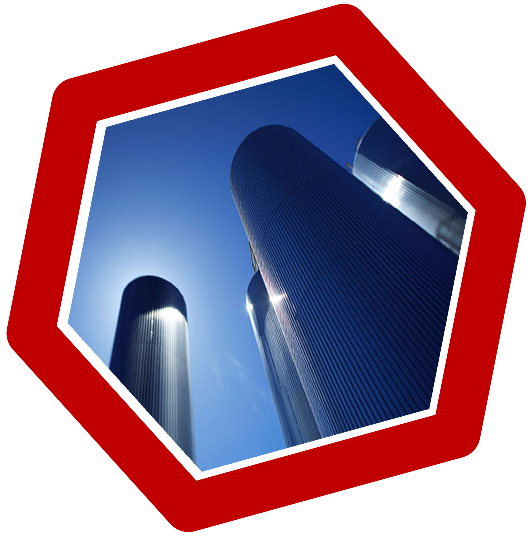


High Performance Acrylic Latex Technologies for Low-VOC Concrete Sealers

Coatings Trends & Technologies Conference

September 2021

VINAVIL®

YOUR PARTNER IN POLYMERS

Agenda

- Decorative Sealer Performance Challenges
- Concrete composition and design
- Polymer and latex design attributes
- Concrete sealer performance across array of acrylic latex emulsion variables
- NEW TECHNOLOGY Self-Crosslinking Acrylic for Concrete Sealer

Decorative Sealer Performance Challenges

Decorative Concrete Sealer Performance Challenges

Protect the surface

- Uniform film
- Prevent degradation from stains
- Tough film for challenging use applications – garage floor, high foot traffic

Moisture Release

- Moisture is free to leave the concrete substrate through the coating film
- A tight film will trap water in the concrete resulting in blushing of the coating
- Water whitening a common failure for conventional water-based latex
- In extreme cases, blistering and severe cracking may result

VINAVIL
YOUR PARTNER IN POLYMERS

Decorative Concrete Sealer Performance Challenges

Maintain Wet-Look

- Solvent based systems traditionally perform well
- Solution polymer flow allows continuity of penetration and wetting into the concrete leading to a rich “wet-look”
- Latex polymer particle flow inhibits penetration continuity and may result in glossy but usually not wet appearance

Durability over time

- Withstand weather elements – sun, rain, snow/ice melt
- Maintain glossy appearance
- Keeps uniform film for an extended period

Concrete Composition and Design

Concrete composition and design play a role in performance of sealed concrete

- Mix 1 has a water-cement ratio of 0.7 and total cement paste of 23%
- Mix 2 has a water-cement ratio of 0.6 and total cement paste of 36%

Mix 1: Lean cement mix with large size aggregates

Mix 2: Rich cement mix with small size aggregates

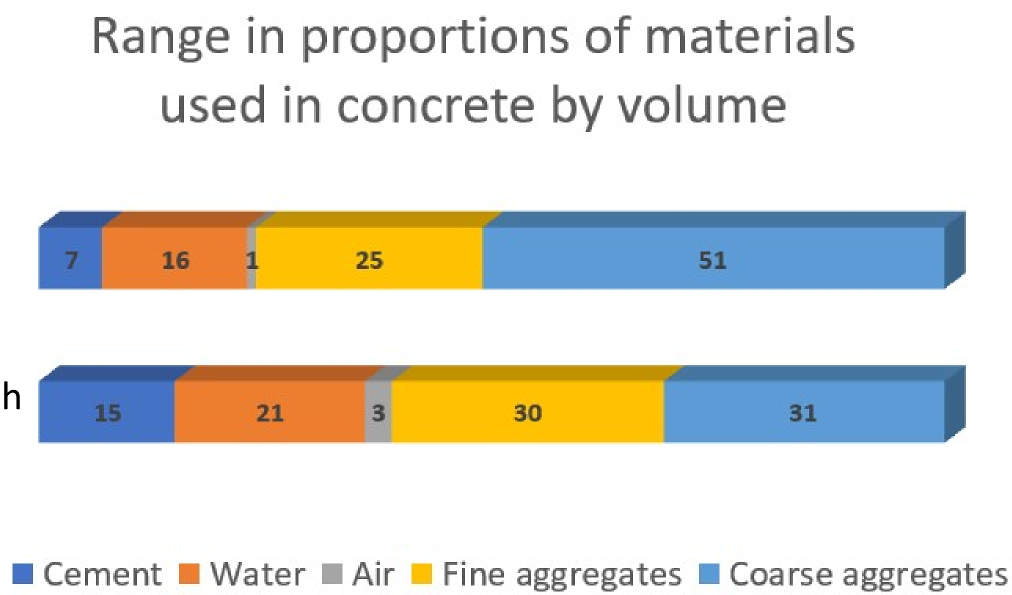
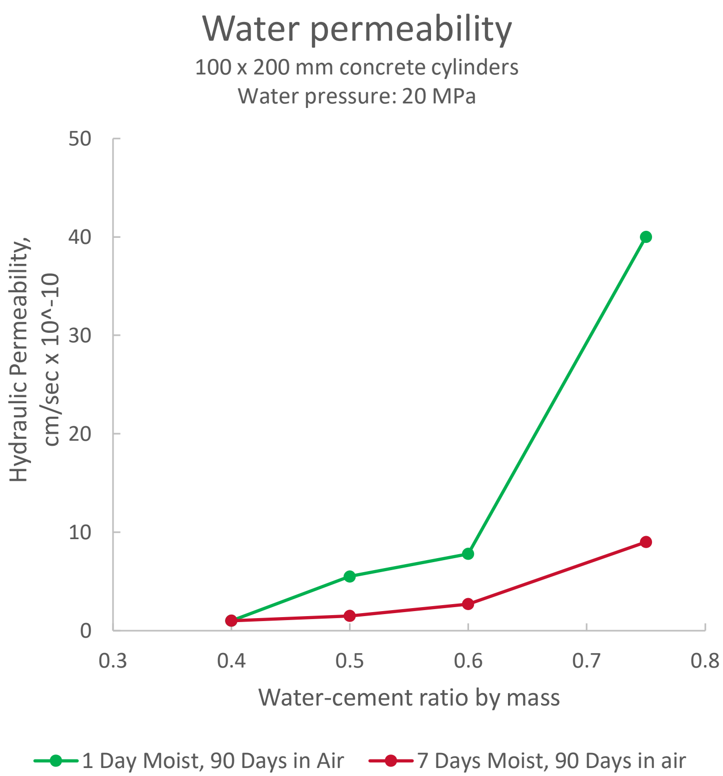


*Figure adapted from *Design and Control of Concrete Mixtures, 14th Edition*. Portland Cement Association, 2002. Used by permission.

