P 00500

Natural and Synthetic Fibers

INTRODUCTION

TEXTILE FIBERS ARE RAW (STRUCTURAL) MATERIALS UTILIZED IN PRODUCING CLOTHING, DOMESTIC AND INDUSTRIAL PRODUCTS.

THESE STRUCTURAL MATERIALS MAY BE NATURAL OCCURRING OR MAN-MADE FROM NATURALLY EXISTING MATERIALS OR TAILORED FROM BASIC ORGANIC OR INORGANIC COMPONENTS

WHAT IS A FIBER ?

MATERIAL CHARACTERIZED BY

1. HIGH LENGTH TO DIAMETER RATIO, L/D
   (AT LEAST 1000 TO 1)
2. LOW BENDING RIGIDITY. VERY FLEXIBLE
3. SMALL DIAMETER
   (10 TO 200 MICRONS)
   (0.0005 TO 0.01 INCHES)

FOR USE AS TEXTILE MATERIAL, MUST ALSO HAVE SOME MINIMUM.

1. STRENGTH.
2. EXTENSIBILITY. (STRETCH ABILITY) SPANDEX
3. TEMPERATURE RESISTANCE. 135° - 150° (HOME) 160° (COMMERCIAL)

STRONG FIBERS:

Kevlar
5 times stronger than steel
bullet proof vest

Carbonized Acrylic / Nylon

Certain varieties of cotton are stronger than steel

2

POLYMERIZATION

MONOMERS	⟶	POLYMERS
MONO	_	ONE
MER	_	UNIT
POLY	_	MANY

POLYMERIZATION _ CONNECTING TOGETHER MONOMERS (SMALL MOLECULES)

— A — — B —

↓

— (ABABABAB) —

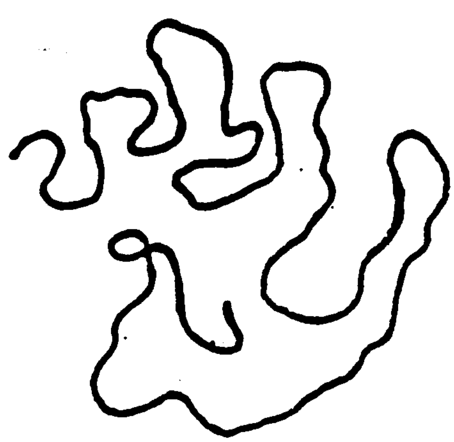
A or B >>> H_2O
larger than

Connect 2000 - 3000 times
to produce fiber

THIS IS THE BASIS FOR THEIR SPECIAL BEHAVIOR THAT CONTRASTS THEM TO SMALL MOLECULES

MACROMOLECULAR HYPOTHESIS

HIGH POLYMERS ARE COMPOSED OF COVALENT STRUCTURES MANY TIMES GREATER IN EXTENT THAN THOSE OCCURRING IN SIMPLE COMPOUNDS AND THIS FEATURE ALONE ACCOUNTS FOR THE CHARACTERISTIC PROPERTIES WHICH SET THEM APART FROM OTHER FORMS OF MATTER



The Character or personality of any textile structure, end-use product, i.e., its appearance, texture, handle, wear performance, mechanical properties, etc., is generally influenced by four factors:

1. The fiber or blend of fibers used
2. Yarn structure or structures - size, twist, etc.
3. Fabric structure - weave, knit, non-woven
4. Type finish or finishes - color added, chemical and/or mechanical finish

