VeoVa™ Silane

WORKS

HEXION™

Responsible Chemistry

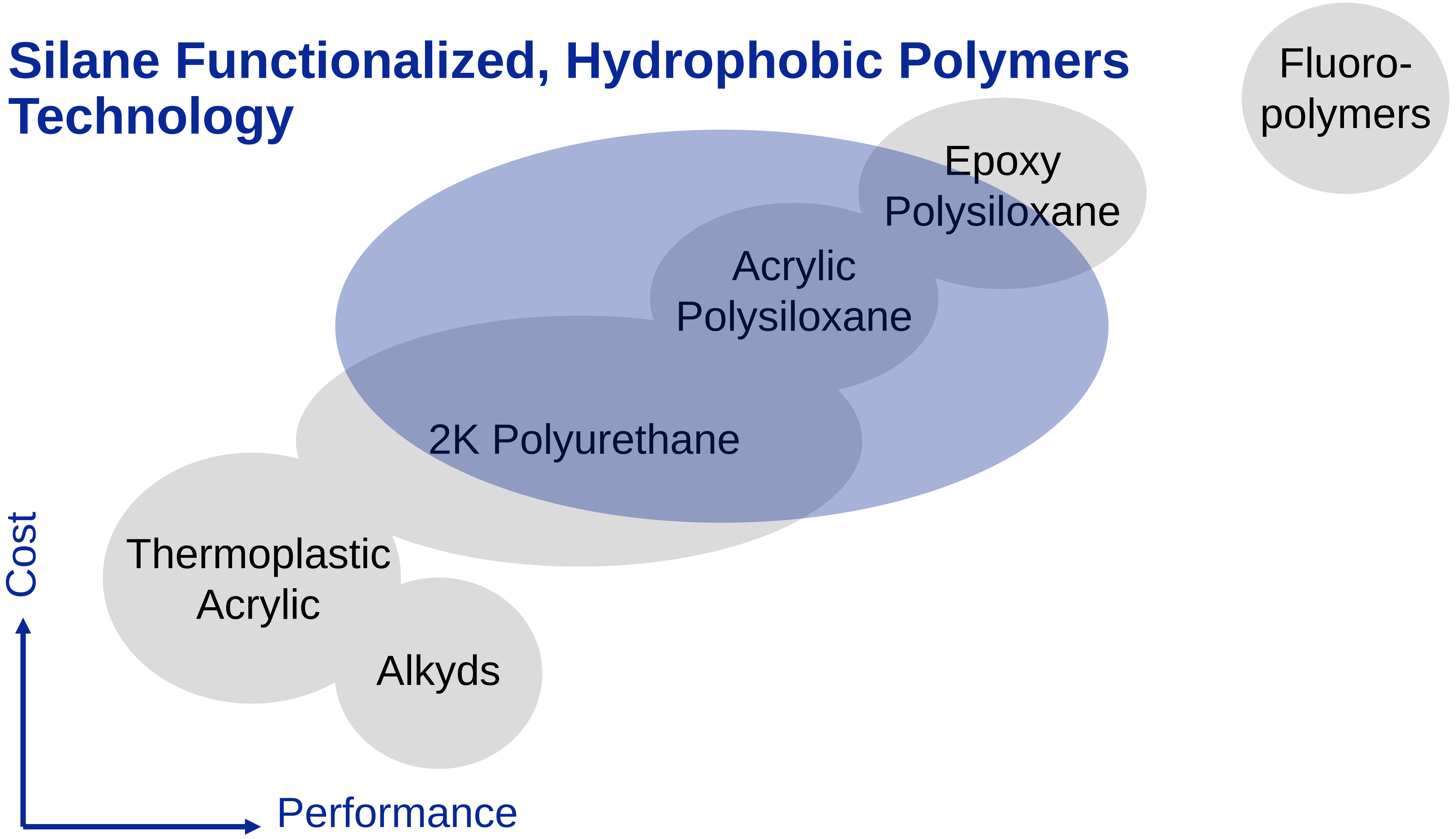
Silane Functionalized, Hydrophobic Polymers for Moisture Curing, Isocyanate-Free Protective Topcoats

Coatings Trends & Technologies Summit
September 7, 2023

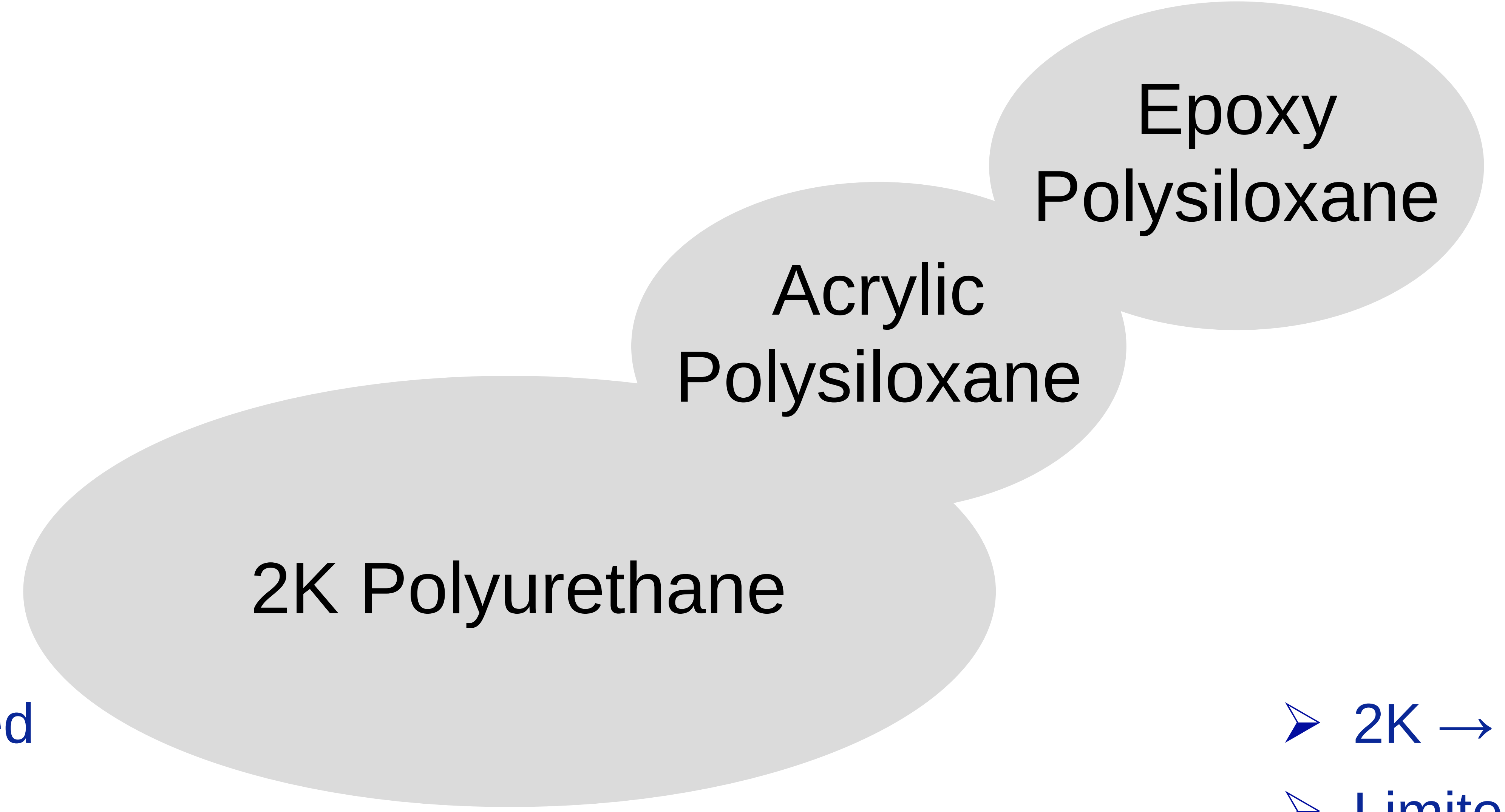
Nathalie Havaux

Silane Functionalized, Hydrophobic Polymers, a Novel 1K and 2K Moisture Curing Alternative to 2K Polyurethane Coatings

Silane Functionalized, Hydrophobic Polymers Technology



2K Polyurethane Advantages - Disadvantages



- Well established
- Long shelf life
- Fast cure
- High gloss
- High durability
- Excellent mechanical properties

- 2K → 2 components to handle
- Limited pot life after mixing
- Toxic isocyanates
- Curing not fast enough
- Expensive

Trends Driving Innovation in the Coatings Industry

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Responsible Chemistry

- Increasing concern about the **negative health effects** of components in coating formulations
- Trend towards ease of use (1-pack) and **waste reduction**
- Solvent borne 2-pack binders (polymer + cross-linker) are used for high performance coatings on metal, wood and plastic
- **Isocyanates** are used as cross-linker in some 2-pack coatings. Are under increasing **environmental pressure**

NØ nasties

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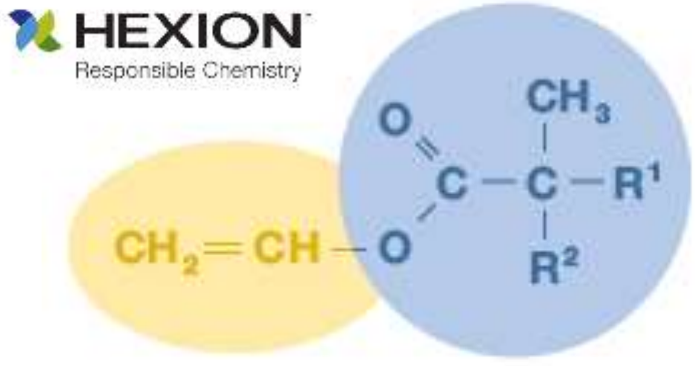
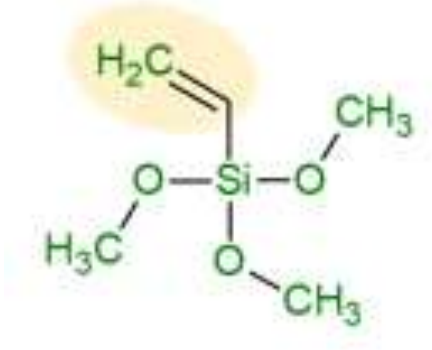


Vinyl neodecanoate

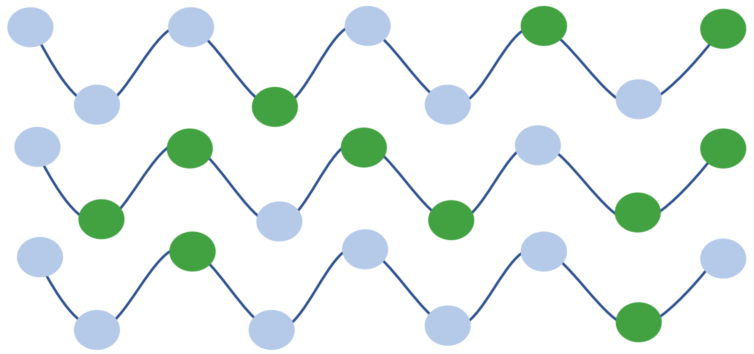
+

2



Silane functional monomers

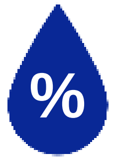
3



Vinyl silane polymer

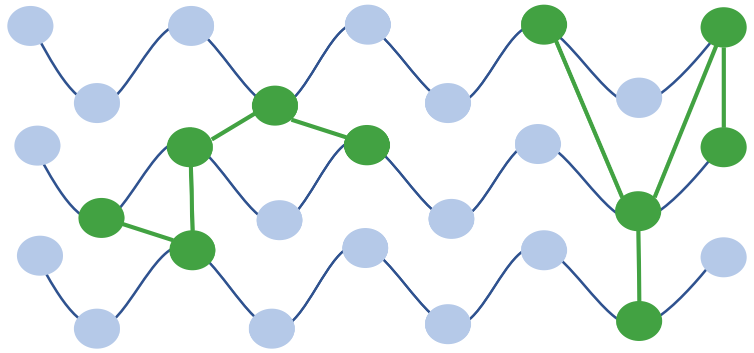
Coating application

4



Moisture curing

5



Cured coating

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Paint formulation

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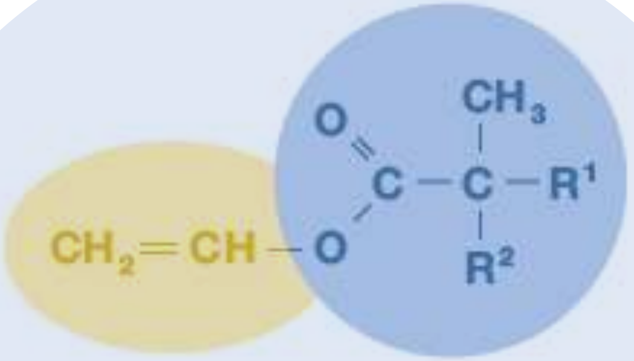
Topcoats

