DOWSIL™ 8016 Waterborne Resin

Low VOC binder for ultra high temperature resistant coating
OUTLINE

• Background
• Product description & positioning
• Performance & formulation guidelines
• Conclusions
• Questions & answers
Main applications & drivers

Applications

- Wood stoves
- Exhaust pipes
- Industrial pipes

Main drivers

Regulatory aspects

Safety aspects

Sustainability
- Replace VOC with water & retain performance

Safety aspects
- Clear trend

Waterborne silicone resins are suitable products offering the desired performance.
Environment, Sustainability & Regulations

**EU:**
- EU member states may define their own regulations to achieve sustainability goals
- Some countries created penalty systems to control the VOC levels emitted in the air

**China:**
- 2018: introduction of the Environmental Protection Tax
- 2018-2021: three-year action plan to fight air pollution
- 2017: most of the freight container coating market must switch to waterborne coatings
- Local initiative: the Guangdong province has banned the use of solventborne coatings in the city of Shunde.
What proportion of industrial coatings used in the world are waterborne in terms of revenues?

1. About 8%
2. About 17%
3. About 35%
### Relevant Benchmarks Contain Solvents

#### Benchmark A

<table>
<thead>
<tr>
<th>Technical Information</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery form</td>
<td>Emulsion</td>
</tr>
<tr>
<td>Appearance</td>
<td>White, turbid liquid</td>
</tr>
<tr>
<td>Non-volatile content</td>
<td>Approx. 50%</td>
</tr>
<tr>
<td>Solvent</td>
<td>Isobutanol/Xylene 1:3</td>
</tr>
<tr>
<td>Ionic charge</td>
<td>Non-ionic</td>
</tr>
<tr>
<td>Efflux time DIN 6 mm/23 °C</td>
<td>Approx. 38 s</td>
</tr>
<tr>
<td>pH value (as supplied)</td>
<td>Approx. 6</td>
</tr>
<tr>
<td>Water content (%)</td>
<td>Approx. 38%</td>
</tr>
</tbody>
</table>

#### Benchmark B

- **Typical general characteristics**
  - **Appearance**: White milky emulsion
  - **Solvent content (xylene)**: <8.0%
  - **Solids content**: 50 ± 2%
  - **Viscosity, dynamic at 25 °C**: 100 – 200 mPa.s
  - **Density at 25 °C**: 1.08 g/cm³
  - **Emulsifier**: Nonionic
  - **Flash point**: 45 °C
  - **Ignition temperature (liquids)**: 450 °C

#### Benchmark C

- **Typical general characteristics**
  - **Appearance**: White, turbid liquid
  - **Non-volatile content**: Approx. 50%
  - **Solvent**: Isobutanol/Xylene 1:3
  - **Ionic charge**: Non-ionic
  - **Efflux time DIN 6 mm/23 °C**: Approx. 38 s
  - **pH value (as supplied)**: Approx. 6
  - **Water content (%)**: Approx. 38%

#### Product Data

<table>
<thead>
<tr>
<th>Typical general characteristics</th>
<th>Inspection method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>White milky emulsion</td>
<td></td>
</tr>
<tr>
<td>Solids content</td>
<td>52-63%</td>
<td></td>
</tr>
<tr>
<td>Viscosity, dynamic at 25 °C</td>
<td>Brookfield</td>
<td>20-300 mPa.s</td>
</tr>
<tr>
<td>Density, dynamic at 25 °C</td>
<td>DIN 51757</td>
<td>1,105 g/cm³</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>Nonionic</td>
<td></td>
</tr>
<tr>
<td>Flash point</td>
<td>ISO 3679</td>
<td>60 °C</td>
</tr>
<tr>
<td>Ignition temperature (liquids)</td>
<td>DIN 51794</td>
<td>458 °C</td>
</tr>
<tr>
<td>pH – Value at 20 °C</td>
<td>Indicator strips</td>
<td>4-9</td>
</tr>
</tbody>
</table>
Which top challenge are you facing with the high temperature coatings which you are currently developing / selling / handling / applying?

