REACTIVE SILOXANE EMULSIONS IN WATERBORNE COATINGS

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Waterborne Coatings – positive trends

- **Market projected to grow at CAGR of 5.05% through 2020**
  (Source: MarketsandMarkets Research Private Ltd).
- **Regulations and Consumer Acceptance & preferences drive growth globally**

Reactive Silicone Emulsions

- Combinations of reactive silicones
  - alkoxysilanes
  - silanols
  - organo-modified siloxanes

- Formulation Aids
  - emulsifiers
  - biocides
  - antifoams
  - catalysts, wetting agents, etc.

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Formulation Chemistry and Film Properties

Silicone Emulsion (Chemistry)	Gloss	Abrasion Resistance (10 = Best)
Emulsion A (amino)	136.0	1
Emulsion N (alkyl)	99.0	3
Emulsion NT (alkyl)	80.3	2
Emulsion IB (alkyl)	104.3	1
Emulsion A1 (amino)	77.0	3
Emulsion P (phenyl)	86.2	2
Emulsion PA (amino phenyl)	92.5	3
Emulsion A2 (amino)	82.3	1
Emulsion A3 (amino)	40.3	5
Emulsion AP (amino phenyl)	75.6	1
Emulsion V (vinyl)	70.2	7
Emulsion A4 (amino)	40.0	5

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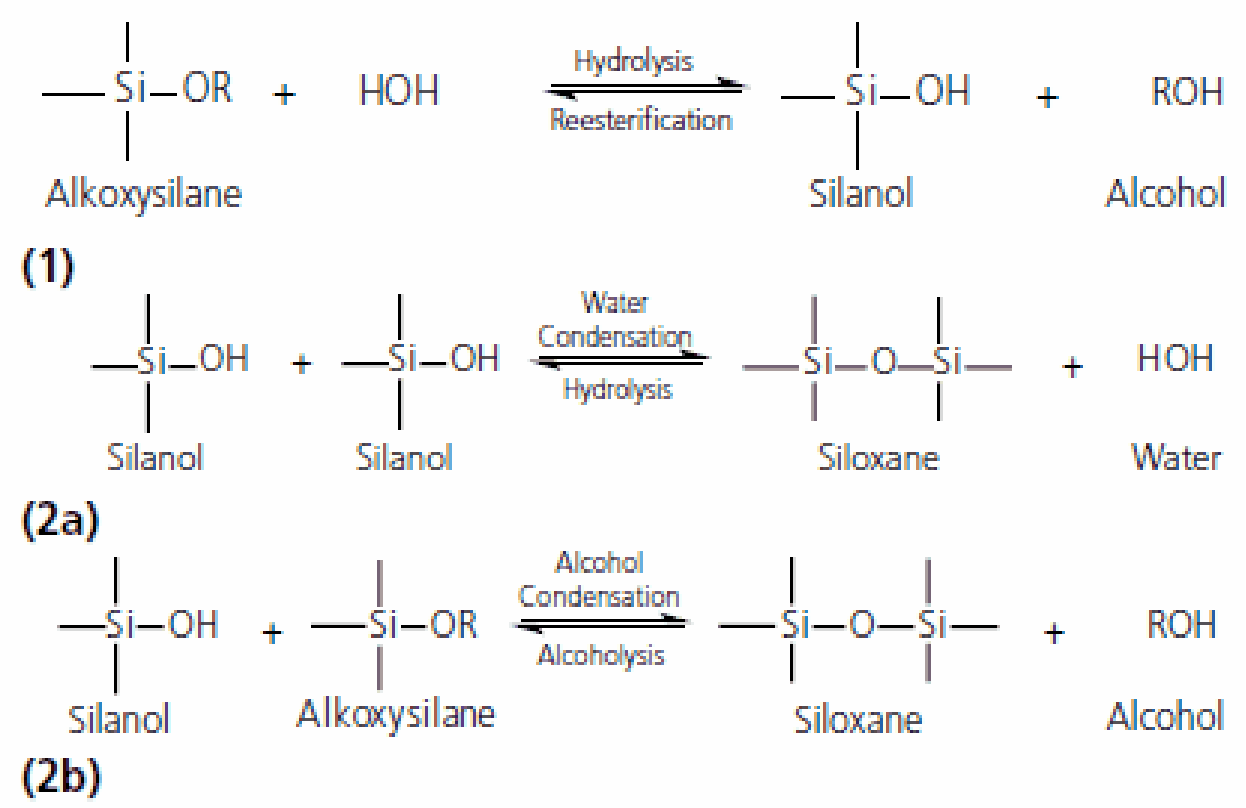
Siloxane Condensation Reaction