FACTORS INFLUENCING THE USE OF A PARTICULAR FIBER IN A TEXTILE

1. ABILITY OF A FIBER TO BE CONVERTED TO A YARN AND THEN TO A FINISHED PRODUCT.

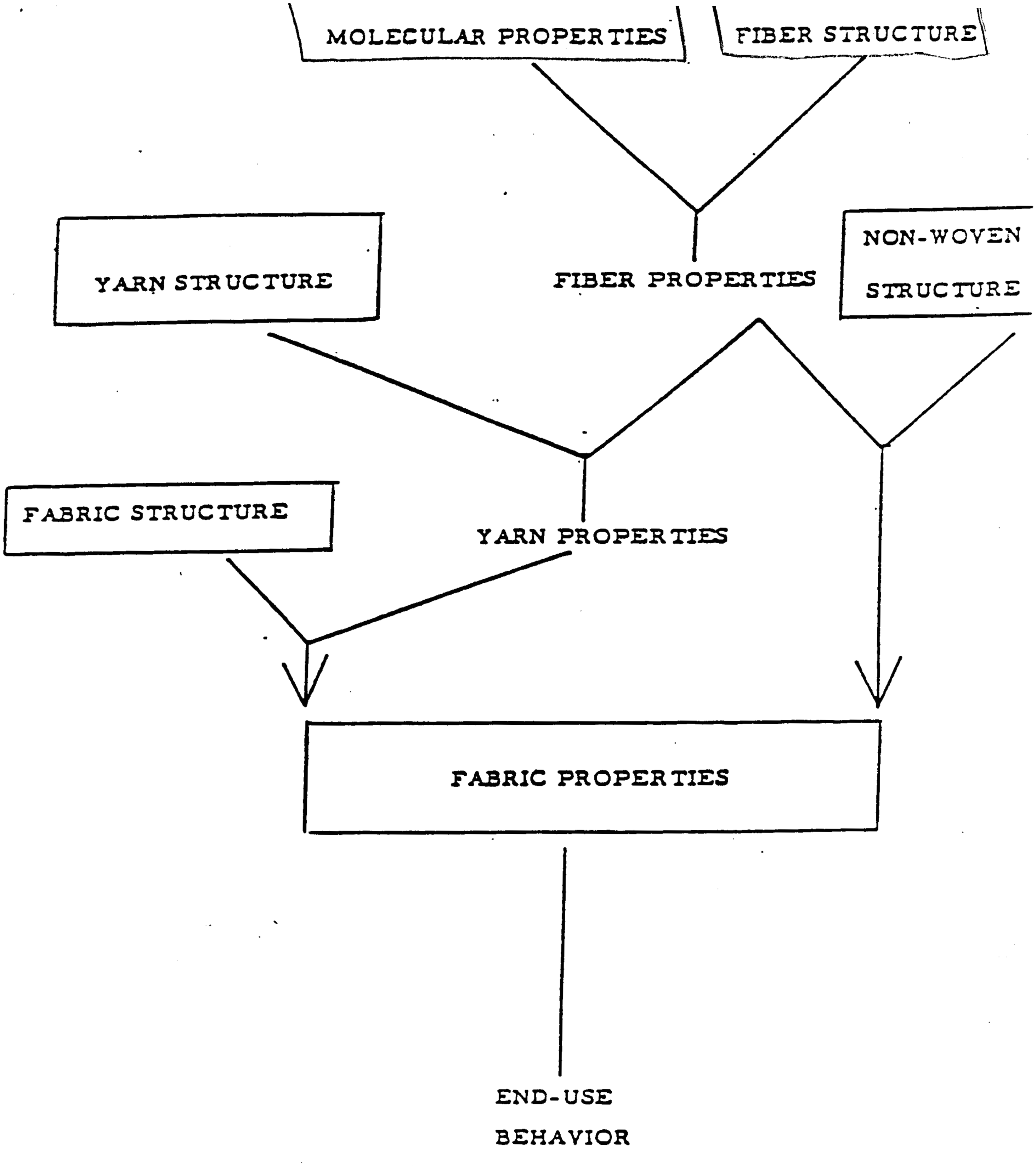
2. AVAILABILITY OF THE FIBER.

