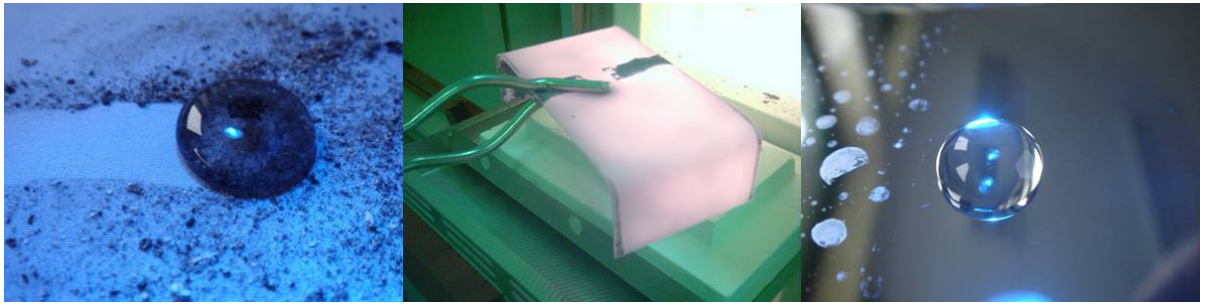


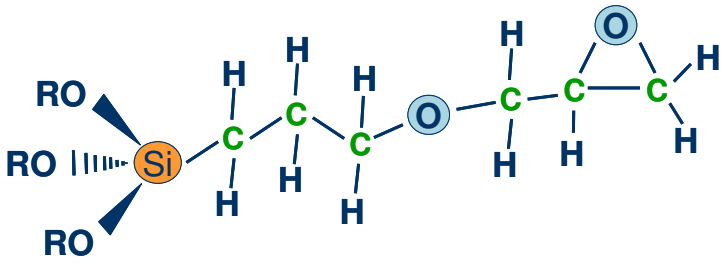
SiliXane Binder Materials
– Potential and Applications –

State of The Art

Silane/ Silicone Technology

1. Step

Silane, e.g. epoxysilane



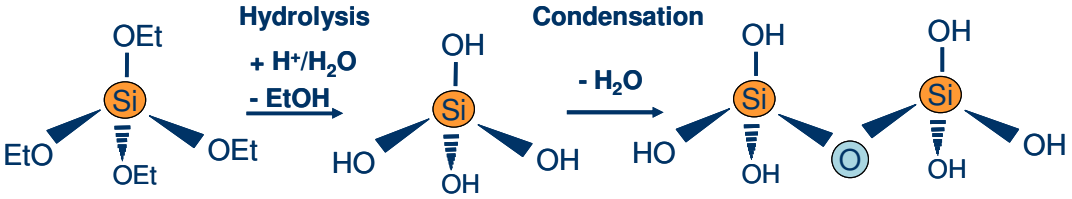
Sol-Gel reaction

- Always water
- Ethanol or Methanol
- Reaction hard to control
- Shelf life

Curing

2. Step

- Organic network
- Reaction with organic copolymers



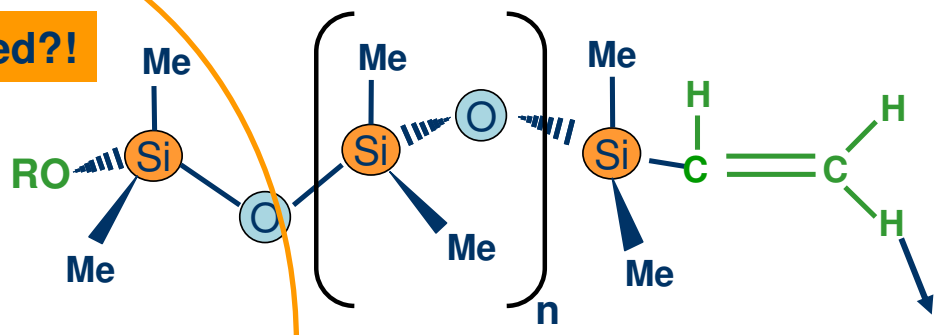
- Inorganic-organic network
- Application as coating materials
- **High** scratch and abrasion resistance
- **Brittle**
- **Low** chemical resistance

State of The Art

Silane/ Silicone Technology

No water needed?!

