

Advanced coating materials based on polysilazane

**Sol-Gel & Polymers
Tours 2008**



Exactly your chemistry.

Dr Can Vu

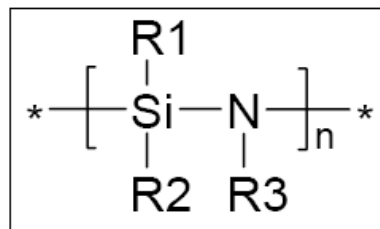
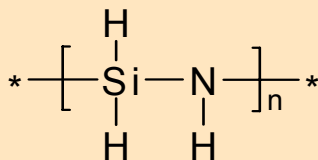
**Clariant Advanced Materials
Group Technology**

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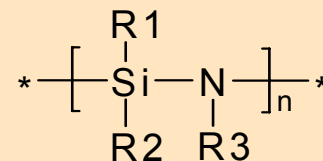
New Materials Technology

Polysilazanes: Si, N, H, C polymers , blockbuilders for advanced materials

**Inorganic
Perhydropolysilazane**



**Organic
Polysilazane**

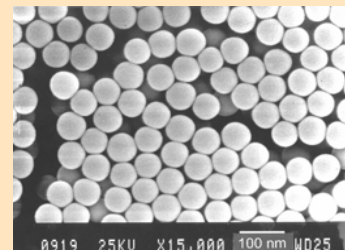


SiO_2 , $\alpha\text{-Al}_2\text{O}_3$
nanosuspensions

10-50 nm

30-50 % solids

aquasol/organosol



**Advance coating materials
based on polysilazanes**

CanVu
Group Technology
New Business Development

Functional polysilazanes

- Various functional groups are incorporated in the polymer backbone
- Copolymers allow adjustment to desired end -product properties and curing conditions
- Products are commercially available at industrial scale

Broad range of applications

Coatings

- **Clear coatings**
- **Anti-corrosion coatings**
- **Gas barrier coatings**
- **Easy-to-clean coatings**
- **High temperature coatings**

