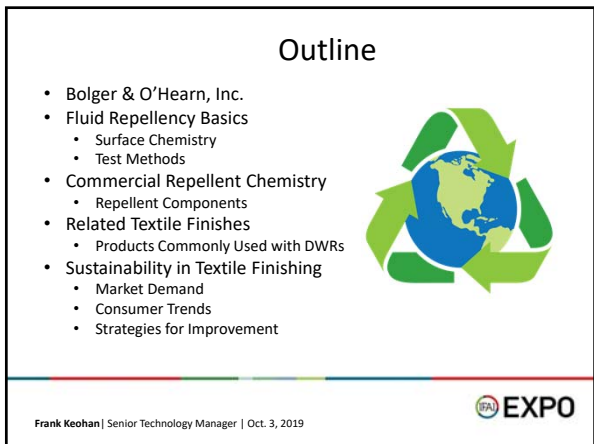




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3

Outline

- Sustainability in Repellents
 - Bio-Renewable Raw Materials
 - Recycled Raw Materials
 - Hazardous Materials Elimination
- Energy Conservation
 - Lower Temperature Cure
 - Alternative Cure Chemistries
- Material Conservation
 - Raw Materials Conservation
 - Water Conservation
- Performance Issues and Opportunities
- DWR-Textile Concepts for Improving Sustainability

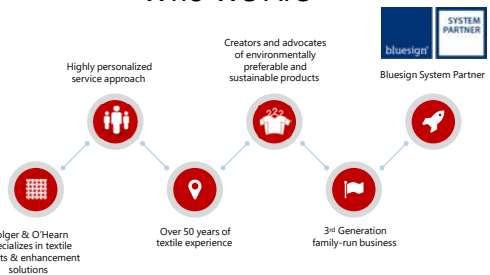


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4

Who We Are



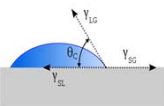
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5

Repellency Terms

- Hydrophobicity - Water fearing
- Hydrophilicity - Water loving
- Surface Tension- the tension of the surface film of a liquid caused by the attraction of the particles in the surface layer by the bulk of the liquid
- Contact Angle



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6

Liquid Repellency

- Creating a surface with energy characteristics that prevent wetting interaction of fluids

- For water, surface needs to be hydrophobic
- For oils, surface needs to be lower in energy than cohesive forces keeping liquid together

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Water Repellency

- Hydrogen Bonding
 - Strong intramolecular attraction
 - High Dipole Moment

- Hydrophobicity (lack of polarity) inhibits water's tendency to interact (wet-out) with low energy surfaces
- Water molecules remain hydrogen-bonded with themselves unless contacting a more polar surface

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Water Repellents

- Water Repellent Finish
 - Chemical treatment at fiber level that renders textiles resistant but not impervious to water penetration
 - Finishes should not be visible or alter physical properties of textiles
- Increase Surface Hydrophobicity
- Preserve Surface Tension of Liquids

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DWR: Durable Water Repellent

- A fabric finish that coats fiber surfaces with hydrophobic layer-does not bridge fibers or reduce breathability
- Typically applied in mill – dip fabric into DWR bath -Squeeze/Dry
- Industry spec- 100 initial spray, 80 spray rating after 20 home laundry cycles (AATCC TM 22)
- Commonly used on awnings, boatcovers, apparel, umbrellas, carpets



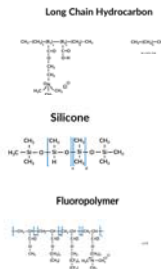
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10

Repellent Chemistry

- Hydrocarbons
 - Hydrocarbon polymers, waxes and derivatives
 - No oil repellency
- Silicones
 - Coats fibers with silicone rubber, water repellency
 - No oil repellency
- Fluoropolymers
 - Coats fibers with low surface energy fluoropolymer for highest level of repellency against water and oils



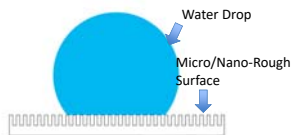
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11

Surface Texture and Repellency

- Physical Requirements for High Water Repellency
 - Hydrophobic Surface
 - Surface Roughness on Microscale and Nanoscale





