3

Man Made Fibers And Their Properties
Man Made Fibers

Generic Name
Acetate  Cellulose Acetate; Triacetate where not less than 92% of the cellulose is acetylated
Acrylic  At least 85% Acrylonitrile unite
Aramid  Polyamide in which at least 85% of the amide linkages are directly attached to two aromatic rings
Glass  Glass
Modacrylic  Less than 85% but at least 35% acrylonitrile units
Nylon  Polyamide in which less than 85% of the amide linkages are directly attached to two aromatic rings
Olefin  At least 85% ethylene, propylene, or other olefin units
Polyester  At least 85% ester of a substituted aromatic carboxylic acid including but not restricted to substituted terephthalate units and parasubstituted hydroxybenzoate units
Rayon  Regenerated cellulose with less than 15% chemically combined substituents
Saran  At least 80% vinylidene chloride
Spandex  Elastomer of at least 85% of a segmented polyurethane
Vinal  At least 50% vinyl alcohol units and at least 85% total vinyl alcohol and acetal units
Wet Spinning

Typical Wet Spun Fibers
- Viscose
- Acrilan
- Creslan

Disadvantages
- Slow (70 - 150 yds/min)
- Washing to remove impurities
- Solvent and chemical recovery

Advantages
- Large tows can be handled
Dry Spinning

Typical Dry Spun Fibers
- Acetate (acetone solvent)
- Triacetate (methylene chloride)
- Spandex (some) (dimethyl formamide)

Disadvantages
- Flammable solvent hazards
- Solvent recovery
- Slow (?) (200 - 400 yds/min)

Advantages
- Yarn does not require purification
Melt Spinning

Typical Melt Spun Fibers
- Nylons
- Polyester
- Polypropylene

Disadvantages
- Separate drawing step (unless spin draw)

Advantages
- High speed (275 to 1500 yds/min); (4000 yds/min spin draw)
- No solvents
- No purification problems
Extrusion Of Man Made Fibers
(Spinning Methods)

A. Wet Spinning (Rayon)

B. Dry Spinning
C. Melt Spinning

Storage Hopper

Melt Grid
Spin Pump

Cooling Air Inlet

Spinneret
Spin Shaft

Finish Roll

Filament Winding

Man Made Fibers And Their Properties 3-7
Textile Fiber Parameters

Fibrous materials should possess certain properties for them to be useful as textile raw materials. Those properties which are essential for acceptance as a suitable raw material may be classified as "primary properties", while those which add specific desirable character or aesthetics to the end product and its use may be classified as "secondary properties".

**Primary Properties**

- Length; length-width ratio
- Tenacity (strength)
- Flexibility (pliability)
- Acceptable extensibility for processing
- Cohesion
- Uniformity of properties

**Secondary Properties**

- Physical shape (cross-section, surface contour, etc.)
- Specific gravity (influence weight, cover, etc.)
- Moisture regain and moisture absorption (comfort, static electricity, etc.)
- Elastic character - tensile and compression
- Thermoplasticity (softening point and heat-set character)
• Dyeability

• Resistance to solvents, corrosive chemicals, micro-organisms, and environmental conditions

• Flammability

• Luster

Note: Cost is always a factor to consider
Figure 3-1  Typical Stress-Strain Curves Of Various Fibers

![Graph showing typical stress-strain curves of various fibers.](image-url)
Key Fiber Properties Determined by Polymer Composition And Structure

- Melting Point
- Modulus
- Elasticity and recovery from strain
- Tensile strength
- Density
- Moisture absorption
- Dyeability
- Comfort
Examples of Fiber Shapes

- **Flat Oval, Lumen Convolutions Cotton**
- **Oval to round, Overlapping scales Medulla Wool**
- **Triangular, Round edges, Uniform in man-mades Silk, Nylon Type 90 Dacron Type 62**
- **Circular, Uniform in diameter Nylon, Dacron Cuprammonium Rayon**
- **Dog-Bone Orlon, Verel, Lycra**
- **Lobular Lengthwise Striations Acetate**
- **Y-Shaped Celacloud Type 20 Acetate Cumulofit Nylon**
- **Ribbon-Shaped Dynel**
- **Circular, Serrated, Lengthwise Striations Viscose Rayon**
- **Trilobal Antron Nylon**
Density and Specific Gravity*

