# *Thank you for signing in early*

The webinar will begin promptly at
12:00 pm ET, 9:00 am PT

SERDP DOD • EPA • DOE | ESTCP

# SERDP and ESTCP Webinar Series

***The webinar will begin promptly at 12:00 pm ET, 9:00 am PT***

- You have two options for accessing the webinar
  1. Listen to the broadcast audio if your computer is equipped with speakers
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     Required conference ID: 6102000
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# "Novel Coatings Systems for Use as High Performance Chemical Resistant Powder Topcoats"

May 4, 2017

SERDP DOD • EPA • DOE | ESTCP

# Welcome and Introductions

Jennifer Nyman, Ph.D., P.E.
Webinar Facilitator

SERDP DOD • EPA • DOE | ESTCP

# Webinar Agenda

- **Webinar Logistics** (5 minutes)

  **Dr. Jennifer Nyman**, Geosyntec Consultants

- **Overview of SERDP and ESTCP** (5 minutes)

  **Dr. Robin Nissan**, SERDP and ESTCP

- **Novel Coatings Systems for Use as High Performance Chemical Resistant Powder Topcoats** (55 minutes + Q&A)

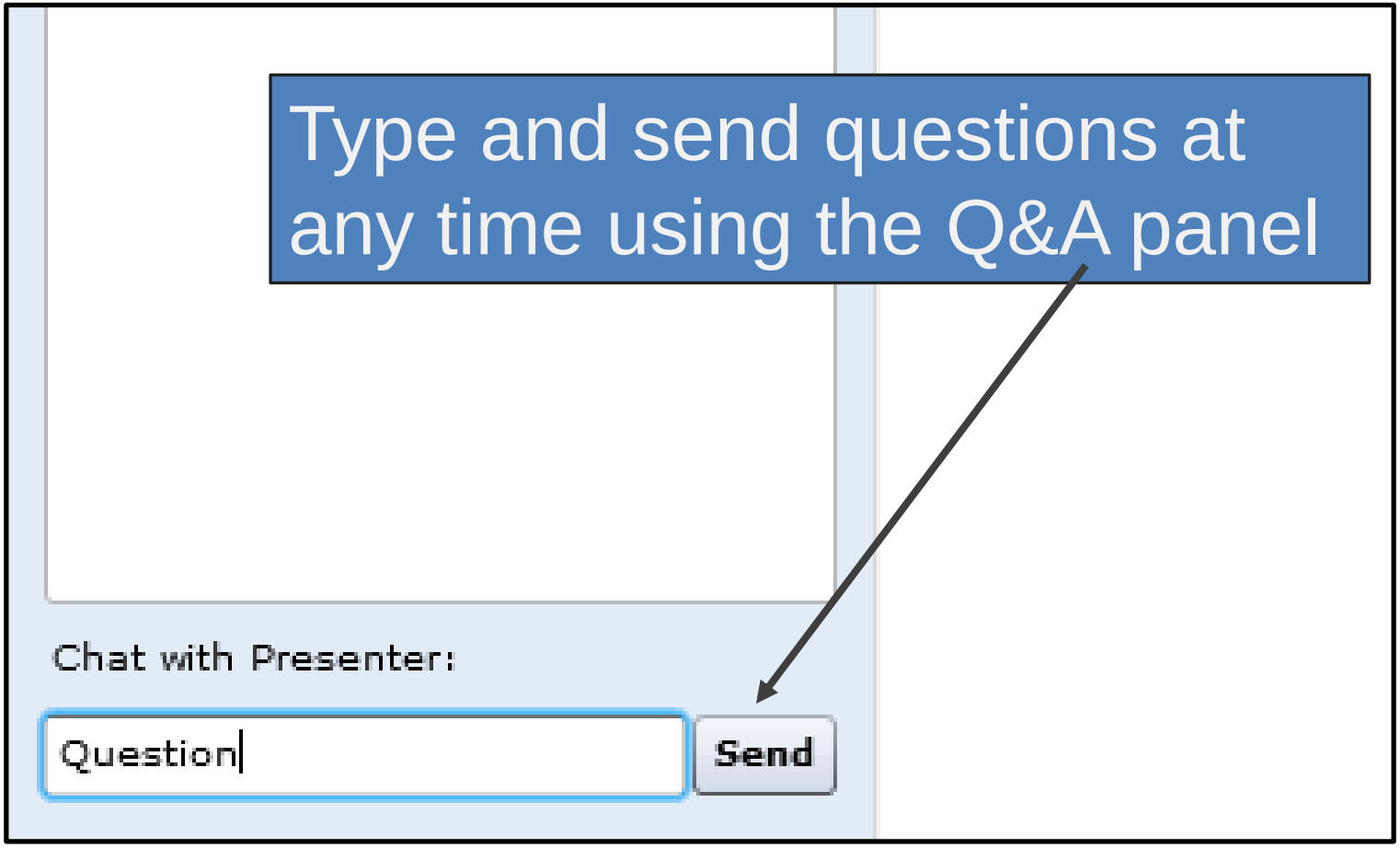
  **Mr. Mark Wytiaz,** The Sherwin-Williams Company

  **Dr. James Wynne,** Naval Research Laboratory

  **Dr. Beth Ann Pearson**, The Sherwin-Williams Company

- **Final Q&A session**

# How to Ask Questions



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- Delays in the broadcast audio
  - Click the mute/connect button
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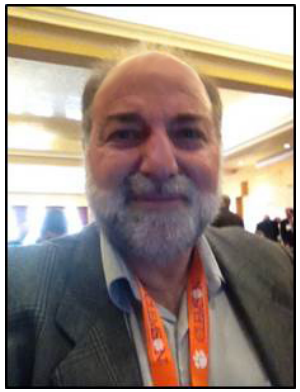
  - If delays continue, call into the conference line
    - Call into the conference line: 303-248-0285
    - Required conference ID: 6102000
- Submit a question using the chat box

# SERDP and ESTCP Overview

Robin Nissan, Ph.D.

SERDP and ESTCP, Weapons Systems and Platforms Program Manager



# SERDP

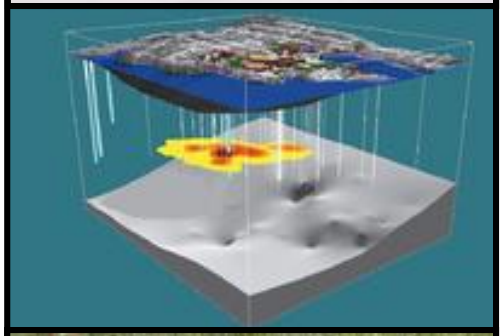
- Strategic Environmental Research and Development Program
- Established by Congress in FY 1991
  - DoD, DOE and EPA partnership
- SERDP is a requirements driven program which identifies high-priority environmental science and technology investment opportunities that address DoD requirements
  - Advanced technology development to address near term needs
  - Fundamental research to impact real world environmental management

# ESTCP

- Environmental Security Technology Certification Program
- Demonstrate innovative cost-effective environmental and energy technologies
  - Capitalize on past investments
  - Transition technology out of the lab
- Promote implementation
  - Facilitate regulatory acceptance

# Program Areas

1. Energy and Water
2. Environmental Restoration
3. Munitions Response
4. Resource Conservation and Resiliency
5. Weapons Systems and Platforms



# Weapons Systems and Platforms

- Major focus areas
  - Surface engineering and structural materials
  - Energetic materials and munitions
  - Noise and emissions
  - Waste reduction and treatment in DoD operations
  - Lead free electronics

# SERDP and ESTCP Webinar Series

| Date | Topic |
|---|---|
| May 18, 2017 | High-Resolution Site Characterization at Chlorinated Solvents Sites |
| June 1, 2017 | Tools for Risk-Based Remediation of Unexploded Ordnance |
| June 15, 2017 | Coupling Geothermal Heat Pumps with Underground Seasonal Thermal Energy Storage |
| June 29, 2017 | Future Vulnerabilities to Alaskan Ecosystems and Tools for Permafrost Assessment |
| July 20, 2017 | Management of Energetic and Propellant Material Releases on Testing and Training Ranges |

**For upcoming webinars, please visit**

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

SERDP DOD • EPA • DOE | ESTCP

# SERDP • ESTCP SYMPOSIUM

2017 | Enhancing DoD's Mission Effectiveness

A three-day symposium showcasing the latest technologies that enhance DoD's mission through improved environmental and energy performance

- November 28 - November 30, 2017
- Washington Hilton Hotel
  1919 Connecticut Avenue, NW
  Washington, DC 20009
- ***Registration is open***

# Novel Coating Systems for Use as High Performance Chemical Resistant Powder Topcoats

Mr. Mark Wytiaz, The Sherwin-Williams Company

Dr. James Wynne, Naval Research Laboratory

Dr. Beth Ann Pearson, The Sherwin-Williams Company

# Presentation Outline

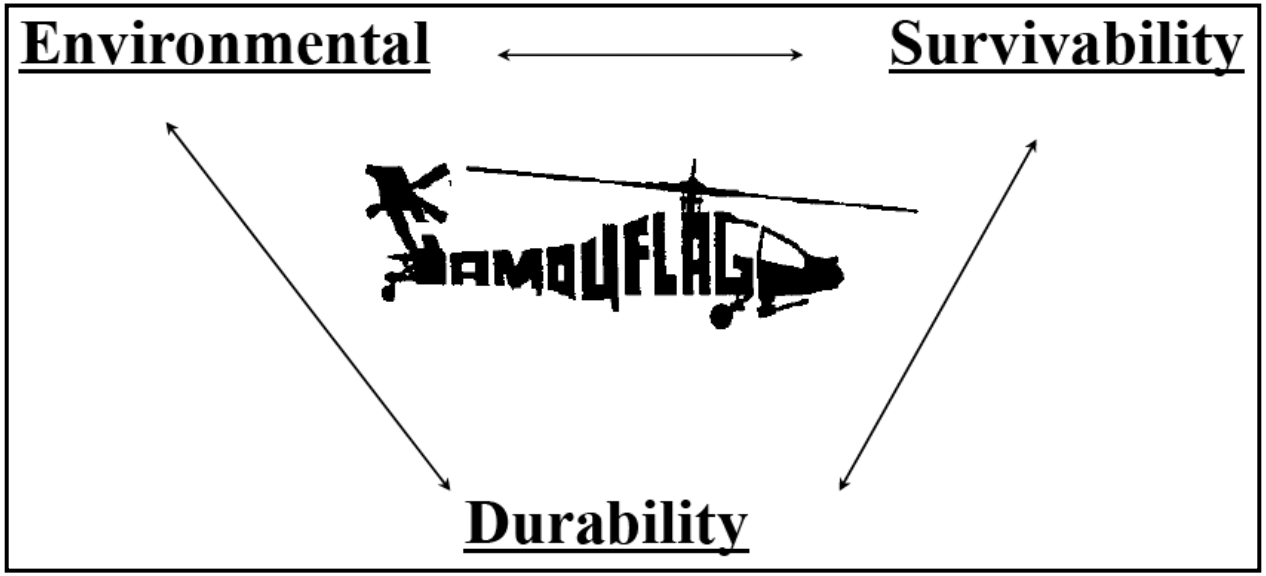
- DoD requirements and coatings development
  - Mark Wytiaz
- Coatings characterization and analysis
  - James Wynne, Ph.D.
- Coatings transition to the military market
  - Beth Ann Pearson, Ph.D.

