



# Novel Silicones

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# Who is Siltech?

- ▶ A 20 year old, Canadian-based specialty silicone manufacturer with >100 employees and two production facilities



# Agenda

- ▶ Design
  - Coatings systems
  - Testing
- ▶ Mono-functional silicones
- ▶ Quaternary Ammonium Silicones
- ▶ Fluoroalkyl Silicones

# Experimental and Methodology:

- ▶ The overall design is to use different basic coatings systems:
  - (2) SB Urethane formulas
  - (2) UV Cured acrylate formulas
  - Cationic UV cured epoxy silicone
  - Commercial Paint
- ▶ Various organomodified silicones are evaluated for slip, COF, defects and mar, stain, and/or fingerprint resistance.

# Testing

**Coefficient of Friction (CoF /Slip):** A ChemInstruments Coefficient of Friction-500 measures static and kinetic coefficients of friction directly.

**Gloss:** Measured with BYK-Gardner 60° micro-glossmeter.

**Finger Print Resistance:** Finger print resistance was determined by visual inspection of finger imprints remaining on the panel surface after gentle pressing and rubbing with fingers. A score of 10 is the best, which represents absence of finger prints, and 0 is the worst.

# Testing (cont)

**Mar Resistance:** measured using a Sutherland 2000 Ink Rub Tester - Dry Rub method with differing settings

Gloss is measured immediately after rubbing for each panel. Record the loss of gloss(%) before and after rubs and a subjective rating from 0 to 10 where 10 is the best and indicates no visible effect.

**Stain Resistance:** One drop of test fluid was applied and allowed to sit for one hour then wiped with a paper towel. Staining is observed and recorded from 1-10 (1 = worst, and 10 = completely clean.)

In some case, a Sutherland 2000 rub tester is used to wipe the stain which is then evaluated again from 1-10.



# Mono-Functional Silicones

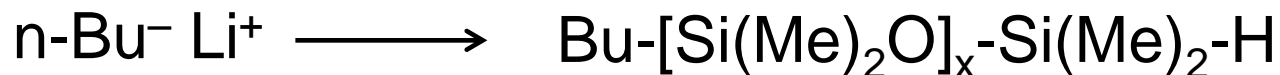
Silmer<sup>®</sup> OH Mo-1 000

Silmer ACR Mo-1 000

Silmer TMS Mo-1 000

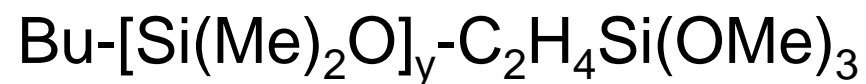


# Silmer<sup>®</sup> Mo-1000 type Synthetic Scheme

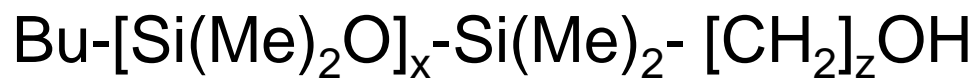


1) D<sub>3</sub>

2) Cl-Si(Me)<sub>2</sub>-H

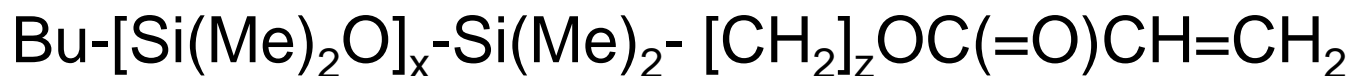


**Silmer TMS Mo-1000**



**Silmer OH Mo-1000**

“Acrylation”



**Silmer ACR Mo-1000**

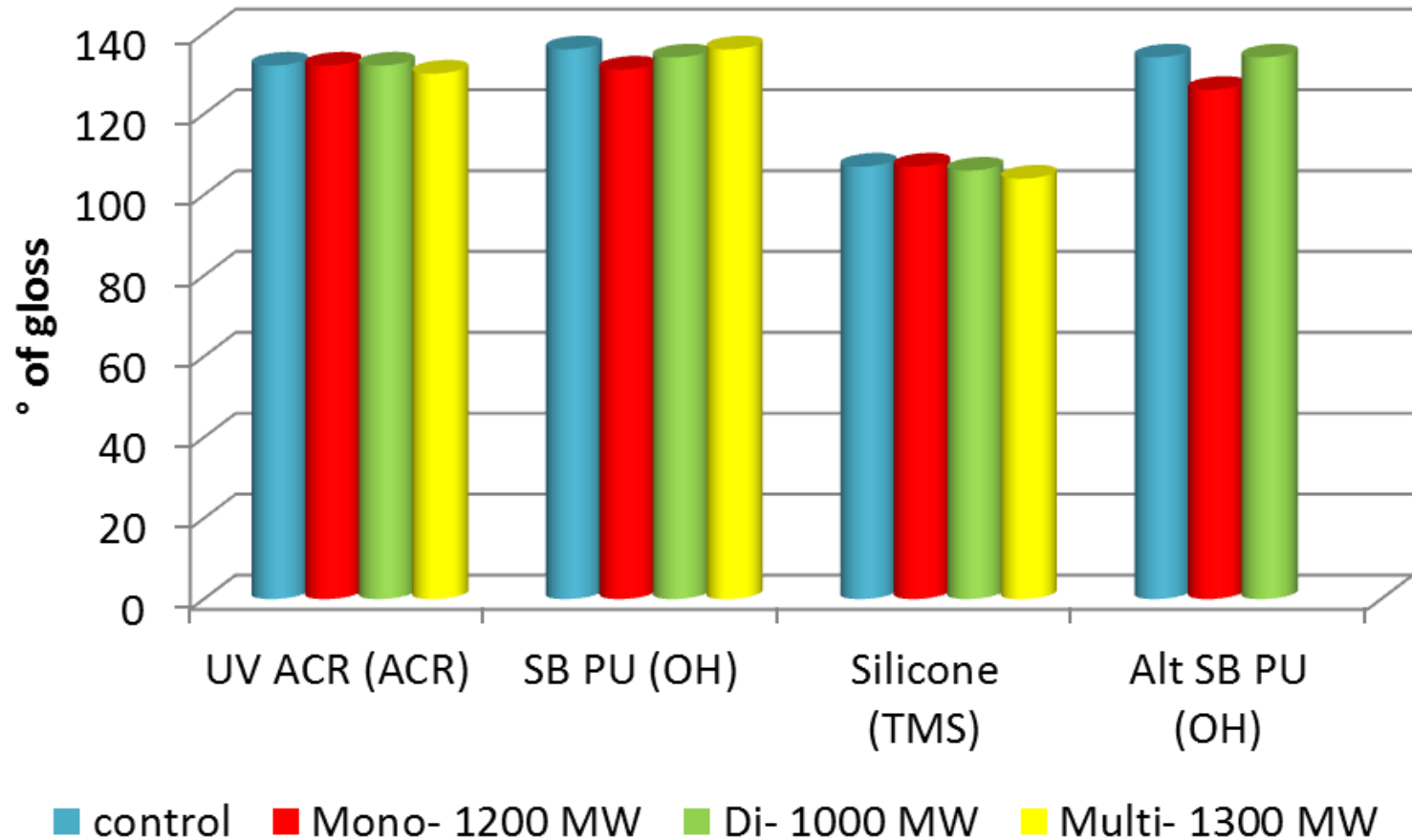




# Mono functional and controls

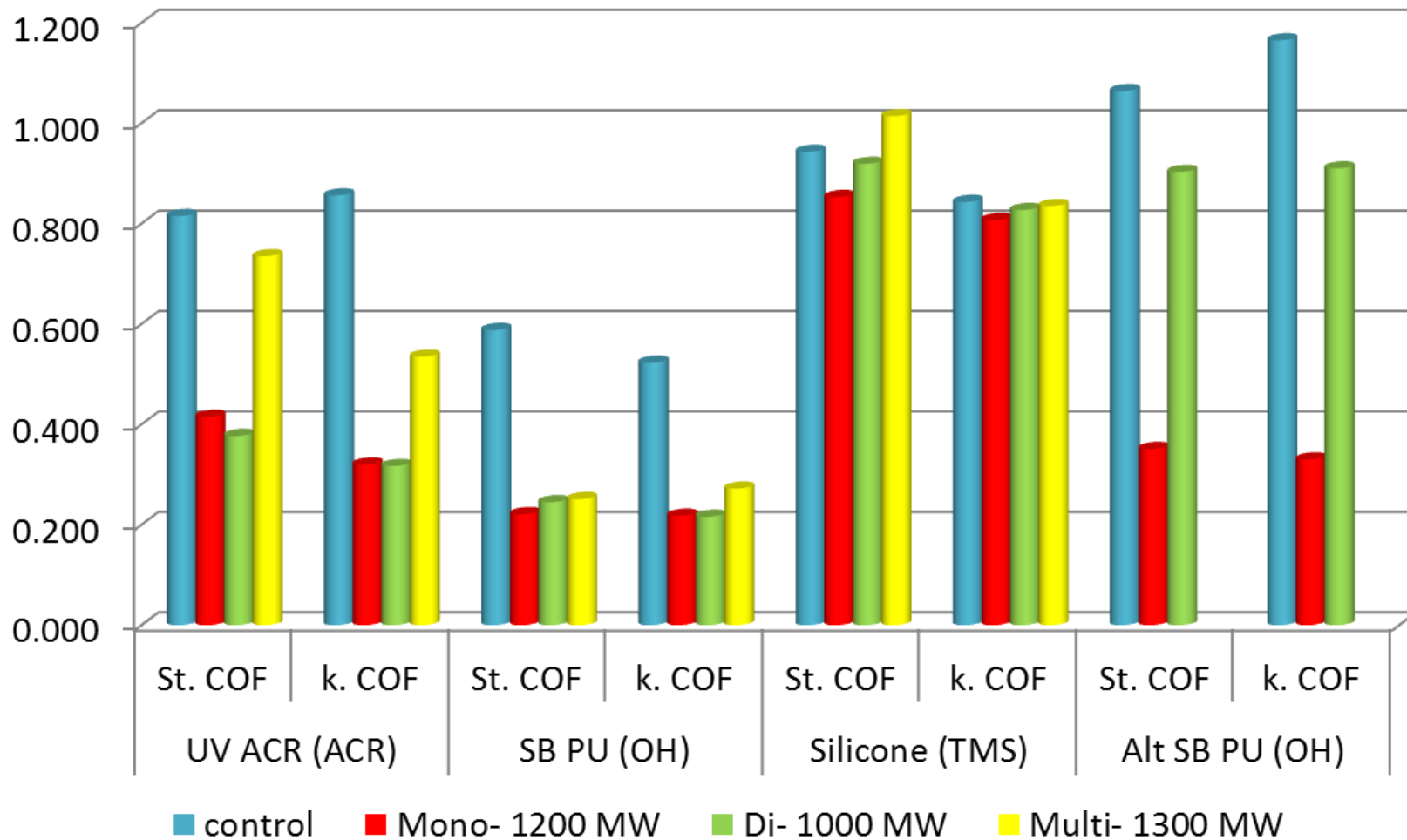
<i><b>Sample name</b></i>	<i><b>Functional group</b></i>	<i><b>MW</b></i>	<i><b>Type</b></i>
Silmer OH Mo-1000	Hydroxyl	1200	Monofunctional Reactive Silicone
Silmer ACR Mo-1000	Acrylate	1200	
Silmer TMS Mo-1000	Trimethoxy Silane	1200	
Silmer OH Di-10	Hydroxyl	1000	Di-functional Reactive Silicone
Silmer ACR Di-10	Acrylate	1000	
Silmer TMS Di-10	Trimethoxy Silane	1000	
Silmer OH D2	Hydroxyl	1300	Multi-functional Reactive Silicone
Silmer ACR D2	Acrylate	1300	
Silmer TMS D2	Trimethoxy Silane	1300	