1. EHS concerns restricting product handling easiness in production (smell, flammability…)
2. Existing or upcoming legislation (associated with VOCs, EU Green Deal …)
3. Performance – in regard of temperature of use resistance
4. Other
Novel low VOC silicone resin emulsion for high temperature resistant coatings

Main features:
- Low VOC (<1% VOC), low cyclics (<0.1%), non-flammable
- Enabling solvent free paint formulations without sacrificing film aesthetics & performance
- Heat cure with potential for air drying in presence of a (Tin free) condensation catalyst
- High temperature resistance up to 500-600°C
- Can be applied directly on metal (CRS)
- Performance can be modulated with paint formulation
- Hydrophobic
- Compatibility with organics (acrylates)

“First ever truly waterborne silicone resin emulsion providing this performance”
Once formulated, our customers appreciated:

• The fully waterborne nature of the product
• The high temperature resistance up to 500°C
• The good corrosion resistance (after 1 day – wood stove application)
• The curing conditions of at least 180°C up to 220°C (1 h)
• The defect free film aspect generated by the binder
• The high compatibility with organic binders such as acrylates
• The product stability
DOWSIL™ 8016 WATERBORNE RESIN – PHYSICAL PROPERTIES

- Appearance: white liquid
- Actives content: 60 ± 2%
- pH: 9-10
- Particle size Malvern – Dv50<1.0 µm
- Conditions of handling: avoid freezing, gently shake before use
- Conditions of storage: 5-40°C
- Shelf life: 365 days
- Viscosity at 25°C: 18 cP (spindle 1 at 20 rpm - viscosimeter LVDVI+ - torque 40%)
WE MAKE COATINGS WORK BETTER – DOW WILL PROVIDE

Raw materials  Performance  Formulation Expertise*  Problem solving  Customer support

*: The performance of DOWSIL™ 8016 Waterborne Resin can vary with the paint formulation.
# DOW MODEL PAINT FOR OVEN CURE APPLICATION

<table>
<thead>
<tr>
<th>Dow model paint</th>
<th>Amount (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black pigment dispersion</td>
<td>40-60</td>
</tr>
<tr>
<td>Filler</td>
<td>4-8</td>
</tr>
<tr>
<td>Defoamer</td>
<td>1-2</td>
</tr>
<tr>
<td>Rheology modifier</td>
<td>0.5-1.5</td>
</tr>
<tr>
<td>Binder</td>
<td>27-45</td>
</tr>
<tr>
<td>Wetting agent</td>
<td>1-2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### Suggested curing conditions:
- ~200°C for 60 min

### Film thickness:
- Wet: ~150 µm - 6 mils
- DFT: ~25 µm - 1 mil (measured)

### Substrate:
- Cold Rolled Steel

### Application:
- Draw down (lab)

Formulation guidelines available upon request
**Performance Profile in Dow Model Paint**

<table>
<thead>
<tr>
<th>Film visual appearance</th>
<th>Curing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pendulum hardness Persoz (oscillations)</td>
<td>200°C / 1 h</td>
</tr>
<tr>
<td>% adhesion loss (before exposure to heat)</td>
<td>Good</td>
</tr>
<tr>
<td>% adhesion loss (after exposure to heat)</td>
<td>0%</td>
</tr>
<tr>
<td>HT resistance – cohesion failure level</td>
<td>0%</td>
</tr>
<tr>
<td>HT resistance - discoloration (ΔE)</td>
<td>Slight material loss</td>
</tr>
<tr>
<td>HT resistance – chalking resistance</td>
<td>Slight chalking</td>
</tr>
</tbody>
</table>
HIGH TEMPERATURE RESISTANCE IN DOW MODEL PAINT

After curing before exposure to heat

No visual defects after curing at 200°C (1 h)

ΔE<5

After exposure to heat (500°C, 2 h, hot plate)

No chalking upon rubbing of the coating surface
Samples were cured at 200°C for 1 h then exposed to high temperature (500°C, 2 h, on hot plate).
Curing recommendation = 200°C (1 h) or above to ensure maximum coating hardness
## Impact of Curing Conditions in Dow Model Paint (2)

### Condensation Test (40°C, 100% RH)

<table>
<thead>
<tr>
<th>Temperature</th>
<th>T0 + 24 h</th>
<th>T0 + 250 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>70°C*</td>
<td>![Image 1]</td>
<td>![Image 2]</td>
</tr>
<tr>
<td>120°C*</td>
<td>![Image 3]</td>
<td>![Image 4]</td>
</tr>
<tr>
<td>140°C*</td>
<td>![Image 5]</td>
<td>![Image 6]</td>
</tr>
<tr>
<td>160°C*</td>
<td>![Image 7]</td>
<td>![Image 8]</td>
</tr>
<tr>
<td>180°C*</td>
<td>![Image 9]</td>
<td>![Image 10]</td>
</tr>
<tr>
<td>200°C*</td>
<td>![Image 11]</td>
<td>![Image 12]</td>
</tr>
</tbody>
</table>