Silane Functionalized, Hydrophobic Polymers Technology Concept Outline



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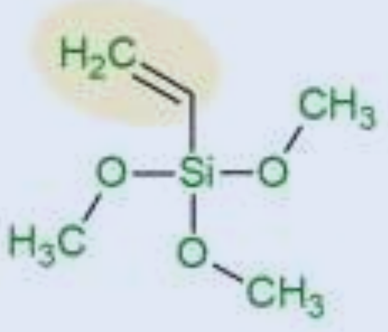
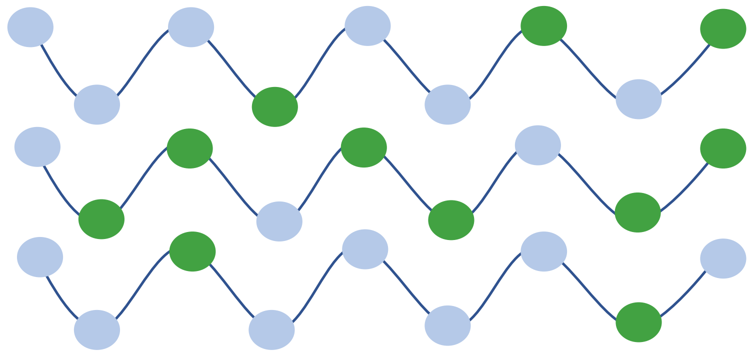
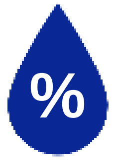


Silane functional monomers

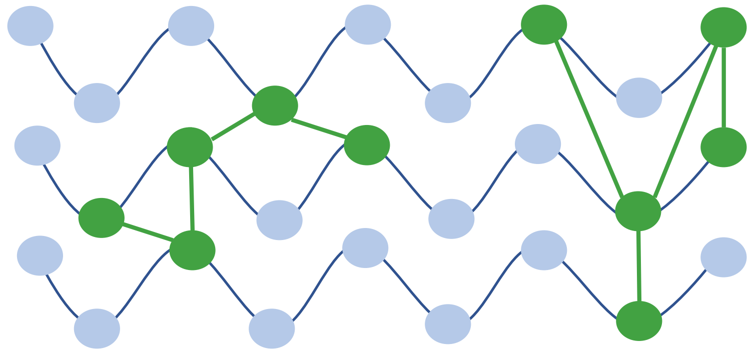


Vinyl silane polymer

Coating application



Moisture curing



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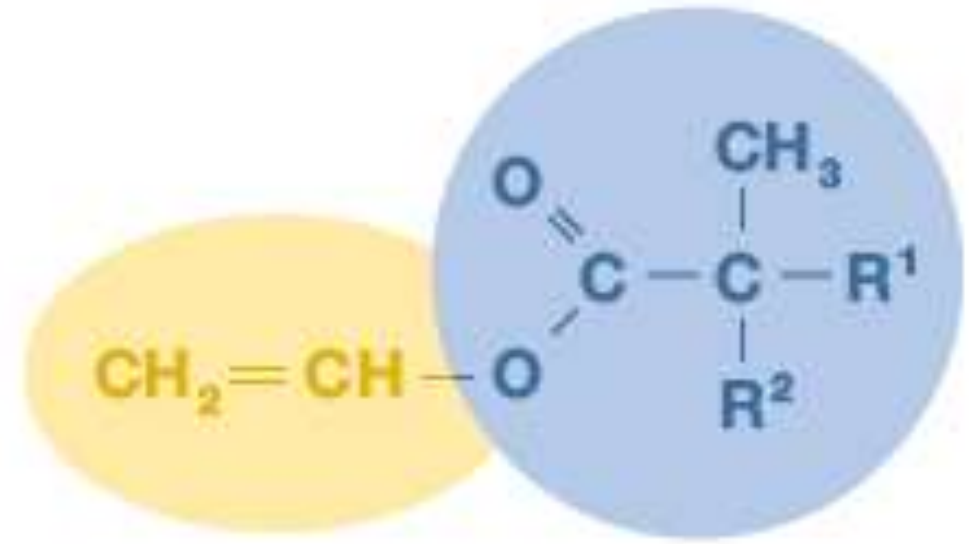
Topcoats

Vinyl Monomers

Vinyl ester

- Easily copolymerisable with vinyl acetate and (meth)acrylates



$R^1 + R^2$ = 7 carbon atoms

Vinyl neodecanoate

Tg = -3°C

$R^1 + R^2$ = 6 carbon atoms

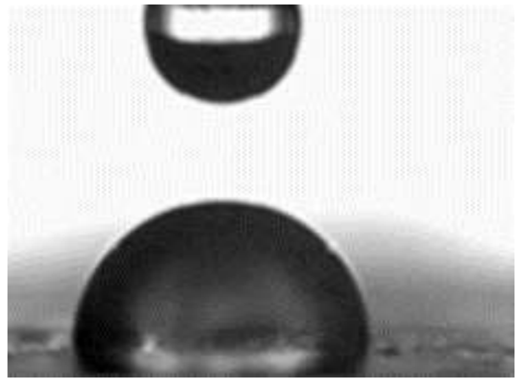
Vinyl neononanoate

Tg = +70°C

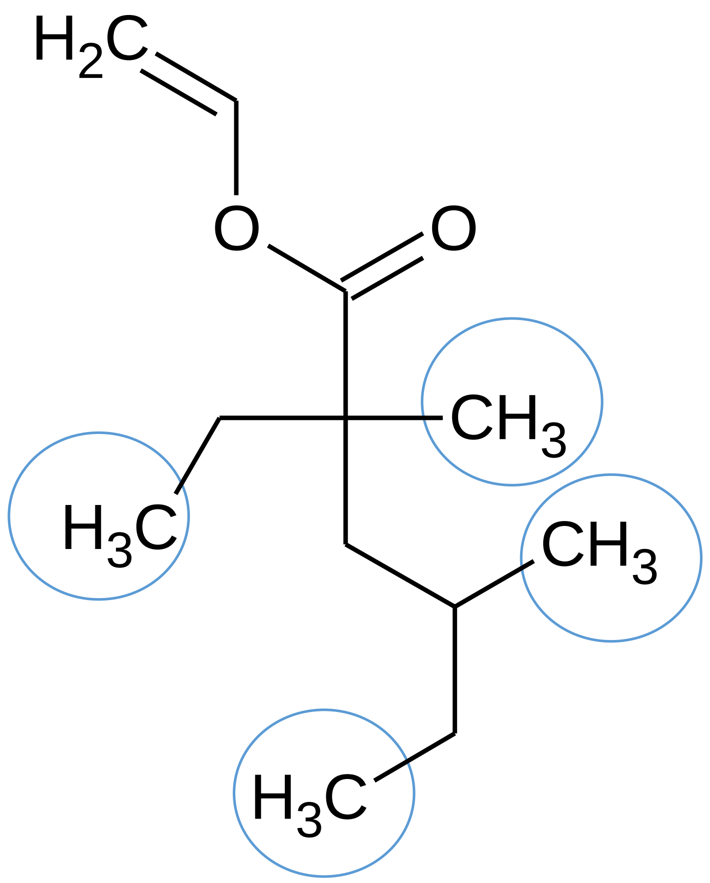
Aliphatic bulky structure

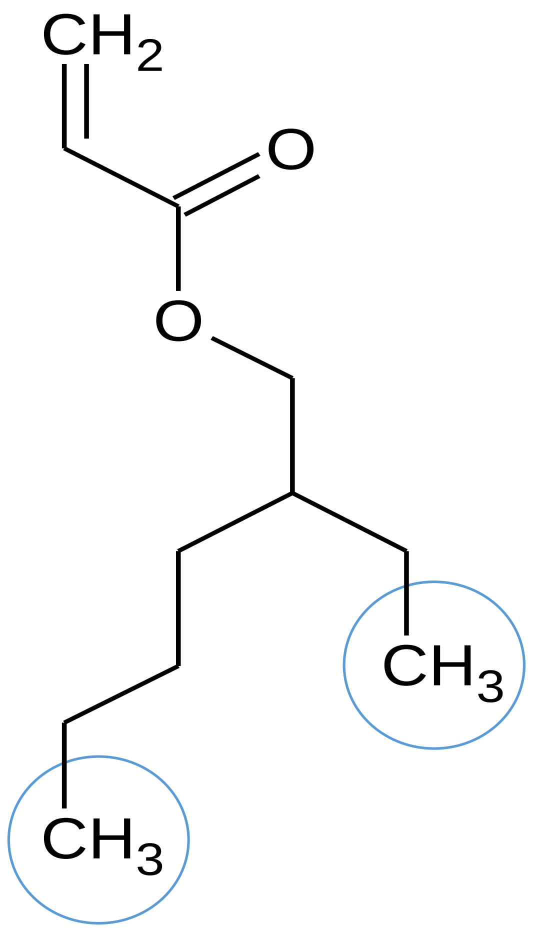
Structure:
- Bulky alkyl chain
- Sterically protected ester group

Performance:
- Hydrophobicity
- Hydrolytic stability
- UV stability
- Low surface tension



