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Replacing PFAS in Waterbased Floor Care Coatings

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WOOD C&S

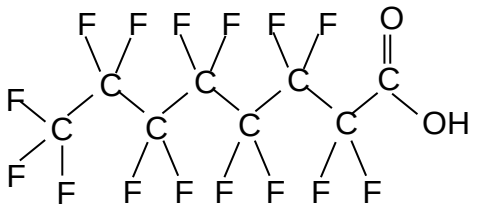
PFOA FREE

Agenda

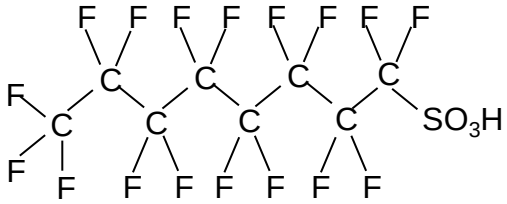
- Concerns around fluorosurfactants (PFAS)
- The challenge of replacing PFAS
- How PFAS are used in floor care coatings
- Methodology for replacing PFAS in floor care coatings
- Results
- Summary
- Conclusion

Concerns around fluorosurfactants

- What do we mean by “fluorosurfactants”
  - PFAS – Perfluoro Alkyl Substances *and* Polyfluorinated Alkyl Substances
    - PFOA – Perfluorinated Octanoic Acid



    - PFOS – Perfluorooctane Sulfonate



- Fluorosurfactants are becoming increasingly scrutinized from a regulatory perspective
  - Persistency: exceedingly long time duration for decay
  - Potential health effects
    - EPA has issued health advisory for PFAS (4parts per trillion)

The challenge of replacing PFAS

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The challenge of replacing PFAS

Surfactant Performance Comparison

Properties	Polysilioxane	Polyacrylate	Fluorocarbon-Modified Polyacrylate
Slip	Very high	None	None
Leveling	Excellent	Good	Good
Flow	Good	Excellent	Excellent
Surface tension reduction	Excellent	Moderate	Excellent
Anti Crater	Excellent	Little	Excellent
Anti fish eye	Good	Average	Excellent
Substrate wetting	Good	Average	Excellent
Anti Bernard Cells	Excellent	None	Good
Possibility for Intercoat Adhesion problem	Yes	No	No
Foam stabilization	High possibility	No	Low

- **Fluorosurfactants perform well in a multitude of areas!!**
- **No other class of chemicals has the same breadth of performance.**
- **Replacing a Fluorosurfactant can be very challenging!**

PFAS Replacement Strategy:

Target performance aspect it provides to a formulation!

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How PFAS are used in floor care coatings

Background & History

- Floor care coatings
  - Very low solids, low viscosity, temporary waterbased coatings
  - Used to coat VCT in institutional settings (hospitals, schools, commercial arenas, etc.)
  - Provide good appearance feature
  - Relatively easy maintenance: periodic strip and recoat to refresh surface
- Fluorosurfactants (PFAS) used exclusively
  - Used to address flow and leveling issues – enable good appearance

Key Performance Feature

    - High efficiency – low dosing levels
    - Provide excellent flow and leveling performance
    - No slip component (safety)
  - Other surfactants were not considered due to performance and efficiency of fluorosurfactants

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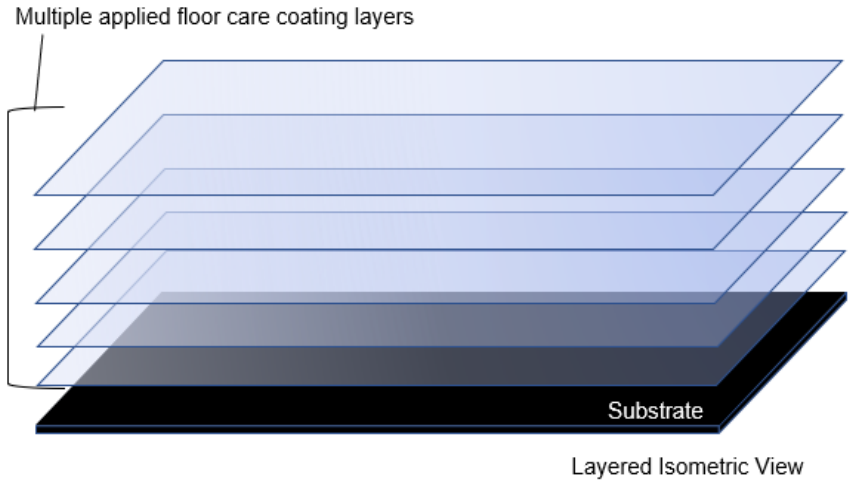
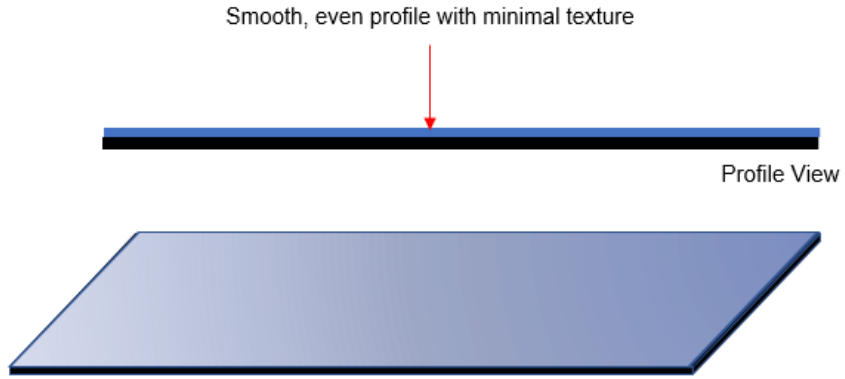
Floor Care Coating Application