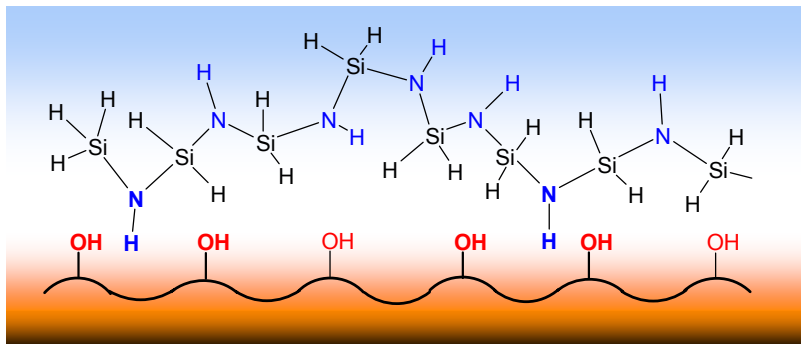
Polymer hybrids

- **Hybrid coatings**
- **Engineering polymers**

Ceramics

- **Ceramic fibers**
- **Ceramic matrix composites**

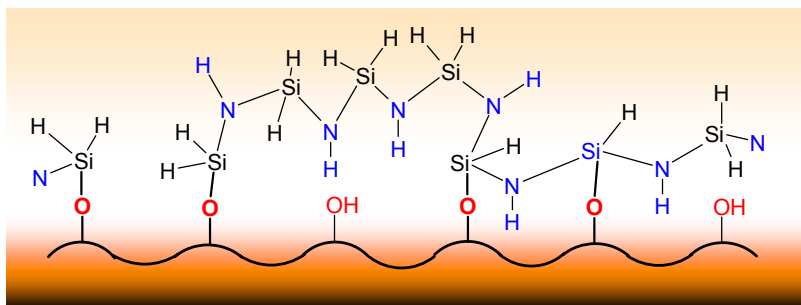
Mechanism of adhesion



polysilazane layer

substrate

curing
↓
- NH₃

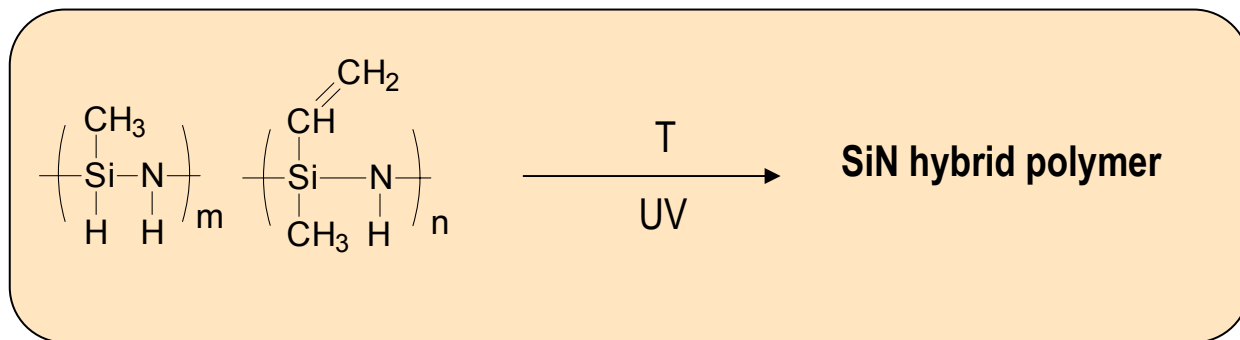
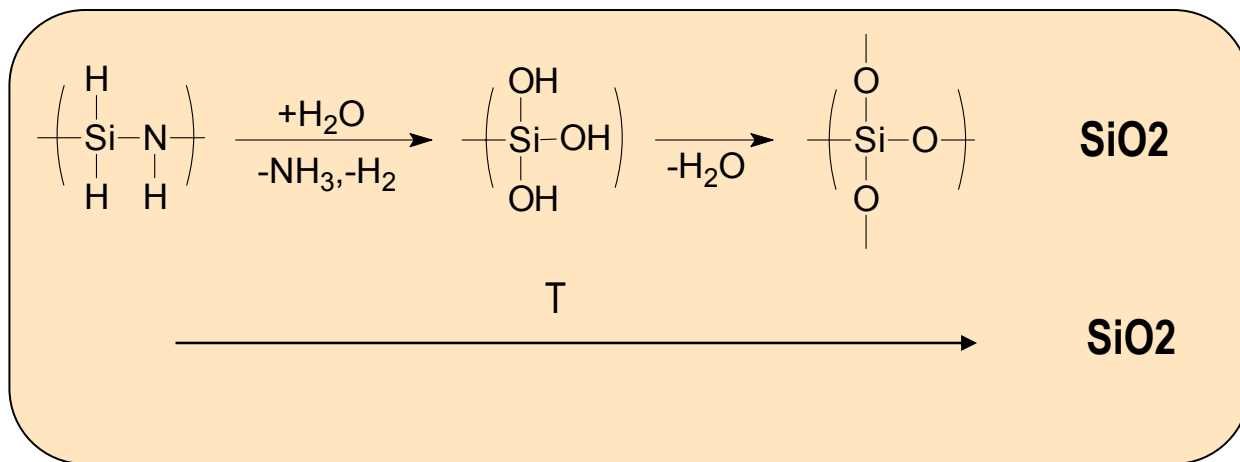


NH-groups react
with polar groups
of substrate

polysilazanes bond
covalently to
substrate

- excellent adhesion on most substrates like glass, polycarbonate, PMMA, PET, aluminium, steel, marble, varnishes, etc.

