High Performance Bio-based Functional Coatings for Wood and Decorative Applications

PERFECOAT

Functional Nanomaterials

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Polyhedral Oligomeric Silsesquioxanes (POSS)

- Introduction
- Progress
- Conclusion

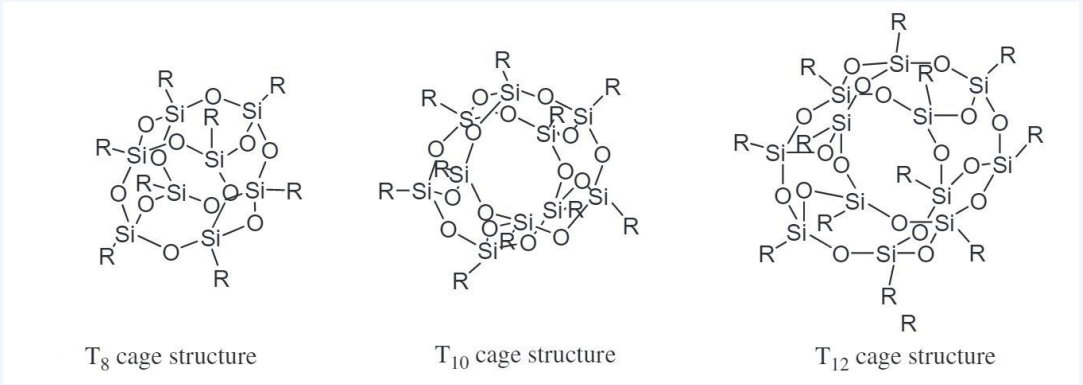
Purpose of POSS

- Hydrophobicity
- UV curing to improve the mechanical strength of coating

What is POSS?

Polyhedral Oligomer SilSesquioxsanes (POSS)

- POSS is a hybrid organic-inorganic branched polymer with organic substituents attached to an inorganic silica core.
  - ➢ Mix of cage structures.
  - ➢ The inorganic silica core gives stability.
  - ➢ Organic modifications of the R-groups can be tailored to desired functionalities.
- POSS improves performance without compromising mechanical properties and is used in various applications.
  - ✓ High performance / high efficiency
  - ✓ Low dosage => does not affect mechanical properties
  - ✓ Thermostability and UV-stability (Si-O-bonds)



T_8 cage structure T_{10} cage structure T_{12} cage structure

POSS means

Polyhedral – three dimensions with flat polygonal faces, straight edges and sharp corners or vertices

Oligo – the existence of a small number of units

Sil – silicon

Sesqui – each Si atom is bonded to 1.5 oxygen

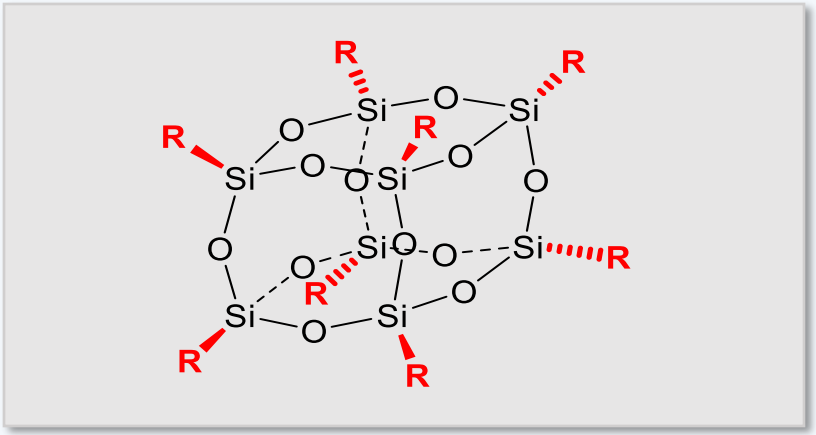
ane – Si atom bonds to one hydrocarbon group

POSS

- **Polyhedral Oligomer SilSesquioxsanes (POSS)**
- POSS is made of the inorganic Si-O-Si cage and R groups (arms) which are organic in nature
- R groups can either be reactive or non-reactive
- Reactive R = aminopropyl, vinyl, 3-chloropropyl,methacrylate, acrylate etc.
- Non-reactive R = methyl, propyl, isobutyl etc