Source https://www.sigmaaldrich.com/technical-documents/articles/material-matters/sol-gel-science-for.html

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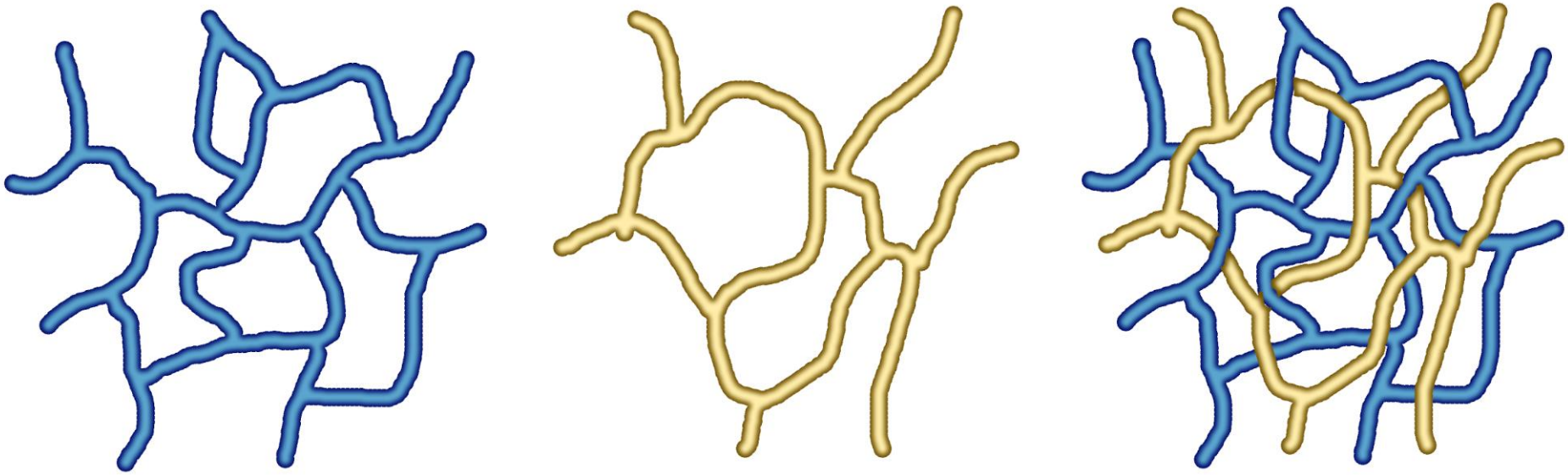
Interpenetrating Networks

Another form of polymer interaction and film formation in addition to copolymerization



Source - http://doktori.bme.hu/bme_palyazat/2016/honlap/Turcsan_Tamas_gpk_en.html

