Regulatory-Driven Innovation

Siltech Corporation

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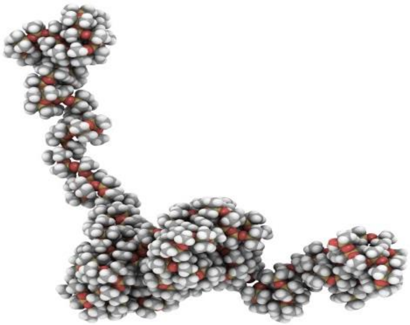
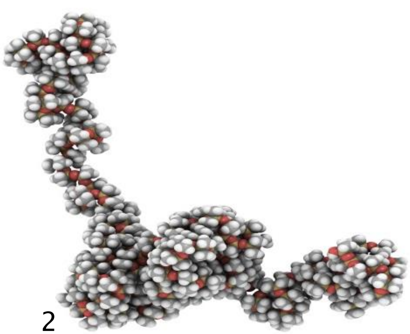
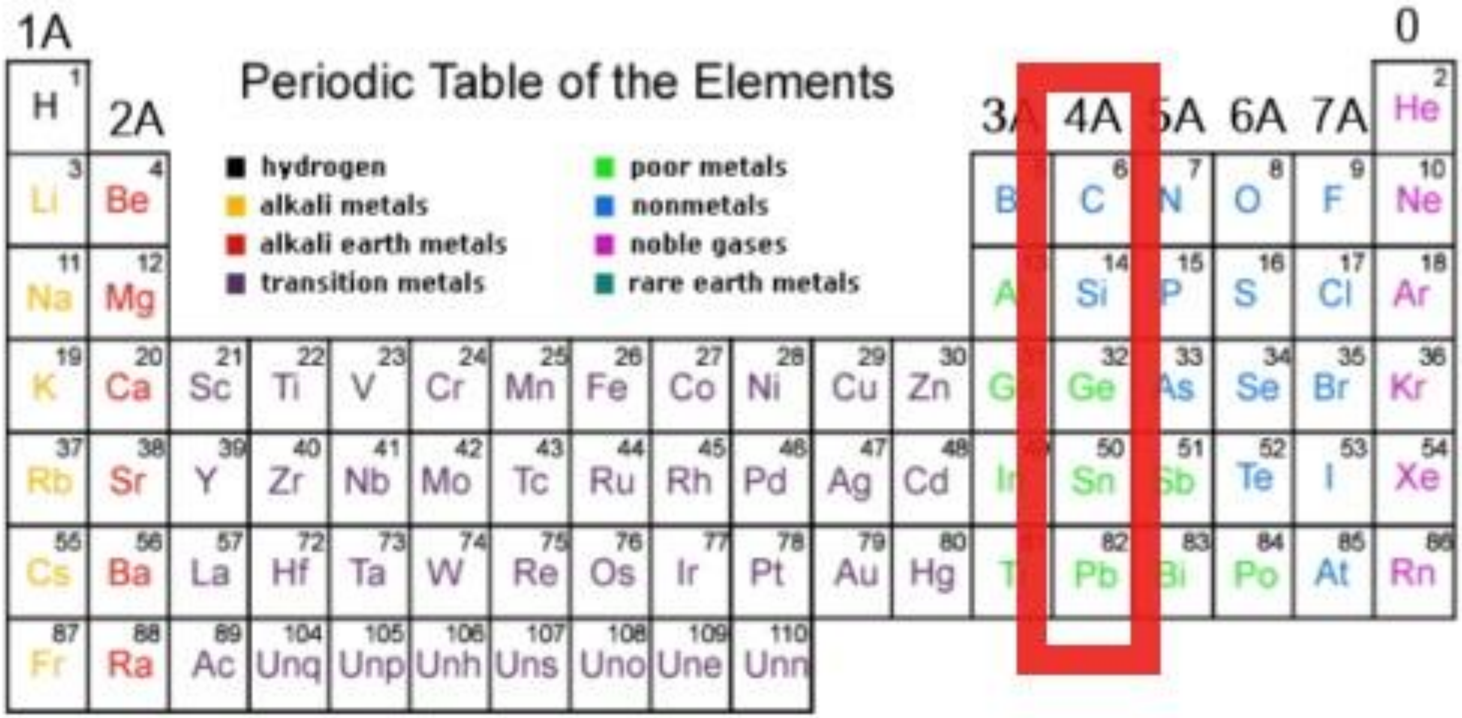


Siltech Corporation

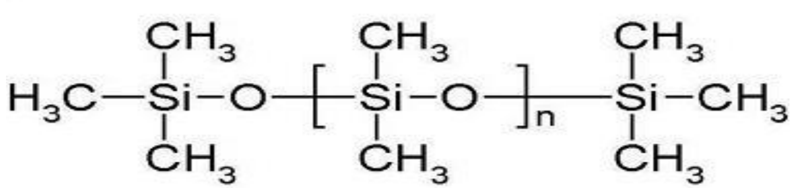
- Regulations are common drivers for innovation
- Examples related to silicone technology presented today

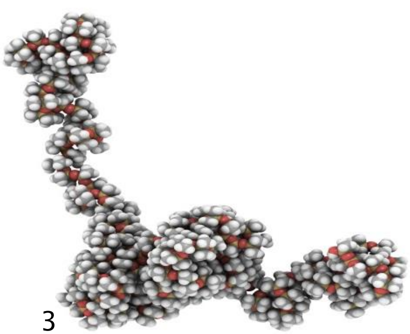


Silicon



Periodic Table of the Elements
1A
2A
3A
4A
5A
6A
7A
0
hydrogen
alkali metals
alkali earth metals
transition metals
poor metals
nonmetals
noble gases
rare earth metals