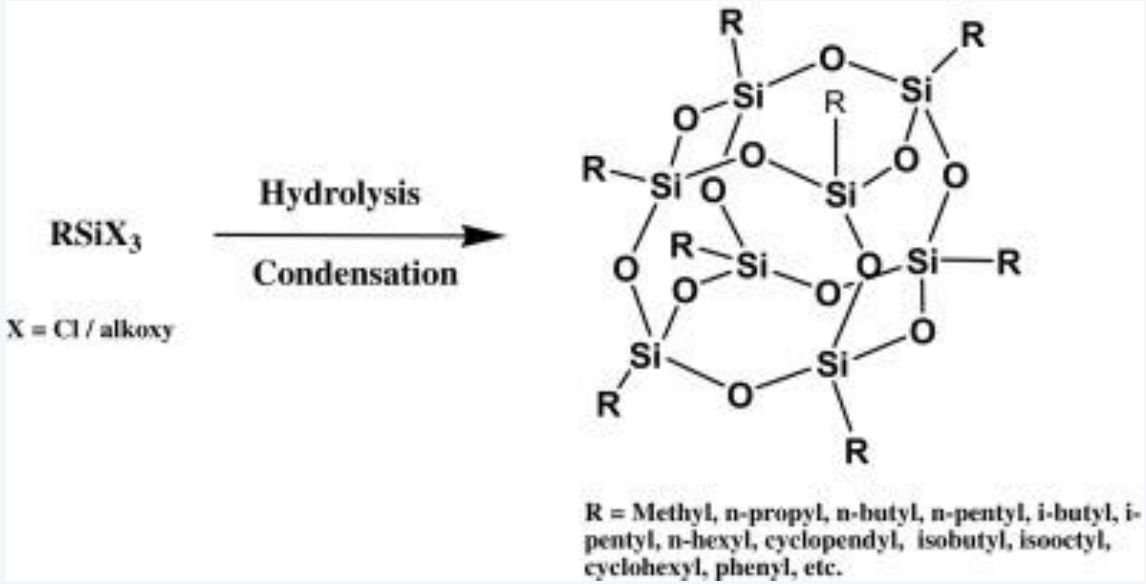
Advantages & Benefits

- Cost-efficient Sol-Gel process
- A versatile technology platform
- Solids – Solutions – Emulsions – Dispersions
- High-performing nanotechnology



POSS synthesis

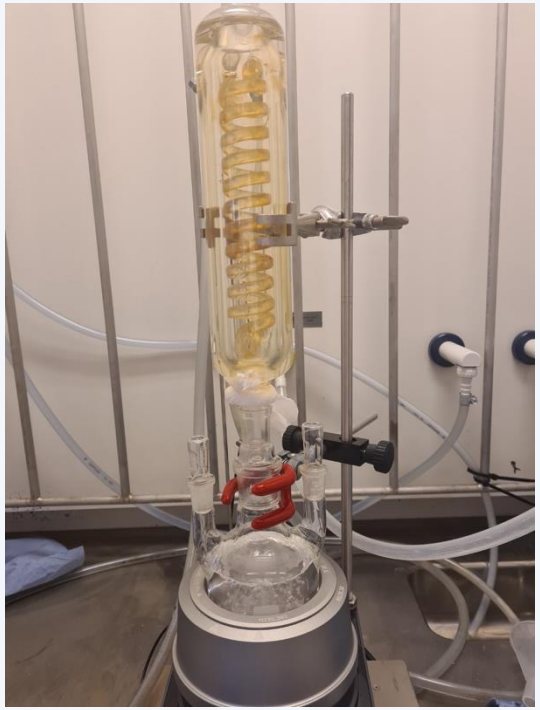
- Alkoxysilanes
- Water
- Catalyst
- Solvent



