Self-cleaning elastomeric cool roof coatings with superior performance

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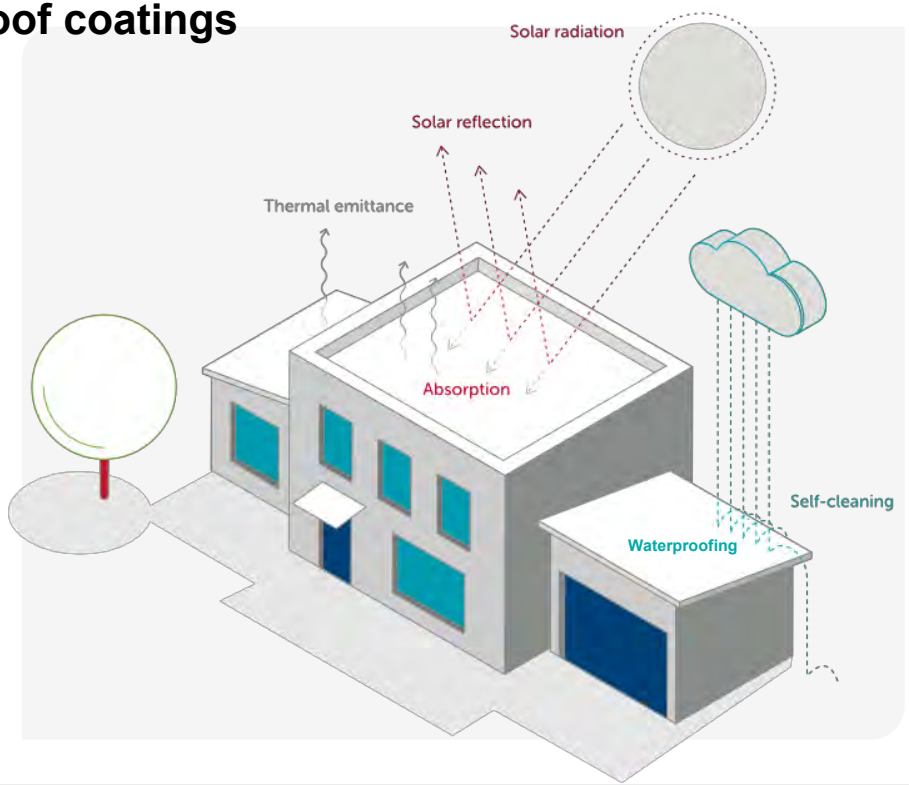
Elastomeric cool roof coatings

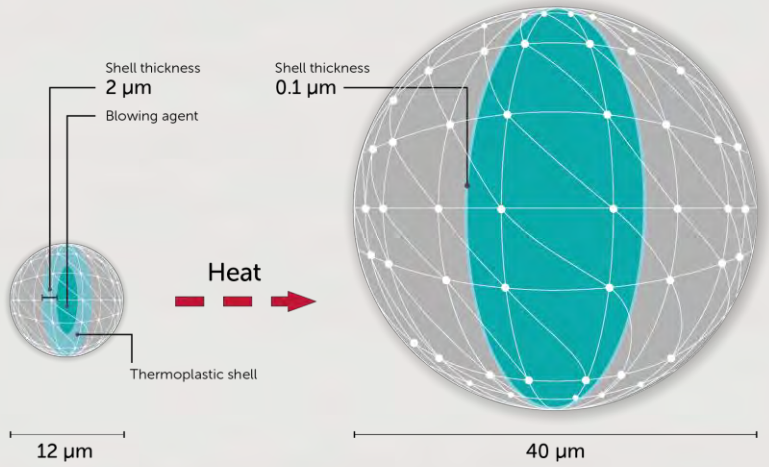
Important properties for elastomeric cool roof coatings

- High total solar reflectance
- High elasticity and strength
- Adherence to substrate
- Good waterproofing
- In-can stability
- UV-resistance
- Dirt pick-up resistance

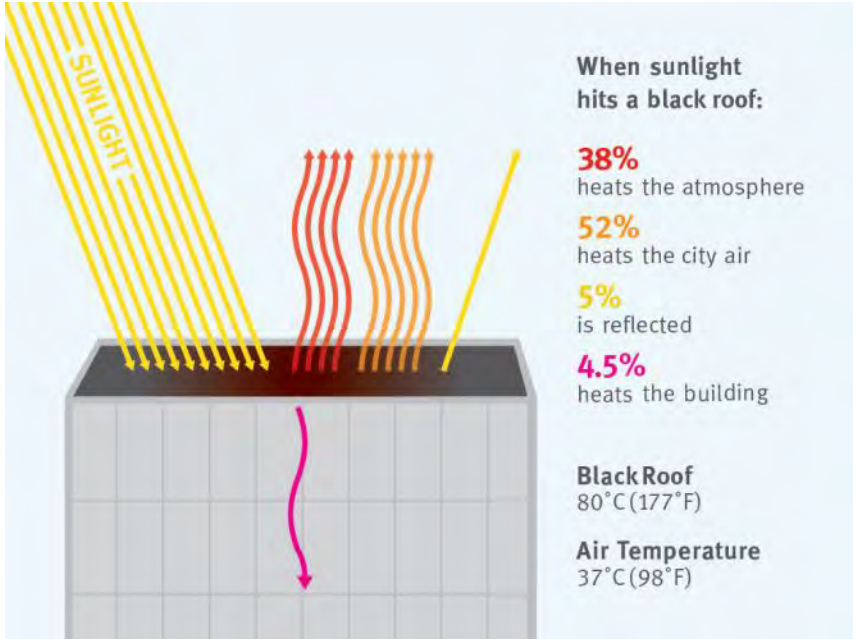


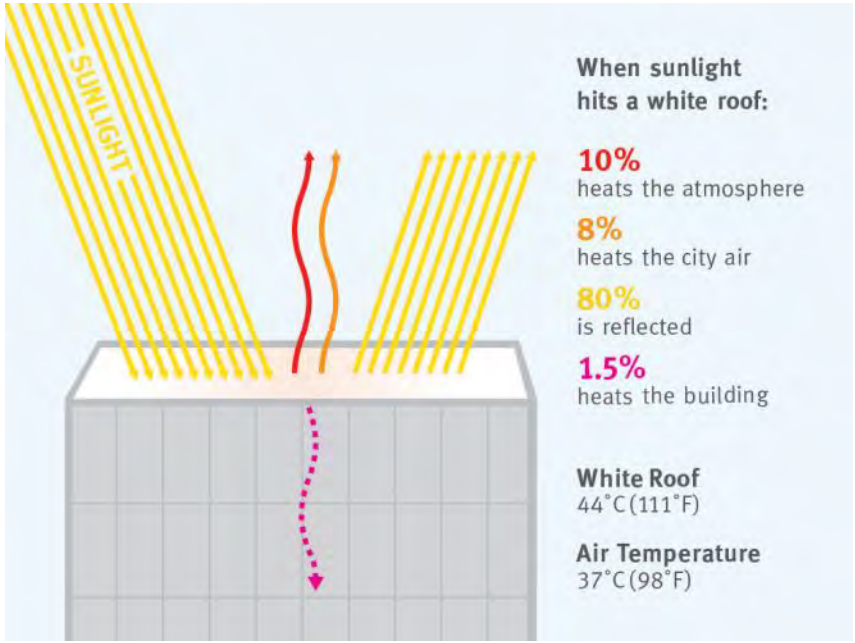
Blowing agent and lightweight filler in one

