5 Visions of NTT-AT

Super Water Repellant Coating

Hirec®

May, 2019

NTT Advanced Technology Corporation

NanoTech Solutions Norway AS

Background for developing Hirec®

NTT radio relay tower

Radio relay steel towers owned by NTT:

Approx. 1,110 nationwide

Constant maintenance needed to prevent any communication obstacles

Problems due to adhering of Snow and Ice

Transmission Interference

Ice/snow adheres to the face of the transceiver

⇒ Line interrupted

Snowed up equipment

Ice/snow adheres to equipment

⇒ Equipment damaged by the weight

75 cm Parabola Antenna (snow adhesion)

- Snow accumulation requires snow removal work
- Quick access is not possible for all locations

Solutions for Ice and Snow Adhesion

Commonly Proposed Measures

- The melting approach (install heaters)
  Problem of maintaining a power supply / environmental impact

- Snow shield coating (PTFE, etc.)
  Not as effective as the situation requires

- Coating with water repellent material
  Can be applied to equipment on site

Water repellent paint shows promising potential against ice and snow buildup

Snow/Ice Adhesion Measure

Evaluation of Commercial Water Repellents

Evaluation Criteria

- Water-repellent ability
- Initial repellent ability
- Water resistance
- Weather endurance

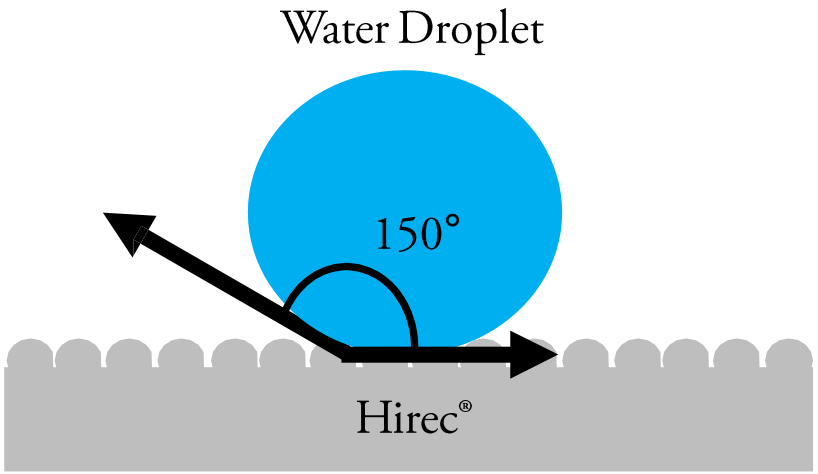
Conclusion

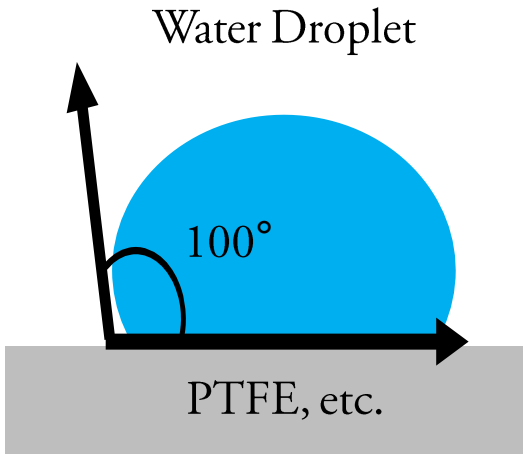
Although initial performance was good, maintaining performance was a problem (contact angle tends to decay)

NTT begins to **develop its own** coating

Contact Angle

- "Wettability" of a material is represented by Contact Angle
  - The angle between the droplet's line of tangent and the solid surface is called the "Contact Angle"
- Larger contact angle means higher water repellency