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Density (g/cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Fibers</strong></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>1.52</td>
</tr>
<tr>
<td>Flax</td>
<td>1.52</td>
</tr>
<tr>
<td>Silk</td>
<td>1.25</td>
</tr>
<tr>
<td>Wool</td>
<td>1.32</td>
</tr>
<tr>
<td><strong>Man-made Fibers</strong></td>
<td></td>
</tr>
<tr>
<td>Acetate</td>
<td>1.32</td>
</tr>
<tr>
<td>Acrylic</td>
<td>1.17 - 1.18</td>
</tr>
<tr>
<td>Aramid</td>
<td>1.38 - 1.44</td>
</tr>
<tr>
<td>Flurocarbon</td>
<td>2.2</td>
</tr>
<tr>
<td>Glass</td>
<td>2.49 - 2.73</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>1.30 - 1.37</td>
</tr>
<tr>
<td>Nylon</td>
<td>1.14</td>
</tr>
<tr>
<td>Nylon Qiana</td>
<td>1.03</td>
</tr>
<tr>
<td>Olefin</td>
<td>0.91</td>
</tr>
<tr>
<td>Polyester</td>
<td>1.22 or 1.38</td>
</tr>
<tr>
<td>Rayon</td>
<td>1.50 - 1.52</td>
</tr>
<tr>
<td>Spandex</td>
<td>1.20 - 1.22</td>
</tr>
</tbody>
</table>

*Ratio of weight of a given volume of fiber to an equal volume of water
## Absorbency

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Moisture Regain*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Fibers</strong></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>7 - 11</td>
</tr>
<tr>
<td>Flax</td>
<td>12</td>
</tr>
<tr>
<td>Silk</td>
<td>11</td>
</tr>
<tr>
<td>Wool</td>
<td>13 - 18</td>
</tr>
<tr>
<td><strong>Man-made Fibers</strong></td>
<td></td>
</tr>
<tr>
<td>Acetate</td>
<td>6.0</td>
</tr>
<tr>
<td>Arnel triacetate</td>
<td>3.2</td>
</tr>
<tr>
<td>Acrylic</td>
<td>1.3 - 2.5</td>
</tr>
<tr>
<td>Aramid</td>
<td>4.5</td>
</tr>
<tr>
<td>Flurocarbon</td>
<td>0</td>
</tr>
<tr>
<td>Glass</td>
<td>0 - 0.3</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>0.4 - 4.0</td>
</tr>
<tr>
<td>Nylon</td>
<td>4.0 - 4.5</td>
</tr>
<tr>
<td>Nylon Qiana</td>
<td>2.5</td>
</tr>
<tr>
<td>Olefin</td>
<td>0.01 - 0.1</td>
</tr>
<tr>
<td>Polyester</td>
<td>0.4 - 0.8</td>
</tr>
<tr>
<td>Rayon</td>
<td>15</td>
</tr>
<tr>
<td>Rayon HWM</td>
<td>11.5 - 13</td>
</tr>
<tr>
<td>Spandex</td>
<td>0.75 - 1.3</td>
</tr>
</tbody>
</table>

*Moisture regain is expressed as a percentage of the moisture-free weight at 70°F Farenheit and 65% relative humidity.
Heat And Textile Materials

**Important Criteria to Consider**

- Softening, melting, or decomposition temperatures

- Tendency of the fiber and fabric to shrink when heat-relaxed, or stretch when heated and under tension

- Ability of the fabric to heat set

- Ability of the fabric to function properly at elevated temperatures in one time or repeated use

- Ability of the fabric to function properly at room temperature (or some other lower temperature) after exposure at high temperature for a given period of time
Table 3-1  Thermal Properties