Expansion up to 60x original volume



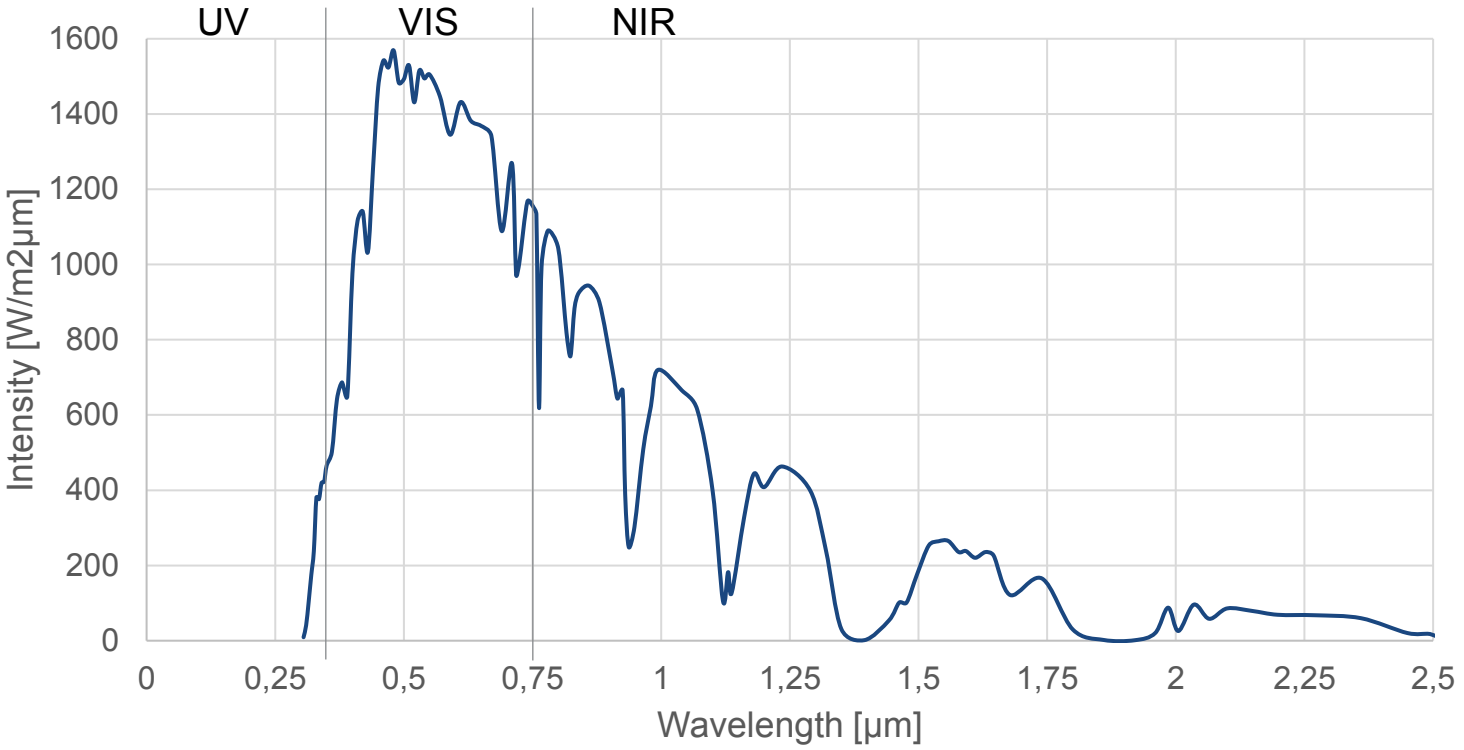
Elastomeric cool roof coatings





Source: www.globalcoolcities.org

Solar energy distribution



Expancel

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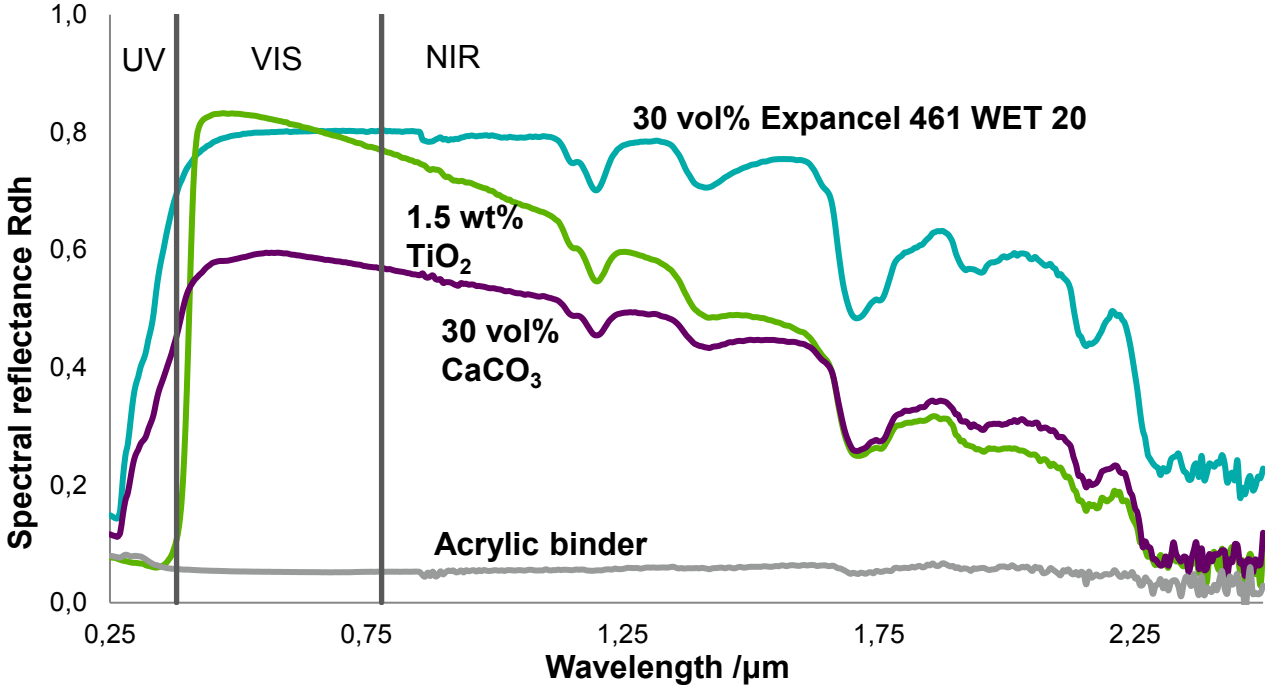
Solar energy distribution

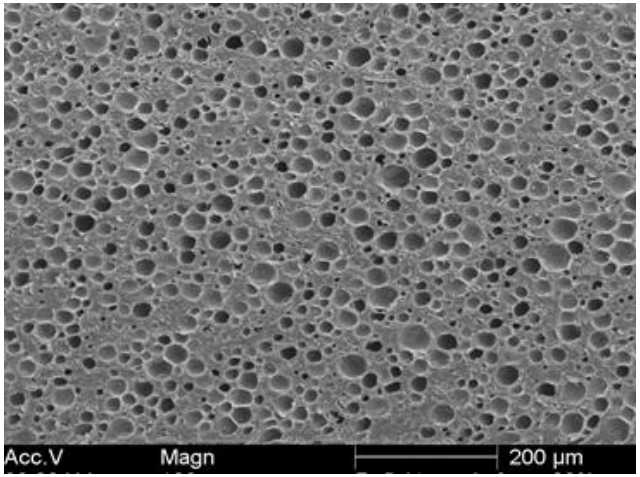


Directional-hemispherical reflection measured at the Bavarian Center for applied energy research (ZAE Bayern). Paint thickness 0.8 ± 0.05 mm.