Ideal



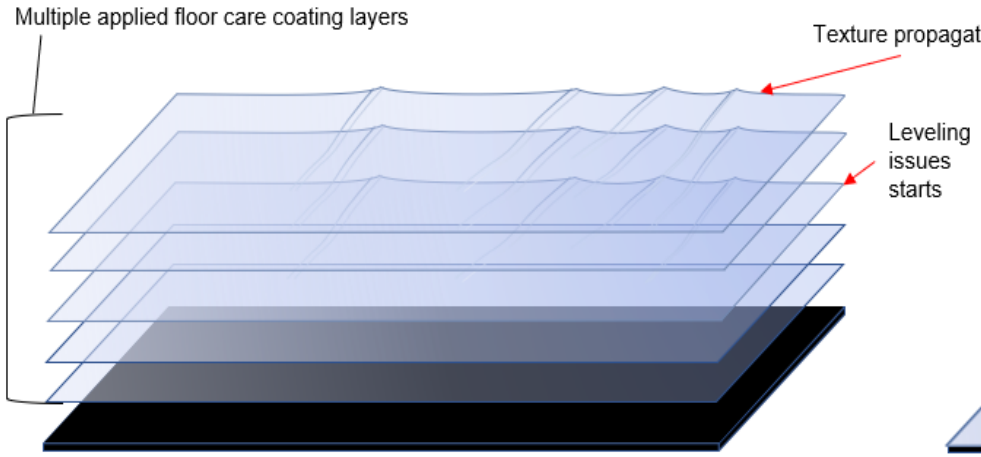
Layered Isometric View



Full Coating Isometric View

Good Flow and Leveling

Reality



Layered Isometric View

Full Coating Isometric View

Poor Flow and Leveling

Fluorosurfactants (PFAS) are used to mitigate/minimize leveling issues

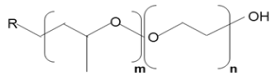
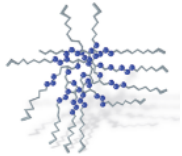
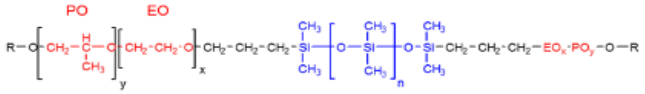
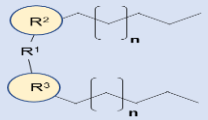
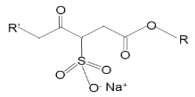
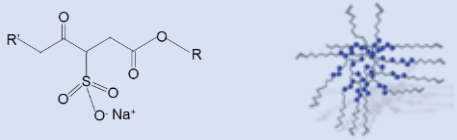
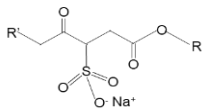
Methodology for replacing PFAS in floor care coatings

- Select a variety of non PFAS surfactants for testing
- Test surfactant candidates in Standard WB Floor Care Rx
  - Dynamic Surface Tension Screen
- Test best performers on VCT tile application
  - Visual assessment
  - Gloss measurement
  - Select floor care tests
- Conduct additional rounds of optimization
  - Surfactant concentration
  - Explore
    - Additional application method
    - Additional substrate