Silicone Resin



- Inorganic curing
- Acids/ e.g. acetic acid, sulfur acid
- Lewis acids (AlOH, ZrOH …)

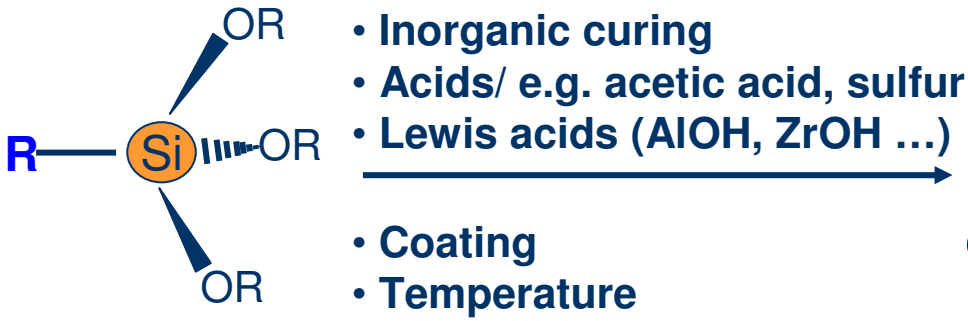
- Inorganic-organic network
- Application as coating materials
- No scratch and abrasion resistance
- Flexible
- High chemical resistance

- Organic curing
- Ionic catalyst
- Radical catalyst

Innovative Idea

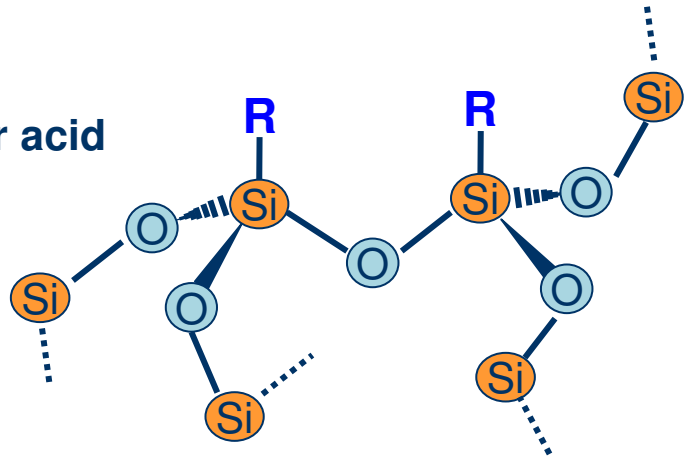
Silane/ Silicone Technology

Silanes cured to siloxanes like a silicone



- Inorganic curing
- Acids/ e.g. acetic acid, sulfur acid
- Lewis acids (AlOH, ZrOH …)

- Coating
- Temperature



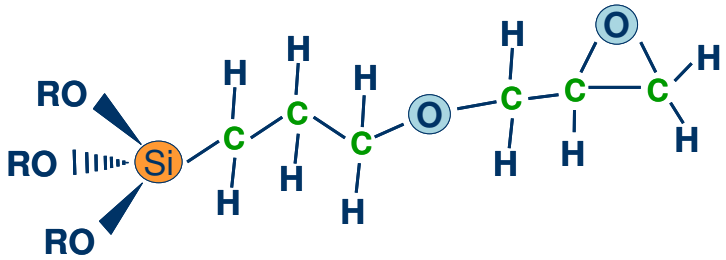
SiliXanes

Silane in alcohol

Water free crosslinking

Problem

Example: Epoxysilane



- Silanes: molecular weight ~ 250 gr/mol
→ Evaporation before curing
- No organic crosslinking
- Not practicable!

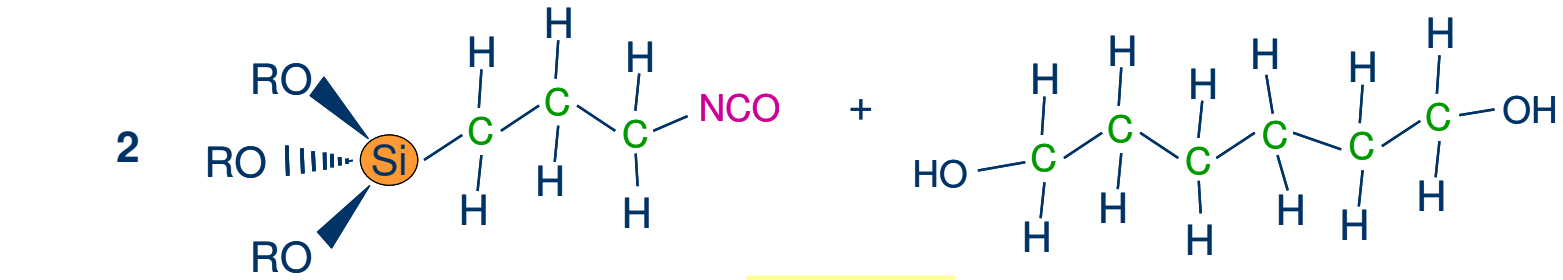
Solution

- Higher molecular weight needed
- Organic crosslinking before inorganic curing!