Vinyl Neodecanoate Compared to 2-Ethylhexyl Acrylate

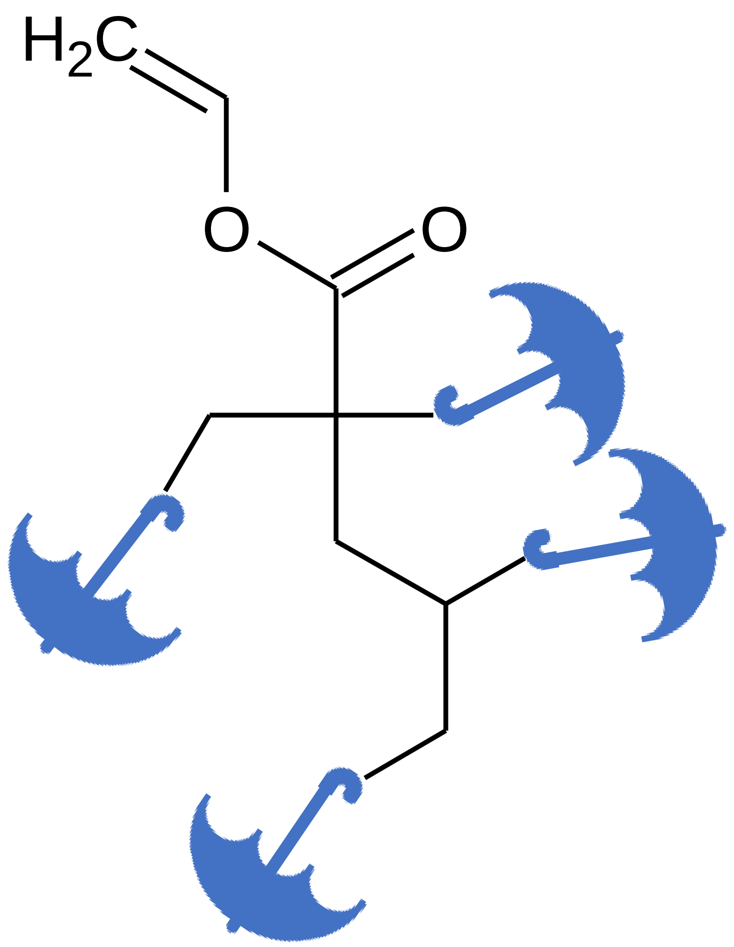




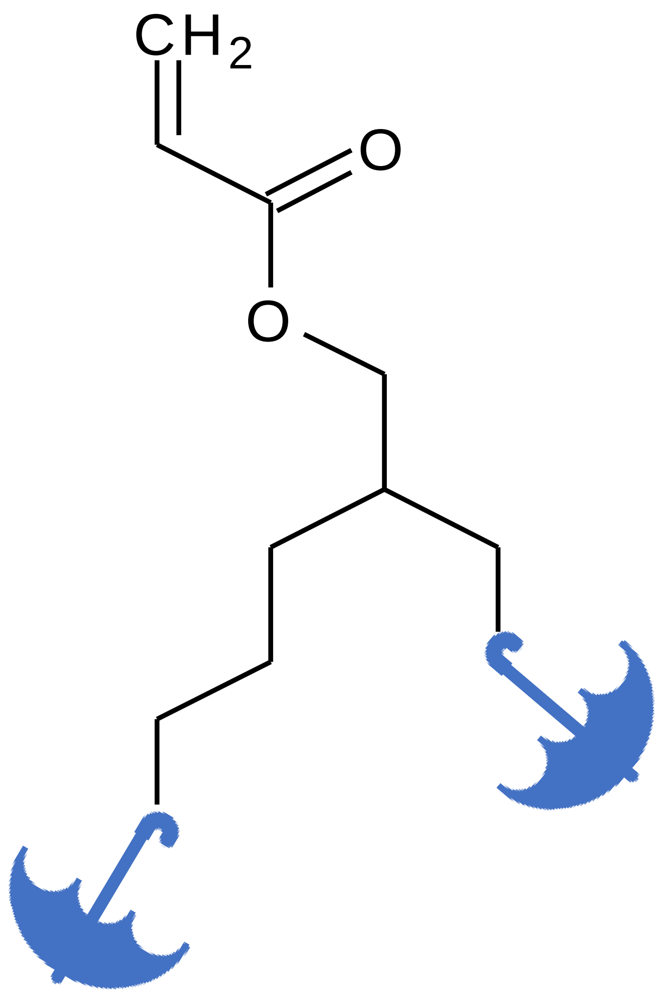
Typical structure of Vinyl Neodecanoate
4 Methyl Groups

Structure of 2-Ethylhexyl Acrylate
2 Methyl Groups

Vinyl Neodecanoate Compared to 2-Ethylhexyl Acrylate



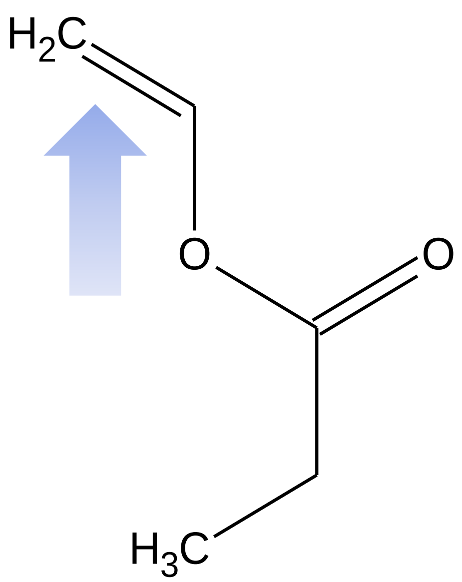
Vinyl Neodecanoate



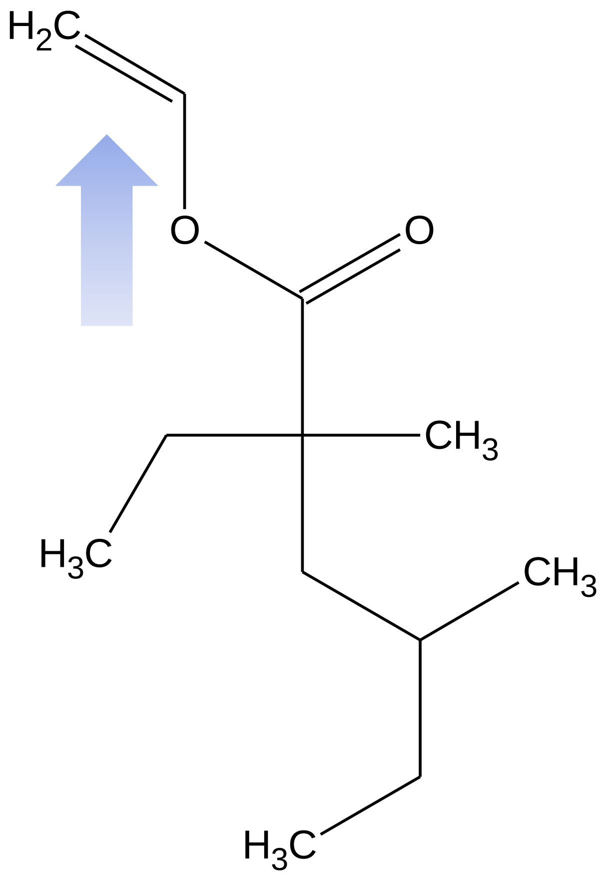
2-Ethylhexyl Acrylate

Lower surface tension ➔ Improved coating durability

Vinyl Neodecanoate Reactivity Compared to Acrylates

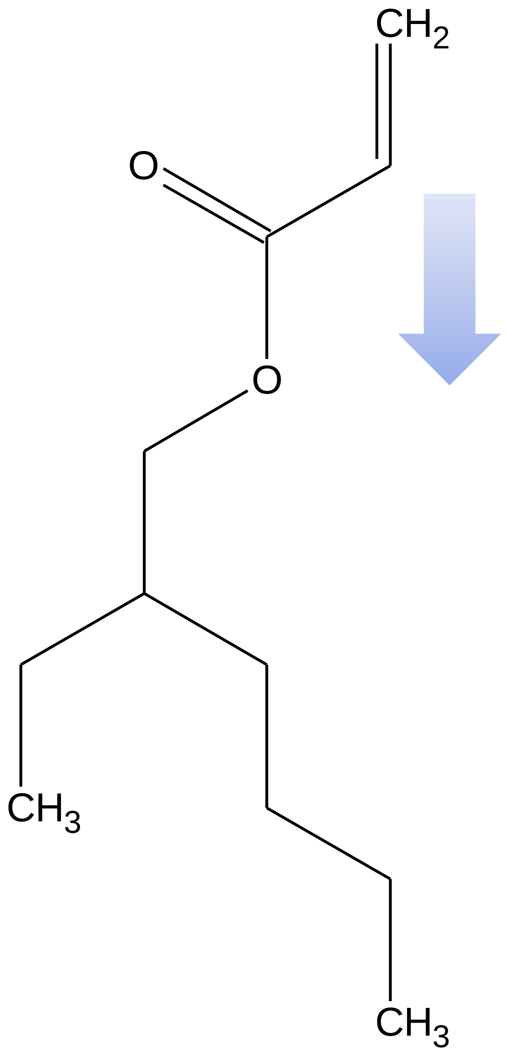


Vinyl acetate



Vinyl neodecanoate

Ester donates electrons to the vinyl group



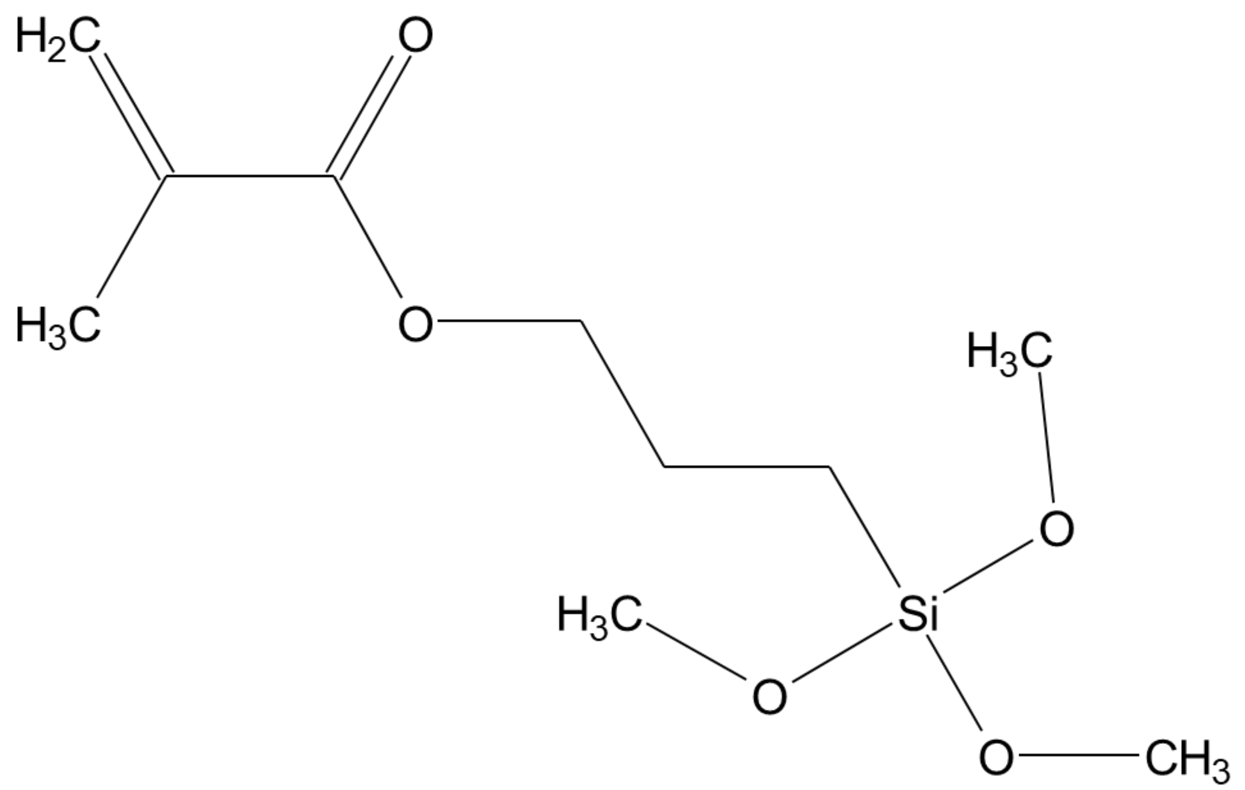
2-Ethylhexyl acrylate

Ester withdraws electrons from vinyl group

The reactivity of the double bond of vinyl esters differs from that of (meth)acrylate

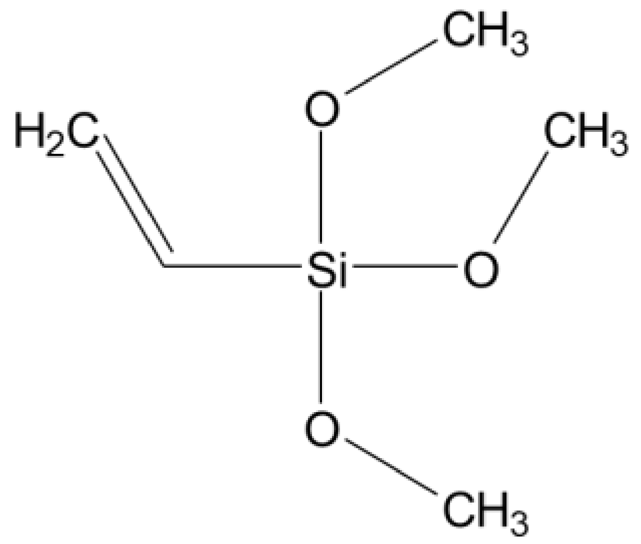
Alkoxysilane Monomers

Methacryloxypropyl tri-Methoxy Silane



- Well-known monomer
- 3 Methoxy silane groups
- C=C good reactivity with methacrylic monomers