Concrete permeability sets the base potential of a surface coating to experience challenge of water moisture



Concrete Permeability Factors

- Quality of the water-cement paste
- Permeability of the aggregate and cement
- Increasing the moist-curing period decreases permeability
- Higher water-cement ratios in the concrete mix give higher water permeability

*Chart adapted from *Design and Control of Concrete Mixtures, 14th Edition*. Portland Cement Association, 2002. Used by permission.

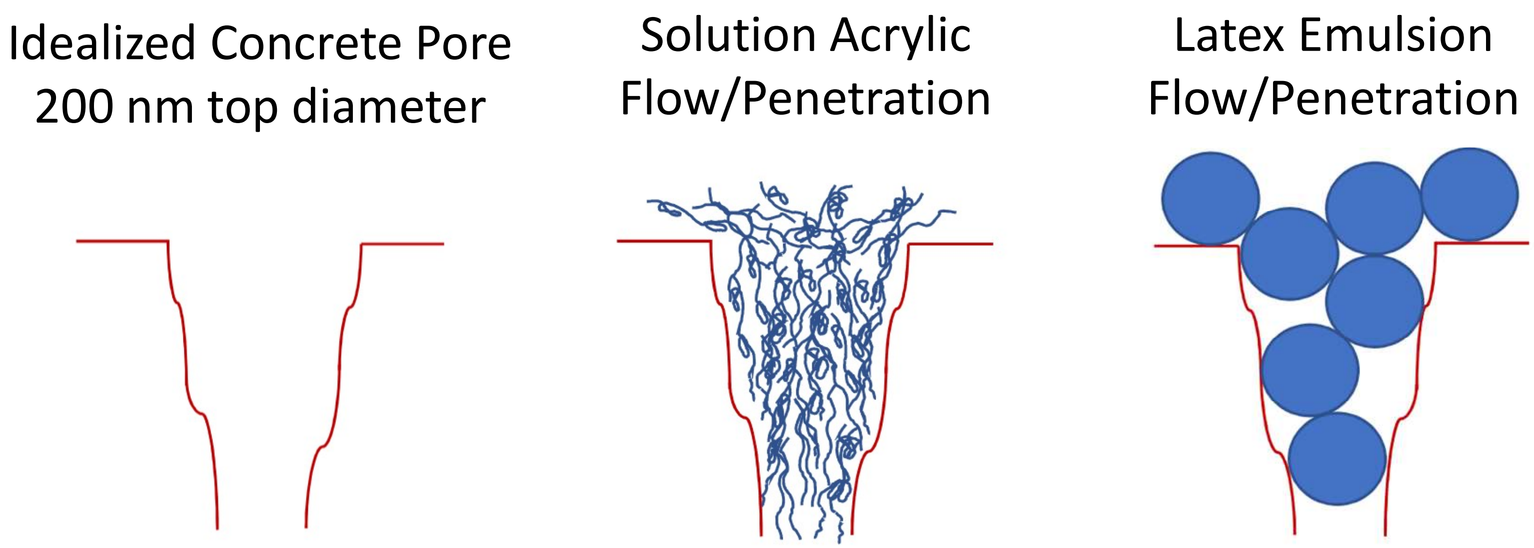
Concrete porosity impacts sealer performance

Concrete Porosity

- Capillary and contraction pores occur in formed concrete and range in diameter from 10-1000 nanometers
- Capillary porosity may be reduced from lower water/cement ratio or use of plasticizers in concrete mix
- Pores in the 100-400 nm range are quite common but pose an interesting challenge for latex particle flow

VINAVIL
YOUR PARTNER IN POLYMERS

Concrete porosity impacts sealer performance



- Solution acrylic flows deeply into small pores; densely packed polymer.
- Latex emulsion particle flow constrained; gaps in polymer packing.

Concrete finishing effects tend to close surface pores and reduce penetration potential for sealers

- Stamping of textures
- Grinding and polishing to achieve terrazzo-style appearance
- Abrasive blasting to remove concrete to a sufficient depth to expose aggregate

Terrazo style finish

Stamped Concrete

Concrete composition and design play a role in performance of sealed concrete

- Summary of the role of concrete composition
  - Composition and curing conditions of concrete impact its inherent water permeability
  - Sealers used on higher permeability concrete will experience a larger challenge from moisture transmission below and through the substrate

Tip: Consider evaluating sealer performance on both high permeability and low permeability concretes

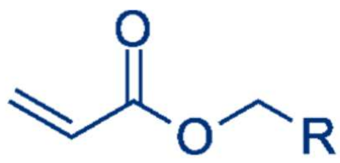
VINAVIL
YOUR PARTNER IN POLYMERS

Polymer and Latex Design Attributes

Polymer and Latex Design Attributes: Monomer Composition

- Hydrophobic monomer characteristics
  - Monomers with longer chain or bulky R groups yield more hydrophobic polymer films
  - Strong hydrophobicity helps prevent water retention penetration into and through the coating film
  - Hydrophobic polymer may trap moisture at the film/concrete surface if sealer formulation does not release moisture – possible water whitening defect