# DoD Requirements and Coatings Development

Mark Wytiaz
The Sherwin-Williams Company

# DoD Requirements

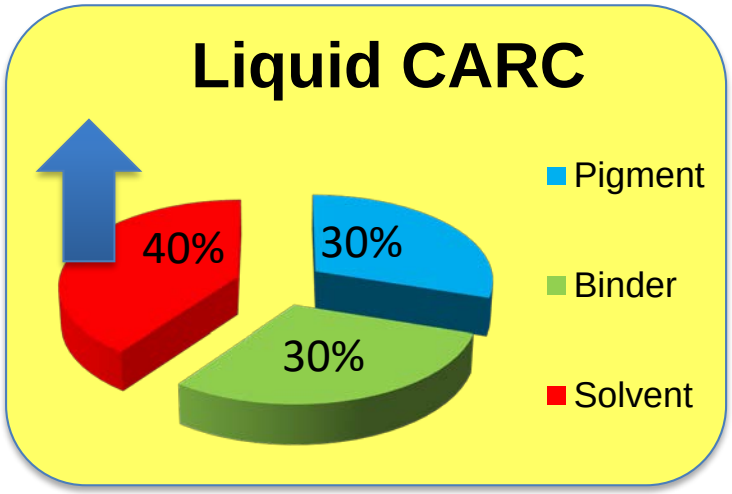
- Military Chemical Agent Resistant Coating (CARC) powder topcoat for ground vehicles
- Meet qualification: MIL-PRF-32348, Type III
- Compatible with current coating systems
- Maximum cure temperature 400 °F
- Identified need >25 years

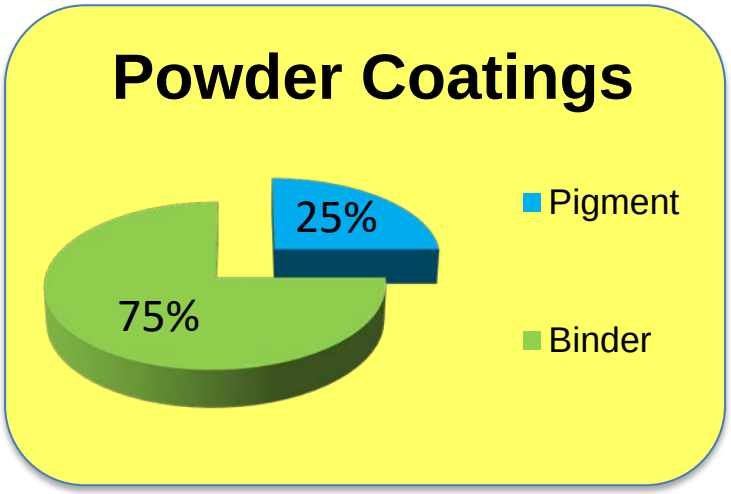


# Technical Approach

## *Coatings Development-Pigmented Systems*

***Leverage knowledge of liquid CARC technology***



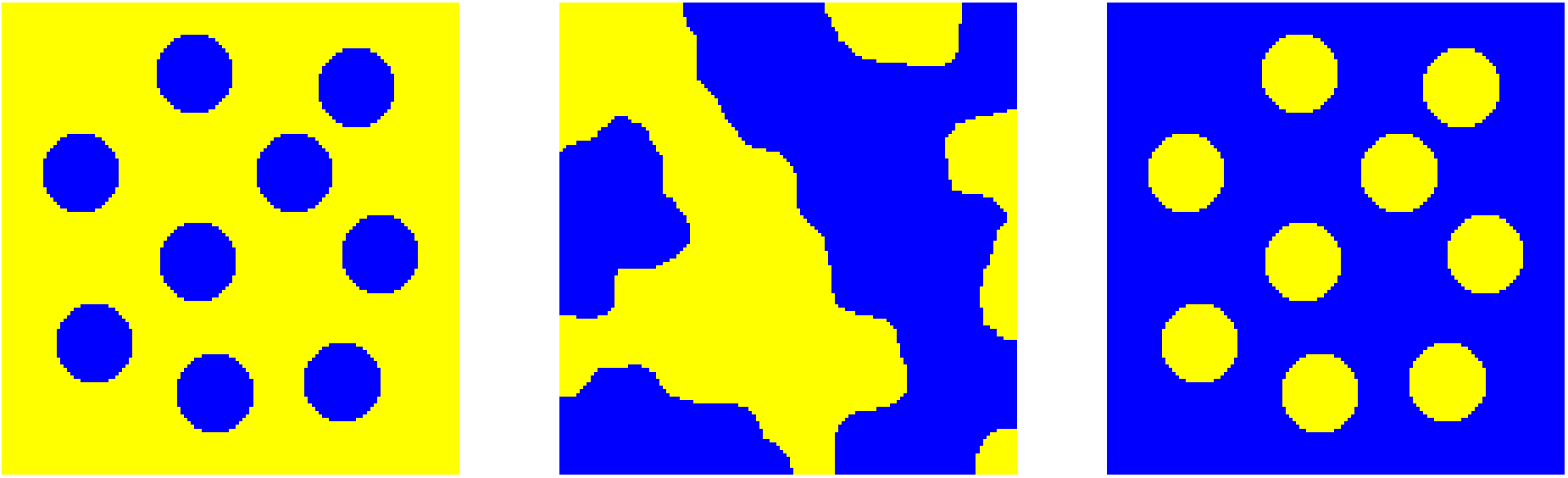




- High filler loadings
- Difficult to obtain live agent resistance and durability

- Low filler loadings
- Exterior durability and live agent resistance expected to improve

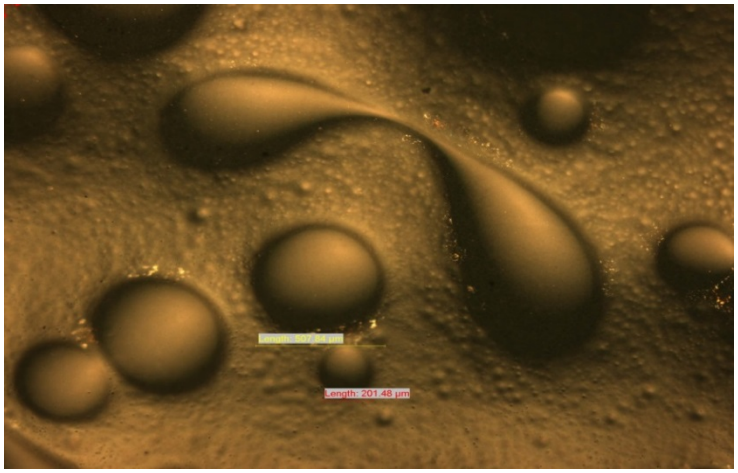
# Technical Approach

- Incompatible polymer domains
  - Superior chemical and weathering resistance



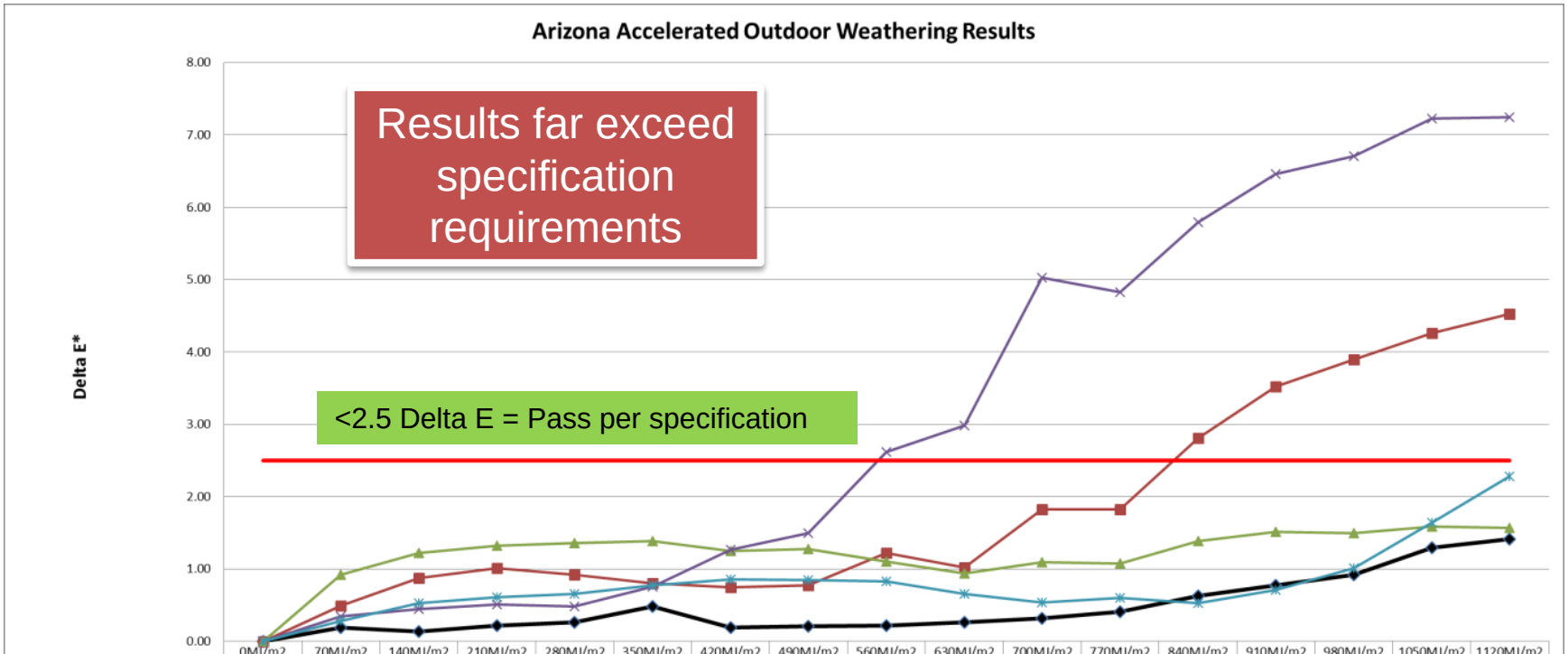
# Challenges Met

- Low gloss
  - DoD camouflage
  - Consistent gloss
  - Less roughness than current CARC topcoats
- Chemical resistance
  - Live agent
  - Solvents
  - Chemicals



# Coatings Performance Testing

## *Accelerated Outdoor Weathering*




| | 0MJ/m2 | 70MJ/m2 | 140MJ/m2 | 210MJ/m2 | 280MJ/m2 | 350MJ/m2 | 420MJ/m2 | 490MJ/m2 | 560MJ/m2 | 630MJ/m2 | 700MJ/m2 | 770MJ/m2 | 840MJ/m2 | 910MJ/m2 | 980MJ/m2 | 1050MJ/m2 | 1120MJ/m2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Powder Topcoat | 0.00 | 0.19 | 0.14 | 0.22 | 0.27 | 0.48 | 0.19 | 0.21 | 0.22 | 0.26 | 0.32 | 0.41 | 0.63 | 0.77 | 0.92 | 1.29 | 1.41 |
| Water Dispersible Silica | 0.00 | 0.49 | 0.88 | 1.01 | 0.92 | 0.80 | 0.75 | 0.77 | 1.22 | 1.02 | 1.82 | 1.82 | 2.81 | 3.52 | 3.90 | 4.26 | 4.52 |
| Water Dispersible Polymeric | 0.00 | 0.92 | 1.22 | 1.33 | 1.36 | 1.39 | 1.25 | 1.27 | 1.11 | 0.94 | 1.10 | 1.07 | 1.39 | 1.51 | 1.49 | 1.59 | 1.57 |
| Solvent borne Silica | 0.00 | 0.34 | 0.45 | 0.51 | 0.48 | 0.75 | 1.26 | 1.49 | 2.62 | 2.98 | 5.02 | 4.83 | 5.79 | 6.46 | 6.70 | 7.22 | 7.24 |
| Solvent borne Polymeric | 0.00 | 0.28 | 0.53 | 0.61 | 0.65 | 0.78 | 0.86 | 0.85 | 0.82 | 0.65 | 0.54 | 0.60 | 0.53 | 0.71 | 1.01 | 1.65 | 2.28 |
| Fail | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 | 2.50 |

560 megajoules/sq.meter ($MJ/m^2$) = 2 years

2 years = specification requirement

# Environmental Advantages

- Nearly zero Volatile Organic Content (VOC's)
- Excellent durability leads to less repainting
- Powder primer corrosion protection
- Three key colors were developed

# Summary

- Technical approach successful in meeting military specification MIL-PRF-32348, Type III

- Observed synergistic effect between polymers and low filler levels
- Exterior durability exceeded requirements
- Three colors developed

# Coatings Characterization and Analysis

James Wynne, Ph.D.
Naval Research Laboratory

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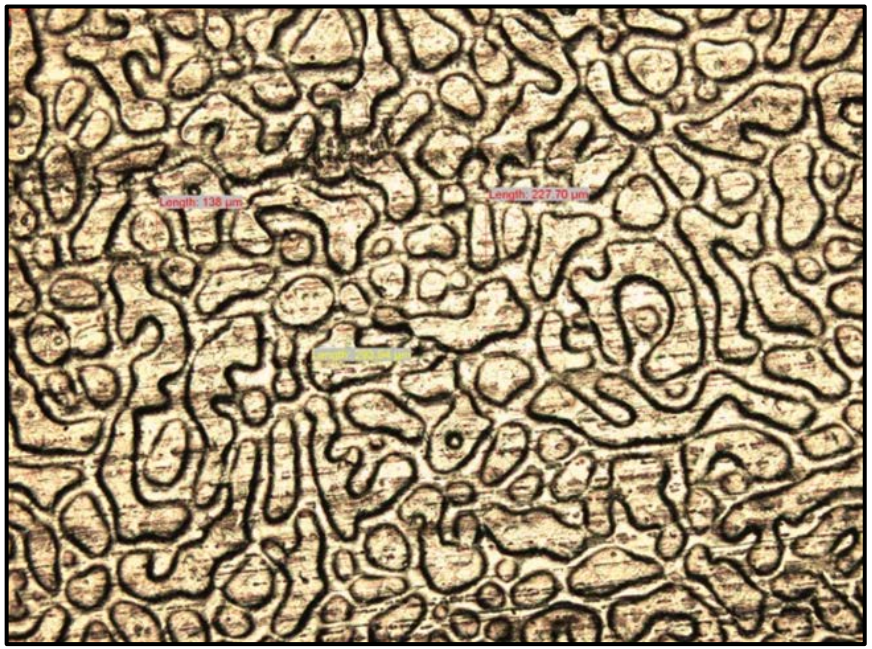
# Utilization of Phase Separation for Gloss Reduction