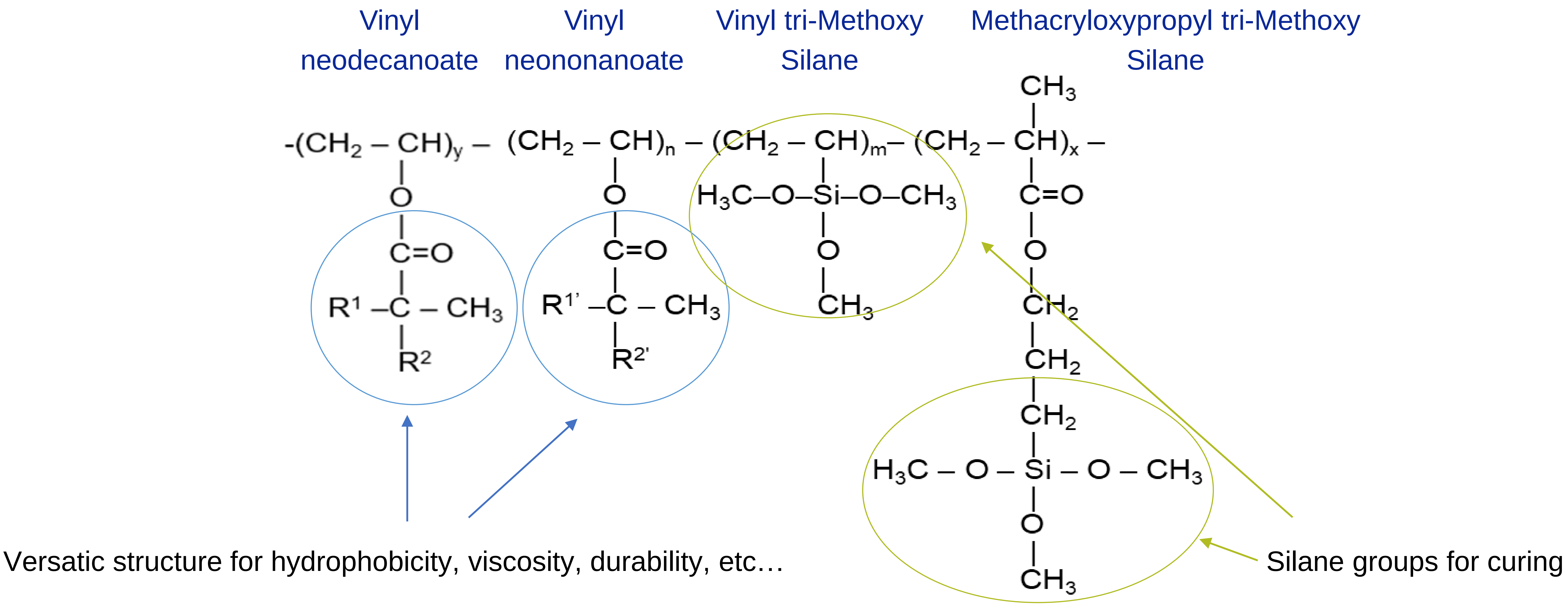
Vinyl tri-Methoxy Silane



- Well-known affordable moisture scavenger
- 3 Methoxy silane groups
- C=C poor reactivity with methacrylic monomers
  Excellent reactivity with vinyl esters

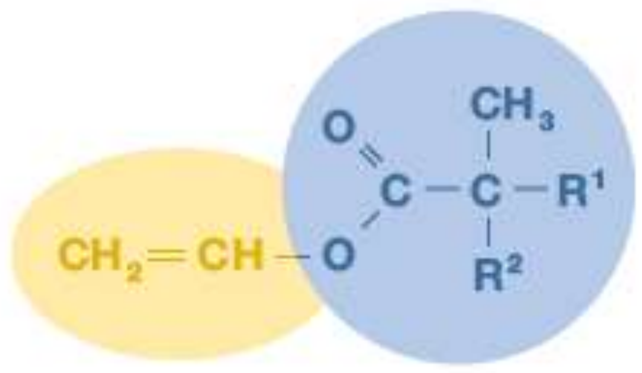
Vinyl silanes and vinyl Neodecanoate are excellent partners for radical polymerisation

Typical Silane Functionalized, Hydrophobic Polymers

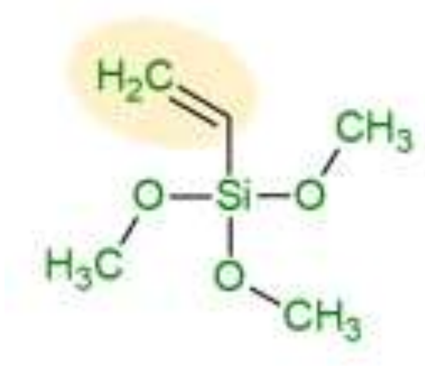


Polymers combining hydrophobic and reactive groups

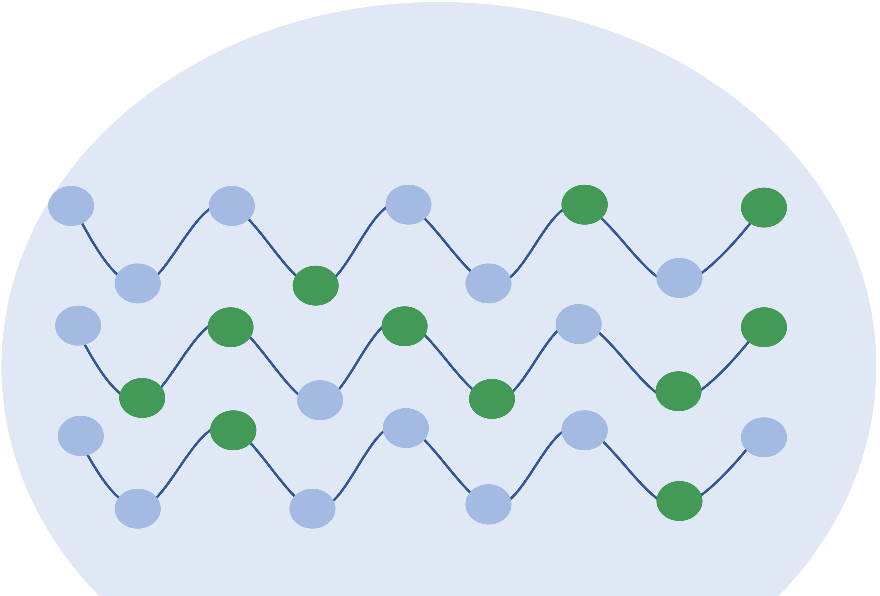
Silane Functionalized, Hydrophobic Polymers
Technology Concept Outline



Vinyl neodecanoate

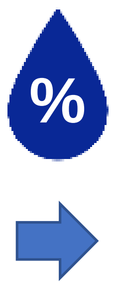


Silane functional monomers

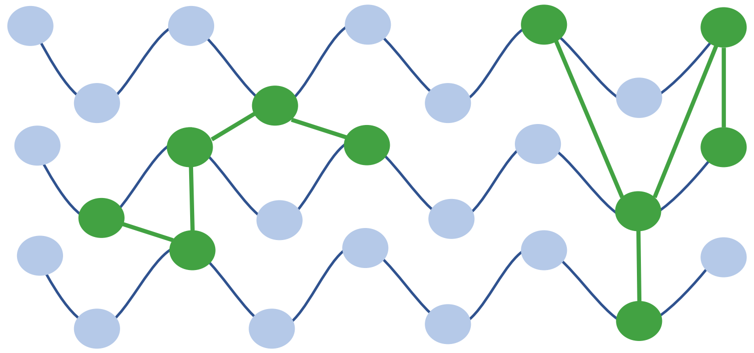


Vinyl silane polymer

Coating application



Moisture curing



Cured coating

Clearcoats

Paint formulation

Topcoats

One Example of Resin Composition and Properties

Composition	Weight phm (per hundred monomers)	Purpose
Vinyl silane	0 - 35	Crosslinking
Methacrylic silane	0 - 15	Higher curing rate
Vinyl neononanoate	0 - 95	High Tg (+70°C) vinyl ester
Vinyl neodecanoate	0 - 95	Low Tg (-3°C) vinyl ester
Organic peroxide	2 - 6	Molecular weight control
Butyl acetate	0 -30	Dilution, viscosity control

Process	Variable	Purpose
Temperature	80 – 140°C	Molecular weight control
Reaction time	2 – 6 hours	Ease of process

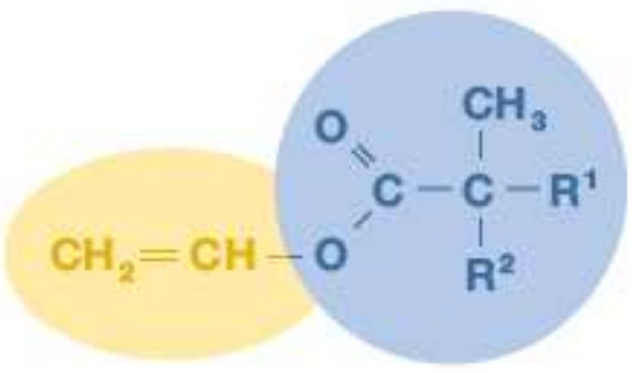
Other monomers like acrylates or vinyl acetate are also usable

Polymer Recipe Variables

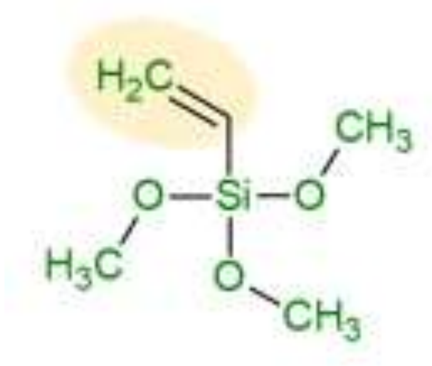
Composition	Weight phm (per hundred monomers)
Vinyl tri-Methoxy Silane	20
Methacryloxypropyl tri-Methoxy Silane	5
Vinyl neononanoate	50
Vinyl neodecanoate	25
Organic peroxide	4
Butyl acetate	25

Properties	
Solid content (%)	80
Molecular weight (g/mole)	12 000
Viscosity (mPa.s)	10 000
Free monomer (%)	0.3

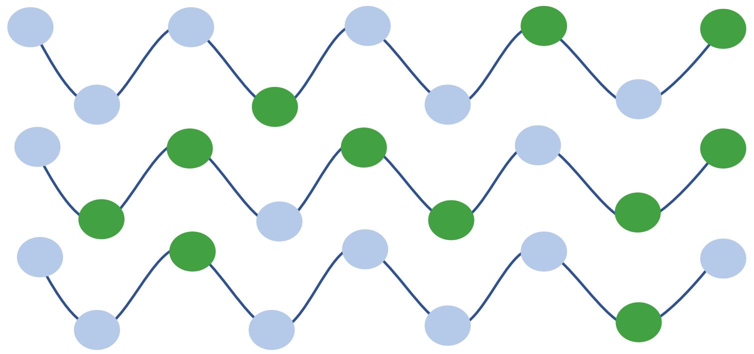
Silane Functionalized, Hydrophobic Polymers Technology Concept Outline