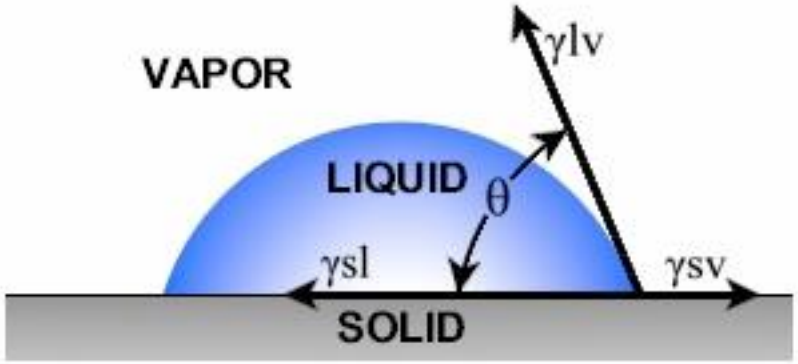




- Surface chemical structure makes the surface energy lower than PTFE, etc.
- The surface's physical form makes a corrugated texture

Water Repellent and Super Water Repellent

- The "contact angle" (θ) refers to the tangent line of the angle formed at the point of contact where the liquid touches the solid
- The contact angle is shown in Young's Equation in the diagrams below



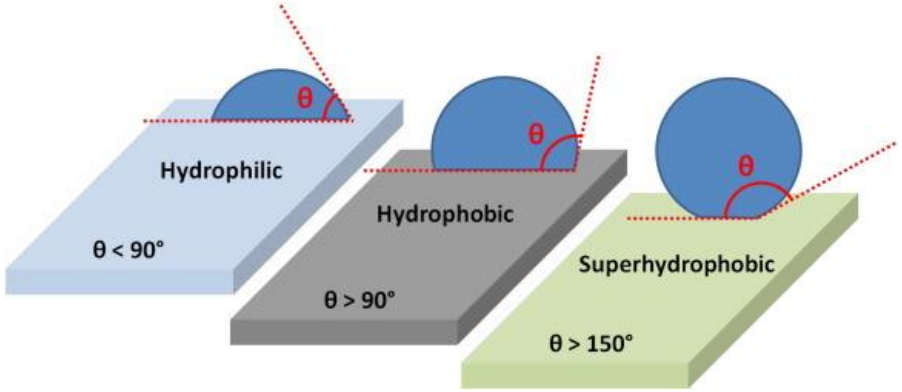
$$\gamma^{sv} = \gamma^{sl} + \gamma^{lv} cos\theta$$

