Lotus Leaf Coatings

We solve difficult cleaning problems for our customers

Technology
Introduction and Benchmarking Data
Increasing Utility Production for PV Solar

Problem: Soiling is a Recognized Problem in PV Solar

Utility Scale Loss can be up to 20% annually depending on location
Est. $4B in losses due in soiling by 2022

Solution: HydroPhil – Anti-Soiling

Increase energy output by 3% and more
Reduces Cleaning Cycles & Protects PV Modules
Applied in the Field or in the Factory
HydroPhil is a proprietary ultrathin material with superior hydrophilic, water loving properties

WATER ATTRACTION
Unique surface structure which attracts water to the surface (contact angle < 10°)

OPTICAL CLARITY
Low haze and high optical clarity due to thickness and surface structure

UV STABLE
• Stable under ambient ultraviolet exposure

DURABILITY
• Exhibits high mechanical, chemical & environmental durability

COATING METHODS
• Dip, spin, spray, curtain
HydroPhil Anti-Soiling Coating

Tunable Surface Energy
• Anti-soiling via the sheeting effect (affinity for water)

Sub-Nanometer Porosity
• Minimal surface stress in moist environments
• Coating < 50 nm which increases durability

UV Stable
• As compared to polymer and silane based coatings
• Maintains properties after QUV weathering

Anti-Reflective (A/R) Compatible
• Bonds to Anti-Reflective Coatings

Seals porous Sol-Gel AR coatings
• Improves mechanical, chemical & environmental durability
# HydroPhil Core Technology Differentiators

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lotus Leaf Hydrophil Coating</th>
<th>Competitive Hydrophilic Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Energy</td>
<td>Tunable via Chemistry</td>
<td>Fixed by Material</td>
</tr>
<tr>
<td>Bonding Strength</td>
<td>Strong Surface Bonds to Glass and AR Coatings</td>
<td>Weak Surface Bonds to Glass and Base Layer Materials</td>
</tr>
<tr>
<td>Optical Clarity</td>
<td>Excellent - Sub-Nanometer Scale and Low Index of Refraction</td>
<td>Good – Nanometer Scale and Medium Index of Refraction</td>
</tr>
<tr>
<td>UV Stability</td>
<td>Excellent – Inorganic Solution</td>
<td>Weak - Organic Polymer Solutions</td>
</tr>
<tr>
<td>Coating Stability</td>
<td>Off-Line Synthesis</td>
<td>On-Line Synthesis (Traditional SiO₂ Sol Gel)</td>
</tr>
</tbody>
</table>
Anti-Soiling Coating Performance

Dust Test Conditions
- 100g ISO Medium Test Dust applied to glass at 45° angle with sifter for even deposition
- Tap sample to remove loose dust
- Visual Inspection with Transmission & Haze Measurement
## Competitive Benchmarking (Glass)

<table>
<thead>
<tr>
<th>Attributes</th>
<th>HydroPhil</th>
<th>Commercial Hydrophilic Coating</th>
<th>Commercial Fluoroalkylsilane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Contact Angle</td>
<td>10°</td>
<td>17°</td>
<td>104°</td>
</tr>
<tr>
<td>Index of Refraction</td>
<td>1.47</td>
<td>1.46*</td>
<td>1.35*</td>
</tr>
<tr>
<td>Transmission (%) **</td>
<td>Up to 94.6 ***</td>
<td>88.6</td>
<td>89.2</td>
</tr>
<tr>
<td>Transmitted Haze (%)</td>
<td>&lt;0.1</td>
<td>1.54</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Base Exposure (CA after 24h @pH 9)</td>
<td>10°</td>
<td>23°</td>
<td>90°</td>
</tr>
<tr>
<td>Acid Exposure (CA after 24h @pH1)</td>
<td>19°</td>
<td>15°</td>
<td>91°</td>
</tr>
<tr>
<td>Boiling H₂O (CA after 30 minutes)</td>
<td>13°</td>
<td>38°</td>
<td>98°</td>
</tr>
<tr>
<td>Mechanical Wear (CA after 1000 CC rubs)</td>
<td>12°</td>
<td>30°</td>
<td>78°</td>
</tr>
</tbody>
</table>

* Published Data  ** Uncoated baseline Transmission 88.9%  *** Subject to coating thickness
HydroPhil AS Before & After Soiling

Lotus Leaf Coatings | FAS-B | Hydrophilic-C
---|---|---
After coating before Soil Deposition

<table>
<thead>
<tr>
<th>Transmission</th>
<th>Haze</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.2%</td>
<td>0.13%</td>
</tr>
<tr>
<td>90.1%</td>
<td>0.10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission</th>
<th>Haze</th>
</tr>
</thead>
<tbody>
<tr>
<td>89.2%</td>
<td>1.30%</td>
</tr>
<tr>
<td>77.3%</td>
<td>25.4%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission</th>
<th>Haze</th>
</tr>
</thead>
<tbody>
<tr>
<td>88.6%</td>
<td>1.69%</td>
</tr>
<tr>
<td>67.8%</td>
<td>39.0%</td>
</tr>
</tbody>
</table>

Post Soil Deposition
Soiling Performance on A/R Coatings

Anti-Soiling Performance on A/R glass

- A/R Broadband Standard
- A/R Broadband HydroPhil-AS

% Haze

- before
- 100g dusted
- air cleaned (post dusted)
Anti-Soiling Coating Performance

Anti-Soiling on Float Glass

%Haze

- Standard Float Glass
- HydroPhil-AS
- FAS-A
- FAS-B
- Hydrophilic-C

Legend:
- before
- 100g dusted
- air cleaned (post dusted)
Mechanical Durability Benchmark

Mechanical Testing - Linear Cheesecloth

Contact Angle

Rubs

HydroPhil AS
Hydrophilic - C
FAS - A
Water Durability Benchmark

Boiling Water Test

Contact angle

- HydroPhil AS
- Hydrophilic - C
- FAS - A

- as prepared
- 30 min boiling water

[Bar chart showing contact angle for HydroPhil AS, Hydrophilic - C, and FAS - A after as prepared and 30 min boiling water treatments.]
Thank You

Lotus Leaf Coatings, Inc.
Albuquerque, NM

Email: info@lotusleafcoatings.com
Phone: 505-346-1492