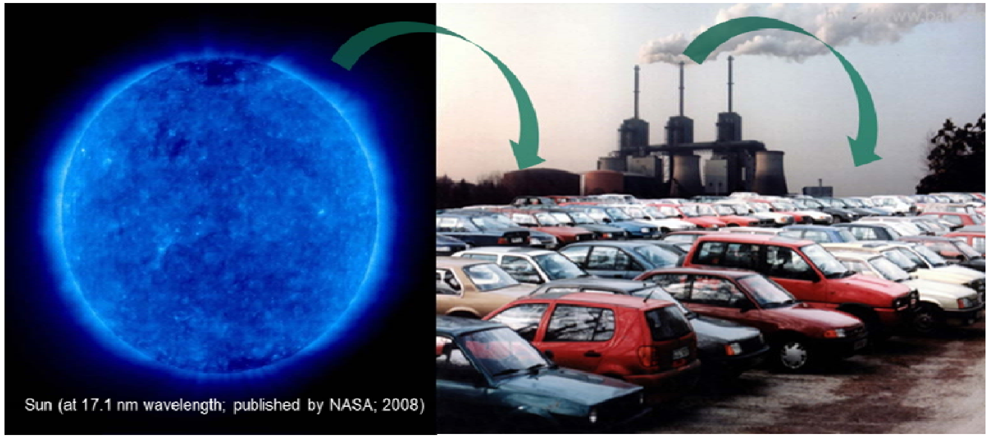
Intelligent modular concepts using nanoscale platelet pigments for protective coatings



Sun (at 17.1 nm wavelength; published by NASA; 2008)

*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

Smart Coatings 2015

February 25-27, 2015 Orlando, Florida USA

Fraunhofer IPA

- Status and needs for improvements of protective coatings -

Status and needs for improvements

- 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

Talcum	d_{10} / µm	d_{50} / µm	d_{90} / µm	d_{98} / µm	PD / nm
LUZENAC 20M	3,6	11,6	30,3	53,3	60 - 121
Talc LP30	**4,8**	**17,9**	**41,4**	**59,5**	**≈ 80**
Mistron 754 G	**2,7**	**11,9**	**31,4**	**45,2**	**80 - 91**

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

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

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 -

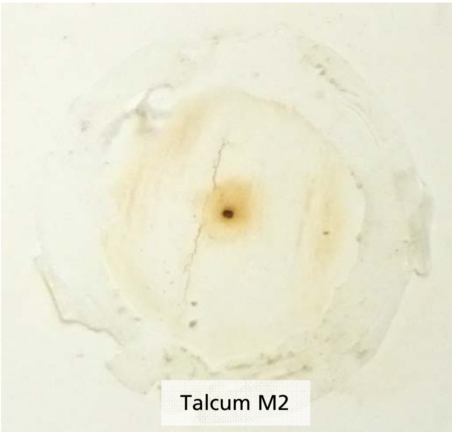
Corrosion protection testing of organically modified nanoscale talcum LP30 in the white primer

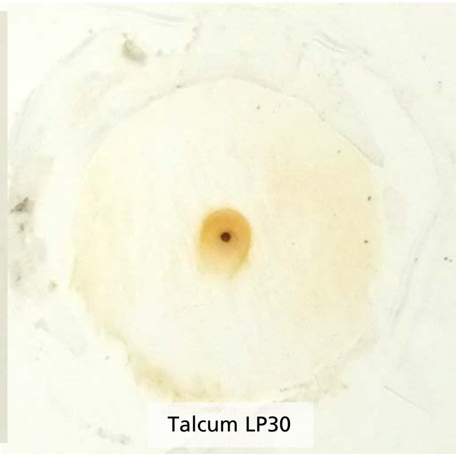
- The coatings were charged with salt spray testing for 240 h

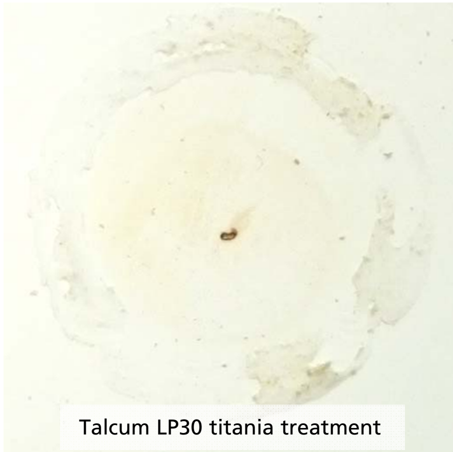
⇨ For the nanoscale talcum LP30 with different organic treatment excellent barrier and corrosion protection was observed

