How Aculon Surface Coatings are Enabling Medical Devices
AGENDA

- Overview
- Aculon surface treatment for medical devices
- Electronics Protection
- Repellency
- Hydrophilic
- Q&A
Aculon is a leading provider of surface modification technologies

- **Surface Solution Experts** – develop & produce technologies to modify a broad variety of surfaces (metals, glass, polymers).

- **Treatments include** - create hydrophobic, superhydrophobic, oleophobic, hydrophilic, & adhesion promoting treatments.

- **Treatments are very thin**, easy to apply and need minimal equipment.

- **Business Model:** produce/ship chemistry & can treat parts at Aculon’s facility
ABOUT ACULON

• Specializes in surface modification treatments.
• Used in medical devices, electronics, oil & gas, optical, industrial and consumer goods.
• Located in San Diego, CA
• Sell globally
WORLDWIDE DISTRIBUTION PARTNERS

- Korea
- Philippines
- Malaysia
- Taiwan/China
- Europe
- Korea
- alpha
- Philippines

Countries and regions marked on the map as distribution partners for Aculon.
SURFACE MODIFICATION EXPERTS

Other Surface Modification

Transition Metal Complexes

Polymeric Organometallics

SAMP & Organometallic
Core Medical Device Modification Technology

1. Electronics Waterproofing

2. Hydrophobic & Oleophobic Modification

3. Hydrophilic Surface Modification
Medical devices are exposed to materials which can cause their electronics to short or fail at critical moments.

- Water
- Saline
- Blood
- Bodily Fluids
Electronic medical device applications where NanoProof is relevant in helping to protect from water, blood, saline and other fluids in a medical/hospital environment.

- Hearing Aids
- Laser Scalpels (LASIK)
- Endoscopy Equipment
- Surgical Instruments
- Hematology Equipment
- Vital Sign Monitors
- Ultrasound Equipment
- Computed Tomography (CT) Equipment
- Clinical Chemistry Instrumentation
- Respiration Monitors
- Glucose Monitors
- Physical Therapy Devices
- Laboratory Measurement Equipment
- Defibrillators
- MRI Equipment
- Diagnostic Imaging Equipment
- Biomedical Testing Devices
- Urinalysis Equipment (Including Disposable Test Strips)
The IPX standards provide a waterproofing scale. and possibly design changes.

<table>
<thead>
<tr>
<th>IPX Level</th>
<th>Definition</th>
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<tr>
<td>8</td>
<td>Protected against continual water submersion in under water conditions.</td>
</tr>
<tr>
<td>7</td>
<td>Protected against water immersion for 30 minutes at a depth of up to 1 meter.</td>
</tr>
<tr>
<td>6</td>
<td>Protected against high pressure water stream from any angle.</td>
</tr>
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<td>5</td>
<td>Protected against low pressure water stream from any angle.</td>
</tr>
<tr>
<td>4</td>
<td>Protected against splashing water from any angle.</td>
</tr>
<tr>
<td>3</td>
<td>Protected against spraying water when tilted up to 60 degrees vertically.</td>
</tr>
<tr>
<td>2</td>
<td>Protected against spraying water when tilted up to 15 degrees vertically.</td>
</tr>
<tr>
<td>1</td>
<td>Protected against condensation or dripping water falling vertically.</td>
</tr>
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## WHAT LEVEL OF WATERPROOFING REQUIRED?

The IPX standards provide a waterproofing scale, and possibly design changes.

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Aculon NanoProof® Series provides water protection from humidity to full water immersion

Winner 2016 Circuits Assembly New Product Introduction Award
Aculon NanoProof® Series provides water protection from humidity to full water immersion

- Utilize proprietary technology
- Surpass competitive coatings in performance and ease of use
- Application equipment affordable and readily available
1. Reduce Product returns due to water damage
2. Improve yields as rework is possible after coating
3. No or minimal masking required
4. Coating is safe, non toxic and can be used in factory environment
5. Affordable
## NANOPROOF® SERIES COMPARISON