# Results: Gloss



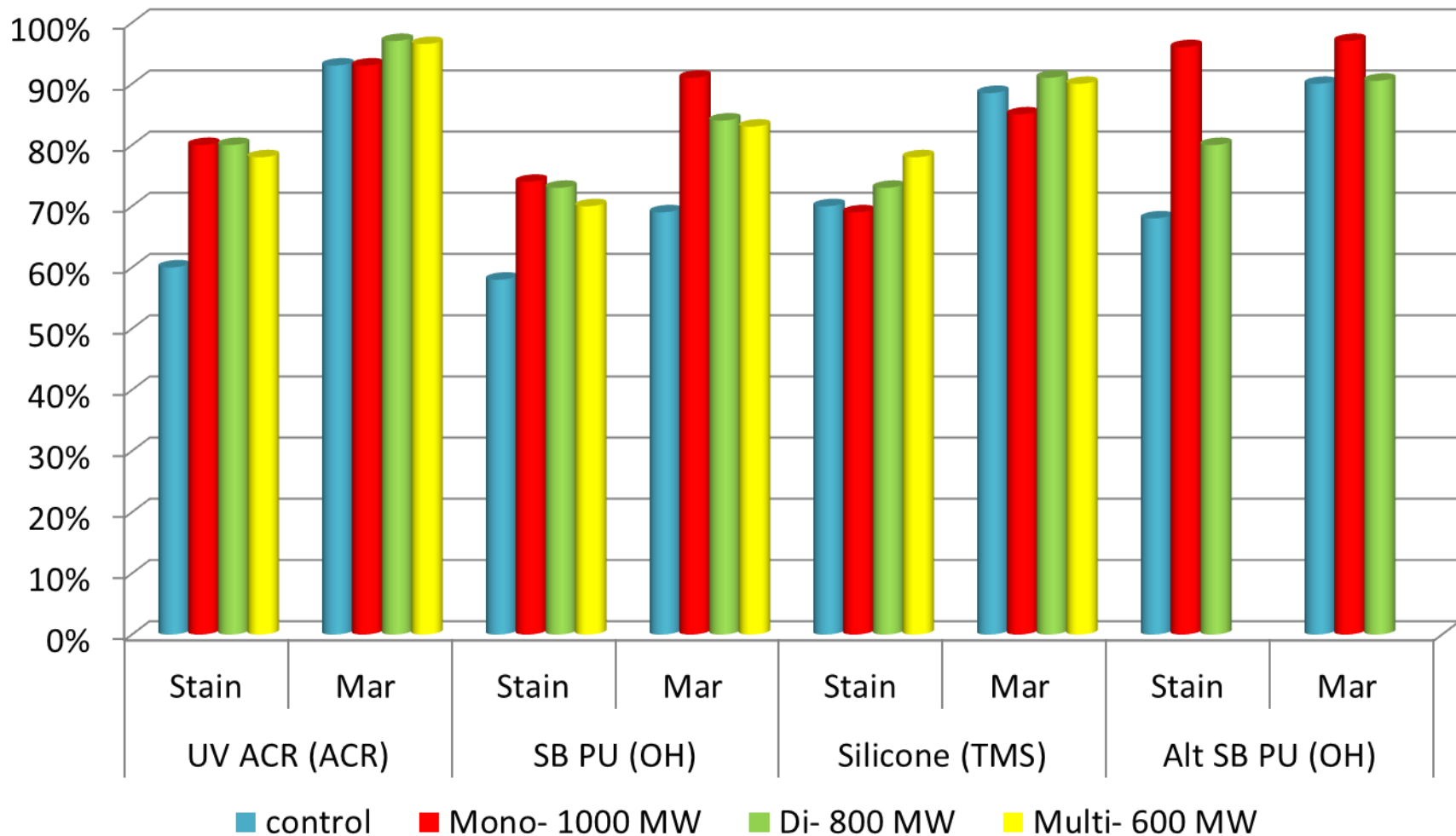
Control is no silicone added  
All silicones screened at 1%

# Results: CoF



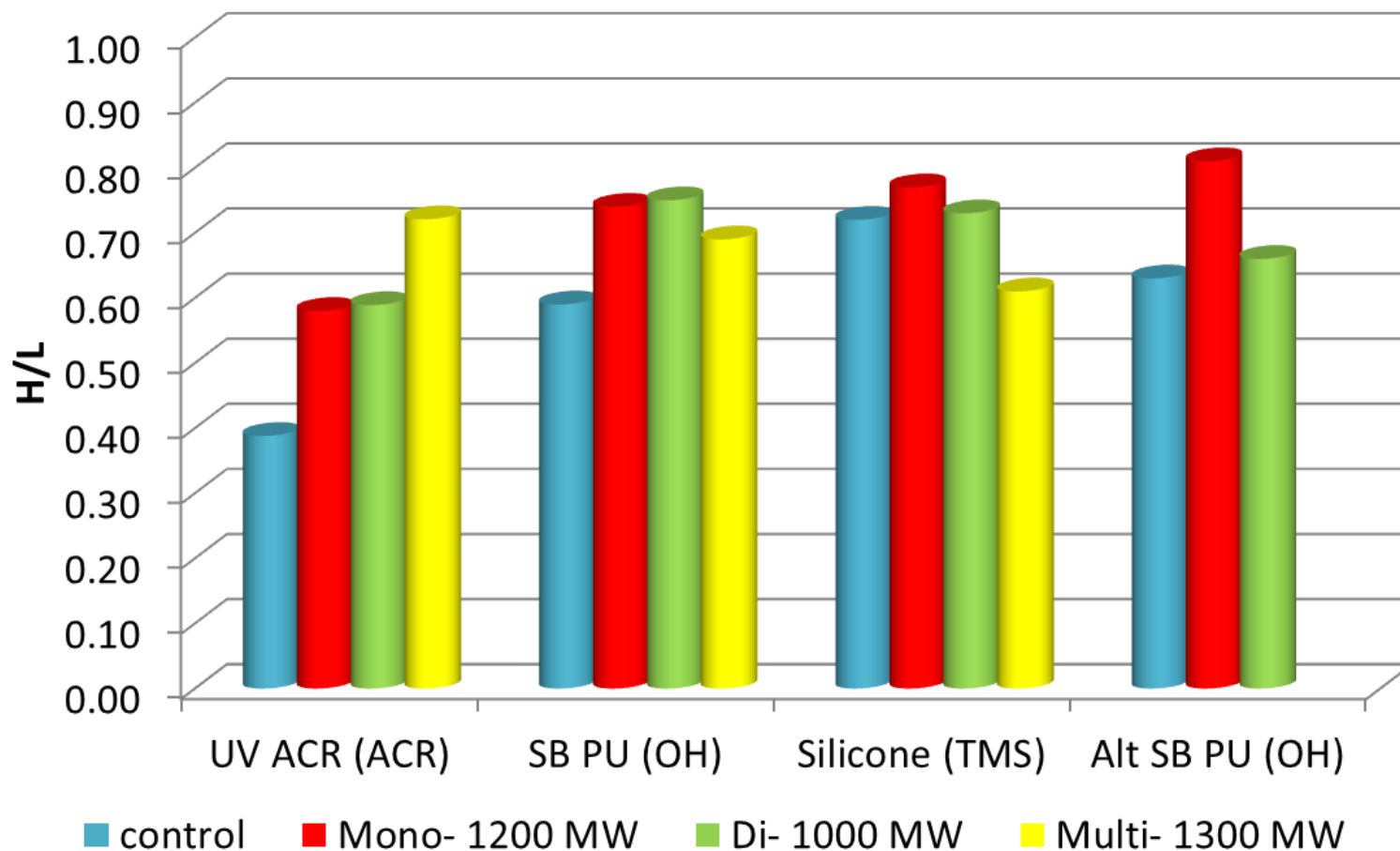
Control is no silicone added  
All silicones screened at 1%

# Results: Avg. Stain and Mar Resist



Stain expressed as % of 10 score

# Results: Contact Angle



Control is no silicone added  
All silicones screened at 1%

# Results: Mono Silicones

- ▶ In this one reactive study, the Mo materials are as good or better: but there is no “super” benefit
- ▶ Gloss is good
- ▶ COF is better than multi- and similar to di-functional materials
- ▶ Contact Angle, Stain and Mar Resistance are slightly better