Acrylate monomer



VINAVIL
YOUR PARTNER IN POLYMERS

Polymer and Latex Design Attributes: Monomer Composition

- Polymer hardness
  - Higher T_g polymers
    - Generally acceptable for rigid stable concrete surfaces
    - Difficult to formulate at very low VOC levels
  - Lower T_g polymers provide film flexibility
    - Could flex and blister with high water pressure behind concrete substrate

Polymer and Latex Design Attributes: Crosslinking

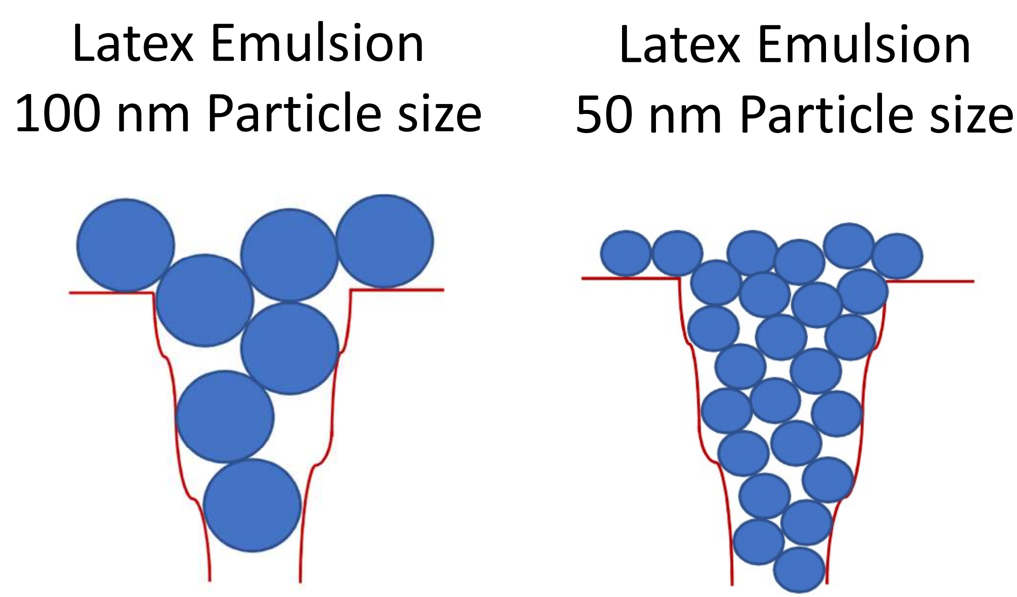
- Crosslinking serves to toughen a concrete sealer film so it can better withstand
  - Exposure to water and chemicals
  - Abrasion from foot traffic
  - Film transfer due to hot tire pickup
- Acrylamide chemistries are often used for self-crosslinking acrylic latex resins

Polymer and Latex Design Attributes: Particle Size

- Emulsion latex polymers come in a variety of particle sizes.
  - Typical average particle size 120-180 nanometers
  - Specialty acrylic latex as small as 30-40 nanometers
- The size variations result in different flow possibilities in porous concrete

VINAVIL®
YOUR PARTNER IN POLYMERS

Polymer and Latex Design Attributes: Particle Size



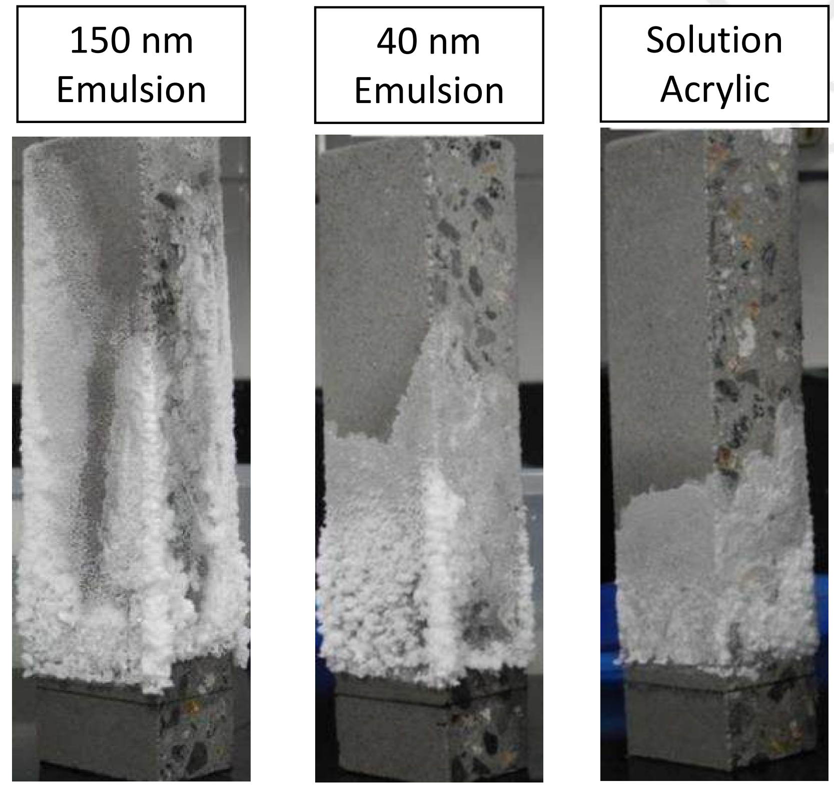
Idealized Concrete Pore, 200 nm top diameter

Reducing particle size by a factor of 2 significantly improves pre-coalescence packing of latex.