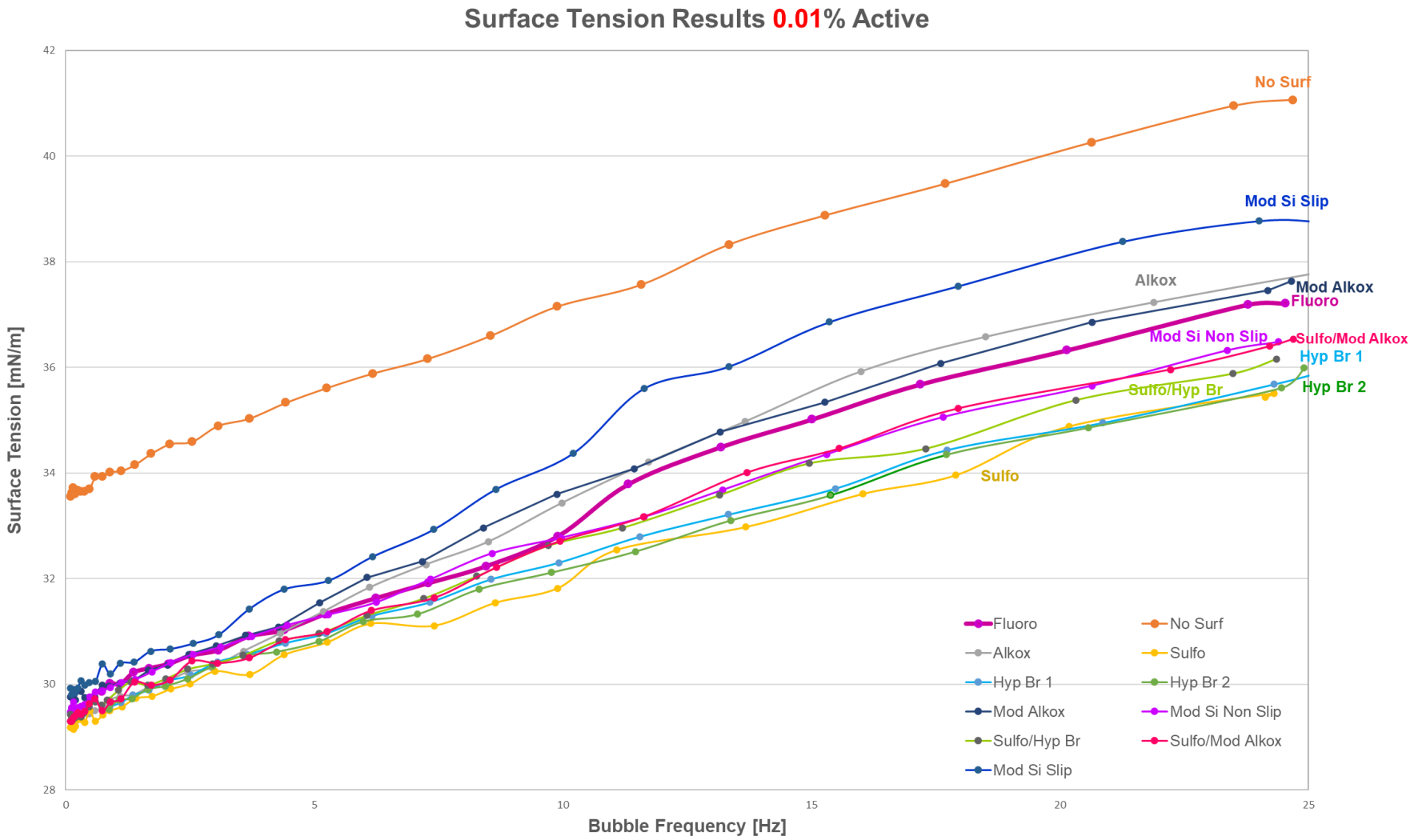
Standard WB Floor Care Rx		
Materials	**% Wt.**	**Function**
Water	35.23	Carrier liquid
Fluorosurfactant (1% active solution)	1.07	Surfactant for flow and leveling
Diethylene Glycol Ethyl Ether (DE)	6.47	Coalescent and evaporation control
2,2,4-Trimethyl-1,3-Pentanediol Diisobutyrate (TXIB)	1.65	Plasticizer
Tributoxy Ethyl Phosphate (TBEP)	2.80	Plasticizer
Resin	**46.59**	Polymer (Primary film properties)
Wax	6.18	Adjust COF
Defoamer	0.01	Eliminate/minimize bubbles/defects
Totals	100.00	

Solids	~25% by Wt.
Density	8.57 lb/US Gal (calculated)
Polymer/ASR/Wax	93/0/7

Alternative non PFAS surfactant technologies examined

Chemistry	General Structure	Value
Alkoxylate		Low foaming; excellent dynamic surface tension reduction
Modified Alkoxylate	Proprietary Composition	Anti-foam, wetting and leveling agent
Hyperbranched Polymer 1		Anti-foam, wetting and leveling agent; higher hydrophobic content
Hyperbranched Polymer 2		Anti-foam, wetting and leveling agent
Modified Silicone 1 (no slip)	Proprietary Composition	Anti-foam, wetting agent; excellent compatibility; no slip
Modified Silicone 2 (slip)		Excellent wetting, flow, leveling with low surface energy (slip, anti-mar)
Gemini Surfactant		Anti-foam, wetting and leveling agent
Sulfosuccinate		High efficiency wetting agent; excellent dynamic surface tension reduction
Sulfosuccinate / Hyperbranched Polymer Blend		Excellent dynamic surface tension reduction with anti-foam
Sulfosuccinate / Mod. Alkoxylate◆ Blend	 ◆ Proprietary Composition	Excellent dynamic surface tension reduction with anti-foam

Results: Dynamic Surface Tension Comparisons



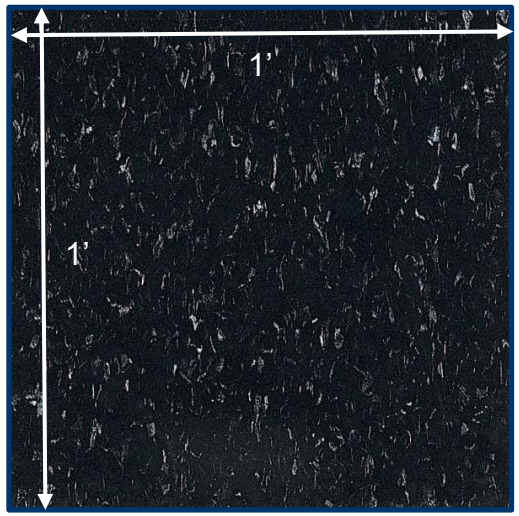
Surfactant type	Dosing level to meet surface tension criteria
Alkoxylate	High
Modified Alkoxylate	Mid, High
Hyperbranched Polymer 1	Low
Hyperbranched Polymer 2	Low
Modified Silicone 1 (no slip)	**Low, Mid, High**
Modified Silicone 2 (slip)	Mid
Sulfosuccinate	**Low, Mid, High**
Sulfosuccinate / Hyperbranched	Low, High
Sulfosuccinate / Mod.	**Low, Mid, High**

