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

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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.

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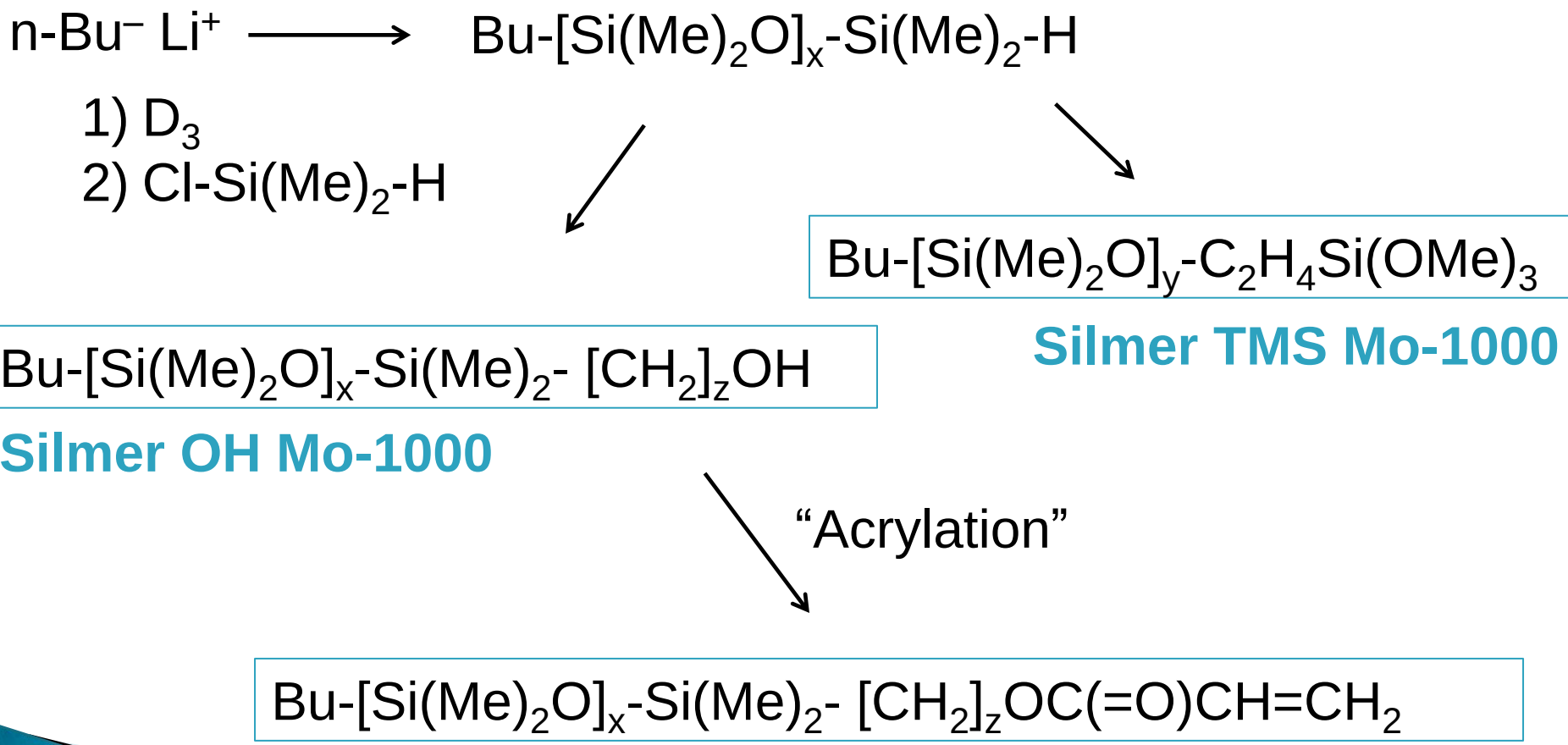
Mono-Functional Silicones

Silmer® OH Mo-1000

Silmer ACR Mo-1000

Silmer TMS Mo-1000

Silmer® Mo-1000 type Synthetic Scheme



Mono functional and controls

Sample name	*Functional group*	*MW*	*Type*
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	

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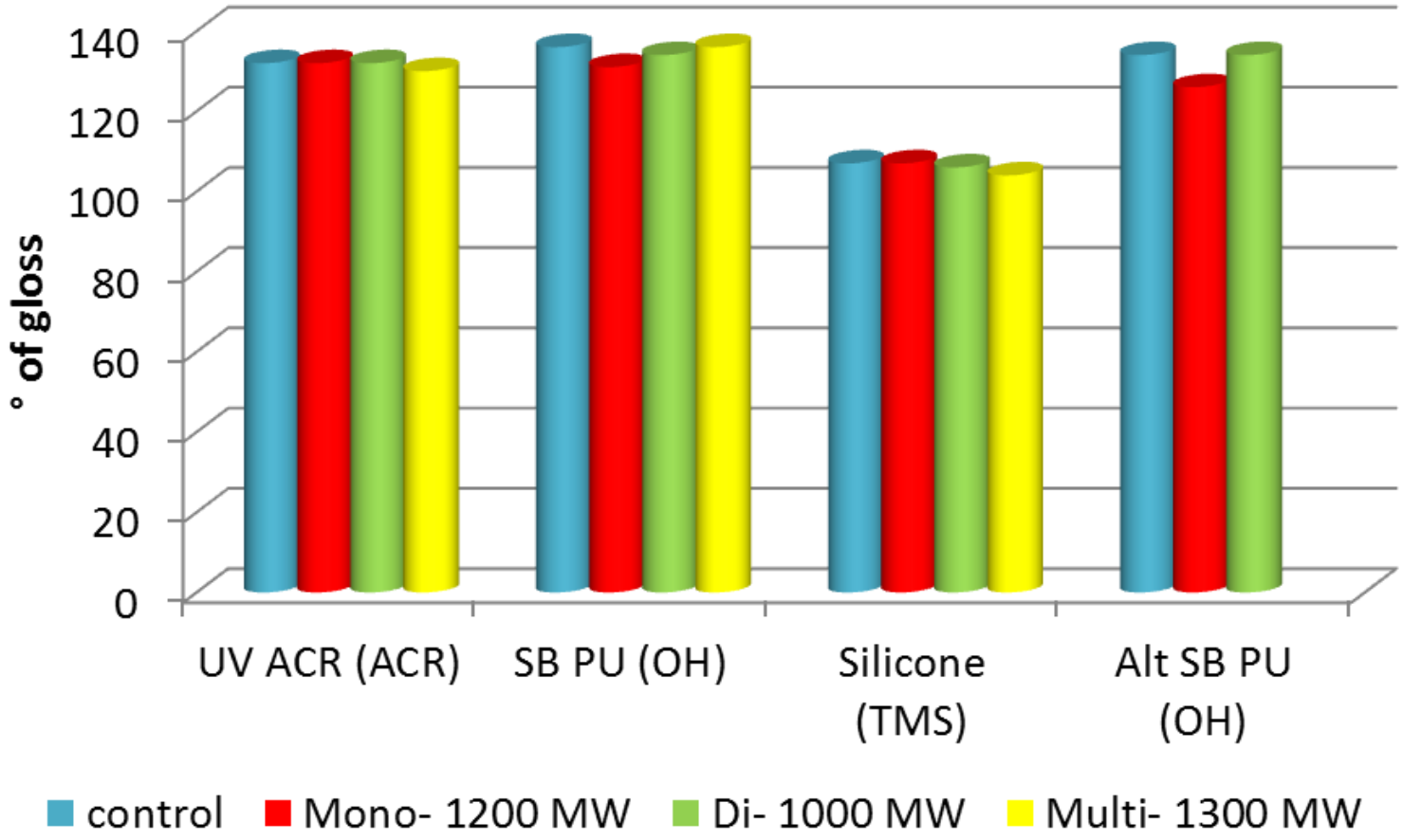
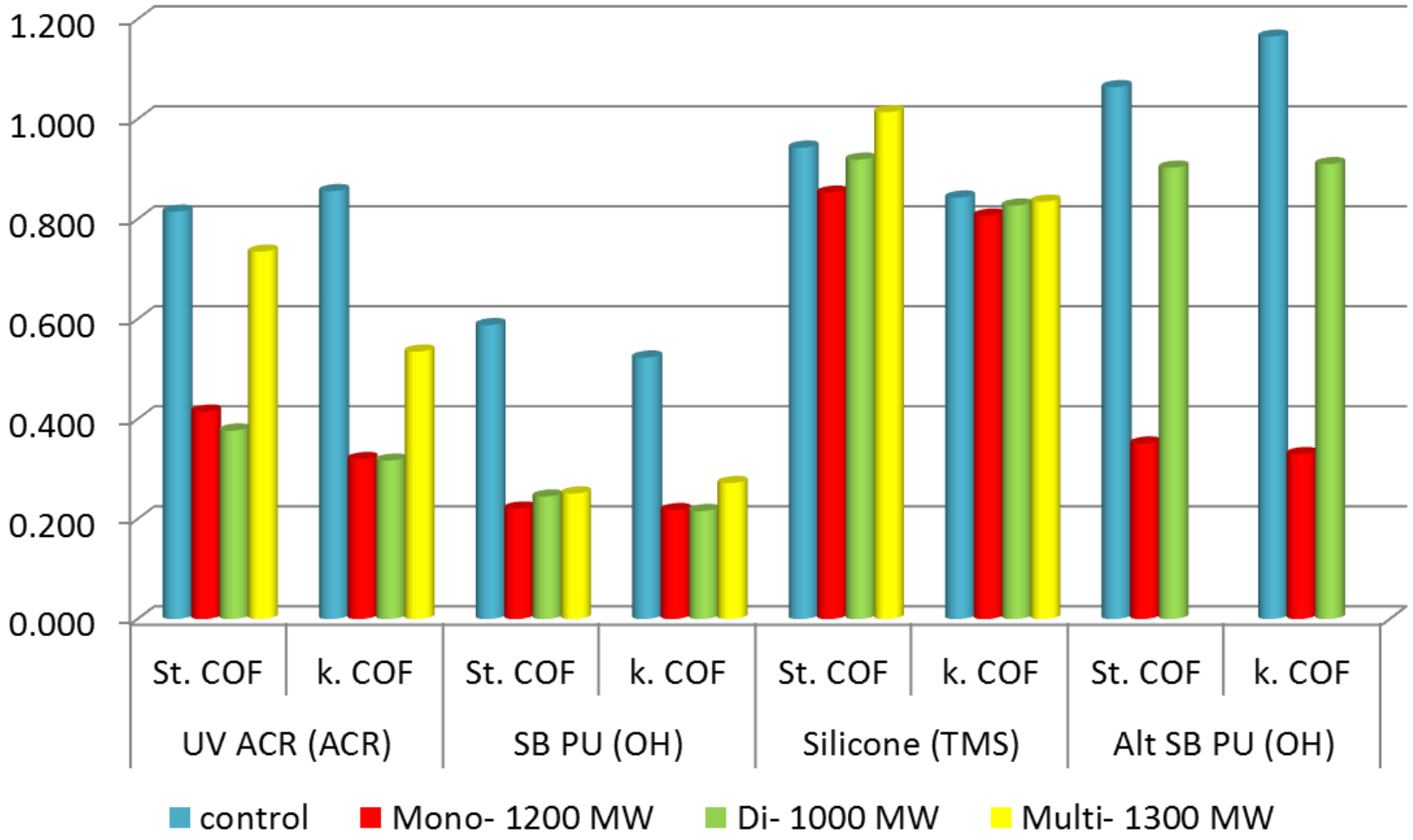
Results: Gloss



