Intelligent modular concepts using nanoscale platelet pigments for protective coatings

A *modular concept of protection* with different nanoscale protective pigments to enable the coating industry to adjust the protection properties

Marc Entenmann, Heinz Greisiger, Roman Maurer, Henry Lehmann
Fraunhofer IPA, Stuttgart, Germany
- Status and needs for improvements of protective coatings -
Corrosion of construction metals causes losses in industrialized countries which are estimated to be approximately 3 % to 5 % of the respective gross domestic products.

These losses originate from insufficient and non-durable corrosion protection of metals with coatings.

3 to 4 separate layers are nowadays used for the corrosion protection of metals.

The general trend in the coating industry can be described by the replacement of thick multilayer coatings with thin, less layer containing, highly efficient and functionalized coatings.

The world wide demand for such new protective coatings will increase considerably, the more important future requirements concerning sustainability and reduction of material or maintenance costs will get.
- The approach -

a modular concept of protection with nanoscale protective pigments to adjust the protection properties of coatings
The approach

- To generate highly efficient and sustainable protective coatings, a concept is proposed, which is based on the combination of different functionalized nanoscale platelet pigments.

- These functionalized nanoscale platelet pigments should be able to integrate multifunctional properties: to improve the mechanical properties, provide photo-degradation stability, increase corrosion protection and endow barrier effects of the protective coatings.

- Because of the nanoscale character, the influence on colour or transparency of the coating layers should be considerably low.

- Through the modular character of the proposed concept, the different functionalized nanoscale platelet particles can be combined and the properties of the protective coatings can be adapted to the predominant environmental situation.
- Experimental aspects -
Comparison of the selected talcum components

<table>
<thead>
<tr>
<th>Talcum</th>
<th>$d_{10} / \mu m$</th>
<th>$d_{50} / \mu m$</th>
<th>$d_{90} / \mu m$</th>
<th>$d_{98} / \mu m$</th>
<th>PD / nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUZENAC 20M</td>
<td>3,6</td>
<td>11,6</td>
<td>30,3</td>
<td>53,3</td>
<td>60 - 121</td>
</tr>
<tr>
<td>Talc LP30</td>
<td>4,8</td>
<td>17,9</td>
<td>41,4</td>
<td>59,5</td>
<td>≈ 80</td>
</tr>
<tr>
<td>Mistron 754 G</td>
<td>2,7</td>
<td>11,9</td>
<td>31,4</td>
<td>45,2</td>
<td>80 - 91</td>
</tr>
</tbody>
</table>

**Distributors**
- Luzenac 20M provided from Rio Tinto Minerals Europe
- Talc LP30 provided from LITHOS Industrial Minerals GmbH
- Mistron 754 G provided from Rio Tinto Minerals Europe

**Determination of properties**
- Particle thickness characterized with SEM
- Particle size measurements performed with LSS
## Simplified and optimized white primer testing formulation

<table>
<thead>
<tr>
<th>Component</th>
<th>Source</th>
<th>% w/w</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acronal Pro 80, 50 %</td>
<td>BASF</td>
<td>52,46</td>
</tr>
<tr>
<td>BYK 022</td>
<td>Byk-Chemie</td>
<td>0,41</td>
</tr>
<tr>
<td>Surfynol 104 PA</td>
<td>Air Products</td>
<td>0,41</td>
</tr>
<tr>
<td>Water</td>
<td>-</td>
<td>8,56</td>
</tr>
<tr>
<td>BYK 347</td>
<td>Byk-Chemie</td>
<td>0,10</td>
</tr>
<tr>
<td>Dimethylaminoethanol (DMAE)</td>
<td>-</td>
<td>0,26</td>
</tr>
<tr>
<td>Butylglycole</td>
<td></td>
<td>1,74</td>
</tr>
<tr>
<td>Heucophos ZMP</td>
<td>Heubach</td>
<td>11,53</td>
</tr>
<tr>
<td>Heucorin RZ</td>
<td>Heubach</td>
<td>1,28</td>
</tr>
<tr>
<td>Talcum 20 M 2</td>
<td>Luzenac</td>
<td>14,34</td>
</tr>
<tr>
<td>Kronos 2310</td>
<td>Kronos</td>
<td>8,09</td>
</tr>
<tr>
<td>CHE-Coat Ci LNF A4</td>
<td>Erbslöh</td>
<td>0,56</td>
</tr>
<tr>
<td>Rheovis PU 1280</td>
<td>BASF</td>
<td>0,20</td>
</tr>
</tbody>
</table>
Testing of the primer formulations

- The testing of the white primer formulations was performed with a dry layer thickness of 70 µm on steel panels.