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12

Repellency Test Methods

- Spray Test (AATCC TM-22)
 - 250 ml, 20 s duration, 6 in drop height
 - Short, gentle spray, qualitative repellency rating
 - Most popular industry-wide
- Impact Penetration (AATCC TM-42)
 - 500 ml, 24 in drop height, witness blotter in back
 - Measures water penetration quantitatively
- Hydrostatic Pressure Test (AATCC TM-127)
 - Quantitatively measures penetration of water under hydrostatic pressure
- Bundesmann
 - Rainstorm simulator
 - Measures repellency, absorption, and penetration
 - Allows control of water impact duration and severity



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13

Fabric Finishes Typically Used with DWRs

- Softeners/Lubricants/Napping Agents
- Anti-Wrinkle/No-Iron/Permanent Press Resins
- Hand Builder Resins
- Antimicrobial
 - Odor Control/Odor Absorption
- Soil Release
- Flame Retardants



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14

Marketability of Sustainable Products

- Sustainability as a Business Opportunity
- Brands Leading the Transition to More Sustainable Textiles
- Consumer Demand for Sustainable Products Significantly Increasing




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15

Consumer Preference for Sustainable Products

- Consumers of Footwear, Apparel and Outdoor Gear were Surveyed on the Effect of Sustainability on their Purchasing
 - 90% considered sustainability/eco-friendliness as an important factor
 - 77% were willing to pay more for sustainable/ eco-friendly products
 - 95% thought that brands having sustainability strategies should advertise it
 - Outdoor Insight, June 2019

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16

Consumer Demand for Higher Performing Fabrics


- North America is the fastest-growing market for performance fabrics in the world. (MarketsandMarkets, Feb 23, 2016)
- Textiles Having High Durability and Tenacity in Demand for Apparel and Technical Textiles (ISPO-2019)
- Only 2% of Apparel and Footwear Shoppers were Willing to Give up Water Resistance for Sustainability (Textile Insight-Sept./Oct., 2018)
- High-performing sustainably produced textiles in greatest demand

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17

Global Trend of Increasing Substitution of Sustainable Technologies

- 81% of global respondents feel strongly that companies should help improve the environment
 - (Nielsen Report -CPG, FMCG & Retail, 11-09-2018)
- Food Industry-replace single-use plastic articles, reduce packaging waste, promoting organic produce
- Transportation – higher efficiency engines, electric vehicles
- Energy-solar, wind, geothermal, higher efficiency heating/cooling systems
- Textiles-hazardous chemical replacement, recycled and bio-based material integration

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18

Forces Behind Sustainability Advancement

- Consumers
 - Searching for options that are healthier for them and for their homes
 - Millennials, Gen Z and Gen X are the most supportive
 - Younger consumers are constantly reacting, evolving, and growing more sophisticated
- Government Initiatives
 - U.S. Office of Federal Sustainability, U.S. EPA, European Commission
- Non-Governmental Organizations (NGOs)
 - Greenpeace, WHO, Healthy Building Network
- Industry Associations
 - Outdoor Industry Association, Retail Industry Leaders Association

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19

Sustainability Assessment for Textile Finishing Products

- NSF/ANSI 336-Sustainability Assessment for Commercial Furnishings Fabric Guide
 - Fiber Sourcing
 - Safety of Materials
 - Water Conservation
 - Water Quality
 - Social Accountability
 - Air Quality
 - Energy
 - Recycling Practices in Manufacturing/End of Use





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20

Sustainable Solutions

- Conservation of Energy/Renewable Energy Integration
- Conservation of Raw Materials
- Conservation of Water
- Renewable/Responsible Materials Integration
- Recycled Materials Integration
- Chemical Hazard Minimization
- Carbon Footprint Reduction




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21

Sustainability Quotient for Chemical Products

- Assign Range of Points for Each Sustainability Category
- Assess Chemical Product for Each and Allocate Points
- Tally Points to Yield Sustainability Quotient
- Use Quotient for Marketing and Quality Management




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22

bluesign® System



- Participation in the bluesign® system significantly aids sustainable textile production.
- It eliminates harmful substances from the manufacturing process in accordance with Zero Discharge of Hazardous Chemicals (ZDHC) protocols
- Sets and controls standards for environmentally friendly and safe production
- Ensures that the final textile product meets very stringent consumer safety requirements worldwide



