New Waterborne Technologies for the Formulation of Problem-Solving Masonry Coatings
OMNOVA Solutions at a glance

Facilities in 7 Countries

2014 Sales $1B
NYSE: OMN

2,300 Employees

Performance Chemicals

76%

Value-added Emulsion Polymers & Specialty Chemicals

Engineered Surfaces

24%

A Focused Polymer Company With Market Leadership Positions

Functional & Decorative Surfaces
Performance Chemicals Division

- Nonwovens & textiles
- Antioxidants
- Oil and Gas drilling
- Specialty rubbers
- Tire cord latex
- Construction
- Tape and adhesives
- Floor polish
- Personal Care

- Coating Resins

Specialty Chemicals 66%

Paper & Carpet Chemicals 34%

- Paper Chemicals
- Carpet Chemicals
Weaknesses of Waterborne Façade Offer

- Adhesion on Chalky Substrate
- Alkali/Efflorescence Resistance
- Resistance to ‘Snail Marks’
OMNOVA’s Problem Solving Technologies

- Adhesion on Chalky Substrate
  - Hydro PLIOLITE® 010

- Alkali/Efflorescence Resistance
  - PLIOTEC® SA 40

- Resistance to ‘Snail Marks’
  - PLIOTEC® LEB 18
Exterior Masonry Coatings based on Hydro PLIOLITE® 010
Solvent based E.M.C. based on PLIOLITE® resins: 60 years of experience!

- « All Weather applications »
- Excellent ageing behavior
- Efflorescence and Alkali resistance
- Freeze/Thaw stable
- Excellent penetrative adhesion (consolidating effect)
- In line with Decopaint 2004/42/EC (Cat. A/c, VOC < 430 g/L)

Water borne Masonry Paints:

- Acrylic
- Siloxane (organo-mineral)
- Acrylic-siloxane

- Low penetration into the substrate
- Film formation is a critical step
Hydro PLIOLITE®

- Hydro PLIOLITE® 010 is a formulated binder designed for waterbased exterior masonry paints
  - Modified acrylic (good balance between weathering and chemical resistance)
  - Glass transition temperature Tg=25°C (low dirt pick-up on natural weathering)
  - Polymers in solution in an aliphatic hydrocarbon solvent

- The solvent content is adjusted to allow good interpenetration of the particles after coalescence
Particle size of the emulsion is twice as large as standard dispersions

The solvent is located into the particles
- The emulsion is odorless
- All the solvent is available for coalescence

The macromolecules are in solution inside the emulsion particle
- Polymer chains are mobile
It is not particle size that drives adhesion but the ability of the particles to deform and to fuse together after the coalescence.

After coalescence the film formation is achieved by simple solvent evaporation, and binder penetration can occur easily by capillarity into the pores of the substrate.
Superior Adhesion on Porous Substrates

- Acrylic paint does not penetrate into the substrate and is easily removed by the adhesive tape

- Hydro PLIOLITE® penetrates deeply into the substrate
Ageing Behavior / Color Retention

• Benchmarking studies frequently carried out with Trade and DIY commercial paints, versus acrylic, acrylic/silicone or silicone paints

• Outdoor exposure ➔ Excellent ageing behavior of Hydro PLIOLITE®:
  - low yellowing, low chalking
  - very good color retention, very good dirt pick up resistance

• Example of panels after 3 years @ 45°
• Hydro PLIOLITE® 010 is a unique emulsion, specifically designed for exterior applications with:
  – Excellent penetrative adhesion, even on chalky substrate (self priming paint, requiring minimal substrate preparation)
  – Very good color retention
  – Excellent resistance to wind-driven rain
  – Excellent microporosity
  – Very good open-time, matt aspect, perfect finish

• We celebrated in 2013 the 10th anniversary of Hydro PLIOLITE®: the resin is a proven technology.