VINAVIL
YOUR PARTNER IN POLYMERS

Polymer and Latex Design Attributes: Particle Size

- Particle size affects penetration
- Demonstrated by relative efflorescence performance
  - Acrylic emulsion, M_V 150 nm
  - Nanotechnology acrylic, M_V 40 nm
  - Solvent-based solution acrylic
- Coated masonry blocks with bottom portion placed in saturated salt solution and allowed to stand for 7 days



40 nm emulsion sealer penetrates pores blocking salt migration

Concrete Sealer Performance across varying Acrylic Latex design variables

VINAVIL
YOUR PARTNER IN POLYMERS

Acrylic Latex Design Variables

	A	B	C	D	E	F
Polymer Type	Acrylic	Acrylic	Acrylic	VeoVa™ Copolymer	Acrylic	Acrylic
Self-Crosslinking	Yes	Yes	No	No	Yes	No
Particle Morphology	Standard	Core-Shell	Standard	Standard	Core-shell	Standard
Particle Size	0.1	0.08	0.15	0.15	0.08	0.03
Polymer T_g [°C]	55	26	16	24	-15, >100	15
MFFT [°C]	30	10	14	13	<10	5

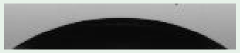
VINAVIL
YOUR PARTNER IN POLYMERS

	Polymer A	Polymers B-F
POLYMER A, 42.5% NV	58.04	-
POLYMER B, 46% NV	-	53.60
WATER	36.92	41.80
ETHYLENE GLYCOL	0	0.7
GLYCOL ETHER DPnB	1.48	1.11
GLYCOL ETHER PPH	0.8	0
BENZOFLEX 50	0.99	0.74
BYK 028	0.2	0.2
BYK 333	0.1	0.1
SURFYNOL 104H	0.9	0.9
AMMONIA, 28% AQ	0.1	0.1
HEUR THICKENER	0.55	0.55
BIT/MIT BIOCIDE	0.2	0.2
TOTAL	100.28	100.00

- All formulations adjusted to 25% solids by Volume
- Polymer A formulation has different coalescent package and more plasticizer to accommodate its higher MFFT.
- Calculated VOC by EPA method 24
  - Polymer A: 97 g/L
  - Polymers B-F: 79-83 g/L

VINAVIL
YOUR PARTNER IN POLYMERS

Water Contact Angle on Polymer Film

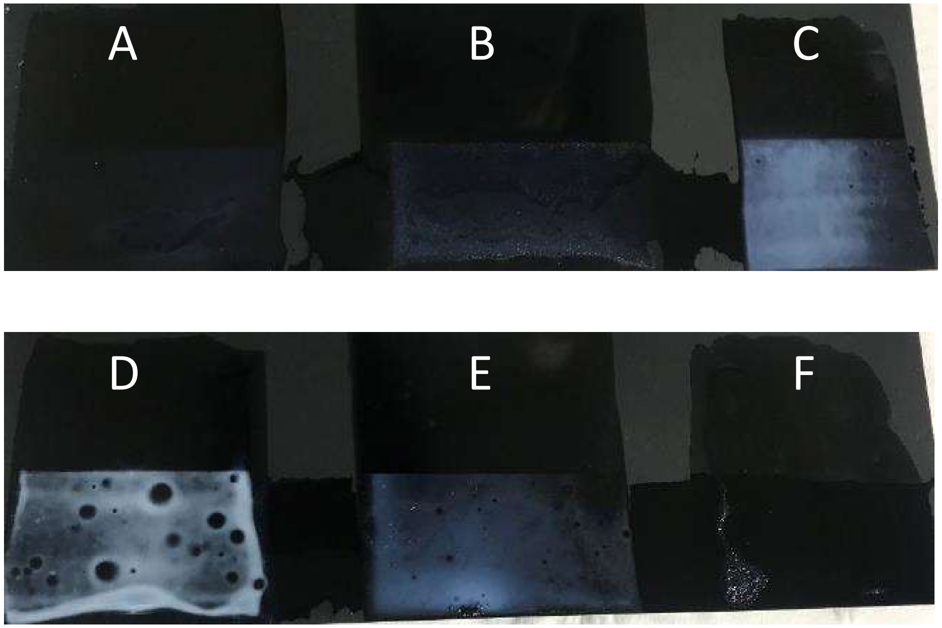
Polymer	Contact Angle	Shape
A	82	
B	64	
C	58	
D	42	
E	86	
F	36	

Films cast from the highest Tg polymers, A and E (hard phase of core-shell), showed the highest contact angle

Early Water Resistance – 2 Hr Dry

<u>Procedure</u>

- 5-mil Bird drawdown on scrub panel
- *2 Hour air dry* at Room Temp
- Water soak for 30 minutes



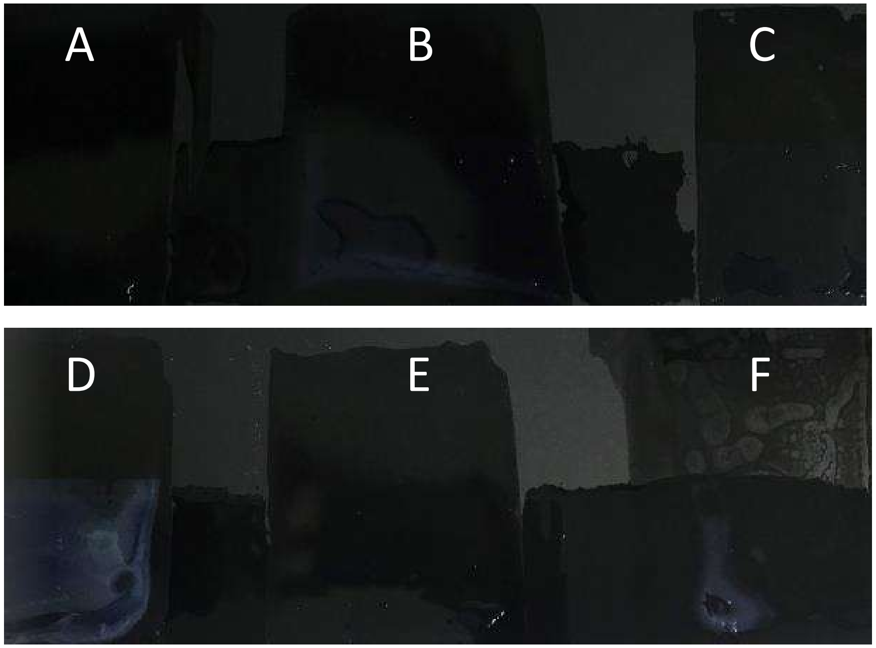
Polymers A and F gave the best overall results for early water resistance.