Diffuse reflectance of a foam

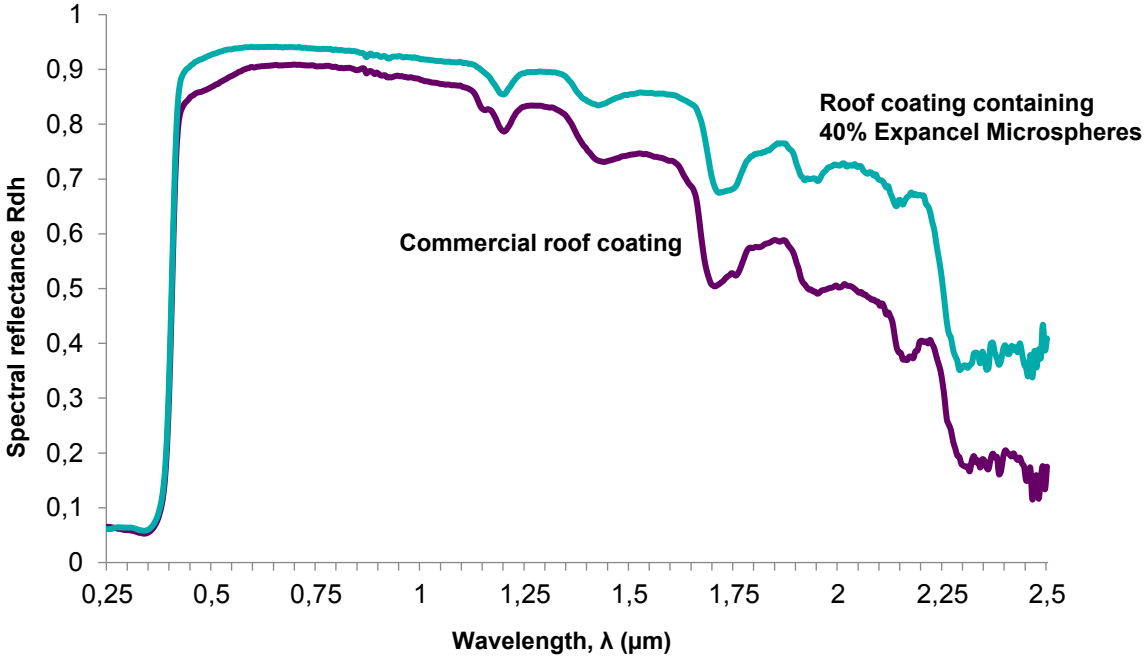
Coating thickness
Bubble size
Bubble concentration

} Number of bubbles



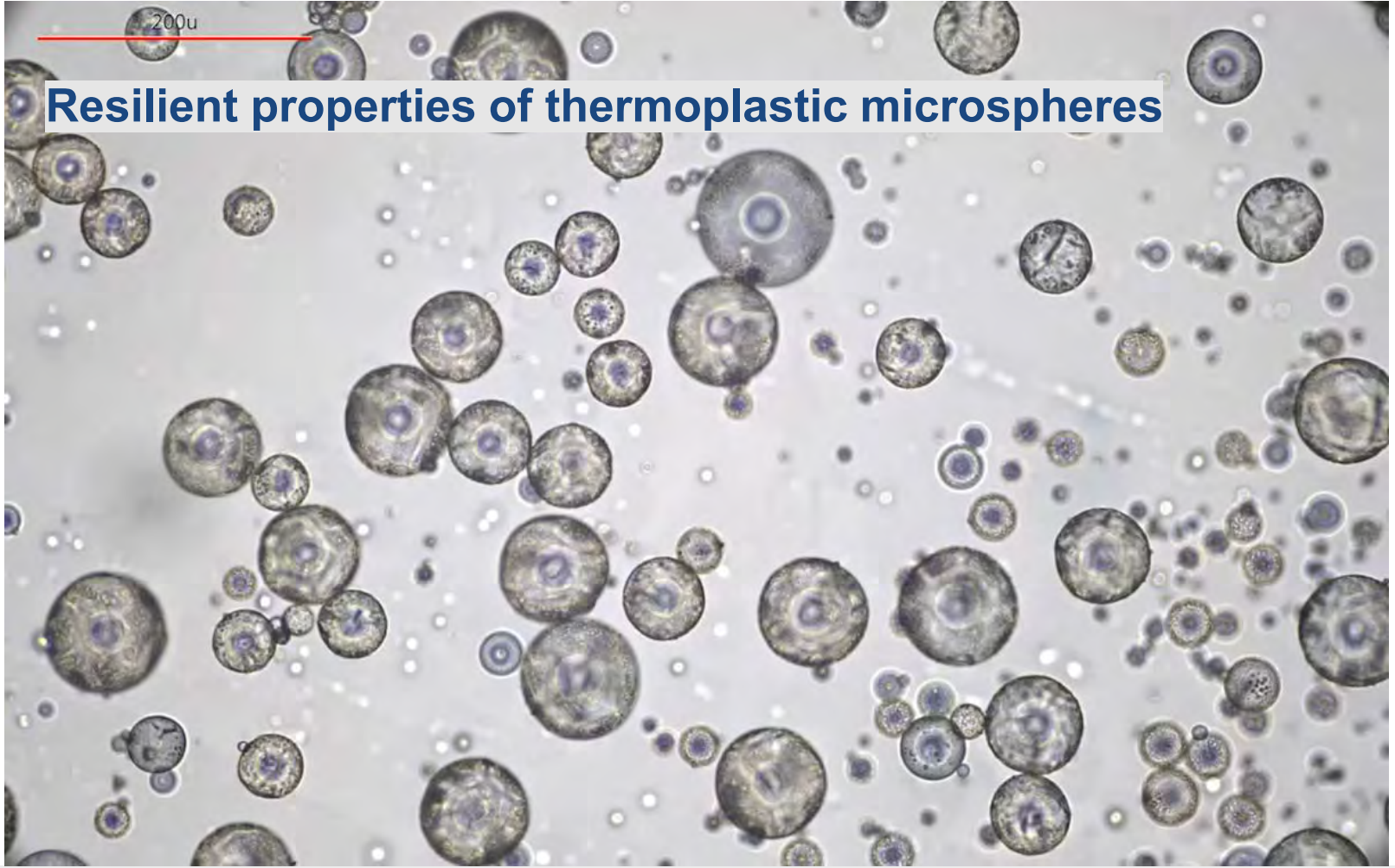
30 vol% 20µm microspheres in an acrylic coating

Solar reflectance of commercial coatings



Measurements performed at the Bavarian Center for applied energy research (ZAE Bayern). Paint thickness 0.8 ± 0.05 mm.

