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Supresil™: Novel technology to increase the pot life of Silicones

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Silicone Family Tree

Elastomers – Sealing & Insulation

Silicone Resins & Encapsulantion

Medicinal products & implants

Silicone-polyether Surfactants

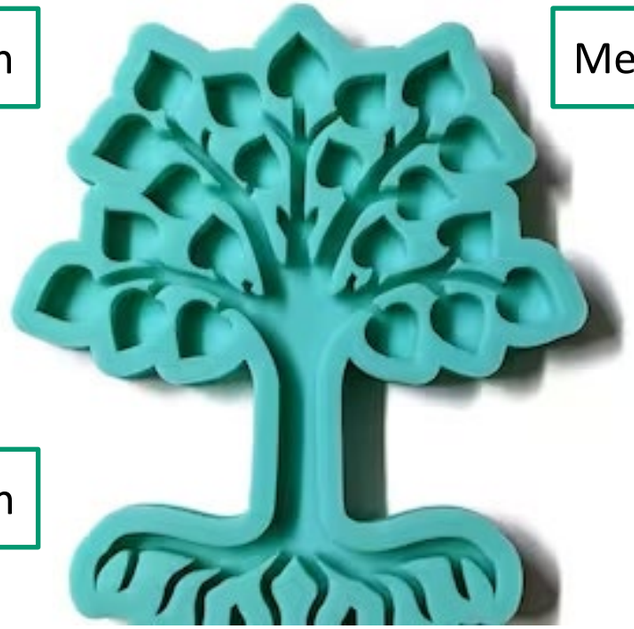
Fluorosilicones

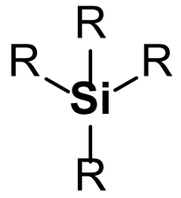
Alkoxy- & Chloro-**silanes**

Organosilicones

Methyl-**silanes** - hydrophobization

Aminosilicones



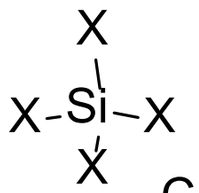


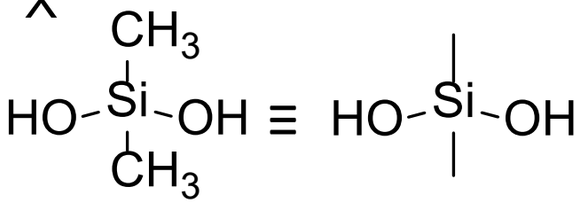
R = H, Me, halogen, OH, OR, $OSiR_3$, etc.

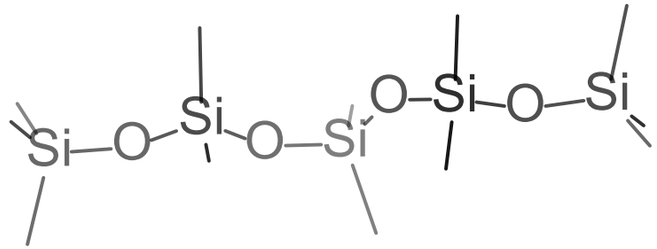
Silicone Nomenclature

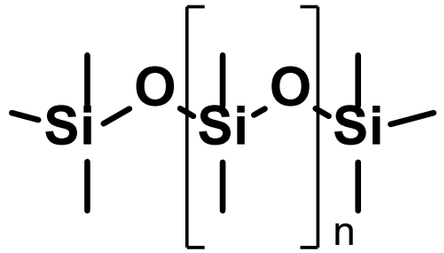
Silicon Si

Silica $SiO_{4/2}$

Silanes 

Siloxanes 





„Silicone“ = Polydimethylsiloxane (PDMS)

Why are Silicones special

	Si-O-Si	C-C-C	C-O-C	units
Bond length	**1.63**	1.54	1.42-1.46 (in PEO)	Å
Bond angle	**130°**	112°	111°	-
Bond energy	**106**	83	86	kcal/mol
Bond barrier	**0.2**	3.6	2.7	kcal/mol

Barrier to rotation (kcal/mol):	
Polyethylene	3.3
Polytetrafluoroethylene	4.7
PDMS	<0.2

Key Point: Siloxane polymers are stronger than carbon polymers, yet the polymer chains are more open and flexible!