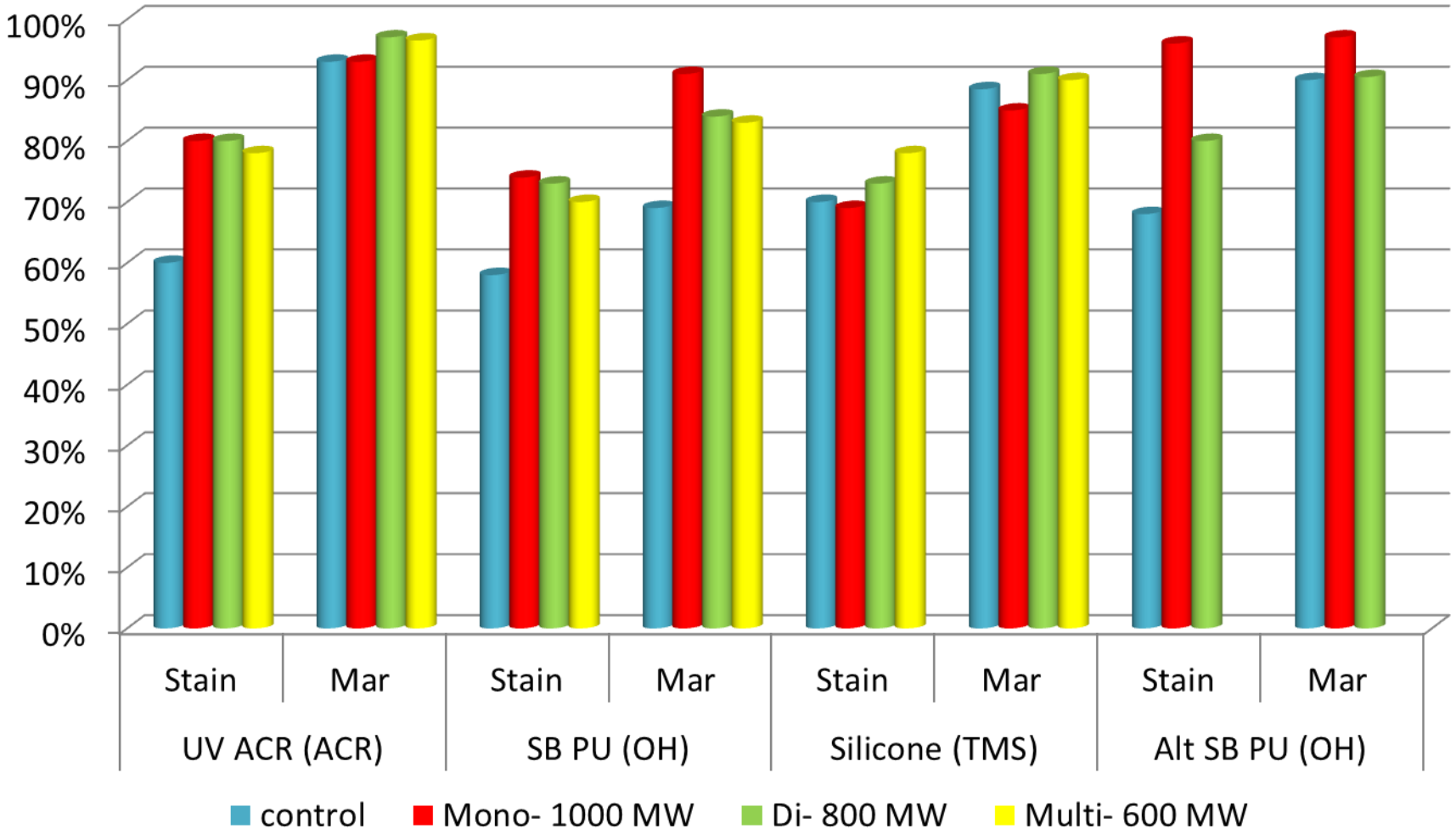
Control is no silicone added
All silicones screened at 1%

Results: CoF



Control is no silicone added
All silicones screened at 1%

Results: Avg. Stain and Mar Resist



Stain expressed as % of 10 score

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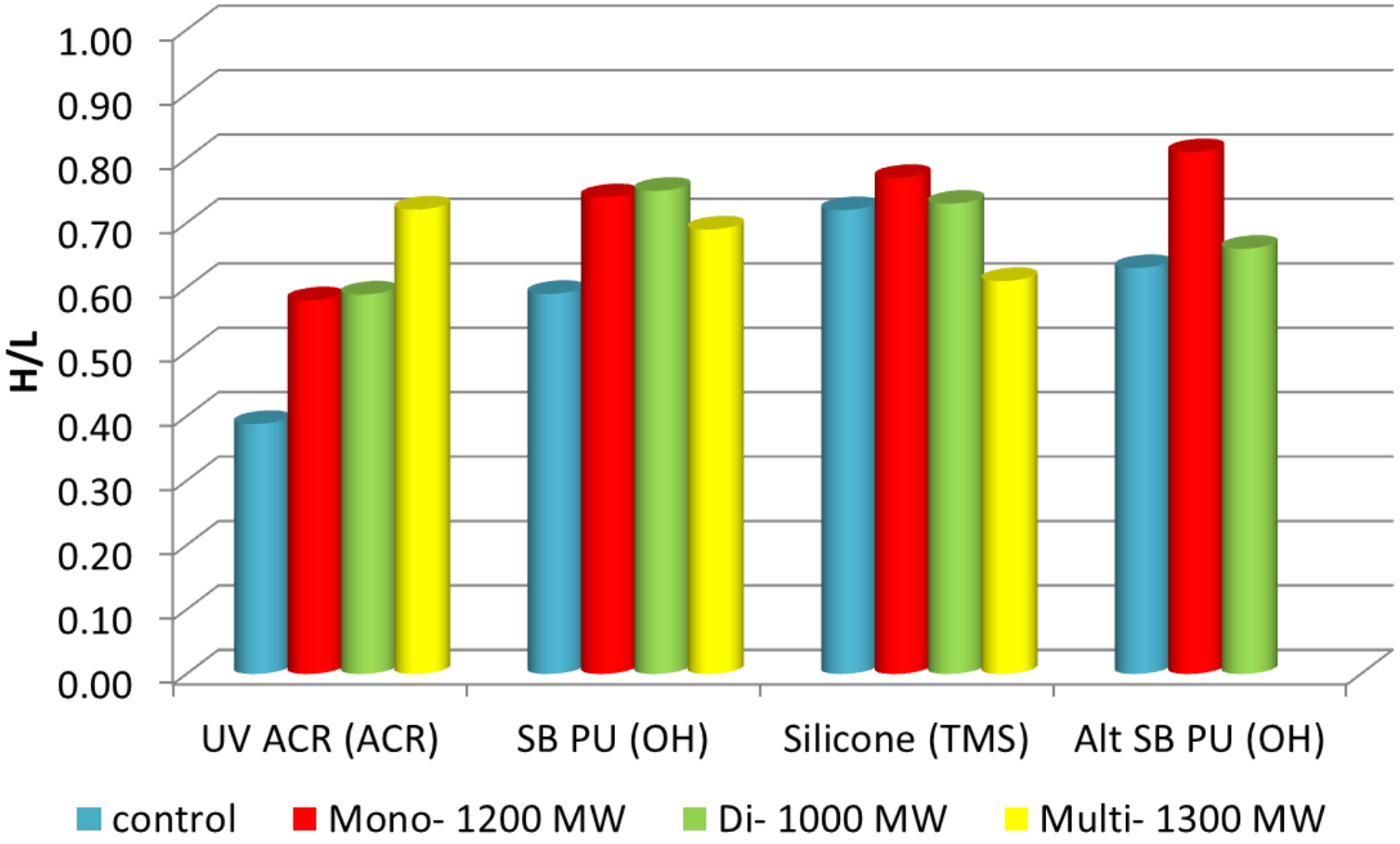
Results: Contact Angle



Control is no silicone added
All silicones screened at 1%

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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® A0