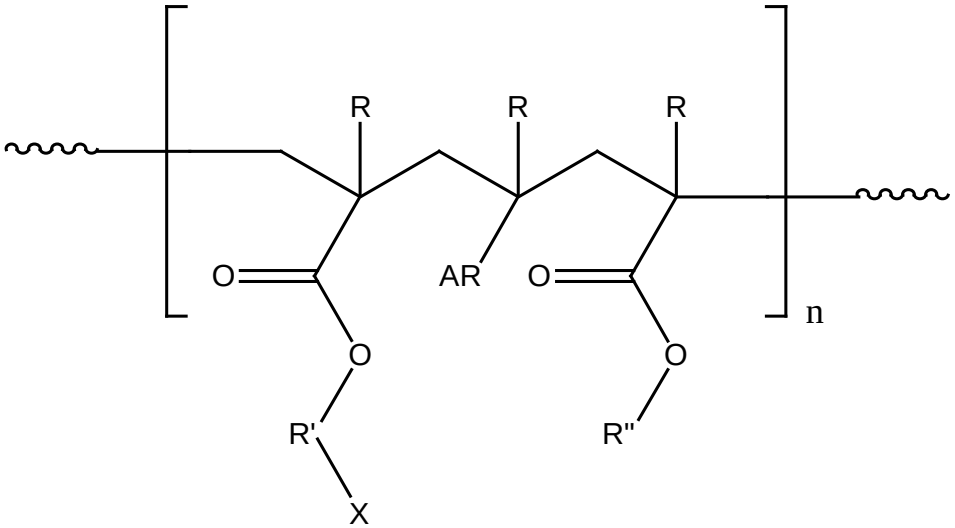



- Minimizing pigment volume concentration (PVC)
- Binder system to supply additional roughness

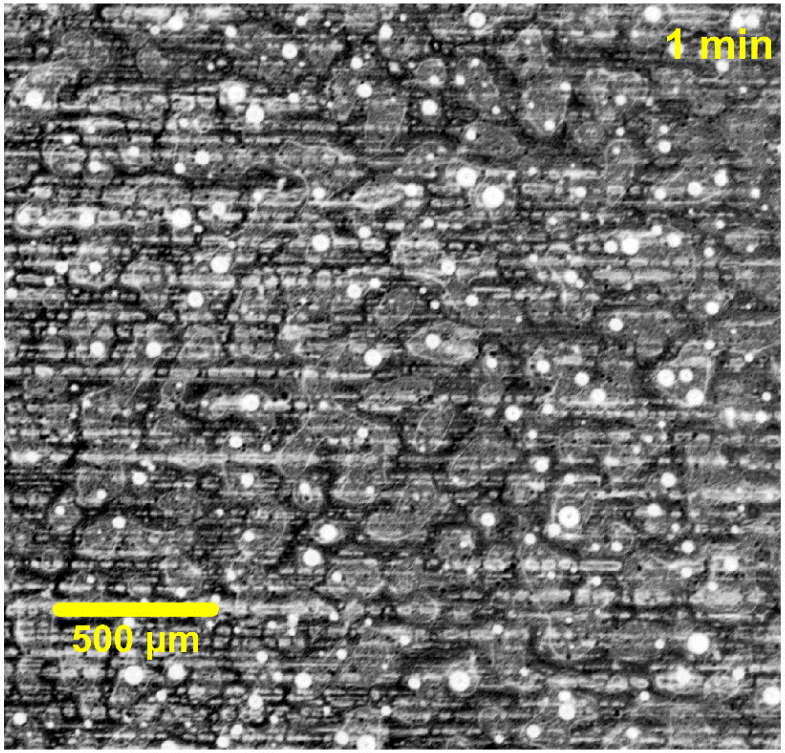
# Polymer Incompatibility

- Change Hansen solubility parameters
  - Hydroxyl (OH) pendant group content
    - High OH vs. low OH content
  - Dispersion, Polar and Hydrogen bonding interactions

$$\delta^2 = \delta_D^2 + \delta_P^2 + \delta_H^2$$



# Incompatibility Resulting in Polymeric Phase Separation

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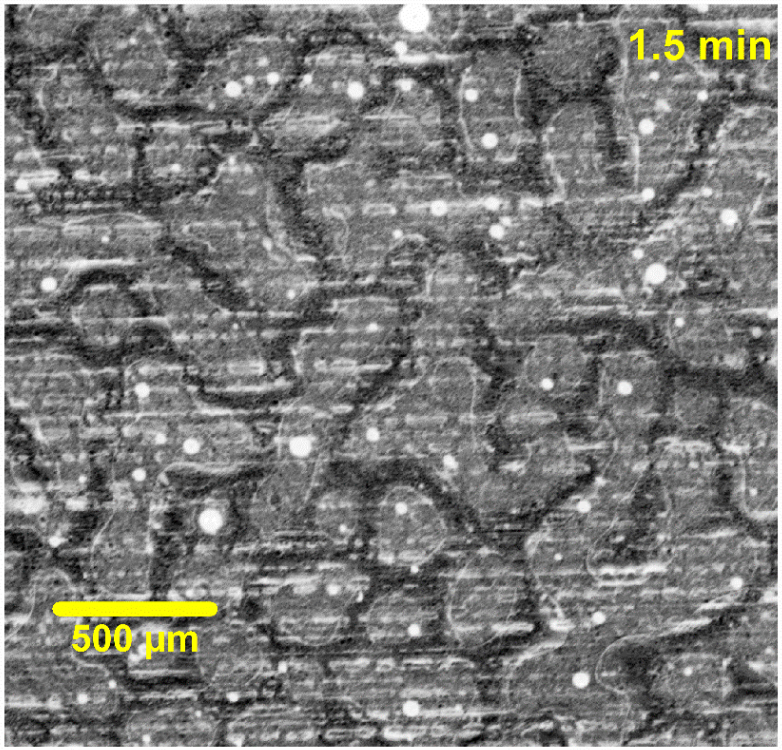


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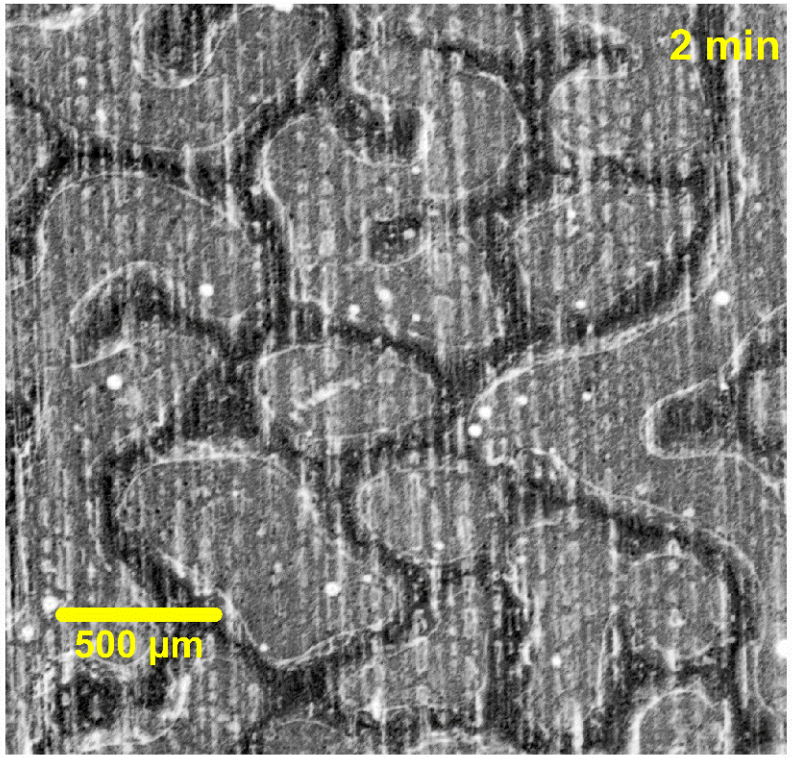


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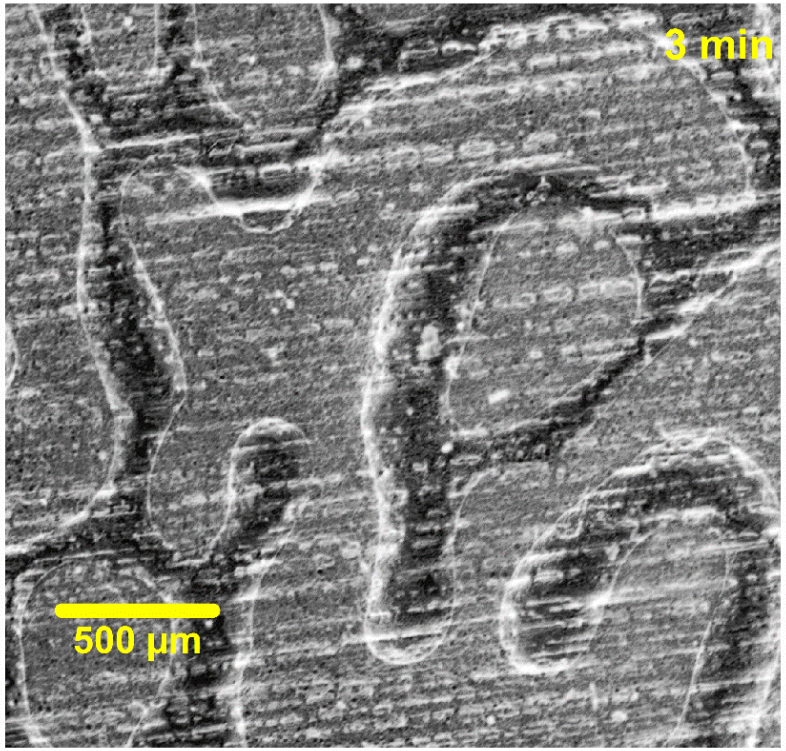


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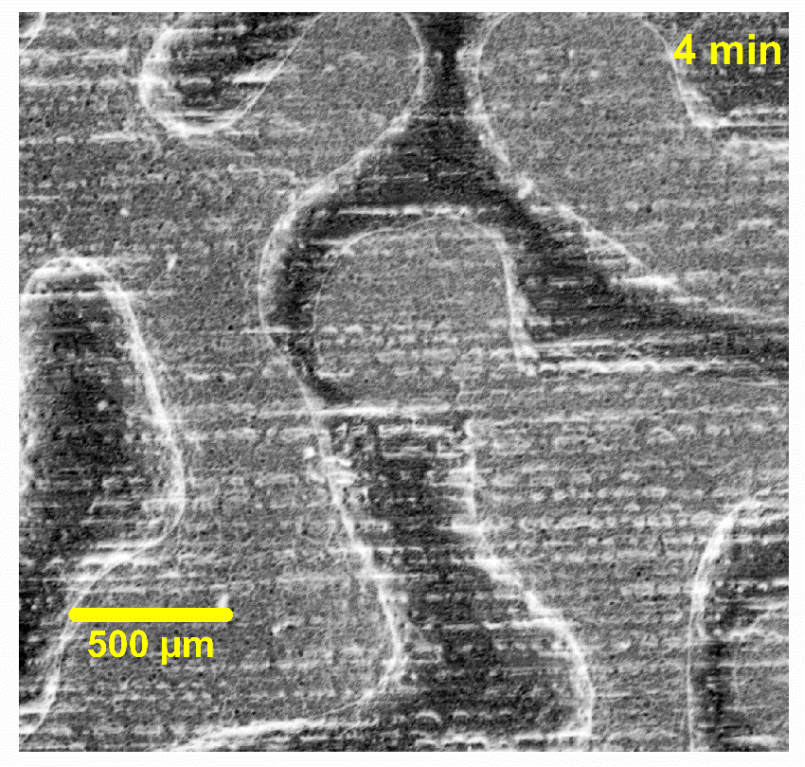


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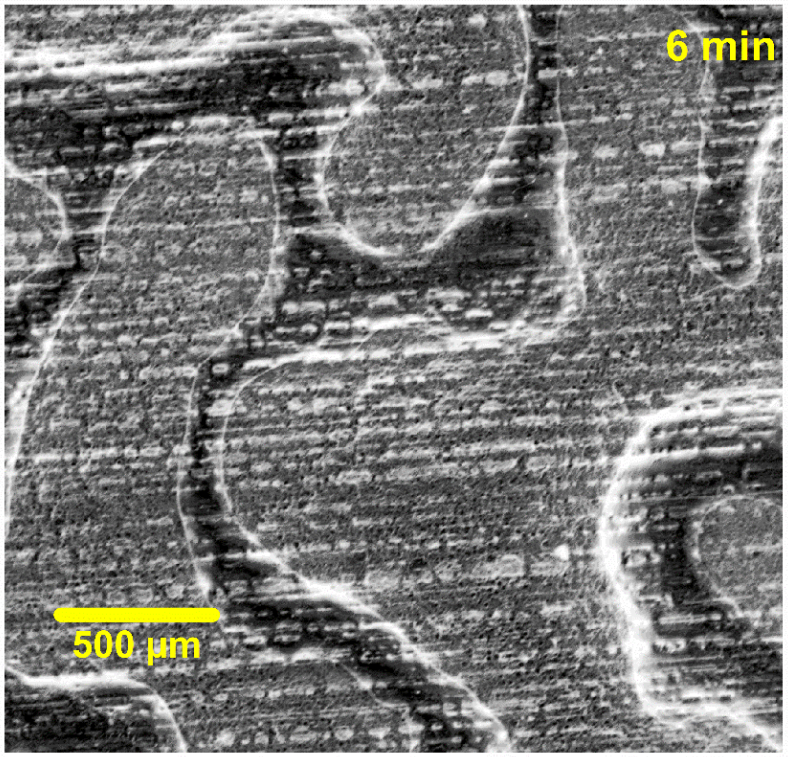