Resilient properties of thermoplastic microspheres



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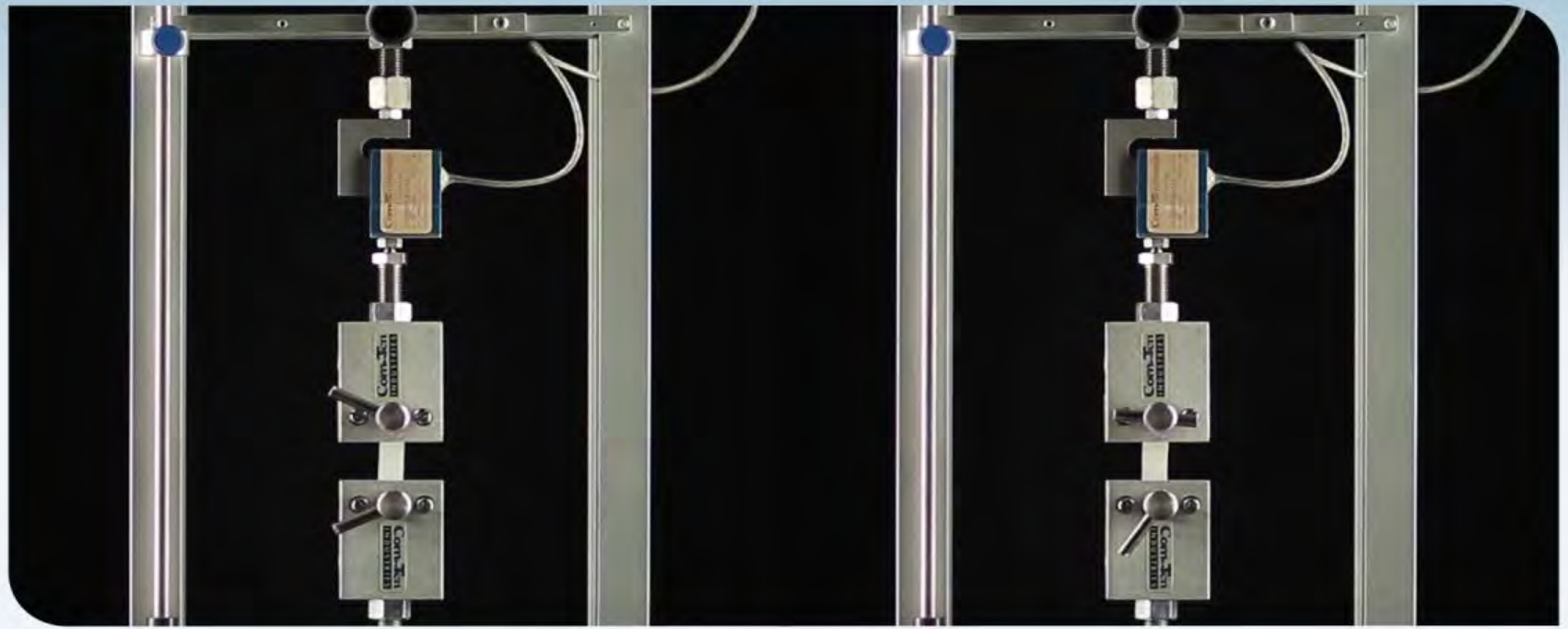
Elastomeric properties of cool roof coatings



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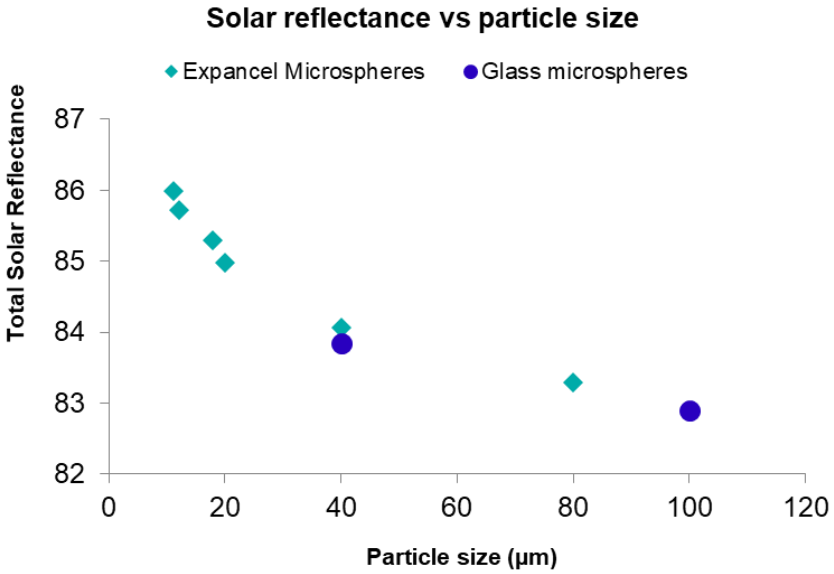
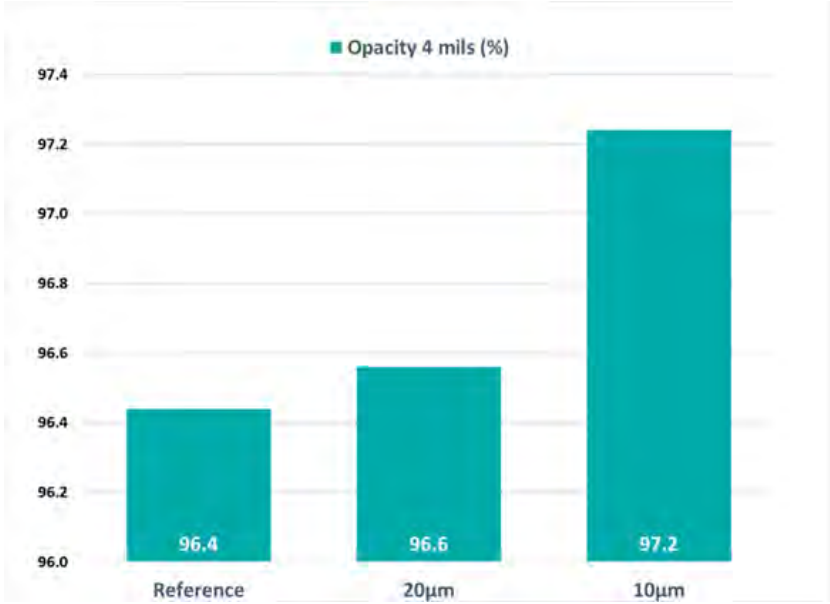
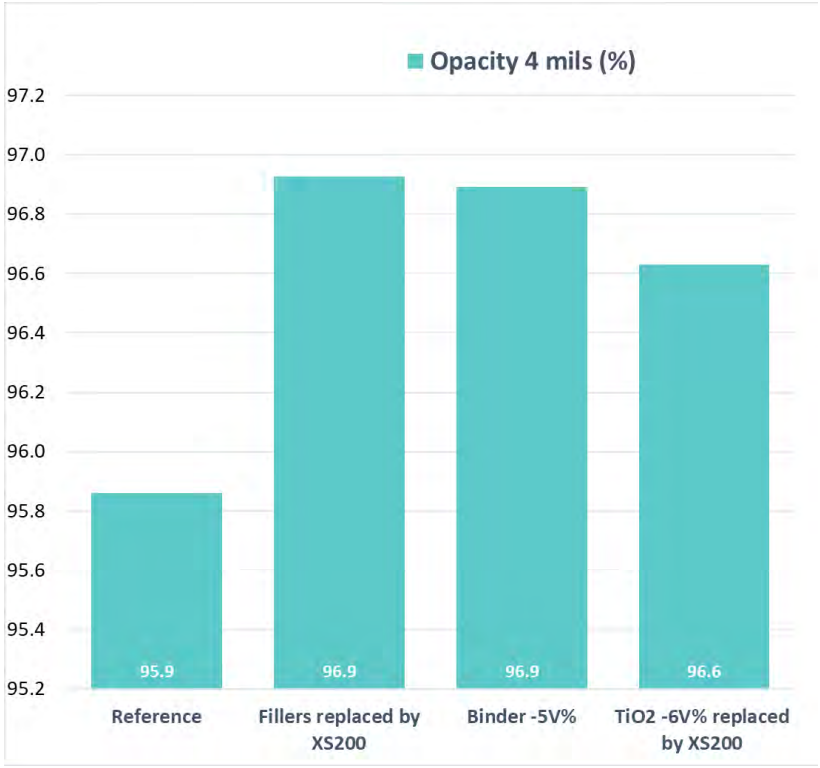
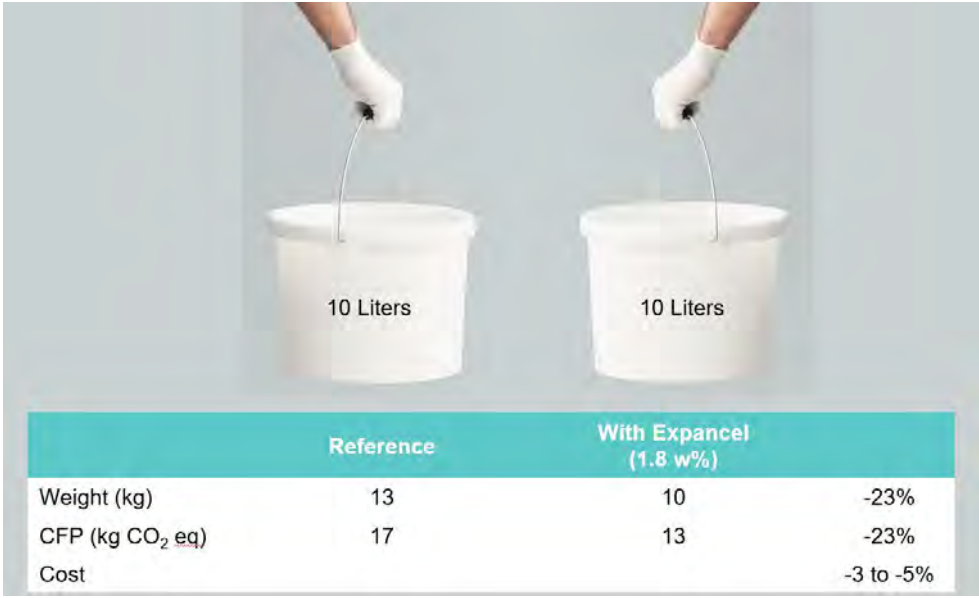
Launch Expancel XS200 WEA 10