VINAVIL
YOUR PARTNER IN POLYMERS

Water Resistance – 24 Hr Dry

Procedure

- 5-mil Bird drawdown on scrub panel
- *24 Hour air dry* at Room Temp
- Water soak for 30 minutes



Sealers from polymers B, C, and E recovered for water resistance after curing for 24 hours.

Hardness

- 1.5-2 mils Dry Film on Aluminum
- Polymers A and E show the best hardness potential
- Polymer F had insufficient dry on Al panel for pendulum hardness test

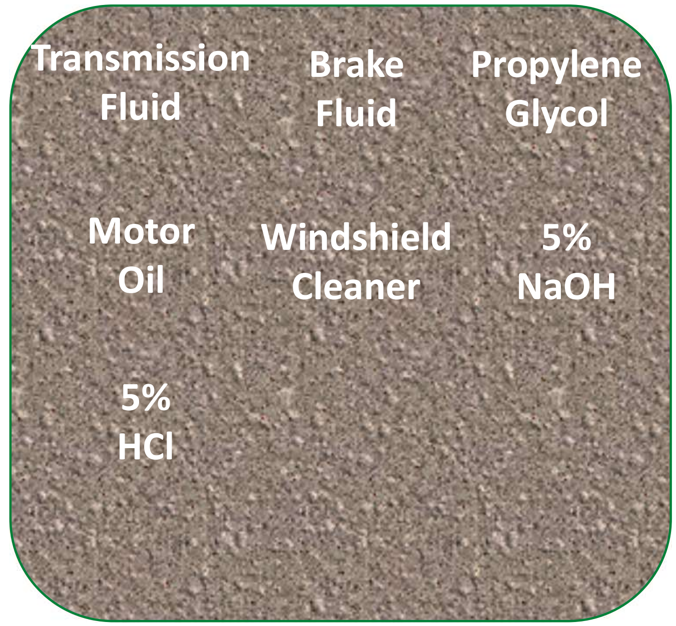
Polymer	Pencil Hardness 7-Day	Konig Pendulum
A	H	21
B	<7B	8
C	<7B	3
D	<7B	5
E	B	32
F	3B	n/a

Chemical Resistance

<u>Procedure</u>

- Apply 2 sealer coats on concrete
- 7-Day Dry at room temp
- 6-hr covered chemical spot test
- Observe staining over time

Test Layout



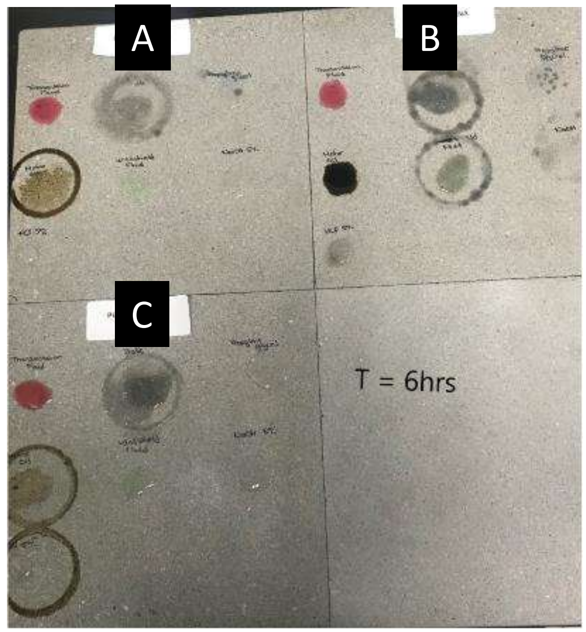
VINAVIL YOUR PARTNER IN POLYMERS

Chemical Resistance

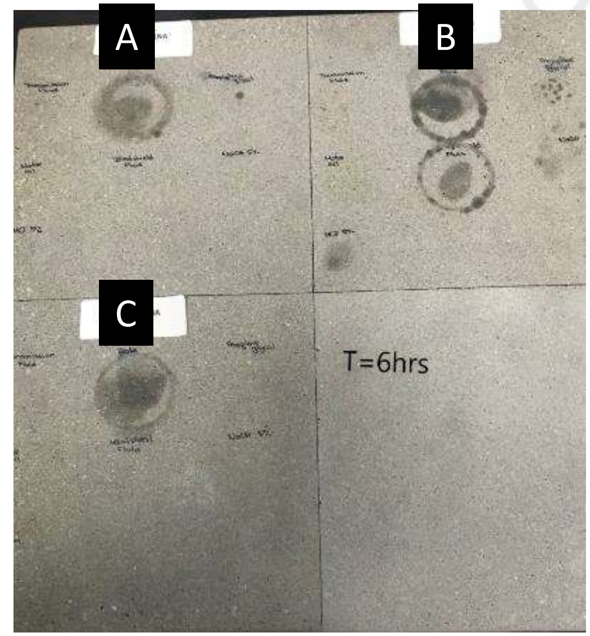
Procedure

- Apply 2 coats on concrete
- 7-Day Dry at room temp
- 6-hr covered chemical spot test