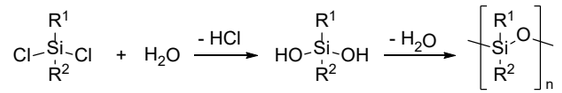
- Thermal stability up to 350 °C
- Stability at 200 °C ~ 10 000 h
- Glass transition at -127 °C (high MW but not solid)
- Inherent elasticity / stretchability
- High gas permeability
- Inherent hydrophobicity
- Very low surface tension/ energy
- Low surface shear viscosity
- Chemical inertness
- Biocompatibility / Non-toxicity
- Little viscosity change with temperature
- Excellent dielectric properties
- Tunability of properties over a wide range
- Very little shrinkage upon curing
- Unusualy low refractive index

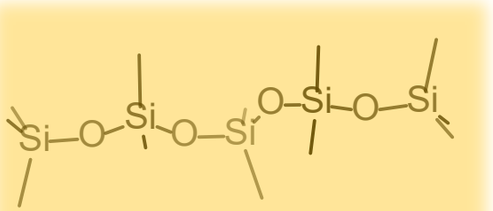
Why are Silicones special

- Initial material is quartz sand
  - $SiO_{4/2}$
  - 26% of the Earth‘s crust
- Reduction to „metallic“ Si^0 with C at 1400 °C. Charcoal?
- MeOH is converted to MeCl with recycled HCl. Biomethanol?

MeCl
Cu catalyst, ΔT

Chlorosilane mix:
Me_2SiCl_2
$MeHSiCl_2$
Me_3SiCl





Silicone oil

Waste & Recovery

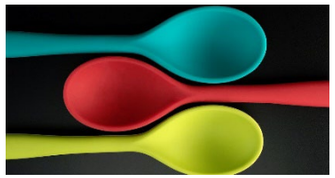
Chemical Recycling

Compounding & Vulcanization

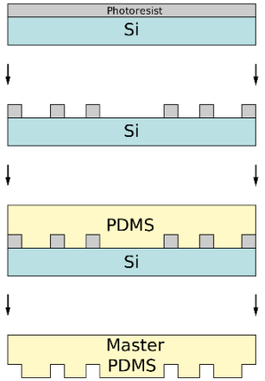
Silicone products

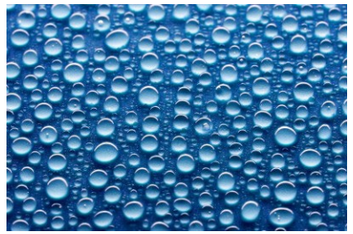
- Not based on fossil oil/ natural gas
- Energy intensive
- 15-17 t CO_2/ 1t SiO_2 (Dow)
- With charcoal 1-2 t CO_2/ 1t SiO_2 (Dow)
- Theoretically CO_2-neutral with Biomethanol & Green Energy
- **Short recycling loop to silicon oil without loss of quality**

Applications of silicones



- Aerospace
- Automotive
- Chemicals/ Petrochemicals
- Construction
- Consumer Products
- Electrical/ Electronics
- Food Processing
- Paints &Coatings
- Medical Products
- Pharmaceuticals
- Personal, Household & Automotive Care
- Plastics
- Textiles, Leather & Wearables
- Pressure sensitive adhesives
- Industrial Maintenance Products
- Microcontact- and Pad-Printing





Types of silicones - classification

Processing temperature

- High Temperature Vulcanizing (**HTV**)
- Room Temperature Vulcanizing (**RTV**)

„Consistency“ - viscosity

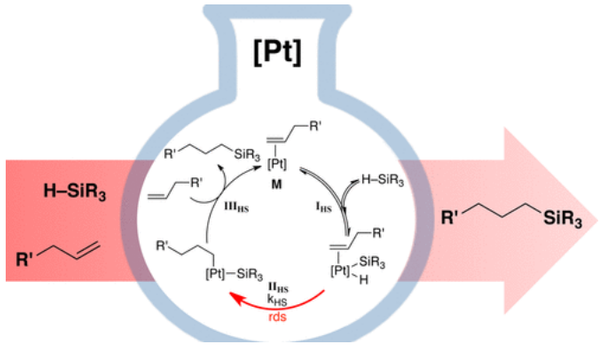
- High Consistency Rubber (**HCR**)
- Liquid Silicone Rubber (**LSR**)

Curing method

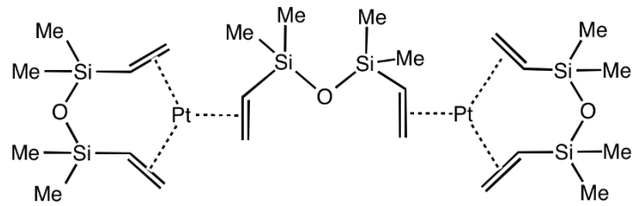
- Peroxide
- Acetate & chloride
- Sn-cure (condensation)
- Pt-cure (addition)