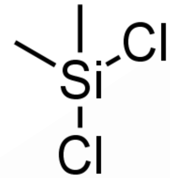
The Journey from Silicon to Silicone

14
Si
28.0855

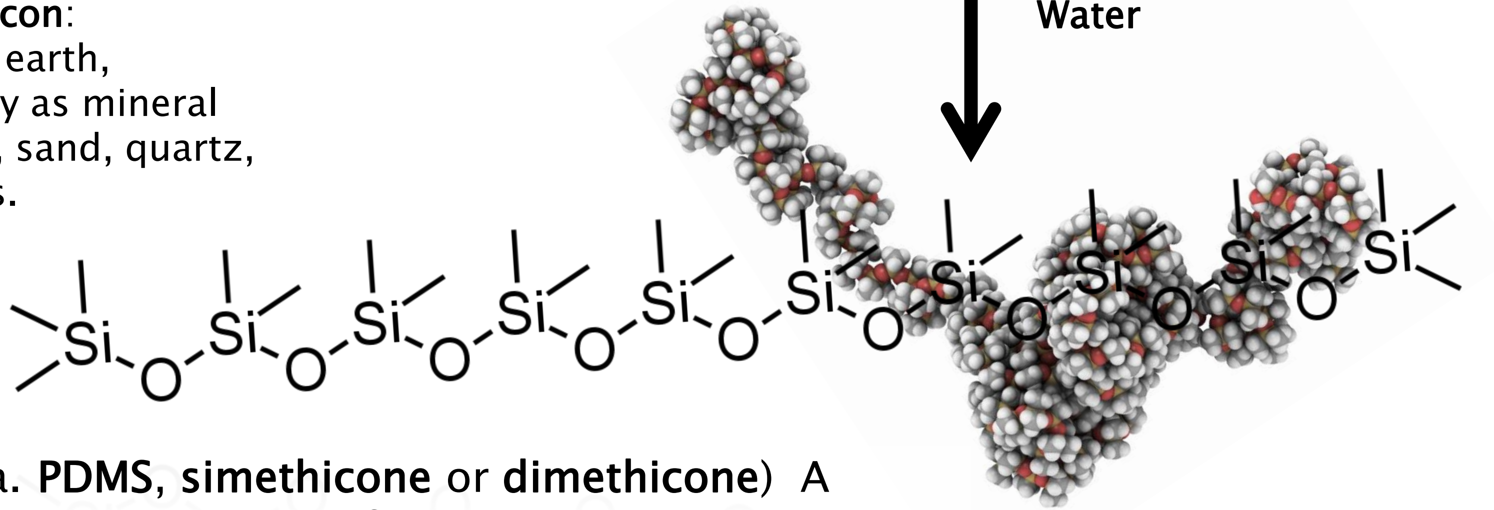
1) **Methanol**: A biochemical very common in nature. Generally made from Natural Gas.
2) **HCl**: a mineral acid

Catalysts:
from the Earth

A variety of **chlorosilanes**: man-made, highly reactive intermediates.



Water



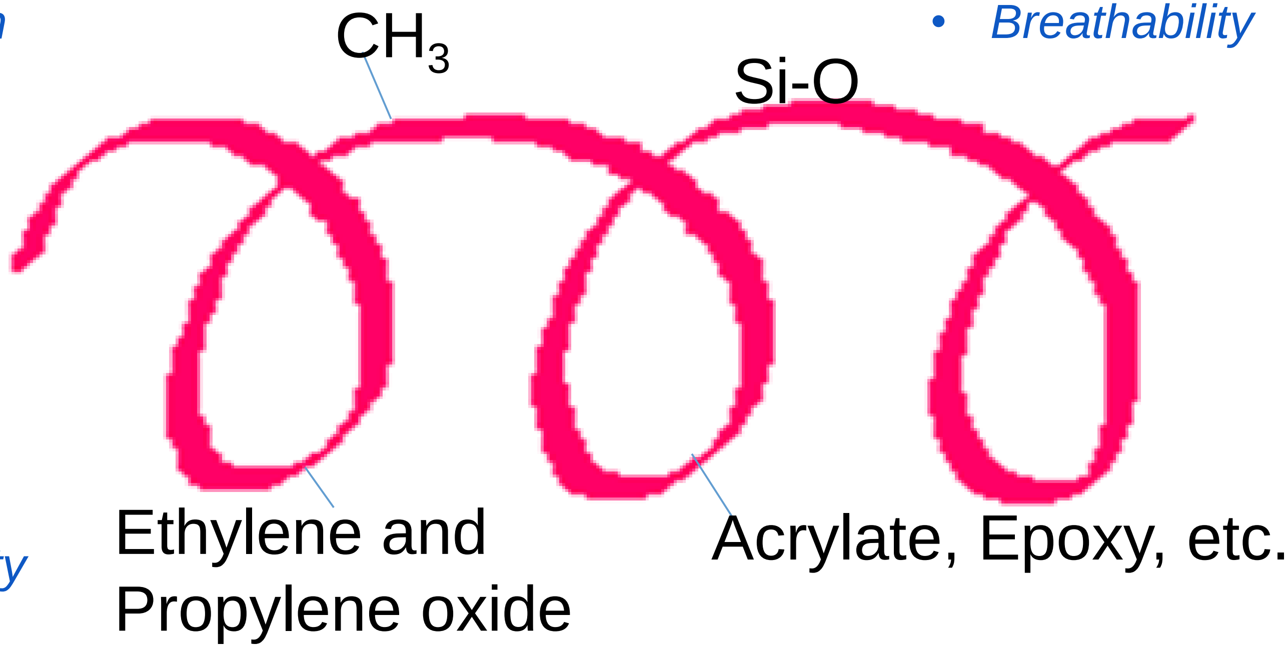
Elemental **Silicon**: Abundant on earth, predominately as mineral oxides; silica, sand, quartz, or gemstones.

Silicone: (a.k.a. **PDMS, simethicone** or **dimethicone**) A polymer used in a wide range of applications. It is among the most toxicologically studied polymers known to humanity and exhibits extremely low toxicity.

Properties of Silicones

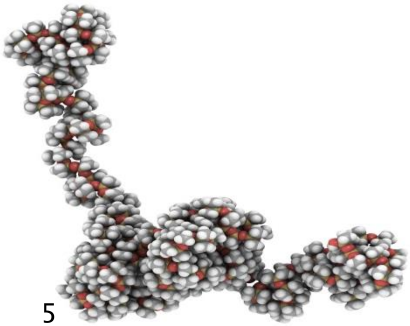
- *Thermal Stability*
- *Chemical Resistance*
- *Weather Resistance*
- *Breathability*

- *Hydrophobic*
- *Release*
- *Lubrication*
- *Gloss*
- *CoF*



- *Levelling*
- *Wetting*
- *Hydrophilic*
- *Compatibility*

- *Reactive*
- *Flexibility*
- *Hybrid properties*

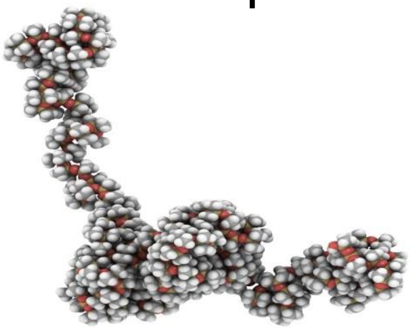


Reality of Public Policy and Regulation

- Today instant, fragmented communication and desire to lessen negative impact on the environment and society drive regulatory and market changes.