Corrosion protection testing of different <u>inorganically</u> 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



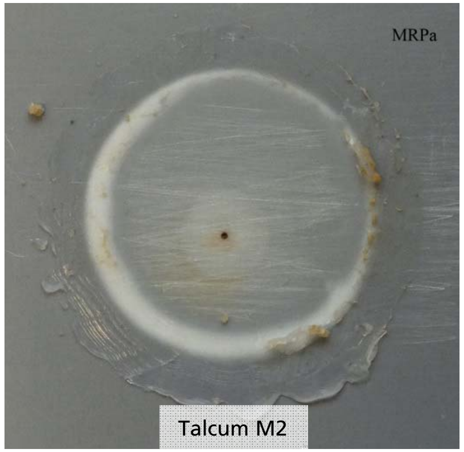


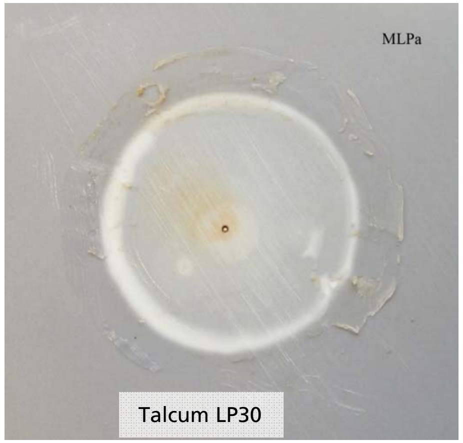


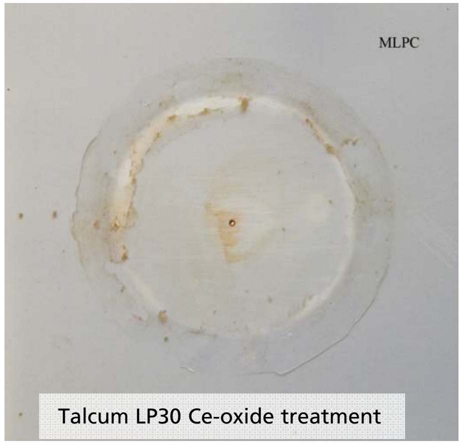
⇨ For the nanoscale talcum treated with TiO_2 and Zn-phosphate (ZP), improved barrier and corrosion protection properties were obtained

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





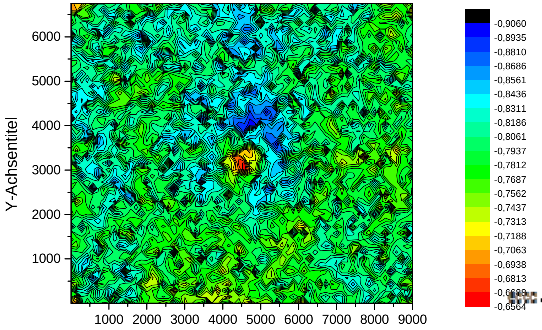


⇨ Nanoscale talcum modified with Zn-phosphate (ZP) showed excellent barrier- and corrosion protection properties in the less pigmented primer, after charging with thermocyclic loading, using a 5 % NaCl-solution

Fraunhofer IPA

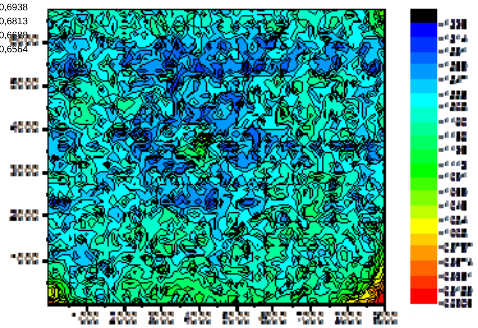
Scanning Kelvin Probe measurements (SKP) of the less pigmented white primer formulations without TiO_2