Number of Components

- **2K**
- **1K**



„Pt-cure“ =
Addition curing *via* **Hydrosylilation**



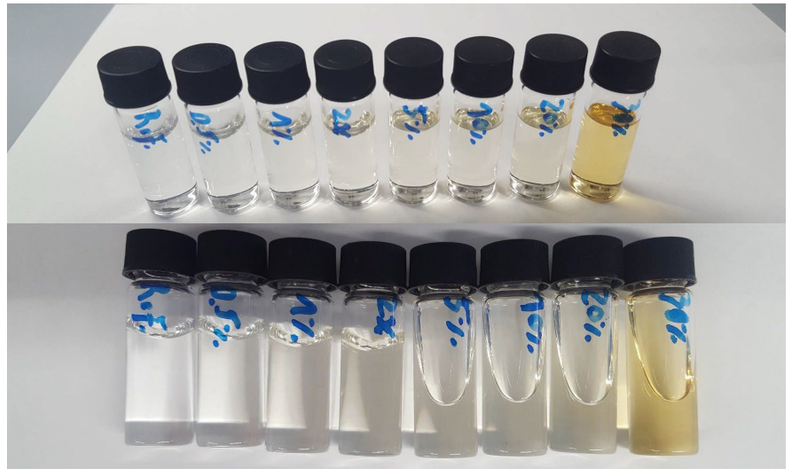
Karstedt‘s Catalyst

[Bis[1,3-bis(η2-ethenyl)-1,1,3,3-tetramethyldisiloxane][μ-(η2:η2-1,3-diethenyl-1,1,3,3-tetramethyldisiloxane)]diplatinum]

Key point: Additive Pt-curing is possible within a temperature span >200 °C. At increased temperature it is fast and has a high yield. Volume shrinkage is minimal (<0.1%). **High-end silicones are made from Pt-cure resins. 2K resins are difficult to work with because they have a short pot life even at RT.**

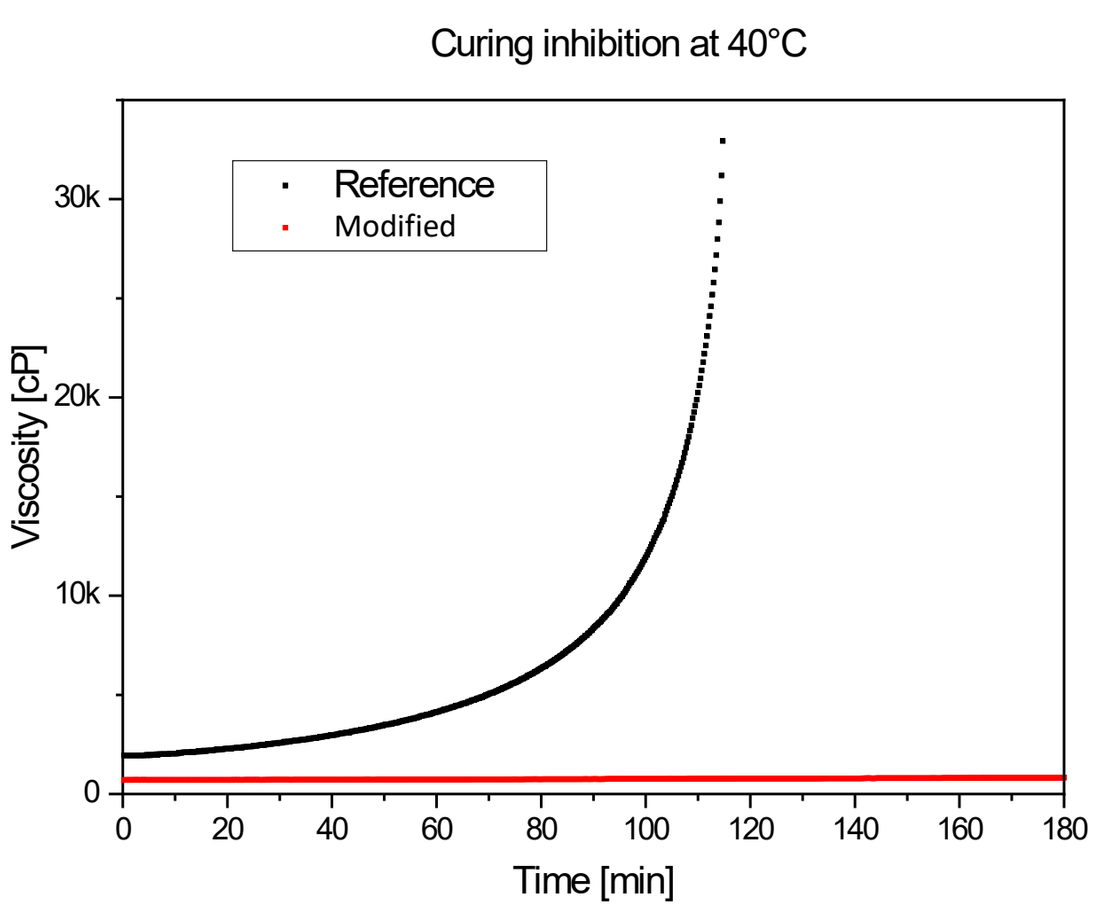
Supresil™ - novel shelf-stable silicones *via* reversible inhibition of hydrosilylation