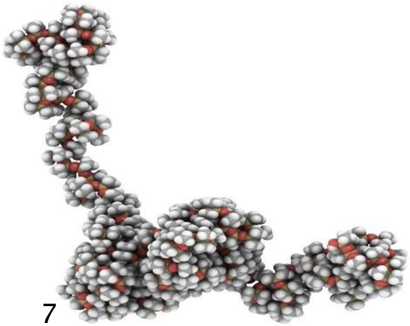
- Perception is the new reality.
  - Chemicals are often guilty until proven innocent
  - Market perception often more important than regulations. And it nearly always precedes regulatory mandate.

- Manufacturers often scramble to stay ahead of the current hot topics with innovation and new product development.

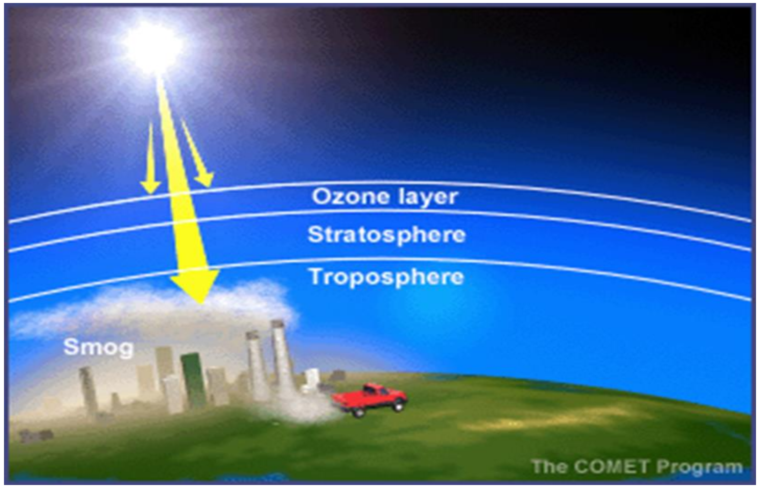


Regulatory Drivers in the Silicone Field

1. Solvents and Volatiles
2. Fluorine
3. Emulsifiers
4. The "Green" Trend

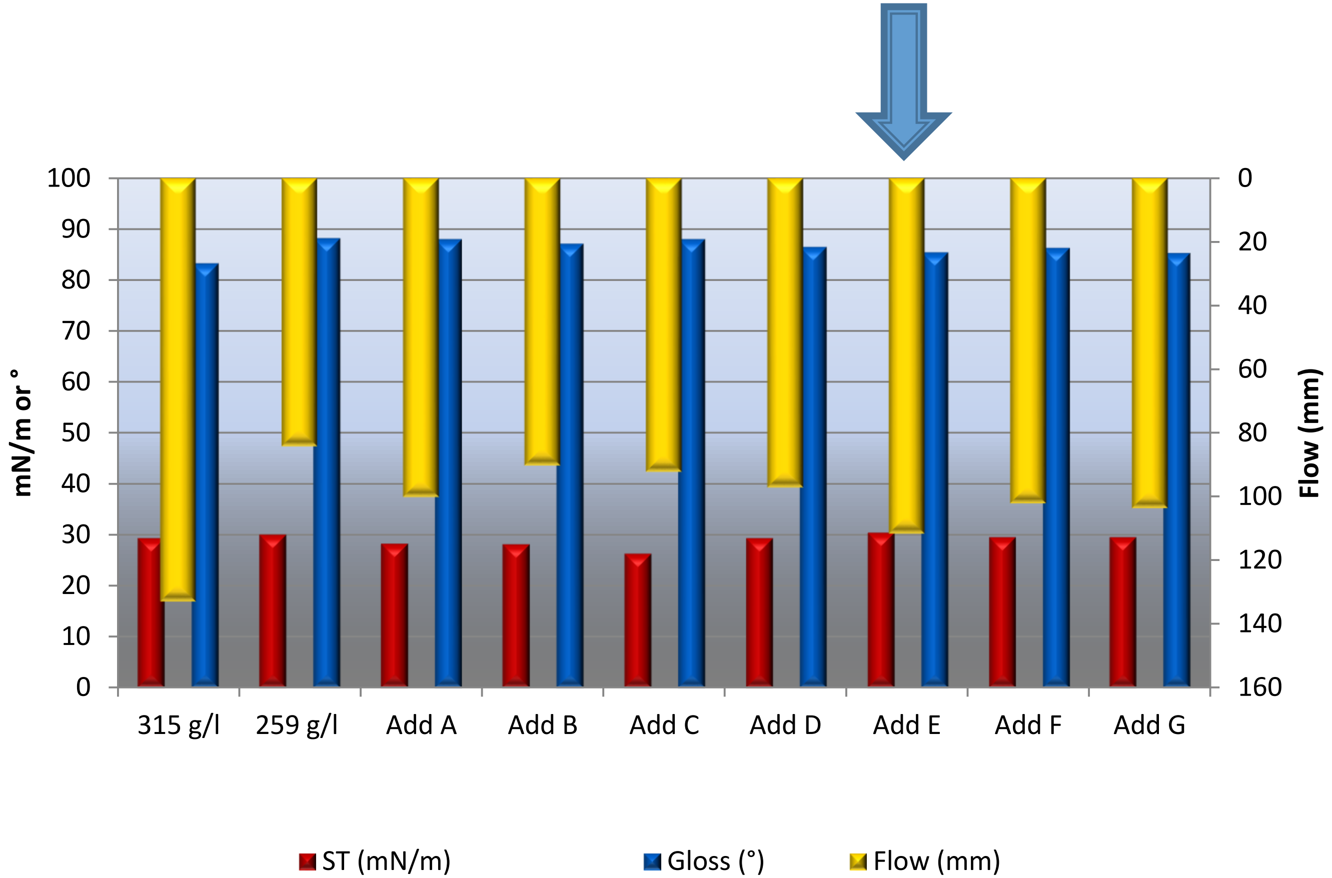


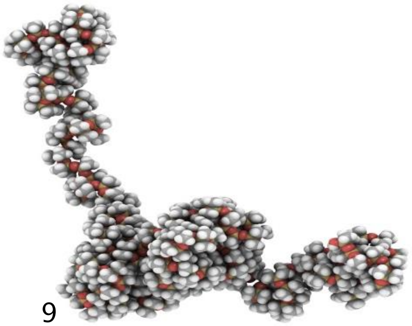
1. Solvents and Volatiles



- Reduce Organic Volatiles and Solvents
- Reduce Volatile Siloxanes and Silicone Solvents