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23

Integration of Renewable Materials in Textile Finishes

- Bio-Renewable Materials
- Recycled Materials



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24

Renewable Raw Materials in Textile Products

- Bio-Renewable Materials
 - Fatty Acids from Vegetable Oils in DWRs, Softeners and Surfactants
 - Natural Waxes in DWRs
 - Starches in Hand Builders and Surfactants
 - Natural Rubber in Waterproof Coatings
 - Pine Oil Isoprenoids in Waterproof Coatings
 - Castor Oil Derivatives for Polyurethane Coatings




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25

Potential Recycled Material Feedstocks

- Monomers from Depolymerized Waste Resins
 - Polyesters
 - Vinyl Polymers, e.g. styrene
- Fatty Acids from Waste Detergents, Soaps and Cooking Oils
 - Stearic Acid
- Waxes from Expired Sealing Products



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26

Minimization of Organic Solvents and Hazardous Ingredients in Textile Finishes

- Solvents Used in DWR Finishes
 - Residual monomers, process VOCs
- Hazardous Chemicals Used in DWR Finishes
 - Long-Chain Fluoropolymers (PFOS, PFOA), Curing Agents, APEO Surfactants
- Alternative Eco-Friendly DWR Formulation and Application Methods



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27

Challenges to Incorporating Bio-Based Raw Materials into Textile Finishes

- Performance Limitations
 - Replacing Specialized Chemicals with Bio-Derived Analogs Seldom Simple
- Diversion of Foodstuffs
 - Corn and soybean derivatives
- Unintended or Detrimental Properties
 - Regrettable Replacements, e.g., BPS for BPA in plastics (BPS can be as hazardous than BPA)

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Using High Performance Additives to Enable Renewable Raw Material Integration

- **Boost** Finish Performance by Using Small Amount of High Performance Additives
- Nanomaterials
 - Graphene, CNTs, Clays
- High Activity Surfactants
- Silicones

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29









Strategies for Improving Sustainability in Textile Finishing

- Product Sustainability Audit
 - Composition of Current Finish
 - Sustainable Material Content
 - Areas for Bio-based Raw Material Integration
- Process Sustainability Audit
 - Water Usage
 - Energy Usage/Renewable Energy Content
- Performance Specifications


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30

Potential Bio-Based DWR Feedstocks

- Cellulosics
 -  α -D-Glucose
 -  Starch
- Lignins
- Natural Oils
 -  β -D-Glucose
 -  Cellulose
- Natural Waxes
- Polyols Derived from Natural Oils
 -  cis-Polyisopren
 -  trans-Polyisopren
- Polyisoprenoids (Tree Sap)
 -  Birtapreneol
 -  Diterpene
- Sugars and Starches


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31

Alternative Processing Methods for Conserving Energy

- Design processes that use less energy
 - Low temperature cure finishes
 - Alternative curing methods such as RF, UV, Ultrasonic
 - Process optimization-don't use more power than is needed to achieve desired results
- Integrate renewable power sources
 - Solar, wind, geothermal
- Reduce power waste
 - Improve insulation and heat transfer processes
- Integrate sustainable materials in your supply chain




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32

Textile Recycling Options

- Reuse/Repurpose
 - Article and fabric-level recycling
- Remelt Fabric/Spin into New Yarn
 - Also other common plastic sources, e.g., PET bottles
- Depolymerization/Repolymerization of Textile Polymers to Virgin Yarn
 - Produces highest quality products
- Limit design of complex constructions (e.g., laminates) to simplify recycling




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33

DWR Applications for Increasing Industrial Sustainability

- Improving Sustainability of DWR Chemistry
 - Design textile products with built-in sustainability throughout supply chain
 - Consider fluorochemical alternatives
 - Reduce or eliminate VOCs and HAPs
 - Increase finish durability
 - Reduce effective dosage
 - Reduce application energy usage
 - Integrate renewable raw materials



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34


Fluorine-Free (C0) DWRs

- Hydrocarbon-Based
 - Oldest and newest technology represented
 - Bio-renewable raw materials integration opportunities
 - Excellent environmental profile
- Silicone-Based
 - Provides softness and repellency
 - Resistant to outdoor weathering
 - More expensive raw materials
 - Storage stability issues
 - Biodegradation and recyclability issues