Curing kinetics



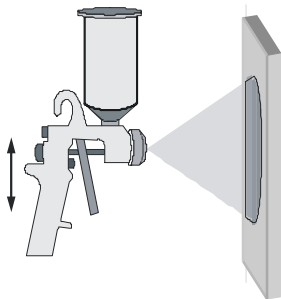
Application of PZane formulations



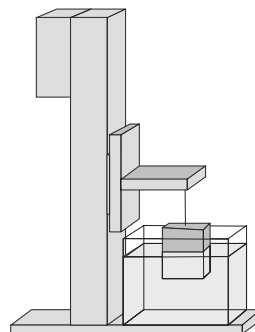
Wiping



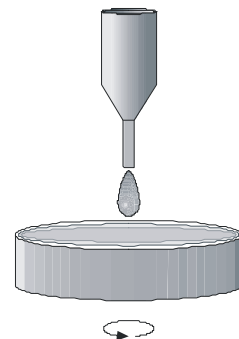
Roll coating



Spray coating



Dip coating



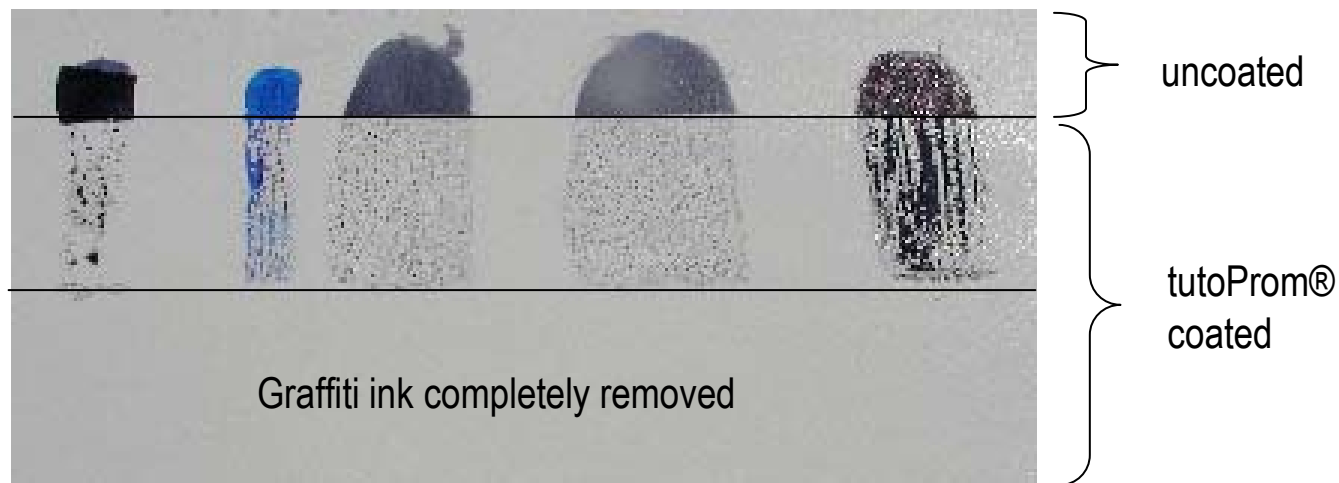
Spin coating

- ☐ Low viscosity, high solids content allows various types of applications
- ☐ Curing: room temperature to 200°C
- ☐ Film thickness: from 0,3 to 50 μm

Easy to Clean applications with Polysilazanes

- Transport: antigraffiti coatings
- Automotive: easy-to-clean rims
- Metal protection: anti-tarnish, anticorrosion
- Architecture: UV protection, self-cleaning