Objective: Surfactants which can provide similar or better surface tension suppression vs fluorosurfactant control

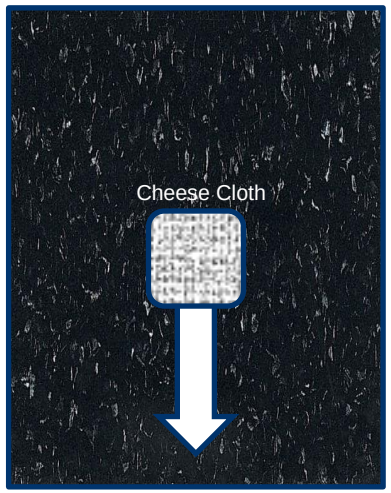
Floor Care Coating Application

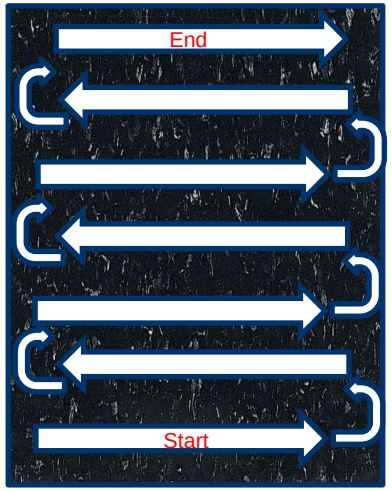
Testing for Flow and Leveling Assessment / Comparison

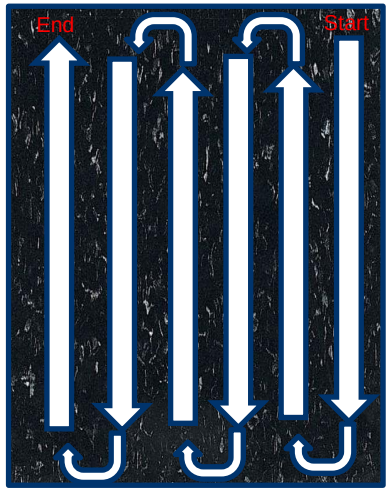
- Cheese cloth method for applying floor care coating formulations:
  - Cheese cloth:
    - 100% pure cotton, reagent grade
      - Certified: USP and Federal Specification CCC-G-101c
      - Mesh size 10: 20 x 12 Vertical × horizontal threads per inch
    - 2” x 2” swatch folded over twice
    - Saturated with coating solution
      - For ½ of a 1’ x 1’ VCT tile, use 3 ml of solution
  - Application methodology:
    - Apply with saturated cheese cloth on center of tile area
    - Follow given application pattern