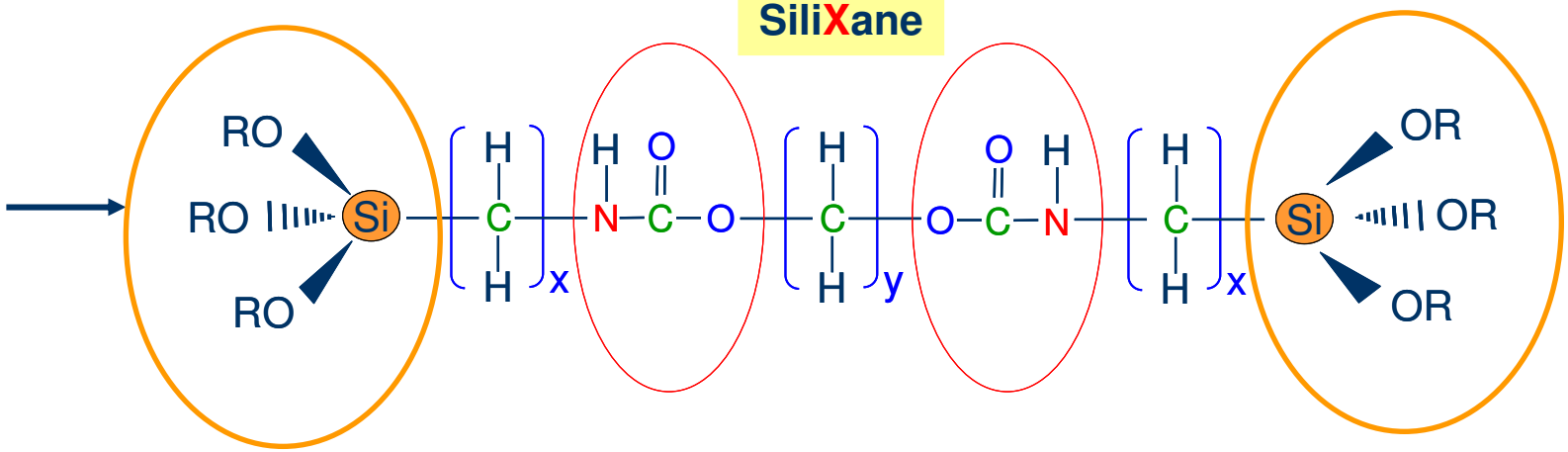
Modeling of New Silanes

SiliXane

Isocyanosilane ICTES + **Di- or polyol, e.g. hexandiol**

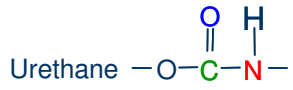


SiliXane



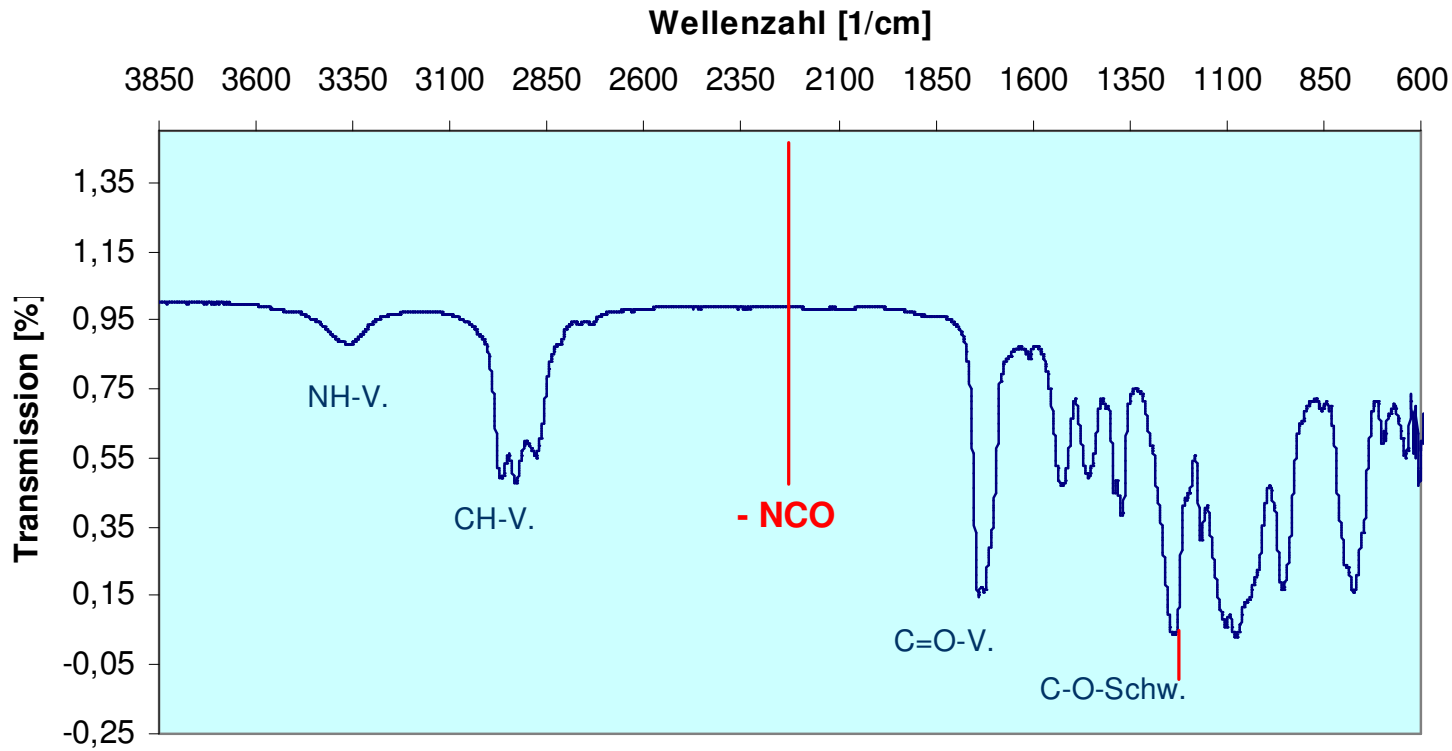
Reactive groups ≥ 6 / molecule → Sol-Gel not practicable!