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Melting Point °F</th>
<th>Softening Sticking Point °F</th>
<th>Safe Ironing Temperature °F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Natural Fibers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>Nonmelting</td>
<td></td>
<td>425</td>
</tr>
<tr>
<td>Flax</td>
<td>Nonmelting</td>
<td></td>
<td>450</td>
</tr>
<tr>
<td>Silk</td>
<td>Nonmelting</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Wool</td>
<td>Nonmelting</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Man-made Fibers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetate</td>
<td>446</td>
<td>364</td>
<td>350</td>
</tr>
<tr>
<td>Arnel triacetate</td>
<td>575</td>
<td>482</td>
<td>464</td>
</tr>
<tr>
<td>Acrylic</td>
<td></td>
<td>400-490</td>
<td>300-350</td>
</tr>
<tr>
<td>Aramid</td>
<td>Does not melt, carbonizes above 800°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td></td>
<td>1400-3033</td>
<td></td>
</tr>
<tr>
<td>Modacrylic</td>
<td>410</td>
<td>300</td>
<td>200-250</td>
</tr>
<tr>
<td>Novoloid</td>
<td>Nonmelting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nylon 6</td>
<td>414</td>
<td>340</td>
<td>300</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>482</td>
<td>445</td>
<td>350</td>
</tr>
<tr>
<td>Olefin</td>
<td>275</td>
<td>260</td>
<td>150</td>
</tr>
<tr>
<td>Polyester PET</td>
<td>480</td>
<td>460</td>
<td>325</td>
</tr>
<tr>
<td>Polyester PCDT</td>
<td>550</td>
<td>490</td>
<td>350</td>
</tr>
<tr>
<td>Rayon</td>
<td>Nonmelting</td>
<td></td>
<td>375</td>
</tr>
<tr>
<td>Saran</td>
<td>350</td>
<td>300</td>
<td>Do not iron</td>
</tr>
<tr>
<td>Spandex</td>
<td>446</td>
<td>347</td>
<td>300</td>
</tr>
<tr>
<td>Vinyon</td>
<td>285</td>
<td>200</td>
<td>Do not iron</td>
</tr>
</tbody>
</table>

*Safe ironing temperature ranges from 300°F to 149°C.
### Comparative Fiber Properties - Effect Of Acids

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Effect of Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>Resistant to most acids</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>Resistant to most acids</td>
</tr>
<tr>
<td>Polyester</td>
<td>Resistant to most mineral acids; disintegrated by 96% sulfuric</td>
</tr>
<tr>
<td>Rayon</td>
<td>Disintegrates in hot dilute and cold concentrated acids</td>
</tr>
<tr>
<td>Acetate</td>
<td>Soluble in acetic acid, decomposed by strong acids</td>
</tr>
<tr>
<td>Triacetate</td>
<td>Similar to acetate</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>Decomposed by strong mineral acids, resistant to weak acids</td>
</tr>
<tr>
<td>Olefin</td>
<td>Very resistant</td>
</tr>
<tr>
<td>Glass</td>
<td>Resists most acids. Etched by hydrofluoric acid and hot phosphoric acid</td>
</tr>
<tr>
<td>Cotton</td>
<td>Similar to rayon</td>
</tr>
<tr>
<td>Wool</td>
<td>Destroyed by hot sulfuric, otherwise unaffected by acids</td>
</tr>
</tbody>
</table>
### Comparative Fiber Properties - Effects Of Alkalies

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>Destroyed by strong alkalies at a boil, resists weak alkalies</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>Resistant to alkalies</td>
</tr>
<tr>
<td>Polyester</td>
<td>Resistant to cold alkalies, slowly decomposed at a boil by strong alkalies</td>
</tr>
<tr>
<td>Rayon</td>
<td>No effect by cold, weak alkalies, swells and loses strength in concentrated alkalies</td>
</tr>
<tr>
<td>Acetate</td>
<td>Saponified, little effect from cold weak alkalies</td>
</tr>
<tr>
<td>Triacetate</td>
<td>Not effected up to pH 9.8, 205°F; better than acetate</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>Little or no effect</td>
</tr>
<tr>
<td>Olefin</td>
<td>Very resistant</td>
</tr>
<tr>
<td>Glass</td>
<td>Attacked by hot weak alkalies and concentrated alkalies</td>
</tr>
<tr>
<td>Cotton</td>
<td>Swells when treated with caustic soda but is not damaged</td>
</tr>
<tr>
<td>Wool</td>
<td>Attacked by weak alkalies, destroyed by strong alkalies</td>
</tr>
</tbody>
</table>
# Comparative Fiber Properties - Effect Of Organic Solvents

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Solubility Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>Soluble in warm acetone, otherwise unaffected</td>
</tr>
<tr>
<td>Polyester</td>
<td>Soluble in some phenolic compounds, otherwise unaffected</td>
</tr>
<tr>
<td>Rayon</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Acetate</td>
<td>Soluble in acetone, dissolved or swollen by many others</td>
</tr>
<tr>
<td>Triacetate</td>
<td>Soluble in acetone, chloroform and swollen by others</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>Generally unaffected, soluble in some phenolic compounds</td>
</tr>
<tr>
<td>Olefin</td>
<td>Soluble in chlorinated hydrocarbons above 160°</td>
</tr>
<tr>
<td>Glass</td>
<td>Unaffected</td>
</tr>
<tr>
<td>Cotton</td>
<td>Resistant</td>
</tr>
<tr>
<td>Wool</td>
<td>Generally resistant</td>
</tr>
</tbody>
</table>
## Comparative Fiber Properties - Effect Of Sunlight