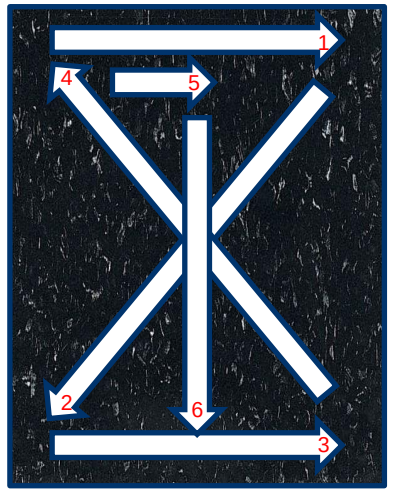


VCT:
Armstrong® Standard Excelon®
Imperial Texture 51910021
C132B







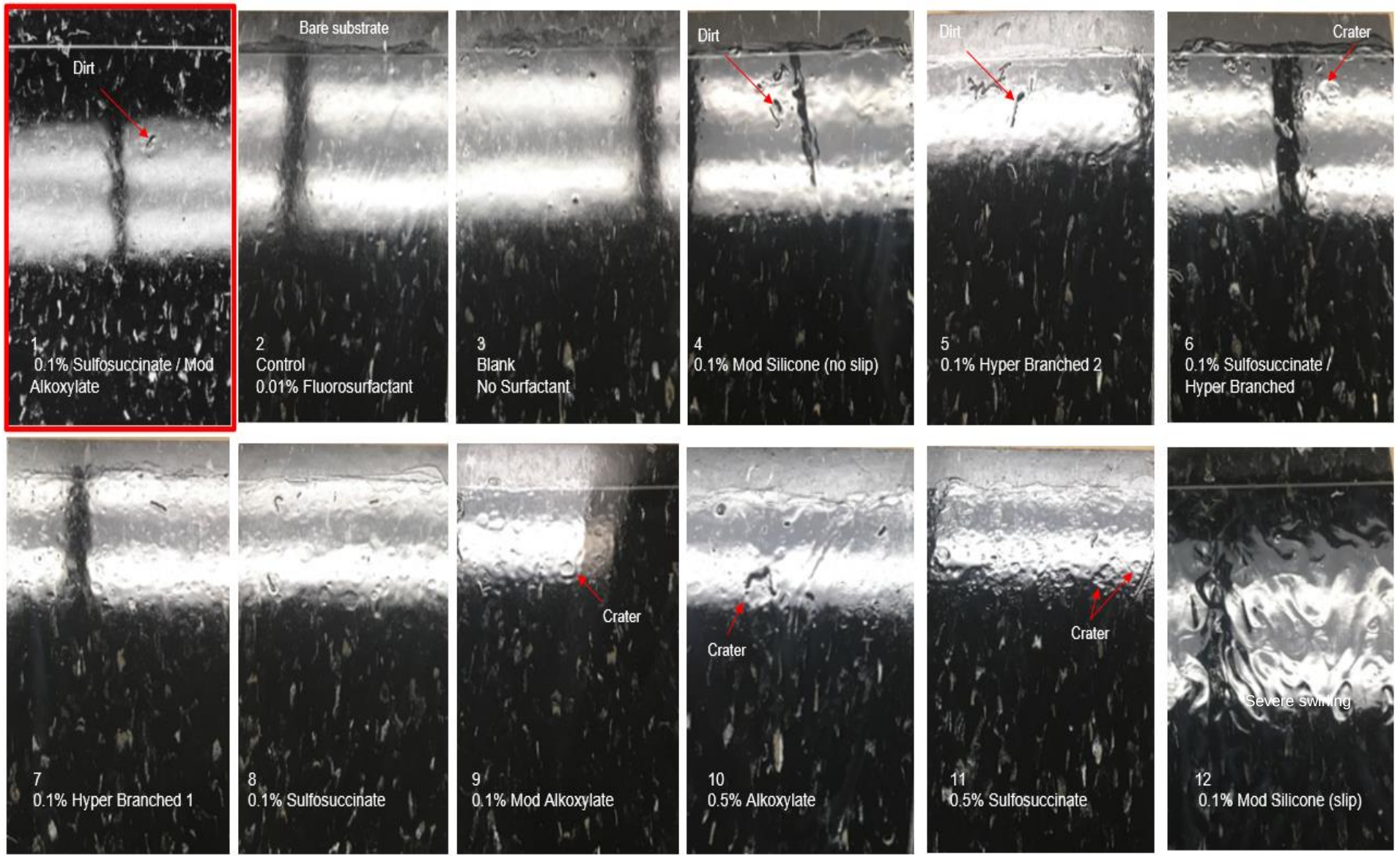


Note: application on ½ of VCT tile

Results: VCT Tile Application @ 5 coats with Cheesecloth

Initial Tests

VCT: Armstrong®
Standard Excelon®
Imperial Texture
51910021 C132B

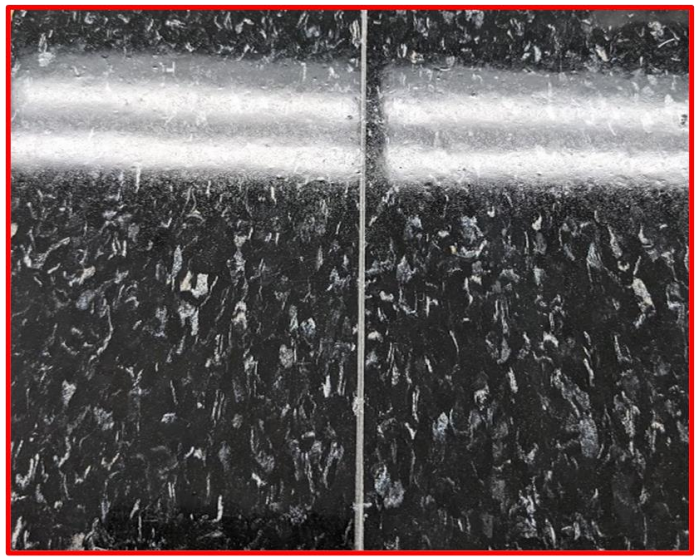


Results: VCT Tile Application @ 5 coats with Cheese Cloth