3. COST OR ECONOMICS OF PRODUCTION.

4. PUBLIC ACCEPTABILITY AND DEMAND

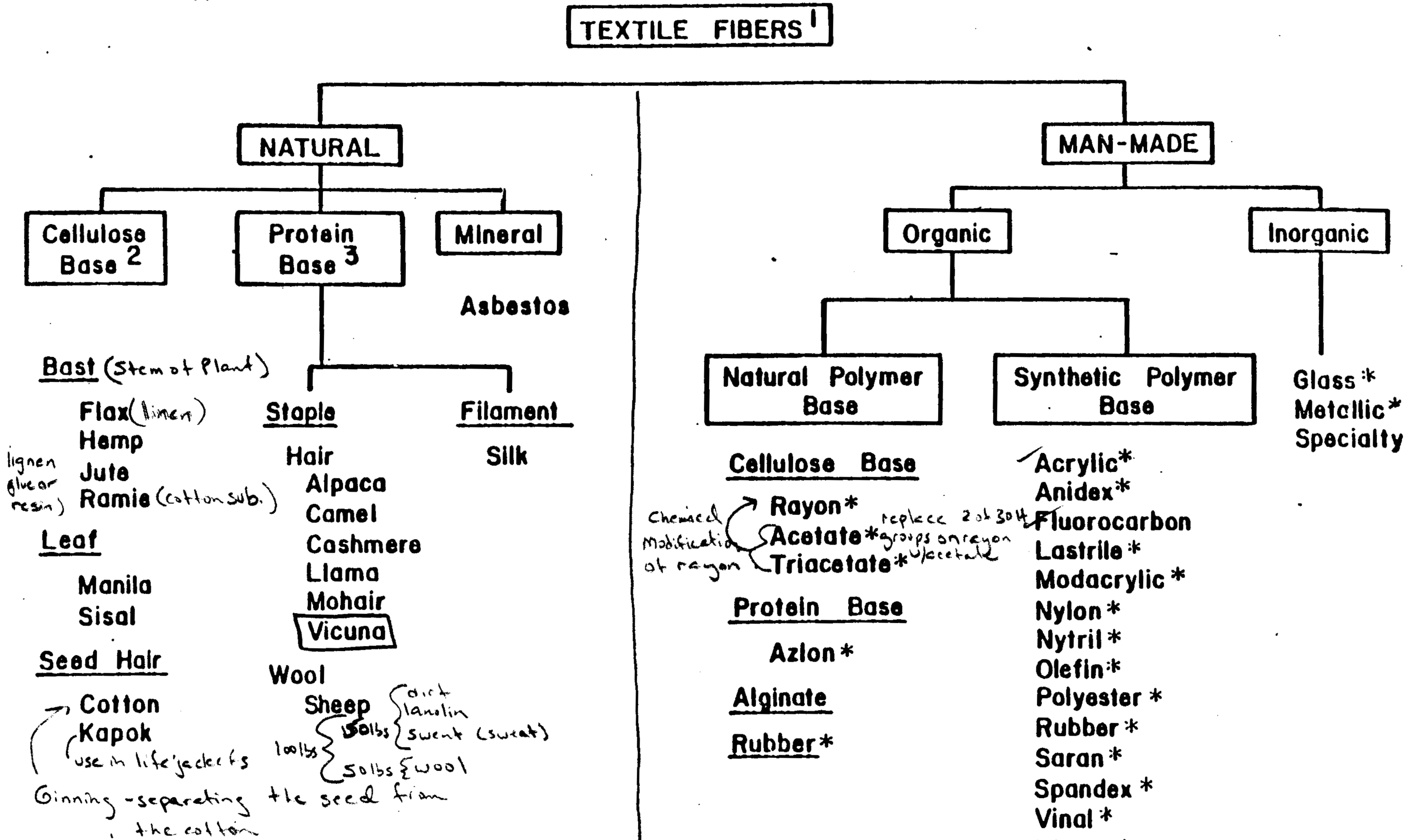
↓

PROFIT



FIBERS---YARNS---FABRIC---END-USE

GENERAL CLASSIFICATION OF TEXTILE FIBERS



*Generic classification based on chemical composition – Textile Fiber Products Identification Act.

[1] Source: 1971 Annual Book of ASTM Standards

[2] Vegetable

[3] Animal

NATURAL FIBERS

AND

THEIR PROPERTIES

CLASSIFICATION OF COTTON

A. GRADE•• ⇐ BUYING A HIGHER GRADE OF COTTON COULD REDUCE CONTAMINANTS

COLOR ----—
LEAF
PREPARATION

B. STAPLE LENGTH ••

C. MICRONAIRE FINENESS •••

• CHARACTER, A DESCRIPTIVE TERM OR VALUE INDICATING FINENESS AND OTHER QUALITIES; WAS USED AS PART OF CLASSIFICATION FOR MANY YEARS.

•• OFFICIAL STANDARDS AVAILABLE

••• PREMIUM AND DISCOUNTS ARE USED.

HVI system:

measures

length (1 - 2½ inches)

length uniformity

strength

elongation

micronaire

leaf

Color

- %R resistance reflectance
- Yellowness
- Combination of lightness & Yellowness in the equivalent 3 digit Color grade US system

Reasons!