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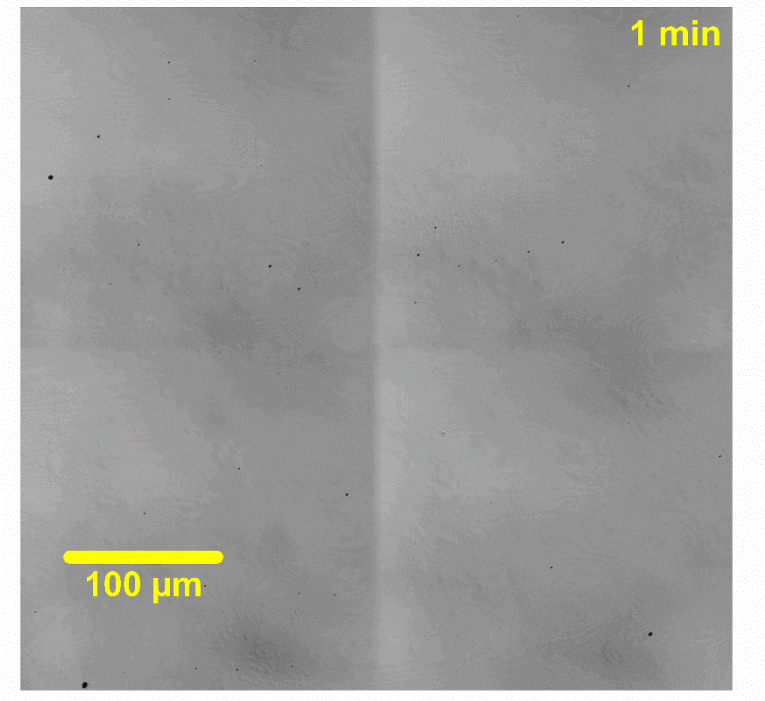
# Implications of Crosslinking on Phase Separation

- Isocyanate curative crosslinks between OH pendant groups
  - Urethane crosslinks form
  - Balance between viscosity increase and phase separation
  - Increasing crosslink density will trap domain formations

# Phase Separation in Crosslinked Coating Results in Surface Roughness

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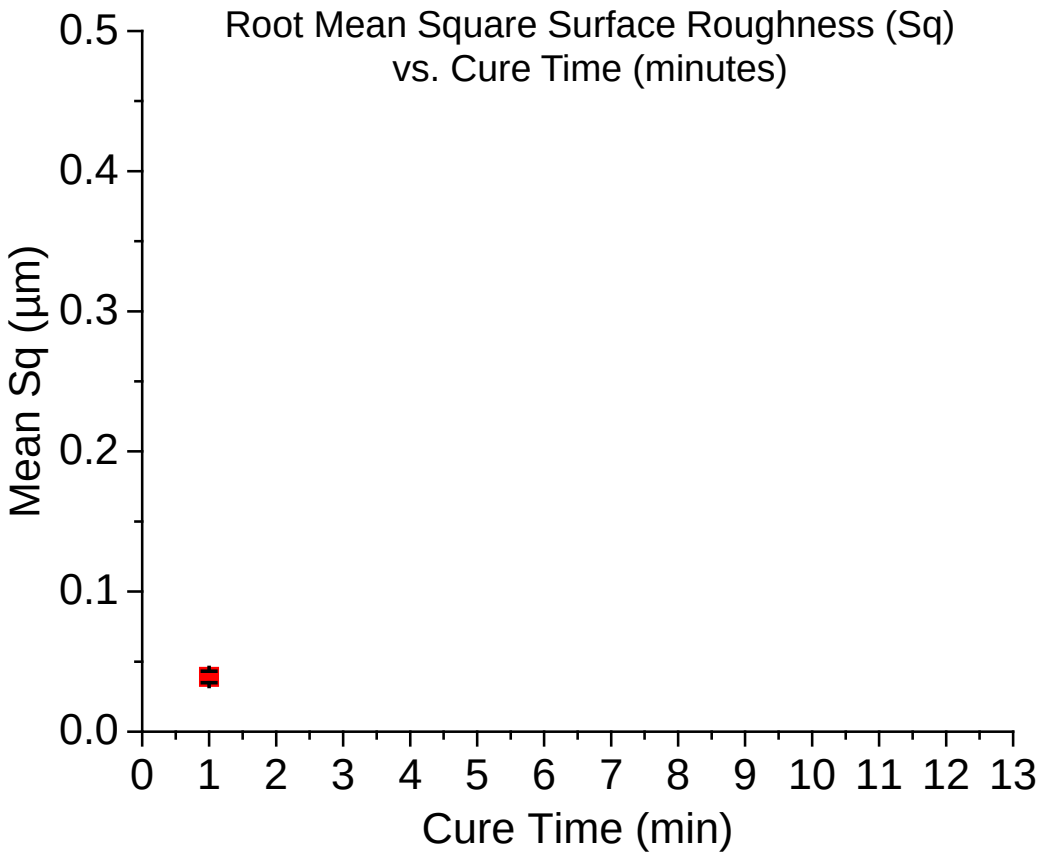

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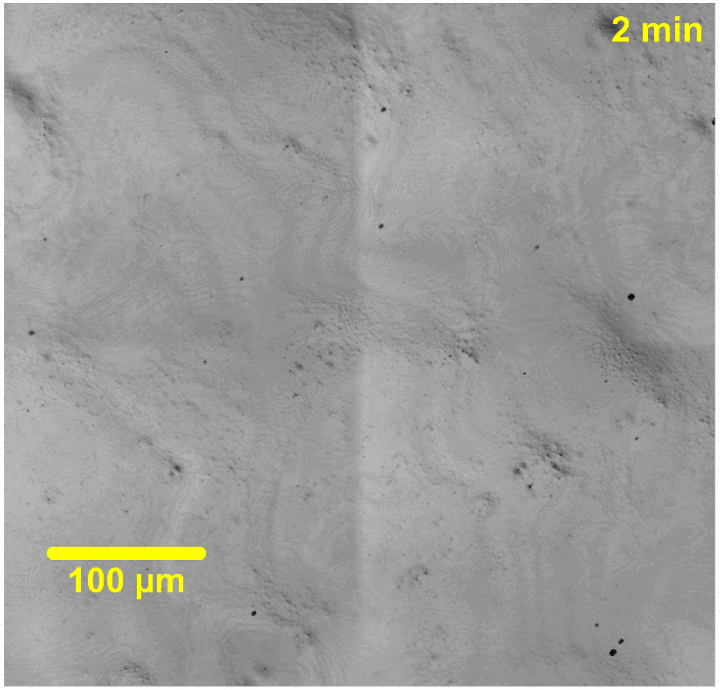


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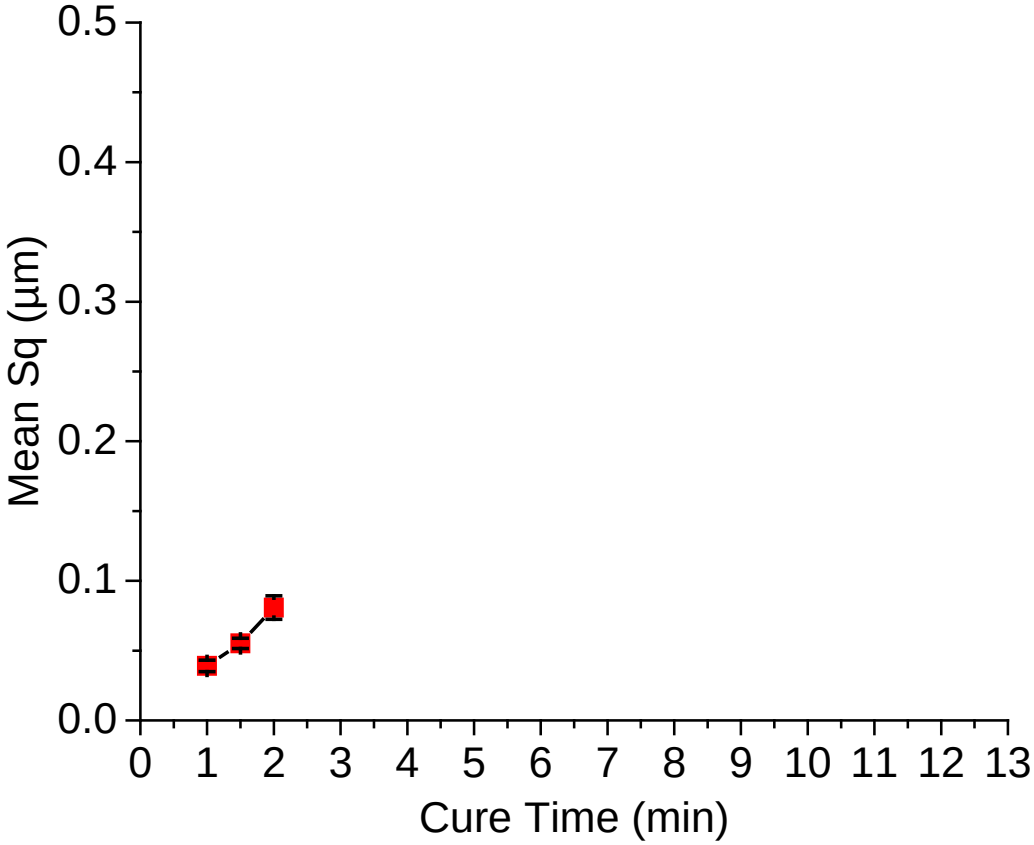

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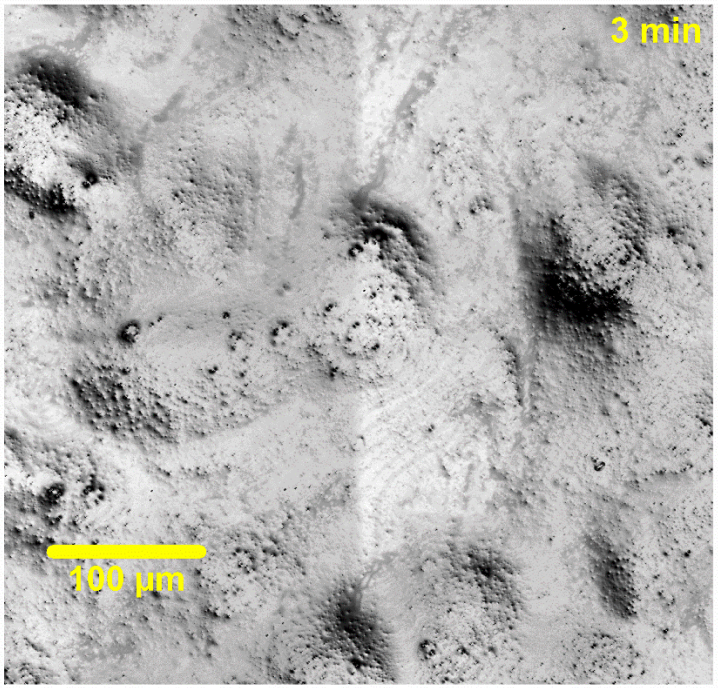


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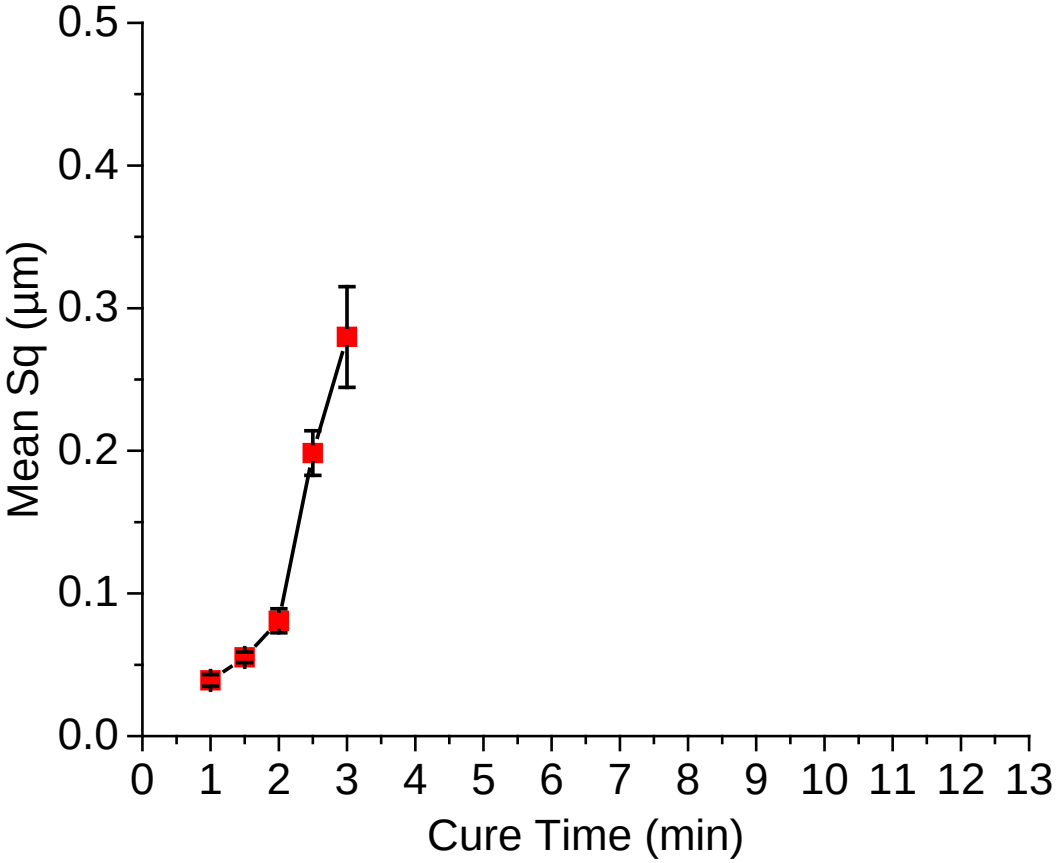
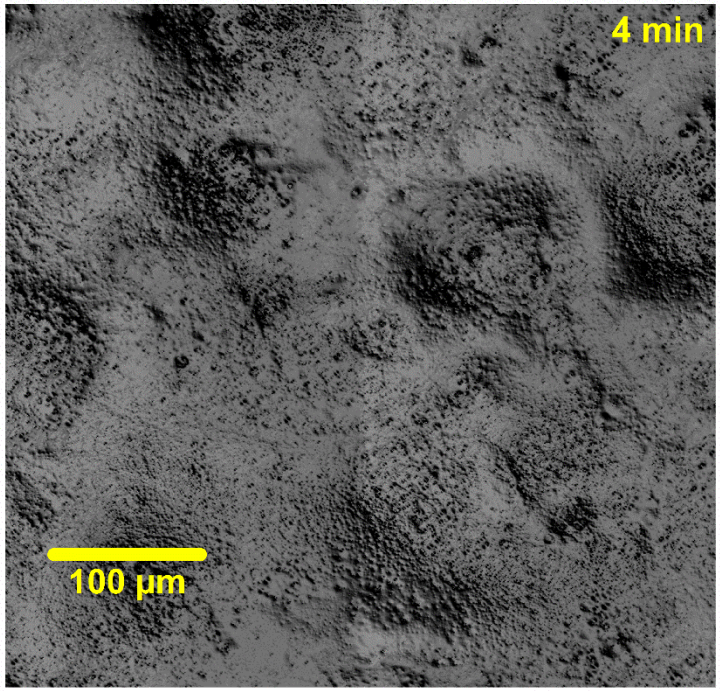