θ = contact angle

γ^{sl} = solid/liquid interfacial free energy

γ^{sv} = solid surface free energy

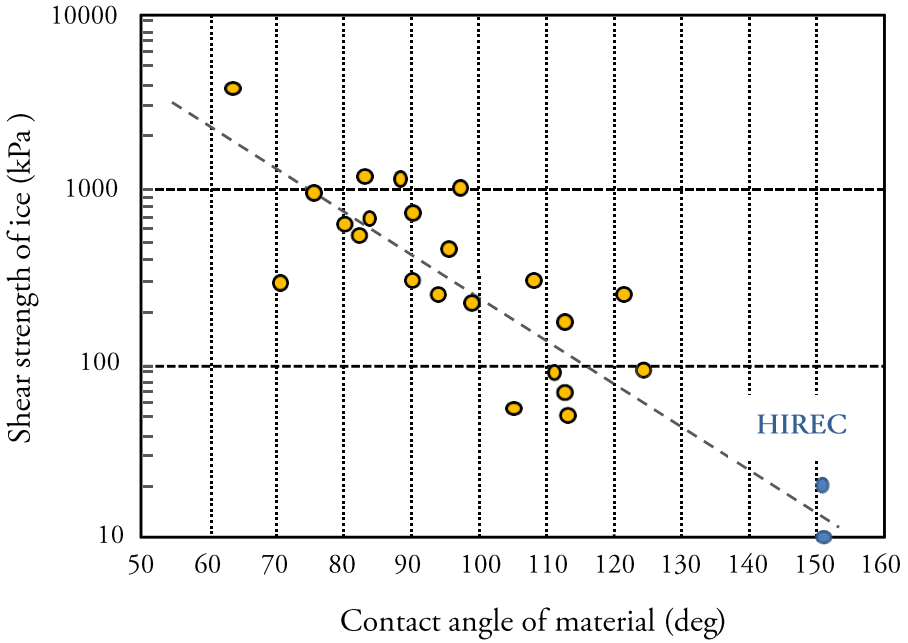
γ^{lv} = liquid surface free energy

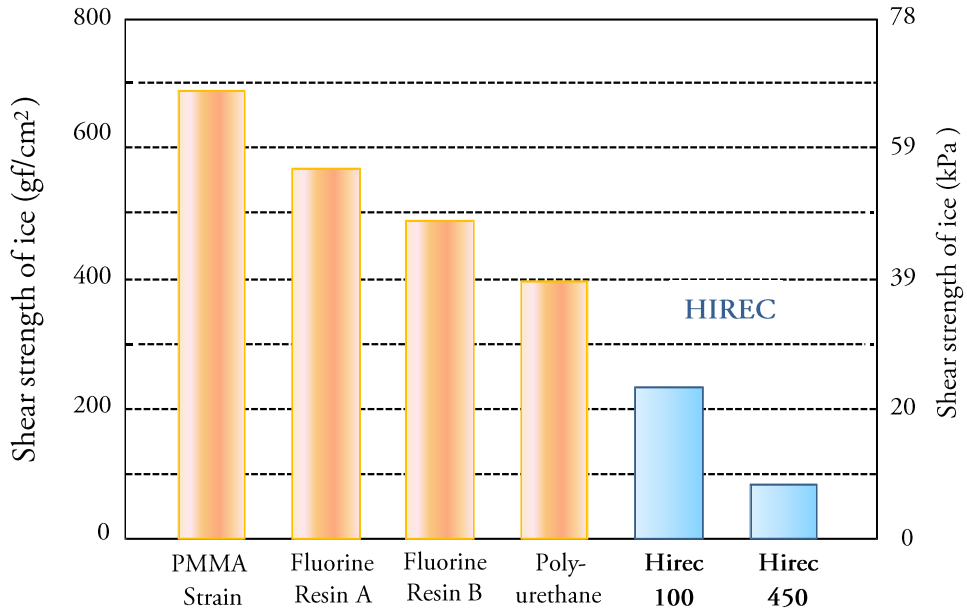


A Contact angle (θ) of more than 150°is "Super Water Repellent"