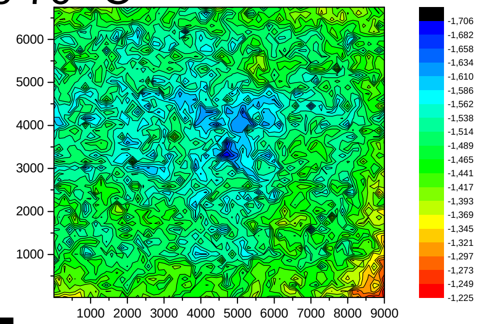
- The coating was charged 48h with a 5 % w/w NaCl-solution on a infraction with a 0.5 mm drill with thermocyclic loading from 23 °C to 70 °C



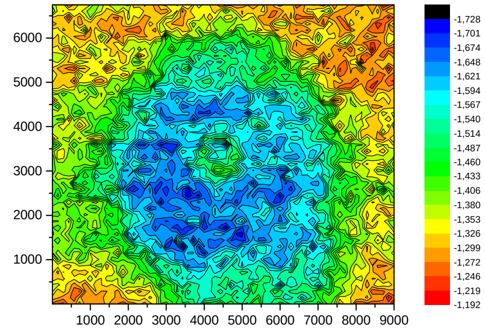
Talcum M2 sample
with anodic processes at the infraction and great cathodic delamination area around

Talcum LP30 sample
with great cathodic delamination area around the infraction





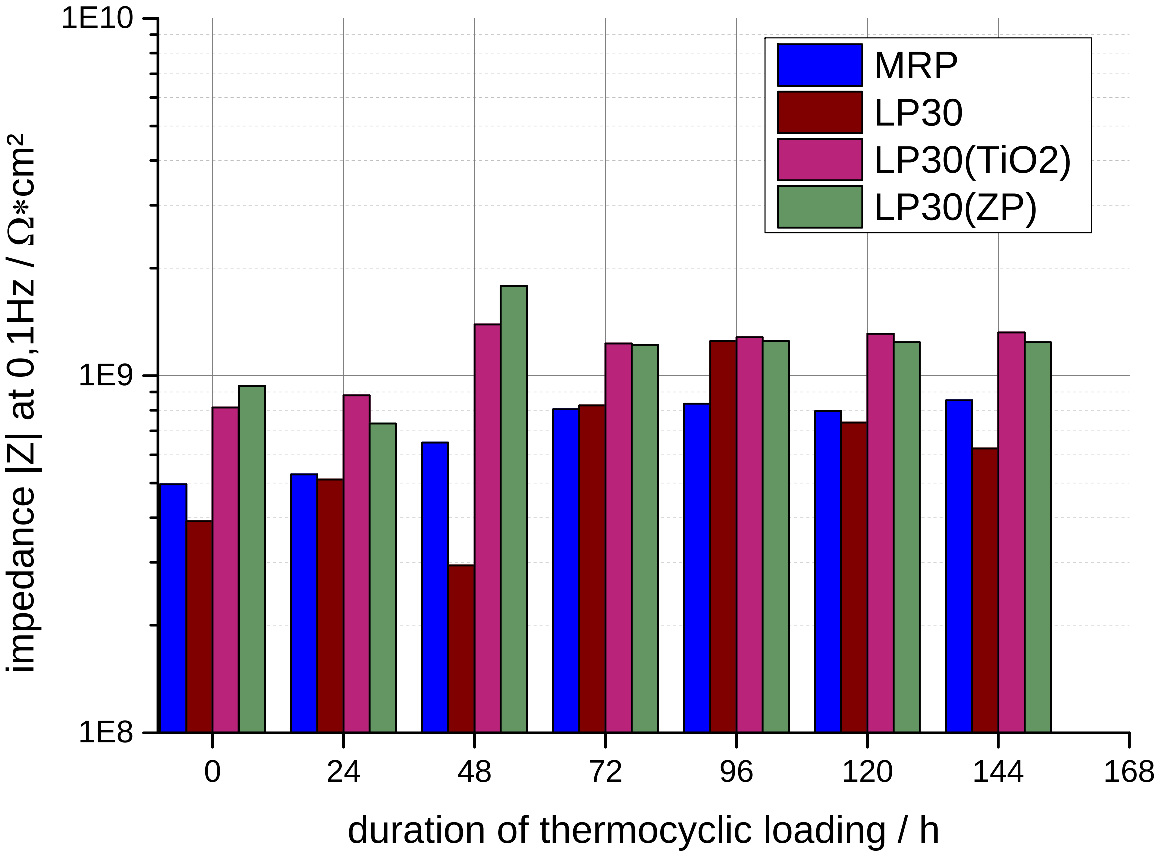
Talcum LP30 / Ce-oxide treatment with cathodic delamination area around the infraction



Talcum LP30 / zinc phosphate treatment
with less active anodic processes at the infraction and a less active cathodic delamination area around.