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Effect Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>Little or no effect</td>
</tr>
<tr>
<td>Modacrylic</td>
<td>Highly resistant, some loss of strength and discoloration after constant exposure</td>
</tr>
<tr>
<td>Polyester</td>
<td>Some loss of strength, no discoloration, very resistant behind glass</td>
</tr>
<tr>
<td>Rayon</td>
<td>Generally resistant, loses strength after long exposure</td>
</tr>
<tr>
<td>Acetate</td>
<td>Approximately same as rayon</td>
</tr>
<tr>
<td>Triacetate</td>
<td>Resistant, loses strength after long exposure</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>No discoloration, strength loss after long exposure</td>
</tr>
<tr>
<td>Olefin</td>
<td>Very resistant, retains 95% strength after 6 months exposure</td>
</tr>
<tr>
<td>Glass</td>
<td>None</td>
</tr>
<tr>
<td>Cotton</td>
<td>Strength loss on long exposure</td>
</tr>
<tr>
<td>Wool</td>
<td>Strength loss, dyeing is affected</td>
</tr>
</tbody>
</table>
Rayon
(A Cellulosic Man-Made Fiber)

Composition
Regenerated cellulose

Physical Properties

- Microscopic Appearance
  - Striations seen in viscose and high-strength rayon
  - If delustered, scattered specks of pigment can be seen.

- Length
  - Filament and staple

- Color
  - Transparent unless dulled by pigments

- Luster
  - High unless delustering pigment added

- Strength
  - Fair to excellent
  - Regular rayon has fair strength
  - High tenacity types have good to excellent strength

- Elasticity
  - Regular rayon is low
  - High strength rayon is good

- Resiliency
  - High wet-strength rayon is better
• **Moisture Absorption**
  — Higher than natural cellulose
  — Fibers swell in water
  — Weaker when wet

• **Heat**
  — Loses strength above 300°F
  — Decomposes between 350 and 400°F

• **Flammability**
  — Burns rapidly unless treated

• **Electrical Conductivity**
  — Fair - static charge can be reduced with special finishes

• **Specific Gravity**
  — 1.52 (similar to cotton)

**Chemical Properties (similar to cotton)**

• Easily damaged by strong acids

• Resistant to alkalies, reduction in strength if concentrated

• Lengthy exposure to sunlight weakens the fabric

• Greater affinity for dyes than cotton
Acrylic
(A Wool-Like Fiber)

Composition
Acrylonitrile and small amounts of other monomers

Physical Properties
• Microscopic appearance
  — Uniform and smooth surface
  — Irregular spaced striations

• Length
  — Mainly a staple fiber

• Color
  — White to off-white

• Luster
  — Bright, semidull, or dull

• Strength
  — Fair to good strength

• Elasticity
  — Good

• Resilience
  — Good

• Water Absorption
  — 1 - 3%
• **Heat**
  — Yellowing may occur above 300° F
  — Softening or sticking about 450° F

• **Flammability**
  — Burns with yellow flame

• **Electrical Conductivity**
  — Fair to good

• **Specific Gravity**
  — 1.14 to 1.19
  — Good bulk and covering power

**Chemical Properties**

• Damaged only by strong concentrated acids

• Not normally affected by alkalies

• Very resistant to ultraviolet light
Nylon
(A Polyamide Fiber)

Composition
Nylon 66 - Polyhexamethylene Adipamide
Nylon 6 - Caprolactam

Physical Properties
• Microscopic Appearance
  — Very smooth and even

• Length
  — Filament and staple

• Color
  — Off-white

• Luster
  — High natural luster can be controlled

• Strength
  — Exceptionally high (60,000 - 108,000) pounds per square inch

• Elasticity
  — Exceptionally high

• Resiliency
  — Very good

• Moisture Absorption
  — 3.8%
- **Heat**
  - High resistance, melts at 482°F

- **Flammability**
  - Melts slowly
  - Does not support combustion

- **Electrical Conductivity**
  - Low, generates static

- **Specific Gravity**
  - 1.14 (low density)

