IMPROVING THE WATER RESISTANCE OF GYPSUM DRYMIX APPLICATIONS

Dr. Daniel Schildbach
Wacker Chemie AG
IMPROVING THE WATER RESISTANCE OF GYPSUM DRYMIX APPLICATIONS

Dr. Daniel Schildbach, Global Gypsum Conference, Istanbul, October 17, 2012
IMPROVING THE WATER RESISTANCE OF GYPSUM DRYMIX APPLICATIONS

• INTRODUCTION – A NEW CONCEPT
• WATER ABSORPTION: EXISTING MARKET PRODUCTS
• WACKER‘S NEW DEVELOPMENT
• CONCLUSIONS
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Low carbon footprint: **Gypsum** is the construction material for a sustainable future.

But to really compete with cementitious systems, its water resistance must be improved.

Discover and extend the possibilities of gypsum construction materials.
REPRISE – WHAT ARE DRYMIX FORMULATIONS AND WHERE ARE THEY USED TODAY?

Main gypsum-based drymix products:

- plasters
- joint fillers
- adhesives
- flooring screeds
- modelling compounds
WHY EQUIP THESE APPLICATIONS WITH WATER REPELLENCY?

- Multi-purpose application of *indoor plasters* including all moist areas like bathrooms, kitchens, basements, garages, mudrooms or breezeways

- **Joint fillers** and **finishes** for moisture-resistant wallboards in all humid areas

- More durable **adhesives, screeds** and all kinds of **gypsum-based dry mortars** for potentially moist areas or after flooding

- Balancing of uneven or strong water absorption levels for optimal **decorative top coats**

- Outdoor applications (in selected regions)
FOR MOST GYPSUM APPLICATIONS, VERY EFFICIENT LIQUID SILICONE WATER REPELLANTS ARE AVAILABLE, ...

<table>
<thead>
<tr>
<th>Application</th>
<th>Wallboards</th>
<th>Blocks</th>
<th>Fiberboards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active substance</td>
<td>Polymethyl-hydrogen-siloxane</td>
<td>Polymethyl-hydrogen-siloxane</td>
<td>Potassium methyl-siliconate</td>
</tr>
<tr>
<td>SILRES®</td>
<td>BS 94</td>
<td>BS 46</td>
<td>BS 16</td>
</tr>
</tbody>
</table>

Above **liquid** silicone products are **not suitable for drymix** formulations
Outdated technologies available on the market:
carrier-based or encapsulated systems

Drawbacks of these technologies:

• only around 30 % active substance
• low efficiency
• too expensive, especially for plasters
• VOC release
• mixing problems and dust formation at the construction site
due to poor wetting properties of finished drymix formulations
A NEW CONCEPT FOR SILICONES IN POWDER FORM

Outdated:
Carrier-based or encapsulated

New:
Pure active substance

Silane or siloxane active substance

SILRES® BS POWDER S
CARRIER-BASED OR ENCAPSULATED SYSTEMS USE ALKOXY SILANES OR SILOXANES AS ACTIVE SUBSTANCE

- Not the active ingredient
- Hydrophobic precursor
- Volatile liquid, migration onto powder
- Mixing issues, dusting

- Reaction takes time (delayed performance)
- Depending on alkalinity

- Active ingredient
- Ethanol is a VOC

\[
\begin{align*}
\text{EtO} & \quad \text{Si} \quad \text{OEt} \\
\text{OH}^- & \quad (\text{alkalinity}) \\
& \quad 3 \text{H}_2\text{O}
\end{align*}
\]

\[
\begin{align*}
\text{R} & \quad \text{OH} \\
\text{OH} & \quad \text{Si} \quad \text{OH} \\
& \quad + 3 \text{EtOH (Ethanol)}
\end{align*}
\]
POTASSIUM SILICONATES CIRCUMVENT ALL THESE ISSUES: NO VOC BEATS LOW VOC

- Active ingredient
- Hydrophilic
- Solid, non-volatile, no migration
- No mixing issues, no dusting

- No reaction, no delay
- No need for alkaline activation

- No VOC
POTASSIUM SILICONATES CIRCUMVENT ALL THESE ISSUES: NO VOC BEATS LOW VOC

\[
\begin{align*}
&\text{R} \\
&\text{HO} \quad \text{Si} \quad \text{OH} \\
&\text{OK}
\end{align*}
\]

available by

- direct drying
- azeotropic drying
- spray drying

SILRES® BS POWDER S
OUR NEW TECHNOLOGY* IS NEITHER CARRIER- NOR ENCAPSULANT-BASED, BUT PURE ACTIVE SUBSTANCE

<table>
<thead>
<tr>
<th>SILRES® BS POWDER S</th>
</tr>
</thead>
<tbody>
<tr>
<td>• silicone hydrophobizing powder additive for drymix</td>
</tr>
<tr>
<td>• optimized for gypsum-based construction materials</td>
</tr>
<tr>
<td>• highly efficient in water absorption reduction</td>
</tr>
<tr>
<td>• excellent mixing properties</td>
</tr>
<tr>
<td>• supports dust suppression during mixing</td>
</tr>
</tbody>
</table>