Low Shear Strength for Ice & Snow

Contact Angle vs. Shear Strength of various materials



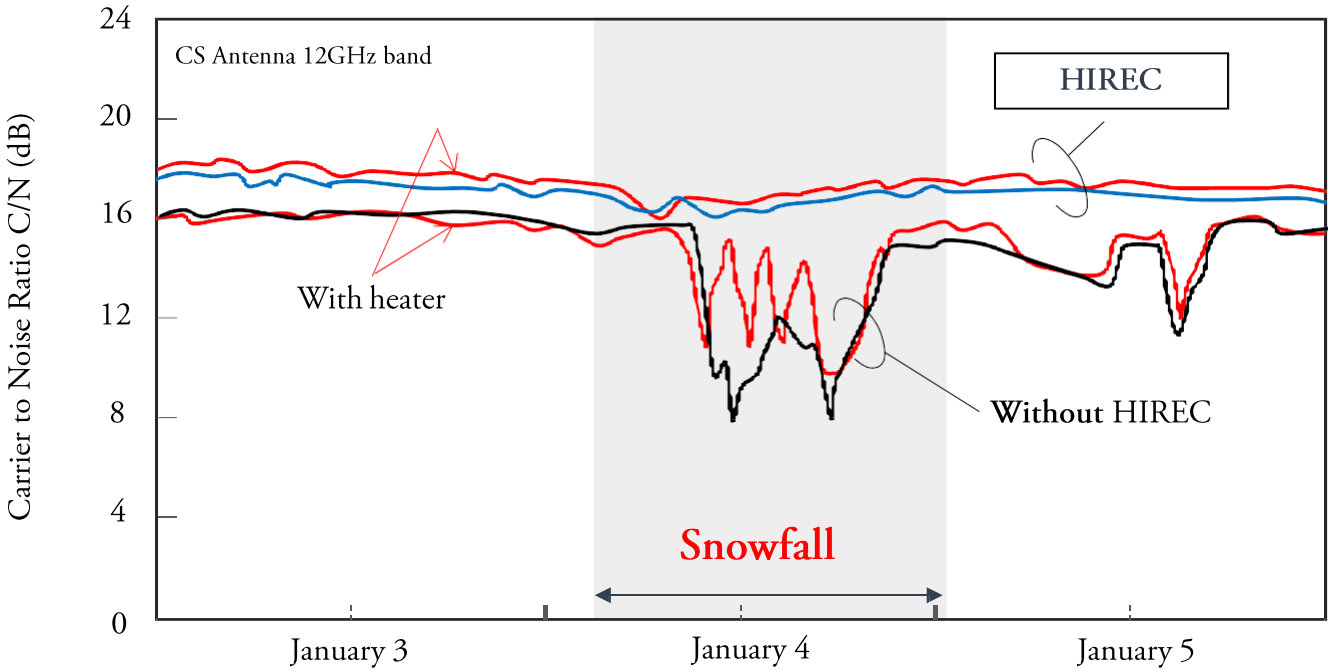


- Hirec® reduces the surface shear strength and effectively prevents the accumulation of ice and snow on the surface

Snow Accretion

Without Hirec®

With Hirec®



- Four CS antennas were set up for the test: With/without Hirec® and with/without a heater for melting snow