Introduction

Where POSS is born

Small scale equipment



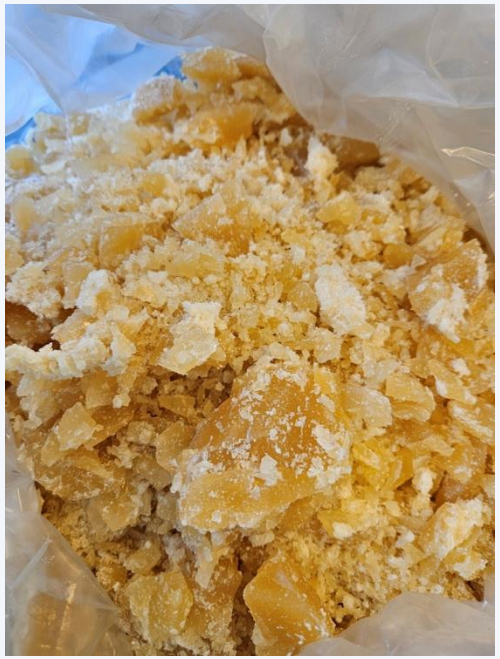
2L reactor

Pilot-scale reactor – 30L

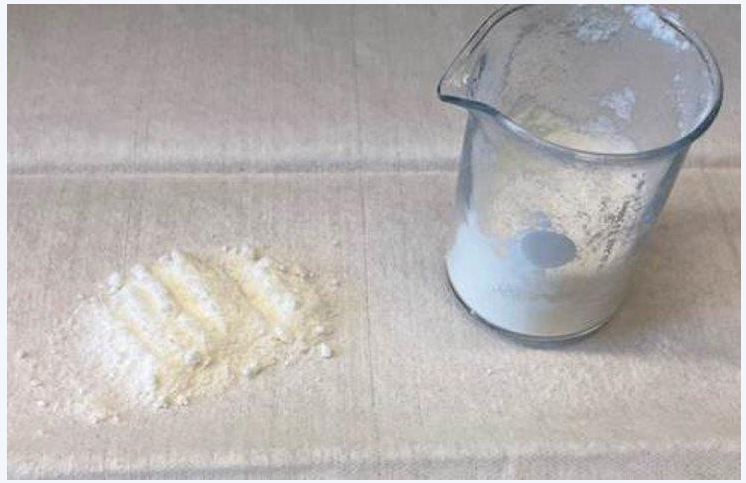
Physical state of POSS

Viscous liquid

Solid



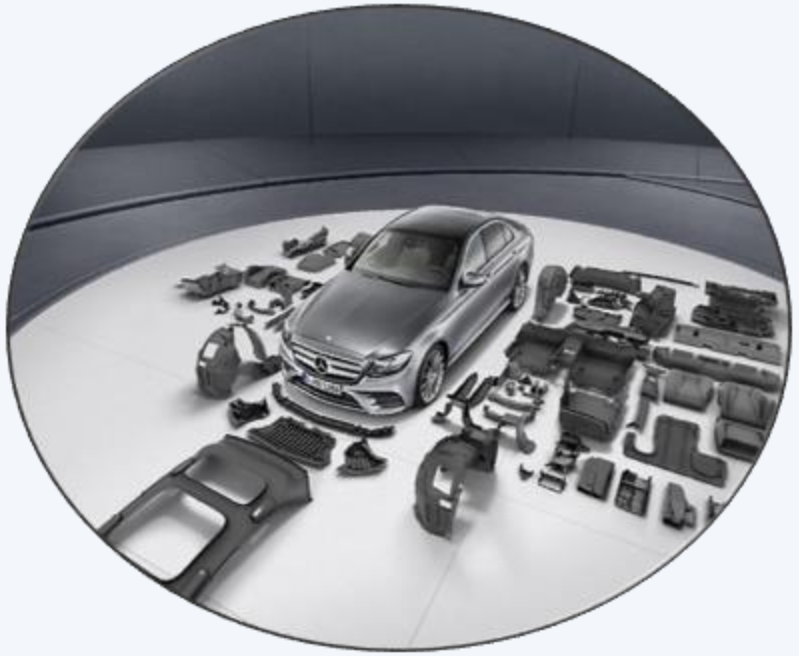
Powder



Introduction

Located at Herøya Industrial Park - Porsgrunn, Norway

Main areas of POSS application in Bioenvision



Flame retardants
- D-PYRE® portfolio

Water-repellent/
Gas and Moisture Barriers
- Funzionano® portfolio

Confirmed (✓) and opportunities (•) for D-PYRE® technology

Based on Base Material

- ✓ **Polyvinyl Chloride**
- ✓ **Polypropylene**
- ✓ **Polyurethane**
- ✓ **Adhesives**