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Products Tested

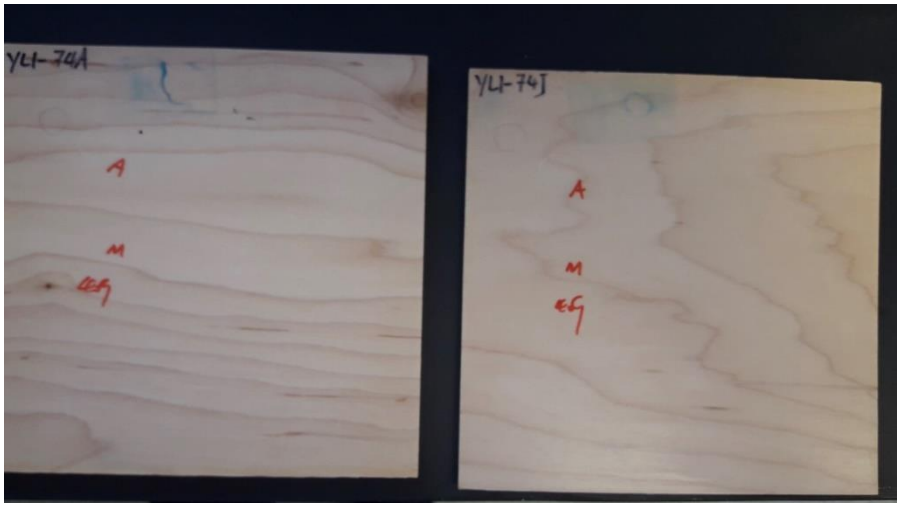
- Three commercially available water based coatings primarily intended for wood
  - Acrylic
  - Polyurethane
  - Modified Polyurethane (designated “II”)

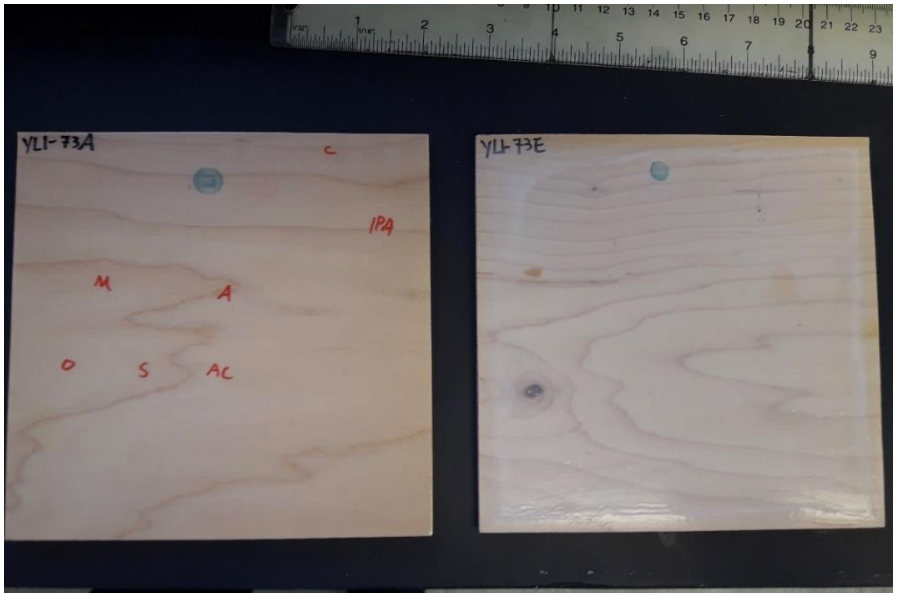
Formulations

Test formulations were prepared by post adding the reactive silicone emulsions to the control waterborne acrylic and polyurethane coatings. The control coatings are commercially available formulations primarily intended for wood coating applications.

Test Methods Utilized

- ✓ Formulations were applied to red oak wood panels
- ✓ Three coats applied
- ✓ Cured at 50° C for 1 hour
- ✓ Conditioned at ambient 7 days prior to testing