Reduce Organic Solvent





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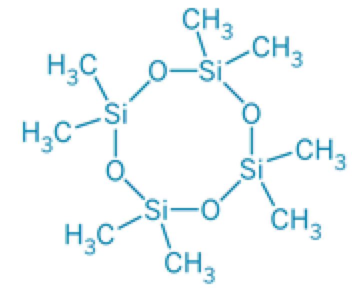
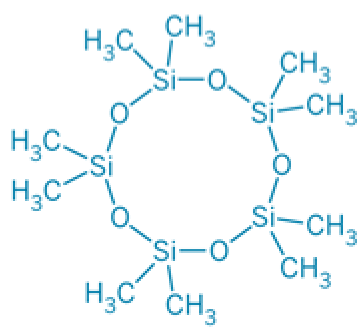
Volatile Cyclic Siloxanes

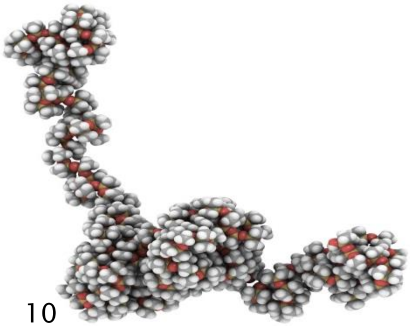
- Silicones are non-HAPs
- Extensive toxicological and environmental testing has been completed
- Some early results led to concern over volatile silicones D_4/D_5
  - Personal Care Industry
  - Canada and Norway



D4

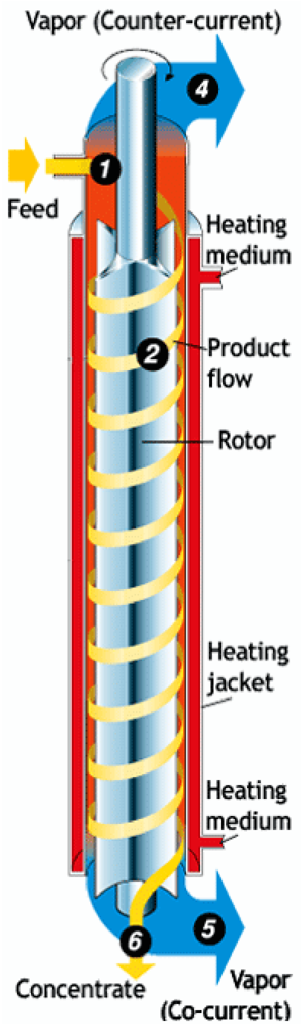


D5

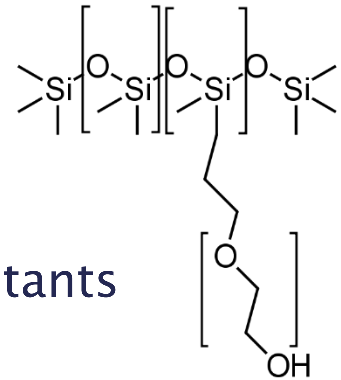


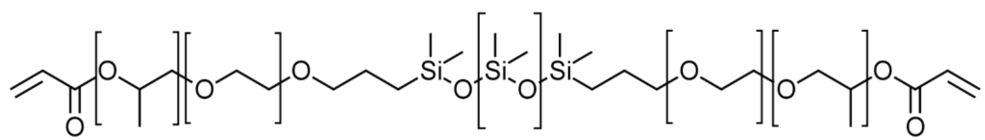
Volatile Cyclic Siloxanes

WFE

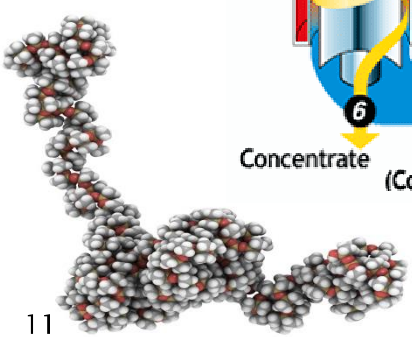


Silicone surfactants





Silicone di-acrylates



2. Fluorine –

Ambiguity for sure…

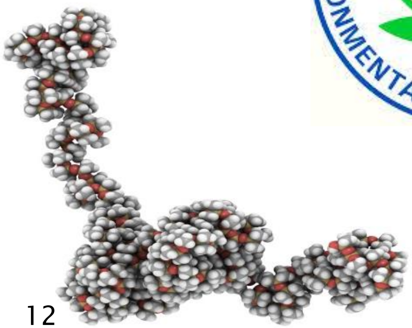
What are the concerns related to PFOA?

PFOA is very persistent in the environment and has been found at very low levels both in the environment and in the blood of the general U.S. population. Studies indicate that PFOA can cause developmental and other adverse effects in laboratory animals. PFOA also appears to remain in the human body for a long time. All of these factors….

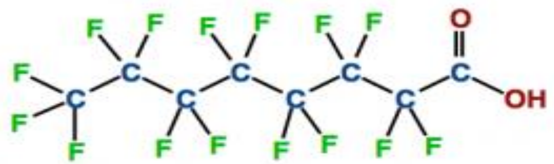
What are fluoropolymers and telomers and how are they used?

Fluoropolymers impart valuable properties, including fire resistance and oil, stain, grease, and water repellency. They are used to provide non-stick surfaces on cookware and waterproof, breathable membranes for clothing. They are employed in hundreds of other uses in almost all industry segments, including the aerospace, automotive, building/construction, chemical processing, electrical and electronics, semiconductor, and textile industries.