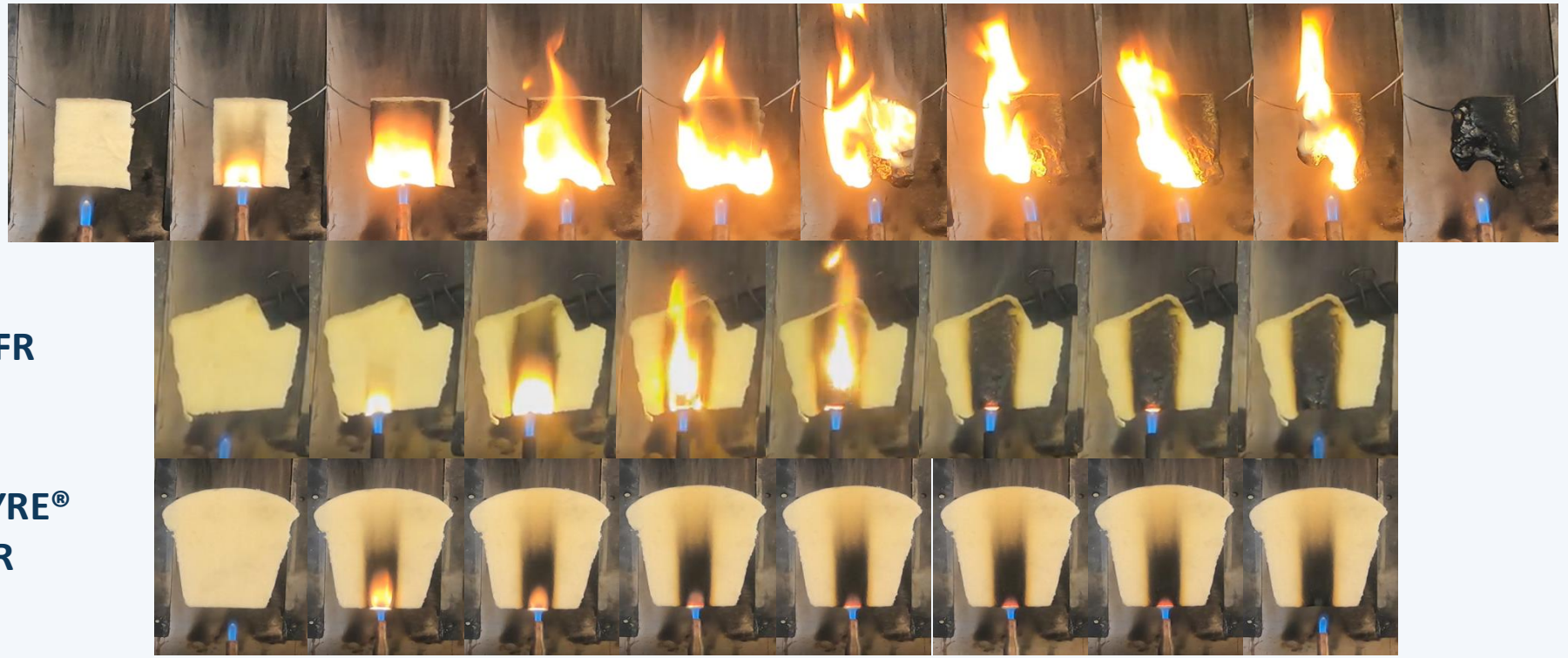
- Polycarbonate
- Polyethylene
- Polyethylene Terephthalate
- Polystyrene
- Polyesters Unsaturated