YLI-74A
A
M
EG
YLI-74J
A
M
EG


YLI-73A
C
IPA
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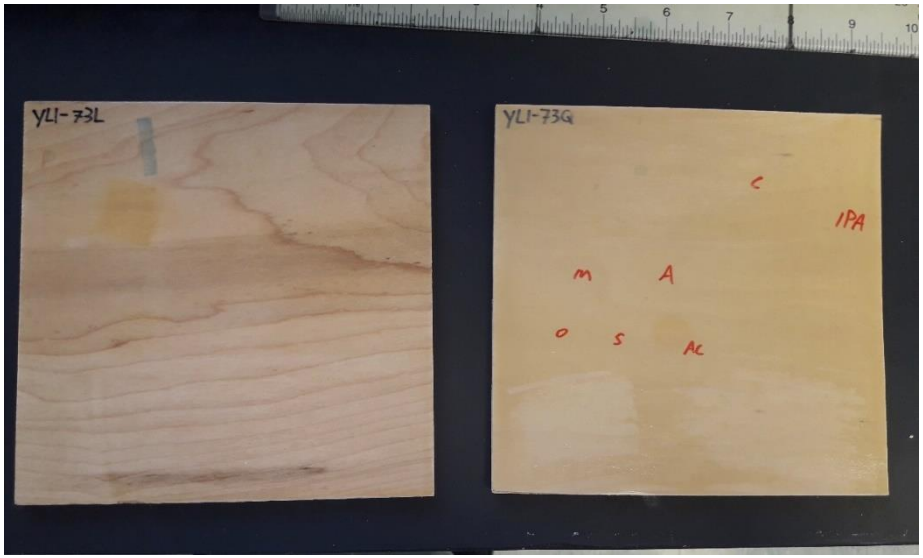
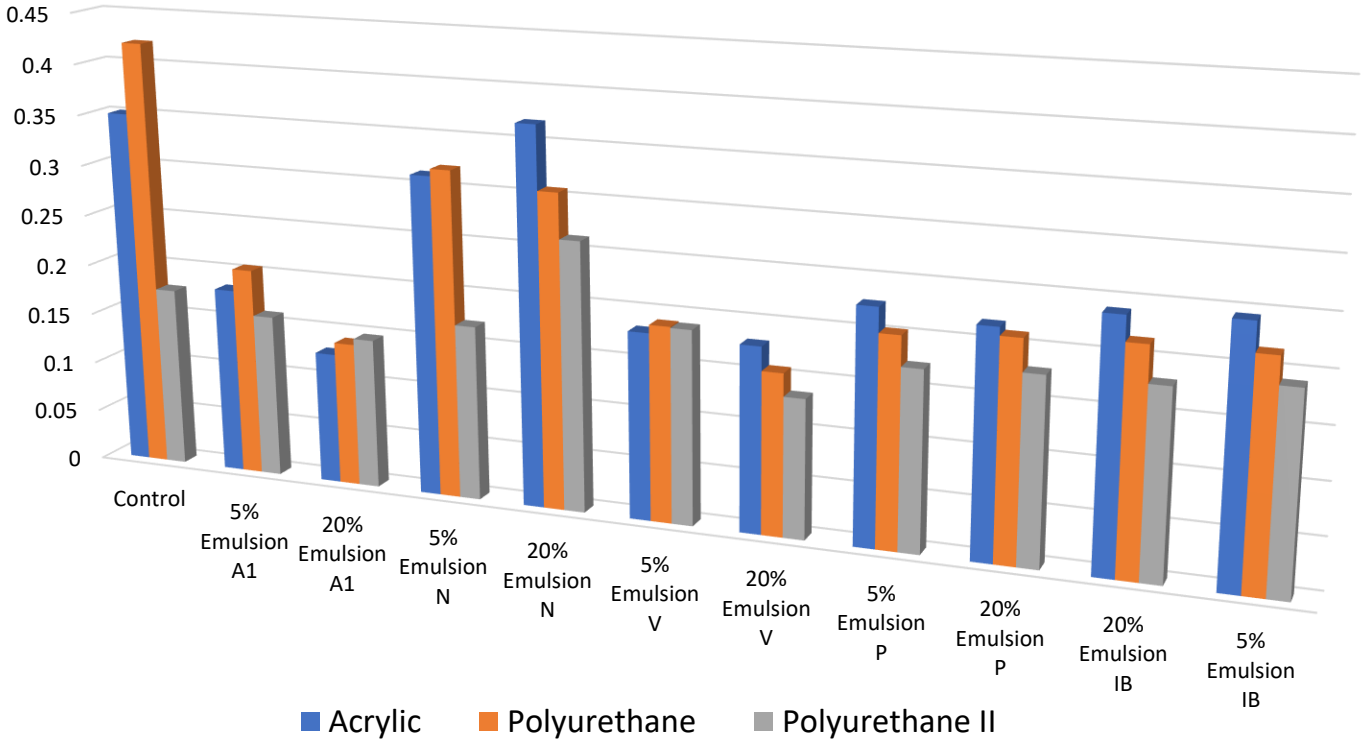
A
O
S
AC
YLI-73E