tutoProm®, graffiti removal



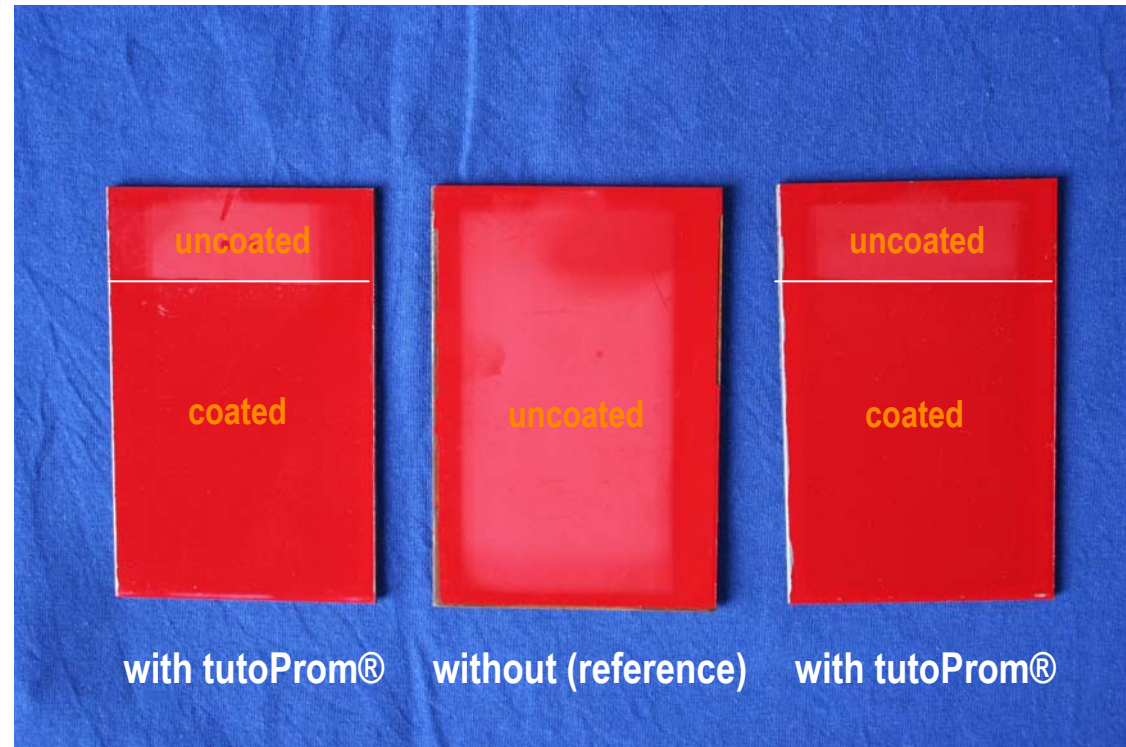
- interior lining samples of DB, partially coated with tutoProm®
- different „bad inks” were applied
- poor wetting of graffiti inks on coated substrate
- graffiti inks can be completely removed with graffiti cleaners
- penetration of ink into uncoated substrate -> graffiti removal not possible

Anti-graffiti coating, tutoProm[®]

- tutoProm[®] is approved by German railway (DB)
- fluorine-free anti-graffiti coating
- based on organopolysilazane
- cures at room temperature
- coating thickness: ca. 3 μm
- outstanding adhesion and stability
- for interior and exterior application
- prevents the penetration of graffiti paints and inks into laquered surfaces
- excellent performance demonstrated after 10 months of application on ICE high speed train



tutoProm[®], weathering test

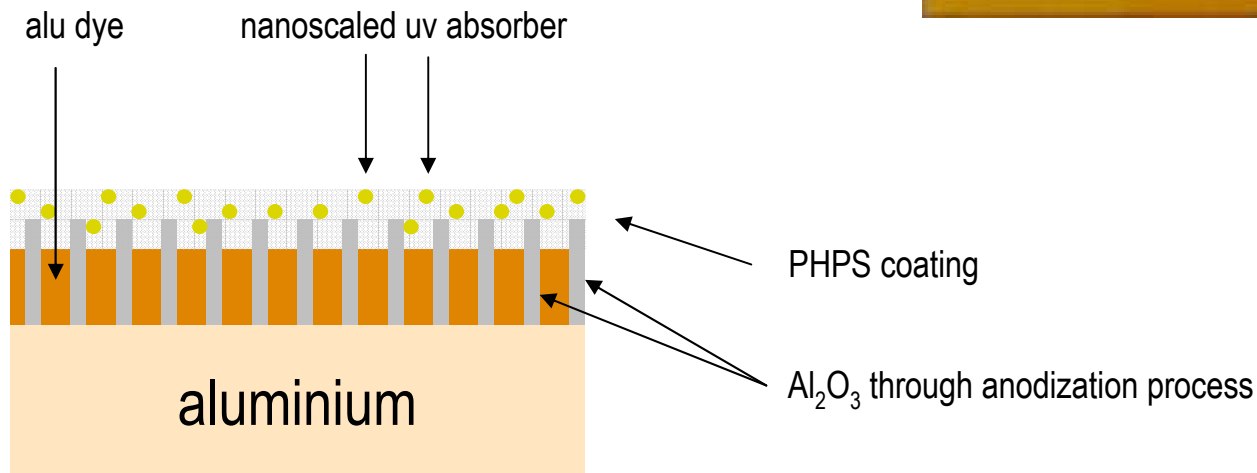
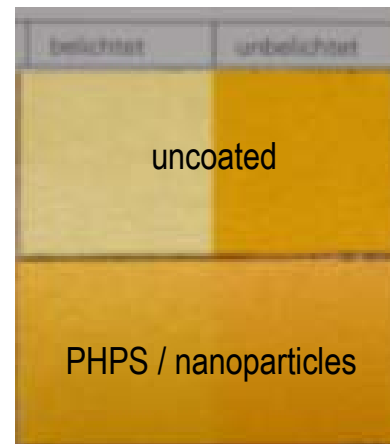