Vinyl neodecanoate

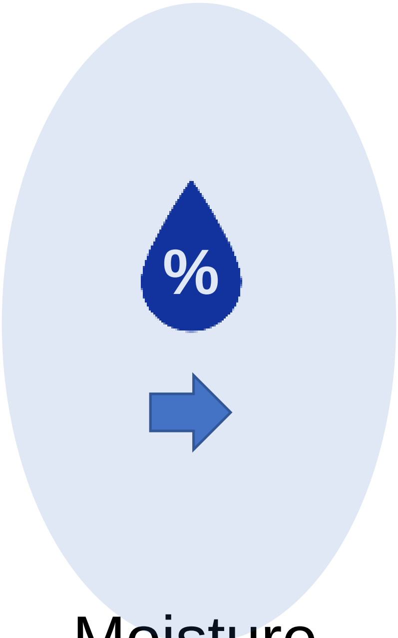


Silane functional monomers

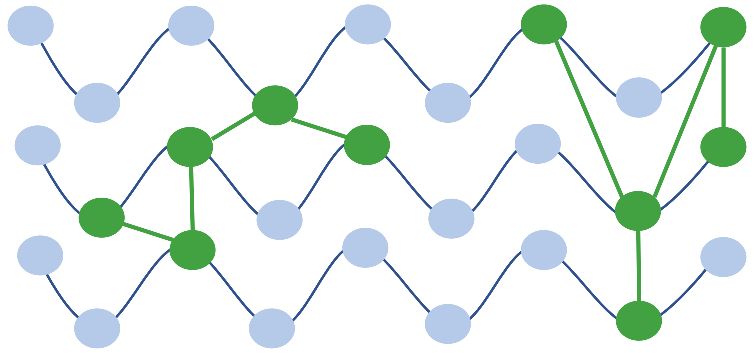


Vinyl silane polymer

Coating application



Moisture curing



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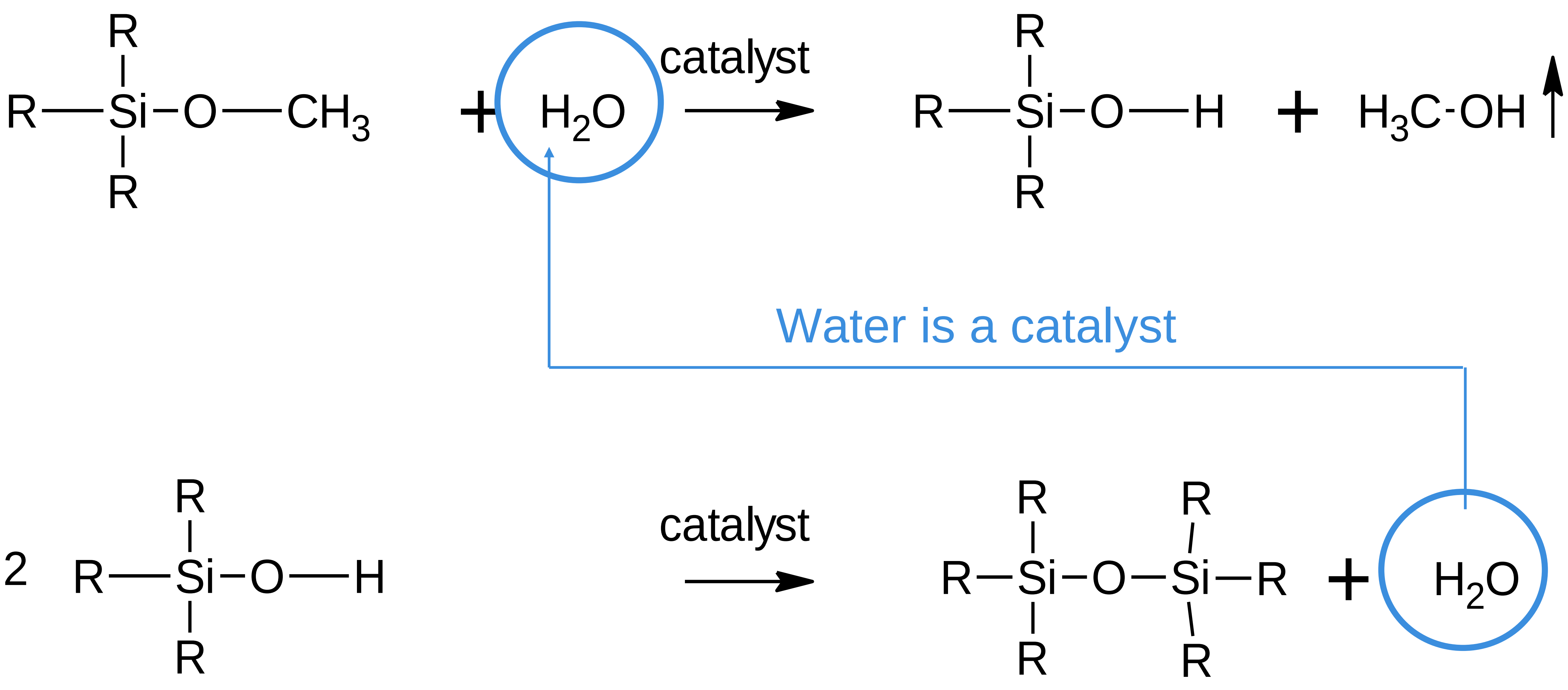
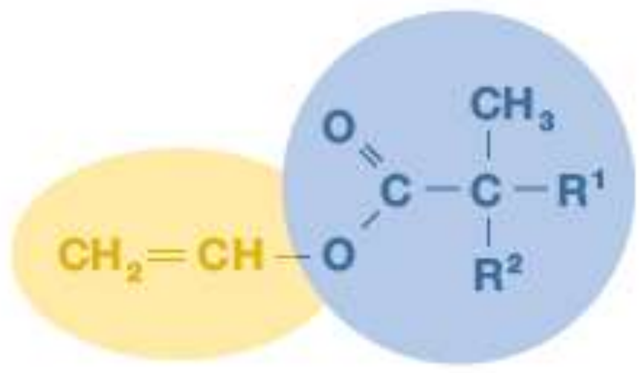
Moisture Curing of Methoxysilanes

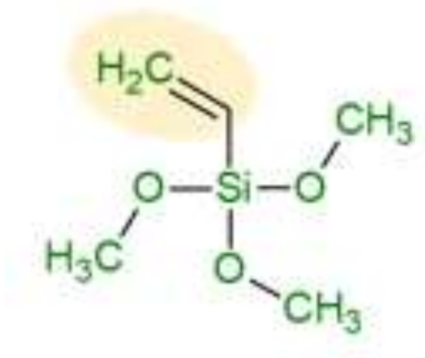


- ➔ **Alkoxysilanes crosslink by reaction with ambient moisture**
- ➔ **Alcohols are released**
- ➔ **Water is a catalyst (possible cure of thick coatings layers)**

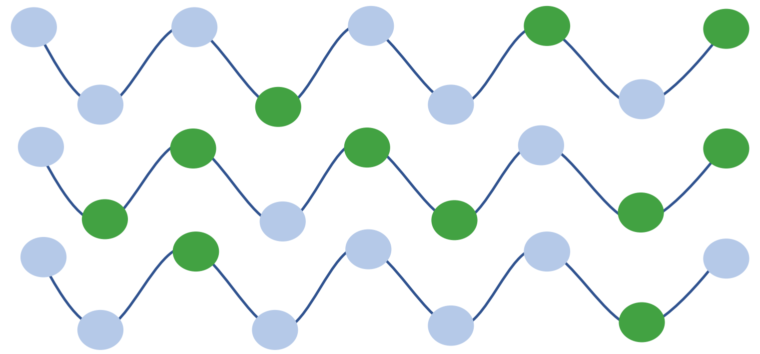
Silane Functionalized, Hydrophobic Polymers Technology Concept Outline



Vinyl neodecanoate



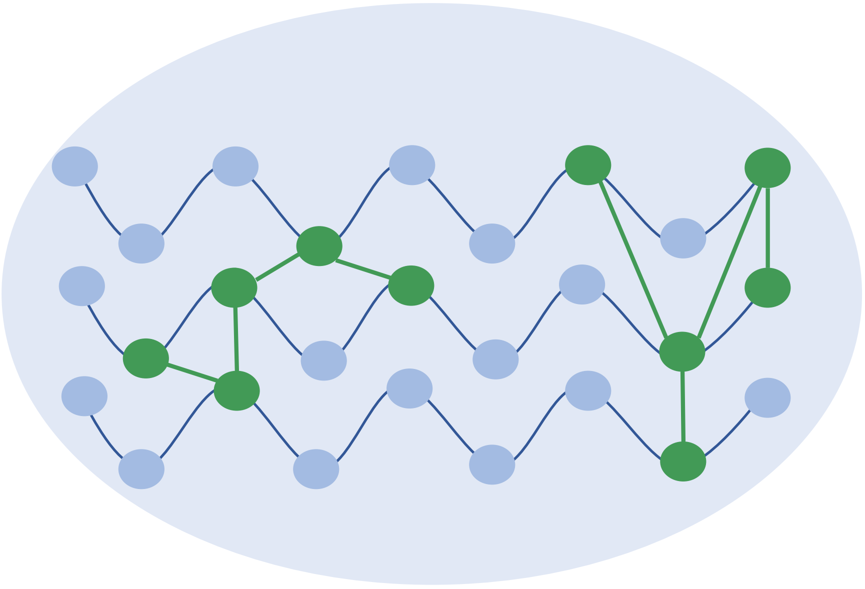
Silane functional monomers



Vinyl silane polymer

Coating application

Moisture curing



Cured coating

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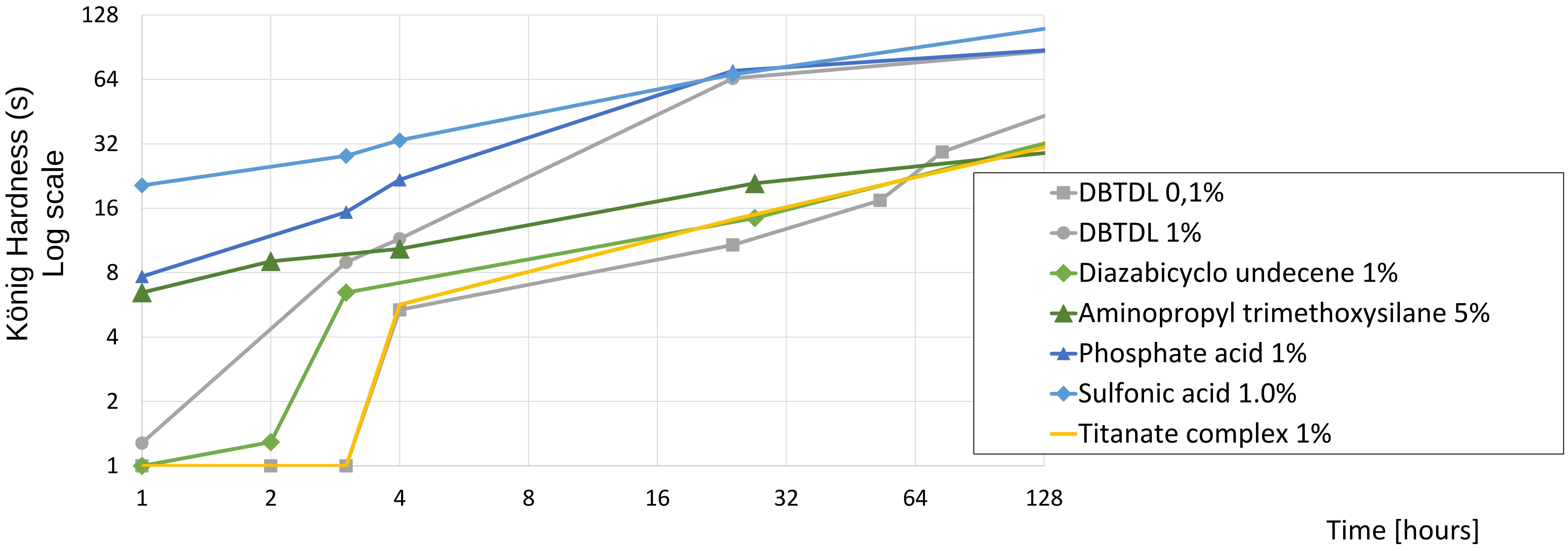
Catalyst Selection for Clearcoats