YLI-73L
YLI-73G
C
IPA
M
A
O
S
AC

- Coefficient of Friction - CoF Test

- Slip was measured with ChemInstruments Coefficient of Friction

Kinetic CoF

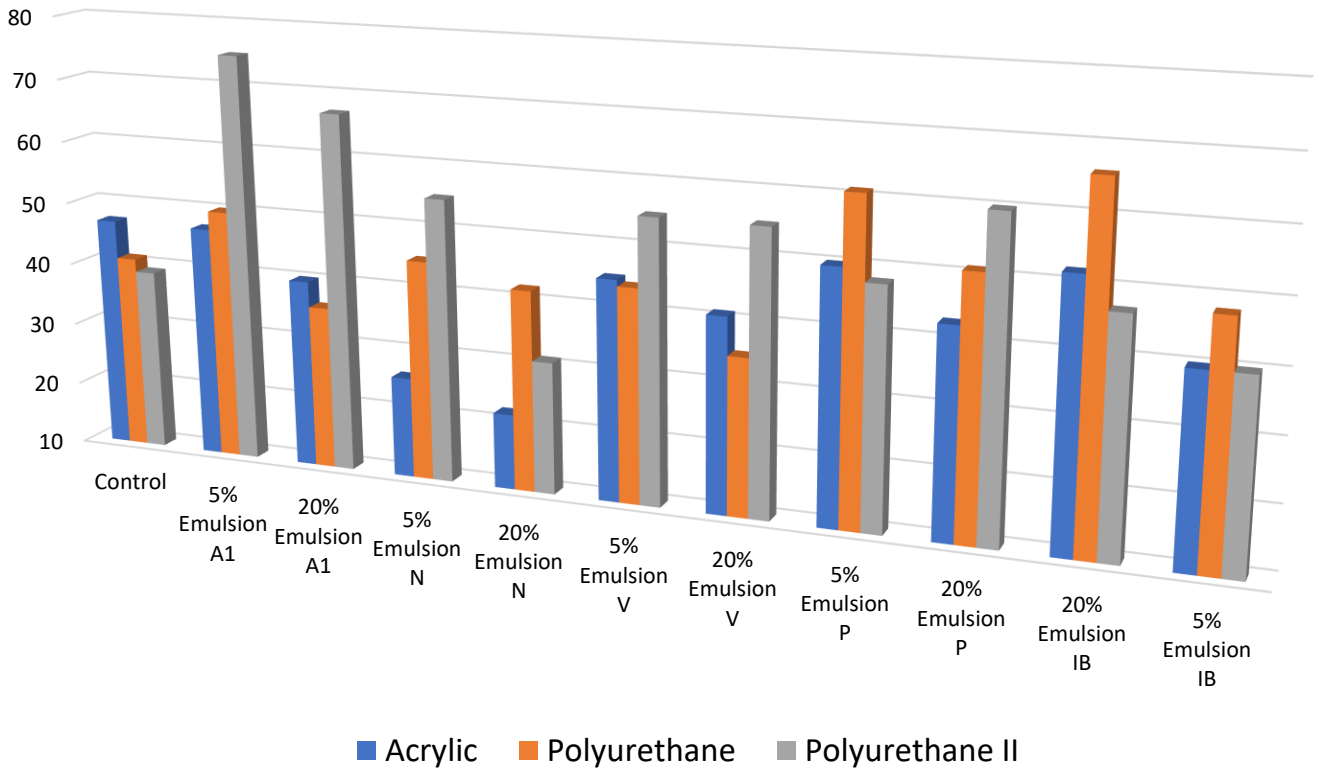


- Polyacrylic and Polyurethane with additives have lower CoF than controls.
- Polyurethane II additives gave similiar CoF values as the control.

- Water Repellency Test

- Water repellency is determined by inclination angle of water droplet. The inclination angle is the angle of tilted panel for which a 50 µl water droplet starts to slide.