**Chemical Properties**
- Weakened by concentrated strong acids
- High resistance to alkalies
- Loses strength in prolonged exposure to sunlight - bright yarn more resistant than dull yarn
Polyester
(Most Versatile Fiber)

Composition
Combination of Terephthalic Acid or Dimethylterephthalate and Ethylene Glycol

Physical Properties

- Microscopic Appearance
  - Smooth, even, rodlike, different cross-sectional shapes

- Length
  - Filament and staple

- Color
  - White

- Luster
  - Bright or dull

- Strength
  - Good to excellent

- Elasticity
  - Fair to good
  - Greater than cotton or rayon

- Resilience
  - Excellent

- Moisture Absorption
  - Less than 1%
- **Heat**
  - Softening or sticking temperature is above 400° F (thermoplastic)

- **Flammability**
  - Burns slowly

- **Electrical Conductivity**
  - Accumulates static changes

- **Specific Gravity**
  - Typically 1.38

**Chemical Properties**
- Good resistance to most acids
- Good resistance to most alkalies
- Good sunlight resistance
Figure 3-2 Production of Polyester

1. Drawing Tow
2. Crimping
3. Drying/Heat Setting
4. Cutting
Acetate
(A Cellulosic Man-Made Fiber)

Composition
Acetate Ester of Cellulose

Physical Properties
- Microscopic Appearance
  - Striations farther apart than viscose rayon
  - Lobed cross-section

- Length
  - Filament and staple

- Color
  - Transparent unless dulled by pigments

- Luster
  - Bright, semibright, or dull

- Strength
  - Moderate
  - Less than rayon when wet

- Elasticity
  - Not very high
  - Similar to rayon

- Resilience
  - Poor
- **Moisture Absorption**
  - 6%, little strength loss when wet

- **Heat**
  - Ironing temperatures of 275° F are satisfactory

- **Flammability**
  - Slowly combustible

- **Electrical Conductivity**
  - Good

- **Specific Gravity**
  - 1.32

**Chemical Properties**

- Concentrated strong acids will decompose it

- Strong alkalies will damage it

- Long exposures to sunlight produce a weakening effect
Polypropylene
(An Olefin Fiber)

Composition
Propylene

Physical Properties
- Microscopic Appearance
  — Smooth and rodlike

- Length
  — Filament and staple

- Color
  — Translucent

- Luster
  — Dull, semidull, bright

- Strength
  — Excellent strength (depends on degree of polymerization)

- Elasticity
  — Good

- Resilience
  — Good resistance to crushing

- Moisture Absorption
  — None
• **Heat**
  — Melts at about 330° F
  — Progressive shrinkage can occur at 140° F to 212° F

• **Flammability**
  — Slow burning

• **Electrical Conductivity**
  — Excellent

• **Specific Gravity**
  — 0.90 to 0.91

**Chemical Properties**
• Very resistant to most acids

• Very resistant to alkalies

• Dye pigments usually added to the liquid before fibers are extruded

• Loses strength in sunlight, degrades upon long exposure
Polyethylene
(An Olefin Fiber)

Composition
Ethylene

Physical Properties
• Microscopic Appearance
  — Smooth and rodlike

• Length
  — Filament and staple

• Color
  — Translucent

• Luster
  — Dull, semidull, bright

• Strength
  — Fair to good (depends on degree of polymerization)

• Elasticity
  — Good

• Resilience
  — Good resistance to crushing

• Moisture Absorption
  — None
• **Heat**
  — Very heat-sensitive
  — Melts at about 260° F