D-PYRE® in PU FOAM

Without FR additives

With standard FR additives

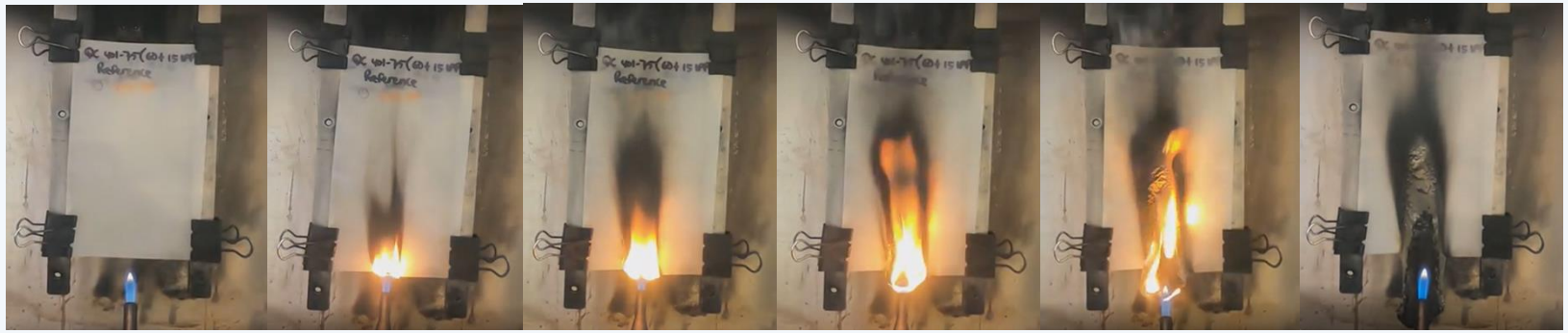
With 1.5% D-PYRE® and standard FR additives