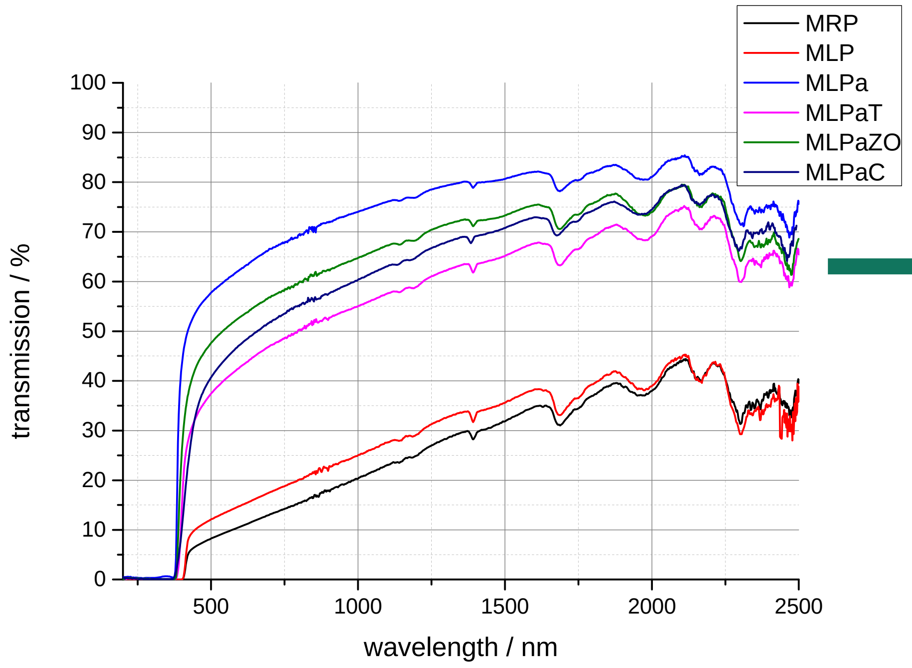
- ⇨ The visual detectable corrosion effects could be confirmed by performing SKP-measurements
- ⇨ Nanoscale talcum modified with Zn-phosphate (ZP) showed less cathodic delamination outside the infraction
- ⇨ For nanoscale talcum modified with Zn-phosphate (ZP), less active anodic processes at the infraction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

Impedance measurements of different inorganically modified talcum in the white primer

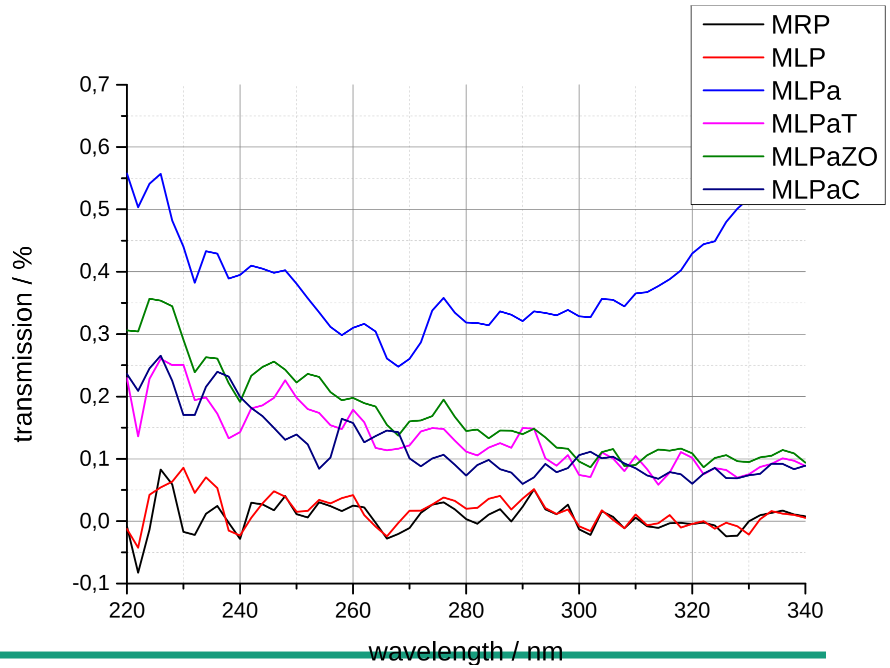


⇨ The improved corrosion protection of the nanoscale talcum modified with Zn-phosphate (ZP) could also be confirmed by performing impedance measurements