Long Chain Hydrocarbon



Silicone



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35

Co-Optimization of C0-DWRs and Fabric Construction For Improved Textile Product Sustainability

- Performance of C0 DWRs highly dependent on fabric type, auxiliary products, and pre-finish fabric quality
- Develop database of repellency properties for different C0 DWR/fabric combinations
- Design textile products based on optimum C0 DWR/fabric combinations
 - Use **minimum** DWR add-on to achieve repellency specs
 - **Reduce** curing energy requirements


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36

Properties Obtainable for Selected Textiles Finished with High-Performance C0 DWRs

- 90+ AATCC 22 spray rating after 30 HL on synthetics
- Equivalent water repellency to C6 products on cotton
- Excellent resistance to staining by aqueous liquids
- Optimized C0 DWR/fabric combinations show high Bundesmann repellency performance




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37

Co-Optimization of C6 DWRs and Fabric Construction For Improved Textile Product Sustainability

- C6 DWRs offer high performance on a wide variety of fabrics styles and compositions
- Employ high performance fluorochemical repellents in ways that improve textile product sustainability
 - **Use minimum** DWR add-on to achieve repellency specs
 - **Reduce** curing energy requirements
 - **Combine** fabric construction with advanced repellents to reduce product complexity and provide new performance category



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38

Co-Engineering Textile Products for Performance and Sustainability

- Define Final Textile Product Properties/ Features
 - Consult Database of Fabric-Finish Combinations
 - Design Product Accounting for Fabric and Finish
 - Select Fabric and Finish Candidates that Yield Simplest and Most Sustainable Solution
- Prepare Prototypes and Measure Performance




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39

**New Performance Fabric Category
for Increased Sustainability**

Stormproof/Breathable™



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40

Waterproof/Breathable Fabrics



- Waterproof/Breathable Textiles Characterized by High Hydrostatic Resistance with Water Vapor Permeability
- Waterproof/Breathable Textiles Include Coated Fabrics and Complex Laminated Structures
- Waterproof/Breathable Textiles in Demand
 - 45% of Snow Sports Apparel Consumers Polled Listed this Attribute Most Important (Textile Insight, Jan./Feb., 2018)
- Waterproof/Breathable Fabrics Found in Sports Apparel, Footwear, Workwear, Boat and Car Covers, Medical Garments


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41

DWR Performance Meaning

- An AATCC 22 spray rating of 100 means you will be protected for about 2 minutes.
 - 20-second test duration, light spray
- An AATCC 22 spray rating of 70-80 means that after 20 seconds in the rain, you will likely be drenched.
- A Bundesmann rating of 5 after 20 minutes means you will protected for 20 minutes or longer in the rain.

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42

Stormproof/Breathable™ Characteristics

- What Constitutes the New Stormproof/Breathable™ Category?
 - Nonlaminated, uncoated simple fabric constructions for enhanced sustainability
- **Stormproof:** defined as the ability to maintain the highest repellency ratings (4-5) after one hour duration in a **Rainstorm Simulation test**
- **Breathable:** defined as a finished fabric or fabric construction having **≥ 95% of air permeability** (e.g. CFM) as the pre-finished fabric or non-laminated fabric construction.

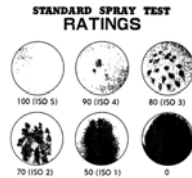
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43

Standard Repellency Standards

- Typical Industry Water Repellency Spec
 - 100, 80/20 Water Spray
 - 100 rating Initial, 80 rating after 20 launderings
 - (AATCC Method 22)



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44

Stormproof/Breathable™ Treatments for Industrial Fabrics

- Ability to Manufacture Sustainable 'Membrane-Free' Protection
 - Prevent backside moisture accumulation
 - Decrease dry time
 - Provide increased article design options
 - Simplify fabric recyclability
 - More sustainable manufacturing
- Sustained High Water-Impact Resistance
 - Measured in lab using Rainstorm Simulation test
- High Breathability


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45

Stormproof Standards

- **Stormproof**
 - Maintenance of 4-5 Bundesmann rating after 60 minute rainstorm simulation
 - Maintenance of 100 spray rating after simulated rainstorm exposure