Before Wiping



After Wiping



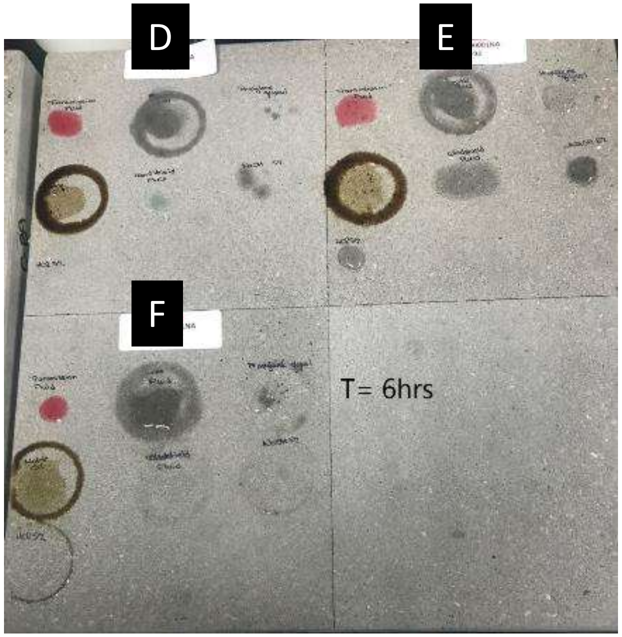
VINAVIL
YOUR PARTNER IN POLYMERS

Chemical Resistance

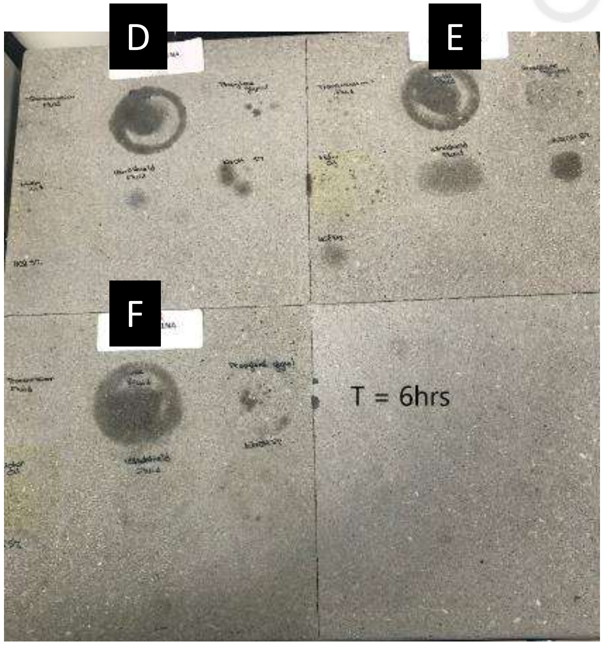
Procedure

- Apply 2 coats on concrete
- 7-Day Dry at room temp
- 6-hr covered chemical spot test

Before Wiping



After Wiping



VINAVIL
YOUR PARTNER IN POLYMERS

Chemical Resistance

Time when stain remains after wiping

Polymer	Transmission fluid	Brake fluid	Propylene glycol	Dirty motor oil	Windshield washer	NaOH 5%	HCl 5%
A		1 - 2 hrs	2 hrs				
B		15 min	1 hr		1 hr	15 min	15 min
C		1 hr					
D		15 min	2 hrs		2 hrs	1 hr	
E	6 hrs	15 min	2 hrs	6 hrs	15 min	15 min	15 min
F		15 min	1 hr		15 min	1 hr	1 hr

Polymers A and C gave the best overall results for chemical resistance.

VINAVIL®
YOUR PARTNER IN POLYMERS

Achieving strongest concrete sealer performance driven in part by varying acrylic latex design

- Results Summary
  - Polymer A, a harder self-crosslinking acrylic polymer, gave strong performance in basic concrete sealer tests in 100 g/L formulation
  - Traditional acrylic latex such as Polymer C, gave a soft finish but otherwise performed well
  - There was no conclusive advantage to using small particle size or core-shell morphology latex as a sole binder for concrete sealer
- Coalescent optimization and particle size blend approaches should be evaluated to determine best potential performance for each individual binder

Enhancing Concrete Sealer Performance using Novel Self-Crosslinking Acrylic

VINAVIL®
YOUR PARTNER IN POLYMERS

Self-Crosslinking Acrylic for Concrete Sealer

Emulsion for horizontal and vertical sealers/coatings for concrete and masonry applications. Highly versatile for formulating clear, tinted and opaque coatings for interior and exterior applications

Substrates	Key Benefits
Concrete, masonry	▪ Nanoparticle, pure acrylic, self-crosslinking emulsion ▪ Excellent early water resistance and blush resistance ▪ Superior abrasion resistance and scrub resistance ▪ Excellent chemical resistance and hot-tire resistance

VINAVIL®
YOUR PARTNER IN POLYMERS

Wet-Look Formulation

Raw Materials	lbs/100gal
Acrylic (42.5% NV)	555.00
Water	251.78
Glycol Ether PPH	22.00
Non-VOC Coalescent	15.6
Defoamer	2.00
Surfactant / Surface Wetting	4.00
Ammonia	0.85
Associative Thickener	2.00
Surfactant/Surface Tension Reducer	1.00
Mildewcide	1.5
BIT – Aqueous Biocide	1.5
Total	857.23
% solid Vol	24.6
% Solid WT	22.9

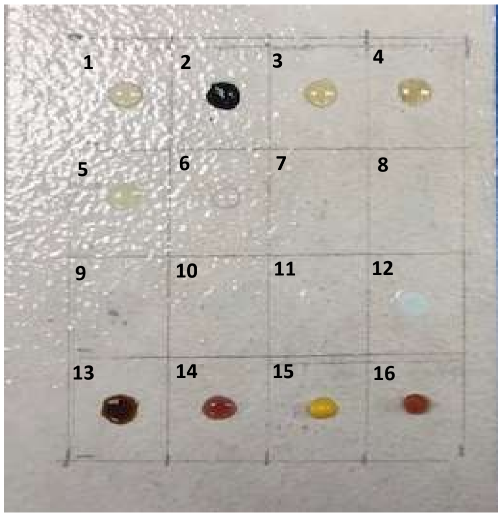
- Vinavil Acrylic in Wet-Look formulation compared to a National Brand commercial water-based wet look sealer
- Vinavil Sealer Drawdown Gloss
  - 20° - 68
  - 60° - 85