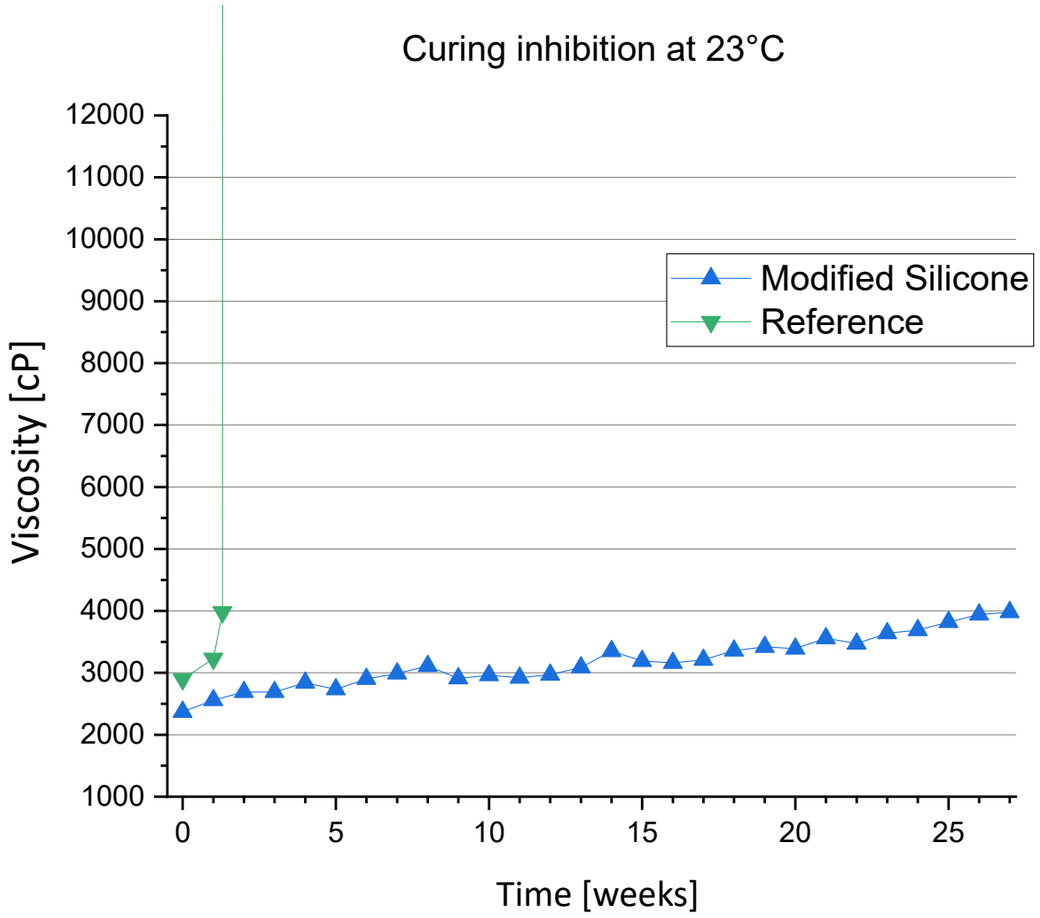
- Shelf stable formulation for an addition cured PDMS elstomer resin
- Standard Pt-catalyzed PDMS thermoset
- **Full curing inhibition – single component (1K) ink!**
- Volatile inhibitors (boiling point < 110 °C)
- Compatible with Fluorosilicones
- Excellent processability
- Traceless
- Applicable in dispensing, screen-printing, aerosoljet-printing, inkjet printing, etc.



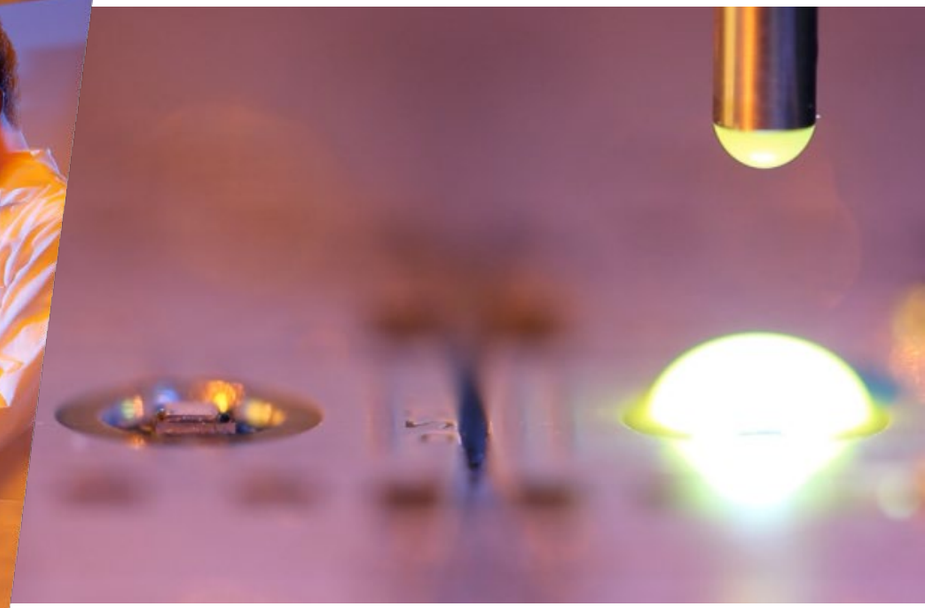
US 11,731,115 B2 and EP 4074790
„Inhibitors of Hydrosilylation Catalysts“