x-bond® U 9036

Urethane  x-bond® U

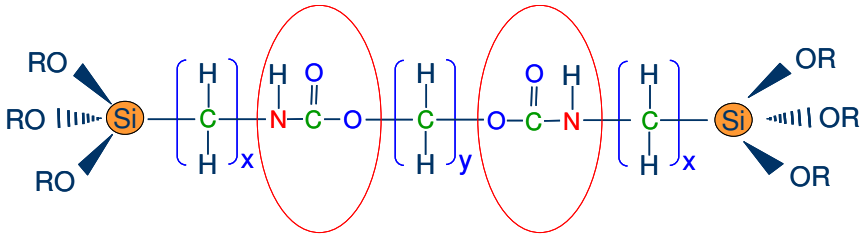
SiliXane

ICTES with 1,6-hexandiol in butylglycole = x-bond® U 9036

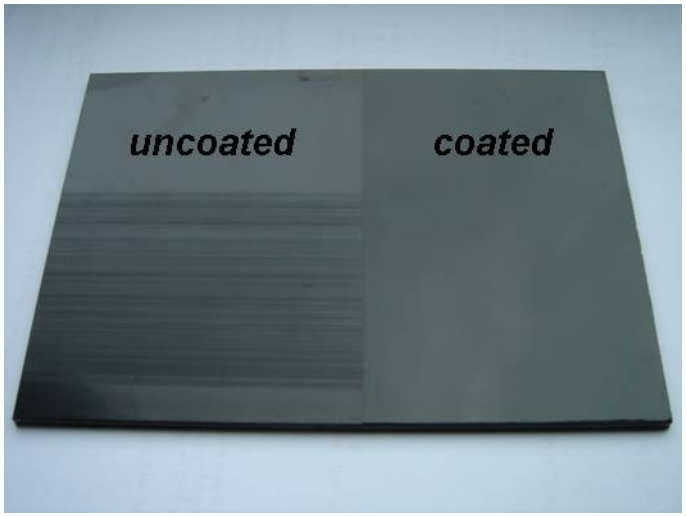


Modeling of New Silanes

SiliXane



- **Al catalyst**
- **Flow coating**
- **Pocan**
- **100 °C**



Half-side coated Pocan® DP 7645 after 500 cycles scrubbing test with the abrasive fleece 3M Scotch Brite Nr. 7448

Test substances

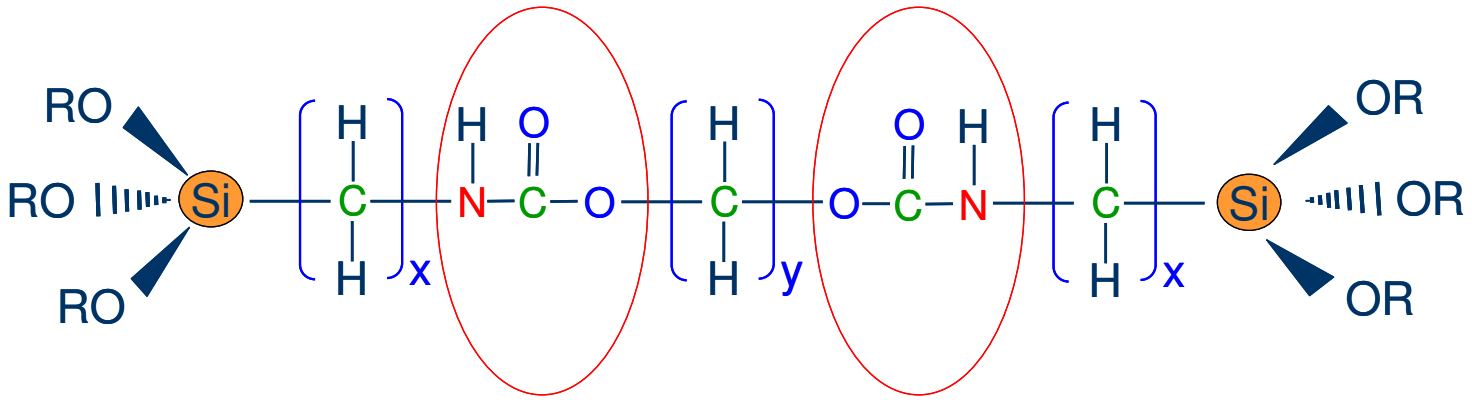
- **Methylene blue**
- **Chewing gum**
- **Red wine**
- **Coffee**
- **Mustard**
- **Oil**

After cleaning:

Coated part shows no colouring or penetration!