Silquat Di-10

Silquat D2

Silicone Quaternary Ammonium Salts

$(Me)_3SiO\text{-}[Si(Me)RO]_x\text{-}[Si(Me)_2O]_y\text{-}\ Si(Me)_3$

Silquat® pendant type

$R = alkyl\text{-}N^+(Et)_2Me\ Cl^-$

$R(Me)_2SiO\text{-}[Si(Me)2O]_x\text{-}Si(Me)_2\text{-}R$

Silquat Di type

$(Me)_3SiO\text{-}Si(Me)RO\text{-}Si(Me)_3$

Silquat A0 trisiloxane type

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Silicone Quats

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

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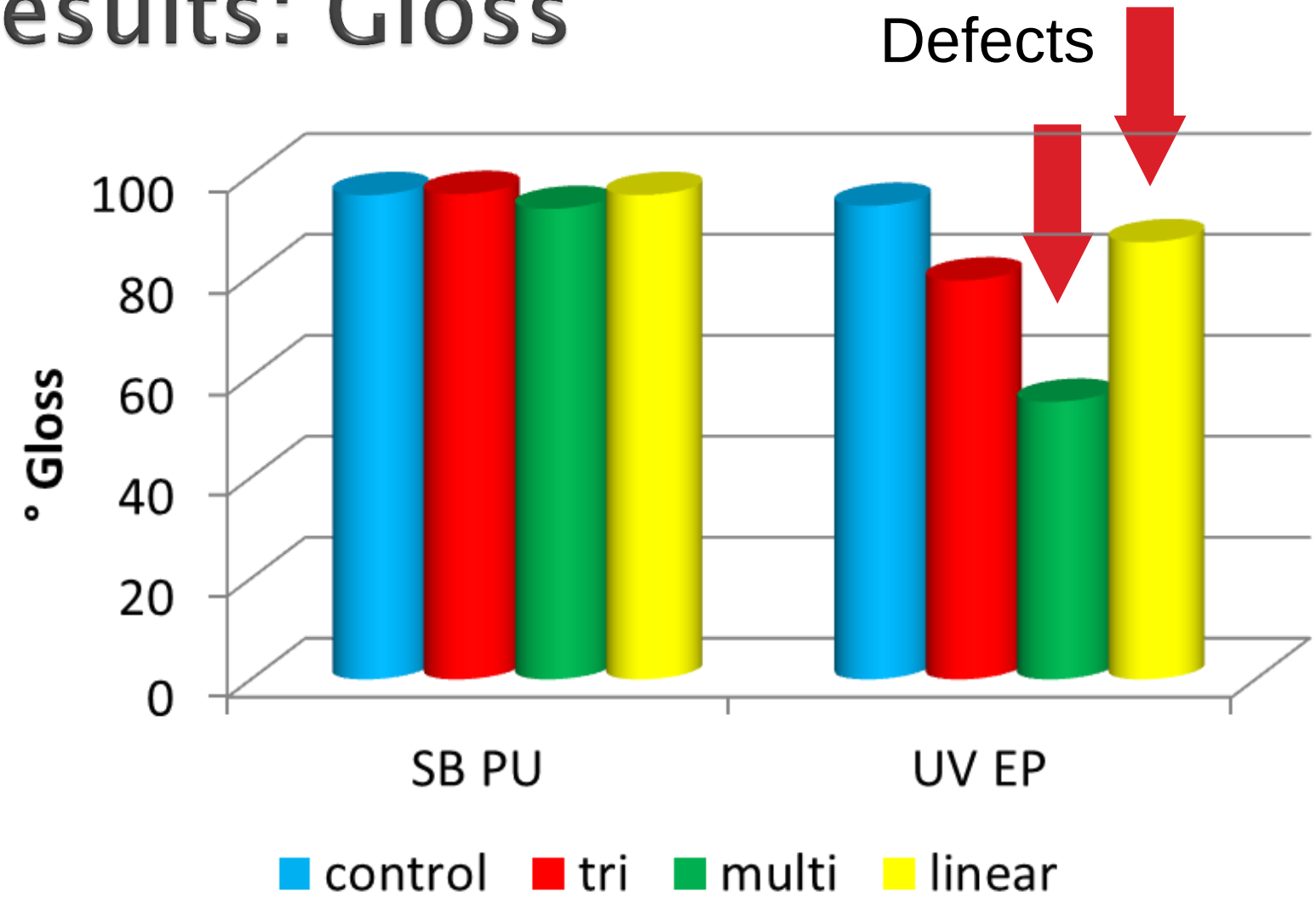
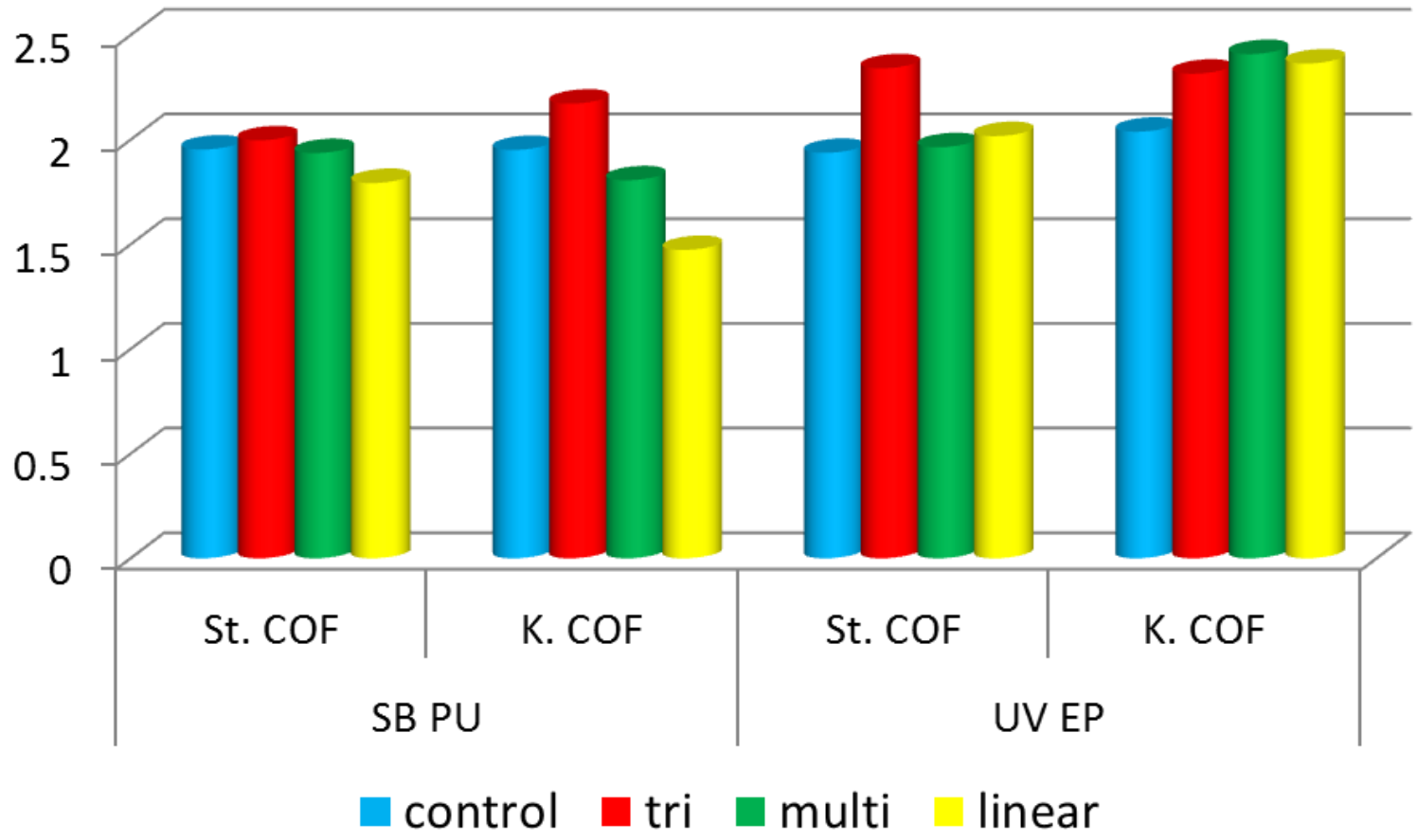
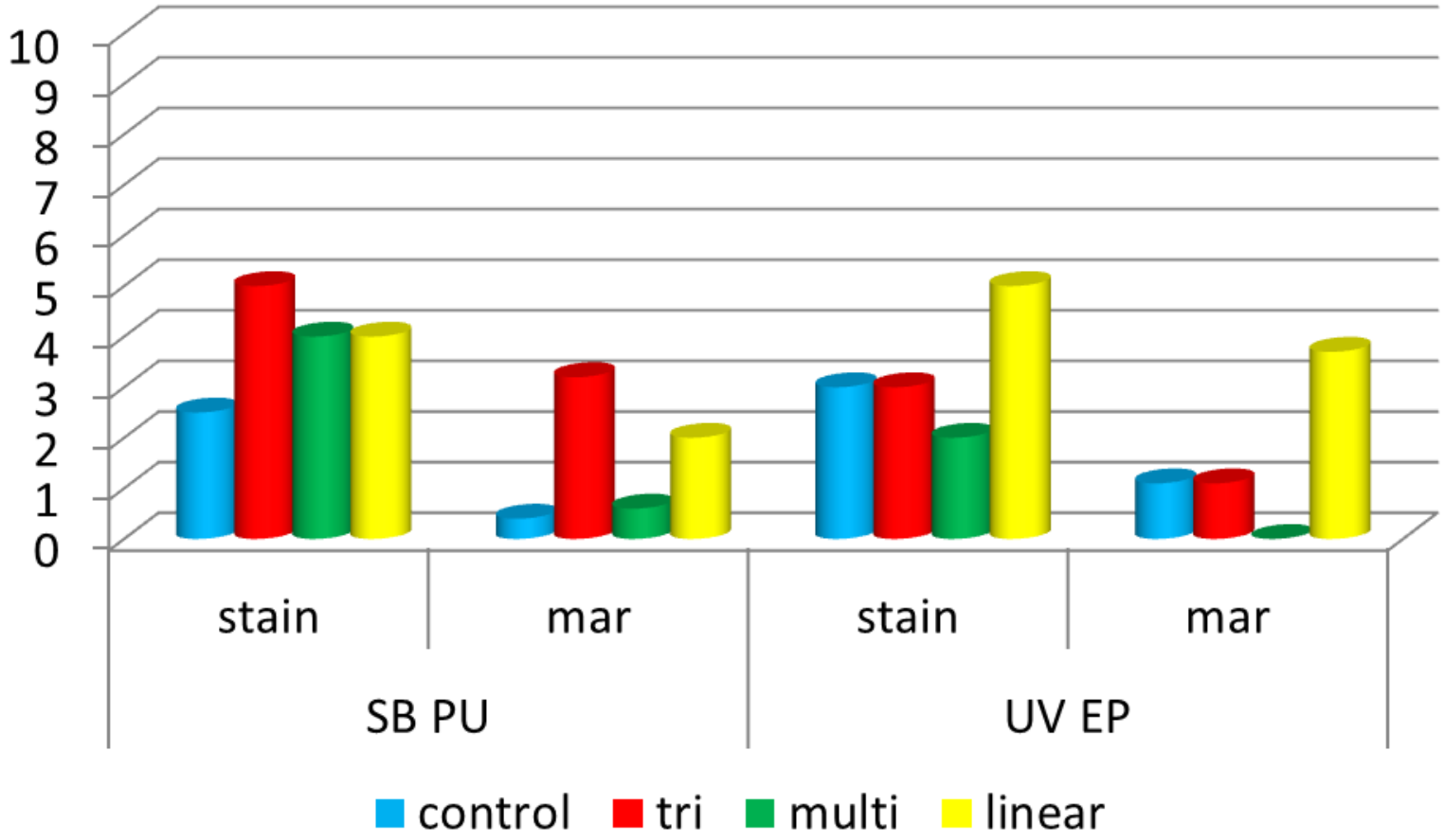
Results: Gloss