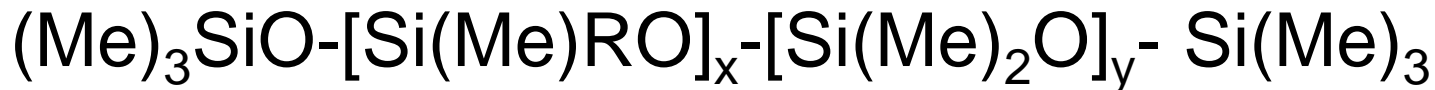


# Quaternary Ammonium Alkyl Functional Silicones

Silquat<sup>®</sup> A0  
Silquat Di-10  
Silquat D2



# Silicone Quaternary Ammonium Salts



**Silquat® pendant type**

R = alkyl-N<sup>+</sup>(Et)<sub>2</sub>Me Cl<sup>-</sup>



**Silquat Di type**

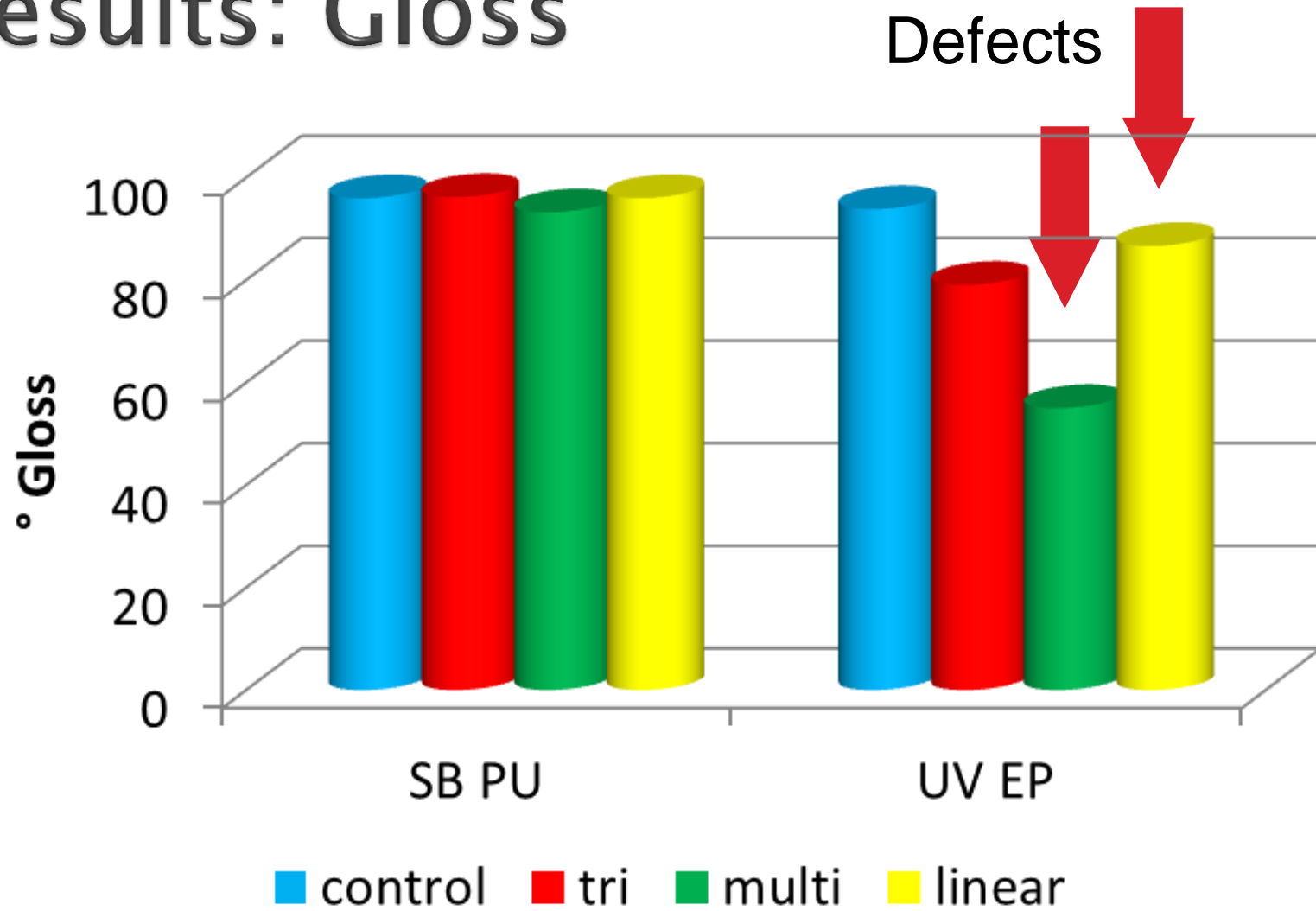


**Silquat A0 trisiloxane type**

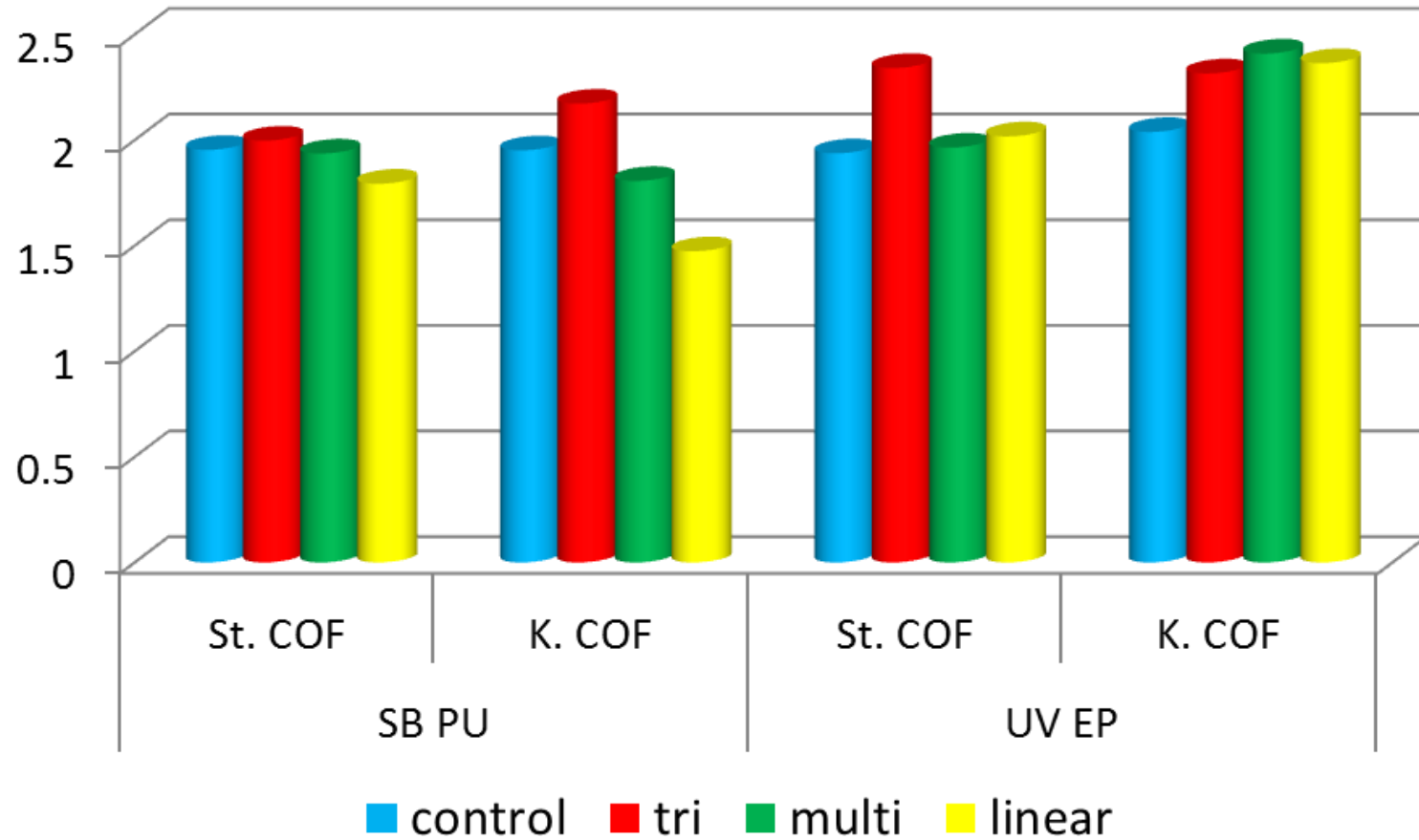
# Silicone Quats

<b><i>Sample name</i></b>	<b><i>Surface Resistivity* <math>\Omega</math>/sq.</i></b>	<b><i>MW</i></b>	<b><i>Type</i></b>
Silquat A0	$2.88 \times 10^6$ (Dissipative)	500	Trisiloxane
Silquat Di-10	$1.58 \times 10^7$ (Dissipative)	1300	Di-functional
Silquat D2	$9.40 \times 10^6$ (Dissipative)	1900	Multi-functional
Higher MW	$\times 10^{11}$ (Insulative)	NA	Many evaluated