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46


Difference Between Standard 80/20 DWR and Stormproof/Breathable™ Finishes

Stormproof/Breathable™ finishes are like a healthy dense forest with uniform, adherent, and well-organized coatings for optimal water repellency




Stormproof/Breathable™

Standard DWR finishes form partially organized coatings that provide light spray resistance



Standard AATCC 22 100 Spray Rating DWR

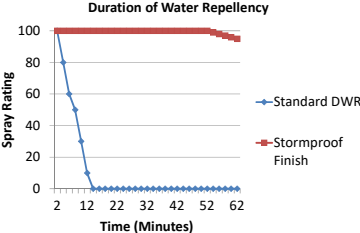
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47

Standard DWR Vs. Stormproof Finish


Duration of Water Repellency



| Time (Minutes) | Standard DWR Spray Rating | Stormproof Finish Spray Rating |
|----------------|---------------------------|--------------------------------|
| 2 | 100 | 100 |
| 12 | 50 | 100 |
| 22 | 10 | 100 |
| 32 | 0 | 100 |
| 42 | 0 | 100 |
| 52 | 0 | 100 |
| 62 | 0 | 100 |

- **Stormproof** finishes prevent fabric wet-out for extended rain protection

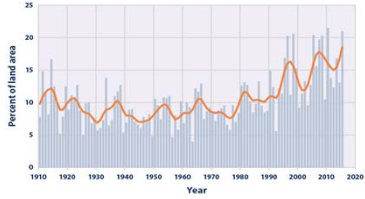
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48

Why Do We Need Stormproof/Breathable™ Products?

- **Figure 1.** Extreme One-Day Precipitation Events in the Contiguous 48 States, 1910–2015



- Extreme rainfall events becoming more frequent in U.S.
Data source: NOAA, 2016

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49

Fabric Weather Protection Options

- **Durable Water Repellents (DWRs)**
 - Finish that makes water bead up on fabric
- **Coated Fabrics**
 - Water blocking coating
 - Like *house paint*
 - Face fabric can be finished with DWR
- **Membrane-Fabric Laminates**
 - Water-blocking film glued to fabric
 - Like *house wrap*
 - Face fabric can be finished with DWR



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50

Stormproof Vs. Standard DWR



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51

Standard Repellency Standards Vs. Stormproof Demonstration

- Treated 100% Polyester Canvas with
 - Standard DWR (100, 80/20 Water Spray 22)
 - Stormproof/Breathable™ Finish
- Measured Hydrostatic Pressure Resistance (Hydros)
- Exposed Each Sample Set to 10 minutes Rainstorm Simulation (Bundesmann)
- Measured % Water Absorption and remeasured Hydros Immediately after Exposure

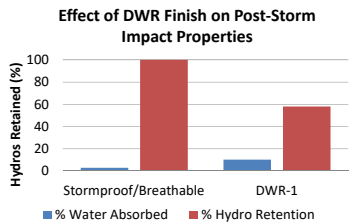
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52

Stormproof/Breathable™ Finish Effects on Polyester Canvas


Effect of DWR Finish on Post-Storm Impact Properties



| Finish | % Water Absorbed | % Hydro Retention |
|-----------------------|------------------|-------------------|
| Stormproof/Breathable | ~5% | ~95% |
| DWR-1 | ~15% | ~60% |

- Stormproof/Breathable™ finish enhances protection value of canvas materials

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53

Sustainability Advantages of Using Advanced DWR Finishes

- Single-ply Fabrics Finished for Stormproof/Breathable™ Performance Save Energy And Materials in Manufacturing
- Avoiding the Different Adhesives, Films, and Coatings Used in Laminated Textiles Greatly Simplifies the Recycling of the Used Products



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54

Market Applications for Fabrics Finished with Advanced Sustainable DWRs

- Awnings
- Boat Covers and Bimini Tops
- Convertible Car Tops and Covers
- Indoor-Outdoor Upholstery
- Outdoor Apparel



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55

Summary

- Variety of chemistries available for making repellent textiles
- Most repellents give a low but reliable level of repellency
- Demand for sustainably manufactured textile products increasing
- Sustainability can be raised by using renewable and recycled raw materials, more efficient processes, and eco-friendly product design
- Emerging DWR technology can deliver high performance while improving product sustainability

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56

Thank You



57



58