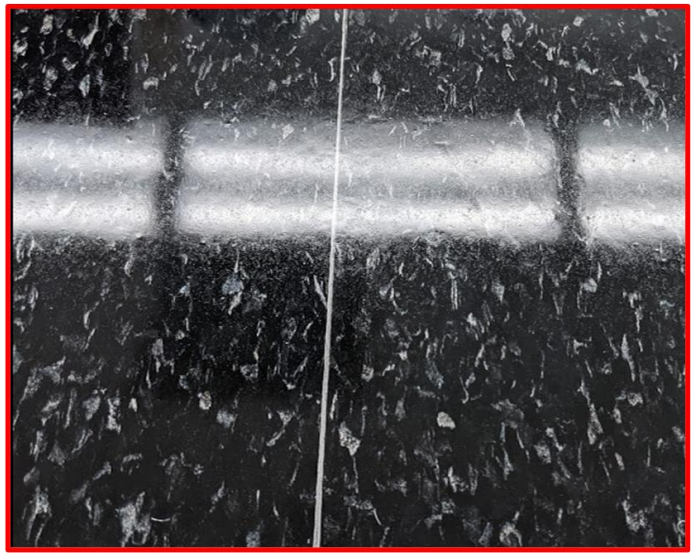
Best Candidates after optimization

VCT: Armstrong®
Standard Excelon®
Imperial Texture
51910021 C132B

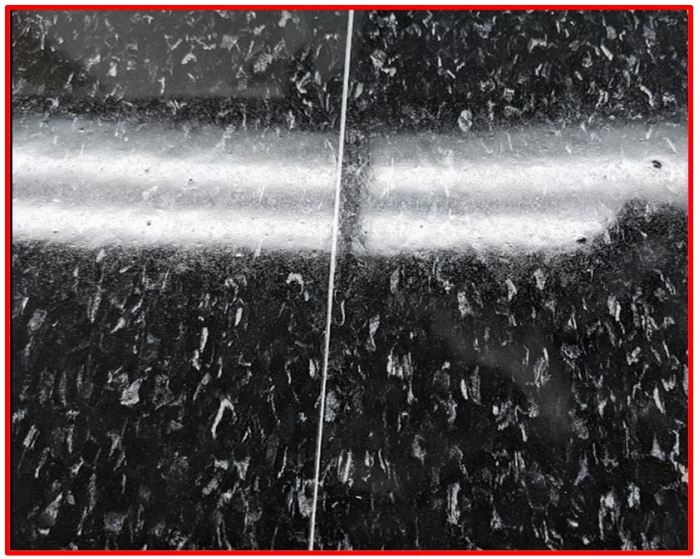
0.01% Fluorosurfactant Control



0.05% Hyper Branched 2



0.01% Fluorosurfactant Control



0.15% Gemini surfactant

0.01% Fluorosurfactant Control

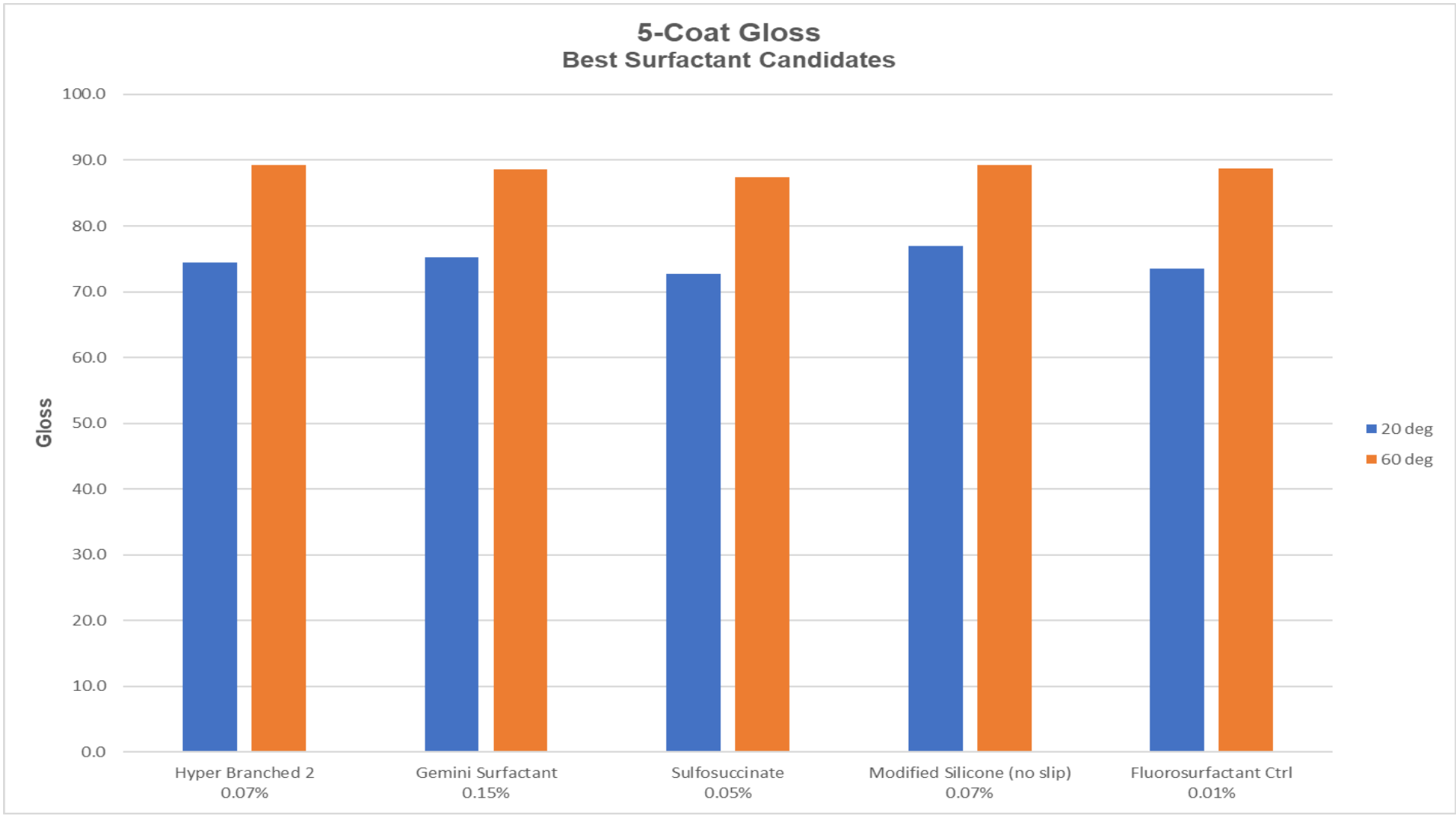
0.05% Sulfosuccinate

0.01% Fluorosurfactant Control

0.07% Modified Silicone (no slip)