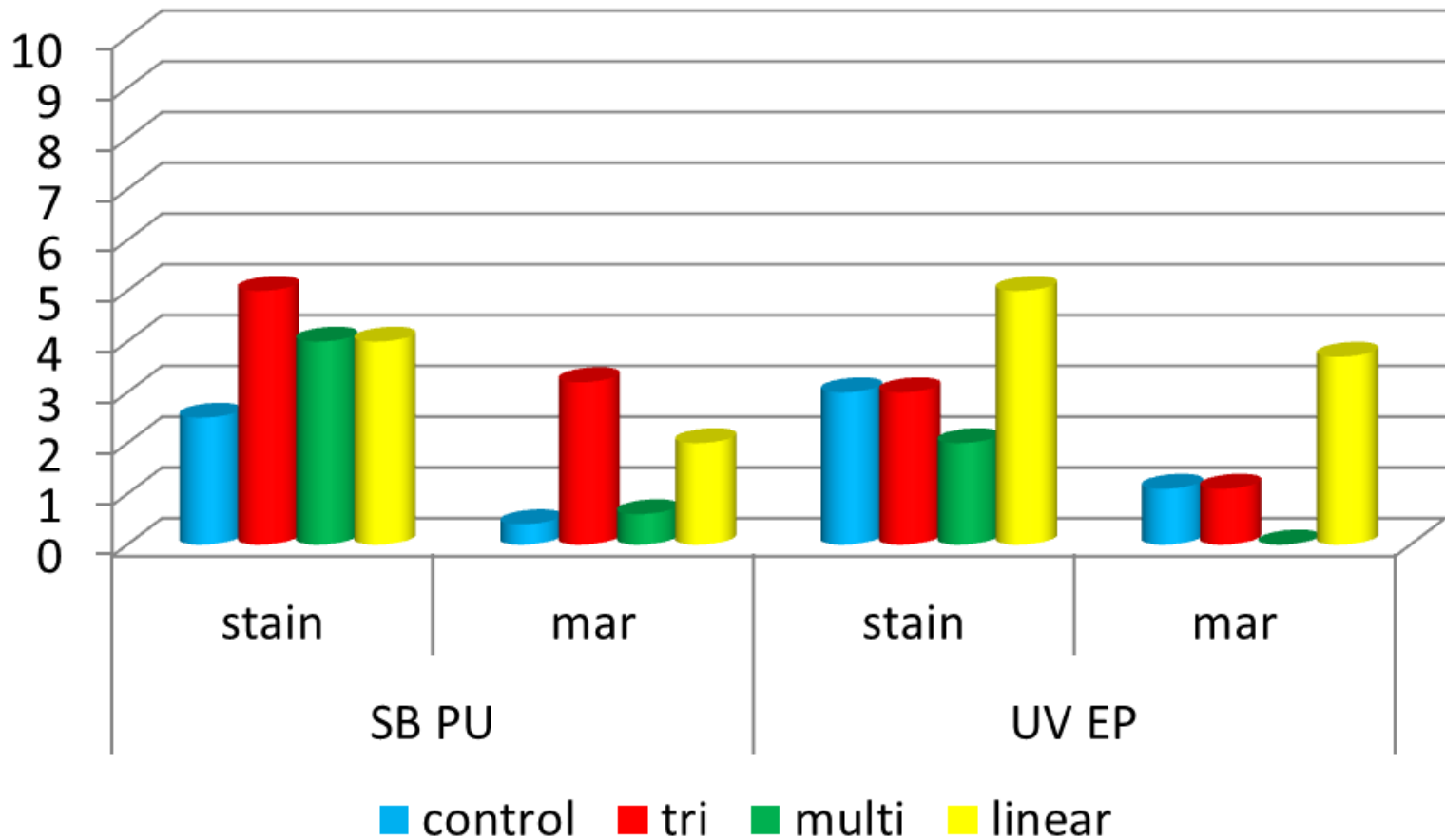
# Results: Gloss



# Results: COF



# Results: Avg. Stain and Mar Resist



# Silicone Quats Summary

- ▶ The small MW species give dissipative properties to coatings.
- ▶ These materials are weaker than other silicones at COF reduction, flow and leveling and stain and mar resistance.

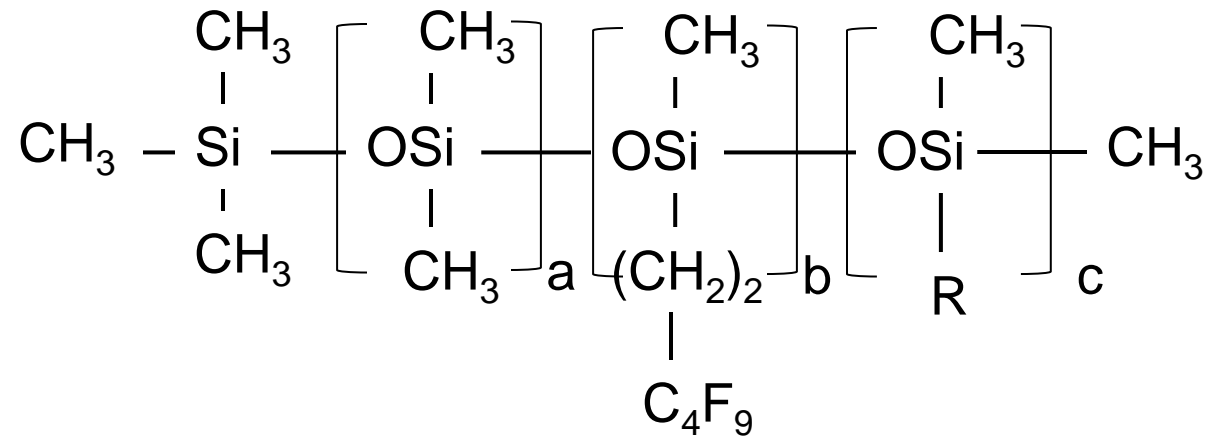


# Fluoroalkyl Silicones

Various structures



# Silicone Variations



	C	R
FPE	>0	$(\text{CH}_2)_3(\text{OC}_2\text{H}_4)_d(\text{OC}_3\text{H}_6)_e \text{OH}$
FS	0	
FA	>0	$\text{C}_n\text{H}_{(2n)} \text{R}'$

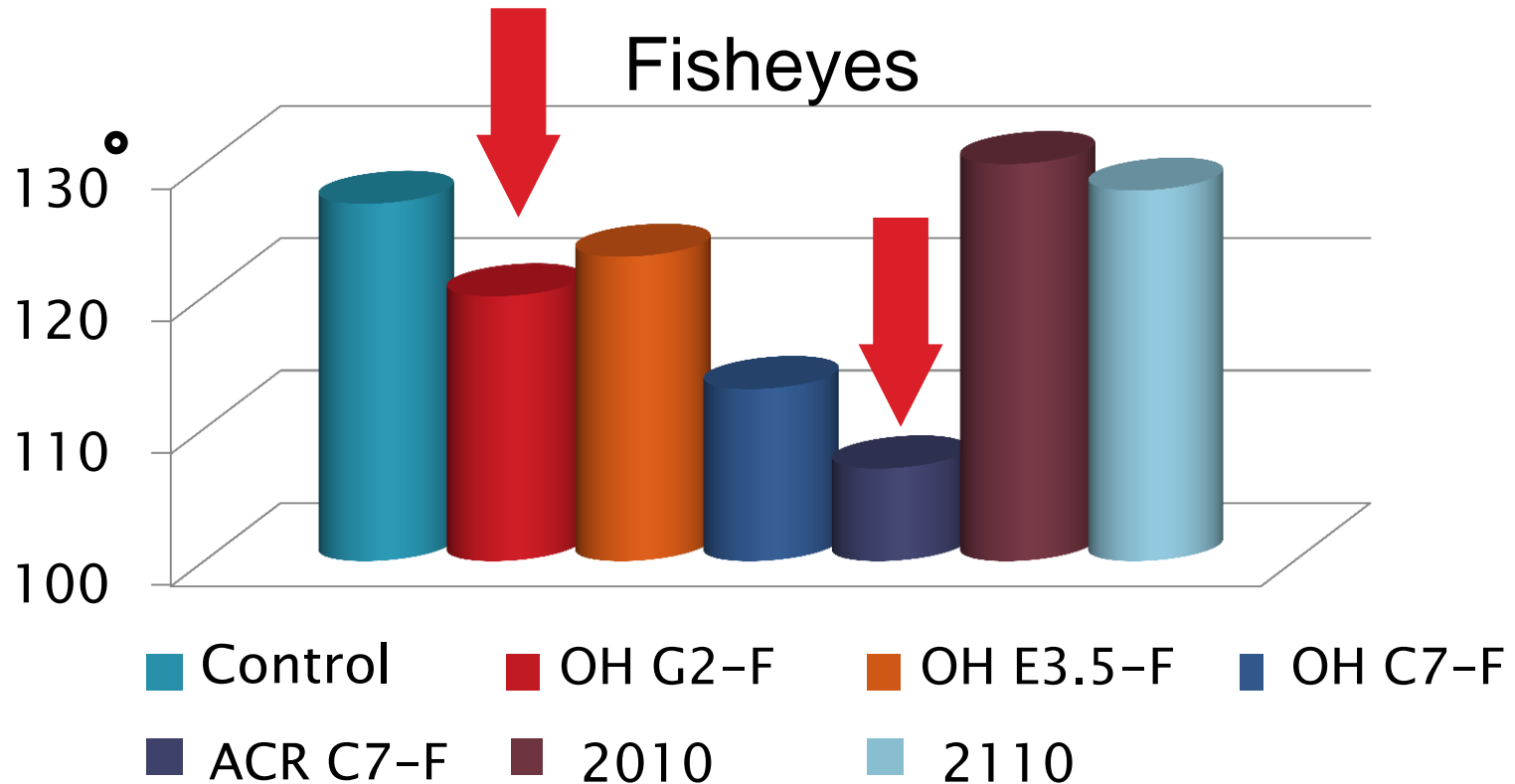
# Structural Details

Fluorosil®	Wt % Silicone	Wt % CF <sub>2</sub>	Reactive Site	Water Miscible	MW	Type
2010	37%	8%	OH	1%	3000	fluoroalkyl polyether silicone
2110	27%	3%	OH	10%	7000	
D2	52%	48%	no	no	2000	fluoroalkyl silicone
J15	83%	17%	no	no	14000	
OH G2-F	57%	41%	OH	no	3000	alkyl, fluoroalkyl silicone
OH E3.5-F	68%	30%	OH	no	3000	
OH C7-F	81%	17%	OH	no	2000	
ACR C7-F	81%	17%	ACR	no	2000	
H418	60%	20%	no	no	5000	