- weathering test results after ca. 3000 h (DIN 11341, xenon test)
- no chalking when coated with tutoProm[®]
- good colour and gloss conservation of DB coating system with tutoProm[®]

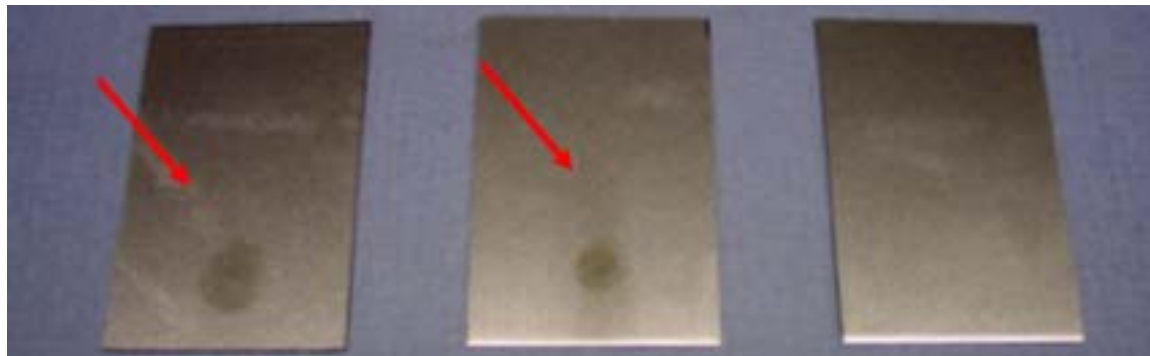
uv protection coatings, polysilazanes and nanoscaled metal oxides

- uv protection of dyes for anodized aluminium
- reduces fade out of alu dyes significantly
- PHPS and nanoscaled metal oxide

uv exposed unexposed



Brake dust barrier coatings



reference
80°C / 2 h

reference
160°C / 2 h

organopolysilazane
160°C / 2 h

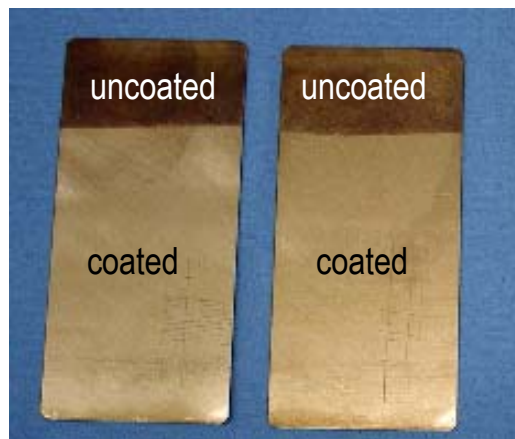
- simulation of brake dust impact on clear coated rims
- reference: conventional rim coating system
- brake dust was mixed with water and applied on sample, exposed at 80°C and 160°C
- attack of brake dust on rims is prevented



Metal protection

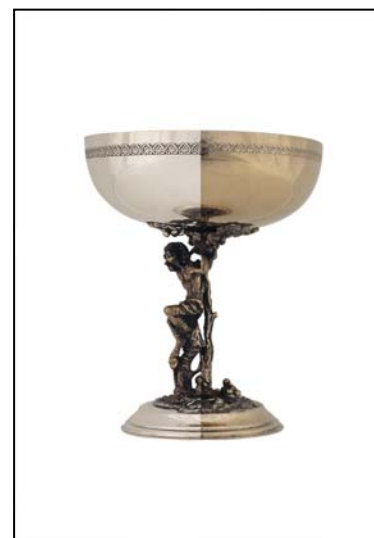
- **anti-tarnish**
- **anti corrosion**

Anti-tarnish coatings, AgTive[®]