Results: COF


2.5
2
1.5
1
0.5
0
St. COF
K. COF
St. COF
K. COF
SB PU
UV EP
control
tri
multi
linear

Results: Avg. Stain and Mar Resist



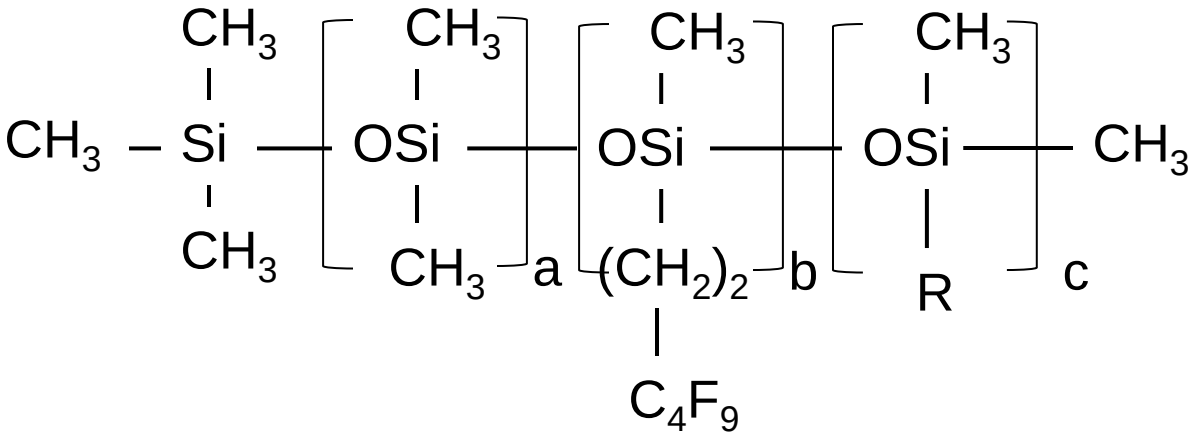
Silicone Quats Summary

- 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	$(CH_2)_3(OC_2H_4)_d(OC_3H_6)_e$ OH
FS	0	
FA	>0	$C_nH_{(2n)}$ R’

Structural Details

Fluorosil®	Wt % Silicone	Wt % CF_2	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	

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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

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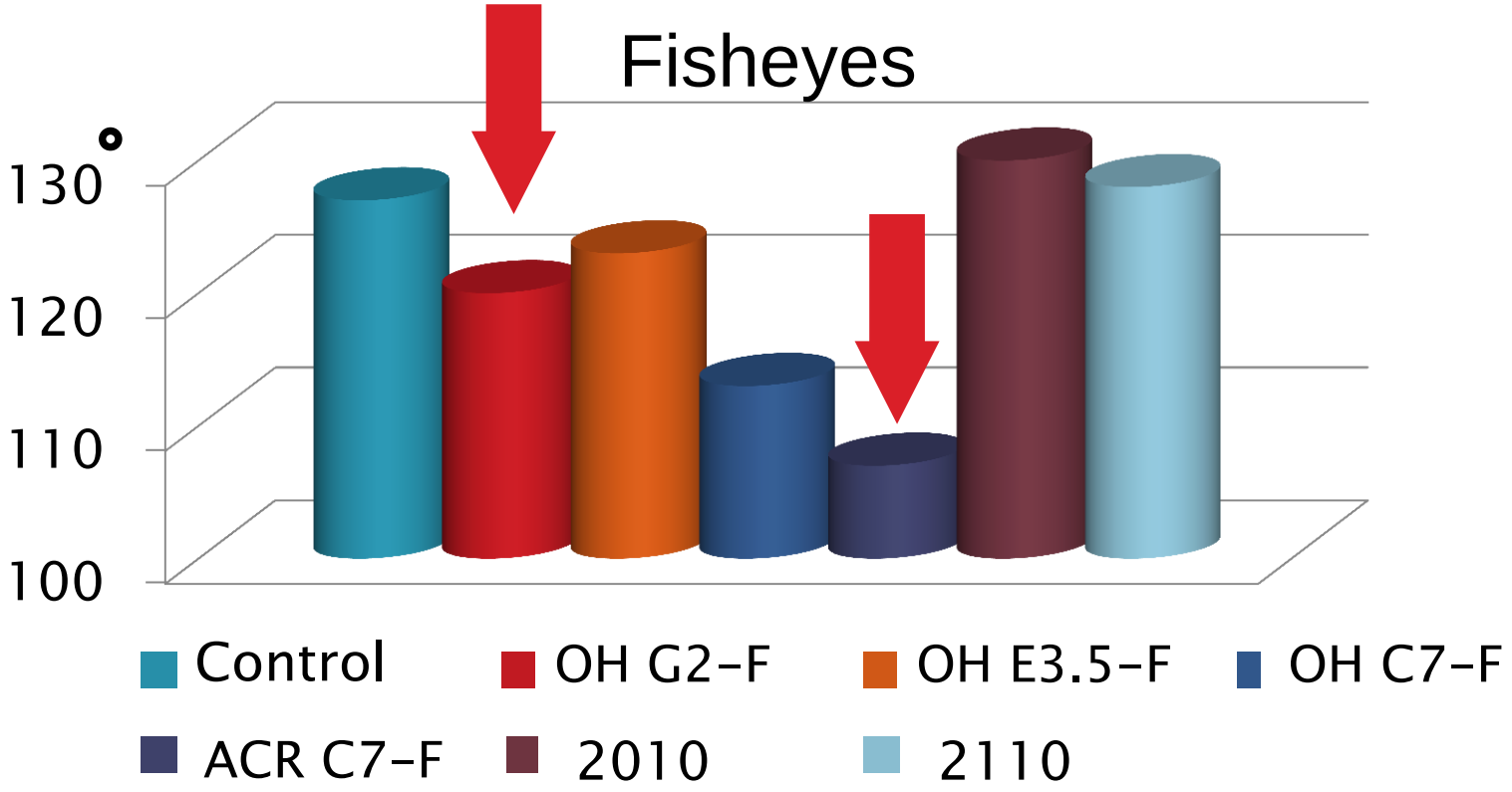
Gloss: SB Urethane