# Film Properties: SB Urethane

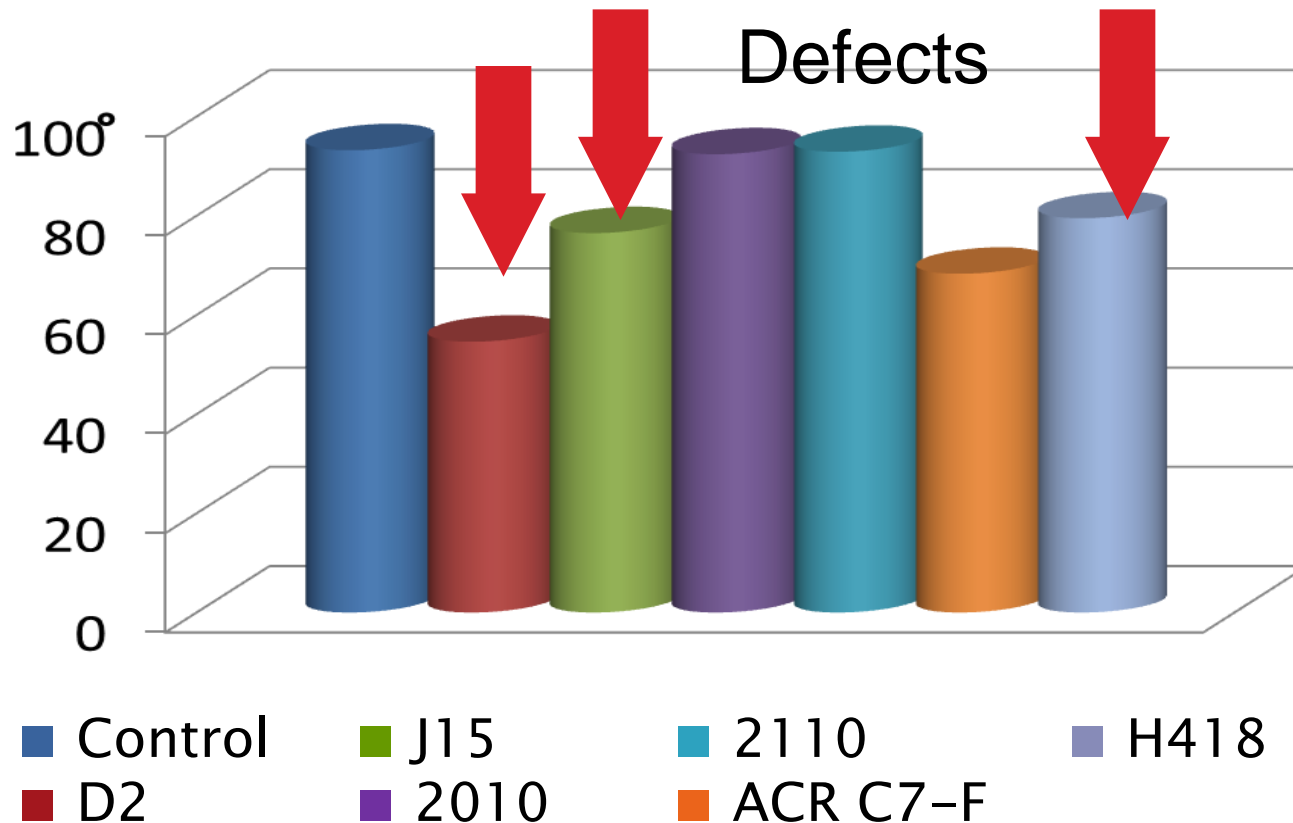
Fluorosil®	Static COF	Kinetic COF	Gloss	%Gloss Retained	Mar Resist	Surface appearance
Control	1.397	1.500	127	77.2%	1.1	Smooth
OH G2-F	1.274	1.204	120	95.0%	6.4	Fisheyes
OH E3.5-F	0.940	1.115	123	86.2%	4.3	Smooth
OH C7-F	0.794	0.756	113	87.1%	4.3	Smooth
ACR C7-F	0.405	0.422	107	93.1%	6.4	Fisheyes
2010	0.577	0.631	130	96.7%	6.4	Smooth
2110	0.681	0.711	128	96.4%	6.4	Smooth

# Gloss: SB Urethane



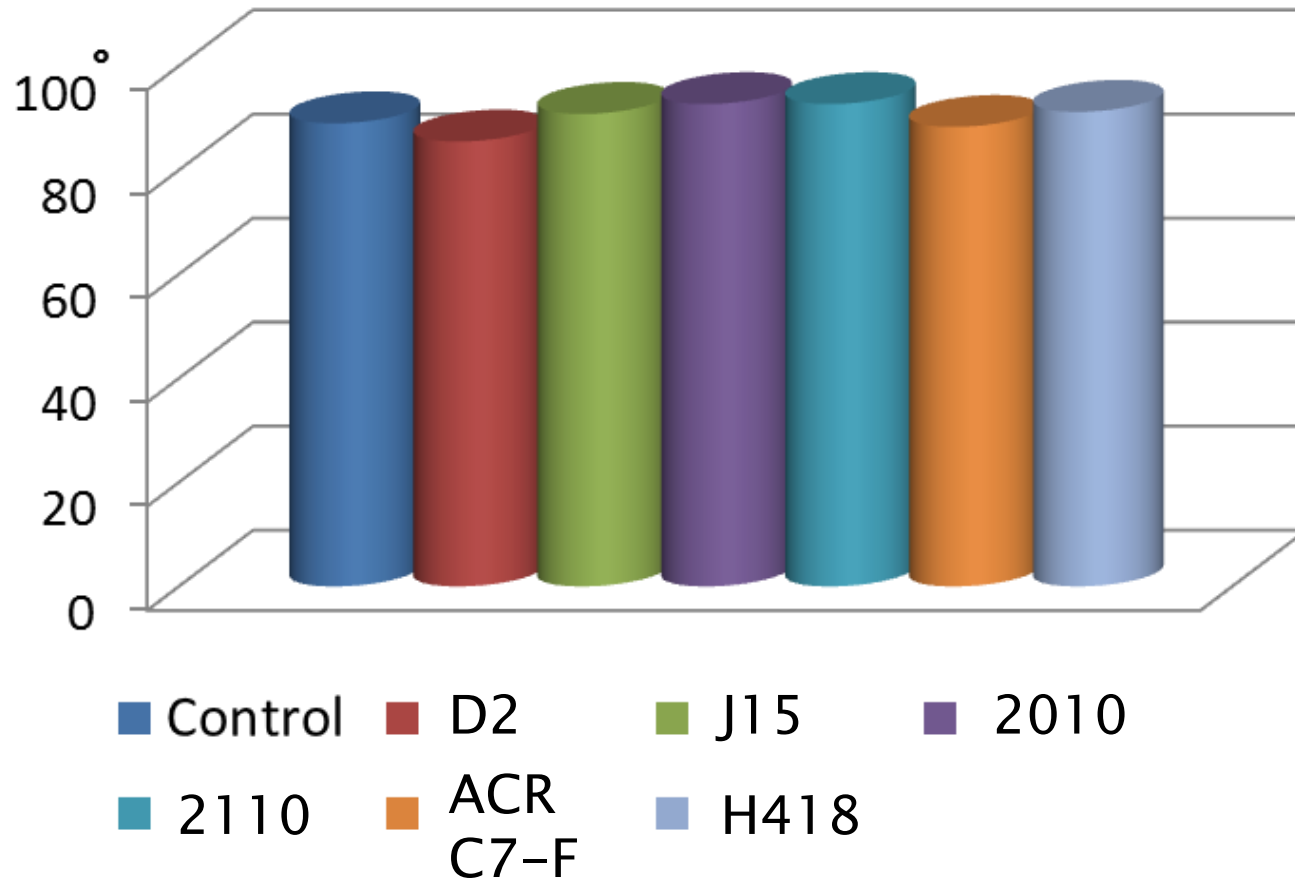
- FPE are most miscible, improve gloss
- FA type decrease gloss cause defects

# Gloss: UV Urethane Acrylate



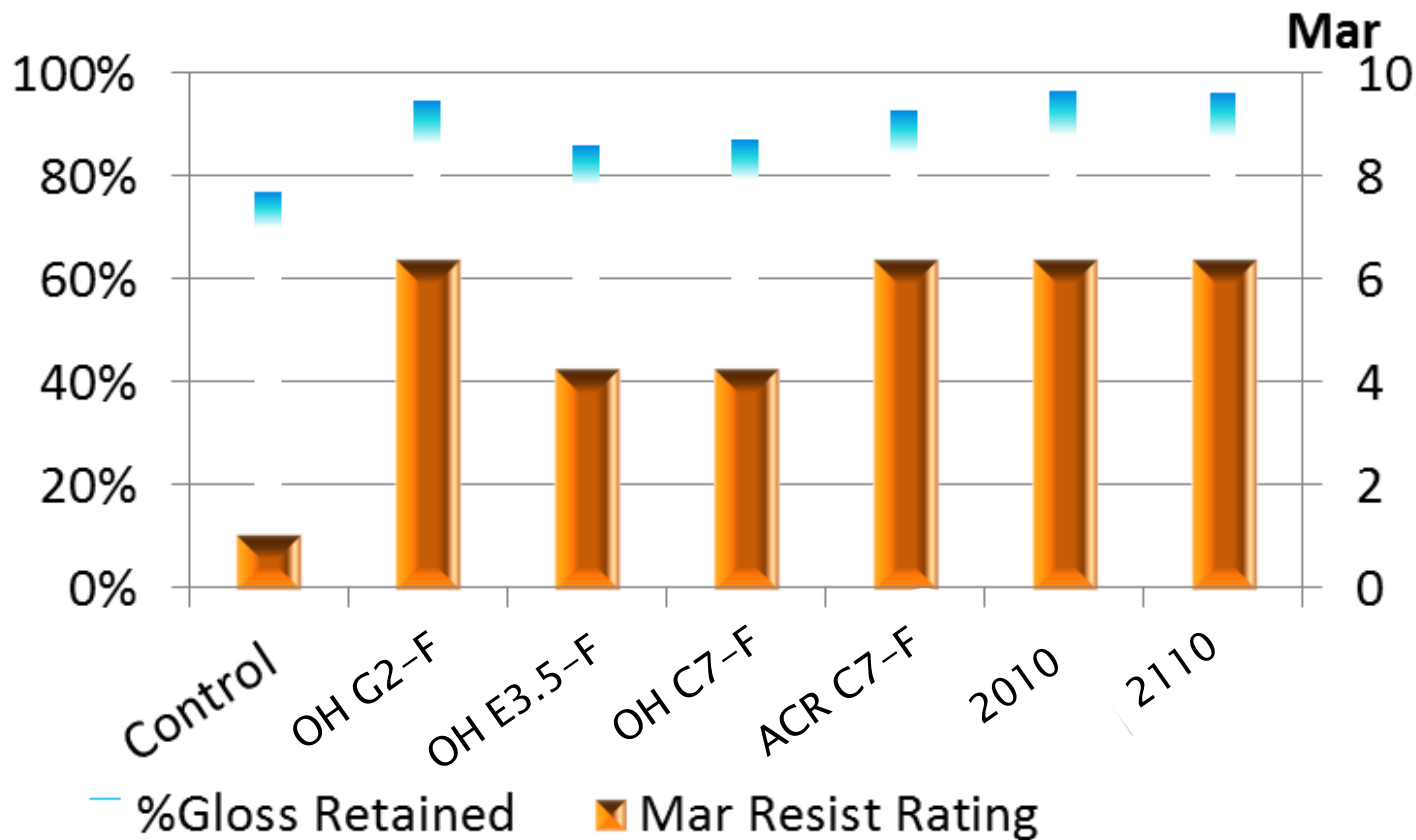
- FPE are most miscible, keep gloss
- FA and FS types decrease gloss