# Phase Separation Resulting in Surface Roughness

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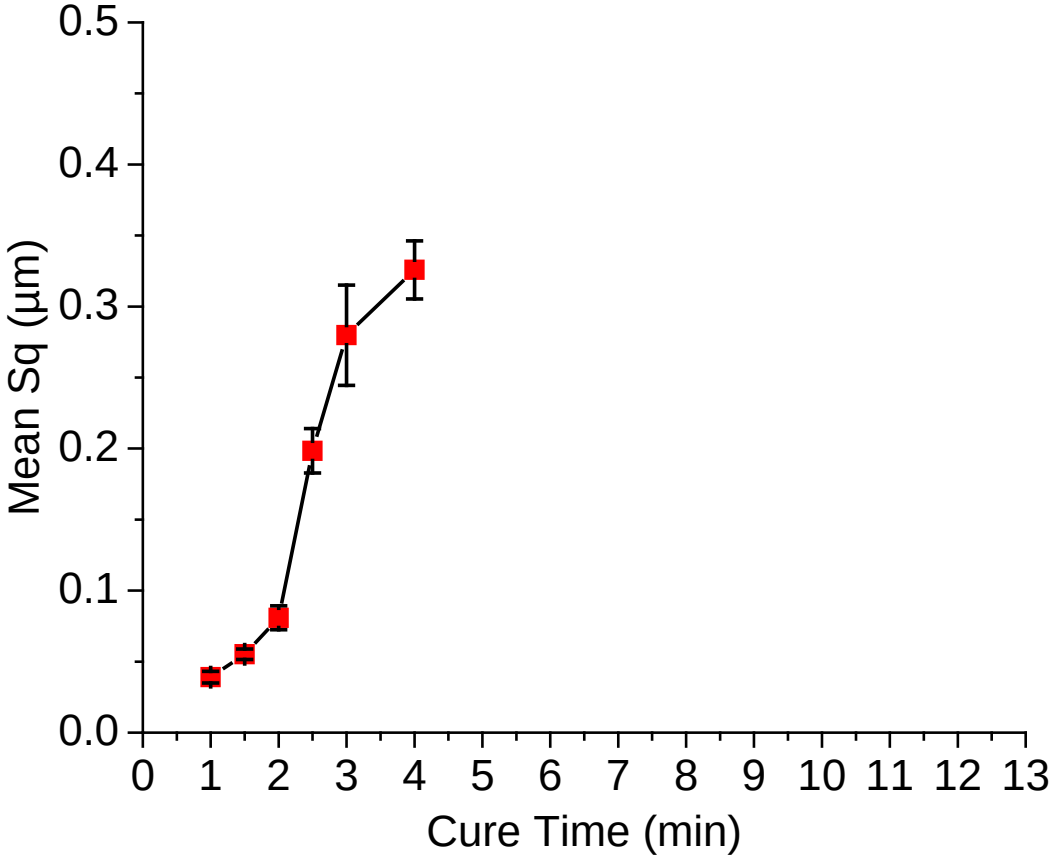

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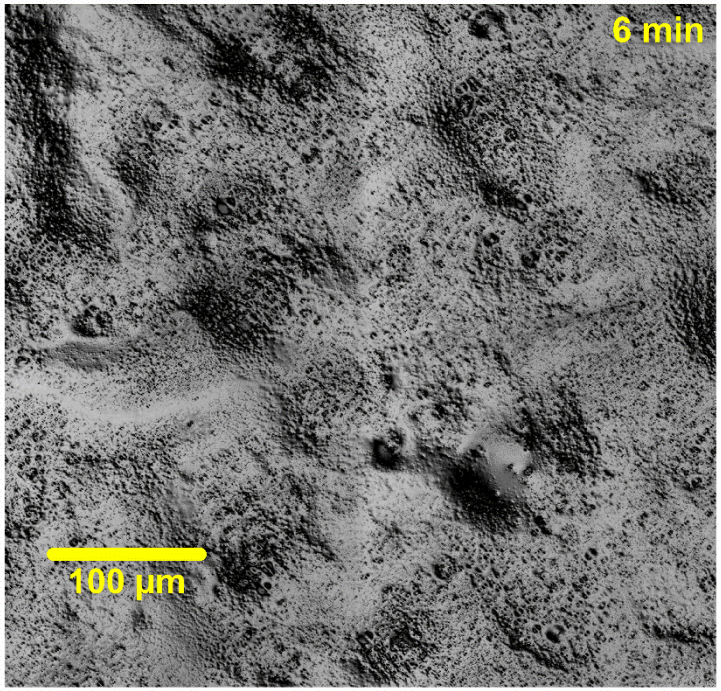


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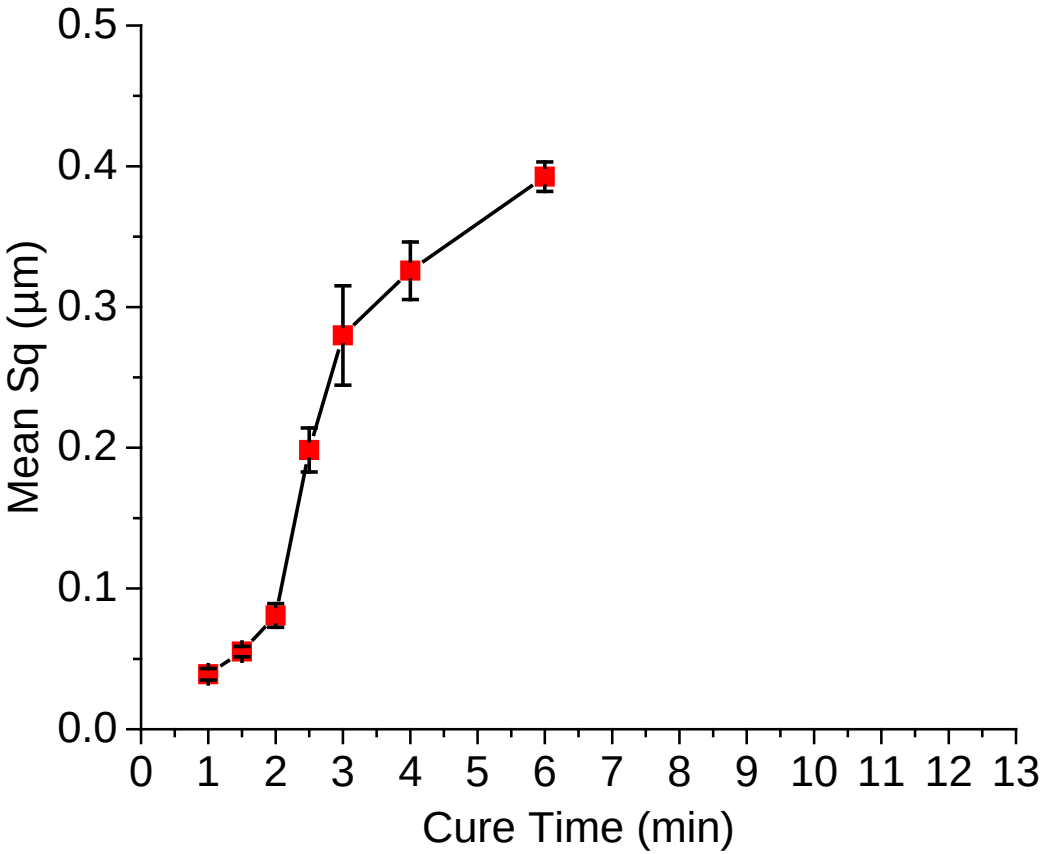

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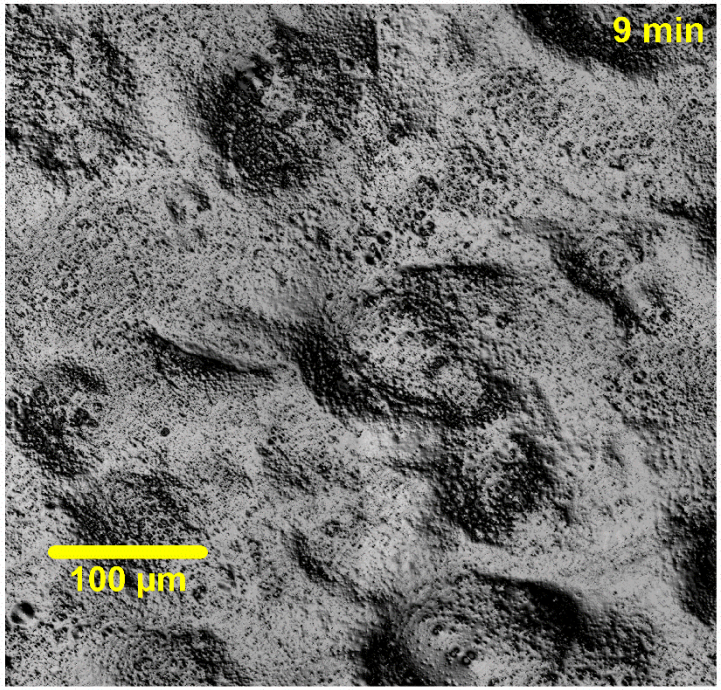


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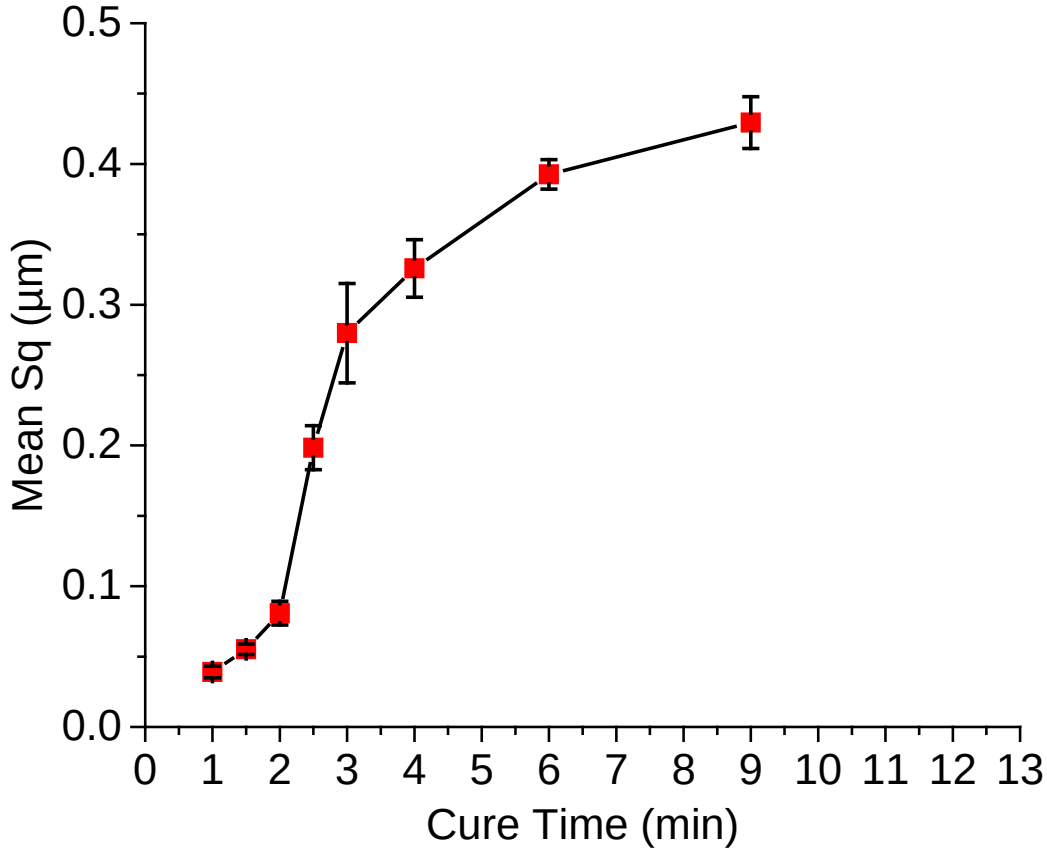