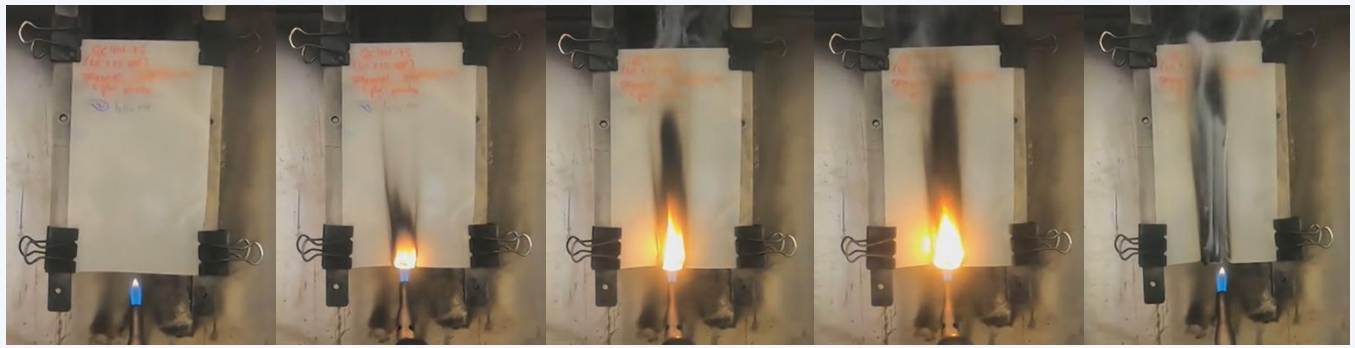
* 5 sec Sequence of pictures from video

Performance of D-PYRE® in high-plasticised PVC

PVC ***without*** D-PYRE®



PVC ***with 1 PHR*** D-PYRE®



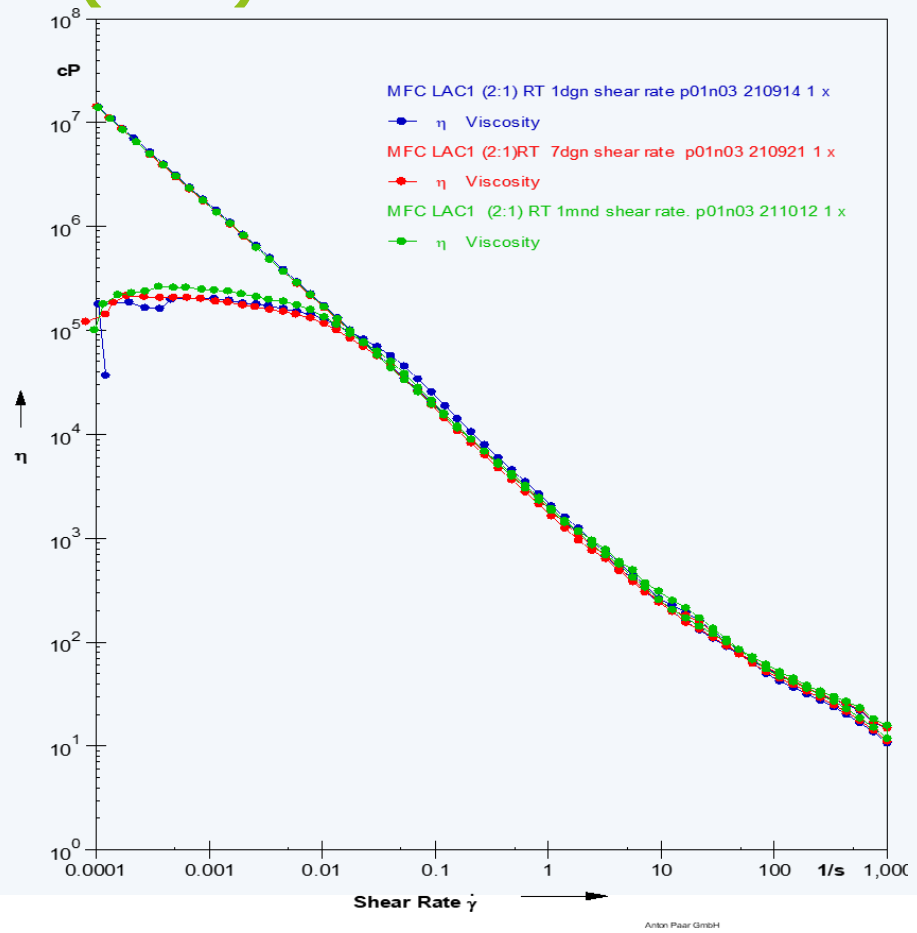
*** 10 sec sequence of pictures from videos**

Synergism hydrophilic POSS with micro fibrillated nano cellulose (MFC)

- MFC is used as a rheology modifier
- The MFC used here is Exilva, which is 100% bio-based. (From Borregaard AS)
- In this case we see the homogeneous dispersion of hydrophilic POSS and MFC

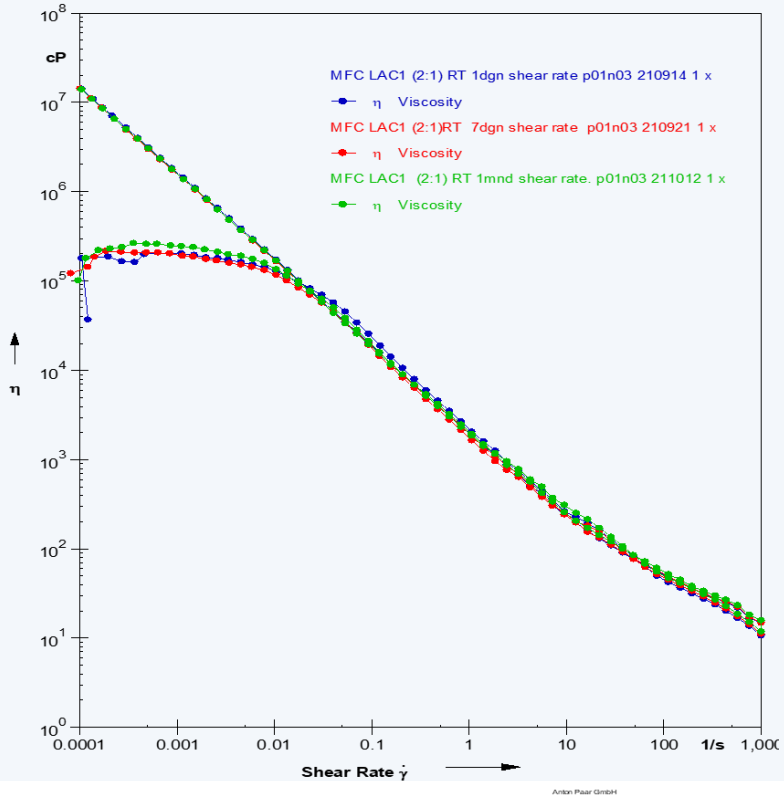
Synergism with micro fibrillated nanocellulose (MFC)

- Viscocity tests were performed at Sintef.
- The dispersion's viscosity is unchanging over one month.