Comparison of UV-absorption properties of inorganically modified talcum LP30 in the white primer



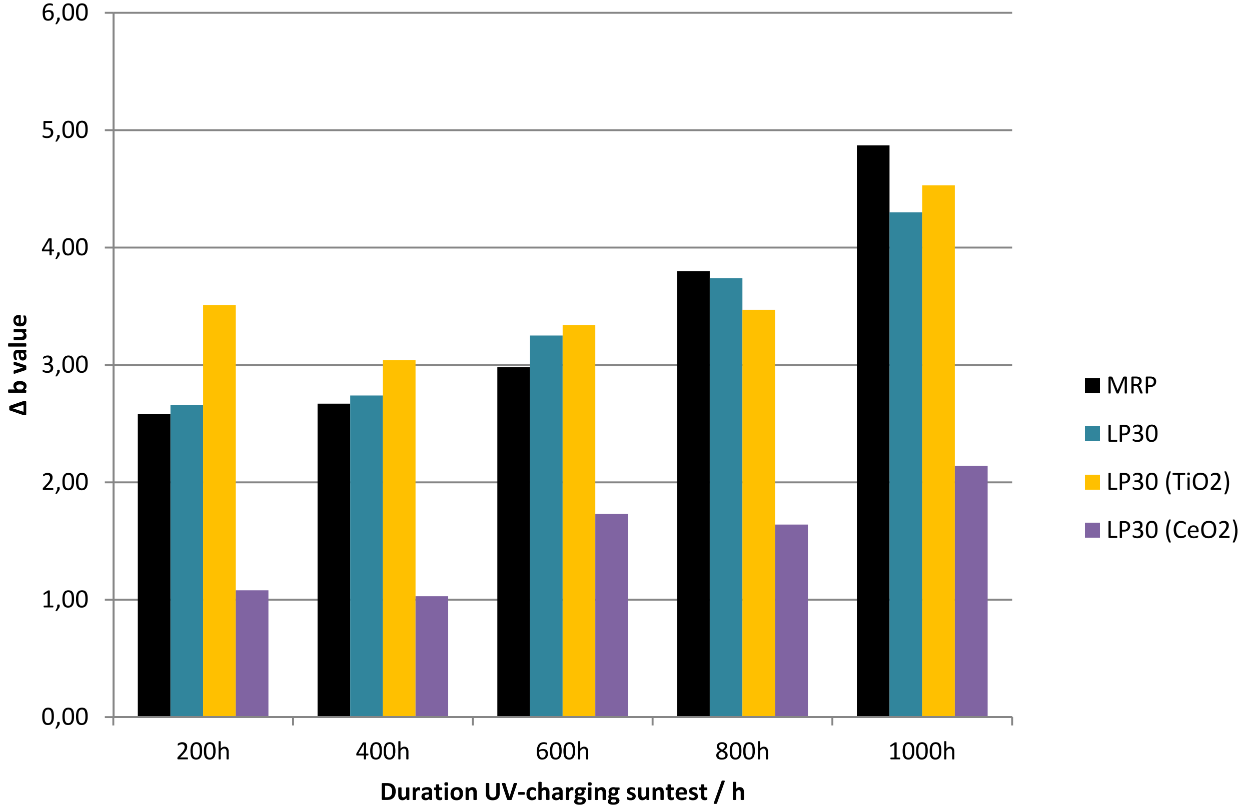
For **primer coatings** without TiO_2, **containing inorganically modified nanoscale talcum** LP30, **higher transparency values** from 500 nm to 2500 nm were obtained



⇨ **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 TiO_2 (MLPa) pigments

Fraunhofer IPA

- 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**

Fraunhofer IPA

- 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**

FORSCHUNGSGESELLSCHAFT
FÜR PIGMENTE UND LACKE E.V.

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

- 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 -

cornet

AiF

Wallonie

SPW
Service public
de Wallonie

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

MateriaNova
MATERIALS R&D CENTRE

FPL FORSCHUNGSGESELLSCHAFT
FÜR PIGMENTE UND LACKE E.V.

Fraunhofer
IPA

CoRI
Coatings Research Institute