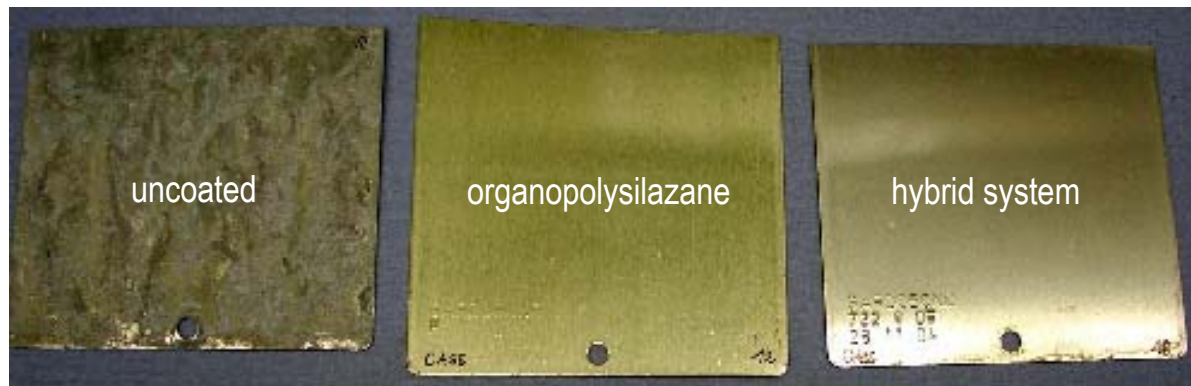
Copper, 14 days of outdoor weathering

- anti-tarnish coatings for silver, copper, brass and bronze
- barrier effect of AgTive[®] coating prevents silver from tarnishing, even in H₂S atmosphere
- based on inorganic polysilazanes or organopolysilazanes



Silver, after H₂S exposure

Corrosion protection coatings



chromated aluminium panels after CASS test, 240 h

- excellent adhesion on different aluminium alloys
- CASS test passed (240 h), DIN 50021, with
 - organopolysilazanes
 - organopolysilazanes combined with silica nanoparticles
 - hybrid systems
- coating thickness between 8 – 10 microns

Automotive applications

- **easy-to-clean RIMS**
- **gas manifold, heat exchanger**

Ceraset High temperature coatings



Heat exchanger coated with **Ceraset HTT**



Engine Manifold coated with
Pigmented **Ceraset HTT**

Features:

- No delamination
- Excellent resistance to thermal oxydation
- Excellent resistance to corrosive atmospheres
- Efficient thermal barrier,
- High efficiency engines, energy saving

Heat resistant Coatings on various Metals

- Conversion of polysilazanes to ceramics at high temperature provides good protection against oxidation and corrosion
- Adhesion is excellent e.g. on mild steel even after several cycles of heating to 1000°C and immersion into cold water
- Can be used for coating heat exchangers, engine manifolds, exhaust pipes etc.

Brass coupon, half coated



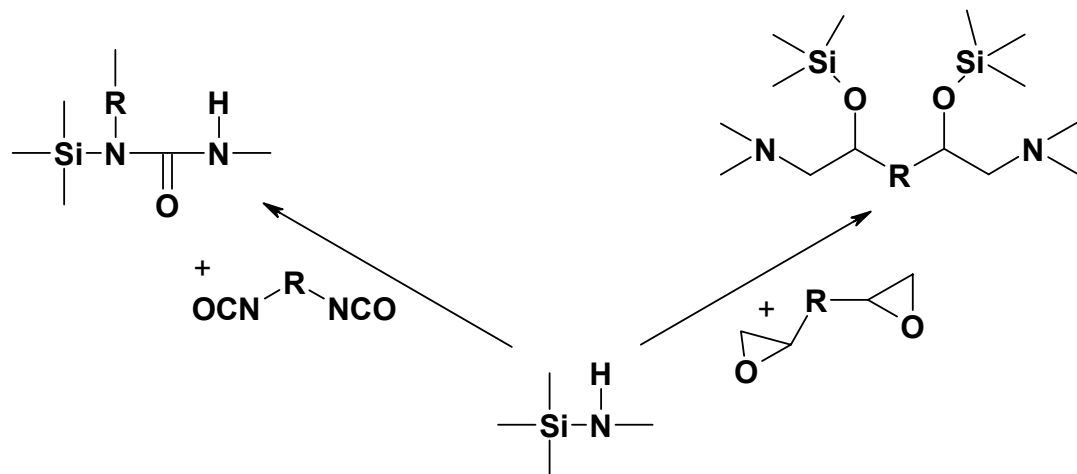
Polymer Hybrid Composites with Polysilazane