Name	# coat	20 deg		60 deg	
		avg	std	avg	std
Control Fluorosurfactant (0.01%)	1	15.4	1.2	51.1	1.6
	2	43.4	3.8	76.4	1.1
	3	61.9	2.8	85.2	1.0
	4	69.6	2.5	87.0	0.3
	5	73.5	2.9	88.8	0.7
Modified Silicone (no Slip) (0.07%)	1	15.5	1.1	49.6	0.9
	2	42.9	2.3	76.6	1.3
	3	60.4	5.0	85.4	0.7
	4	72.9	1.0	88.3	0.5
	5	76.9	2.3	89.3	0.7
Gemini Surfactant (0.15%)	1	27.3	3.3	64.7	3.3
	2	50.2	4.0	81.1	1.7
	3	60.4	7.9	86.1	0.6
	4	74.4	0.7	88.1	0.4
	5	75.2	0.4	88.6	0.5
Sulfosuccinate (0.05%)	1	17.7	1.2	52.1	1.4
	2	38.4	3.1	75.2	1.3
	3	63.5	6.2	85.2	1.3
	4	62.5	1.4	83.7	0.6
	5	74.7	3.1	88.6	1.0
Hyperbranched 2 (0.05%)	1	15.0	1.2	48.2	2.1
	2	41.8	2.7	76.9	1.7
	3	65.7	4.6	86.1	0.7
	4	64.2	3.1	81.7	2.2
	5	69.7	5.6	85.7	1.3

Results: Gloss Performance of Best Candidates



VCT: Armstrong®
Standard Excelon®
Imperial Texture
51910021 C132B

Best candidates provided similar gloss to fluorosurfactant control

Results: VCT Tile Application @ 5 coats with Fiber Mop

Best Candidates after optimization

VCT: Armstrong®
Standard Excelon®
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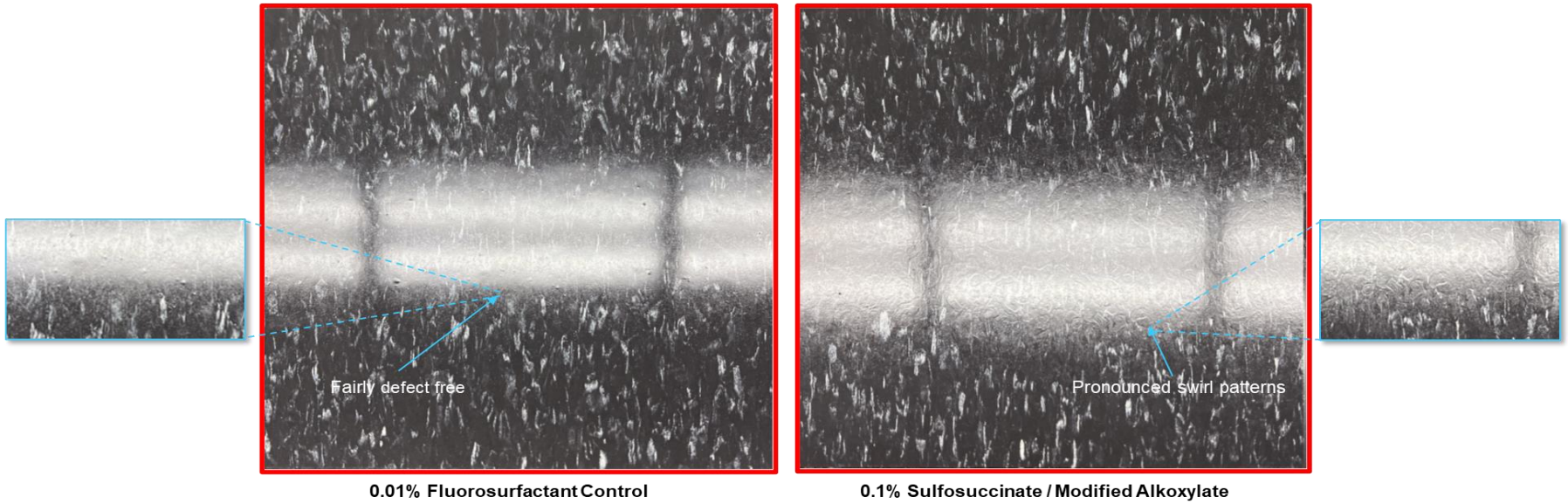
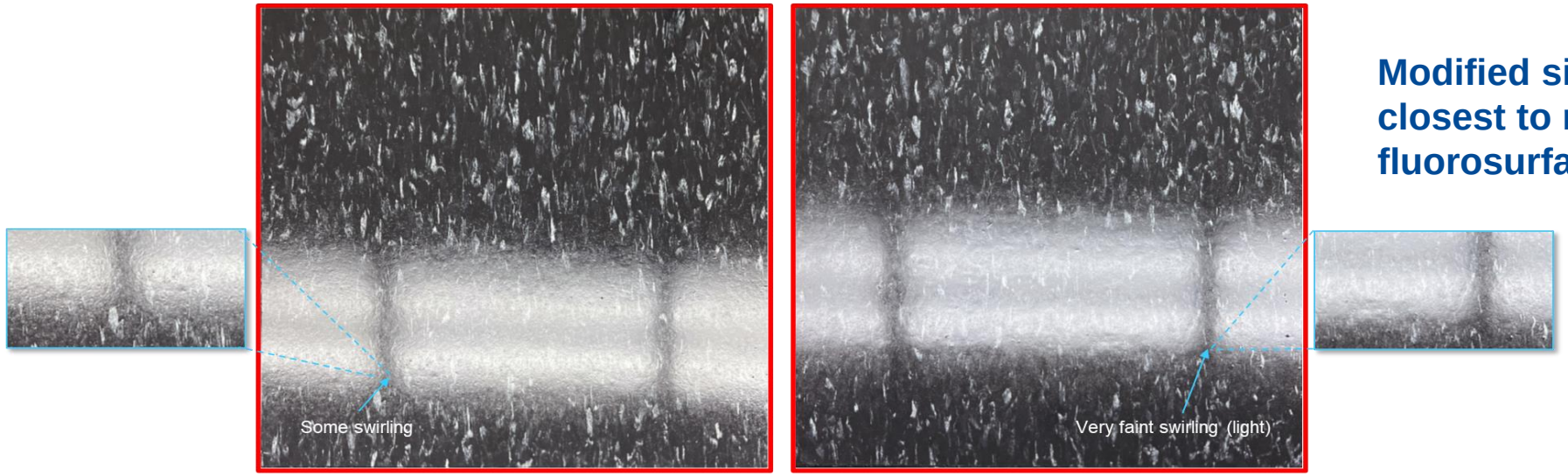
51910021 C132B