Supresil™ - novel shelf-stable silicones





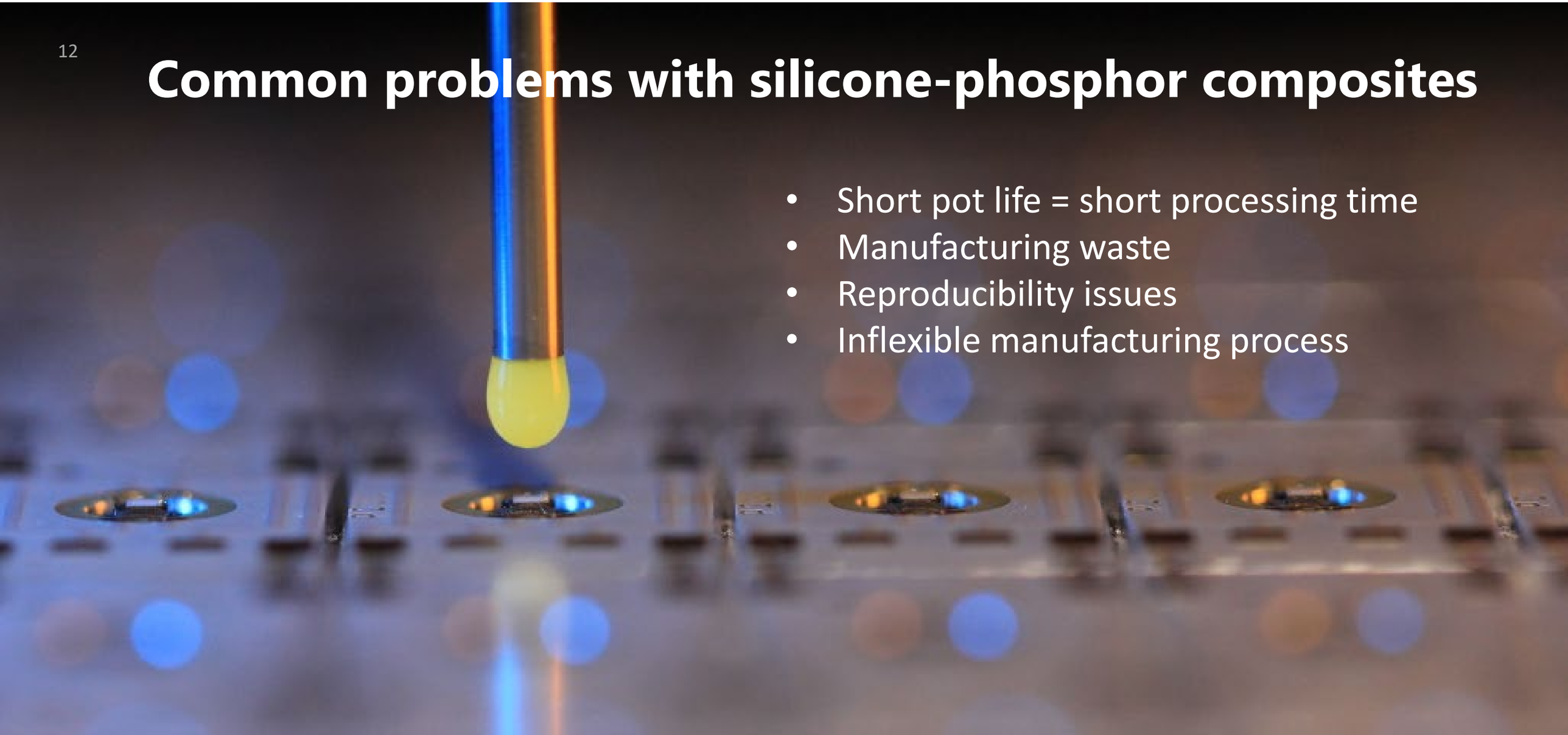
Case study: Shelf-stable silicone-phosphore composites for LED packaging



Pt-cure Silicone is the preferred resin for phosphor encapsulation in white LEDs:

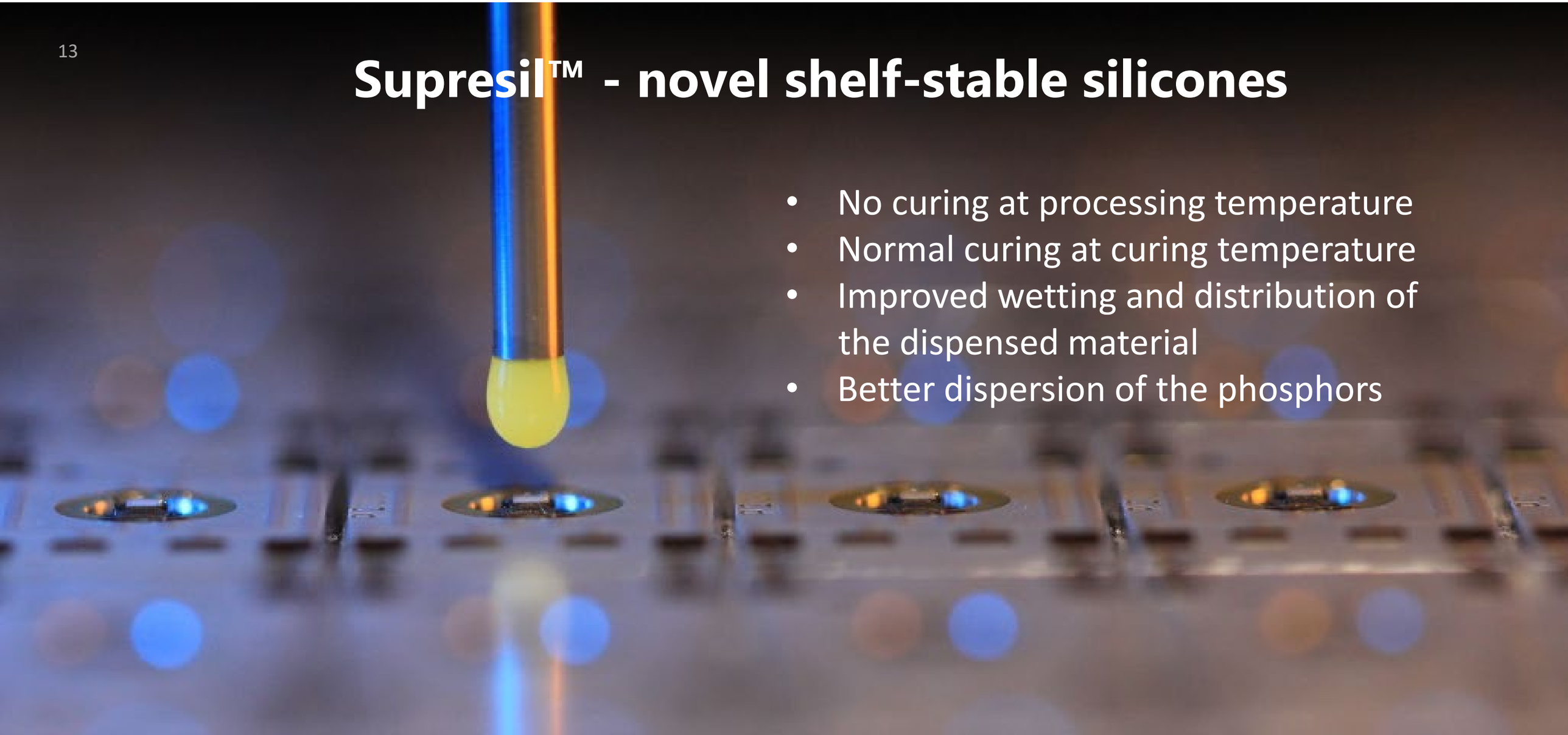
- Temperature stability at high temperature
- Stable mechanical performance
- No oxidation or yellowing
- Low shrinkage
- Excellent transparency

Common problems with silicone-phosphor composites



- Short pot life = short processing time
- Manufacturing waste
- Reproducibility issues
- Inflexible manufacturing process