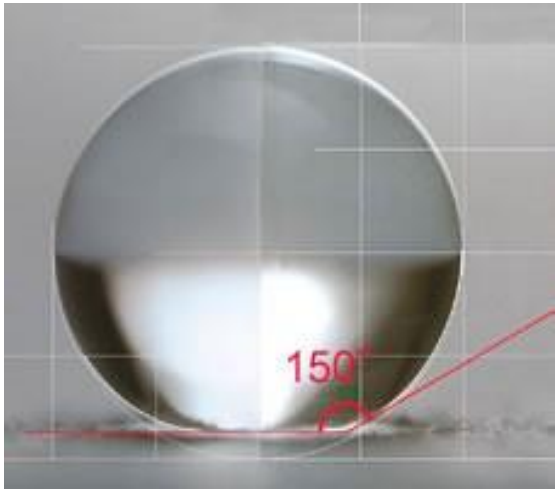
Superiority of Hirec®

Excellent hydrophobicity / water repellency

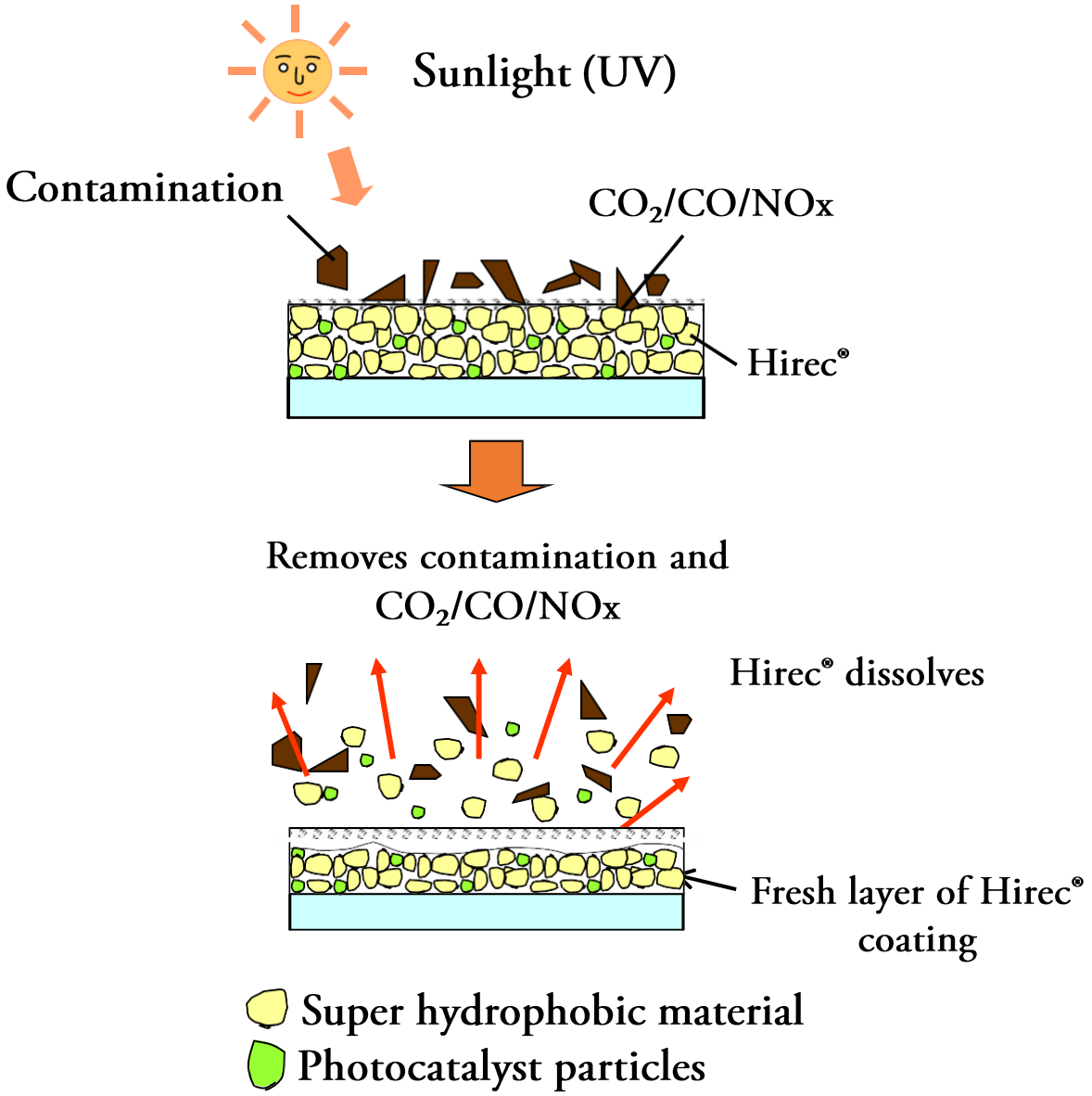
- Contact angle as high as 150°
- Microscopic surface morphology (ruggedness) realizes ultimate water repellency
- Withstanding a frosted surface is essential to realize the performance