Properties

SiliXane



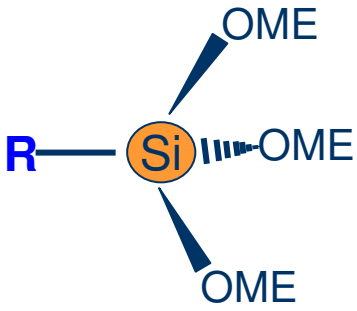
- Inorganic-organic network
- Application as coating materials
- High scratch and abrasion resistance
- Flexible
- High chemical resistance

- High UV stability
- No water needed
- No ethanol or methanol in solution
- High shelf life

Curing mechanism?

Curing Mechanism

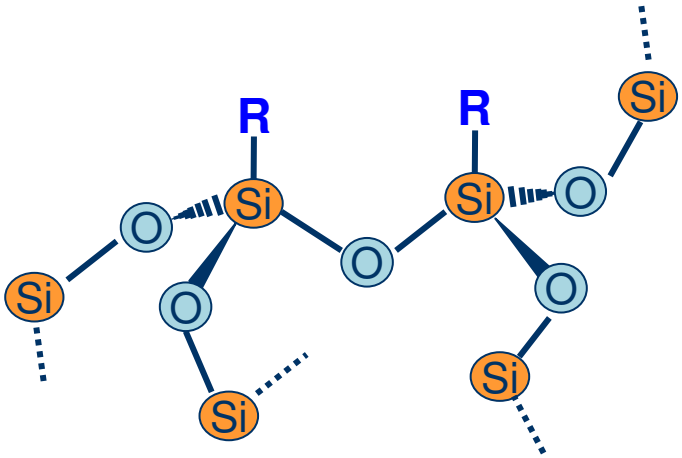
SiliXane



- MeOH???

But: no water!

- Me-O-Me !!!



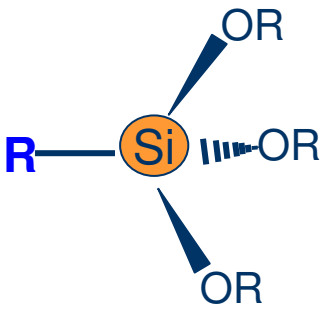
+ catalyst
+ temperature

Model: formation of dimethyl-ether

Under investigation in the moment!

Curing Catalyst

SiliXane



Lewis acids (AlOH, ZrOH …)