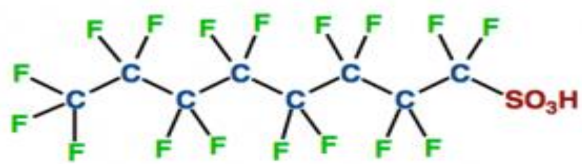
(Source: http://epa.gov/oppt/pfoa/pubs/faq.html#concerns)



Fluoropolymers



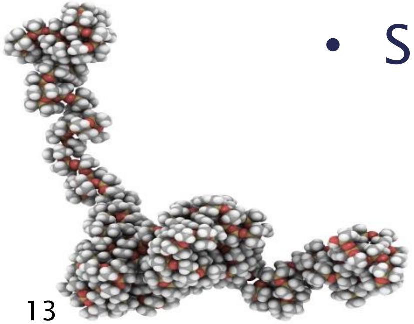
PFOA - perfluorooctanoic acid



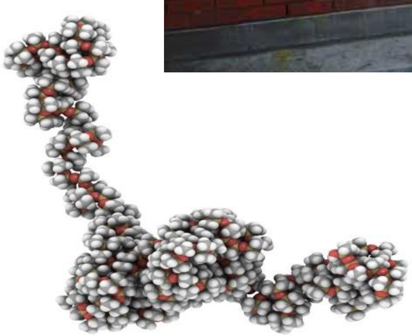
PFOS - perfluorooctanesulfonic acid

Strategies for managing concerns and regulatory change

- Reduce length of fluorine chain
- Substitute fluorocarbons with fluorosilicones

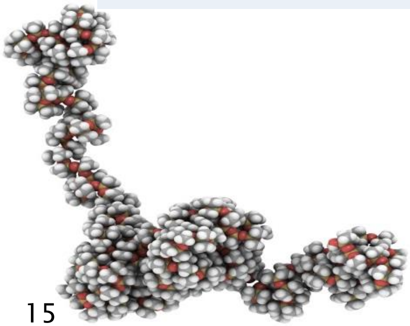


Challenges from Staining, Fouling, Graffiti, Fingerprints, Chemicals....

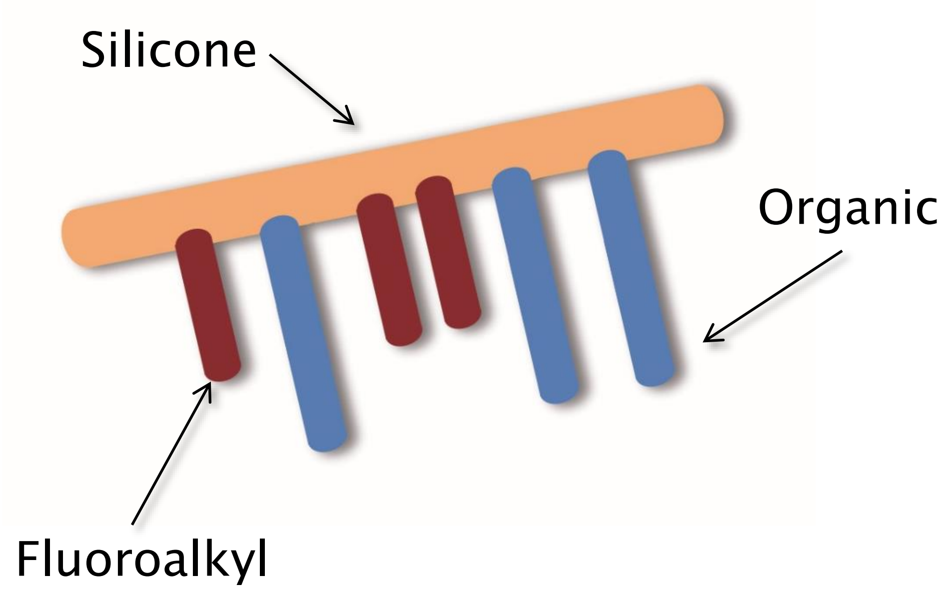


Comparison of Selected Properties of Silicone and Fluoropolymers

Silicone	Fluoropolymer
✓ Low surface energy	✓ Very low surface energy
✓ Very good thermal flexibility	✓ Marginal thermal flexibility
✓ Good chemical resistance	✓ Very good chemical resistance
✓ Marginal oil resistance-swelling	✓ Very good oil resistance
✓ Very good water resistance	✓ Good water resistance
✓ Marginal abrasion resistance	✓ Low abrasion resistance
✓ High cost	✓ Very high cost
✓ Effective at low use levels	✓ Effective at low use levels



