic esters vs. FACE/FAE

Formulation:
- S-PVC, k value 60: 100 phr
- Ca/Zn Stabilizer: 3.0 phr
- MBS Impact modifier: 5.0 phr
- PMMA Processing aid: 1.0 phr
- GDO: 0.3 phr
- Lubricant: 0.3 phr

Collin Two Roll Mill
220 g, 195 °C, 15/20 rpm

Sticking power vs. time [sec.]
Clariant Waxes for PVC Processing
Film Compounds - Summary

– All Montan Waxes provide better anti-sticking performance than fatty acid complex ester mixtures

– Licolub WE 4 performs best

– Transparency is excellent
PVC Pipes - Replacement of FT Paraffins, Ca/Zn-Stabilized

→ Lower pressure and torque vs. FT paraffins...

**Pressure along the barrel**

- 0.3 / 0.05 phr FT80/FT1
- 0.35 phr Licocene PE 4201
- 0.35 phr Licocene PP 6102

**Formulation:**
- S-PVC, k value 68: 100.0
- CaCO3 (90T): 15.0
- Ca/Zn Core stabilizer: 1.18
- Test products: 0.35

**Extrusion Parameters:**
- Single Screw Laboratory Extruder: Collin E 30M, L/D= 25/1;
- Round section Die; Temp.: 170-180-190-195-195 °C
- Die : 195-195 °C; Speed: n= 60 rpm
PVC Pipes - Replacement of FT Paraffins, Ca/Zn-Stabilized

→ ...and lower energy consumption of the extruder with Licocene

**Energy consumption at different screw speeds**

- 0.3 / 0.05 phr C80/H1
- 0.35 phr Licocene PE 4201
- 0.35 phr Licocene PP 6102

**Formulation:**
- S-PVC, k value 68: 100.0 phr
- CaCO3 (90T): 15.0 phr
- Ca/Zn Core stabilizer: 1.18 phr
- Test products: 0.35 phr

**Extrusion Parameters:**
- Single Screw Laboratory Extruder: Collin E 30M, L/D = 25/1
- Round section Die; Temp.: 170-180-190-195-195 °C
- Die: 195-195 °C; Speed: n = 60/80/90 rpm
PVC Pipes - Replacement of Paraffins, Sn-Stabilized

→ Lower pressure with lower dosage of Licocene PP 6102 ...

[Graph showing pressure along the barrel with various components and their dosages listed.]

- 1 phr Hydrocarbon wax
- 1 phr Licocene PP 6102
- 1 phr Licocene PE 4201
- 0.7 phr Licocene PP 6102
- 1 phr Hydrocarbon wax
- 1 phr Licocene PP 6102

Extrusiometer E 30 M
D= 30 mm, 25 L/D
n= 30 rpm,
180-185-190-200-210°C
round-section die: 215°C
PVC Pipes - Replacement of Paraffins, Sn-Stabilized

→ ... and lower energy consumption/higher output

![Energy consumption and Output graph](image)

Extrusiometer E 30 M
D= 30 mm, 25 L/D
n= 30 rpm,
180-185-190-200-210°C
round-section die: 215°C
PVC Profiles [Ca/Zn] – Metallocene vs. Standard PO Waxes

→ Lower pressure and torque with Licocene ...

Pressure along the barrel

PVC Profiles [Ca/Zn] – Metalloocene vs. Standard PO Waxes → ... and lower torque + similar output vs. standard PE wax


Formulation:
- S-PVC k-value 68: 100 phr
- Ca/Zn-Stabilizer compound: 2,4 phr
- Impact modifier: 7 phr
- Processing aid: 1 phr
- TiO₂: 4 phr
- Chalk: 6 phr
- Di stearyl phthalate: 0,5 phr
- Calcium stearate: 0,5 phr
- Oxidized PE-wax: 0,2 phr
- Test product: 0,2 - 0,3 phr

<table>
<thead>
<tr>
<th>Dosage: 0,3 phr</th>
<th>Dosage: 0,2 phr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque [%]</td>
<td>Torque [%]</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>75</td>
<td>75</td>
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<td>70</td>
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<td>25</td>
<td>25</td>
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<tr>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

Output [kg/h]:
- standard PE wax
- Licocene PP 6102
- Licocene PE 4201
- Licocene PP 6102
- Licocene PE 4201

Test product: 0,2 - 0,3 phr
PVC Profiles [Ca/Zn] – Licolub WE 40 Performance

→ ... and lower energy consumption with WE 40!

Formulation:

- S-PVC k-value 68: 100 phr
- Ca/Zn-Stabilizer compound: 2.4 phr
- Impact modifier: 7 phr
- Processing aid: 1 phr
- TiO₂: 4 phr
- Chalk: 5 phr
- Di stearyl phthalate: 0.4 phr
- Oxidized PE-wax: 0.15 phr
- PE Wax: 0.20 phr
- Test product: 0.3 phr

Weber CE 3Z, D= 52 – 24 mm, n= 30 rpm, Temperature: 185-185-185-185°C, flat die: 190 °C (VN99498ff)
PVC Profiles \([\text{Ca/Zn}]\) – Licolub WE 40 Performance

→ Higher output and faster gelation vs. fatty acid complex ester

**Basic formulation:**
- S-PVC, k value 64, impact mod,
- Ca-Stearate: 0.5 phr
- Zn-Stearate: 1.0 phr
- Hydrotalcit: 1.0 phr
- \(\beta\)-Diketone: 0.6 phr
- Di-Trimethylol Propane: 0.5 phr
- Phenolic Antioxidant: 0.1 phr
- 100.0 phr

**Extrusiometer**
- Extrusion temperature: 70-180-190-195°C
- Screw: 5/2, die: 75/5, 60 rpm

**Brabender® Plastogram**
- Extrusion temperature: 35 g, 150°C, 40 rpm
Clariant Waxes for PVC Processing
Profile / Pipes Compounds - Summary

– Pipes:
   Licocene PP 6102 is an excellent FT replacement with room for dosage reduction and plate out minimizing

– Profiles:
   - Licocene PP 6102 performs outstanding compared to standard PE waxes with saving opportunities
   - Licolub WE 40 shows lower energy consumption, fast gelation combined with high Vicat Softening Temperature resp. Heat Distortion Temperature.
Clariant Waxes for PVC Processing

what is precious to you?