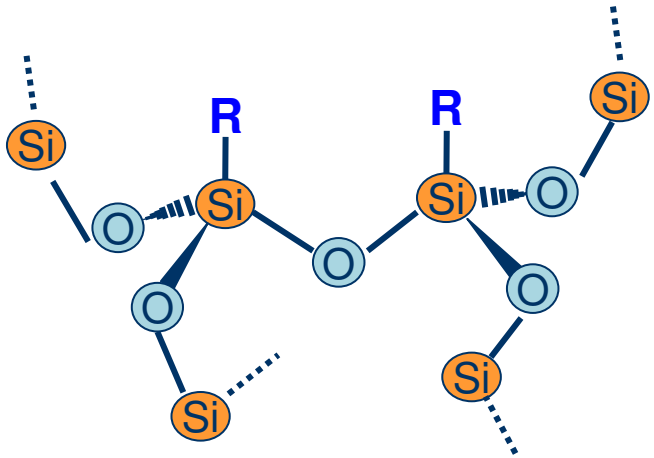
Starting temperature: 80°C

Acetic acid, phosphoric acid

Starting temperature: > 120°C

Sulfuric acid, strong alkalines

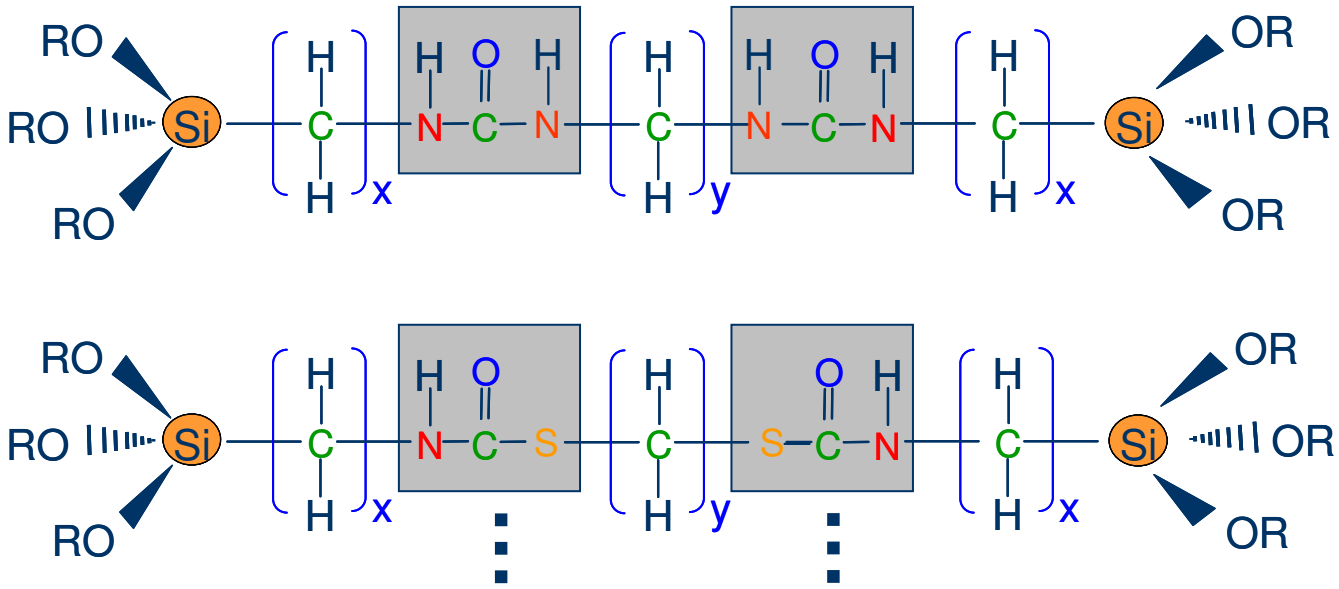
Starting temperature: RT!!!



Adaptation of several curing conditions with the right curing catalyst is possible!

Silane Modeling

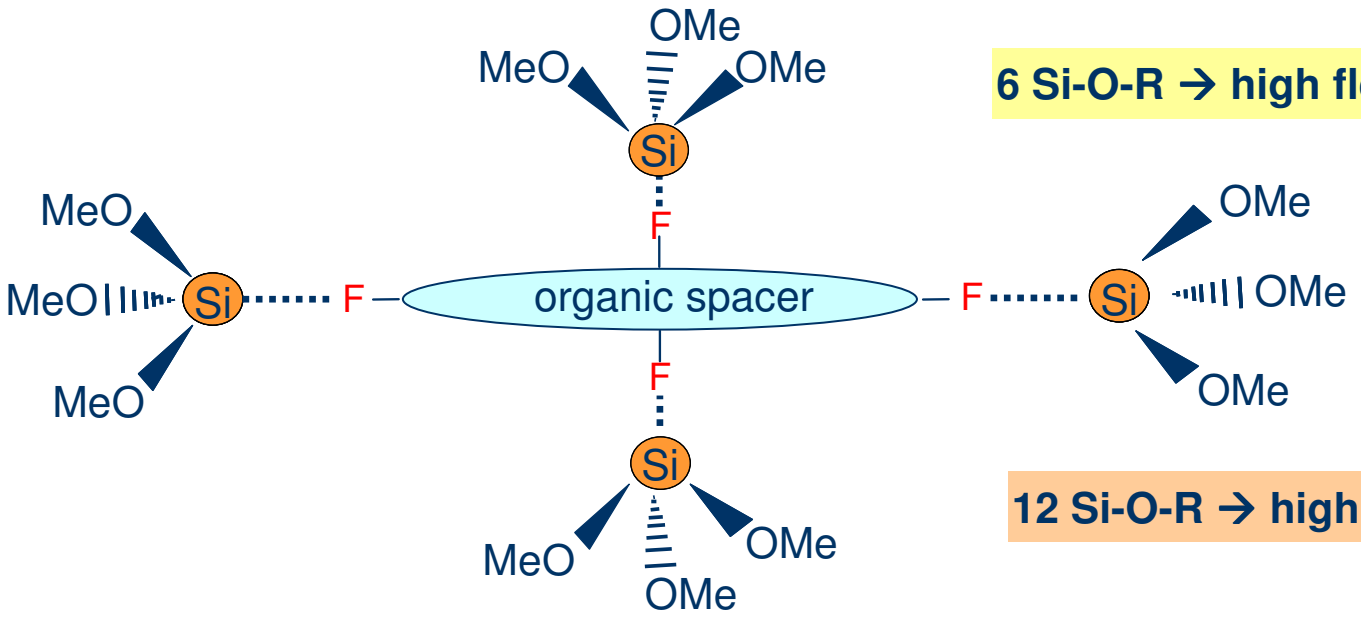
Functional Group



Adaptation of the functional group F using organic bonding principles!