Inclination Angle- Water Repellency

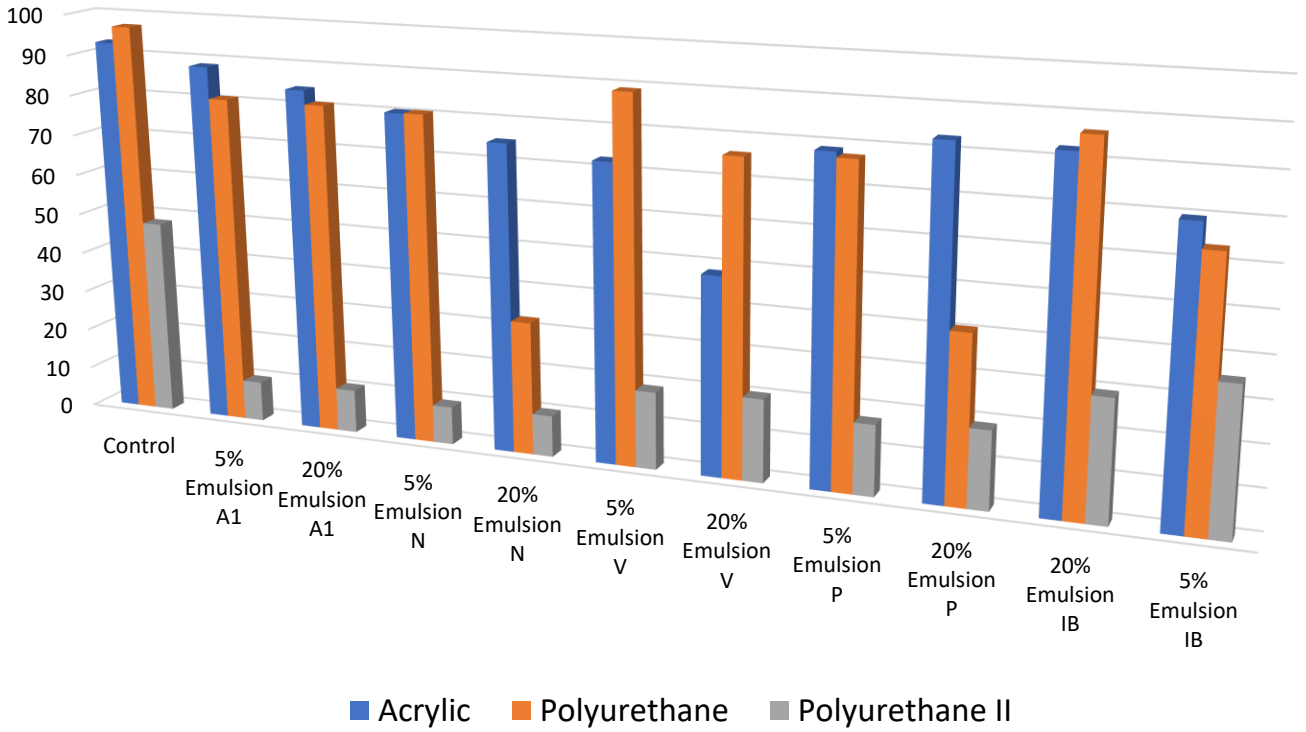


- Additives provided little or no improvement in water repellency.
- Samples with 20% additive had better water repellency than 5% silicone additive.

- Gloss Test

- Gloss was measured with BYK-Gardner 60 ° micro-glossmeter. The value was directly recorded from the micro-glossmeter. 0 is the lowest and 100 is the highest.