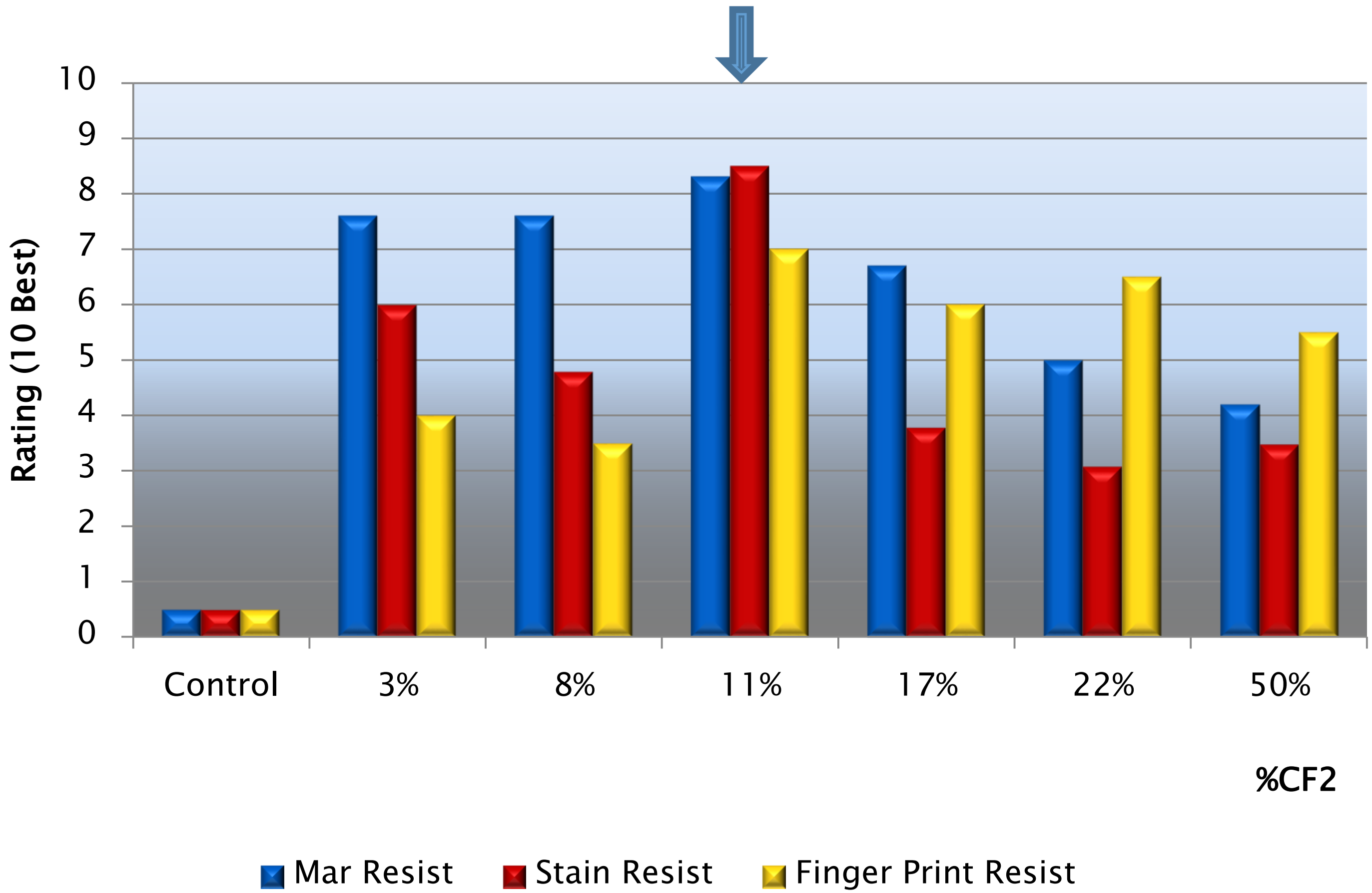
Fluoroalkyl Silicone Variants



- Silicone provides slip, surface tension reduction, mar resistance, hydrophobicity.
- Fluoroalkyl provides oleophobicity, stain and chemical resistance
- Organic provides miscibility

By varying the number, length and type of fluoroalkyl and/or organic substituents covalently bound to the silicone we can control properties.

Substitution of Fluorocarbons



Reduce total F +

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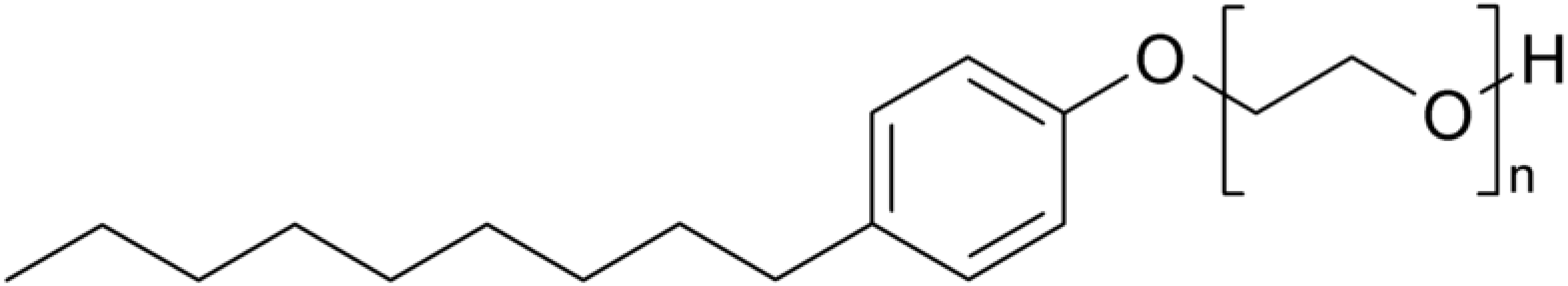
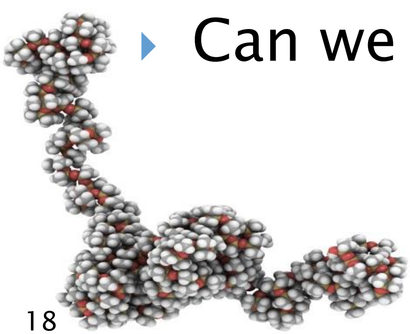
3. Emulsifiers (APEO- and EO-free surfactants)



- Most pressure is on Nonyl
- Lipophilic and Hydrophilic Balance
- Good emulsifying and dispersing properties
- Low toxicity but degradation products are cited
- Greenpeace DETOX
- Can we have APEO- and EO-free too?