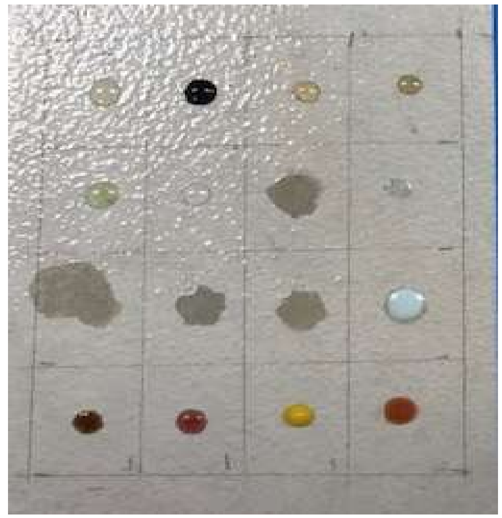
VINAVIL
YOUR PARTNER IN POLYMERS

Chemical Stain Resistance (ASTM D1308)

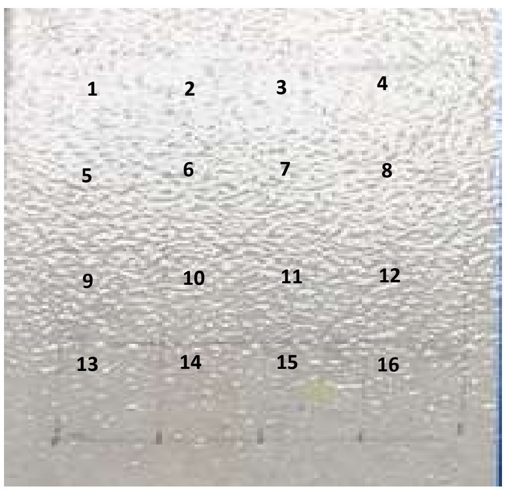
Vinavil Concrete Sealer | Commercial Wet-Look

Chemicals Applied





Chemicals Removed – 1 Hour Recovery



	Chemicals Used
1	New Motor Oil
2	Used Motor Oil
3	Brake Fluid
4	Gasoline
5	Antifreeze
6	Mneral Oil
7	Rubbing Alcohol
8	Nail Polish Remover
9	Fantastik
10	Windex
11	Formula 409
12	15% Bleach Solution
13	Hot Coffee
14	Red Wine
15	Mustard
16	Ketchup
	Total out of 160

Chemical Stain Resistance (ASTM D1308)

Chemical Resistance	Stain #	Chemical	Vinavil	Commercial Wet Look Sealer
Automotive Chemicals	1	New Motor Oil	10	10
	2	Used Motor Oil	10	9
	3	Brake Fluid	10	9
	4	Gasoline	10	10
	5	Antifreeze	10	10
Household Chemicals	6	Mneral Oil	10	10
	7	Rubbing Alcohol	10	9
	8	Nail Polish Remover	10	10
	9	Fantastik	9	7
	10	Windex	10	10
	11	Formula 409	10	10
	12	15% Bleach Solution	10	8
	13	Hot Coffee	8	8
	14	Red Wine	10	10
	15	Mustard	8	8
	16	Ketchup	10	10
		Total out of 160	155	148

Film Changes or Defects	Fail (0) and Pass (2)
Film Degradation/Loss of Adhesion	2
Discoloration	2
Gloss Change	2
Film Softening	2
Swelling/Blistering	2
Total Score:	**10**

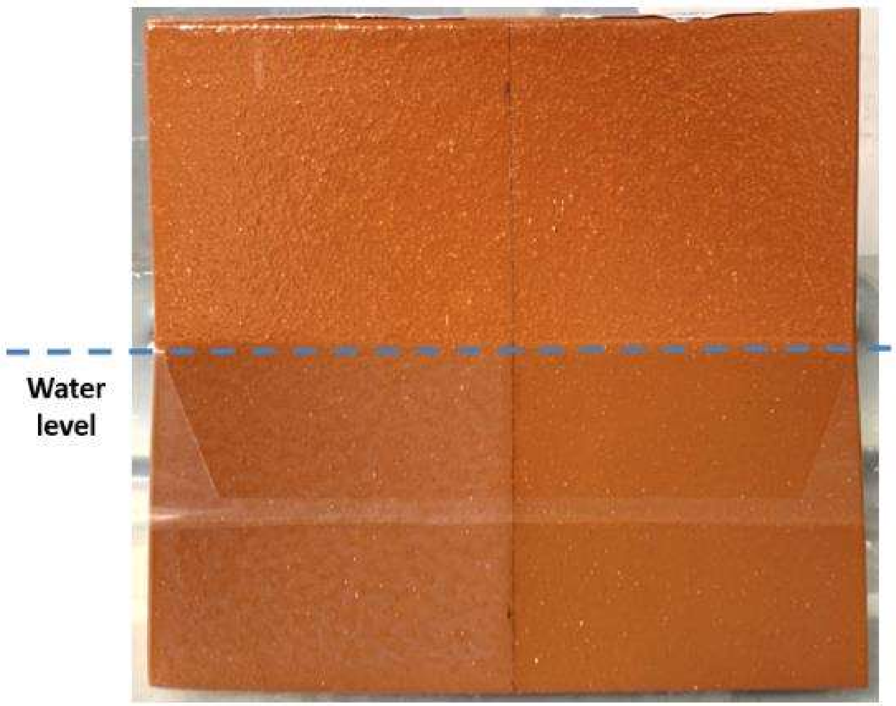
Strong film toughness delivered by Vinavil self-crosslinking acrylic