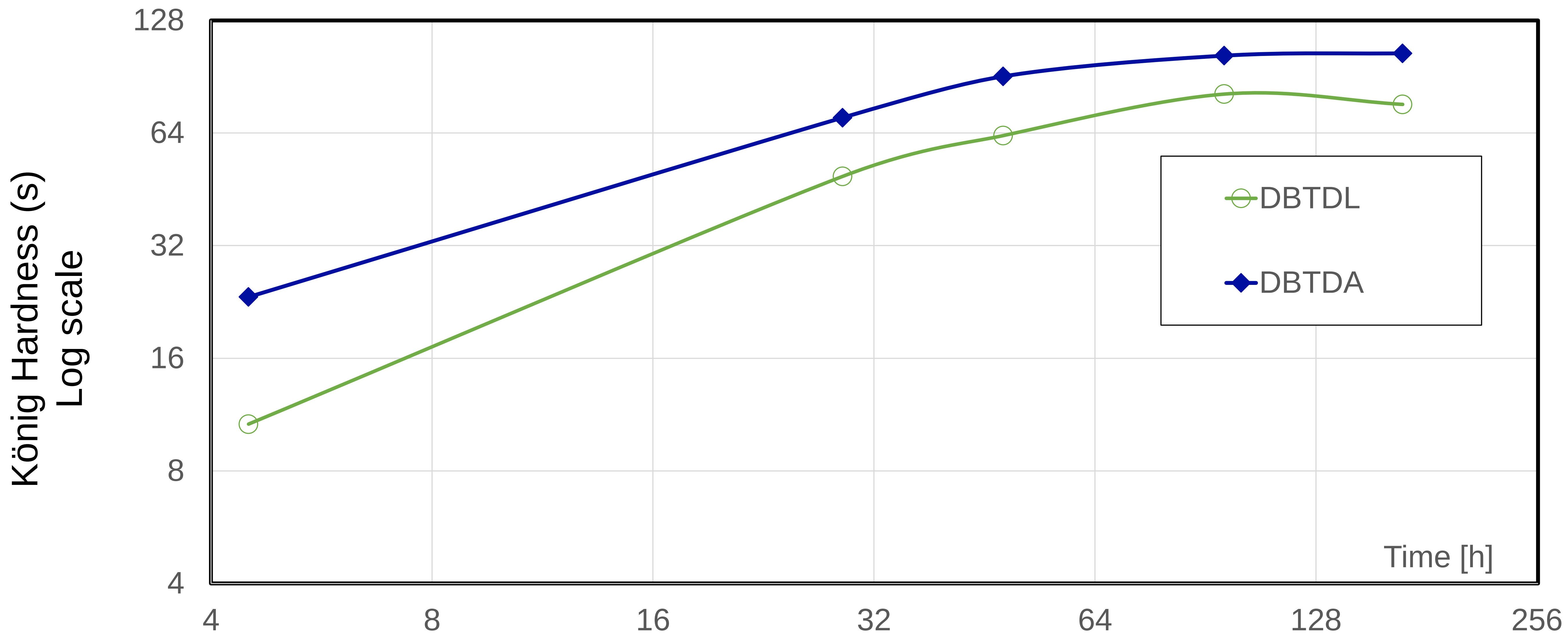
➔ Extremely fast hardening with strong acid catalyst

➔ Wide choice of catalyst (selection by trial and error)

➔ Tin-based catalysts are not mandatory

Tin Based Catalysts in Clearcoats

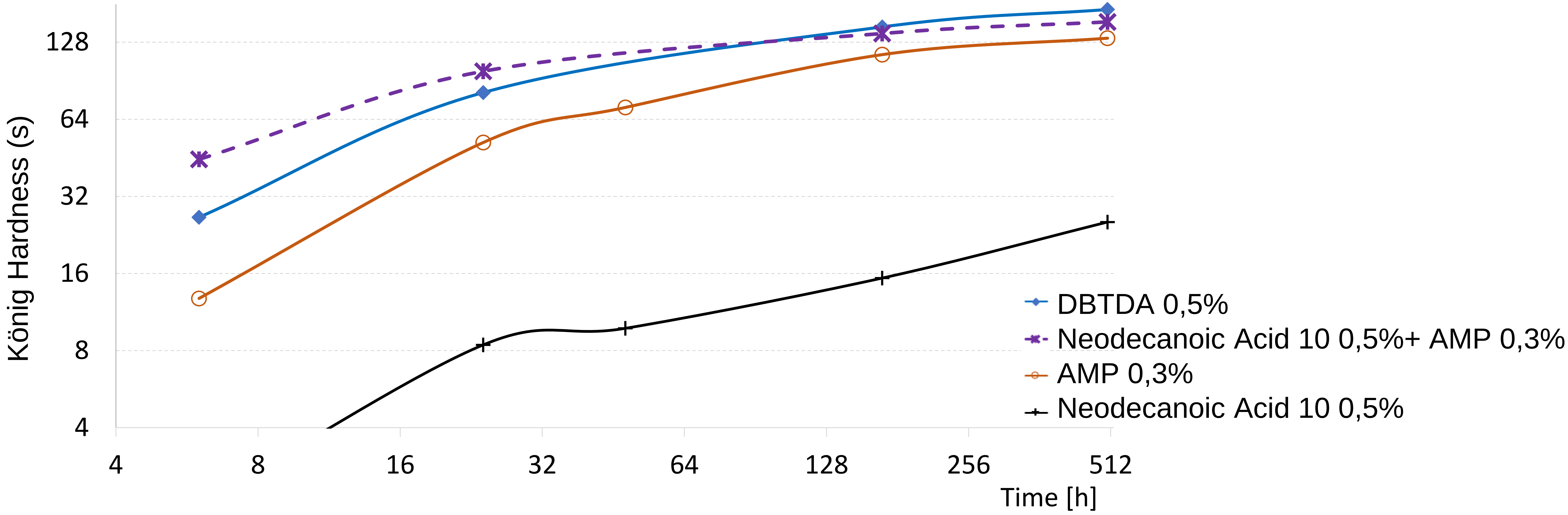
Dibutyltin diacetate (DBTDA) is more efficient than dibutyltin dilaurate (DBTDL)



➔ **Recommended level is ≤ 0,5wt% DBTDA on solid resins**

Synergy Between Catalysts

2-Amino 2-methyl 1-propanol (AMP) and Neodecanoic Acid 10 as alternative catalyst

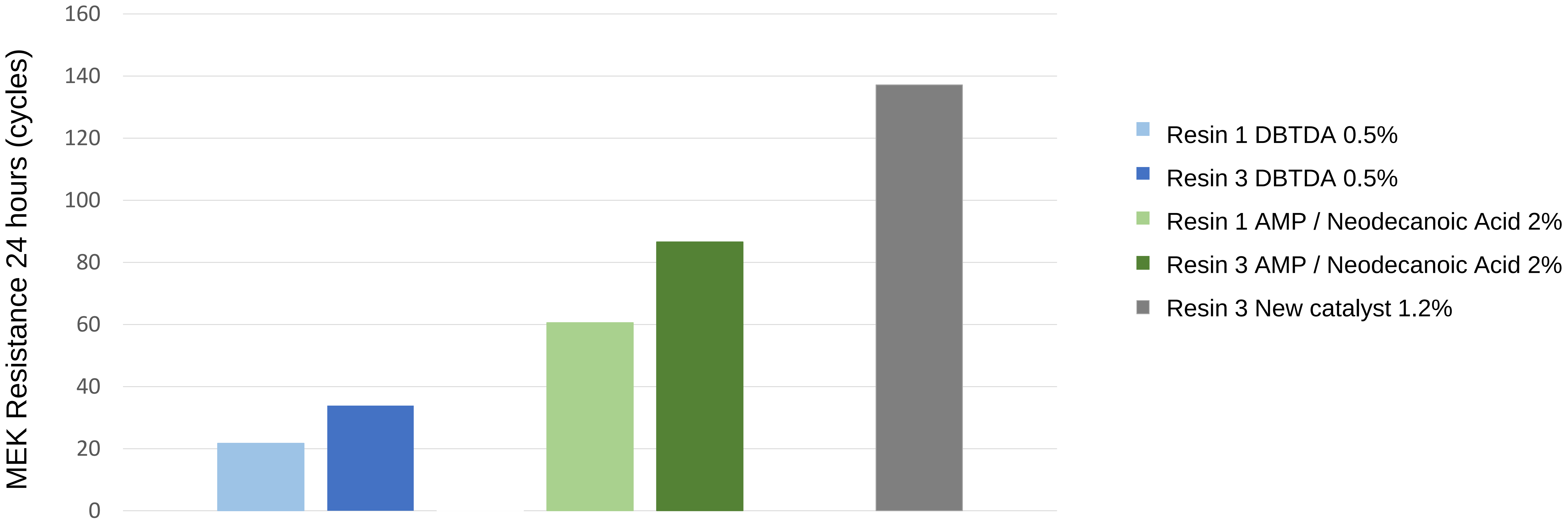


➔**Excellent synergy between Neodecanoic Acid 10 and AMP during first days**
➔**Better pH control during evaporation?**
➔**1 catalyst / reaction? (hydrolysis – condensation)**

Clearcoats Solvent Resistance

Catalyst and Resins Improvement

MEK Double Rubb

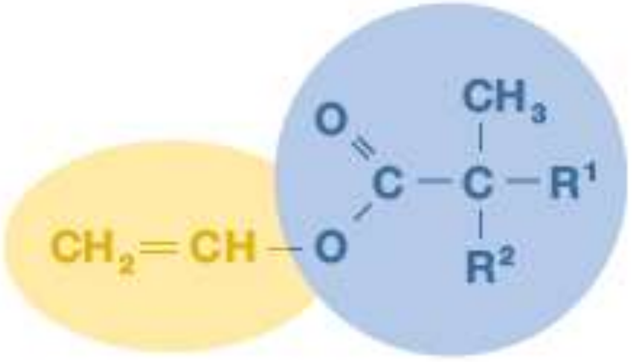


Example of Clearcoat Performance

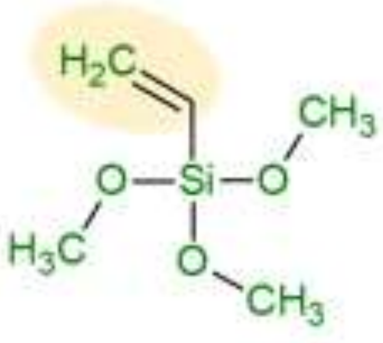
Property	Silane Functionalized, Hydrophobic Polymers	Commercial 2K PU
Solids (%)	60	50
Viscosity (mPa.s)	100	100
Shelf life / Pot life	> 12 months	~ 4 hours
Applied layer (wet) (µm)	150	150
Dust free time (cotton ball)	< 12 min	< 20 min
König hardness development (s)	107 (24h) 180 (14d)	22 (24h) 113 (14d)
Water contact angle (°)	84	83
MEK rubs (after 3 weeks) (cycles)	180	>200

Silane Functionalized Hydrophobic Polymers Outperforms a Commercial 2K PU

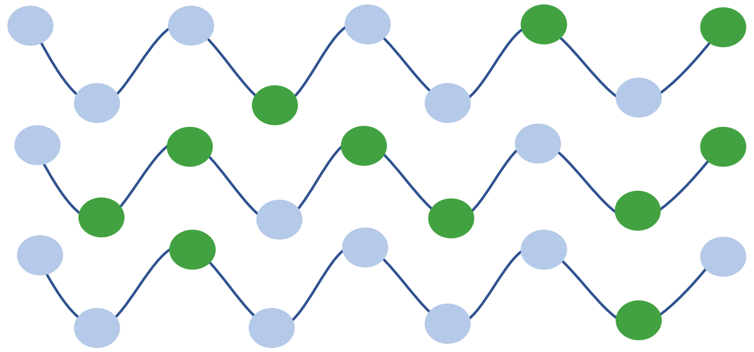
Silane Functionalized, Hydrophobic Polymers Technology Concept Outline