<table>
<thead>
<tr>
<th>Technology</th>
<th>NanoProof 1.0</th>
<th>NanoProof 3.5</th>
<th>NanoProof 4.0</th>
<th>NanoProof 5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Hydrophobic TMC based coating in hydrocarbon solvent</td>
<td>Hydrophobic / oleophillic siloxane based coating in hydrocarbon solvent</td>
<td>Hydrophobic siloxane based coating in hydrocarbon solvent</td>
<td>Hydrophobic / oleophobic fluoroacrylate based coating in fluorosolvent</td>
</tr>
<tr>
<td><strong>Water Contact Angle</strong></td>
<td>100° - 115°</td>
<td>110°-115°</td>
<td>115°-120°</td>
<td>120°-125°</td>
</tr>
<tr>
<td><strong>Oil Contact Angle</strong></td>
<td>&lt;20°</td>
<td>&lt;20°</td>
<td>&gt;20°</td>
<td>&gt;80°</td>
</tr>
<tr>
<td><strong>Barrier Effectiveness</strong></td>
<td>Good</td>
<td>Better</td>
<td>Even Better</td>
<td>Best</td>
</tr>
<tr>
<td><strong>Thickness</strong> (Sprayed - 2 Double Passes)</td>
<td>1µm</td>
<td>10µm</td>
<td>10µm</td>
<td>6µm</td>
</tr>
<tr>
<td><strong>Includes UV Tracer</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>During solvent evaporation</td>
</tr>
<tr>
<td><strong>Deformable?</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Dip/Dispense/Spray options</td>
</tr>
<tr>
<td><strong>Sprayable</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>Connectivity</strong></td>
<td>Make electrical contact through barrier</td>
<td>Allows for push through connectivity</td>
<td>Allows for push through connectivity</td>
<td>While drying allows for push through connectivity</td>
</tr>
<tr>
<td><strong>Handling Post treatment</strong></td>
<td>Ok</td>
<td>Carefully</td>
<td>Carefully</td>
<td>OK</td>
</tr>
</tbody>
</table>
NanoProof material on the PCB can be inspected by UV inspection system (UV fluorescent bulb).
• Technical Paper available for download: www.aculon.com/nanoproofpcbrepellency.php

• Aculon tested at 3 volts, 6 volts, 12 volts.
NANOPROOF® – IPX TESTING RESULTS

✓ Aculon NanoProof® 1.0 exceeds IPX-3
✓ Aculon NanoProof® 3.5 exceeds IPX-4
✓ Aculon NanoProof® 4.0 exceeds IPX-5
✓ Aculon NanoProof® 5.1 can exceed IPX-7
✓ Aculon NanoProof® treatments outperform competitive products
The coating process depends on the application and including:

1. Spray – “Preferred”
2. Dispense
3. Dip

Spraying
Dispensing
**COMPARISON WITH PARYLENE**

*Aculon NanoProof series has many advantages over Parylene coatings.*

<table>
<thead>
<tr>
<th>Application methods</th>
<th>Aculon</th>
<th>Parylene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Lasting Hydrophobicity</td>
<td>Multiple – Dip, spray wipe</td>
<td>Vacuum Deposition only</td>
</tr>
<tr>
<td>Enables Rework</td>
<td>Yes</td>
<td>Depends</td>
</tr>
<tr>
<td>Capital Equipment</td>
<td>Yes – easily</td>
<td>No</td>
</tr>
<tr>
<td>Production</td>
<td>Minimal</td>
<td></td>
</tr>
<tr>
<td>Cycle time</td>
<td>Continuous</td>
<td>Batch</td>
</tr>
<tr>
<td>Ability to treat complex parts</td>
<td>Fast: &lt;1 minute</td>
<td>Slow: 1hr-5 hrs. depending on part size and thickness</td>
</tr>
<tr>
<td>Masking required</td>
<td>Yes – low surface energy solution</td>
<td>Maybe – depends on throwing capability</td>
</tr>
<tr>
<td>Lowers Internal reject rate</td>
<td>No</td>
<td>Yes and must be “gas tight”</td>
</tr>
<tr>
<td>Energy Usage in Production</td>
<td>Yes – can rework</td>
<td>No – cannot rework</td>
</tr>
<tr>
<td>Part Size</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Treat Batteries</td>
<td>No limit</td>
<td>Large chambers up to 40”</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
ADVANTAGES OVER CONFORMAL COATINGS

- Provides effective water protection - full submersion → reduce return rate
- Flexible application process – spray, dip, dispense
- Minimal capital equipment required
- Production is continuous process, not batch.
- Treatment allows push through conductivity
- NanoProof treatments enables rework → lowers internal reject rate
- No masking required*. Can even coat batteries
- Fast cycle times < 1 minutes versus 1 – 5 hours in a chamber
- Safe - Non-toxic
Every device is different & needs testing!