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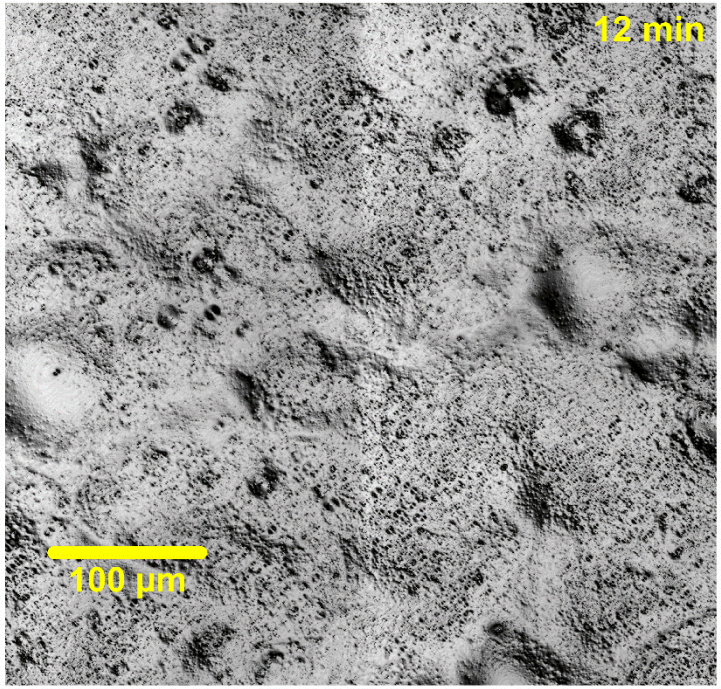


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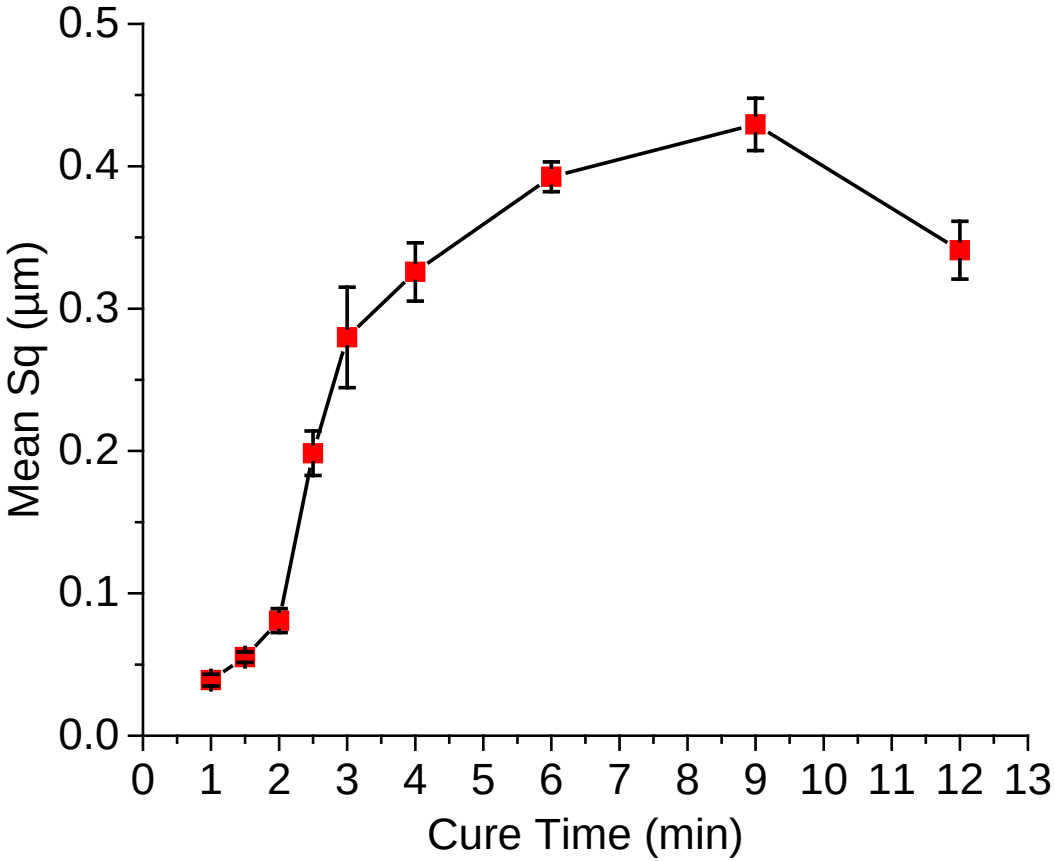
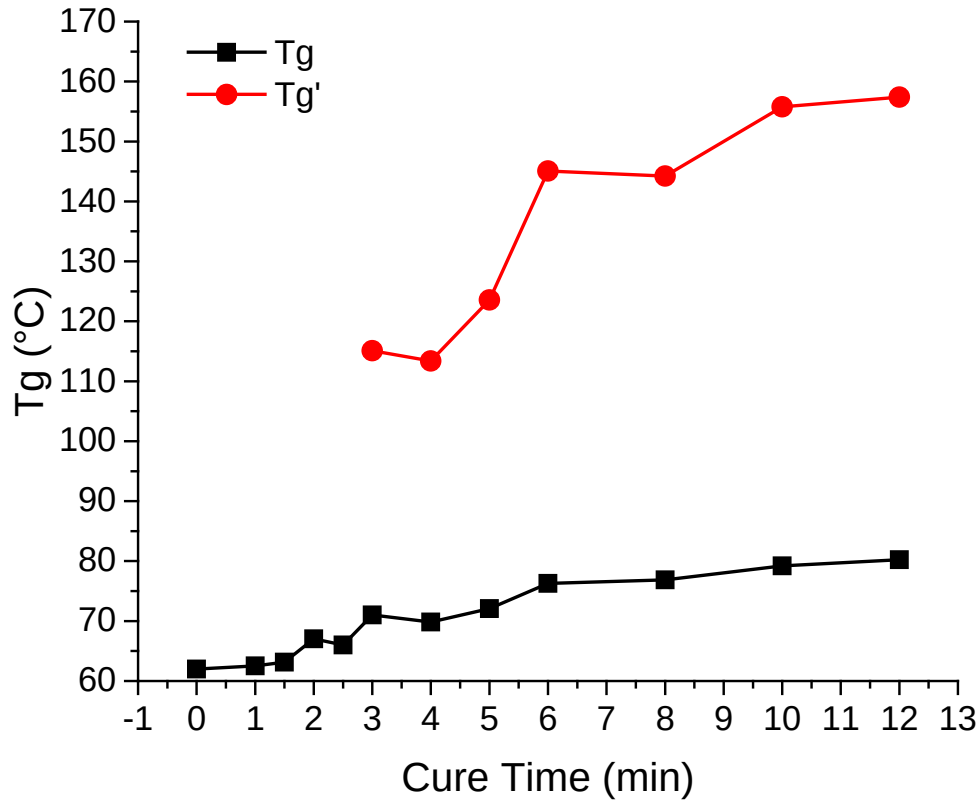
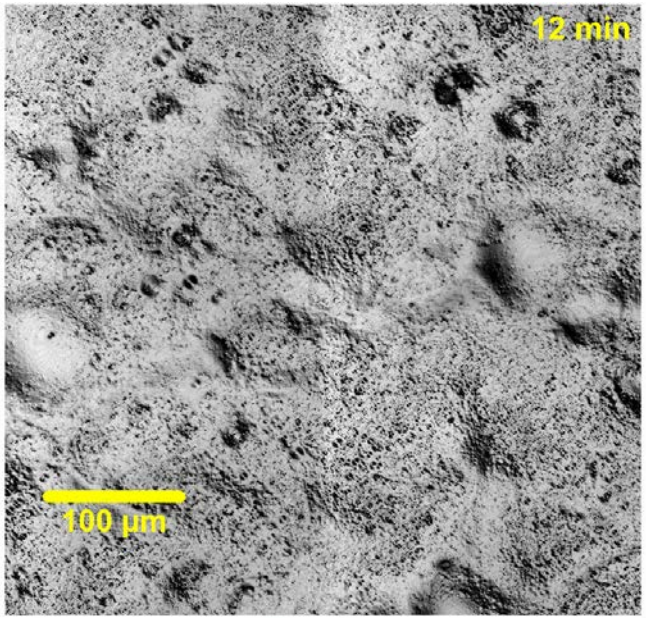


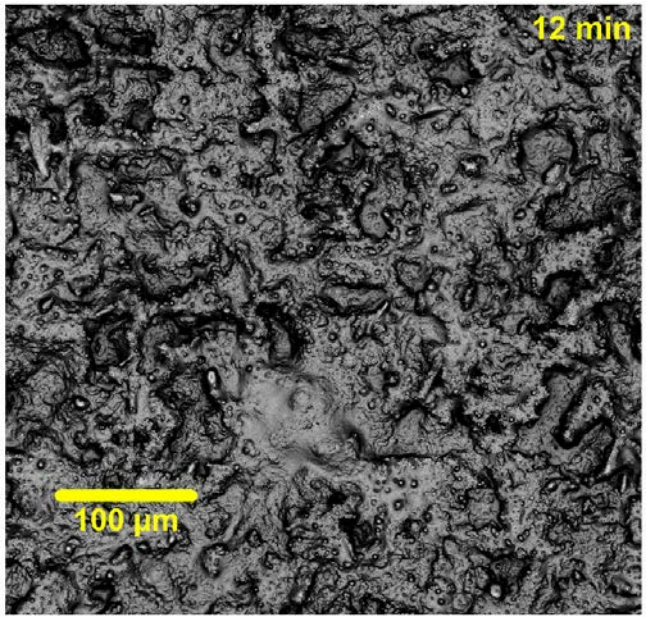
# Thermal Analysis of Phase Separation

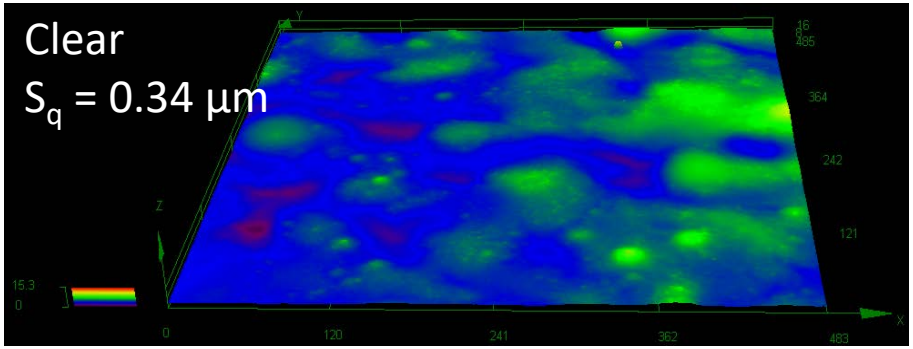
- 2 Glass transition temperatures (Tg's) are characteristic of phase separation
- Increase in crosslink density results in increased Tg