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

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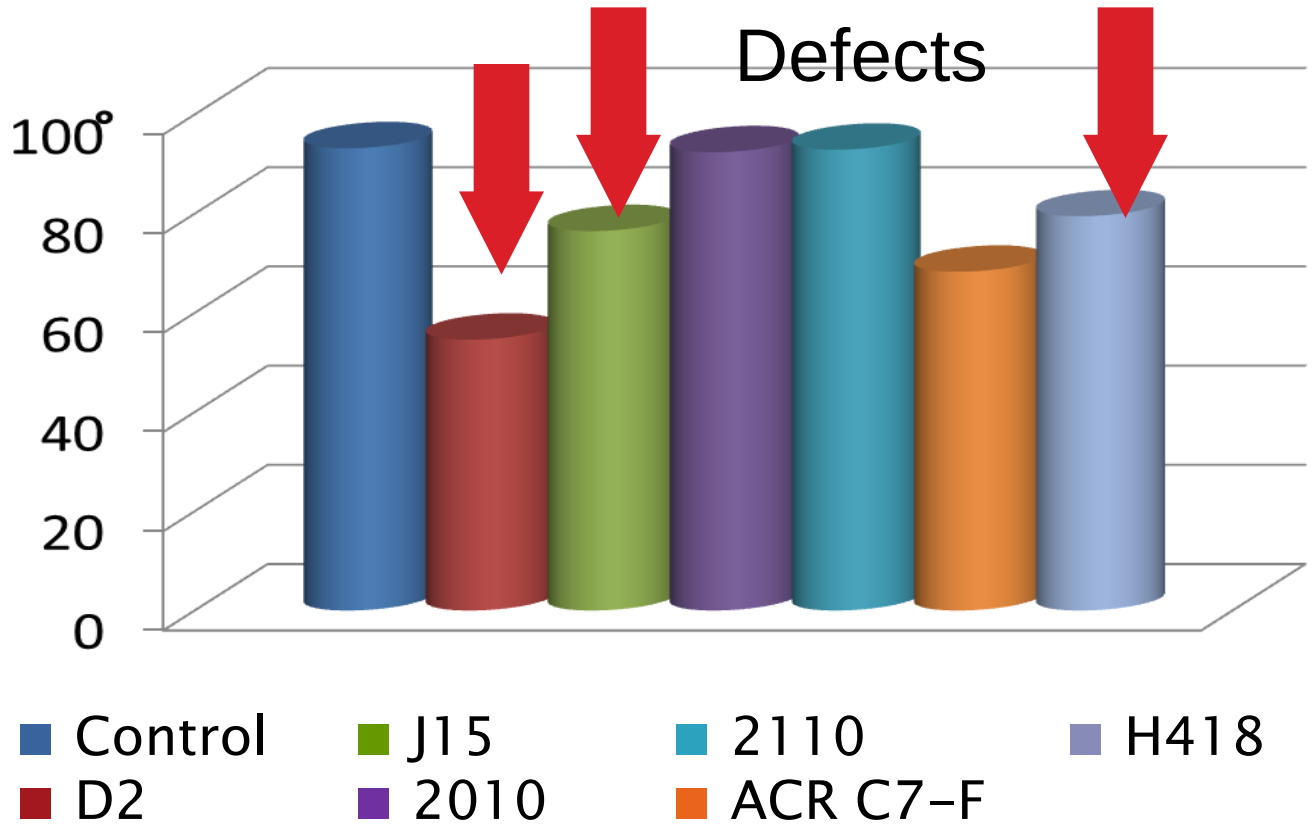
Gloss: UV Urethane Acrylate



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

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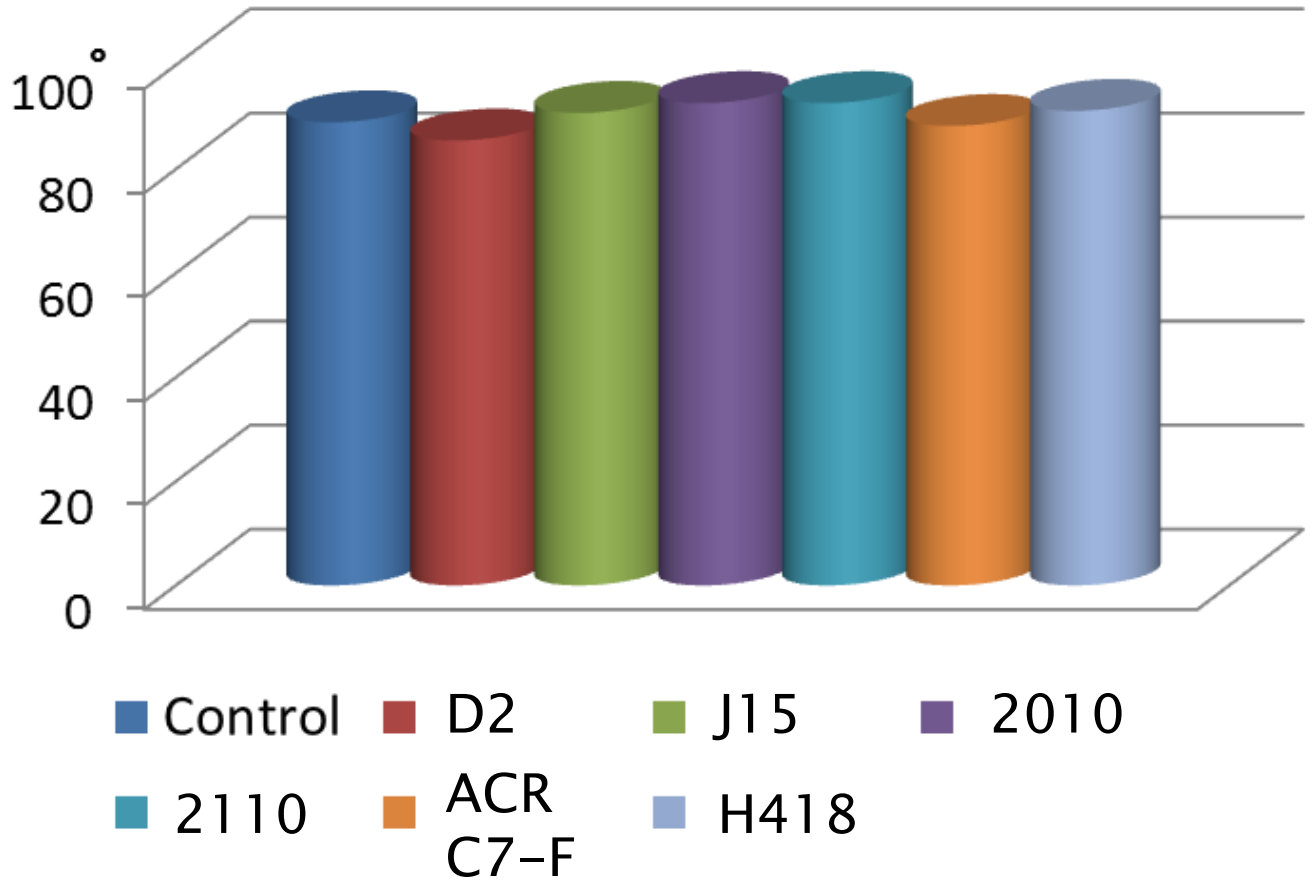
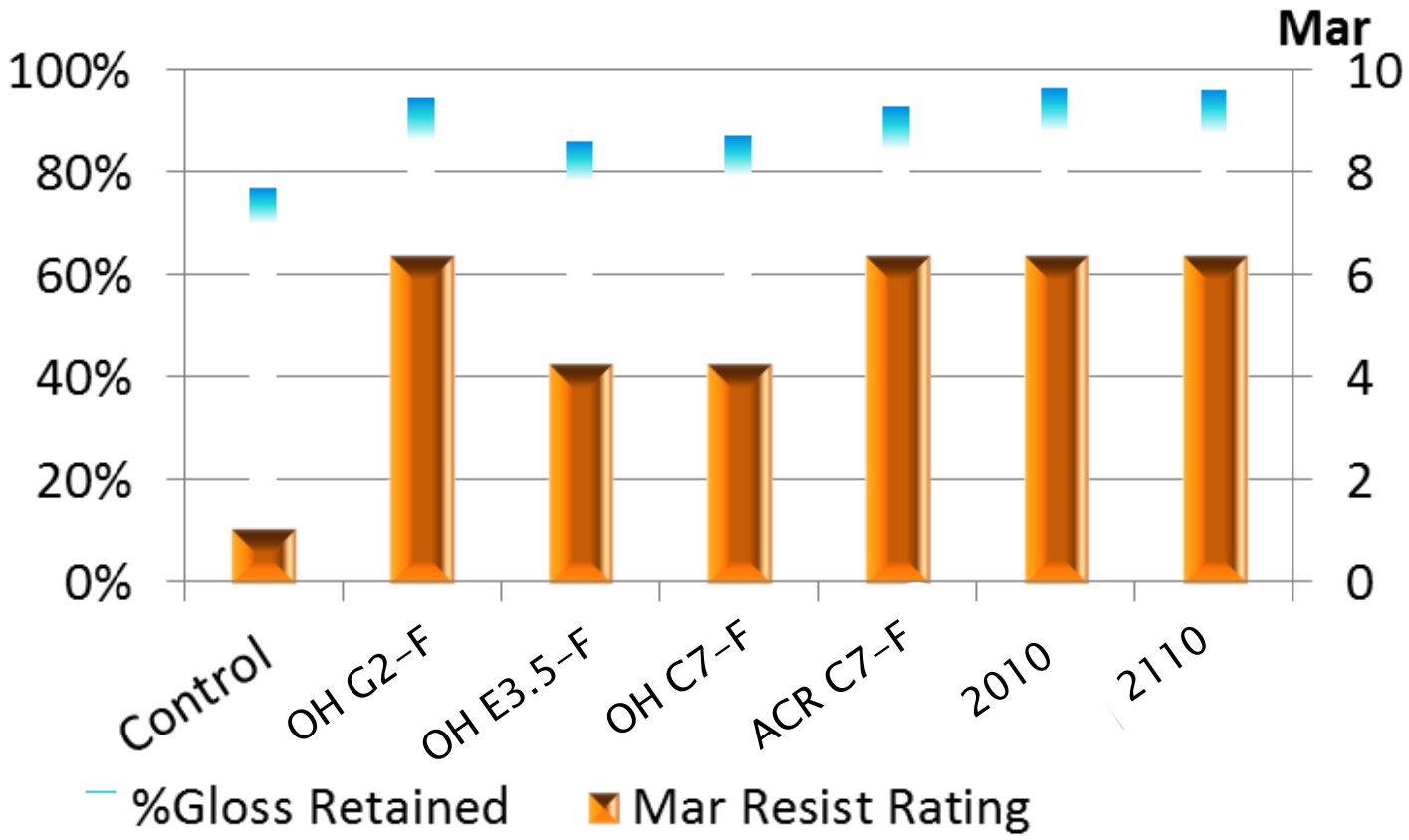
Gloss: UV Epoxy Acrylate