Expancel XS200 WEA 10 interior paint





	Reference	With Expancel (1.8 w%)	
Weight (kg)	13	10	-23%
CFP (kg CO_2 eq)	17	13	-23%
Cost			-3 to -5%

PVC	**38%**	**38%**
CPVC	57%	61%
PVC/CPVC ratio	0.67	0.63
Volume solids (%)	38%	38%
Wet density (kg/dm3)	1.29	1.01
Density dry film (kg/dm3)	1.77	1.02

Technology challenges for elastomeric cool roof coatings

- **Water ponding:**
  Roof coatings, especially those based on acrylic resins, are not 100% waterproof. Wet adhesion to avoid delamination is crucial.

- **Moisture in substrate:**
  Breathability; high vapor permeability (enabling evaporation) combined with low water uptake, is important.

- **Soft coating - Mechanical performance:**
  Traditional elastomeric coatings are flexible and therefore very tacky, which attracts dirt and makes it sensitive to mechanical impact.

- **TSR - Total solar reflectance and dirt pick-up resistance:**
  In order to have good cooling effect – high solar reflectance is needed. To maintain the effect – good dirt pick-up resistance is crucial.

- **In-can stability:**
  Good formulation stability can be a challenge, especially in hot climate.

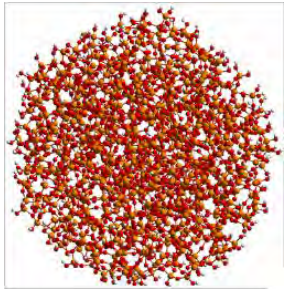
Keep coating clean

Addition of silane modified colloidal silica **Levasil® CC301** significantly enhances the dirt pick-up resistance by reducing tackiness.

What is colloidal silica?

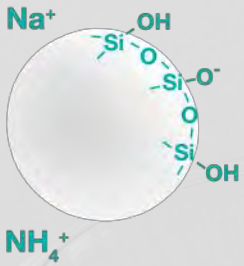
- Very small particles of amorphous silicon dioxide (SiO_2), dispersed in water
- Safe for both humans and the environment
- Large surface area, due to the numerous small particles
- The particles are usually electrically charged, why they can easily interact with one another or to other substances

- The properties of colloidal silica dispersions can be varied in many ways:
  - ❑ Concentration: 7– 50% silicon dioxide
  - ❑ Particle size distribution
  - ❑ Structure: Discrete particles (high S-value) or chains (low S-value)
  - ❑ Particle diameter: 2–100 nm
  - ❑ Surface area: 30-1100 m2/g
  - ❑ pH: 2–12
  - ❑ Modifications: ammonium, aluminate, chloride, silane, deionized



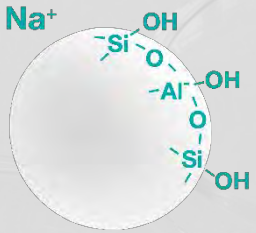
All our products are dispersed in water

Levasil® product categories



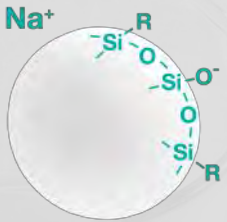
Anionic particles
Sodium or ammonia stabilized

pH 9-11



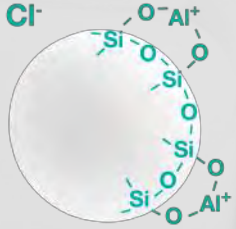
Anionic particles
Aluminate modified

pH 7-11



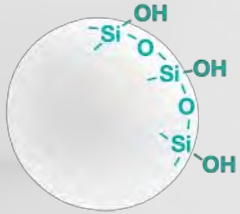
Anionic particles
Silane modified

pH 8-11



Cationic particles
Chloride stabilized

pH 3-4



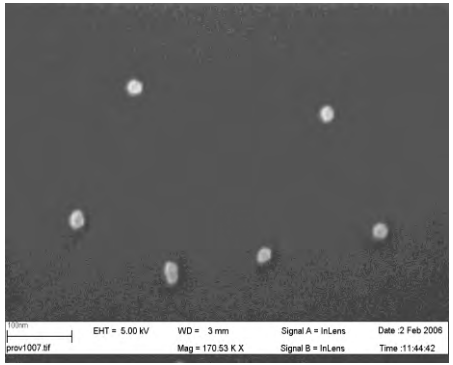
Non-charged particles
Deionized/
Electrolyte free