Supresil™ - novel shelf-stable silicones

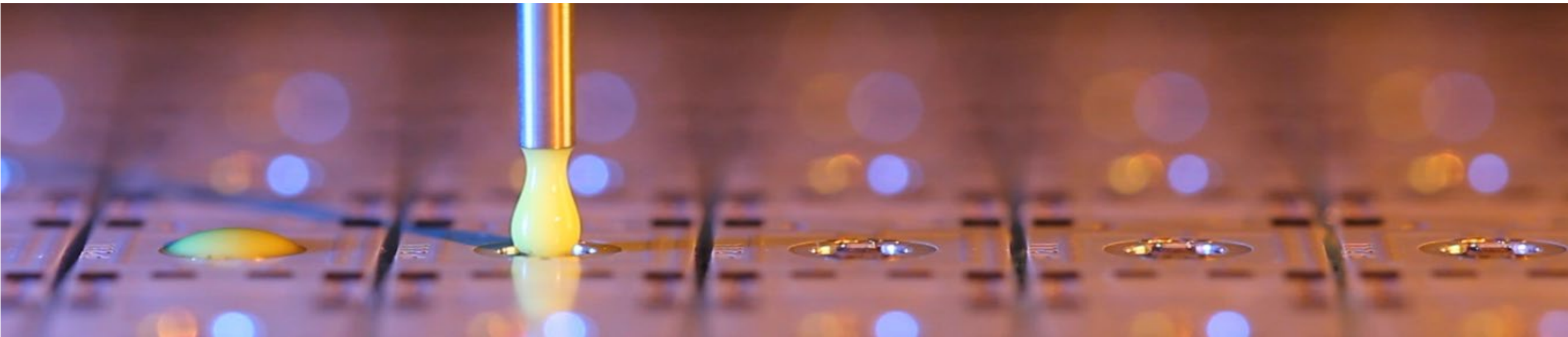


- No curing at processing temperature
- Normal curing at curing temperature
- Improved wetting and distribution of the dispensed material
- Better dispersion of the phosphors

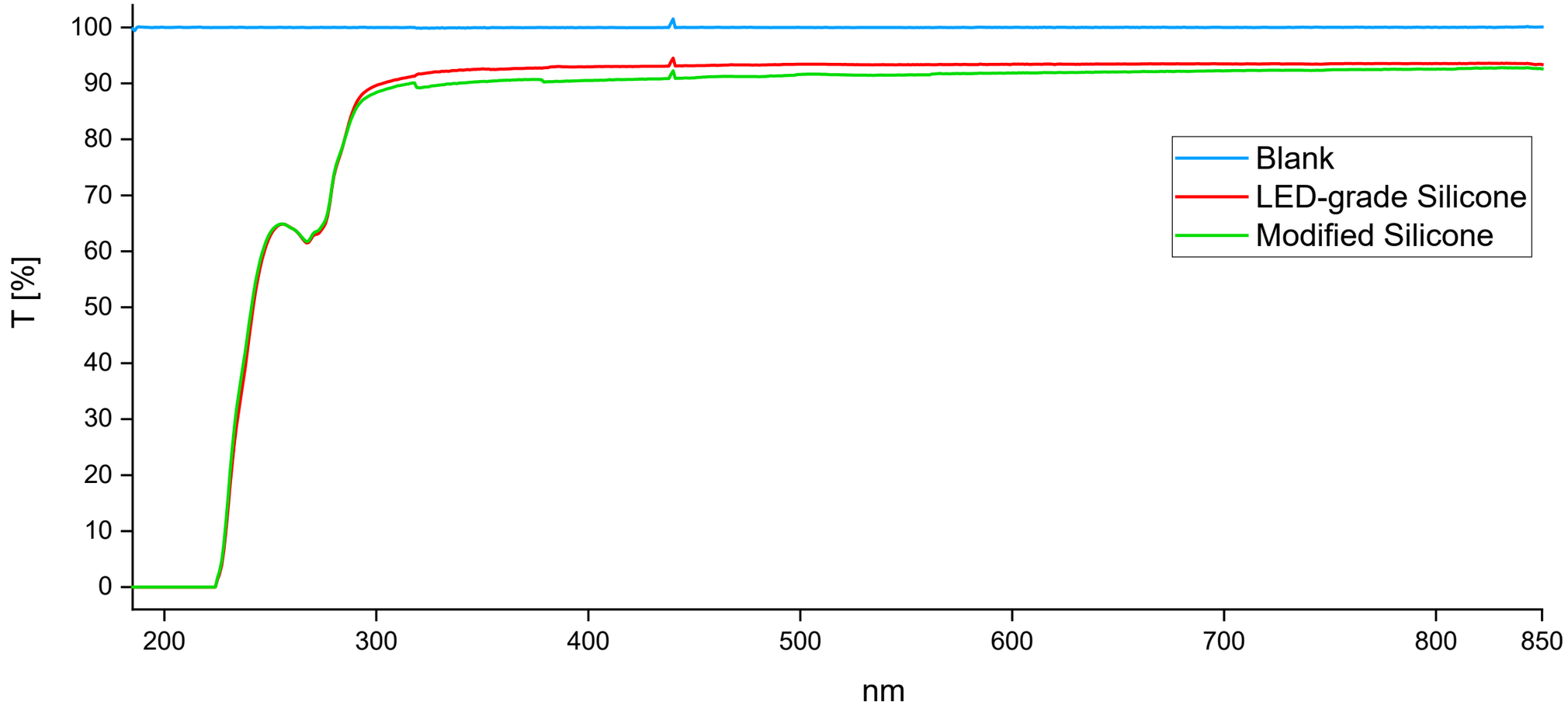
Supresil™ - novel shelf-stable silicones

All physical and optical properties of the silicones stay unchanged

- Low shrinkage
- Unaltered storage modulus
- No change in UV/VIS transmission („yellowing“)