• Thin-film masonry paints based on Hydro PLIOLITE® are recognized by manufacturers, specifiers and painters as universal and safe solutions for new and renovation paint jobs.
Alkali & Efflorescence Resistant Pigmented Primers based on PLIOTEC® SA 40
Concrete is widely used for both residential and commercial construction.

Fresh concrete is highly aggressive by nature → it is often advisable to wait for a min. of 28 days prior to painting.

In practice, time pressures for completion of contracts often means very little time for concrete to achieve full cure.

In many regions, PLIOLITE® based solvent-borne primers are still considered to be the products of choice, but the demand for waterborne alternatives is growing.

Our in-house benchmarking study demonstrated that very few water-borne products achieve a satisfactory resistance to both alkali and efflorescence.

OMNOVA has developed PLIOTEC® SA40 in order to meet the demanding requirements of such applications on green concrete.
**PLIOTEC® SA40**

### Key advantages
- APEO-free carboxylated styrene acrylic dispersion
- Excellent alkali & efflorescence resistance
- Excellent adhesion to concrete
- Good water resistance
- Excellent pigment binding capability
- Odorless

<table>
<thead>
<tr>
<th>Typical properties PLIOTEC® SA40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids (%)</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td>MFFT (°C)</td>
</tr>
<tr>
<td>Tg (°C)</td>
</tr>
<tr>
<td>Particle size</td>
</tr>
</tbody>
</table>

### Formulation Guidelines
- **PLIOTEC® SA40** requires no particular precautions, except to avoid raw materials with possible negative influence on water sensitivity.
- In order to provide the best barrier effect, solid content and paint viscosity would have to be adjusted to ensure a relevant film thickness (min. 60 µm DFT).
- The masonry primer should be formulated below CPVC. OMNOVA extensive formulation work has demonstrated that a PVC in the range of 30-40% provides the optimum performance on fresh concrete.
## Starting Formulation WB ARP 02

<table>
<thead>
<tr>
<th>WB ARP 02</th>
<th>% w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>3.60</td>
</tr>
<tr>
<td><strong>Pliotec® SA40</strong></td>
<td><strong>20.80</strong></td>
</tr>
<tr>
<td>Dispersing Agent</td>
<td>0.40</td>
</tr>
<tr>
<td>Amine</td>
<td>0.20</td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>0.10</td>
</tr>
<tr>
<td>Titanium Dioxide</td>
<td>7.40</td>
</tr>
<tr>
<td>Calcium Carbonate 5µm</td>
<td>13.60</td>
</tr>
<tr>
<td>Calcium Carbonate 10µm</td>
<td>15.20</td>
</tr>
<tr>
<td>Talc</td>
<td>7.00</td>
</tr>
<tr>
<td><strong>Pliotec® SA40</strong></td>
<td><strong>26.50</strong></td>
</tr>
<tr>
<td>Coalescing Aids 1</td>
<td>0.80</td>
</tr>
<tr>
<td>Coalescing Aids 2</td>
<td>0.80</td>
</tr>
<tr>
<td>Plasticizer</td>
<td>2.90</td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>0.10</td>
</tr>
<tr>
<td>Associative Thickener (high shear)</td>
<td>0.20</td>
</tr>
<tr>
<td>Associative Thickener (low shear)</td>
<td>0.40</td>
</tr>
</tbody>
</table>

### Characteristics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>1.41</td>
</tr>
<tr>
<td>PVC</td>
<td>39.6 %</td>
</tr>
<tr>
<td>PVC / CPVC</td>
<td>0.65</td>
</tr>
<tr>
<td>Volume solids</td>
<td>53.4 %</td>
</tr>
<tr>
<td>Weight Solids</td>
<td>66.1 %</td>
</tr>
<tr>
<td>VOC content</td>
<td>25 g/L</td>
</tr>
<tr>
<td>ICI Viscosity</td>
<td>0.21 Pa.s</td>
</tr>
<tr>
<td>MFFT</td>
<td>- 2°C</td>
</tr>
<tr>
<td>Spreading rate</td>
<td>160 g / m²</td>
</tr>
</tbody>
</table>
Alkali Resistance on Fresh Concrete

• **Scope**
  The ability of a primer to resist high alkalinity of fresh cement mortar can be checked in the laboratory by using a simple visual test.

