Dynamic contact angle measurements as an assessment tool for the weathering of water repellent treated surfaces

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Why understand weathering?

- Aesthetic appeal is becoming increasingly important
- Key replacement criteria for outdoor structures
- Leading reason for material substitutions

Understanding weathering

- Wood is not photo stable
- Wood is not moisture stable
- Much time and effort invested

Current solutions

• Paints
• Stains
• Inorganic treatments
• Wood modification

No perfect solution

- Peeling
- Fading
- Splitting
- Expensive
- Hazardous
Better solutions must be found
How do we evaluate possible alternatives

- Outdoor or artificial weathering
- Visually evaluate the surface
- Monitor moisture cycling
- Measure cupping and bowing

- Evaluate color
- Characterize checking
- FTIR analysis
- Scanning election microscopy
- Contact angle analysis
How do we evaluate possible alternatives

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Contact angle analysis - Theory

- Used to determine the hygroscopicity of the surface
- $90^\circ$ differentiates hydrophobic from hydrophilic
Can we use dynamic contact angle measurements to evaluate surfaces and how do the results relate to checking and discoloration?
Methods – Sample preparation

- Matched Radiata and southern pine
- Treated with two water repellents at two equal retentions (treatments are denoted as treatment A and B)
- Reconditioned to 12% MC
- Smoothed surface
- Characterized initial surface
Methods – Sample exposure

• Mounted to aluminum racks
• Exposed in Charlotte NC
• Reconditioned
• Re-characterized surface
Methods – Data analysis

• Tracked static contact angle after the drop had been on the surface for 20 seconds
• Calculated slope of dynamic contact angle curves after each exposure period

![Graph showing contact angle over time with regression line.](image)

- $R^2 = 0.973$
- Slope = -2.598
Results – Radiata pine static contact angles

• Contact angles for all samples initially increased with exposure due to surface deactivation
• Untreated samples reached a maximum contact angle of 70 degrees before decreasing again
• Treatment A plateaued at 100 degrees while treatment B plateaued at 120 degrees
• No dose effects were evident
Results- Radiata pine dynamic contact angle data

• Rate of contact angle decay differed by treatment
  – Greatest rate of decay in untreated samples; accelerated with time
  – Least decay in treatment B, with a slope of zero after stabilization
  – No dose effect was evident even after nearly 1400 MJ/m² of radiation
Is there a color effect?

Treatment A 0.5%
Treatment A 1.0%
Treatment B 0.5%
Treatment B 1.0%
Untreated
Results - Radiata pine checking

Average number of checks

Treatments

0.5% Treatment A 0.5% Treatment B 1.0% Treatment A 1.0% Treatment B Untreated

106 MJ/m² 213 MJ/m² 426 MJ/m² 676 MJ/m² 1032 MJ/m² 1336 MJ/m²
Results - Radiata pine checking index

Checking index = Average number of checks x average check area
Results – Southern pine contact angle data

• Static contact angle data similar to that seen in Radiata pine
• Rate of contact angle decay (as determined over 20 seconds) indicates that Treatment B is performing similarly in both species
• Rate of contact angle decay is increasing after 600 MJ/m² of exposure for treatment A
  – Dose effect may be evident after 1000 MJ/m² for treatment A
• Untreated southern pine is behaving similarly to Radiata pine
Results – Southern pine color change

![Graph showing color change (delta E) vs. exposure (Mj/m²) for different treatments.]

- 0.5% Treatment A
- 1.0% Treatment A
- 0.5% Treatment B
- 1.0% Treatment B
- Untreated
Conclusions

- Can delineate between treatments
- Differentiate between doses?
- Radiata pine allowed for better differentiation between treatments
- Contact angle could be used to identify compounds with self cleaning properties
- Contact angle data could be used to predict checking depending on the wood species
Future directions

• Variability and sample size
• Statistical tools
• Prediction models
• Comparison between timber species
• Accelerated weathering methods
• End user focus groups
• Development of treatments that perform and are cost effective
Thank you