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New Business Development

Hybrid polymers with polysilazanes

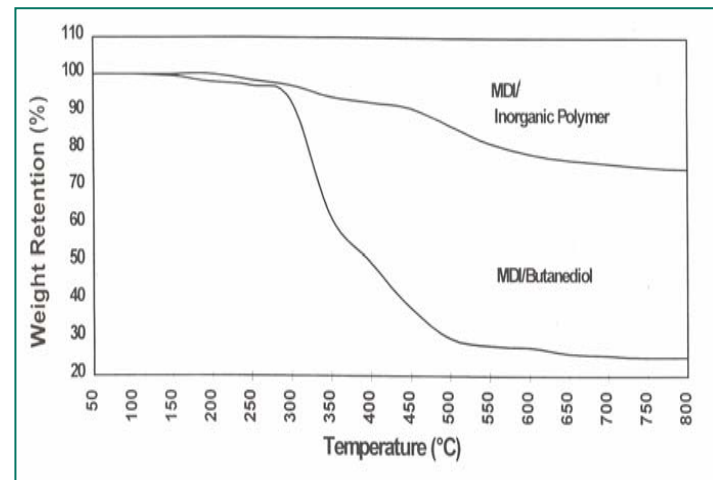
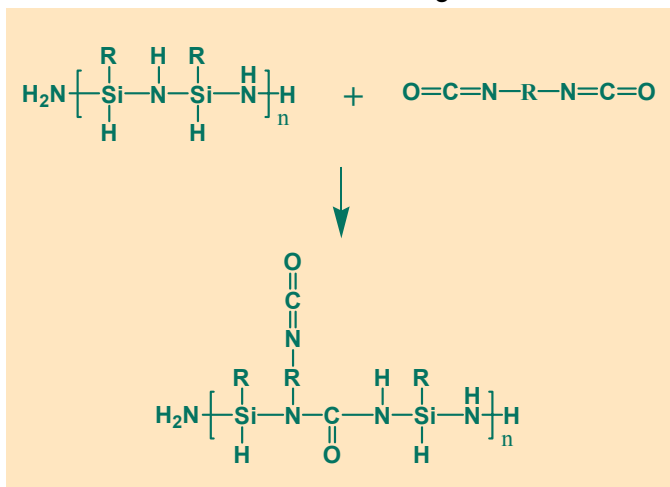
Example: reactivity of PZanes with isocyanate and epoxy groups



- SiH and NH are reactive groups
- Genuine hybrid polymers can be made
- Exceptional properties expected: mechanical strength, resistance to chemicals, to temperature and excellent adhesion on various substrates

Products: PZane-Isocyanate Composites

Ceraset VL20 / HDI trimer/fiber glass



- Exceptional Strength
- Extreme Durability
- Non-Burning
- No Smoke Generation
- Cost Effective (High Fill Loading)
- Uses include products for transportation components, sporting goods, civil infrastructure components, ship components, marine structures, chemical process components, etc.

Composite **PU2K** system with VL20/ IPDI

Composite **PU1K** system with VL20/ blocked HMDI

Conclusions

- Polysilazanes are a new class of inorganic polymers produced at industrial scale by Clariant
- Large scope of applications:
Protection coatings, Hybrid coatings, composites PMC, ceramics CMC
- Advanced properties:
very good resistance to thermal, chemical, mechanical, environmental aggression.