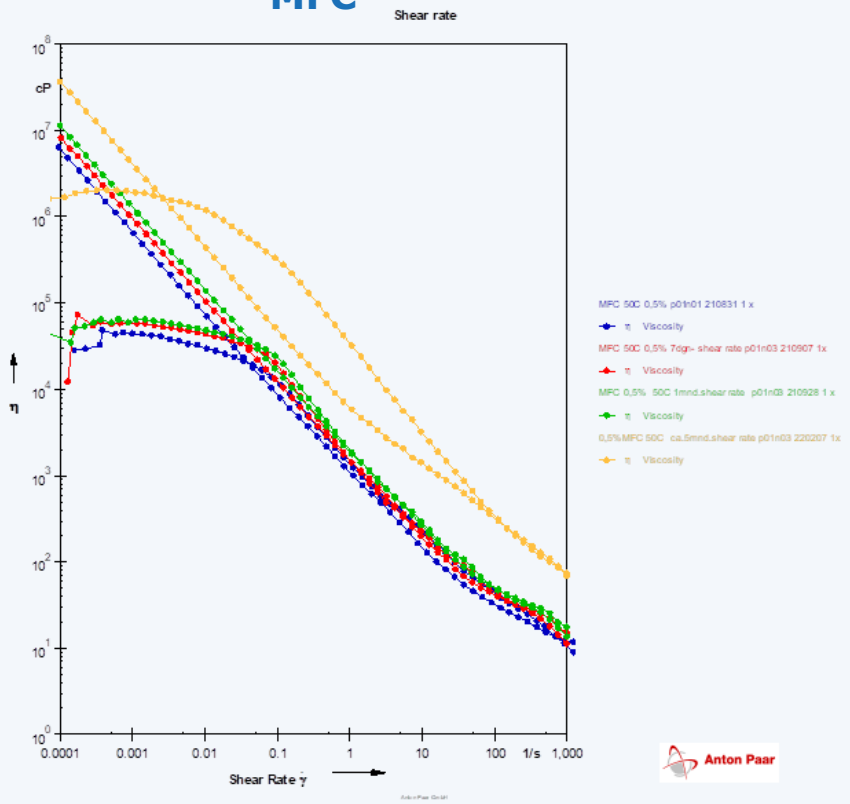


Viscosity of MFC compared to MFC+POSS with time.