Gloss



Additives gave lower or similar gloss values compared to controls

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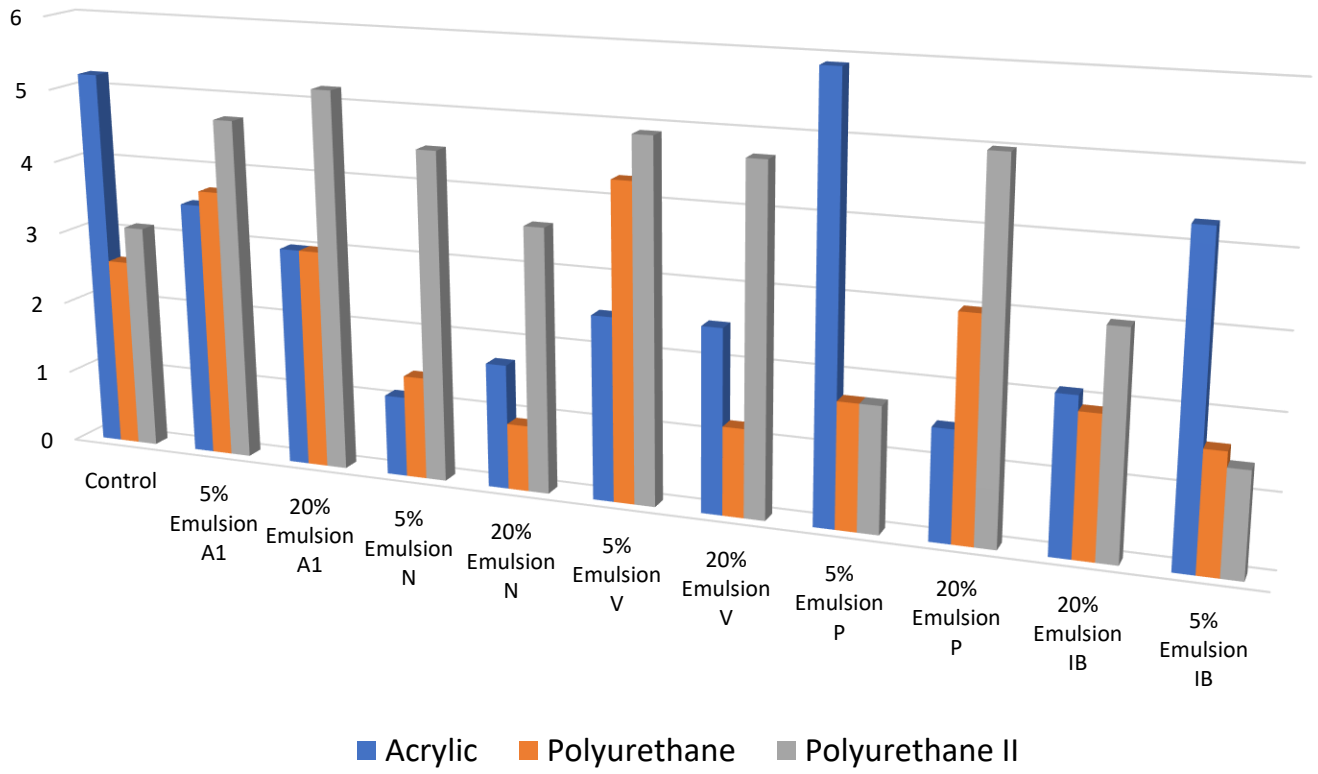
- Mar Resistance Test

- Mar resistance was measured using Sutherland 2000 Ink Rub Tester - Dry Rub method

Mar Resistance



- Mar resistance lower in all samples except 5% Emulsion P in the acrylic system.
- Mar resistance with additives in the PU systems same as controls.

- Stain Resistance Test

- Stain resistance testing was conducted according to Chemical and Stain Spot Resistance.

- Water, Mustard, Vinegar, IPA, MEK, Salad Dressing, Coffee, Lemon Oil, Formula 409, Red Wine, Marker, Acetone