*patents pending
WETTING, MIXING AND DUST SUPPRESSION ARE GREATLY IMPROVED FOR HYDROPHOBIZED GYPSUM DRY MORTARS

Outdated technology: Carrier-based system

New technology: SILRES® BS POWDER S

mixing time 3 min 30 sec

mixing time 1 min 45 sec
• INTRODUCTION – A NEW CONCEPT
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• CONCLUSIONS
BENCHMARKING OF EXISTING MARKET PRODUCTS: WATER ABSORPTION / LOW-PH JOINT FILLER

<table>
<thead>
<tr>
<th>Joint Filler</th>
<th>pH 9</th>
<th>Water/solids = 0,50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water/solids</td>
<td>EN 520</td>
<td>prep: EN 196-1 water absorption</td>
</tr>
</tbody>
</table>

**Additive Dosage [weight %]**
- ref.
- 0.4
- 0.8
- 1.2

**Carrier**
- 0.4
- 0.8
- 1.2

**Encapsulated**
- 0.4
- 0.8
- 1.2
BENCHMARKING OF EXISTING MARKET PRODUCTS: WATER ABSORPTION / GYPSUM LIME HAND PLASTER

Hand plaster
pH 12
Water/solids = 0.67
prep: EN 196-1
water absorption: EN 520
BENCHMARKING OF EXISTING MARKET PRODUCTS: WATER ABSORPTION / GYPSUM LIME MACHINE PLASTER

- **Machine plaster**
  - pH 12
  - Water/solids = 0.60
  - prep: EN 196-1
  - water absorption: EN 520

<table>
<thead>
<tr>
<th>2 hour water absorption [weight %]</th>
<th>ref.</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
<th>0.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encapsulated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Additive Dosage [weight %]**
- 0
- 0.2
- 0.4
- 0.6
- 0.8
GYPSUM MANUFACTURERS EXPRESSED VERY PRECISELY WHAT THEY WERE LOOKING FOR

<table>
<thead>
<tr>
<th>Customer requests</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water absorption</td>
<td>&lt; 5 %</td>
</tr>
<tr>
<td>Dosage level</td>
<td>&lt; 0,5 %</td>
</tr>
<tr>
<td>Mixing properties</td>
<td>Excellent</td>
</tr>
<tr>
<td>Dusting</td>
<td>None</td>
</tr>
<tr>
<td>VOC</td>
<td>None</td>
</tr>
</tbody>
</table>
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• CONCLUSIONS
SILRES® BS POWDER S: WATER ABSORPTION / LOW-PH JOINT FILLER

-95%

Joint filler
pH 9
Water/solids = 0.50
prep: EN 196-1
water absorption: EN 520

0
0.1
0.2
0.4
0.6
additive dosage [weight %]

0
5
10
15
20
25
2 hour water absorption [weight %]
SILRES® BS POWDER S:
WATER ABSORPTION / GYPSUM LIME HAND PLASTER

Hand plaster
pH 12
Water/solids = 0.67

prep: EN 196-1
water absorption: EN 520

IMPROVING THE WATER RESISTANCE OF GYPSUM DRYMIX APPLICATIONS
Dr. Daniel Schildbach, Global Gypsum Conference, Istanbul, October 17, 2012, Slide 22
SILRES® BS POWDER S:
WATER ABSORPTION / GYPSUM LIME MACHINE PLASTER

2 hour water absorption [weight %]

<table>
<thead>
<tr>
<th>additive dosage [weight %]</th>
<th>ref.</th>
<th>0.1</th>
<th>0.2</th>
<th>0.4</th>
<th>0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 hour water absorption</td>
<td>39</td>
<td>12</td>
<td>-93%</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Machine plaster
pH 12
Water/solids = 0.60
prep: EN 196-1
water absorption: EN 520
SILRES® BS POWDER S:
WATER ABSORPTION / GYPSUM LIME MACHINE PLASTER

-90 %

Machine plaster
30 % stucco
70 % carbonate filler
pH 12
Water/solids = 0,35
SILRES® BS POWDER S: WATER ABSORPTION / SELF-LEVELLING SCREED

Flooring screed

pH 11
Water/solids = 0,17

prep: EN 196-1
water absorption: EN 520

Additive dosage [weight %]

-96 %

2 hour water absorption [weight %]
LONG-TERM WATER RESISTANCE AFTER 7 DAYS ON A GYPSUM HAND PLASTER FROM THE MARKET

![Graph showing water absorption over time for different samples.](image)

- **reference**
- **0,3% SILRES® BS POWDER S**
- **0,5% SILRES® BS POWDER S**
- **0,8% SILRES® BS POWDER S**
- **carrier**
- **MR market plaster**
SILRES® BS POWDER S WITH STRONG BEADING IN ADDITION TO LOW WATER ABSORPTION

Untreated gypsum plaster

<table>
<thead>
<tr>
<th>droplet test</th>
<th>Gypsum hand plaster</th>
<th>Gypsum machine plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ref. 0,2 %</td>
<td>0,5 %</td>
</tr>
<tr>
<td>time (min)</td>
<td>0</td>
<td>253</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>215</td>
</tr>
</tbody>
</table>

+0,3 % POWDER S
The mechanical properties of test specimen were investigated using 4×4×16 prisms (EN 196-1).