Long term durability of water repellency

- Even after 3 years, the contact angle still is >140°
- Usually, contamination on the coated surface causes deterioration
- Hirec® can maintain the initial performance by virtue of spontaneous contamination elimination



Self cleaning



Sunlight (UV)

↓

Photo catalysis has strong oxidation power

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Pollution, gases and hydrocarbons dissolves

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Contamination is removed

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Polymer in Hirec® degrades

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The surface dissolves

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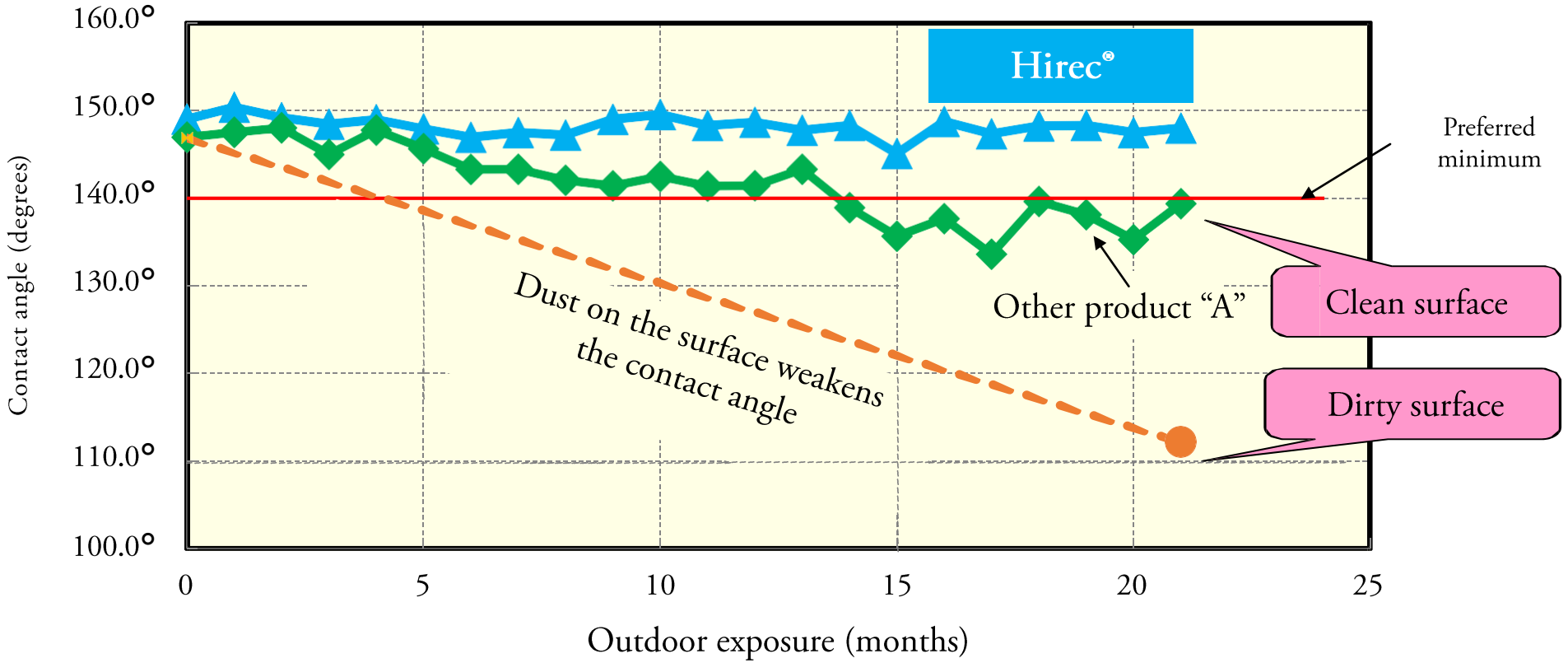
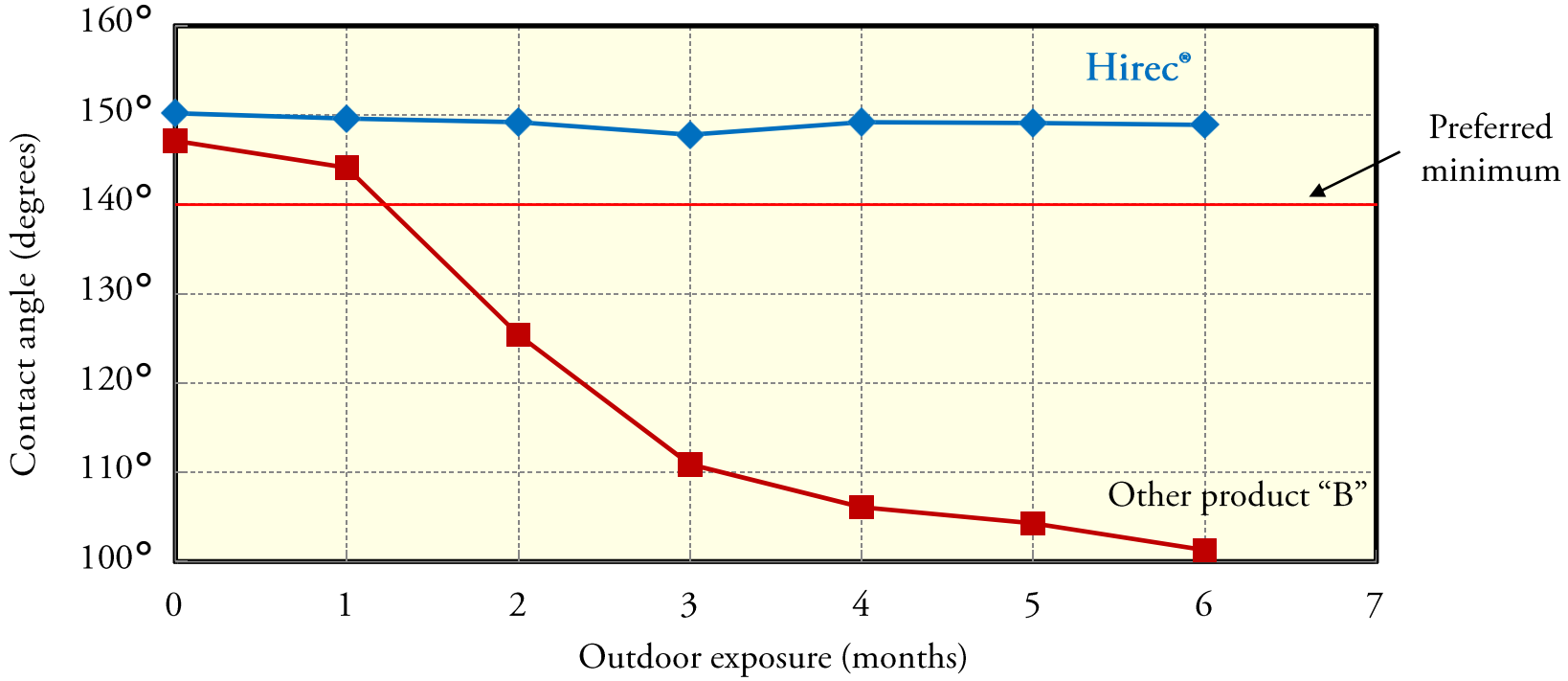
Fresh layer of Hirec® coating