• **Test Method**
  - Concrete blocks are prepared from standard mortar mix in moulds, and demoulded after only 1 day of curing under standard conditions.
  - Primers under test are applied directly by brush to the upper face and sides of the blocks. Coverage is controlled by weighing (according to recommended spreads rate).
  - After 24hr drying, a WB styrene-acrylate topcoat, tinted with an alkali sensitive pigment (C.I. Pigment Red 104), is applied and left to dry for 24h.
  - Then blocks are placed (painted sides upwards) on wet sand.
  - Colour changes are observed up to a maximum of 28 days.

(Detailed test method WI-0342 available upon request)
Alkali Resistance on Fresh Concrete

• Results after 3 weeks:

PLIOTEC® SA 40 based primer

Same formulation with a competitive binder

No discoloration of the pink topcoat ➔ Effective barrier to Akali with Primer based on PLIOTEC® SA40
Efflorescence Resistance

• **Scope**

  Efflorescence (formation of unsightly salt deposits on the surface of the applied coating) is a common problem since many masonry substrates contain soluble salts either from the materials used in their construction, or from high salt content in the groundwater which can easily migrate up the wall.

• **Test Method**

  - The method consists of applying the coating (in 2 coats / 24h between coats) to porous clay bricks, leaving a few centimeters at the bottom of the brick uncoated.
  
  - After 24h of drying, the bricks are placed in a saturated salt solution for several weeks, adding water or salt to the solution from time to time to ensure that the level remains constant.
  
  - Changes in film appearance (blisters, salt deposits, cracking, etc.) are observed up to a 4 weeks.
Efflorescence Resistance

• Results after 4 weeks:

PLIOTEC® SA 40 based primer

Same formulation with a competitive binder

No salt deposits along the porous clay brick ➔ Effective barrier to Efflorescence with Primer based on PLIOTEC® SA40
Conclusion

- **PLIOTEC® SA40** is a unique copolymer resin, suitable for interior/exterior applications with:
  - Excellent efflorescence and alkali resistance
  - Excellent adhesion to concrete
  - Low VOC content / low odor

- **PLIOTEC® SA40** shows a good all-round performance and, in particular, a significant improvement over binders used in typical **water-borne masonry primers** present in the market today.
Exterior Masonry Coatings based on PLIOTEC® LEB18
**Surfactants in Coatings**

- **Role of surfactants**
  - Surface tension reduction of a liquid
  - Reduction of interfacial tension between two liquids or a solid and a liquid

- **Sources of surfactant in coatings**
  - Latex or polymer dispersion
    - Surfactant used to emulsify monomer micelles in the first step of emulsion polymerization process
    - Then they act as:
      - Colloidal stabilization of polymer particle as they are formed
      - Surface tension reduction of the latex helping in substrate wetting
  - **Wetting and dispersing additives used in:**
    - Pigmented coatings for dispersion and suspension of pigments and extenders
    - Pre-dispersed colorants, the preferred choice today for tinting of decorative paints

- **Negative effect**

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**Surfactants**

- Water sensitivity
- Mobility
- Tendency to congregate

**Hydrophilic zone**

**Water absorption and transport through the film**
Problem of Exudation

- Known as “Surfactant Leaching”, “Surfactant Staining” or “snail trails”
- Liable to occur on any water-borne exterior paint
- Migration of water soluble components within the coating to the surface
  - Normal process promoted by atmospheric conditions
  - Over a period of many weeks or months after the application
- But under certain atmospheric conditions (often in spring and in autumn) exudation process can be accelerated

Exudation caused by dew formation / condensation

Formation of condensation on freshly painted exterior facade due to temperature falling below dew point.

Moisture causes surfactants to migrate to surface.