Silane Modeling

SiliXane



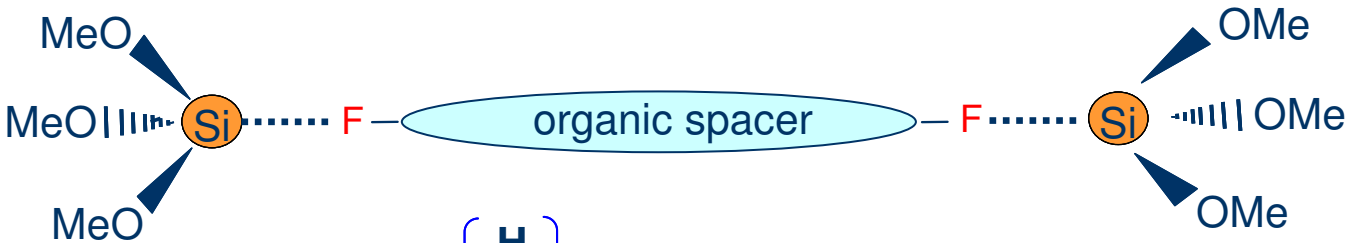
6 Si-O-R → high flexibility

12 Si-O-R → high density

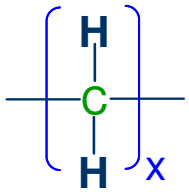
Adaptation of the number of the Si-O-R groups/molecule to adjust the density!

Silane Modeling

SiliXane

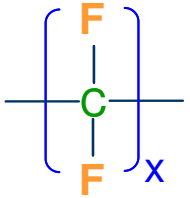


x-bond® U



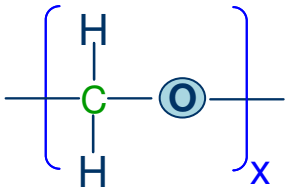
hydrophobic

hydrophobic/oleophobic



x-bond® F

x-bond® O

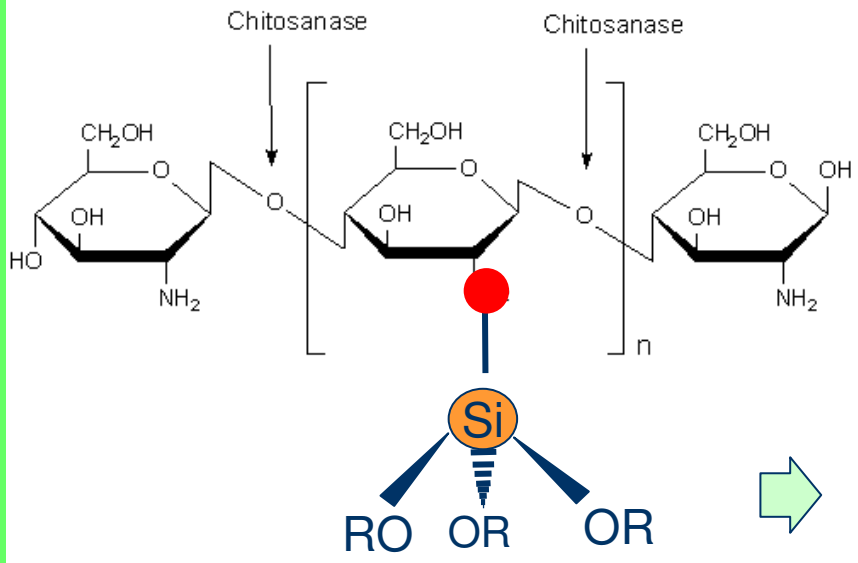


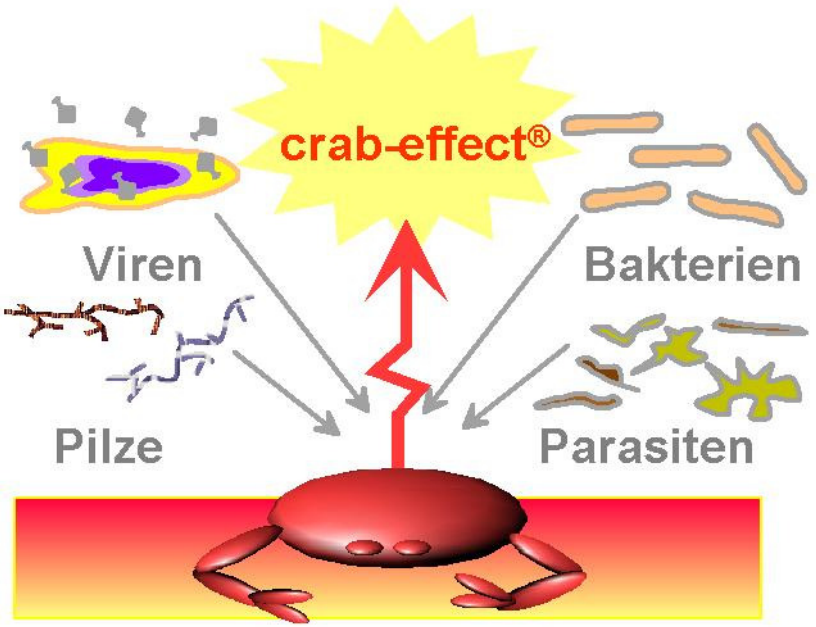
hydrophilic

Adaptation of the surface free energy changing the organic spacer!