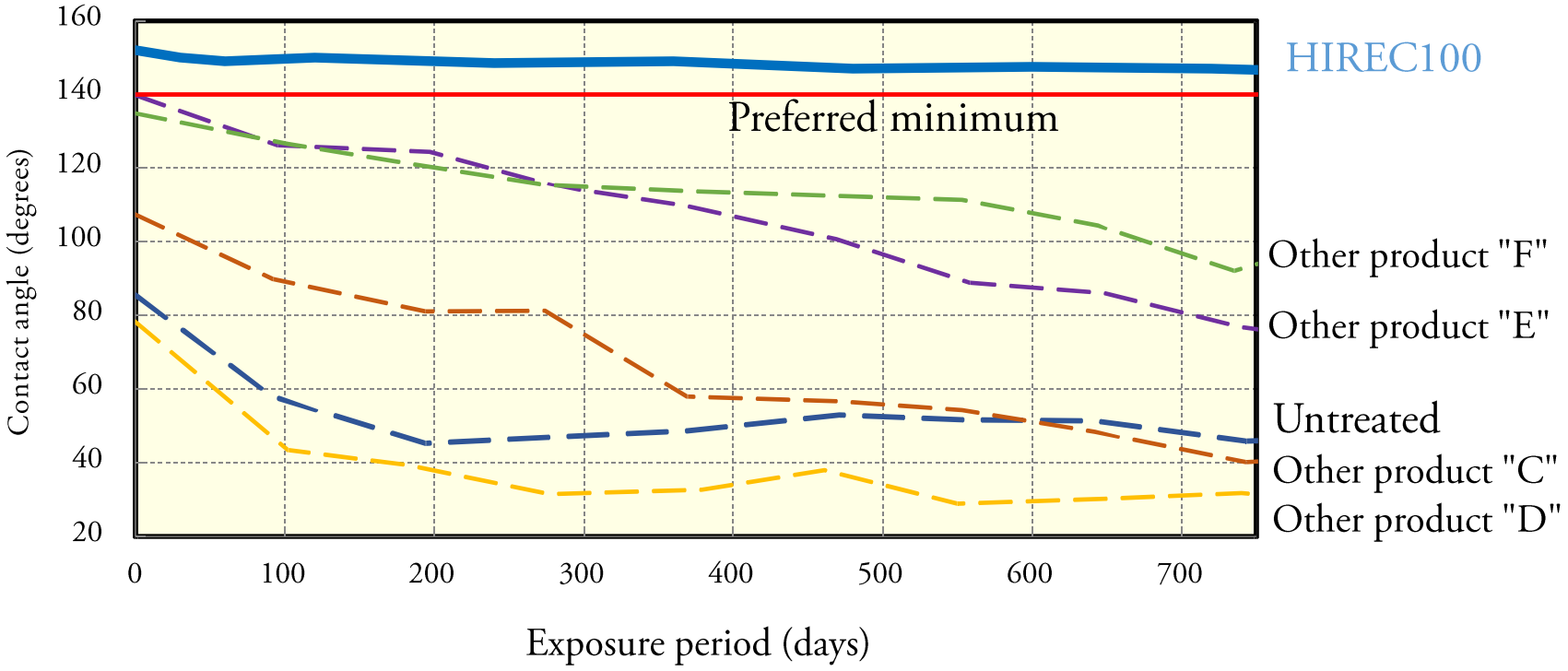
Importance of a clean surface



Degradation of contact angle



Hirec vs. Competitive solutions



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