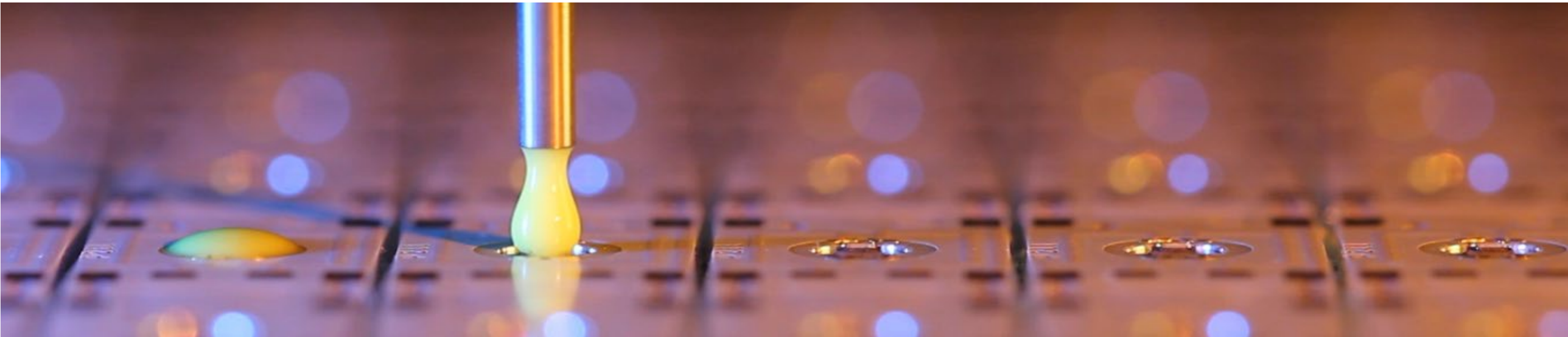
UV/VIS of cast silicones (100 µm)



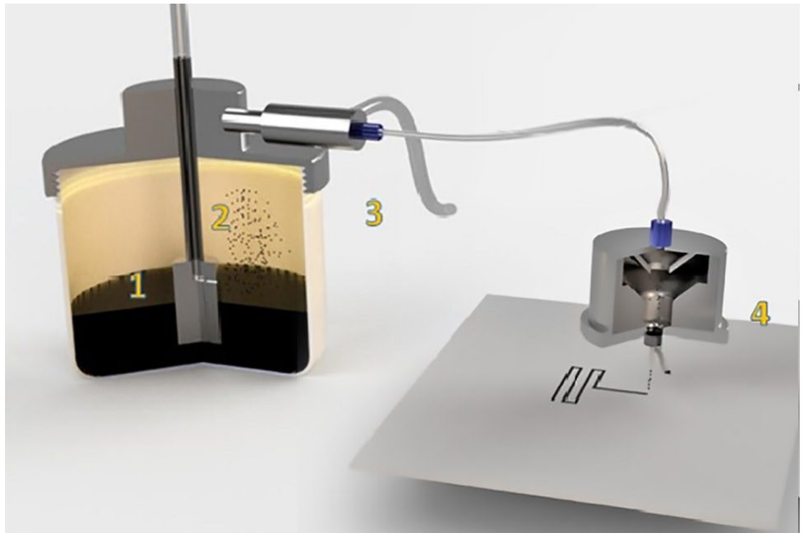
Take home message (commercial)

JR can make your silicone shelf-stable with Supresil™

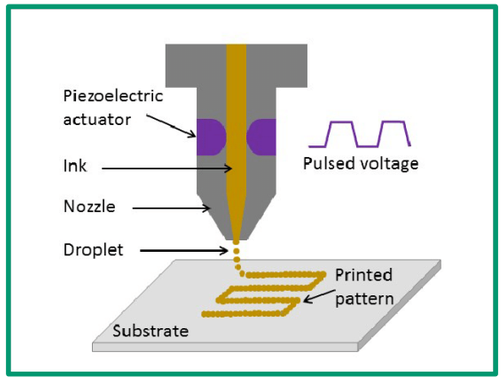
- Save time & cost for preparation
- Save expensive LED-grade silicone material
- Save the planet – Stop generating non-recyclable waste

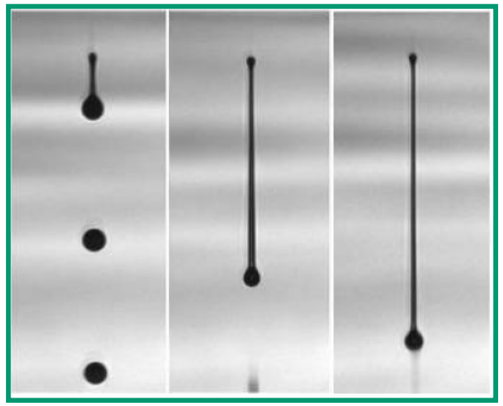


Current research: Aerosol-Jet Printing & Casting



Current research: Inkjet Printing





Find out more about Supresil™ at

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Danke für Ihre Aufmerksamkeit!

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