- Selecting IPX performance requirement drives selection of which NanoProof
  - Impacts coating thickness
  - Impacts costs
  - Handling requirements & manufacturing process

- In general we have experienced no impact on the following
  - Signal strength, WIFI, Bluetooth.
  - Speakers and MIC.*
  - Camera
  - Antenna

- Application method available
  - Spray vs. Dip vs. Dispense

- Board Cleaning – Cleaner is better!
  - Use available PCB cleaning solutions

* Excluding NanoProof® 5.1
HEARING AIDS

Requirement: Protection from sweat and splashing water, full immersion proofing not required. IPX3 required, IPX4 desired.

Collaboration: Customer obtained and tested samples successfully

Material selected: NanoProof 4.0

Application: Excluding audio speaker, all electronics sprayed utilizing PVA FCS300 Valve

Performance: Passes customer IPX4 Qualification
**DEVICE CONTROLLER**

**Requirement:** Protection from sweat and splashing water, full immersion proofing not required. IPX4 required, IPX5 desired.

**Collaboration:** Aculon/Customer collaboration determined most robust option (5.1) needed to protect high voltage components.

**Time:** 9 months

**Material selected:** NanoProof 5.1

**Application:** Excluding audio speaker, and optical components all electronics sprayed utilizing PVA FCS300 Valve with NanoProof 5.1. Electrical connections made using diluent solvent.

**Performance:** Passes customer IPX5 Qualification Required
In summary

- Leading supplier of NanoScale Electronics Repellency Technology
- Prevent critical device failures due to liquid exposure
- NanoProof Series provides Performance/Cost options based on requirements
- Easy to apply & cost effective
- Application equipment readily available
- Outperforms and more easily implemented than competitive technology
1. Electronics Waterproofing

2. Hydrophobic & Oleophobobic Modification

3. Hydrophilic Surface Modification
Modification Type: Repellency

1. **TMC Technology**  Aculon reacts Organometallic compounds + Hydrophobic polymers = transition metal complexates (TMC) for polymer modification
   • TMCs are dissolved into solvents for coating formulations

2. **SAMP Technology**  Aculon uses hydrophobic self assembled monolayer of phosphonates (SAMPs) to react with metals, organometallics, and epoxies.
   • Deposited via dip, wipe, or spray

3. **Polymeric Growth Technology**  Aculon uses proprietary technology for deposition of highly specialized polymers for unique applications.
   • Applied at Aculon facility
Aculon’s proprietary “Self Assembled Monolayer of Phosphonates” (SAMP) can treat surfaces to impart repellency. The SAMP monolayer is comprised of a phosphonic acid and a repellent, carbon-based molecule:

1. Phosphonic acid reacts with the surface and creates a covalent bond at the substrate: phosphonic acid interface
2. The organic group connected to the phosphonic acid is the functional mono layer
3. The monolayer is less than 5 nanometers thick
TAILORING THE “R” GROUP

“Hook”
Strong Chemical Bonds
Corrosion-Resistant
Thermally-Stable

“Tail”
Surface Functionality - Lubricity, Cleanability, Anti-Corrosion
Interfacial Functionality - Adhesion, Conductivity

Example "R" Groups

R= -OH   R = CH₃
R= -COOH  R = CF₃
R= C₂H₅
R= S

Substrate
Metal oxides
ACULON – R
ACULON – R
ACULON – R

例

R= -OH   R = CH₃
R= -COOH  R = CF₃
R= C₂H₅
R= S
The process depends on the application but can include:

- Dip Applied
- Spray Applied
- Polymer Growth
- Wipe Applied
- Gravure Printing
- Pad Printing
## Performance: Repellent Technology