0.01% Fluorosurfactant Control

0.1% Sulfosuccinate / Modified Alkoxylate



0.07% Hyper Branched 2

0.07% Modified Silicone (no slip)

Modified silicone came closest to matching fluorosurfactant

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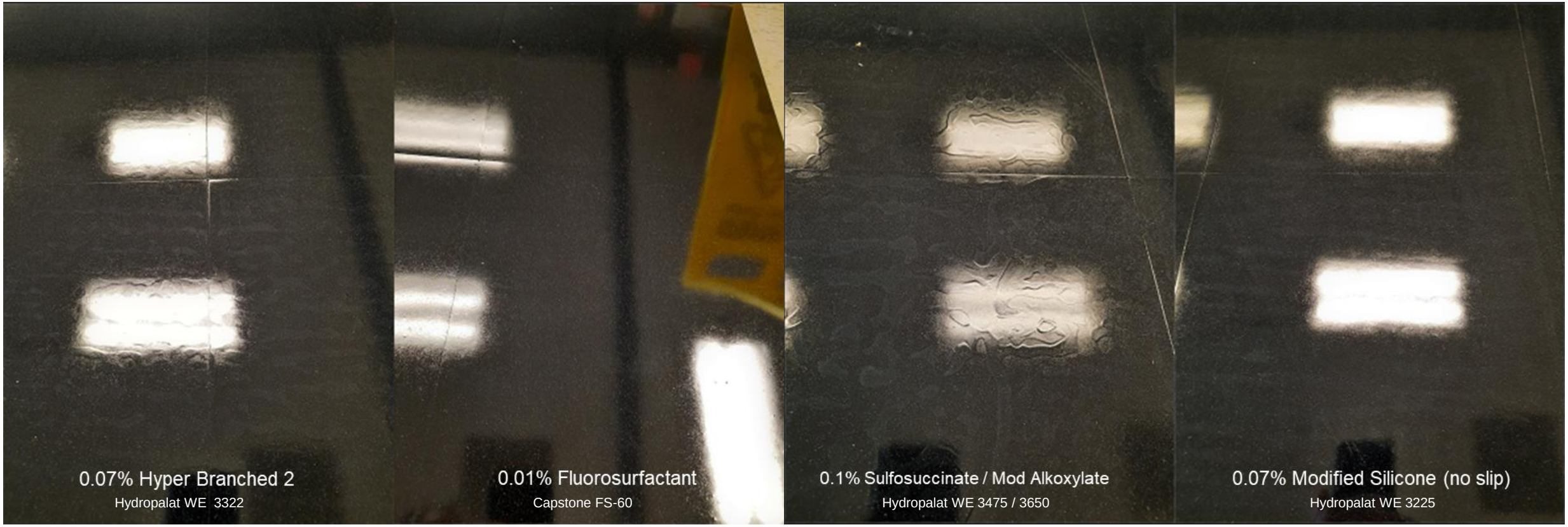
Results: VCT Tile Test Floor Application @ 5 coats with Fiber Mop Best

Candidates after optimization



VCT: Armstrong Premium Excelon® 56790 Black

Performance did not match that of other VCT tile type – Differences in surface treatments on tiles

Modified silicone came closest to matching fluorosurfactant – some faint lap lines

Summary

- A variety of surfactant chemistries tested in a floor care coating application vs fluorosurfactant control
- Best surface tension reduction and stability over a range of concentrations
  - Sulfosuccinates
  - Modified Silicone (no slip)
  - Sulfosuccinate / Modified Alkoxylate
- Best candidates for flow and leveling performance after optimization around concentration
  - Modified Silicone (no slip)
  - Gemini Surfactant*
- Key Learnings
  - Flow and leveling issues tend to occur at some intermediate layer during application
  - VCT tile substate is a factor on performance
  - Application methodology is a factor on performance

Conclusion

- Use of non-fluorinated surfactants in floor care coatings shows promising results
  - Flow and leveling performance approaching that provided by fluorosurfactants at up to 5 coats
  - Proper selection for surface tension reduction and concentration optimization is important
- Future Steps: Additional work to further narrow performance gap (7+ coats)

  Areas of focus:
  - Understanding of controlling mechanism for flow and leveling
  - Formulary approaches to improving flow and leveling performance
  - Development / use of other objective measurements for flow and leveling

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