Antibacterial Properties

crab-effect®





Bonding of chitosane molecules on functional silanes
→ Curing with a SiliXane binder!

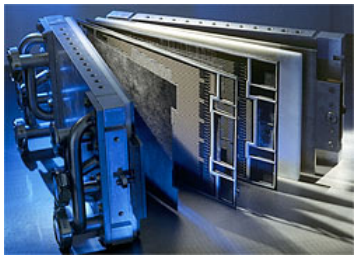
- **Bacteria retardant**
- **Natural material**
- **No influence of health**

Applications

SiliXanes

- Hydrophobic and oleophobic
- Antibacterial
- Scratch resistant

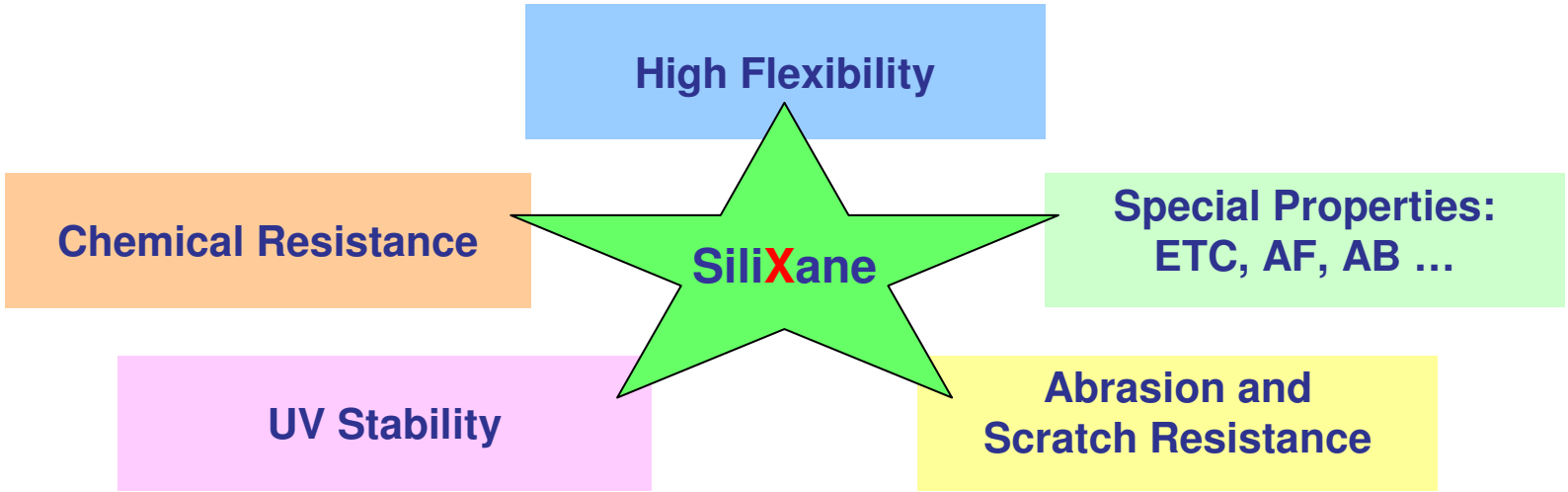
- Corrosion protection
- Antifingerprint
- Adhesion promoter
- UV stable
- Powder Coatings



- Hydrophilic

Conclusion

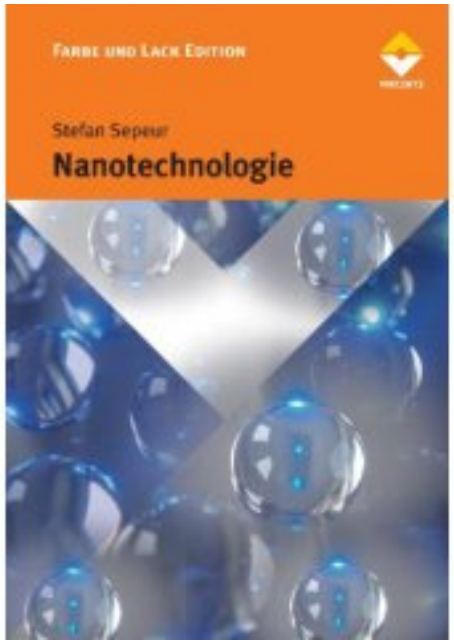
SiliXane



A new class of binders is developed!

Thanks for your attention!

Literature



Book: Nanotechnology
Sepeur et al.
Available
German: since march 2008
English: June 2008
www.amazon.de