# Gloss: UV Epoxy Acrylate



- Minor incompatibility

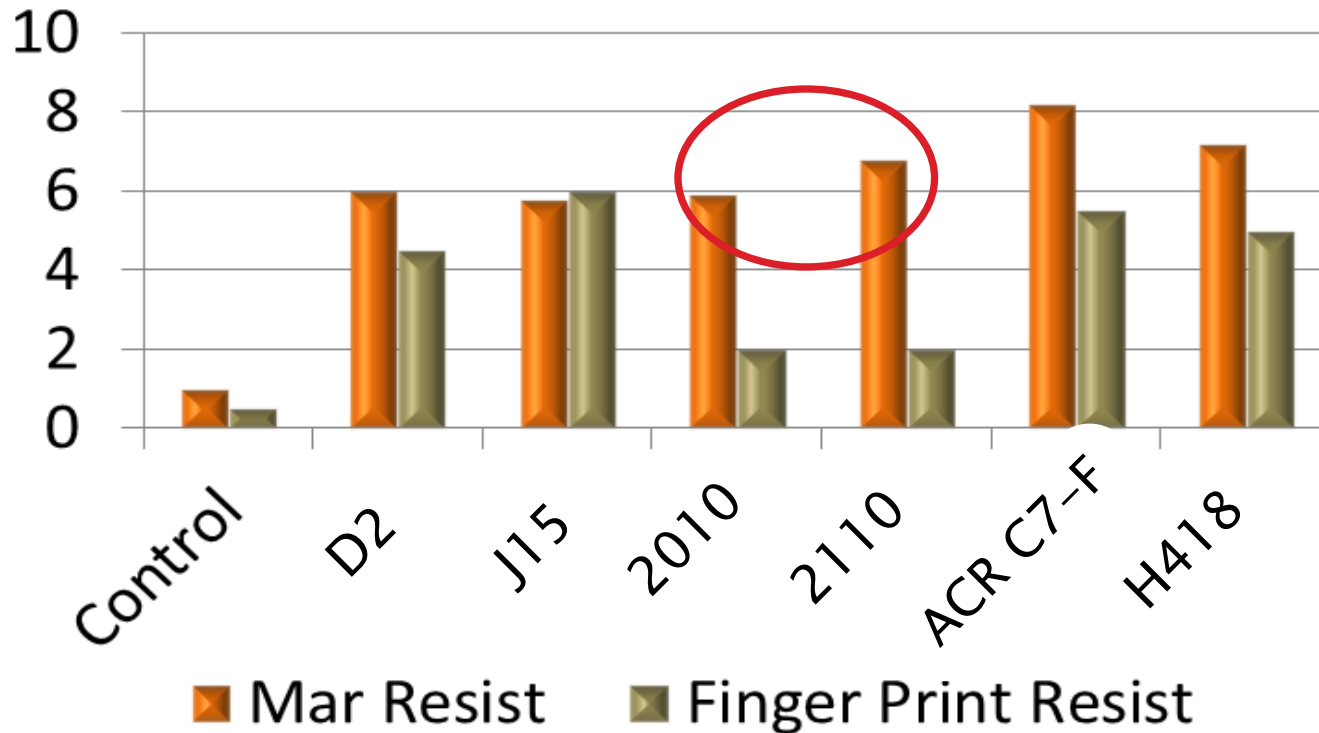
# Mar Resist: SB Urethane



- All improve mar resistance

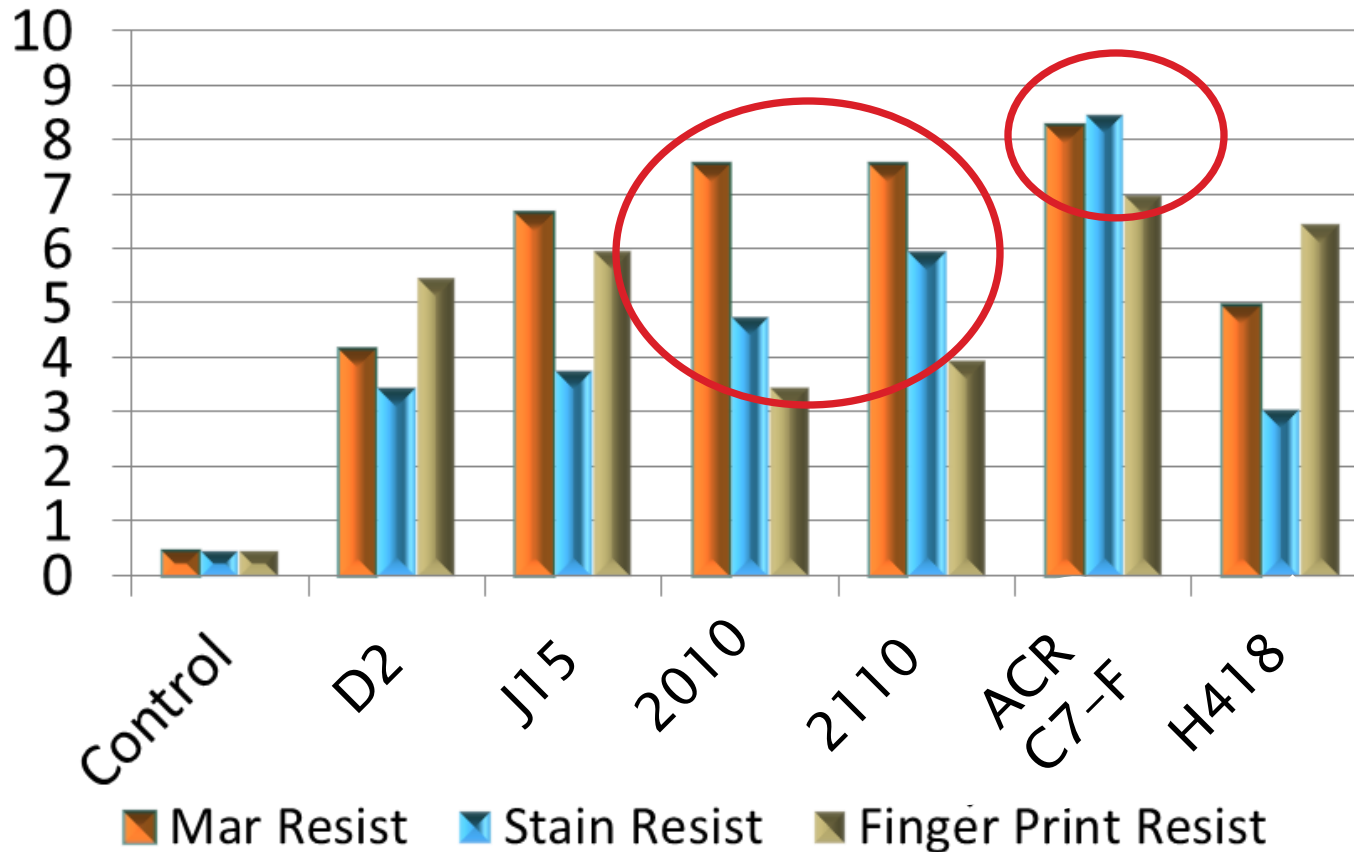


# Mar/ Finger Print: UV Ureth. Acryl.



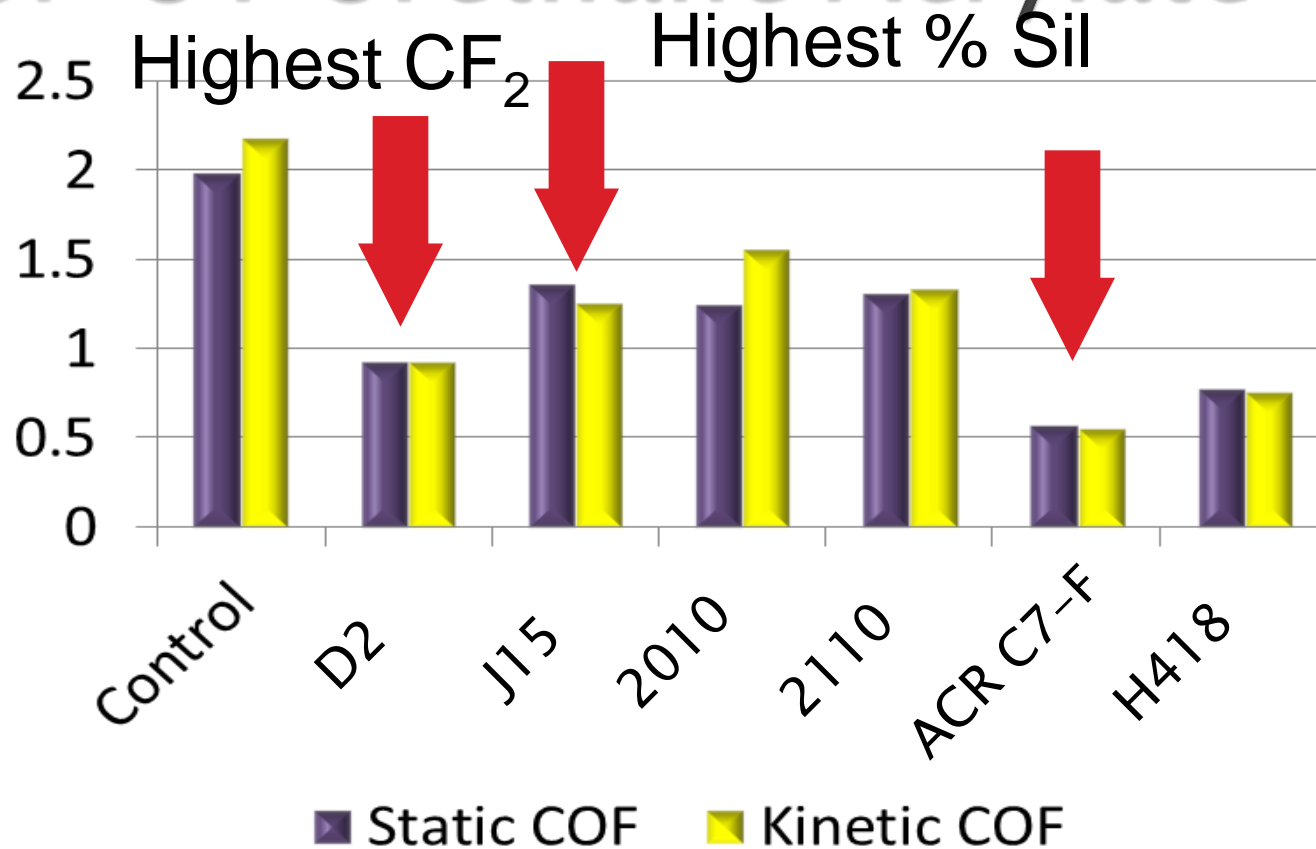
- All improve mar resistance
- All improve anti-finger print