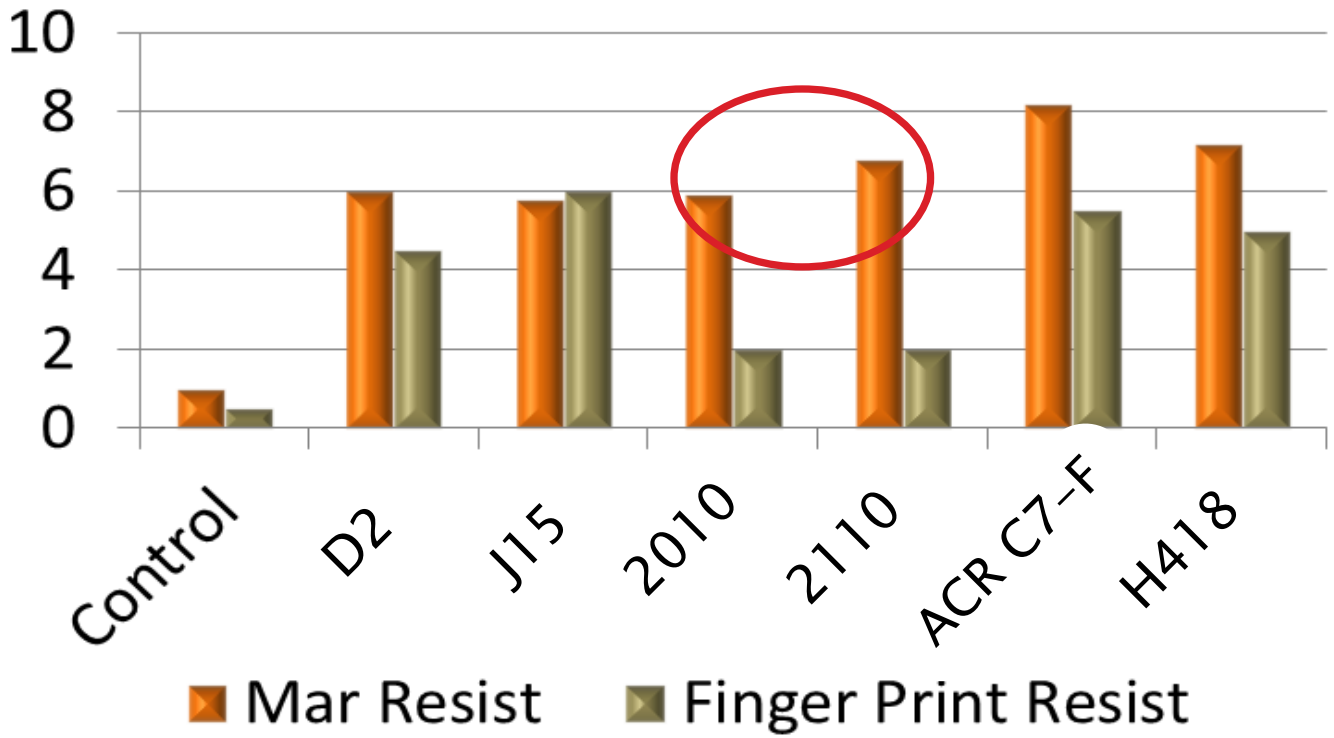
- Minor incompatibility

Mar Resist: SB Urethane



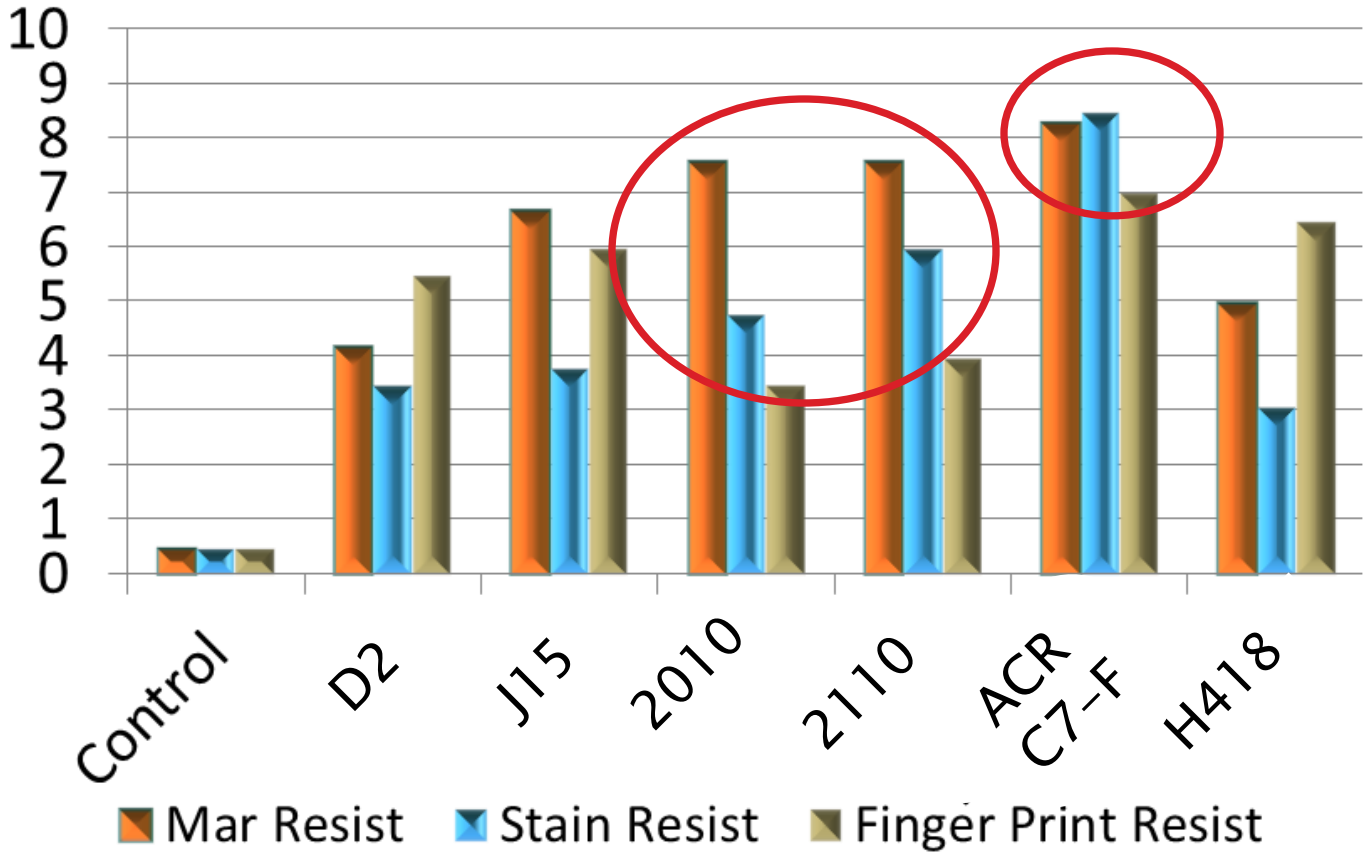
- All improve mar resistance

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

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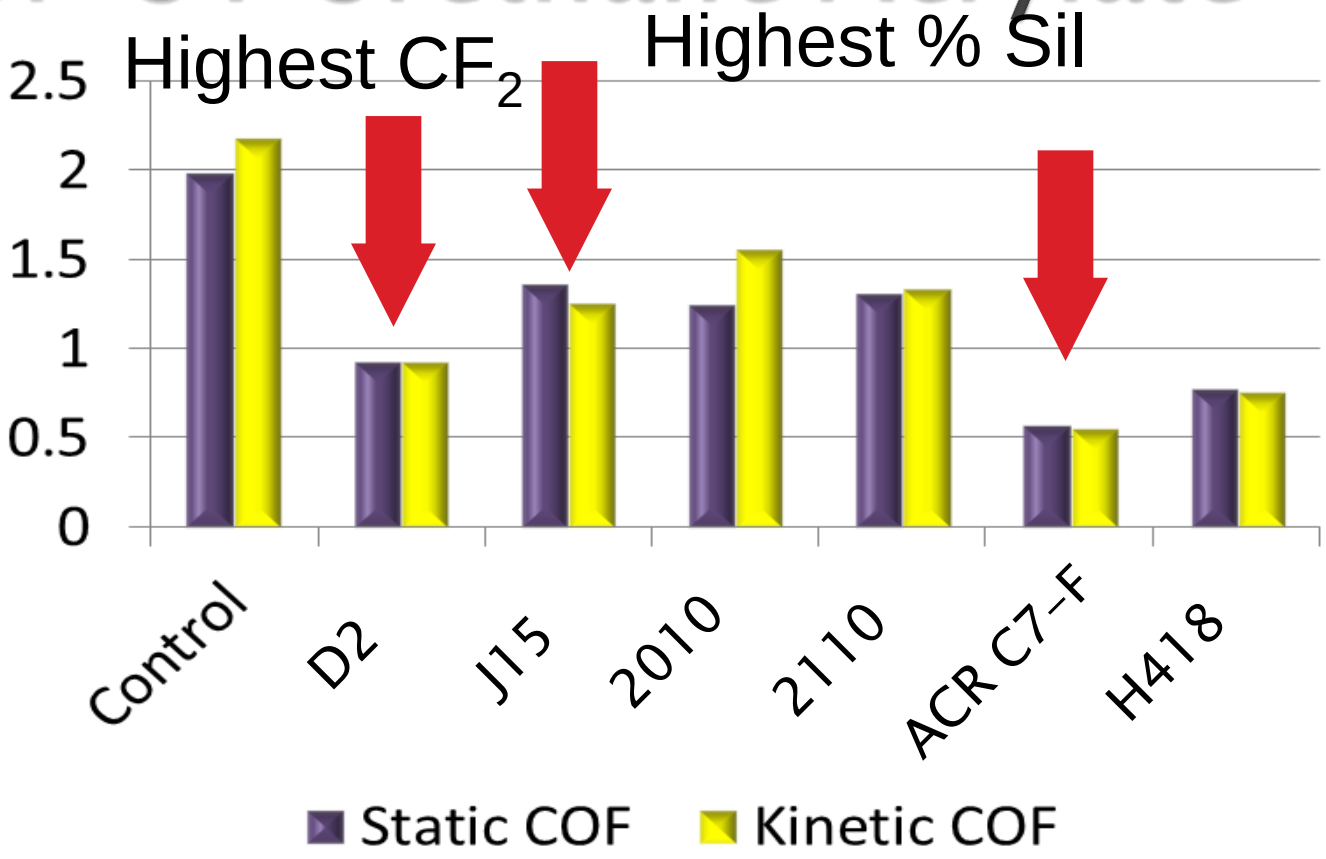