VINAVIL
YOUR PARTNER IN POLYMERS

Clear Sealer Blush Resistance on Quarry Tile

2 Hours submerged underwater

Vinavil Concrete Sealer | Commercial Wet-Look



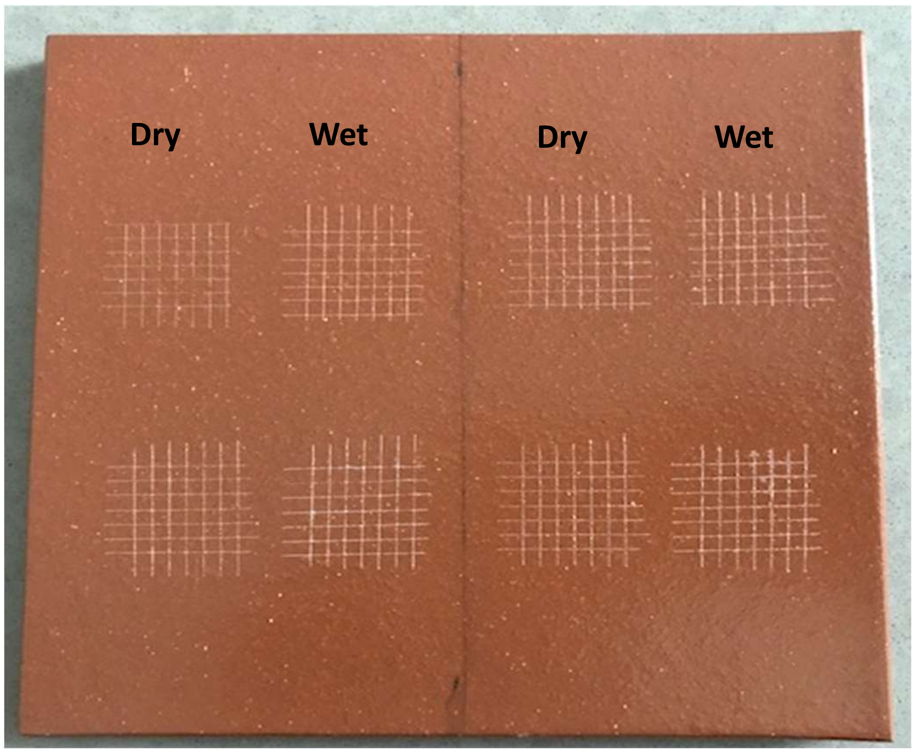
Good blush resistance of both systems in water submersion test. No significant discoloration or whitening observed.

Adhesion on Quarry Tile – Clear Sealer

Vinavil Concrete Sealer | Commercial Wet-Look

ON

7 Day



Both Vinavil polymer and the commercial wet-look sealer have desirable adhesion characteristics in dry or wet environments.

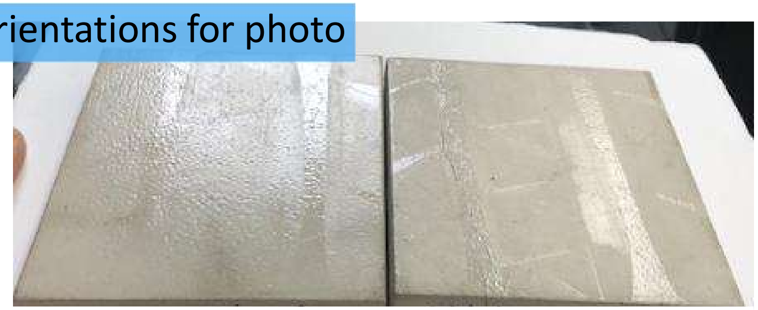
VINAVIL
YOUR PARTNER IN POLYMERS

Clear Sealer – Hot Tire Pickup Test

Hot Tire Pick up		Vinavil Sealer	Commercial Wet Look
Coating Pick up	**1-10 (10 coating fully intact, 0 Complete failure)**	10	10
Coating Compression	**1-10 (10 no compression, 1 Extreme compression)**	8	6
Coating Black Mark	**1-10 (10 No black mark, 1 very dark black mark)**	9	8
Gloss Loss		Slight	Significant

Same tiles, 2 orientations for photo

Vinavil Concrete Sealer Commercial Wet Look



Vinavil Concrete Sealer Commercial Wet Look

Tire Condition: Tire Set in the water bath in the 140°F oven for 1 hour

Pressure Duration: 2 hours at room temperature

PSI: 150

Concrete Sealer Comparison Summary

Property	Vinavil Concrete Sealer	Commercial Wet Look
Gloss “Wet-Look” appearance	=	=
Chemical Resistance	Slight +	=
Blush Resistance/Whitening: 2 Hour submersion	=	=
Adhesion	=	=
Hot Tire Pickup	+	=

Vinavil self-crosslinking acrylic emulsion polymer example gives strong performance for wet-look sealer and possibility for tough applications such as garage floor coatings.

VINAVIL
YOUR PARTNER IN POLYMERS

Summary and Conclusion

- Concrete Quality and Composition
  - Decorative concrete sealers must be versatile for use over a range of concrete compositions with varying permeability and porosity
  - Nano-particle size acrylic emulsions are capable to form a dense polymer network by packing into concrete pores

VINAVIL® YOUR PARTNER IN POLYMERS

Summary and Conclusion

High performance acrylic latex emulsions are capable to formulate low VOC decorative concrete sealers that

- provide tough protective films
- display desirable appearance
- demonstrate long term durability

- New Self-Crosslinking Acrylic technology delivers strong performance for both water-based concrete sealers and floor coatings

VINAVIL®
YOUR PARTNER IN POLYMERS

References

- Kosmatka, Steven H. et al. *Design and Control of Concrete Mixtures*, 14th Edition. Portland Cement Association, 2002.
- Tepfers, R. "Concrete technology – porosity is decisive," ibidem-Verlag, Befestigungstechnik, Bewehrungstechnik und ...II. Stuttgart 2012. ISBN-13: 978-3-8382-0397-3. pp. 571-575.
- Jennings, H, et al. "Cements as Porous Materials," *Handbook of Porous Solids*, Chapter 6.11. Wiley, 2002. Online ISBN: 9783527618286.

Questions?

VINAVIL
YOUR PARTNER IN POLYMERS