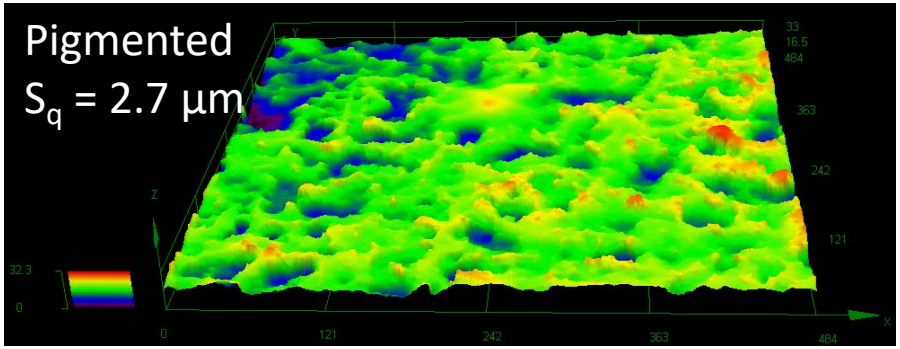


# Synergistic Effect of Phase Separation and Filler/Pigment Incorporation



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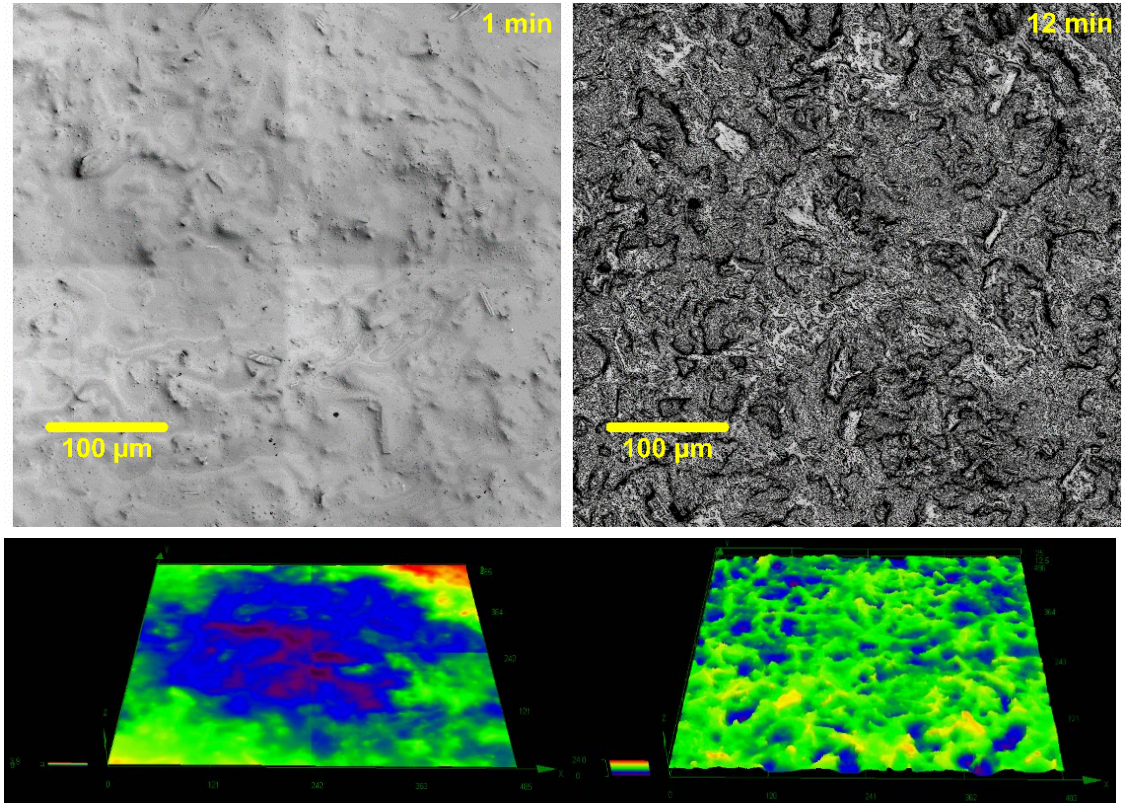


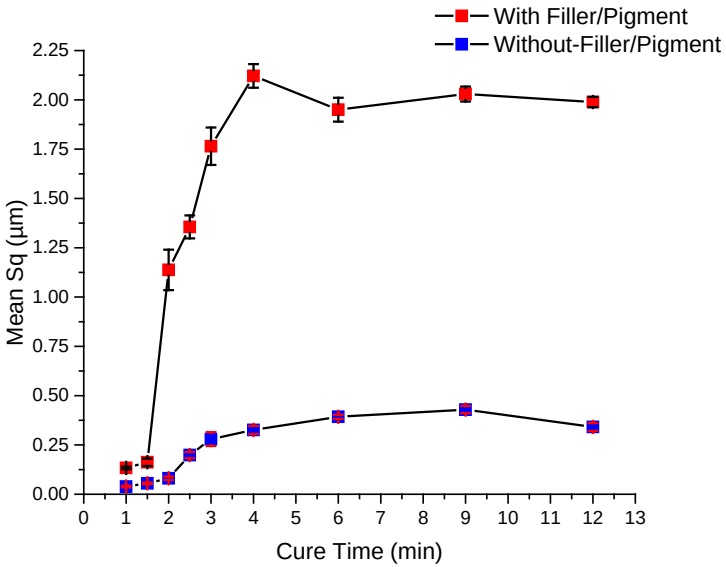


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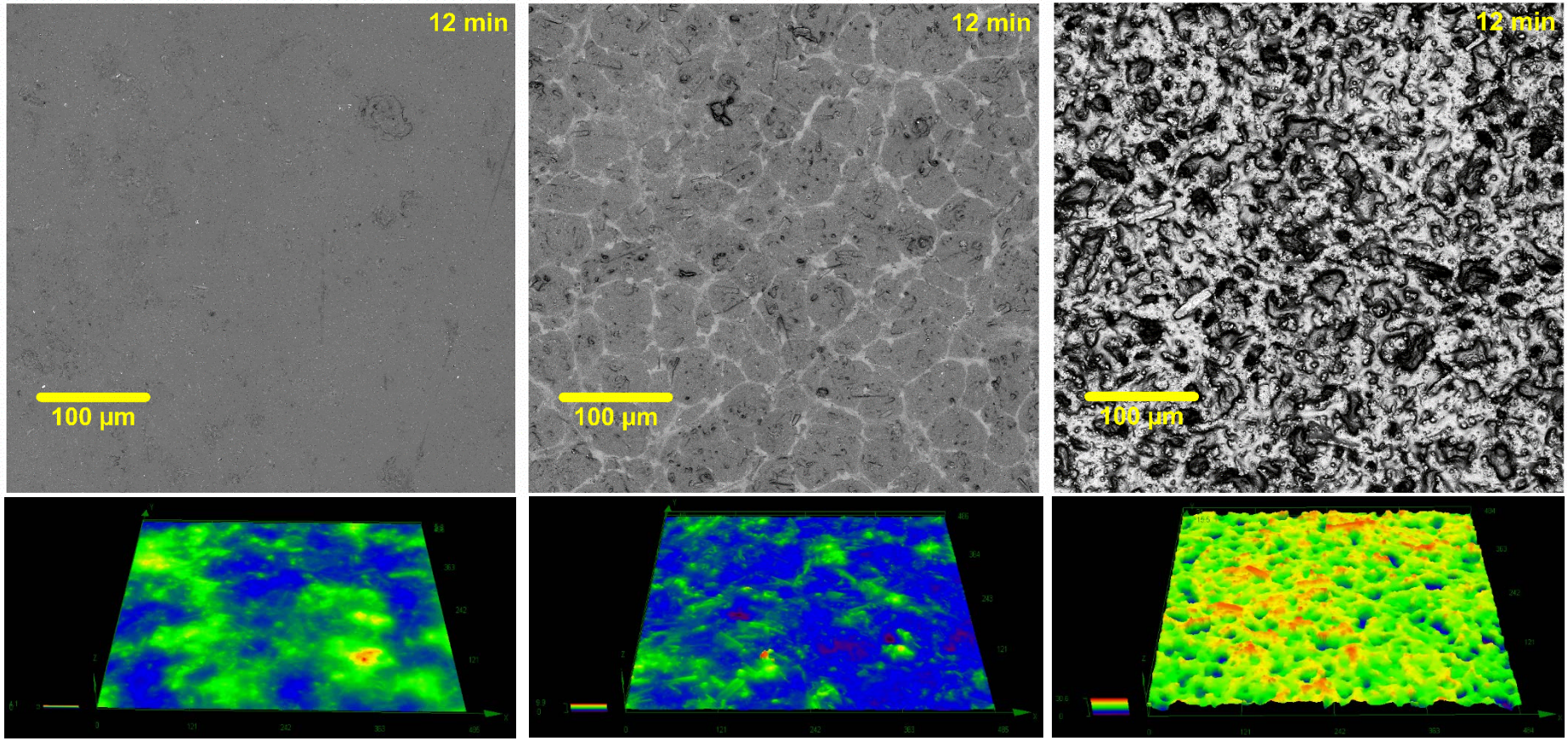
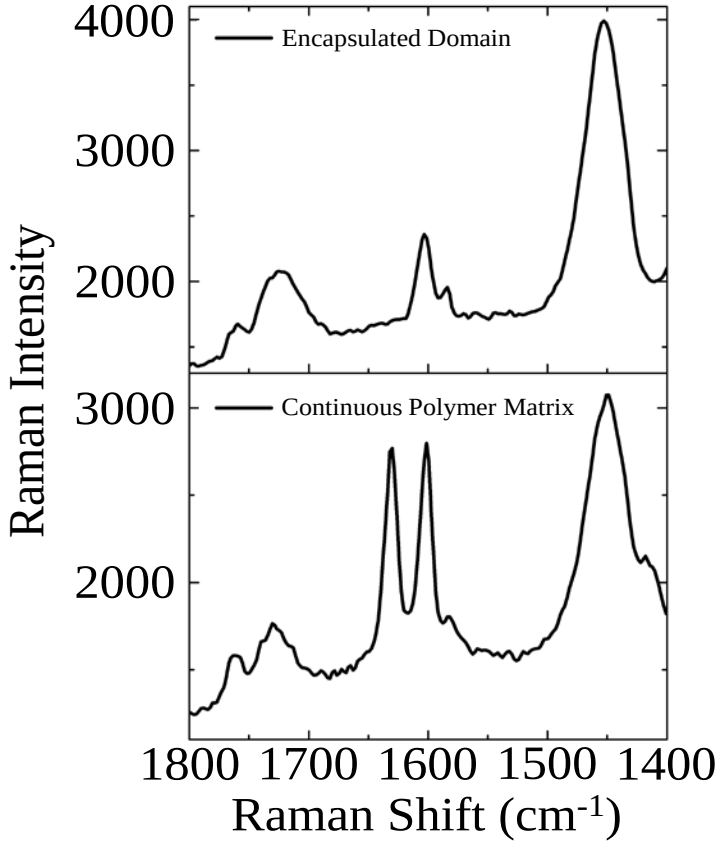
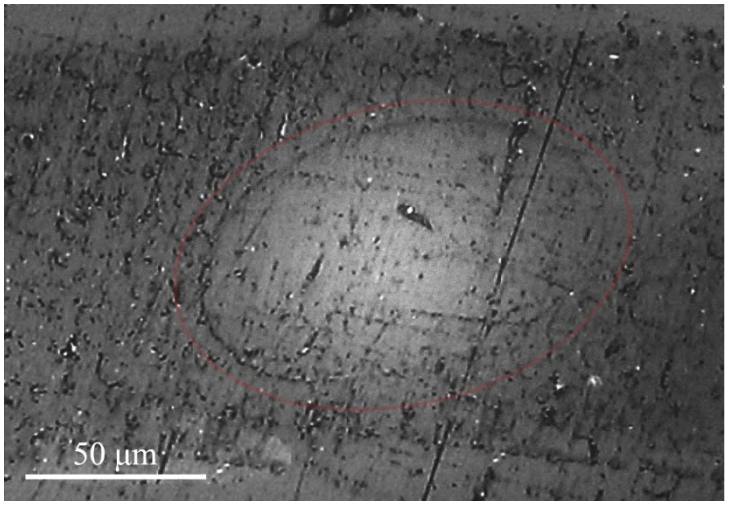
# Surface and Gloss Comparison of Individual Resin Films and the Blend

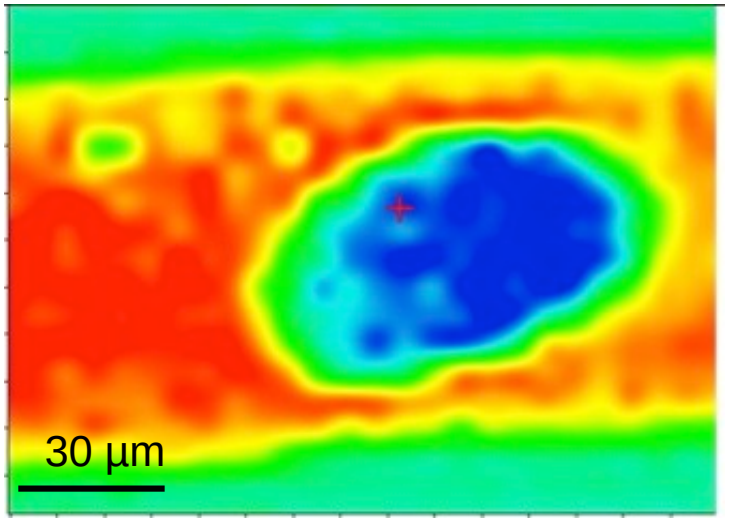



| Low OH | High OH | High/Low Blend |
|---|---|---|
| Sq = 0.13 µm | Sq = 0.40 µm | Sq = 2.9 µm |
| 60° Gloss = 66 Gloss Units (GU) | 60° Gloss = 16.5 GU | 60° Gloss = 0.8 GU |