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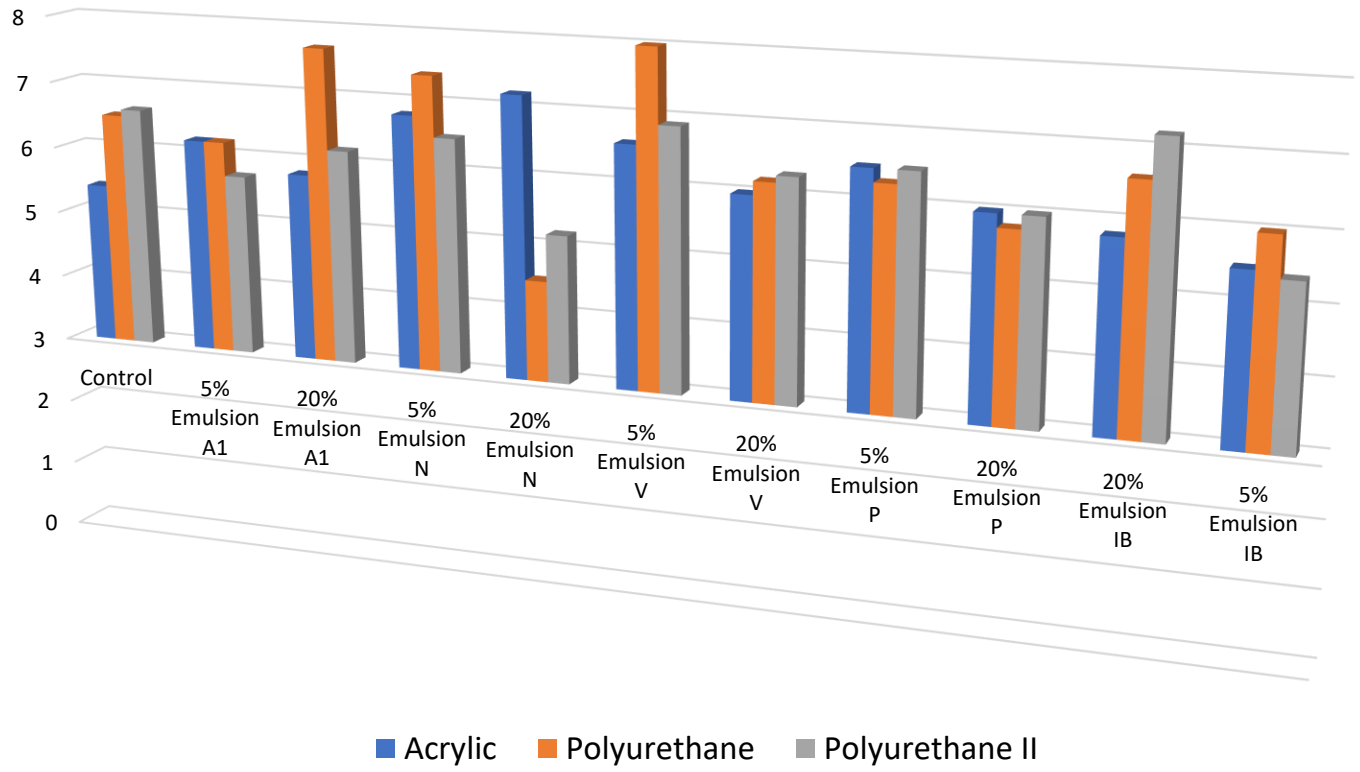
Stain Resistance



- Emulsion N (20%) improved stain resistance by 33% in the acrylic coating
- Emulsion V (5%) provided a 23% increase in stain resistance the PU coating

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Conclusions

- The organic functionality present in the silicone emulsions influenced the compatibility within coating systems testing.
- The percentage of silicone emulsion formulated into the system did not always result in a dose response to the coating property tested.
- The gloss reduction observed with some of the silicone additives correlated to level of compatibility within the coating systems.

Conclusions

- Nearly all of the silicone emulsions tested reduced coefficient of friction values in the coatings.
- While reductions in CoF values usually translate to improved mar resistance, this did not occur in this testing.
- Stain resistance was generally improved with the addition of silicone emulsions. Adding 5% of Emulsion V or 5% Emulsion IB improved the stain resistance for all three coating systems with increases in performance of up to 33%.

Conclusions

- Reactive silicone emulsions impact the performance of waterborne coating systems via simple post addition. Further work to improve compatibility, polymer interactions and synergies are required to optimize performance for specific properties. Surfactant interaction and polymer cross link densities appear to be particularly important.

Thank You

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