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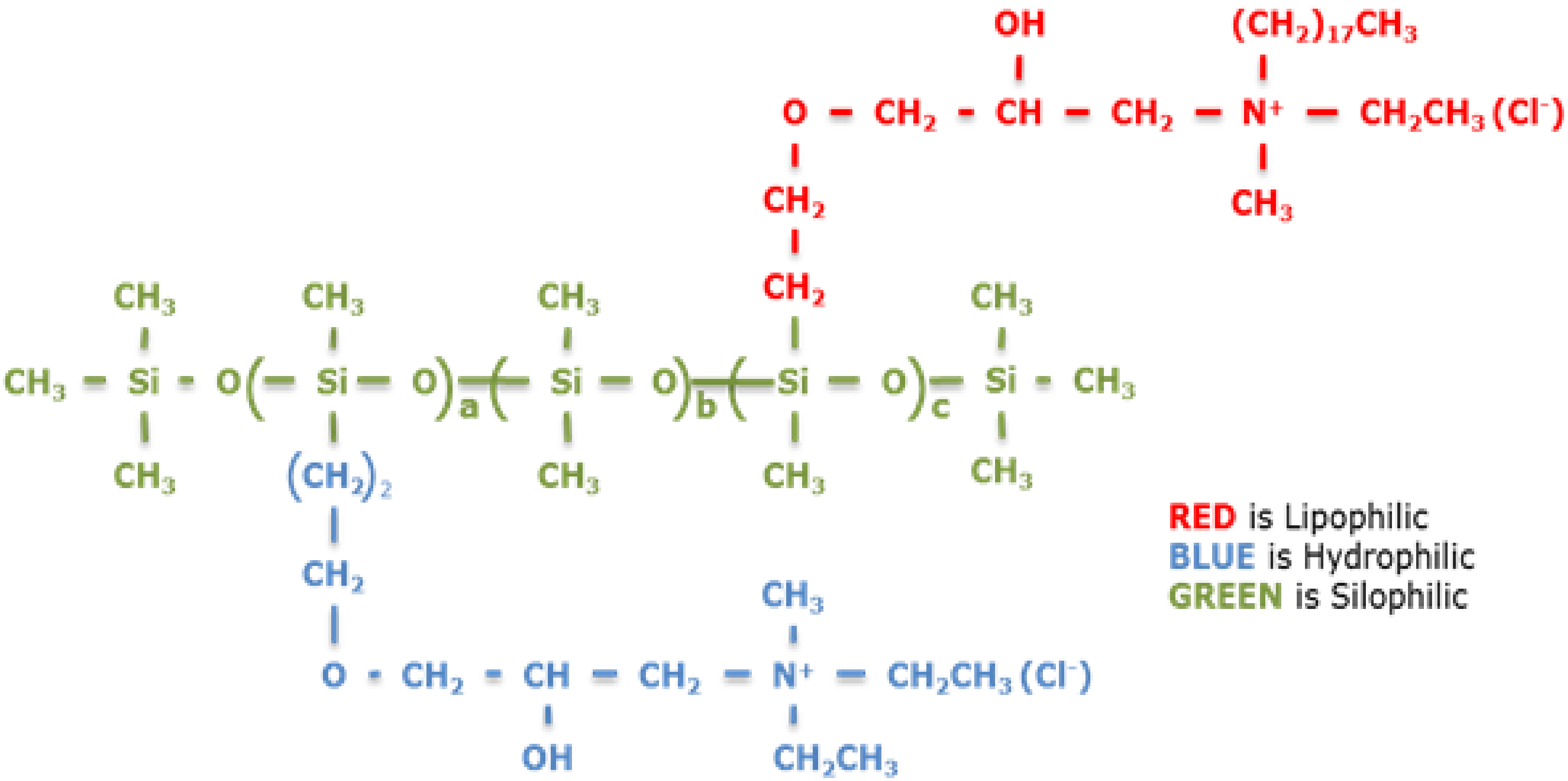
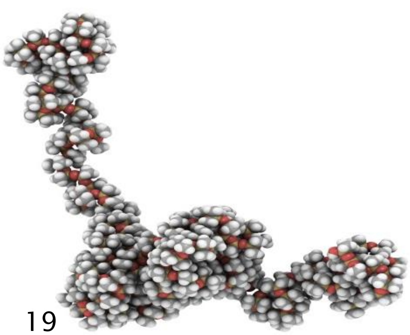
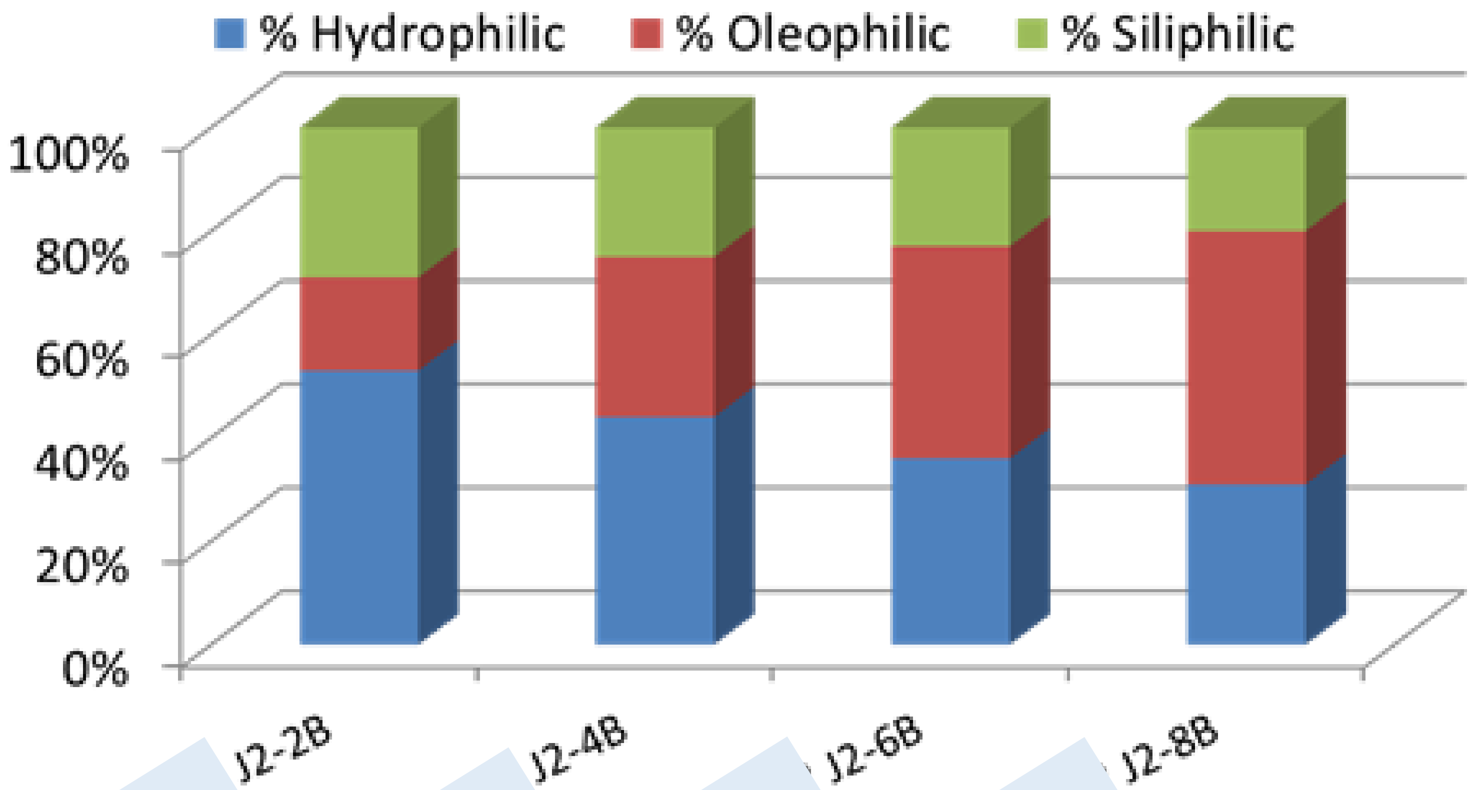
Silicone Quaternary materials