Vinyl neodecanoate

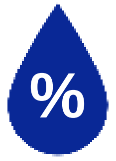


Silane functional monomers

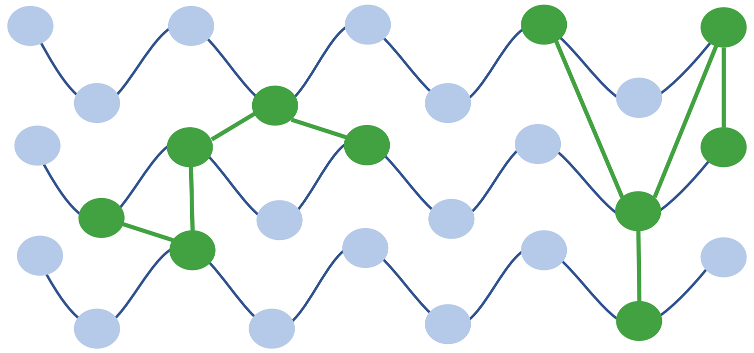


Vinyl silane polymer

Coating application



Moisture curing



Cured coating

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Paint formulation

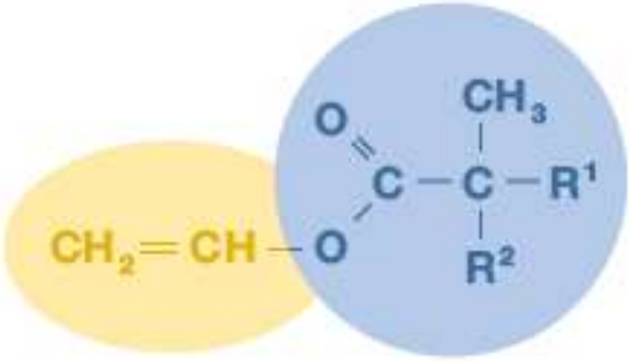
Topcoats

Silane Functionalized Hydrophobic Polymers Paint Formulation

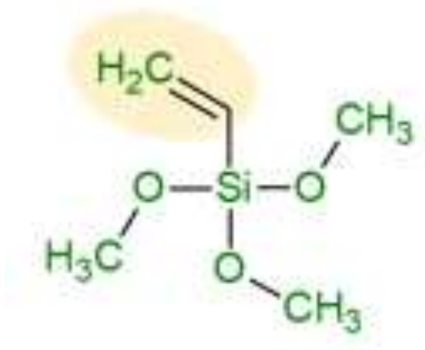
Key Messages

- Pigment selection: hydrophilic surfaces tend to absorb water, which reduce shelf-life
- Ingredients selection: water-free; avoid hydrophilic ingredients
- Stabilization: addition of water scavenger (process + post-process)
- Catalyst Selection: careful selection; clearcoat ≠ topcoats
- In-Can Stability

Silane Functionalized, Hydrophobic Polymers Technology Concept Outline



Vinyl neodecanoate



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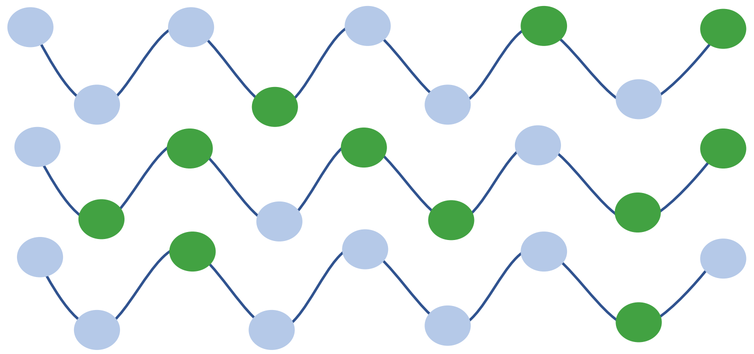
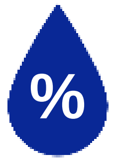
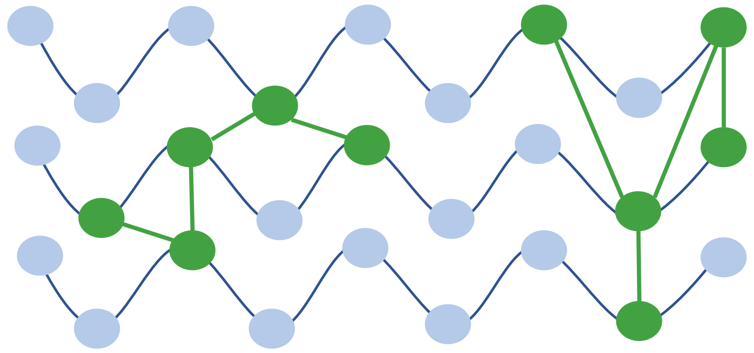


Vinyl silane polymer

Coating application



Moisture curing



Cured coating

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Benchmarking with Commercial Coatings

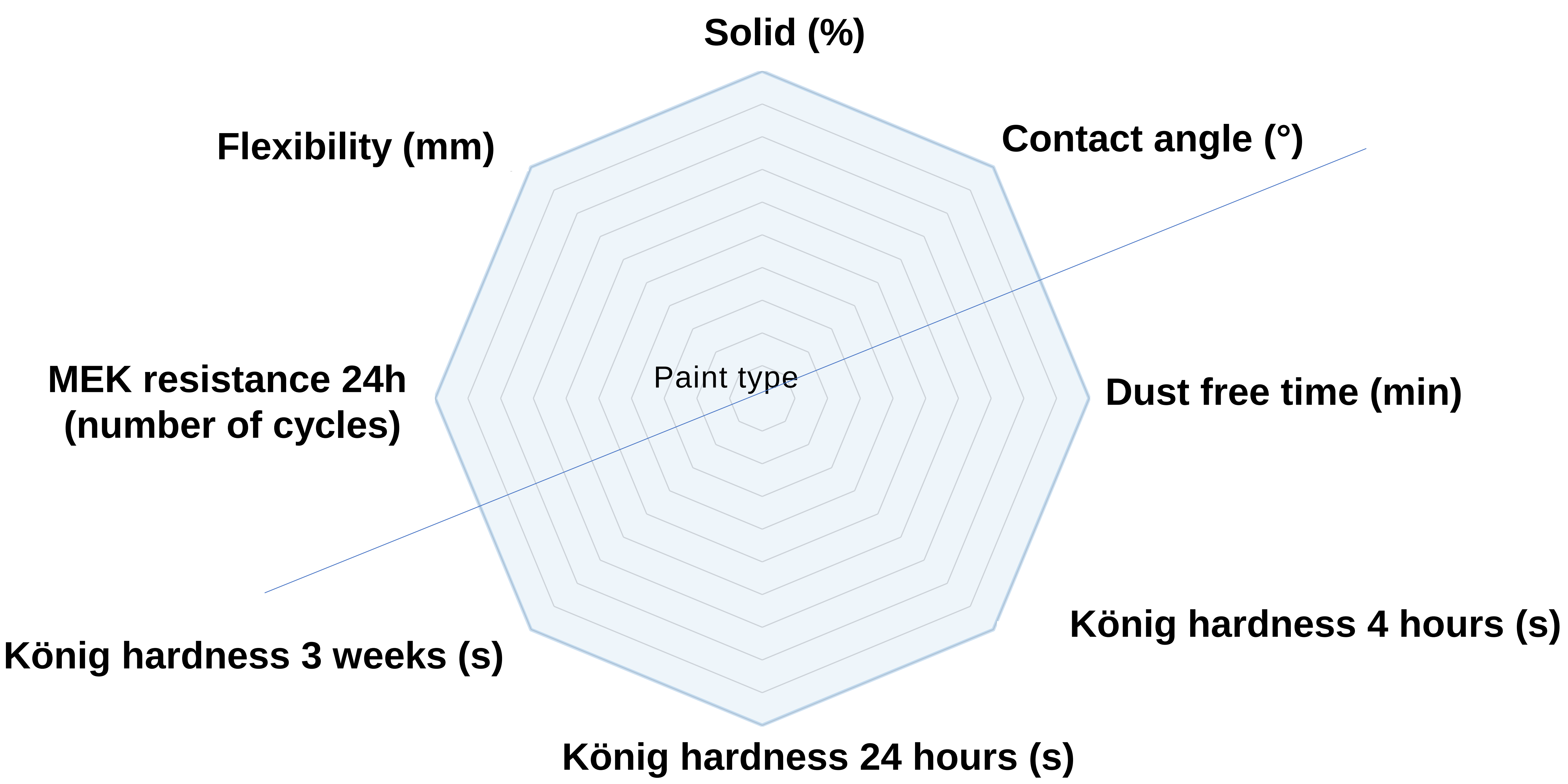
Topcoat Characteristics

	Silane Functionalized, Hydrophobic Polymers
Silane functional monomers (wt %)	20
Vinyl neodecanoate / neononanoate (wt %)	80
Calculated Tg (°C)	35
Solid content (%)	80.3
Molecular Weight (weight average)	16 700
Viscosity (Pa.s)	15.5

Coating name	Characteristics
Silane Functionalized, Hydrophobic Polymer	Based on high performance fast drying resin
2K polyurethane Hexion paint formulation	Paint prepared in Hexion lab from commercial polyol 70% solids with OH value at 2.5%
Commercial 2K polyurethane	Fast drying 2K PU recommended for corrosive environment
Commercial acrylic polysiloxane B	1K moisture curing recommended for marine, offshore and onshore protective coatings
Commercial acrylic polysiloxane A	