pH 2-3

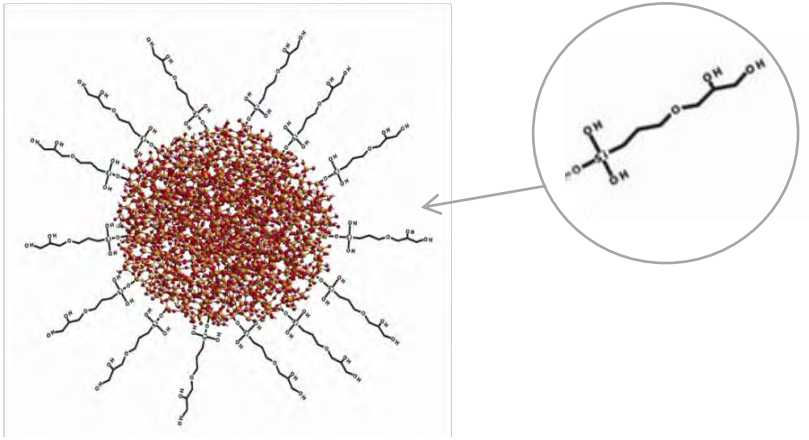
Nouryon

Silane modified colloidal silica in detail

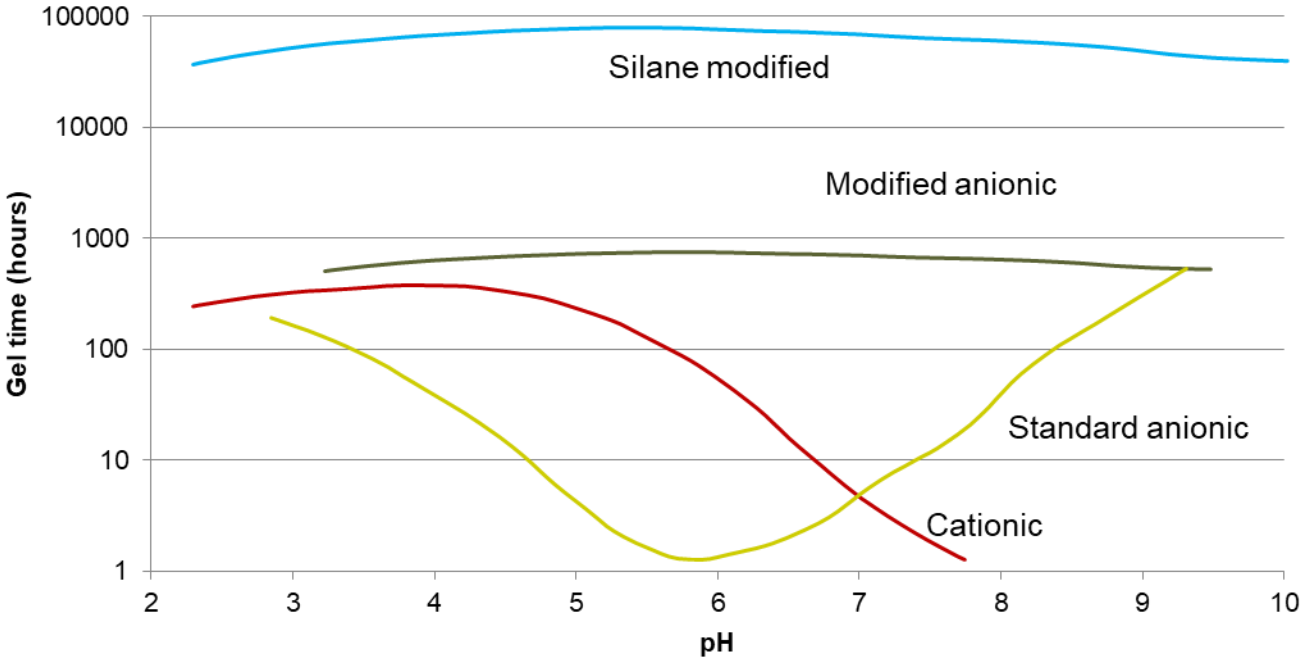
- Discrete mono-disperse particles
- Particle sizes: 5 – 12 nm
- Neutral pH and reduced sodium content is possible (both beneficial in coating area)
- Great stability throughout the pH range, 2-12
- Total solids: 15 - 40 wt-%
- Compliant with current and proposed VOC legislation, Scandinavian and EU eco labelling



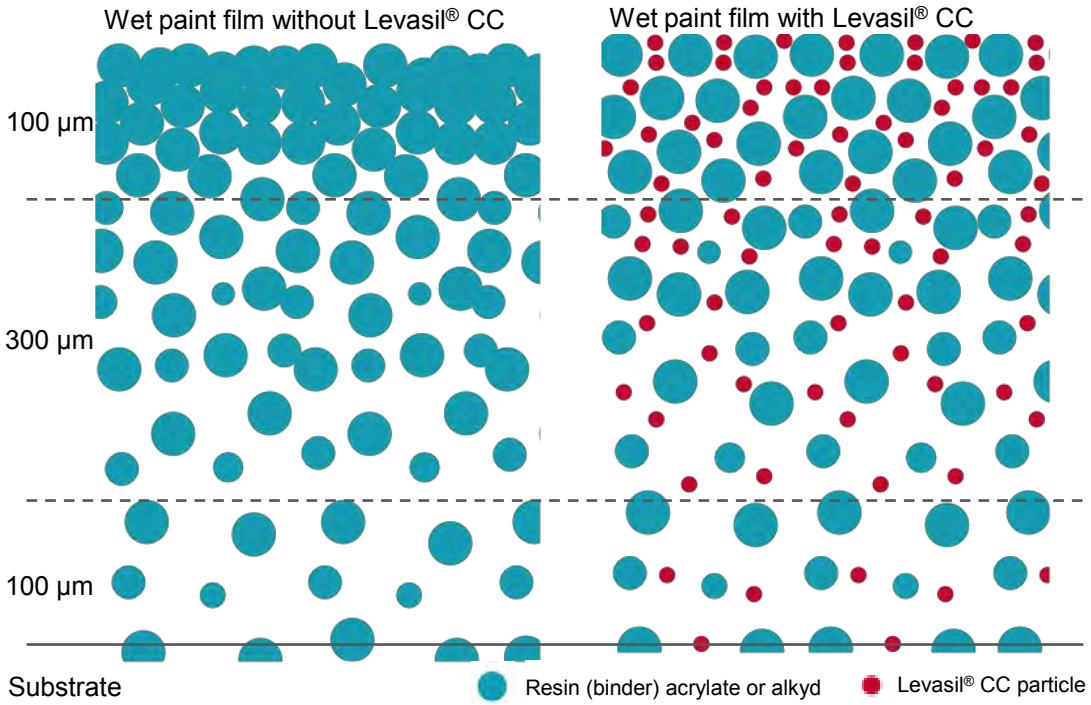
Levasil® CC301: 7 nm in size , TS=30 wt-%
Magnification: 170 000 times



Colloidal silica stability as function of pH



Levasil® CC in elastomeric roof coatings - How it works



Enrichment of Levasil® CC at the coating surface

- Enhanced coating surface hardness and less tackiness – better mechanical properties
- Reduced skin formation at the coating surface – better vapor permeability

Enrichment of Levasil® CC close to the substrate

- Improved adherence of coating to substrate – both wet and dry

Formulation example

Table 1 – Reference formulation based on ARM-91-D1 Elastomeric Roof Coating Formulation with Rhoplex/Primal EC-1791 acrylic binder, with Expancel® (18.5%) and Levasil® CC301 (10 %)

Component	Commercial name	Weight (g)
Mill-Base		
Water		46.66
Dispersant	Orotan™ 851	1.60
Dispersant	KTPP (1)	1.40
De-foamer	DAPRO™ 7580	1.90
Calcium carbonate	Snowhite™ 12	176.22
TiO_2	Kronos ™ 2160	90.00
Zinc oxide	Zoco™ 101	20.00
Let-Down		
Binder-Latex (acrylic emulsion)	Primal™ EC-1791	479.00
De-foamer	DAPRO™ DF 7005	1.90
Solvent (propanediol monoester)	DAPRO™ FX 511	7.00
Mildewcide (Fungicide)	Acticide™ MBS	2.10
Mildewcide (Fungicide)	Acticide™ MKW2	1.20
Solvent (propylene glycol)		24.40
Diisononyl phthalate (DINP)	Jayflex™ DINP	3.00
1,2-Cyclohexane dicarboxylic acid diisononyl ester	Hexamoll™ DINCH	35.00
Colloidal Silica	Levasil® CC301	124.8
Expancel®	461WE20d36	18.70
Hydrophobically modified ethylhydroxycellulose.	Bermocoll™ EBM 8000	4.20
Total		1039
Total Solid content (wt%)	56.5%	
Pigment Volume Concentration	43.1%	