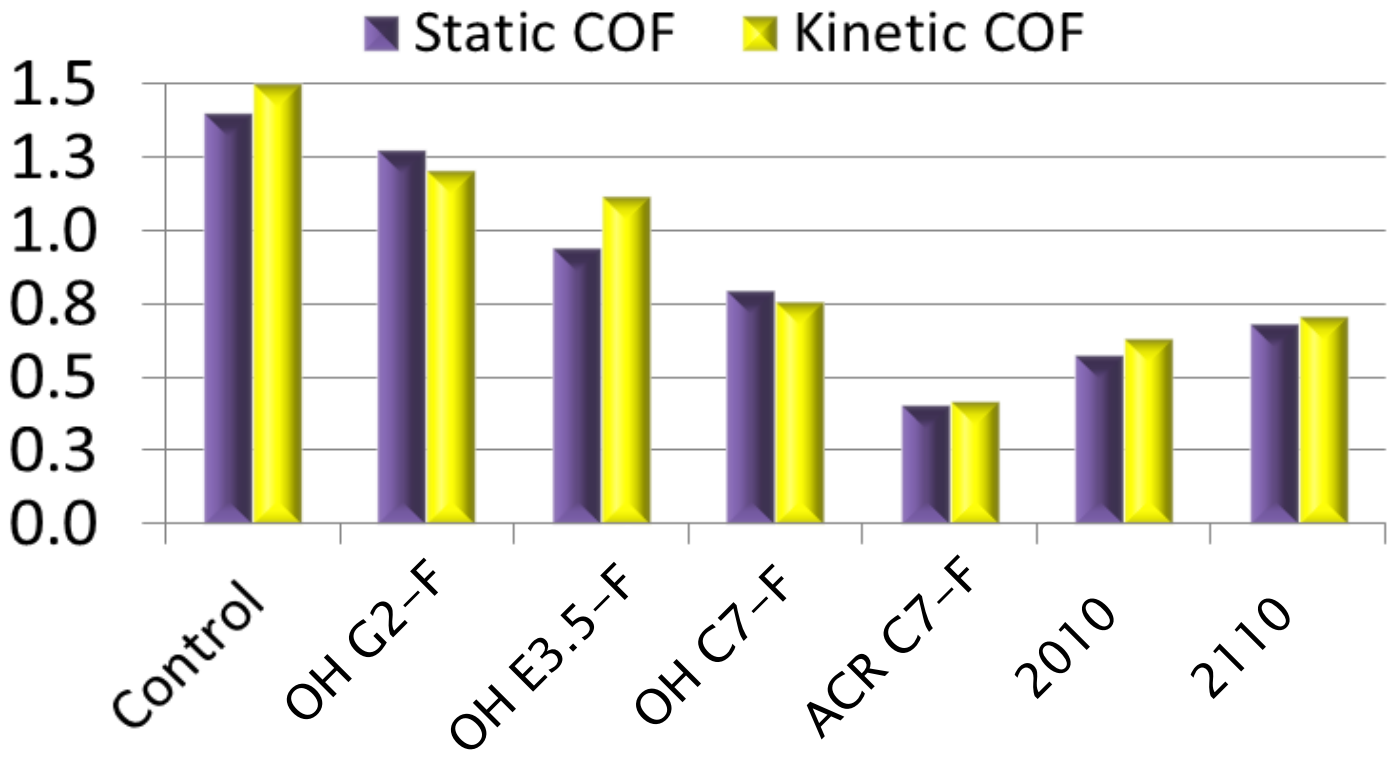
Slip: UV Urethane Acrylate



- All improve COF
- More with > wt% CF_2

COF Reduction: SB Urethane



- All improve COF
- More with > wt% silicone

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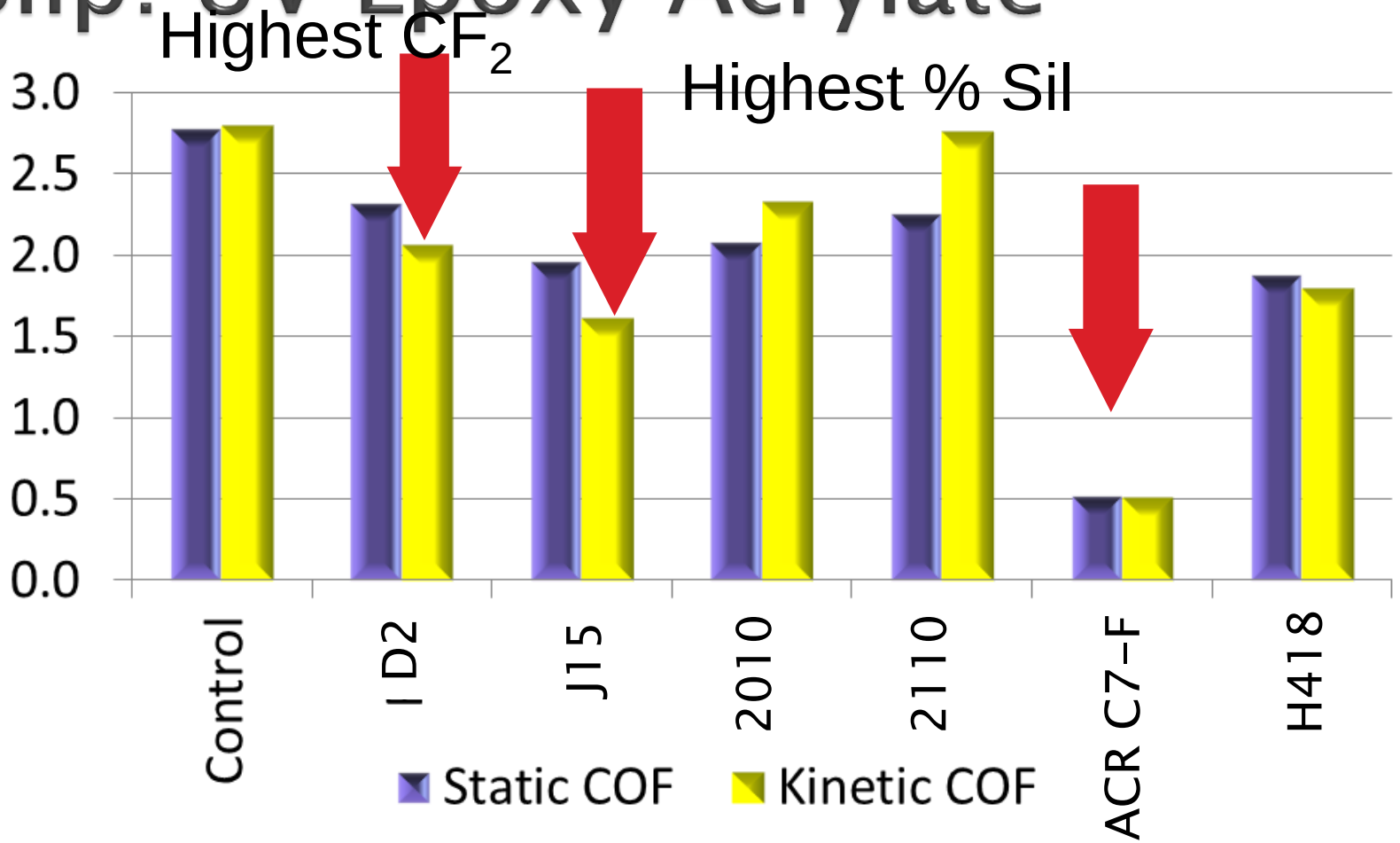
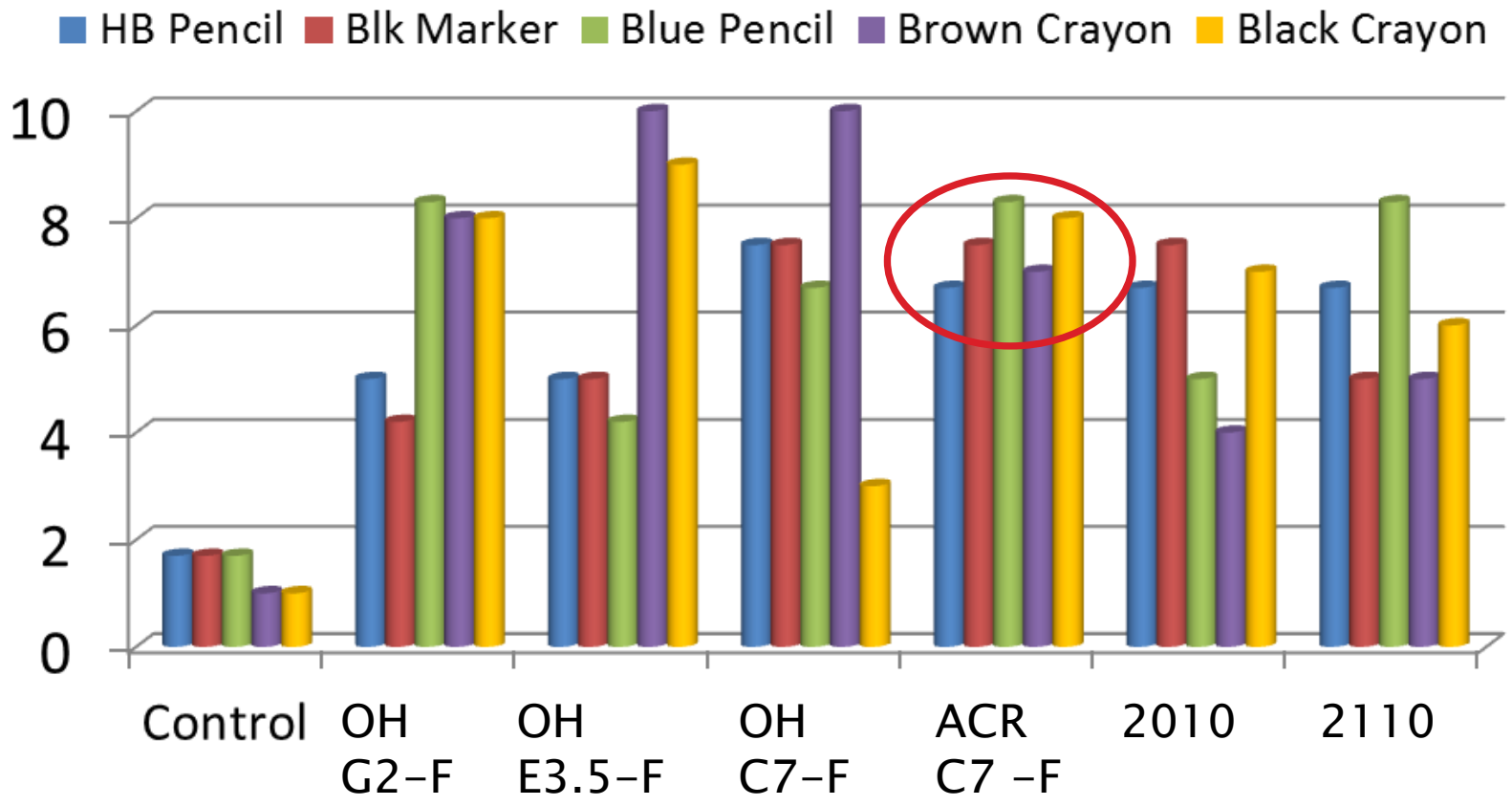
Slip: UV Epoxy Acrylate