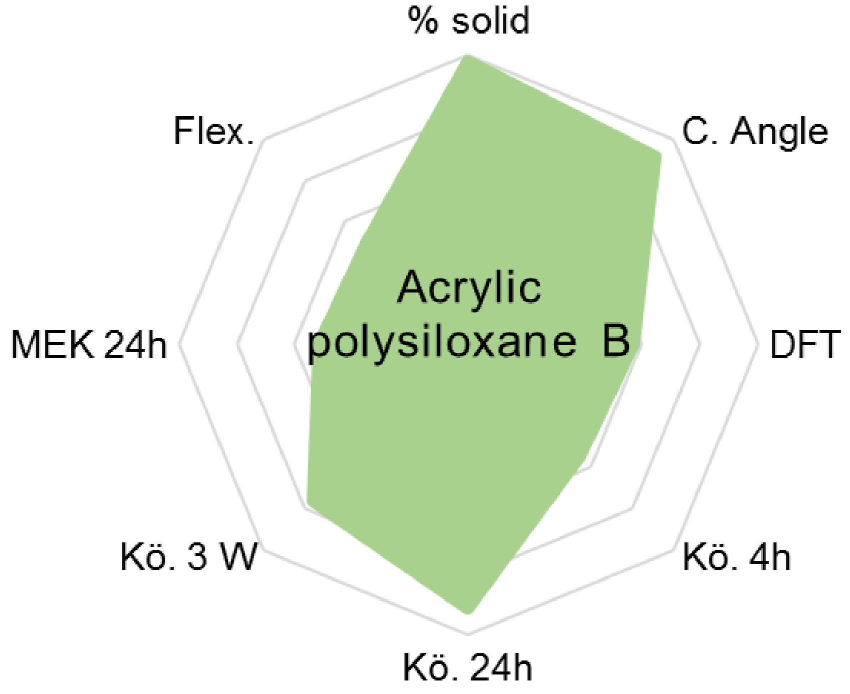
Benchmarking

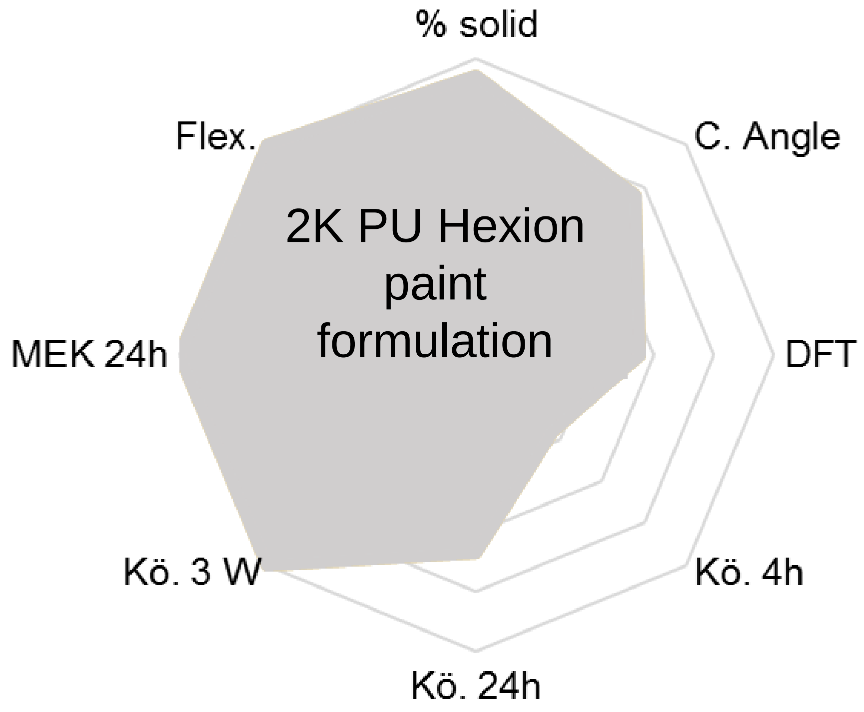
Screened Properties

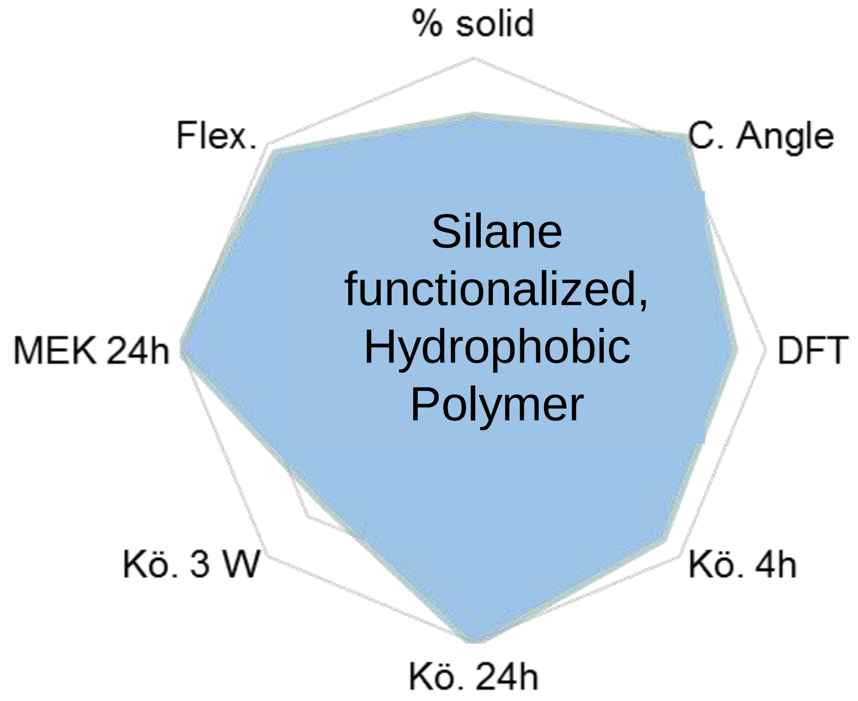


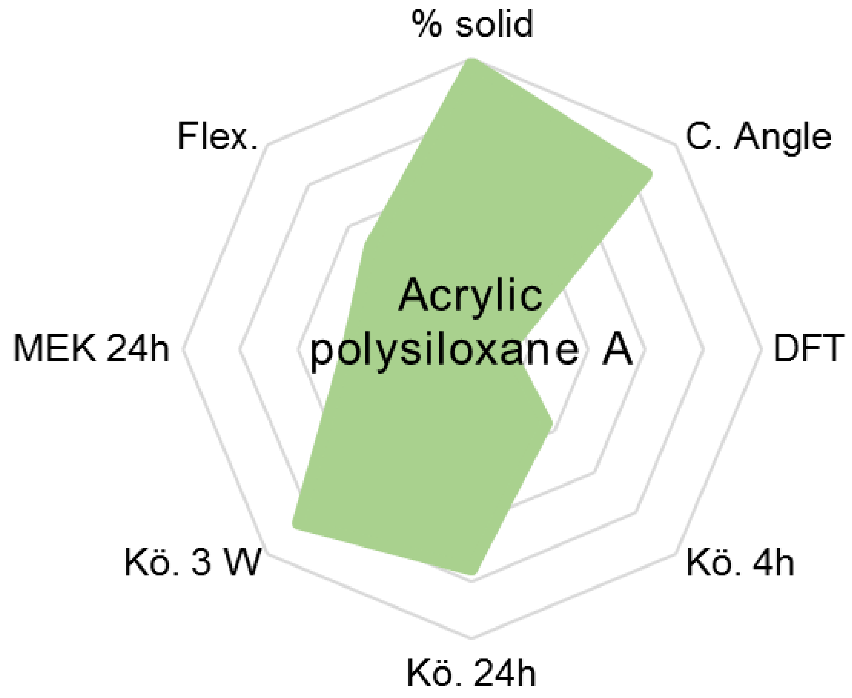
Benchmarking with Commercial Coatings

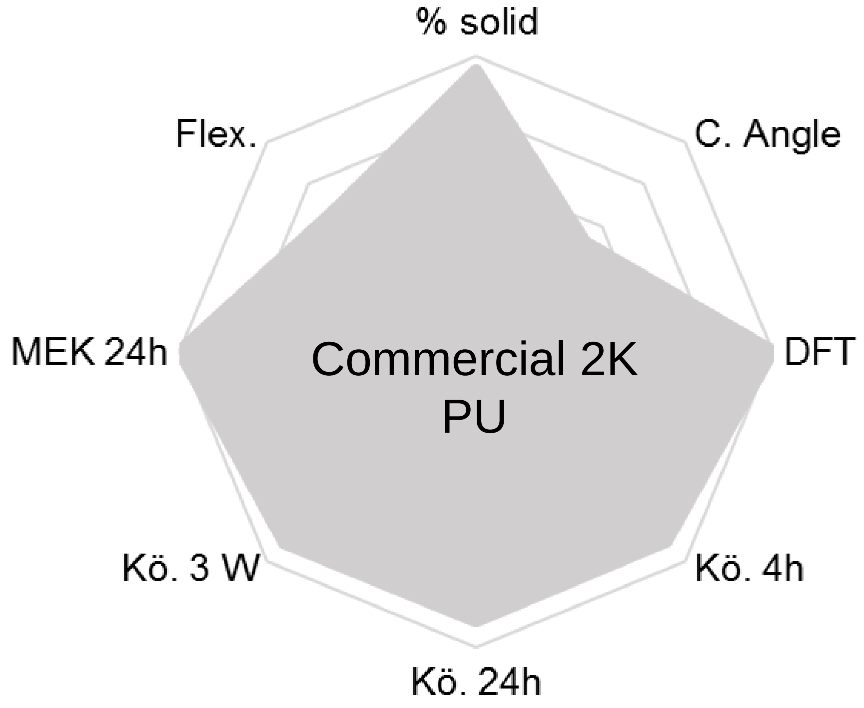
Balance of Properties







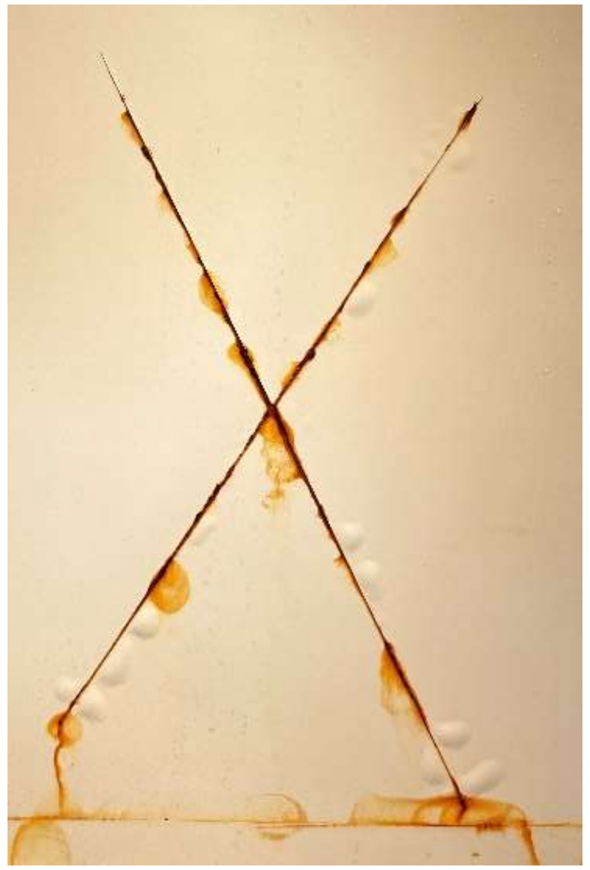




Topcoat Performance

Anti Corrosion

Silane Functionalized, Hydrophobic Polymers



Commercial 2K polyurethane

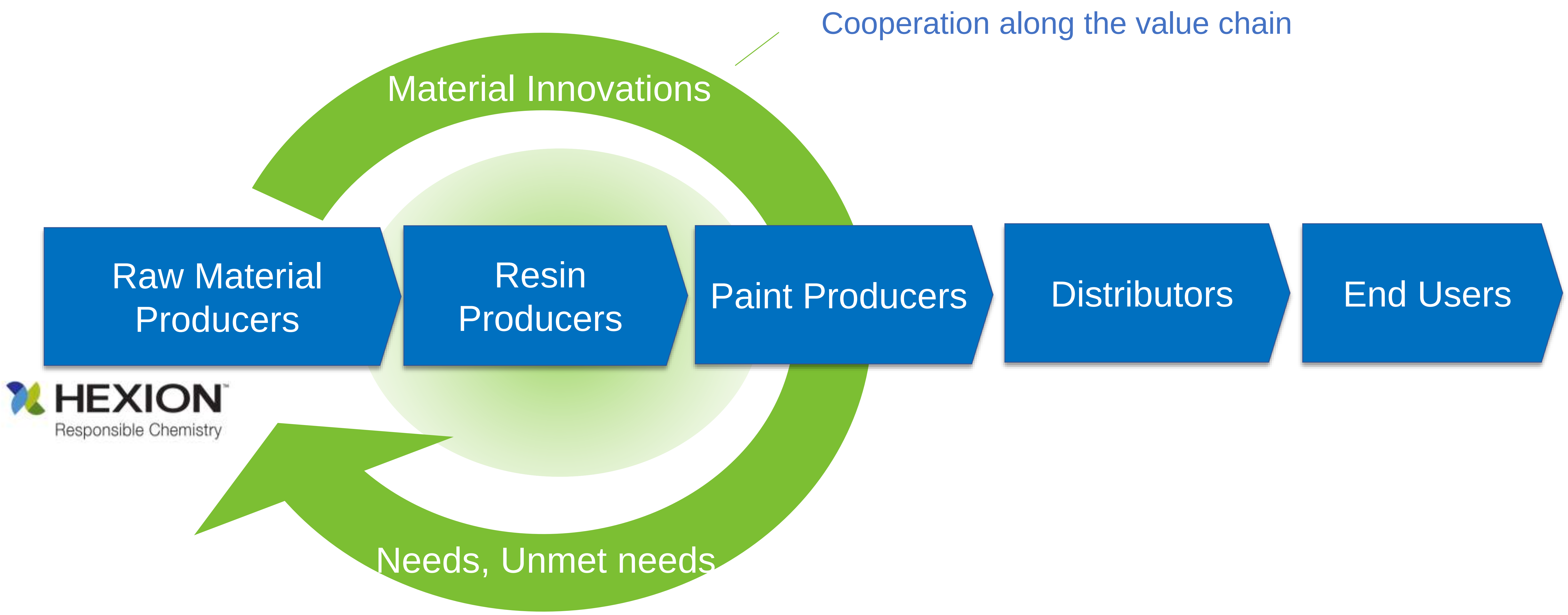
Commercial acrylic polysiloxane B

Commercial 2K Epoxy acrylic polysiloxane A

Easy-to-clean

Hexion Versatics

Customer-Driven Innovation Approach



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VeoVa™ Silane WORKS

HEXION™
Responsible Chemistry

Silane Functionalized, Hydrophobic Polymers

- ✓ Easy copolymerization
- ✓ Moisture Curing, Isocyanate-Free
- ✓ Cost benefit vs high performance polymers
- ✓ Performance benefit over conventional 2K solvent borne
- ✓ Less waste (1K) / Easy to handle

Thank you

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