(1) Potassium tetrapyrophosphate

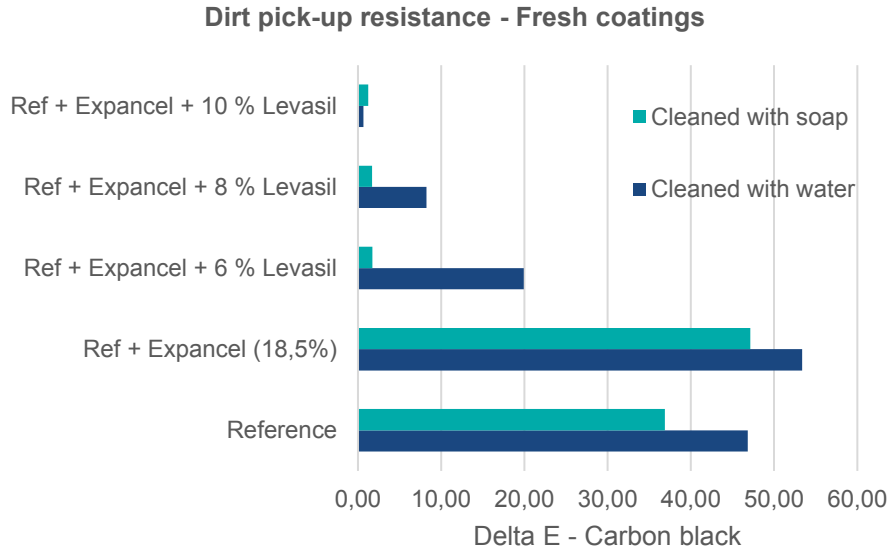
Improved long term stability

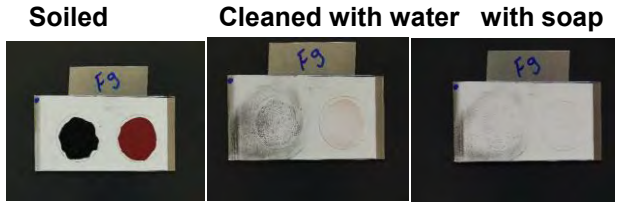
- The formulations containing Expancel® and Levasil® show improved long-term stability compared to the reference.
- The increase in formulation stability is most likely a result of the additional dispersing/stabilising effect on the system and reduced amount of calcium carbonate upon Expancel® and Levasil® addition.

Rheometer data	Initial Viscosity, (Pas), shear rate: 1/s	Viscosity (Pas) after 1 month Room Temperature, shear rate: 1/s		Viscosity (Pas) after 1 month at 50°C, shear rate:1/s	
			Viscosity increase (Pa s)		Viscosity increase (Pa s)
Reference	34.39	39.58	5.19	45.97	11.58
Ref + Expancel® (18.5 %)	18.33	18.88	0.55	18.66	**0.33**
Ref+ Expancel® (18.5 %) + 6% Levasil® CC301	28.73	29.69	0.96	29.83	**1.10**
Ref + Expancel® (18.5 %) + 8% Levasil® CC301	21.76	22.82	1.06	22.29	**0.53**
Ref + Expancel® (18.5 %) + 10% Levasil® CC301	20.71	21.47	0.76	20.67	**-0.04**

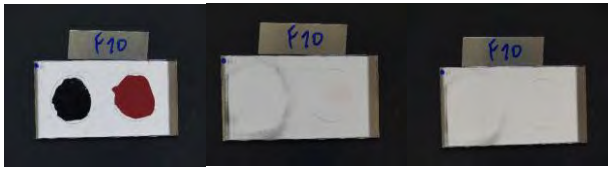
Improved dirt pick-up resistance

- Addition of Levasil® CC301 reduces dirt pick-up dramatically
- Efficient towards both hydrophobic (carbon black) and hydrophilic dirt (iron oxide)

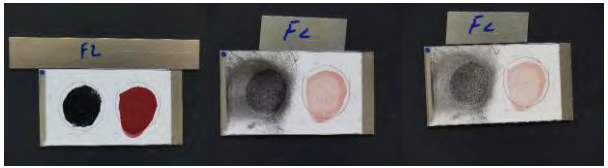




Reference + Expancel® (18.5 %) + 8% Levasil® CC301



Reference + Expancel® (18.5 %) + 10% Levasil® CC301



Reference + Expancel® (18.5 %)

Mechanical properties - Increasing strength and hardness and maintaining flexibility

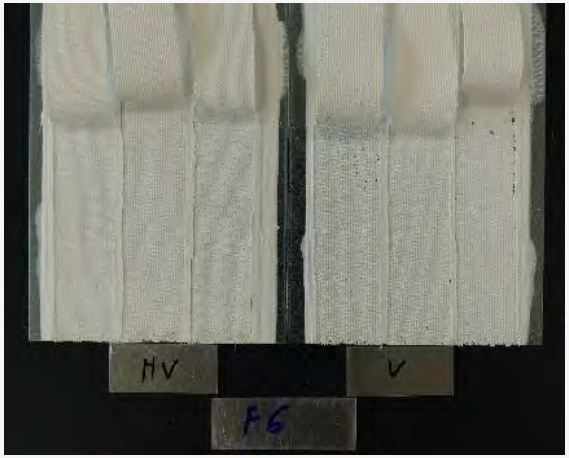
- Addition of colloidal silica improves both the hardness and the tensile strength, without detrimental effects on the elongation-at-break performance, up to 10% Levasil® CC301 dosage.
- For ASTM D6083, a value for elongation at break of ≥ 100 % is required after 1000 h of accelerated ageing. All formulations met the requirement.

	Initial			After 1000 h		
Formulation	**Hardness** Young Modulus (MPa)	**Flexibility** Elongation at break (%)	**Strength** Tensile strength (MPa)	**Hardness** Young Modulus (MPa)	**Flexibility** Elongation at break (%)	**Strength** Tensile strength (MPa)
Reference	3.61	230.56	0.89	2.80	190.59	1.10
Ref + Expancel® (18.5 %)	1.45	267.40	0.67	1.94	278.25	1.10
Ref + Expancel® (18.5 %) + 6% Levasil® CC301	2.64	224.15	0.94	9.60	185.16	1.64
Ref + Expancel® (18.5 %) + 8% Levasil® CC301	3.16	220.70	0.93	4.12	199.90	1.29
Ref + Expancel® (18.5 %) + 10% Levasil® CC301	4.24	207.60	1.04	3.86	205.39	1.16

Improved Adherence

Improvements in wet and dry adherence, particularly **wet adherence**, can be seen with Levasil® CC301 in the formulation.

Formulation	Adherence (dry) N/M	Adherence (wet) N/m
Reference (Ref)	753	256
Ref + Expancel® (18.5%)	677	388
Ref + Expancel® + 6 % Levasil® CC301	732	**632**
Ref + Expancel® + 8 % Levasil® CC301	752	**938**
Ref + Expancel® + 10 % Levasil® CC301	811	**811**



Application by brush on galvanized steel in two layers with the cloth strip in between DFT = 500 µm. Drying time 14 days @ 23°C/50% HR, traction rate= 50 mm/min, angle = 180°. Submersion in tap water during 168h prior to testing for wet adherence.

