Surface modification of textiles using eco-friendly plasma technology for dry finishing of cotton

Shital Palaskar & A. N. Desai
Bombay Textile Research Association (BTRA) Mumbai, India

• BTRA was established in 1954 as research association by textile mill owners of Mumbai. It is a all India body catering to needs of Indian textile industries.

• The mandate is to undertake research and other scientific work in connection with the textile trade or industry and other trades or industries allied therewith or accessory thereto.
Main Activities

Technical Services
- Consultancy in all aspects of textiles
- Utilities / Conservation
- Quality & Environment Management
- Decentralised Sector

Training Services
- HRD
- Need based training

Research Projects
- Government funded
- In house

Testing Services
- Physical and chemical testing
- Polymer and Eco-Parameters testing
- Technical textiles / composites testing
- Microbiology

For more details-
Website- www.btraindia.com
Email-btra@vsnl.com
-91-022-2500-2652
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Plasma Technology

PHASES OF MATTER

Structure of an atom:
- Proton (+ charge)
- Electron (- charge)
- Neutron (no charge)

Solid
Liquid
Gas
Plasma

Low
Temperature or Energy
High
How Does Plasma Work?

Fabric Surface

Plasma Zone

Clean & plasma Activated Fabric
Plasma-surface Interactions

non polymerising gas plasma

polymerising gas plasma

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Advantages of Plasma Technology

• Dry & clean processing
• No effluent hence Non polluting
• No Change in Bulk Properties
• Reduced water, chemical and energy consumption
• Eco-friendly
Our Work

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
<th>Plasma Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water loving cotton fabric</td>
<td>Water repellent cotton fabric</td>
<td>Hydrophobic</td>
</tr>
<tr>
<td>Water repellent polyester</td>
<td>water absorbent polyester</td>
<td>Hydrophilic</td>
</tr>
<tr>
<td>Dyed cotton fabric</td>
<td>Dyed cotton after plasma fabric</td>
<td>Improved Dyeing</td>
</tr>
</tbody>
</table>

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The Plasma Machine is from GRINP - www.grinp.com

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Hydrophobic Finishing

100% cotton fabric
HMDSO plasma
Discharge power: 2000W, Argon Plasma
Duration: 80-320 s
Monomer flow –1.25 mL/min

Untreated cotton          HMDSO Plasma Treated
Water Repellency Spray Test
AATCC-22-2005

- 100: No sticking or wetting
- 90: Random sticking or wetting
- 80: Wetting at spray points
- 70: Partial wetting beyond spray point
- 50: Complete wetting of the face
- 0: Complete wetting of specimen

Spray Rating vs. Plasma Treatment Time

<table>
<thead>
<tr>
<th>Plasma Treatment Time</th>
<th>0</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ctrl</td>
<td>0</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>80 sec</td>
<td>0</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>160 sec</td>
<td>0</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>240 sec</td>
<td>0</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>320 sec</td>
<td>0</td>
<td>60</td>
<td>50</td>
<td>40</td>
<td>30</td>
</tr>
</tbody>
</table>

Before wash

After 5 wash
Water Repellency

Contact Angle and Surface Energy

Plasma Treatment time

- Purple: Contact angle °
- Red: Surface energy d/cm
- Blue: Contact angle after 10 wash
- Green: Surface energy after 10 wash

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## Surface Chemistry - FTIR

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Band</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1256 cm⁻¹</td>
<td>Symmetric CH₃ deformation</td>
</tr>
<tr>
<td>2</td>
<td>840 cm⁻¹</td>
<td>Si–C rocking vibrations in the Si-CH₃ groups</td>
</tr>
<tr>
<td>3</td>
<td>795 cm⁻¹</td>
<td>Si–CH₃ rocking vibrations</td>
</tr>
<tr>
<td>4</td>
<td>1029 cm⁻¹</td>
<td>Si-O-Si, Si-O-C stretching</td>
</tr>
</tbody>
</table>

### Band Assignments

- **1256 cm⁻¹**: Symmetric CH₃ deformation
- **840 cm⁻¹**: Si–C rocking vibrations in the Si-CH₃ groups
- **795 cm⁻¹**: Si–CH₃ rocking vibrations
- **1029 cm⁻¹**: Si-O-Si, Si-O-C stretching

### Absorbance

- **a)** Untreated cotton
- **b)** t=80s
- **c)** t=160s
- **d)** t=240
- **e)** t=320s

### Wavenumber (cm⁻¹)

| 4000 | 3650 | 3300 | 3050 | 2950 | 2850 | 2750 | 2650 | 2550 | 2450 | 2350 | 2250 | 2150 | 2050 | 1950 | 1850 | 1750 | 1650 | 1550 | 1450 | 1350 | 1250 | 1150 | 1050 | 950  | 850  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
Surface Morphology by SEM

- Untreated cotton
- Plasma Treated for 80Sec
- Plasma Treated for 160Sec
- Plasma Treated for 320Sec
## Physical Properties of Plasma Treated Samples

<table>
<thead>
<tr>
<th>Sample details</th>
<th>Mean</th>
<th>Variance</th>
<th>t&lt;sub&gt;table&lt;/sub&gt;</th>
<th>t&lt;sub&gt;calculated&lt;/sub&gt;</th>
<th>WVT (mg/cm²/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>15.5</td>
<td>0.2</td>
<td>1.7</td>
<td>--</td>
<td>3.0</td>
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<tr>
<td>80sec</td>
<td>11.8</td>
<td>0.4</td>
<td>20.8</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>160sec</td>
<td>11.1</td>
<td>0.1</td>
<td>32.1</td>
<td>2.9</td>
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</tr>
<tr>
<td>240sec</td>
<td>11.5</td>
<td>0.5</td>
<td>21.4</td>
<td>2.6</td>
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<tr>
<td>320sec</td>
<td>11.2</td>
<td>1.0</td>
<td>17.1</td>
<td>2.7</td>
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</tbody>
</table>
## Tensile Properties

<table>
<thead>
<tr>
<th>Sample</th>
<th>warp Tenacity (RKm)</th>
<th>variance</th>
<th>weft Tenacity (RKm)</th>
<th>variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>17.9</td>
<td>4.6</td>
<td>17.6</td>
<td>1.5</td>
</tr>
<tr>
<td>80sec</td>
<td>18.6</td>
<td>4.6</td>
<td>16.7</td>
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<tr>
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<td>18.9</td>
<td>4.8</td>
<td>16.3</td>
<td>1.3</td>
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<tr>
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<td>17.8</td>
<td>2.4</td>
<td>17.14</td>
<td>2.2</td>
</tr>
<tr>
<td>320sec</td>
<td>18.4</td>
<td>3.1</td>
<td>16.3</td>
<td>4.2</td>
</tr>
</tbody>
</table>
Summary

• Hydrophobic finishing on cotton fabric is developed by using plasma technology in dry manner

• It is an Eco-friendly, sustainable technology

• Applicable in all technical textile field

• Apart from water repellency plasma is being used for many other applications in textile like hydrophilic, oil repellent, improved dyeability
IP Status

- Patent Filed for Multi-functional Cotton Fabric
- 12 peer reviewed papers in national and international journals
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