# Mar, Stain, Print: UV Ep. Acryl.



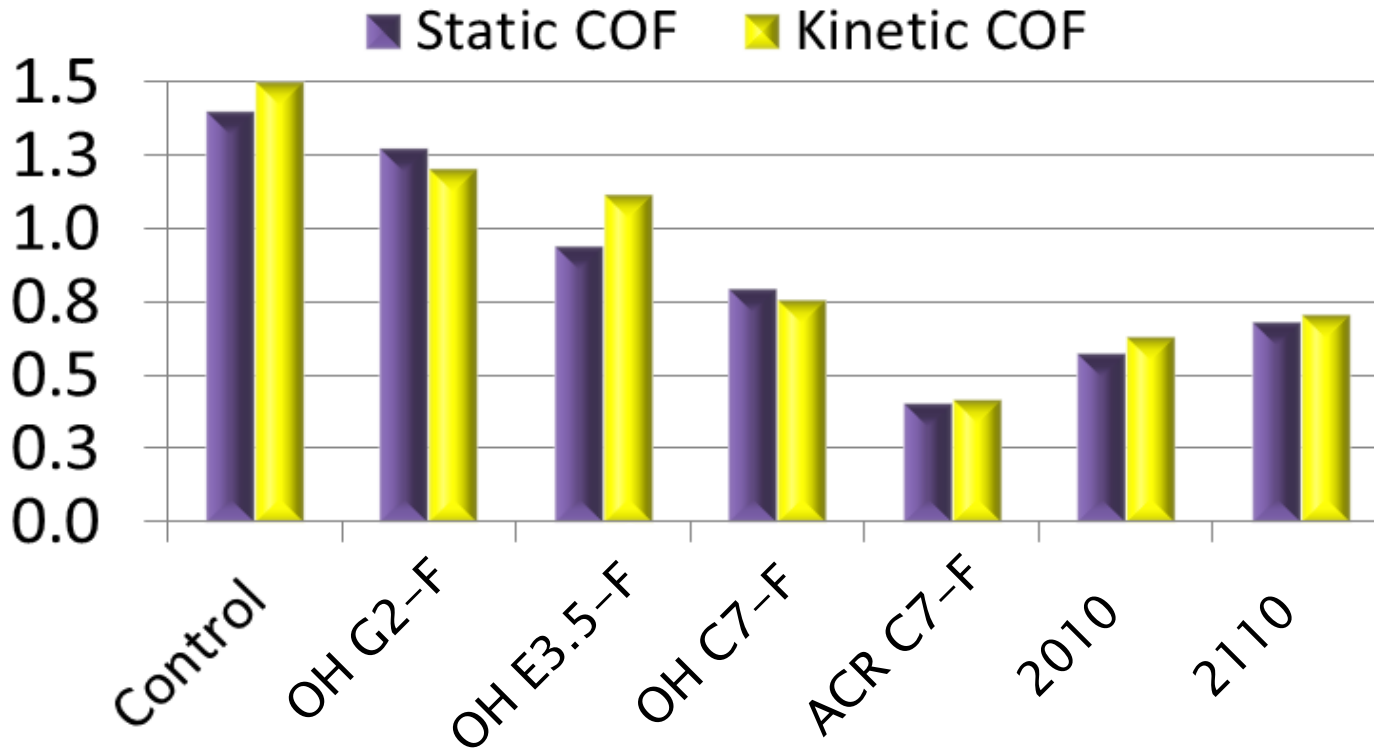
- All properties are improved
- FPEs weak on fingerprint
- ACR C7-F strong on all

# Slip: UV Urethane Acrylate



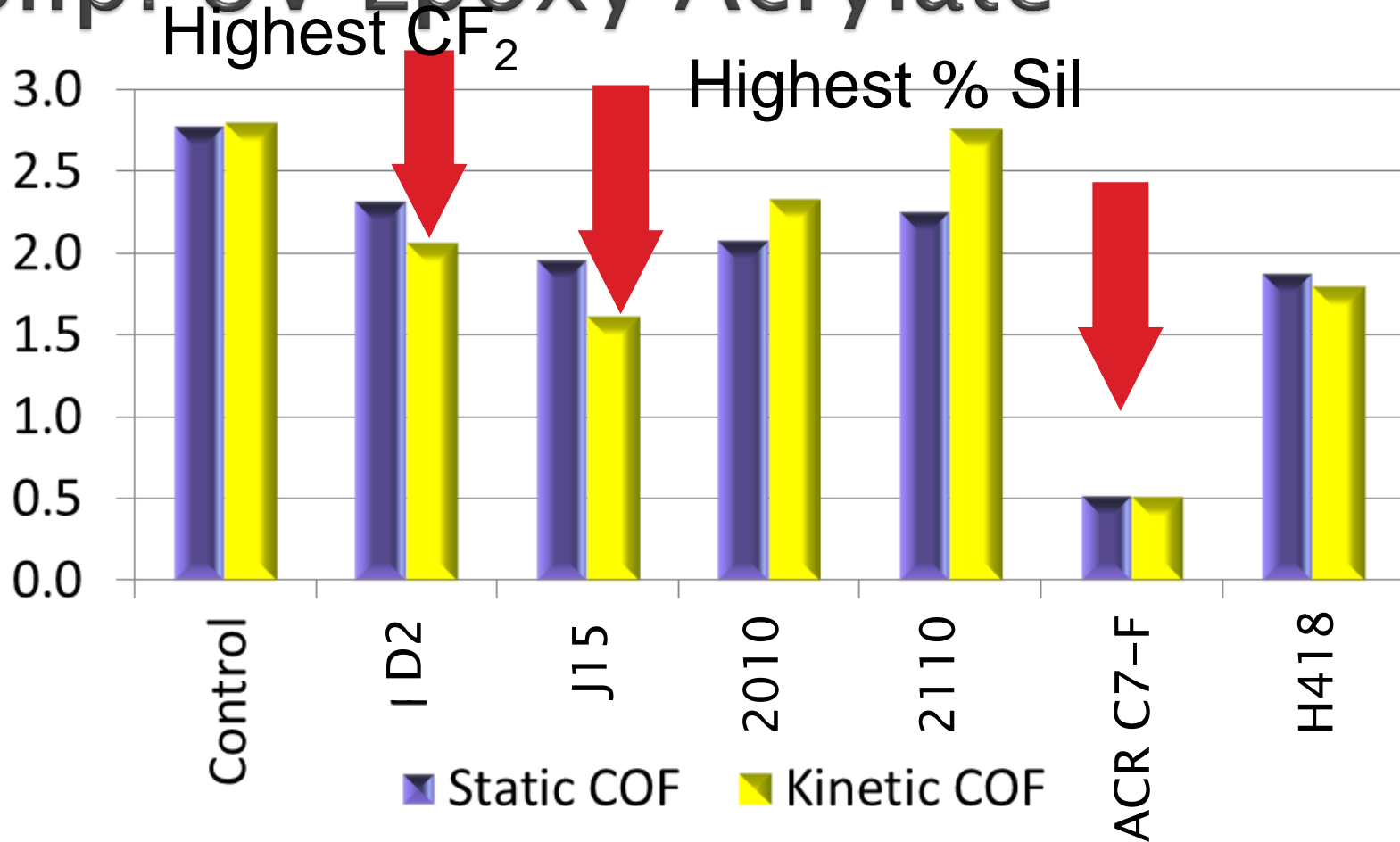
- All improve COF
- More with  $>$  wt%  $\text{CF}_2$

# COF Reduction: SB Urethane



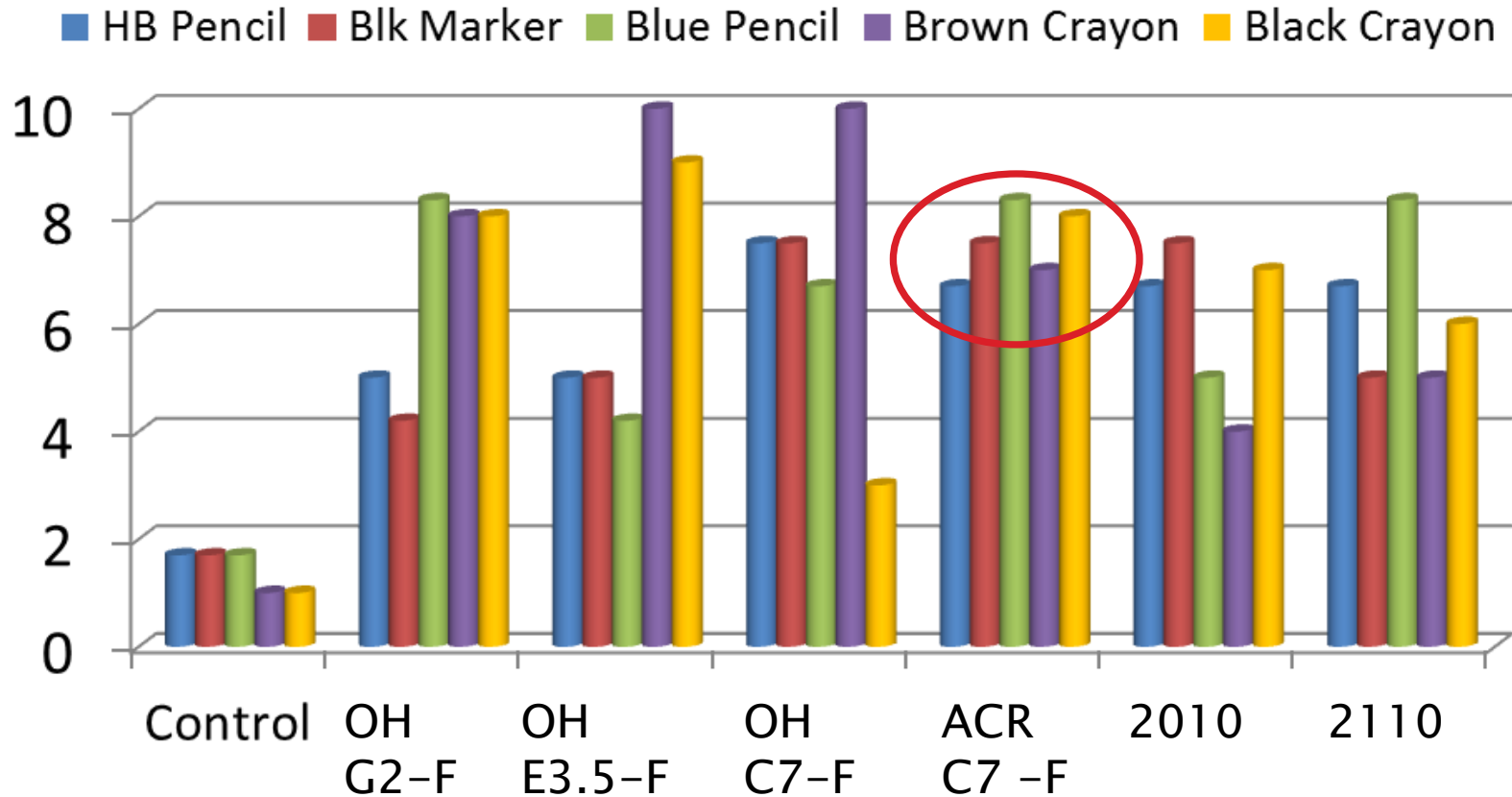
- All improve COF
- More with > wt% silicone