• **Flammability**
  — Slow burning

• **Electrical Conductivity**
  — Excellent

• **Specific Gravity**
  — 0.90 to 0.91

*Chemical Properties*

• Very resistant to most acids

• Very resistant to alkalies

• Dye pigments usually added to the liquid before fibers are extruded

• Loses strength in sunlight, degrades upon long exposure
<table>
<thead>
<tr>
<th>Fiber</th>
<th>Specific Gravity</th>
<th>Tenacity (wet) (gpd)</th>
<th>Tenacity (gpd)</th>
<th>Moisture Regain (%)</th>
<th>Elongation (%)</th>
<th>Softening Melting Point (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1.5 - 1.55</td>
<td>3.0 - 4.9</td>
<td>3.3 - 6.4</td>
<td>7 - 8</td>
<td>3 - 7</td>
<td>NONE</td>
</tr>
<tr>
<td>Acetate</td>
<td>1.32</td>
<td>1.3 - 1.5</td>
<td>1.2 - 1.4</td>
<td>6</td>
<td>23 - 24</td>
<td>(s)400-445°F (m)500°F</td>
</tr>
<tr>
<td>Acrylic</td>
<td>1.16 - 1.18</td>
<td>2.0 - 3.6</td>
<td>1.6 - 2.9</td>
<td>1.5 - 2.5</td>
<td>35 - 39</td>
<td>(s)420°F</td>
</tr>
<tr>
<td>Glass</td>
<td>2.50 - 2.55</td>
<td>9.6 - 19.9</td>
<td>6.7 - 19.9</td>
<td>NONE</td>
<td>3.1 - 5.3</td>
<td>(s)1350-1560°F</td>
</tr>
<tr>
<td>Nylon 66</td>
<td>1.14</td>
<td>3.0 - 7.2</td>
<td>2.6 - 6.1</td>
<td>4.2 - 4.5</td>
<td>16 - 66</td>
<td>(s)445°F (m)480-500°F</td>
</tr>
<tr>
<td>Polyester</td>
<td>1.38</td>
<td>2.2 - 6.6</td>
<td>2.2 - 6.6</td>
<td>0.4 - 0.8</td>
<td>12 - 67</td>
<td>(s)445°F (m)482°F</td>
</tr>
<tr>
<td>Rayon, HT</td>
<td>1.50 - 1.53</td>
<td>3.0 - 5.7</td>
<td>1.9 - 4.3</td>
<td>13</td>
<td>9 - 26</td>
<td>DNM Decomposes 350-400°F</td>
</tr>
<tr>
<td>Wool</td>
<td>1.31</td>
<td>1 - 1.5</td>
<td>1.9 - 4.3</td>
<td>13</td>
<td>9 - 26</td>
<td>DNM Decomposes 350-400°F</td>
</tr>
<tr>
<td>Silk</td>
<td>1.25</td>
<td>3 - 5</td>
<td>1.9 - 4.3</td>
<td>13</td>
<td>9 - 26</td>
<td>DNM Decomposes 350-400°F</td>
</tr>
</tbody>
</table>
Summary Of Properties Desired For Textile Fibers

**Apparel and Domestic Requirements**

- Tenacity: 3 - 5 grams/denier
- Elongation at break: 10 - 35%
- Recovery from elongation: 100% at strains up to 5%
- Modulus of elasticity: 30 - 60 grams/denier
- Moisture absorbency: 2 - 5%
- Zero strength temperature (excessive creep and softening point): above 215°C
- High abrasion resistance (varies with type fabric structure)
- Dyeable
- Low flammability
- Insoluble with low swelling in water, in moderately strong acids and bases and conventional organic solvents from room temperature to 100°C
- Ease of care

**Industrial Requirements**

- Tenacity: 7 - 8 grams/denier
- Elongation at break: 8 - 15%
- Modulus of elasticity: 80 grams/denier or more conditioned, 50 grams/denier wet
- Zero strength temperature: 250°C or above
## Fiber Property Chart