When condensation subsequently dries, surfactants are deposited on the surface of the paint, causing staining or discoloration.
Resistance to Exudation and Efflorescence

• Dried film of standard latex
  – Residual surfactants from the polymerization process concentrated at areas where particle interfaces existed before coalescence
  – Very easy route by which water can permeate the film

• “Surfactant free” dispersions are based on use of polymerizable surfactant
  – Reactive group on the hydrophobic part that can participate in free-radical emulsion polymerization
  – Covalently bonded to the particle surface
  – Water repellency and water resistance of the coating are improved
  – Effective use and incorporation of polymerizable surfactants is not easy

Low Exudation Binder (LEB) Technology

- Latex stabilized with anionic groups bonded to the polymer
- Multi-step process designed to favour the distribution of the functional monomers at surface of particles
- Reduced « free » surfactant content
Durability & Crack-Bridging Resistance

• Polymer is key component influencing durability and mechanical properties

• Phenomena influencing discoloration of exterior masonry coatings
  ⇒ Yellowing / Chalking / Dirt pick-up

• Polymer Tg
  – Main parameter influencing dirt pick-up
    ➥ High Tg ⇒ High dirt pick-up resistance
  – Crack-bridging property at ambient temperature
    ➥ Tg must be below 15°C

PLIOTEC LEB 18

- Monomeric composition adjusted so as to achieve good balance between yellowing and chalking resistance in 35% to 60% PVC range
- Tg = 12°C to combine dirt pick-up resistance and crack-bridging ability
- Polymer structure providing built-in flexibility
• Characteristics
  – Modified acrylate copolymer
  – APE free
  – No added formaldehyde

• Typical Properties
  – Particle size = 120 nm
  – Tg = 12°C
  – MFFT = -1°C
  – Viscosity (60rpm / 25°C) = 400 cPo.
  – Solid Content = 42.5%
  – pH = 9
  – VOC = 20 g/L
  – Film formation: coalescence and solvent evaporation
Comparison of an LEB latex with commercial lattices
Focus on resistance to exudation
Tested in a typical formulation for high build masonry coatings
  - Pigment Volume Concentration: 40%
  - Solid Content: 54%
Most important parameters for exudation resistance
  - Quantity and type of surfactant
  - Tg of the latex
Characteristics of lattices evaluated:

<table>
<thead>
<tr>
<th>Reference of Latex</th>
<th>Chemical Nature</th>
<th>Solid Content (%)</th>
<th>Particle Size (nm)</th>
<th>pH</th>
<th>Glass Transition Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New LEB</td>
<td>Modified Styrene Acrylic</td>
<td>42,5%</td>
<td>120</td>
<td>9,0</td>
<td>12</td>
</tr>
<tr>
<td>StyAc 1</td>
<td>Styrene Acrylic</td>
<td>49,1%</td>
<td>134</td>
<td>7,0</td>
<td>16</td>
</tr>
<tr>
<td>StyAc 2</td>
<td>Styrene Acrylic</td>
<td>49,0%</td>
<td>148</td>
<td>7,9</td>
<td>20</td>
</tr>
<tr>
<td>StyAc 3</td>
<td>Styrene Acrylic</td>
<td>49,4%</td>
<td>145</td>
<td>7,8</td>
<td>22</td>
</tr>
<tr>
<td>Ac</td>
<td>Acrylic</td>
<td>48,2%</td>
<td>118</td>
<td>8,5</td>
<td>25</td>
</tr>
</tbody>
</table>
• International standards recently issued (ISO and ASTM)
  – Not reliable for exterior masonry coatings subjected to wind-driven rain because they involve immersion in water
  – Need for in-house method suitable for façade paints to predict the behaviour in terms of release of water soluble components in the early steps of drying in adverse climatic conditions

**Test Method**

- Application of the paint by brush to the exterior of plastic cans (375g/m²)
- After 16 hours of drying, cans are filled with water and ice (4°C)
- Cans are placed in a climatic chamber at 25°C and 90% relative humidity for a period of 90 min.
- Leachate collected in a cup positioned below the can
- Degree of leaching is measured weighing the exudates after evaporation during 4.5 hours at 60°C
Evaluation of Latex Performance / Exudation