- As steel substrates, 200 x 100 x 2,0 mm³ s DC 04 B steel panels, with round edges, sandblasted on both sides with a medium roughness of R_z 20 - 30 µm were used.

- For testing of the barrier effect the talcum M2 was substituted with the organic inorganic modified/unmodified nanoscale equivalents.

- For testing of the UV-protection and barrier properties, formulations without the Kronos 2310 were tested and the talcum M2 was additionally exchanged with the new synthesized nanoscale organic and inorganic modified/functionalized talcum components.
- Obtained results -
Corrosion protection testing of organically modified nanoscale talcum LP30 in the white primer

- The coatings were charged with salt spray testing for 240 h

⇒ For the nanoscale talcum LP30 with different organic treatment excellent barrier and corrosion protection was observed
Corrosion protection testing of different inorganically modified talcum in the white primer

- The coating was charged 96 h with a 5 % w/w NaCl-solution on an infraction with a 0.5 mm drill as well as with a cut (scribe) at 23 °C

⇒ For the nanoscale talcum treated with TiO₂ and Zn-phosphate (ZP), improved barrier and corrosion protection properties were obtained
Corrosion protection testing of the less pigmented white primer formulations without TiO$_2$

- The coating was charged 48 h with a 5 % w/w NaCl-solution on a infraction with a 0.5 mm drill with thermocyclic loading from 23 °C to 70 °C

⇒ Nanoscale talcum modified with Zn-phosphate (ZP) showed excellent barrier- and corrosion protection properties in the less pigmented primer, after charging with thermocyclic loading, using a 5 % NaCl-solution
Scanning Kelvin Probe measurements (SKP) of the less pigmented white primer formulations without TiO₂

- The coating was charged 48h with a 5 % w/w NaCl-solution on a infraction with a 0.5 mm drill with thermocyclic loading from 23 °C to 70 °C

- The visual detectable corrosion effects could be confirmed by performing SKP-measurements
- Nanoscale talcum modified with Zn-phosphate (ZP) showed less cathodic delamination outside the infraction
- For nanoscale talcum modified with Zn-phosphate (ZP), less active anodic processes at the infraction point could be determined
Impedance measurements of different inorganically modified talcum in the white primer

The improved corrosion protection of the nanoscale talcum modified with Zn-phosphate (ZP) could also be confirmed by performing impedance measurements.
Comparison of UV-absorption properties of inorganically modified talcum LP30 in the white primer

For primer coatings without TiO$_2$, containing inorganically modified nanoscale talcum LP30, higher transparency values from 500 nm to 2500 nm were obtained.

Primer coatings without TiO$_2$, containing inorganically modified nanoscale talcum LP30, showed only slightly increased UV-transparency, in comparison to the reference samples with TiO$_2$.

© Fraunhofer IPA
UV-protection testing of inorganically and organically modified nanoscale talcum LP30 in white primer

For the nanoscale talcum LP30 treated with Ce-oxide, in the more transparent primer with reduced pigment concentration, improved UV-protection properties were obtained, in comparison to the reference systems which contains (MRP, MLP) or doesn´t contain TiO₂ (MLPa) pigments.
- Conclusions -
Conclusions

- Inorganic or organic, and especially a combination of both functionalizations of nanoscale talcum, successfully improve UV-absorption and protection as well as barrier- and corrosion protection properties.

- Primer formulations, for example with Ce-oxide treated nanoscale talcum, with higher transparency and lower pigmentation levels, but with comparable UV- and corrosion protection properties as the alternatives with additional 8 % titania pigmentation, could be achieved.

- For the samples charged with thermocyclic loading with NaCl-solution, it was only the transparent primer formulation with Zn-phosphate treated nanoscale talcum, with showed excellent corrosion protection.
Acknowledgements
Acknowledgements

This project was conducted at Fraunhofer Institute for Manufacturing Engineering and Automation IPA, coordinated by the Research Society for Pigments and Coatings (FPL e.V.) and financially funded via AiF by the German Federal Ministry of Economic Affairs and Energy.

Our sincere thanks for supporting the protective coatings research in the project are given to our institute partners and especially to our industrial partners.
- Thank you for attention -