<table>
<thead>
<tr>
<th></th>
<th>plaster</th>
<th>gypsum hand plaster</th>
<th>gypsum machine plaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>POWDER S dosage</td>
<td>Ref.</td>
<td>0,2 %</td>
<td>0,5 %</td>
</tr>
<tr>
<td>air content (%)</td>
<td></td>
<td>0</td>
<td>-29</td>
</tr>
<tr>
<td>DIN EN 1015-7</td>
<td></td>
<td>0</td>
<td>-5</td>
</tr>
<tr>
<td>slump (cm)</td>
<td></td>
<td>0</td>
<td>-13</td>
</tr>
<tr>
<td>DIN EN 1015-12</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>tensile strength (N/mm²)</td>
<td></td>
<td>-6</td>
<td>+4</td>
</tr>
<tr>
<td>DIN EN 1015-11</td>
<td></td>
<td>0</td>
<td>+9</td>
</tr>
<tr>
<td>compressive strength (N/mm²)</td>
<td></td>
<td>0</td>
<td>-5</td>
</tr>
</tbody>
</table>
SILRES® BS POWDER S IS A FREE FLOWING WHITE POWDER OF HIGH ALKALINITY

Currently available:
- 0.4 kg sample
- 5 kg drum
- 80 kg drum
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CONCLUSIONS

• SILRES® BS POWDER S: Well-suited for all gypsum-based powder products requiring drymix hydrophobizing

• More effective, more efficient than current technologies on the market – works instantly without delays

• No release of organic substances (VOC)

• Processing and workability remain unchanged within the recommended dosage ranges

• Mixing problems caused by the water repellant belong to the past
CLICK FOR FURTHER INFORMATION: WWW.WACKER.COM/POWDER-S
THANK YOU FOR YOUR KIND ATTENTION!
PLEASE VISIT US AT BOOTH 29

SILRES® VINNAPAS®

Durability  Workability  Water resistance  Adhesion  Flexibility

WACKER

CREATING TOMORROW'S SOLUTIONS
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• BACKUP
### ADVANTAGES AND OTHER PROPERTIES OF SILRES® BS POWDER 68520

<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Powder</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>White</td>
</tr>
<tr>
<td><strong>Odor</strong></td>
<td>Odorless</td>
</tr>
<tr>
<td><strong>Active substance</strong></td>
<td>&gt; 99 %</td>
</tr>
<tr>
<td><strong>Bulk density</strong></td>
<td>Approx. 640 kg/m³</td>
</tr>
<tr>
<td><strong>pH Value</strong></td>
<td>12 (20 °C, 50 g/l H₂O)</td>
</tr>
<tr>
<td><strong>Minimum ignition energy</strong></td>
<td>&gt; 10000 mJ</td>
</tr>
</tbody>
</table>

Contains / releases no VOC  
(no alkoxy silanes)  
(Virtually) no vapor pressure  
No alkaline activation  
(pre-hydrolysis) necessary  
No nano-scale material
THE PERFORMANCE IS NOT AFFECTED BY LARGE AMOUNTS OF FILLERS – 500 MICRON CARBONATE FILLER

![Graph showing the effect of carbonate filler content on water absorption and water/solids ratio.](image)

- Reference
- 0.2% SILRES® BS POWDER S
- 0.3% SILRES® BS POWDER S

*2 hour water absorption [weight %]*

*Water/solids ratio*

*plaster pH 12*
THE PERFORMANCE IS NOT AFFECTED BY LARGE AMOUNTS OF FILLERS – 80 MICRON DOLOMITE FILLER
THE PERFORMANCE IS NOT AFFECTED BY LARGE AMOUNTS OF FILLERS – QUARTZ SAND FILLER

- Water absorption over 2 hours
- Quartz sand filler content vs. water/solids ratio
- Reference vs. 0.22% SILRES® BS POWDER S
- pH 12
WATER ABSORPTION TEST BY PRISM OR CYLINDER? VIRTUALLY NO DIFFERENCE

**Preparation:**
- EN 196-1
- Water absorption: EN 520

**Graph:**
- Machine plaster
- Hand plaster

**Graph Data:**
- Reference
- 0.3% SILRES® BS POWDER S
UNCHANGED MIXING, MODELLING AND FINISHING PROPERTIES FOR DOSAGES $\leq 0.3\%$
THE DIFFERENCE IS OBVIOUS AFTER A PERIOD OF NATURAL OUTDOOR WEATHERING

6 months of natural weathering (Sep – Feb 2012) (gypsum lime hand plaster)
PREPARATION OF GYPSUM SAMPLES IN WACKER’S CONSTRUCTION CHEMISTRY LABS
cylindrical gypsum test bodies (2 cm x 8 cm Ø) are prepared using ring-shaped standardized PVC molds.

water absorption test according to DIN EN 520 (gypsum test bodies forced under water using steel weights).