# Slip: UV Epoxy Acrylate



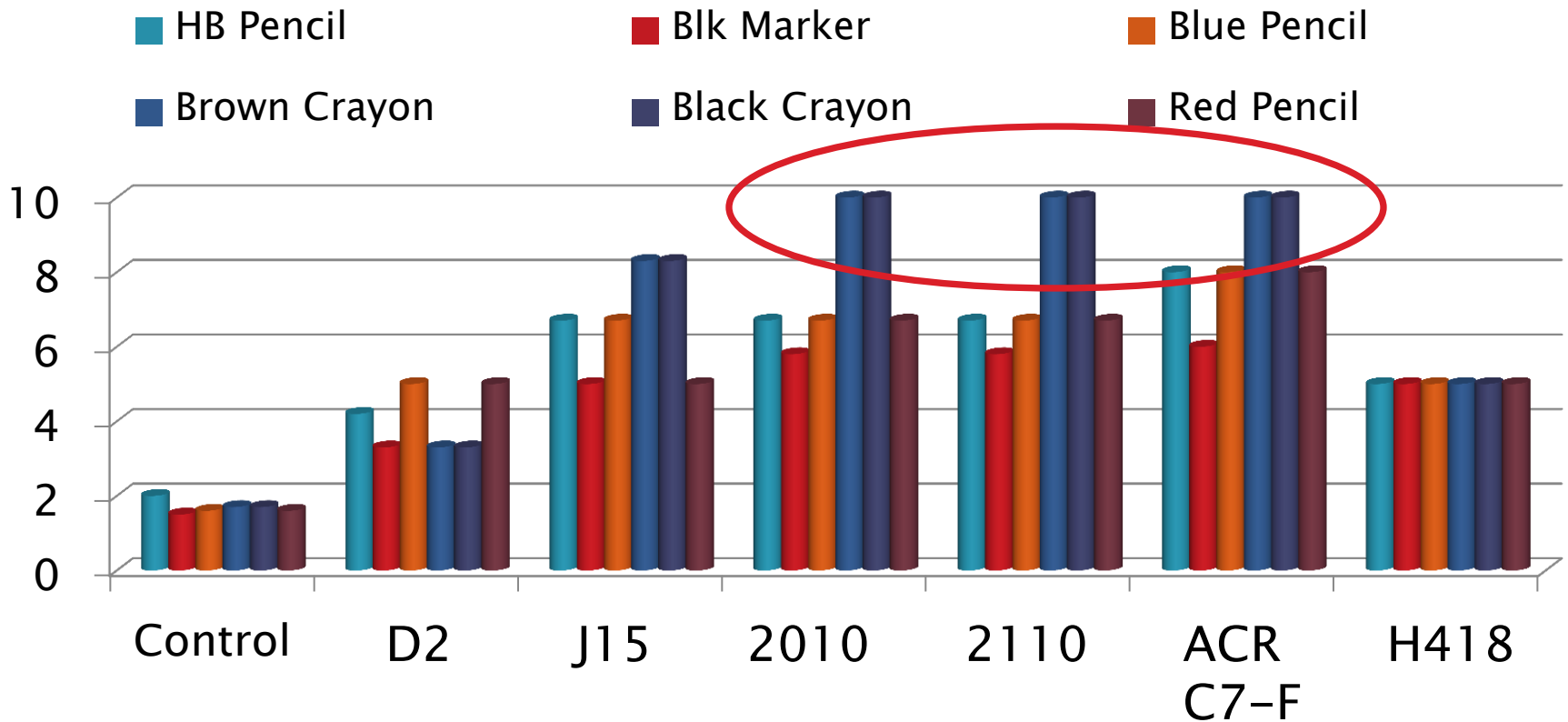
- All improve COF
- More with > wt% silicone

# Stain Resist: SB Urethane



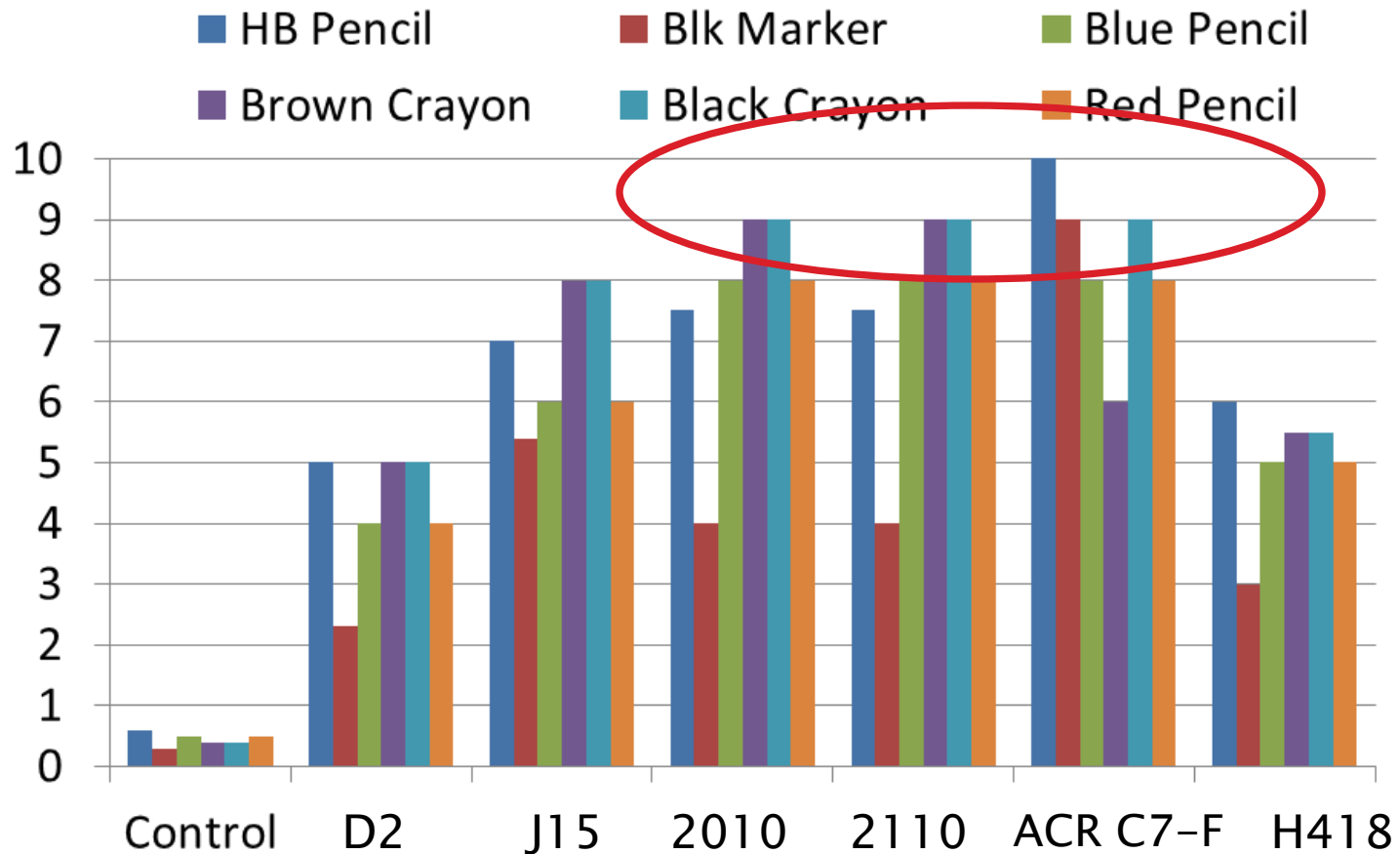
- Fluorosil OH C7-F and ACR C7-F are strong

# Stain Resist: UV Urethane Acrylate



- ACR C7-F and FPEs are effective

# Stain: UV Epoxy Acrylate



- Highest %CF<sub>2</sub> is least effective
- ACR C7-F and FPEs are effective



# Results

- ▶ All FAS additives improve COF, mar and stain resistance and to a lesser degree fingerprint resist.
- ▶ FPE are the only compatible FASs and give good slip, mar and anti stain, but weak finger print resist
- ▶ ACR C7-F, 2010 & 2110 again give relatively high ratings for gloss, mar and stain resistance.
- ▶ Best results are for crayons
- ▶ J15, H418 & ACR C7-F give the best fingerprint resist.
- ▶ Highest  $\text{CF}_2$  content is only important for fingerprint resist. For other properties %Sil and % $\text{CF}_2$  are both needed

# Recommendations

- ▶ Mono materials did not give strong performance: may give smart properties.
- ▶ Silquat products for dissipative needs only.
- ▶ Fluorosil<sup>®</sup> 2010, Fluorosil 2110 are very good for all but fingerprint resistance
- ▶ Fluorosil OH C7-F and Fluorosil ACR C7-F are best overall including for fingerprint resistance.
  - They are not always compatible.
- ▶ Use levels are up to 5% and more is better in most cases.

**THANK YOU**