<table>
<thead>
<tr>
<th><strong>Fiber Property</strong></th>
<th><strong>Is Due To</strong></th>
<th><strong>Contributes To Fabric Property</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion Resistance</td>
<td>Tough outer layer, scales, or skin</td>
<td>Durability</td>
</tr>
<tr>
<td></td>
<td>Fiber toughness</td>
<td>Abrasion resistance</td>
</tr>
<tr>
<td></td>
<td>Flexible molecular chains</td>
<td>Resistance to splitting</td>
</tr>
<tr>
<td>Absorbency or Moisture Regain</td>
<td>Hydroxyl groups, Amorphous areas</td>
<td>Comfort, warmth, water repellency, absorbency, static build-up</td>
</tr>
<tr>
<td>Aging Resistance</td>
<td>Chemical structure</td>
<td>Storing of fabrics</td>
</tr>
<tr>
<td>Chemical Reactivity</td>
<td>Polar groups of molecules</td>
<td>Care required in cleaning/bleaching; ability to take acid or alkali finishes</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>Crimp or twists</td>
<td>Resistance to ravel</td>
</tr>
<tr>
<td>Cover</td>
<td>Crimp, curl, or twist, Cross-sectional shape</td>
<td>Warmth in fabric, Cost - less fiber needed</td>
</tr>
<tr>
<td>Creep</td>
<td>Lack of side chains, cross links, strong bonds; poor orientation</td>
<td>Streak dyeing and shiners in fabric</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Density</td>
<td>see Specific Gravity</td>
<td></td>
</tr>
<tr>
<td>Dyeability</td>
<td>The fibers' receptivity to coloration by dyes</td>
<td>Amorphous areas and dye sites</td>
</tr>
<tr>
<td>Elastic Recovery</td>
<td>The ability of fibers to recover from strain</td>
<td>Molecular structure: side chains, cross linkages, strong bonds</td>
</tr>
<tr>
<td>Elasticity</td>
<td>The ability of a stretched material to return immediately to its original size</td>
<td></td>
</tr>
<tr>
<td>Electric Conductivity</td>
<td>The ability to transfer electrical charges</td>
<td>Chemical structure: polar groups</td>
</tr>
<tr>
<td>Elongation</td>
<td>The ability to be stretched, extended, or lengthened; varies at different temperatures and when wet or dry</td>
<td>Fiber crimp, Molecular structure: molecular crimp orientation</td>
</tr>
<tr>
<td>Feltability</td>
<td>The ability of fibers to mat together</td>
<td>Scale structure of wool</td>
</tr>
<tr>
<td>Flammability</td>
<td>The ability to ignite and burn</td>
<td>Chemical composition</td>
</tr>
<tr>
<td>Hand</td>
<td>The way a fiber feels: silky, harsh, soft, crisp, dry</td>
<td>Cross-sectional shape, crimp, diameter, length</td>
</tr>
<tr>
<td>Heat Conductivity</td>
<td>The ability to conduct heat away from the body</td>
<td>Crimp, Cross-sectional shape</td>
</tr>
</tbody>
</table>
Heat Sensitivity
The ability to soften, melt, or shrink when subjected to heat

Hydrophilic or Hygroscopic
see Absorbency

Luster
The light reflected from a surface; more subdued than shine; light rays are broken up

Loft or Compressional Resiliency
The ability to spring back to original thickness after being compressed

Mildew Resistance
Low absorption

Moth Resistance
Molecule has no sulfur

Pilling
The bailing up of fiber ends on the surface of fabrics

Specific Gravity and Density
The measures of the weight of a fiber; Density is the weight in grams per cubic centimeter and specific gravity is the ratio of the mass of the fiber to an equal volume of water at 4°C.

Heat vibrates molecules
Fewer intermolecular forces and cross links

Determine safe washing and ironing temperatures

Smoothness
Fiber length
Flat or lobal shape

Luster
Luster
Shine

Fiber crimp
Stiffness

Springiness, good cover
Resistance to flattening

Care during storage

Fiber strength
High molecular weight

Pilling
Unsightly appearance

Molecular weight

Warmth without weight
Loftiness - full and light
Buoyancy to fabric
<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stiffness or Rigidity</strong></td>
<td>The opposite of flexibility; the resistance to bending or creasing</td>
<td>Ratio of breaking stress to breaking strain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Body of fabric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resistance to insertion of yarn twist</td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>The ability to resist stress; expressed as tensile strength (pounds per</td>
<td>Molecular structure: orientation, crystallinity, degree of polymerization</td>
</tr>
<tr>
<td></td>
<td>square inch) or as tenacity (grams per denier)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Durability, tear strength, sagging, pilling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheerer fabrics possible with stronger fine fibers</td>
</tr>
<tr>
<td><strong>Sunlight Resistance</strong></td>
<td>The ability to withstand degradation from direct sunlight</td>
<td>Chemical composition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Durability of curtains and draperies, outdoor furniture, outdoor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>carpeting</td>
</tr>
<tr>
<td><strong>Toughness</strong></td>
<td></td>
<td>Outer surface of &quot;skin&quot; of fiber</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resists rupture from deformation, gives frictional resistance</td>
</tr>
<tr>
<td><strong>Wicking</strong></td>
<td>The ability of a fiber to transfer moisture along its surface</td>
<td>Chemical and physical composition of outer surfaces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Makes fabrics comfortable</td>
</tr>
</tbody>
</table>
Fiber Blends - Some Reasons For Blending

- To facilitate processing

- To improve properties
  - Abrasion resistance
  - Strength
  - Absorbency
  - Add bulk and warmth
  - Hand
  - Dimensional stability
  - Resistance to wrinkling

- To produce multi-color fabrics

- To reduce cost