*: curing time = 1 h

Curing recommendation = 180-200°C (1 h) to ensure sufficient resistance to water
### Impact of Binder Content in Dow Model Paint (1)

<table>
<thead>
<tr>
<th>% Binder in Dry Coating</th>
<th>45.2%</th>
<th>35.7%</th>
<th>26.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT Resistance - Discoloration ($\Delta E$)</td>
<td>3.3</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>HT Resistance - Adhesion</td>
<td>Good</td>
<td>V. good</td>
<td>V. good</td>
</tr>
<tr>
<td>HT Resistance - Chalking</td>
<td>No Chalking</td>
<td>No Chalking</td>
<td>Severe Chalking</td>
</tr>
<tr>
<td>HT Resistance - Film Cohesion</td>
<td>Severe Cohesive Failure</td>
<td>Low Cohesive Failure</td>
<td>Very Low Cohesive Failure</td>
</tr>
</tbody>
</table>

Samples were cured at 200°C for 1 h then exposed to high temperature (500°C, 2 h, on hot plate).
A suitable binder content is needed to ensure appropriate film cohesion.

Samples were cured at 200°C for 1 h then exposed to high temperature (500°C, 2 h, on hot plate).
**IMPACT OF BINDER CONTENT IN DOW MODEL PAINT (3)**

<table>
<thead>
<tr>
<th></th>
<th>T0 + 24 h</th>
<th>T0 + 250 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/o corrosion inhibitor</td>
<td>45.2%*</td>
<td>45.2%*</td>
</tr>
<tr>
<td>35.7%*</td>
<td>35.7%*</td>
<td></td>
</tr>
<tr>
<td>26.4%*</td>
<td>26.4%*</td>
<td></td>
</tr>
</tbody>
</table>

Condensation test (40°C, 100% RH)

A higher binder content leads to improved resistance to water
Samples were cured at 200°C for 1 h then exposed to high temperature (500°C, 2 h, on hot plate).

A proper “pigment to filler” ratio is needed to achieve low film discoloration upon exposure to heat + sufficient adhesion on metal after exposure to heat.
The optimization of the rheology profile can improve the paint shelf life and the film aesthetics upon curing in oven.
## DOWSIL™ 8016 Waterborne Resin vs Benchmarks

<table>
<thead>
<tr>
<th>DOWSIL™ 8016 WB Resin</th>
<th>Benchmark 1</th>
<th>Benchmark 2</th>
<th>Benchmark 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>% loss of adhesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chalking resistance</td>
<td>No chalking</td>
<td>Chalking</td>
<td>Slight chalking</td>
</tr>
<tr>
<td>Hardness (Persoz)</td>
<td>113</td>
<td>108</td>
<td>84</td>
</tr>
</tbody>
</table>

Samples were cured at 200°C for 1 h then exposed to high temperature (500°C, 2 h, on hot plate).
DOWSIL™ 8016 waterborne resin – conclusions

DOW is launching a novel silicone resin emulsion for high temperature coatings which:

• Eliminates EHS concerns related to the use of existing solventborne products
• Reduces tax & costs associated with VOC emission and handling
• Delivers comparable performance to market standards
• Can provide tailored performance thanks to its compatibility with acrylic emulsions

DOW wants to position itself as:

• Preferred partner for the development of innovative and sustainable solutions
• Expert in coating formulation & technical support

Literature and samples available upon request. Please contact our Technical Customer Service:
the web ‘Contact Us’ form

Please visit us on www.dow.com/coatings to discover new product launches & events!
WE MAKE COATINGS WORK BETTER – TWO NEW PRODUCT LAUNCHES!

DOWSIL™ 8016 Waterborne Resin

Novel low VOC silicone resin emulsion for high temperature resistant waterborne coatings

DOWSIL™ 107F Additive

New generation foam control agent with improved compatibility & optimal performance for waterborne coatings
Thank you & stay safe
Q & A session
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