- Exudation resistance of high build coatings formulated with different types of latex
  - Higher tendency to exudation when Tg is lower
  - LEB latex exhibits the best resistance to exudation despite lowest Tg
**Influence of binder Tg decrease on exudation**

- The required binder Tg is sometimes achieved by formulators using a blend of 2 lattices (Tg 20°C and Tg -25°C for example)
- In this 2nd series, this type of blends have been tested
- At similar Tg level, LEB allows to reduce the quantity of exudable water-soluble components by at least 50% compared to conventional technologies
Main Applications

PLIOTE⁵ LEB 18 is suitable for a wide variety of end uses:

- Flat exterior masonry coatings (thin film)
- High build exterior masonry coatings (semi-thick, semi-flexible)
- Top coats for renovation of old elastomeric coatings
- Top coats for ETICS (Exterior Thermal Insulation Coating Systems)
- House plinths (base of exterior walls)

In this last part, focus is made on High Build Coatings, being by nature more prone to surfactant leaching problem
High Build Exterior Masonry Coatings

- Decorative and waterproofing renovation of façade
- Old and cracked or micro-fissured façade
- High technical characteristics:
  - Excellent build
  - Suitable flexibility
  - Great versatility in use
  - Associated to a primer on new masonry and direct application over old coatings in good conditions

- In addition to normal requirement of thin film exterior masonry coatings (adhesion, durability, water resistance, breathability)
  - Application at high thickness without mud-cracking (spreading rate ~ 400g/m²/coat)
  - Crack-bridging ability
    - According to EN1062-1: E4 : film thickness between 200µm and 400µm
      - A1 : crack-bridging ability > 100µm at 23°C

- High Build formulations are more prone to exudation problems

35% < PVC < 50% (55 to 35% of latex)
+ Application at High Thickness

High « free surfactant » content
## Starting Formulation: FPS 306

### Raw Material

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLIOTEC LEB 18</strong></td>
<td>41.00</td>
</tr>
<tr>
<td>Water</td>
<td>5.70</td>
</tr>
<tr>
<td>Hydroxyethylcellulose Thickener</td>
<td>0.10</td>
</tr>
<tr>
<td>Amine</td>
<td>0.25</td>
</tr>
<tr>
<td>Dispersing Agent</td>
<td>0.40</td>
</tr>
<tr>
<td>Anti-foam Agent</td>
<td>0.60</td>
</tr>
<tr>
<td>Titanium Dioxide</td>
<td>12.70</td>
</tr>
<tr>
<td>Calcium Carbonate 5µm</td>
<td>13.60</td>
</tr>
<tr>
<td>Calcium Carbonate 25µm</td>
<td>18.20</td>
</tr>
<tr>
<td>Talc</td>
<td>6.20</td>
</tr>
<tr>
<td>Associative Thickener (Low Shear)</td>
<td>0.20</td>
</tr>
<tr>
<td>Associative Thickener (High Shear)</td>
<td>0.50</td>
</tr>
<tr>
<td>Algicide/Fungicide</td>
<td>0.55</td>
</tr>
</tbody>
</table>

### Formulation Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PVC (%)</td>
<td>50.4%</td>
</tr>
<tr>
<td>PVC/CPVC</td>
<td>0.80</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.52</td>
</tr>
<tr>
<td>Volume Solids</td>
<td>54.8%</td>
</tr>
<tr>
<td>Weight Solids</td>
<td>69.1%</td>
</tr>
</tbody>
</table>

### Paint Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.5</td>
</tr>
<tr>
<td>MFFT</td>
<td>0°C</td>
</tr>
<tr>
<td>VOC</td>
<td>14 g/L</td>
</tr>
<tr>
<td>Gloss 85°</td>
<td>1.0%</td>
</tr>
<tr>
<td>W</td>
<td>0.01 kg/m².h⁰.⁵</td>
</tr>
<tr>
<td>Sd</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Crack B.</td>
<td>A1 (ISO1062-7)</td>
</tr>
</tbody>
</table>

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**Note:** The values in the tables are illustrative and may not correspond to actual formulations.
**Evaluation of Commercial High Build Coatings**

- Representative products from European market have been benchmarked and extensively tested vs. our starting formulation FPS306.