Breathability - High water vapor permeability

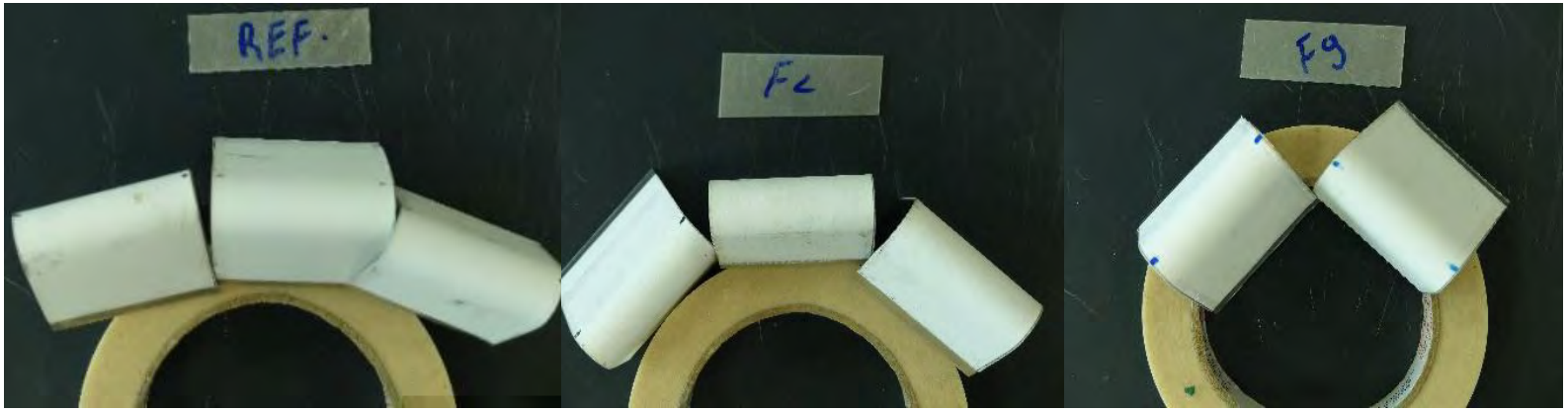
The **water vapour permeation** properties of the coatings meet the ASTM D6083 requirements (≤ 50 US perms).

Formulation	Metric Perms	US Perms (calculated)	Dry Film Thickness (µm)
Reference	5.97	9.06	530.2
Reference + Expancel® (18.5 %)	6.24	9.47	461.2
Reference + Expancel® (18.5 %) + 6% Levasil® CC301	11.48	17.42	473.4
Reference + Expancel® (18.5 %) + 8% Levasil® CC301	13.06	19.82	495.2
Reference + Expancel® (18.5 %) + 10% Levasil® CC301	19.95	30.27	489.4

The relative increase in the vapor permeability upon colloidal silica addition was significantly higher than for the reference, allowing for moisture to escape and is very likely attributed to the hydrophilic character of colloidal silica.

Flexibility meets ASTM D6083

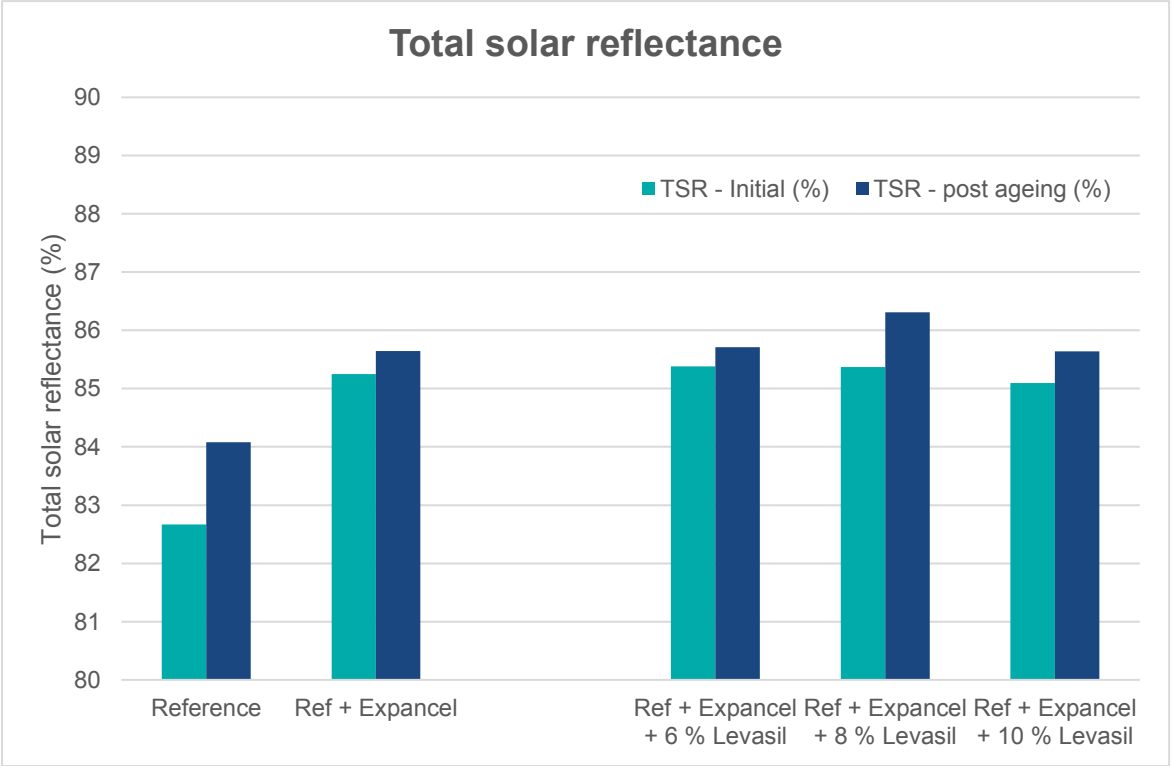
- Low temperature (-26 °C) flexibility properties of the coating are not negatively affected by the use of colloidal silica.
- Testing conducted after 1000 h of accelerated ageing.
- For ASTM D6083 a value of ≤ 13mm is required - All five tested formulations met the requirement.



Reference | Ref + Expancel® | Ref + Expancel® + 8% Levasil®

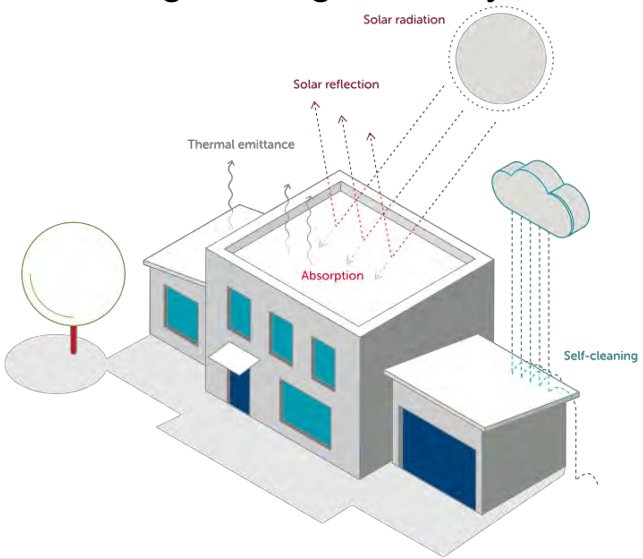
Enhanced solar reflectance

- The total solar reflectance is improved by the addition of Expancel® microspheres
- No influence on solar reflectance from addition of Levasil® colloidal silica



Expancel® and Levasil® synergies in elastomeric cool roof coatings

- High elasticity and excellent solar reflectance can be combined with outstanding dirt pick-up resistance in a cost-efficient manner.
- Strong improvement in adherence of the coating without sacrificing coating flexibility or reflectance for both fresh and aged coatings.
- Long lasting effect on dirt pick-up resistance.



Thank you for listening!

Do you want to know more?

Join us at **Torchiani's booth #605**

https://expancel.nouryon.com/ and
https://colloidalsilica.nouryon.com/