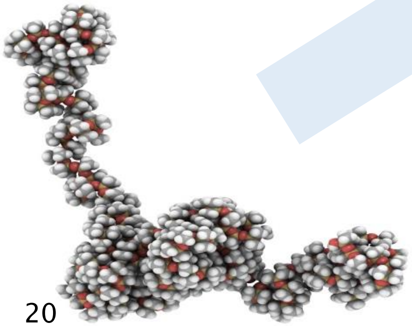
RED is Lipophilic
BLUE is Hydrophilic
GREEN is Silophilic



Versatility in structure

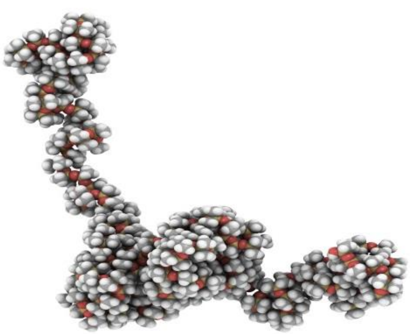


Silicone Quaternary examples



Excellent EO Free O/W Emulsifier primarily used for PC, for now…

Silicone quat examples	Emulsion Type	HLB	Viscosity	Shear needed	Processing Temperature	Applications: Make Up	Applications: Sun Care	Applications: Skin Care	Applications: Hair Care	Applications: Hydroalcoholic Emulsion	Secondary Benefits: Ease of application	Secondary Benefits: water resistance	Secondary Benefits: Lubricity and Release	Secondary Benefits: Pigment dispersion	Secondary Benefits: Sensory Claims
J2-2B	**O/W**	11	7000	H	H	Y			Y	Y					rich non-greasy, luxurious, very soft, smooth powdery feel
J2-4B	**O/W**	9	7500	H	H	Y	Y	Y	Y	Y					
J2-6B	**O/W**	7	7500	H	H	Y	Y	Y	Y	Y					
J2-8B	**O/W**	5	6700	H	H	Y	Y	Y	Y	Y		Y	Y	Y	



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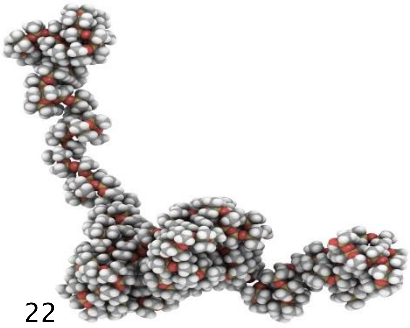
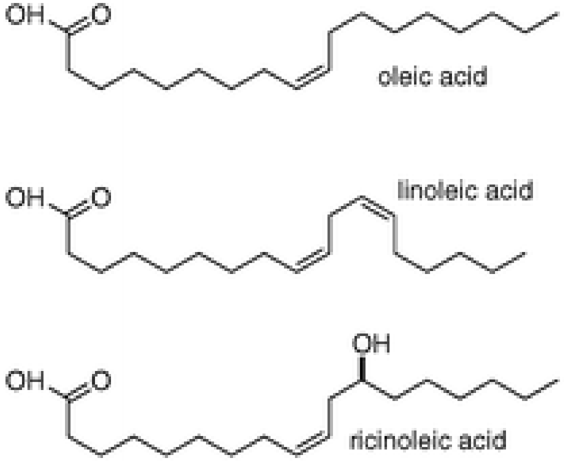
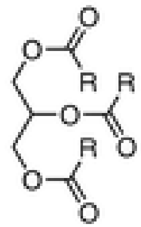
4. The Green Trend

- "Green" has come to mean non-petroleum, preferably naturally derived materials.
- Silicone is synthetic, but is derived from silica – the main component of the earth's crust.
- There is a market need for more natural products.
- A variety of products based on castor oils, peanut, sunflower and essential oils can be made.

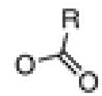


Castor Oil Silicones

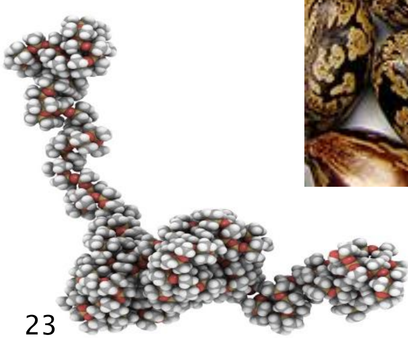




Castor oil

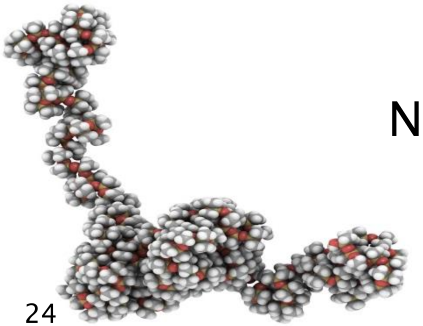


= ricinoleate, 87%
= oleate, 7%
= linoleate, 3%
= others, 3%



Castor Oil Silicones

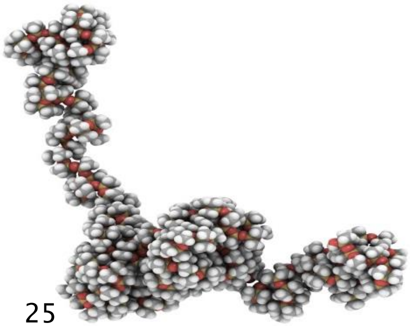
1.74% additive in SB/PU	Gloss	Static COF	Kinetic COF	Marker Resist.	Mar Resist.	Coating Appearance
Silicone Copolymer type						
Silicone Acrylate	92.2	0.405	0.384	7.500	7.5	Mild waves
Silicone Carbonate	97.2	0.680	0.745	7.000	7.6	Mild waves
Silicone Castor Oil	96.3	1.019	0.945	9.000	8.2	Smooth



Natural oils and coatings can be "siliconized"

Conclusion

- Sound science *should* drive regulatory change, but….
- Regulations can foster innovation and result in better and safer chemicals
- Collaboration, creativity and agility are vital



THANK YOU!

QUESTIONS?