<table>
<thead>
<tr>
<th>Reference of Coatings</th>
<th>EN1062-1 Classification</th>
<th>Chemical Nature</th>
<th>Specific Gravity</th>
<th>Volume Solid (%)</th>
<th>VOC (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>E4V2W3A1</td>
<td>StyAc</td>
<td>1.45</td>
<td>55</td>
<td>&lt;40</td>
</tr>
<tr>
<td>#2</td>
<td>E4V2W3A1</td>
<td>StyAc Siloxane Modified</td>
<td>1.25</td>
<td>54</td>
<td>&lt;40</td>
</tr>
<tr>
<td>#3</td>
<td>E4V2W3A1</td>
<td>StyAc Siloxane Modified</td>
<td>1.40</td>
<td>54</td>
<td>&lt;40</td>
</tr>
<tr>
<td>#4</td>
<td>E4V2W3A1</td>
<td>StyAc</td>
<td>1.50</td>
<td>53</td>
<td>&lt;10</td>
</tr>
<tr>
<td>#5</td>
<td>E4V2W3A1</td>
<td>Acrylic</td>
<td>1.25</td>
<td>55</td>
<td>&lt;10</td>
</tr>
<tr>
<td>#6</td>
<td>E4V2W3A2</td>
<td>StyAc Siloxane Modified</td>
<td>1.50</td>
<td>60</td>
<td>&lt;20</td>
</tr>
<tr>
<td>#7</td>
<td>E4V2W3A2</td>
<td>Acrylic Siloxane Modified</td>
<td>1.45</td>
<td>55</td>
<td>&lt;20</td>
</tr>
<tr>
<td>FPS306</td>
<td>E4V2W3A1</td>
<td>Modified Acrylate</td>
<td>1.52</td>
<td>55</td>
<td>14</td>
</tr>
</tbody>
</table>

- Narrow formulation latitude if compliance with European standard is required: at least E4A1

 состояние = печать

- All the products are classified in the same categories for liquid water absorption (W3 best class) and MVTR (V2 medium class).
Evaluation of Coatings / Resistance to Exudation

- LEB technology allows to suppress 50% of exudation compared to the very best commercial products.
- Compared to average performance available on the market the improvement can be even better.
**Evaluation of Coatings / Resistance to Efflorescence**

- **FPS306** is able to withstand these extreme test conditions, thanks to 2 important properties of PLIOTEC LEB 18
  - Very high adhesion on porous mineral substrates
  - Very good resistance to salt and water migration
Evaluation of Coatings / Shower Resistance

**Test Method**
- Application of acrylic textured coating on fiber cement, then 1 week of drying at room temperature
- Application of the coating to be tested at 375g/m², and 20 min of drying at room temperature
- Shower test during 2 min.

**Results after 2 min of test (20 min of drying)**

- Paint #7: NO OK
- FPS306: OK
Conclusion

• Exterior masonry coatings can contain high quantities of free surfactants. This has led to significant issues for paint manufacturers in terms of surfactant leaching or staining of freshly applied façade coatings under certain atmospheric conditions.

• Anticipating the demand for new technology, OMNOVA Solutions has developed an innovative binder with very low free surfactant content, and polymer particle composition allowing high quality of film formation and adhesion.

• Main benefits of this LEB technology are the unmet resistance to surfactant exudation and the very high resistance to efflorescence.

• Built-in flexibility and UV resistance are additional properties of PLIOTEC LEB 18, that makes it a preferred choice for a wide variety of thin and/or thick film exterior masonry coatings.