MFC+POSS

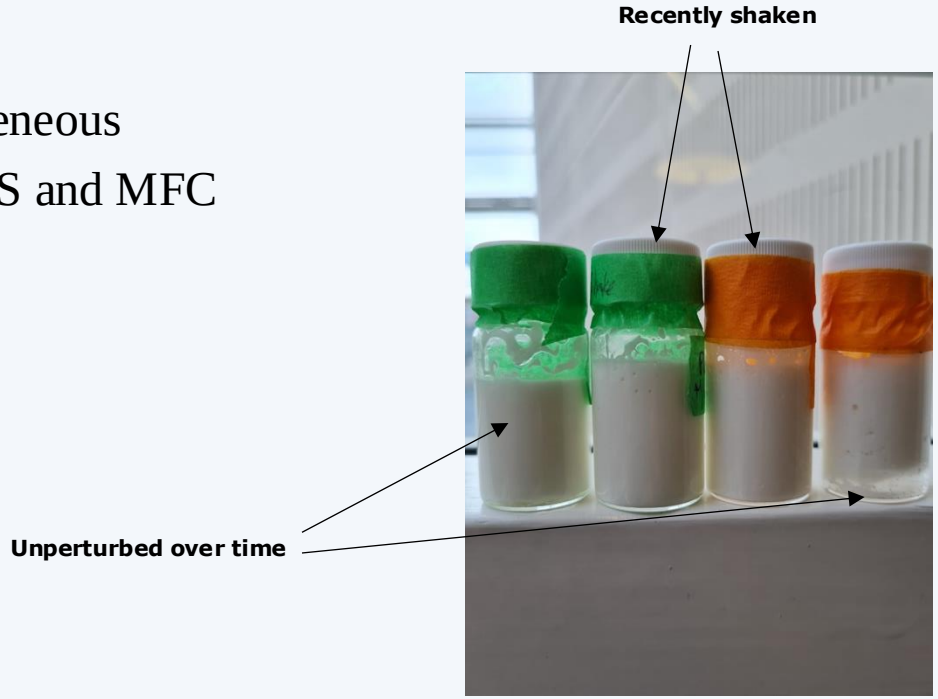


MFC



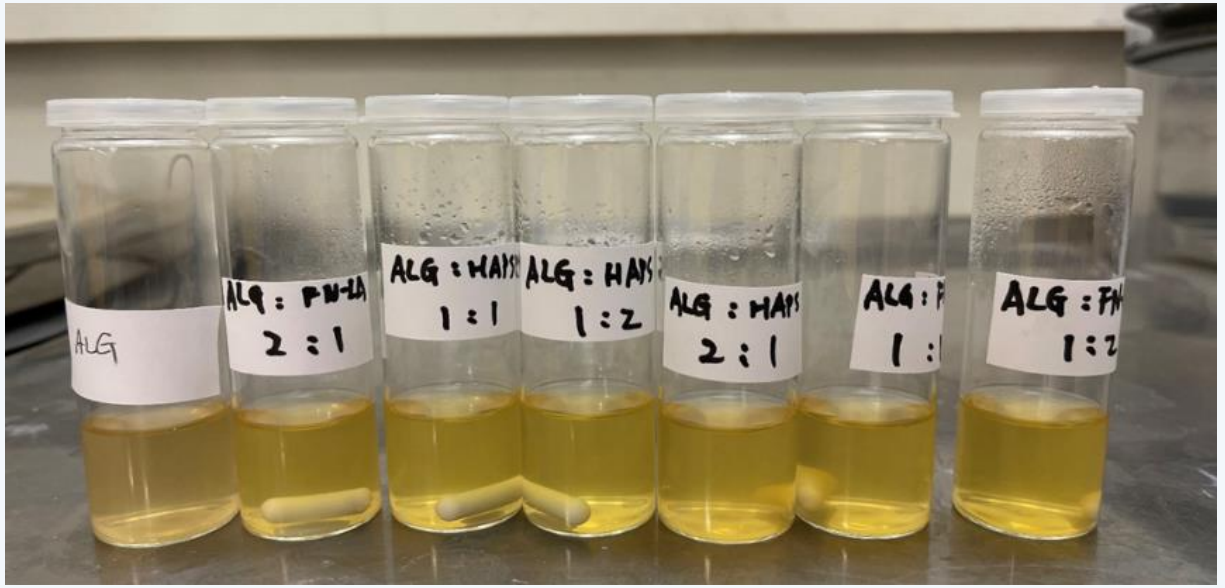
Synergism hydrophobic POSS with micro fibrillated nano cellulose (MFC)

- In this case we see the homogeneous emulsion of hydrophobic POSS and MFC when a defoamer is used.
- Green are with defoamer
- Orange are without defoamer



Synergism with alginate

- Two different hydrophilic POSS formed a homogenous mixture with alginate.



Hydrophobicity

- We see no improvement in the hydrophobicity of the coating

Formulation	No POSS	POSS	POSS in emulsion	No POSS	$CaCO_3$ coated POSS
WCA before watering / °	81-73	97-85	93-82	107 - 96	105 - 100
WCA after watering / °	99-94	101-96	101-88	90 - 78	99 - 95

Martindale anti-scratch test of UV POSS done at Evonik

Without filler	7.5% benchmark filler	7.5% UV POSS
		

Martindale anti-scratch test UV POSS done at Evonik

7.5% benchmark filler + 7.5% UV POSS

15% benchmark filler

15% UV POSS

Conclusion

- Hydrophobicity was not significantly imporved after POSS inclusion.
- Good synergy between POSS and MFC in both the hydrophilic POSS and hydrophobic POSS (with the help of a defoamer)
- Good synergy between POSS and alginate.
- Low amounts of POSS (5-7.5%) have a significant effect on the mechanical strength of the coating.

Thank you. ☺