# Spectroscopic Characterization of Polymeric Phases



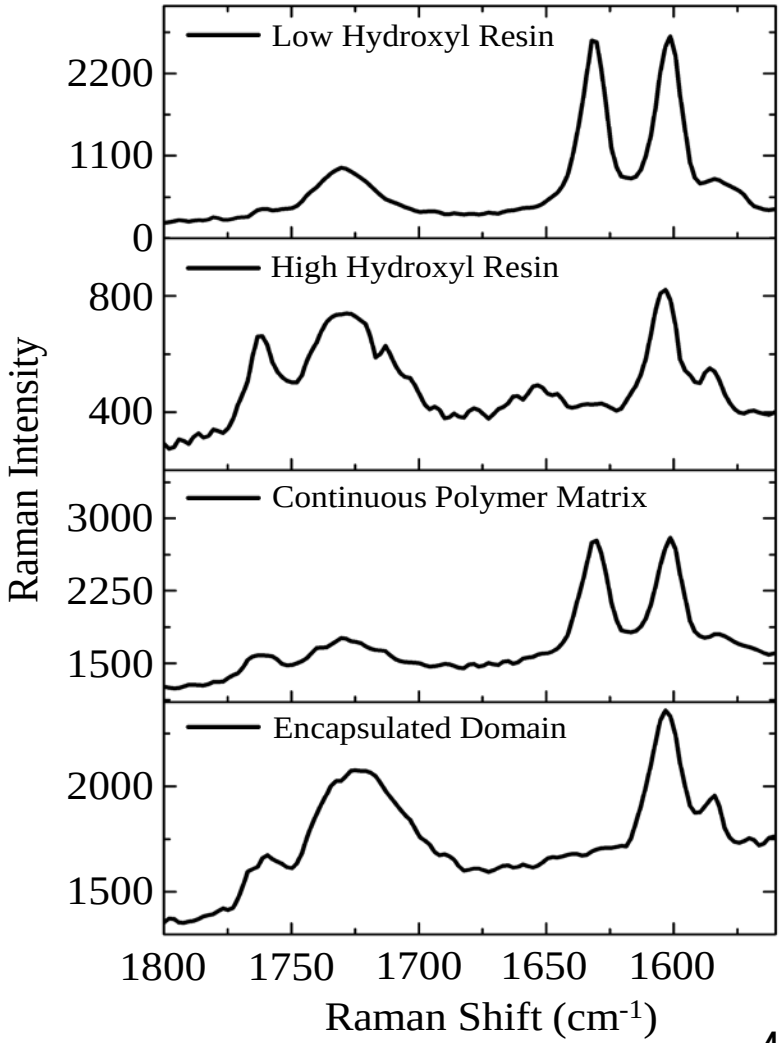



Giles, S. L.; Heller, N. W. M.; Clayton, C. R.; Walker, M. E.; Wytiaz, M. J.; Wynne, J. H. *ACS Appl. Mater. Interfaces* **2016,** *8*, 26251-26257.
Heller, N. W. M.; Clayton, C. R.; Giles, S. L.; Wynne, J. H.; Walker, M. E.; Wytiaz, M. J. *J. Coat. Technol. Res.* **2016**, 1-13.

# Spectroscopic Comparison to Single Component Films

- Low OH resin = continuous polymer matrix
- High OH resin = encapsulated domain





Giles, S. L.; Heller, N. W. M.; Clayton, C. R.; Walker, M. E.; Wytiaz, M. J.; Wynne, J. H. *ACS Appl. Mater. Interfaces* **2016,** *8*, 26251-26257.
Heller, N. W. M.; Clayton, C. R.; Giles, S. L.; Wynne, J. H.; Walker, M. E.; Wytiaz, M. J. *J. Coat. Technol. Res.* **2016**, 1-13.

# Key Findings

- Phase separation results in surface roughness enhancement
- Synergistic effect of domain formation and pigment incorporation
- Domain identification

# Q&A Session 1

SERDP DOD • EPA • DOE | ESTCP

# Coatings Transition to the Military Market

Beth Ann Pearson, Ph.D.
The Sherwin-Williams Company

SERDP DOD • EPA • DOE | ESTCP

# Coating Requirements - DoD

- Survivability of the war fighter
- Outstanding durability
- Excellent corrosion resistance
- Green initiatives
  - Water technologies
  - Elimination of heavy metals
  - Lower VOC's
  - Solvent choices
  - Powder Coatings

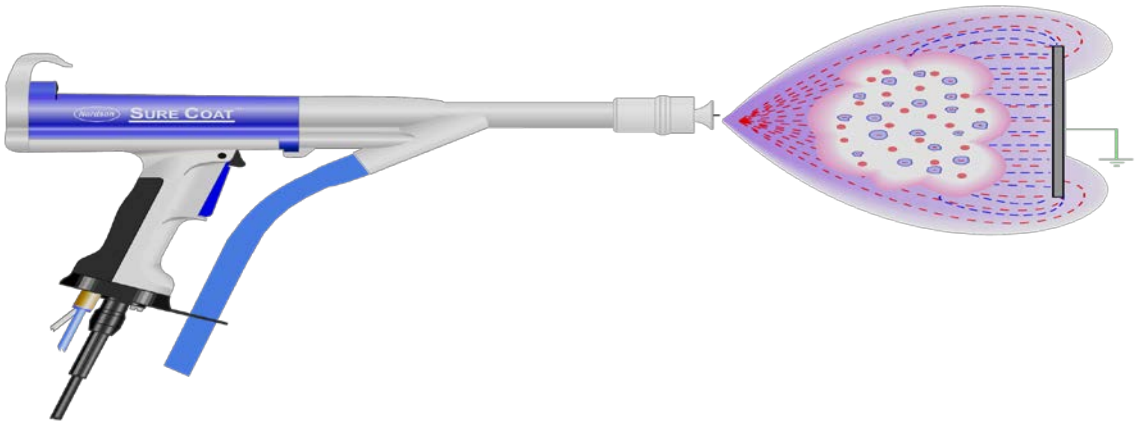
# Advantages of Powder Coatings

- Near zero VOC
- Higher film builds possible
- Specialty effects
- >95% recyclable / re-use
- Ready to apply
- Single coat application
- Resistant to chip / scratch
- Corrosion protection

# Enhancing Corrosion Protection

- United States Congress
  - Enacted legislative requirements
  - Created *Office of Corrosion Policy and Oversight*
    - Within *Office of Under Secretary of Defense for Acquisition, Technology & Logistics*
- Responsibility
  - Prevention and mitigation of corrosion of military equipment and infrastructure

# Application Efficiencies

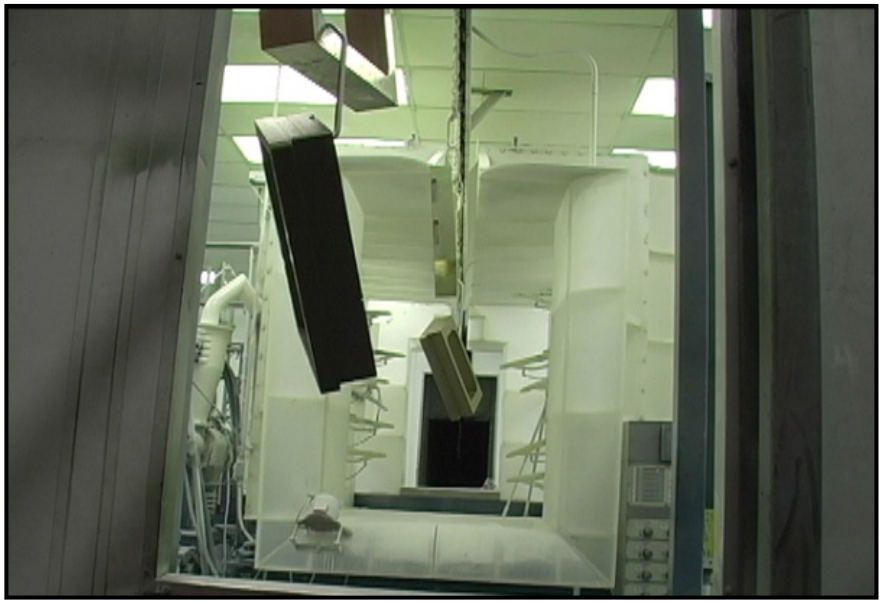



Increased transfer efficiency
=
Lower material cost
=
Lower unit cost

Increased transfer efficiency
=
Less material used
=
Better for the environment

# Fast Cure = Fast Production

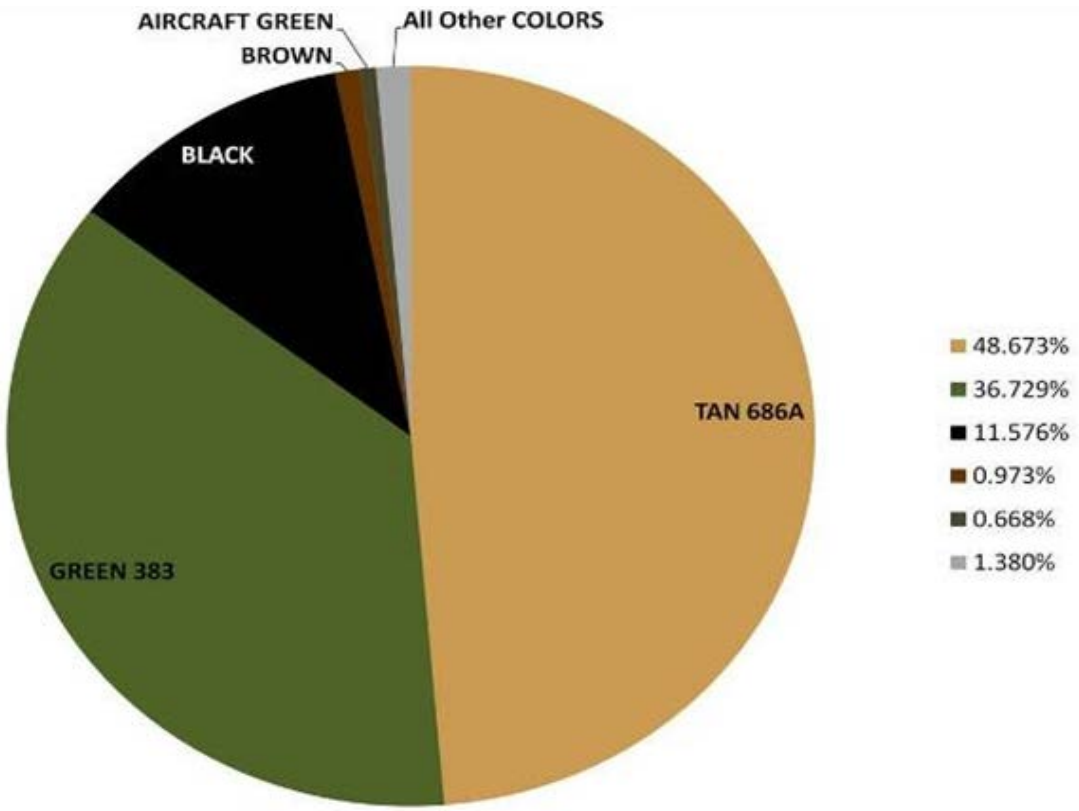
- 10 minutes at 400 $^{o}$F (metal temperature)
- Full cure obtained after bake
- Methyl ethyl ketone (MEK) resistance correlated to cure
- Product maintenance



# Current Status → Commercialization

# Colors Developed

- Developed highest volume colors






Data supplied by Army Research Laboratory

# Development to Commercialization

- Completed extensive statistical studies on robustness of new system
  - Substrates
  - Primers
  - Topcoats (Re-coat)
  - Cure conditions
  - Film thickness
  - Application methods

# Results

- Technology validated
  - Gloss retention
  - Adhesion retention
  - Physical properties
  - Recoat of liquid and powder primers and topcoats over CARC powder
  - Over-bake properties
  - 400 $^{o}$F for 16 hours – only minimal color drift
  - Minimum Dry Film Thickness (DFT) = 2.0 mils
- Summary
  - CARC Powder maintained adhesion and gloss compliance under all conditions

# Application Optimization

- Spray Technique Analysis and Research for Defense (STAR4D)- Cedar Falls, IA
- Marine Depot Maintenance Command (MDMC), Production Plant Albany (PPA)- Albany, GA

*Used with permission of manufacturer*

*Used with permission of manufacturer*

*Used with permission of manufacturer*

*Used with permission of manufacturer*

# Summary

- Successfully developed new CARC Powder Topcoat technology
  - Qualified products (black, green) In process (tan)
  - Completed scale-up to manufacturing
  - Platform technology for future products
- Validated performance in demo and field trials
- Transitioning for broad distribution to the military market

# Acknowledgements

- The Sherwin-Williams Company
  - Mr. Mark Wytiaz
  - Mr. Mark Walker
  - Mr. Edmund Mahn
  - Dr. Morgan Sibbald
  - Mr. Don Gruszka
  - Dr. Beth Ann Pearson
- Naval Research Laboratory
  - Dr. James Wynne
  - Dr. Spencer Giles

# Acknowledgements (Cont'd)

- Army Research Laboratory
  - Mr. John Escarsega
  - Mr. Daniel Pope
- Marine Depot Maintenance Command, Production Plant Albany
  - Mr. Steve Allen
- Estron Chemical
  - Dr. Robert Auerbach
  - Mr. Mike Miller
- Stony Brook University
  - Dr. Clive Clayton
  - Dr. Nicholas Heller

# For additional information, please visit

https://serdp-estcp.org/Program-Areas/Weapons-Systems-and-Platforms/Surface-Engineering-and-Structural-Materials/Coatings/WP-2207

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# Q&A Session 2

SERDP DOD • EPA • DOE | ESTCP

# The next webinar is on May 18, 2017

## “High-Resolution Site Characterization at Chlorinated Solvents Sites”

# Survey Reminder

*Please take a moment to complete the survey that will pop up on your screen when the webinar ends*

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