- All improve COF
- More with > wt% silicone

Stain Resist: SB Urethane



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

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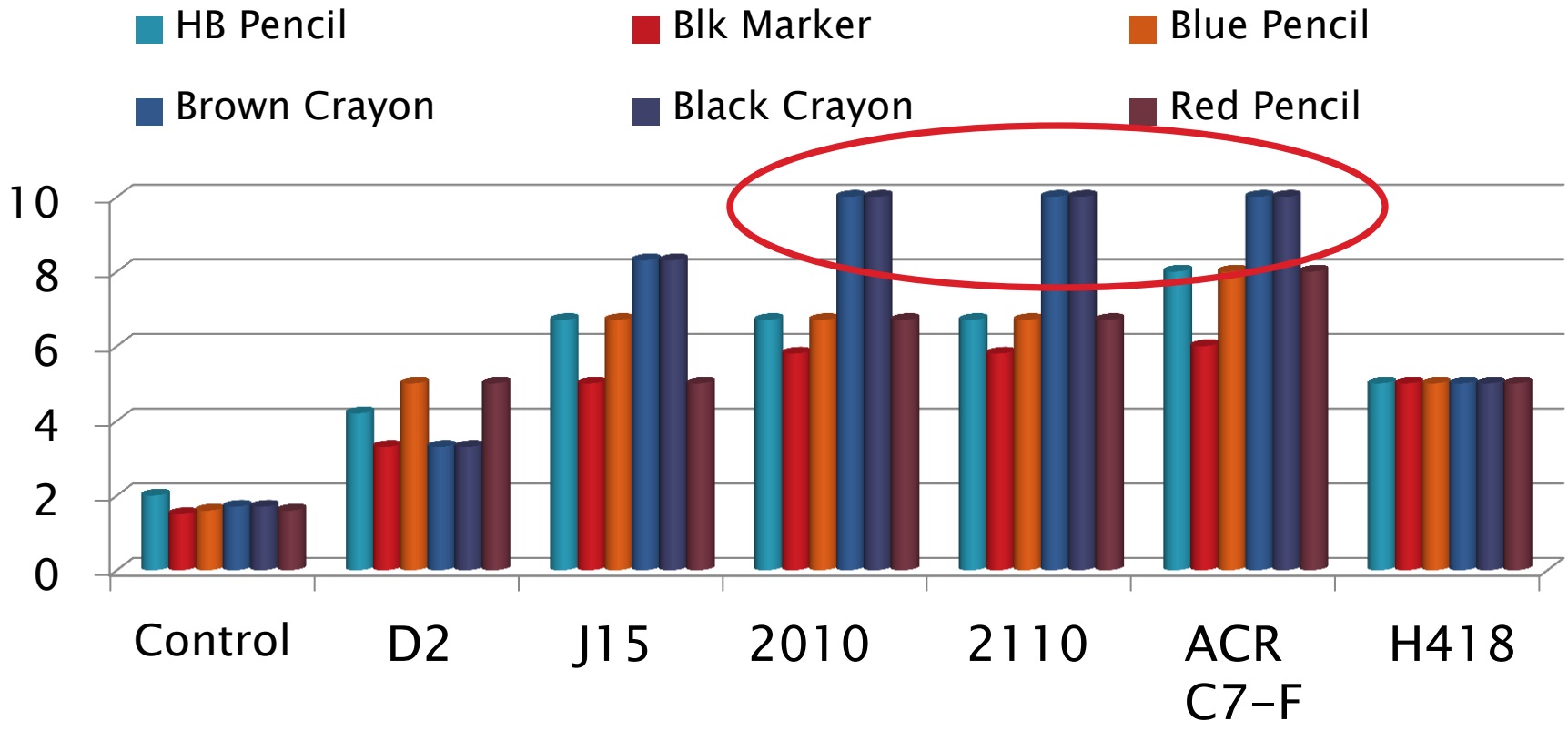
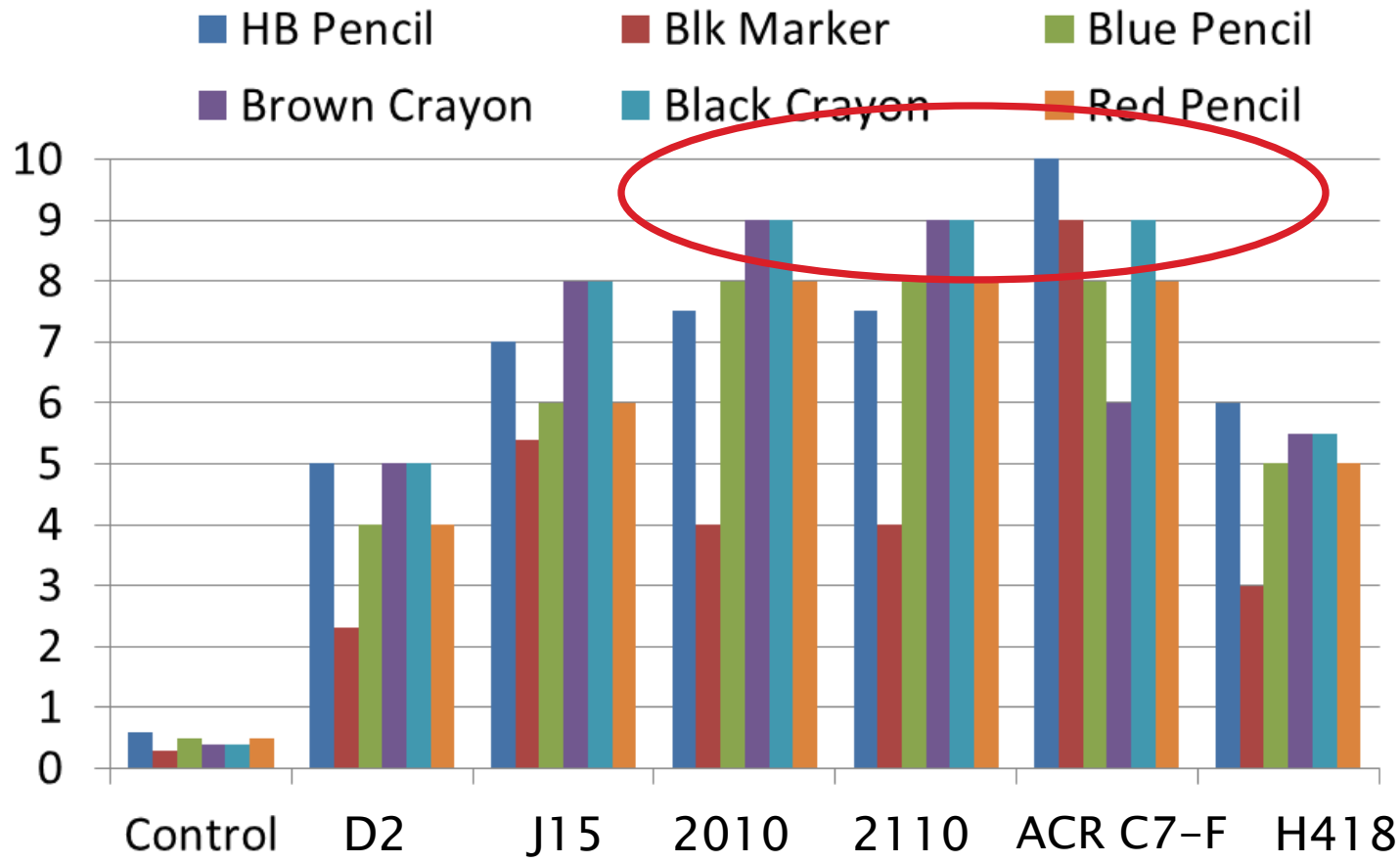
Stain Resist: UV Urethane Acrylate



- ACR C7-F and FPEs are effective

Stain: UV Epoxy Acrylate



- Highest $\%CF_2$ is least effective
- ACR C7-F and FPEs are effective

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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 CF_2 content is only important for fingerprint resist. For other properties %Sil and %CF_2 are both needed

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Recommendations

- Mono materials did not give strong performance: may give smart properties.
- Silquat products for dissipative needs only.
- Fluorosil® 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.

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THANK YOU

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