<table>
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<tr>
<th></th>
<th>TMC Technology</th>
<th>SAMP Repellent Technology</th>
<th>Superhydrophobic SAMP Technology</th>
<th>Polymeric Growth Technology</th>
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<tr>
<td><strong>Substrates</strong></td>
<td>Polymeric, metal, glass, ceramics, oxides, &amp; most other substrates</td>
<td>Metal, oxides, glass, &amp; other oxide containing substrates.</td>
<td>Polymeric, metal, glass, ceramics, oxides, &amp; most other substrates.</td>
<td>Metal, glass, ceramics, oxides, &amp; select polymers.</td>
</tr>
<tr>
<td><strong>Cleaning Step Required:</strong></td>
<td>Preferred but not required</td>
<td>Required, surface prep is important</td>
<td>Preferred but not required</td>
<td>Aculon Proprietary</td>
</tr>
<tr>
<td><strong>Application:</strong></td>
<td>Single step Spray, Dip, Dispense, Print</td>
<td>Typically 1-3 step Spray, Dip, Dispense, Print.</td>
<td>Three step application via Spray</td>
<td>Aculon Proprietary</td>
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</tbody>
</table>
| **Performance**  | • WCA : 105°- 120°  
• OCA : 65°- 80° (Oleophobic TMC) | • WCA : 110°-125°  
• OCA : 70°-90° | • WCA : 130°-170°  
• OCA : >70° | • WCA : 110°-125°  
• OCA : 75°-85° |
| **Durability**   | Low | Covalent bond, high | Low | High |
| **Optical Clarity** | Clear 100% transmission | Clear 100% transmission | Hazy (60% transmission) | Clear (100% transmission) |
Dispensing Tip

**Requirement:** Eliminate accumulation of fluids at stainless steel dispensing tip

**Collaboration:** Customer treated & tested successfully

**Material selected:** Aculon SAMP Repellency Treatment

**Application:** Dip

**Performance:** No droplet accumulation at dispensing tip
Urine Repellency

**Requirement:** Complete Drainage of Urine from Container – No droplets left behind

**Collaboration:** Aculon evaluated customer parts, applied treatment, & customer tested successfully

**Material selected:** SuperHydrophobic SAMP Treatment

**Application:** Three step spray process

**Performance:** WCA >130
Requirement: Hydrophobic patterning

Collaboration: Aculon treated parts & customers tested successfully

Material selected: Aculon TMC on Glass

Application: Pad Printing

Performance: Aqueous Culture Droplets Isolated

Diagnostic Chips
Core Medical Device Modification Technology

1. Electronics Waterproofing

2. Hydrophobic & Oleophobobic Modification

3. Hydrophilic Surface Modification
Hydrophilic Coating Technologies

1. **Hydrophilic TMC** Aculon reacts Organometallic compounds + hydrophilic polymers = transition metal complexates (TMC) for polymer modification
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## Performance: Hydrophilic Technology

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</table>
| **Performance**     | • WCA : <20°  
                     • OCA : <20°                                                   | • WCA : <20°  
                                                             • OCA : <20°                                                   |
| **Durability**      | Low                                                                           | High mechanical and chemical durability                          |
| **Optical Clarity** | Clear (100% transmission)                                                     | Clear (100% transmission)                                        |
**Example Applications: CELL REPELLING**

**Requirement:** Prevent cells from sticking to metal filters

**Collaboration:** Aculon treated filters and customer tested successfully

**Material selected:** Polymer Growth Technology

**Application:** Aculon Proprietary

**Performance:** Water Contact Angles <10 degrees after treatment. Prevents adsorption of biological materials.
Requirement: Permanent mold release on quartz of silicon hydrogels.

Collaboration: Aculon treated molds and customer tested successfully.

Material selected: Polymer Growth Technology

Application: Aculon Proprietary

Performance: Superior mold release. Biocompatible
Requirement: Greater efficiency of fluid transfer for diagnostic chips.

Collaboration: Customer obtained and tested successfully.

Material selected: Aculon TMC

Application: Dispense

Performance: Improved capillary action and wetting of fluidic channels to aqueous solutions.
- Initial WCA 60-90 degrees
- Post treatment: <10 degrees
Adhering Agarose Gels

**Requirement:** Agarose gel bonding to PMMA

**Collaboration:** Customer obtained and tested successfully.

**Material selected:** Aculon OP-287 Hydrophilic TMC

**Application:** Wipe apply the primer, and cure at 60C for 10 minutes, then cast agarose gel

**Performance:** >= 2lbs /sq. inch adhesion
Aculon is a leading provider of surface modification technologies.

- Modify a broad variety of surfaces and particles with a durable easy to apply performance modifying treatments in seconds with little or no capital.

**Treatments include:**

1. Hydrophobic
2. Superhydrophobic
3. Hydrophillic
4. Oleophobic
5. Adhesion promotion
QUESTIONS AND CONTACT INFO

Presentation
- Will be emailed to all attendees

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Questions

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