- aids in verifying specs
- allows for proper lay down of bales
  - prevent costly blow ups in mills

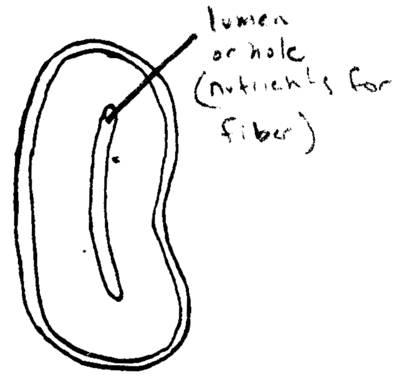
COTTON
(A VEGETABLE FIBER)

COMPOSITION   DEAD COTTON (DID NOT FILL IN SHELL)

- 87 TO 90 PERCENT CELLULOSE
- 5 TO 8 PERCENT WATER
- REMAINDER IS NATURAL IMPURITIES

PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE



CROSS SECTION

LONGITUDINAL VIEW
150 TO 400 TWISTS OR CONVOLUTIONS PER INCH

2. LENGTH

   - 1/8 TO 2½ INCHES
   - LONGER FIBERS ARE EGYPTIAN AND SEA ISLAND
   - MOST AMERICAN COTTONS RANGE FROM 3/4 - 1-3/8 INCHES

3. COLOR - WHITE, CREAM COLORED, GRAY, BROWN

Convolutions decrease luster

4. LUSTER - VERY LITTLE UNLESS MERCERIZED

5. STRENGTH - 3.0 TO 5.0 GRAMS PER DENIER
MERCERIZED COTTON IS STRONGER
10-20% STRONGER WHEN WET

6. ELASTICITY
- NATURAL TWIST INCREASES ELASTICITY
- ELASTIC RECOVERY 70 TO 74 AT 2%
- ELONGATION 3 TO 7 PERCENT

7. RESILIENCY - LOW

8. MOISTURE ABSORPTION - 7-10% medium absorbent
wool twice as absorbent

9. HEAT
- SCORCHES AND TURNS BROWN AT 475%
- DISENTEGRATES ABOVE THIS TEMPERATURE
- WITHSTANDS HOT WATER UP TO 212 F
- DRIED AT 160 TO 200°F

10. SPECIFIC GRAVITY - 1.5 (DENSE)

CHEMICAL PROPERTIES

- EASILY DAMAGED BY STRONG ACIDS
- HIGH RESISTANCE TO ALKALIES
- LOSES STRENGTH UNDER PROLONGED EXPOSURE TO ULTRAVIOLET RAYS OF SUNLIGHT

FLAX

(A BAST VEGETABLE FIBER)

SEGMENTED, HAS LUMEN

MUCH MORE RIGID THAN COTTON

COMPOSITION

ABOUT 70 - 80% CELLULOSE. REMAINDER IS NATURAL IMPURETIES

PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE
   - SMALL FIBERS CEMENTED TOGETHER
   - RESEMBLES A BAMBOO POLE
   - CONTAINS A LARGE CENTRAL CANAL
2. LENGTH
   - GOOD FLAX SHOULD AVERAGE 20 IN.
   - CUT TO PROCESS WITH OTHER FIBERS
3. COLOR
   - YELLOWISH TO GREY
4. LUSTER
   - GREATER LUSTER THAN COTTON
   - ALMOST SILKY IN APPEARANCE
5. STRENGTH
   - MUCH STRONGER THAN COTTON
   - 5.5 - 6.5 GRAMS PER DENIER
6. ELASTICITY
   - NOT VERY ELASTIC
   - 2% ELONGATION
7. RESILIENCY   ability to be crushed and bounce back
   - VERY LITTLE
8. MOISTURE ABSORPTION
   - 10-12%
   - HIGHER THAN COTTON

9. Heat

   Similar to cotton

10. Flammability

   Burns rapidly

11. Electrical Conductivity

   Low

12. Specific Gravity

   1.50

<u>Chemical Properties</u>

Easily damaged by strong acids
High resistance to alkalies
Loses strength in prolonged sunlight

WOOL
(A PROTEIN ANIMAL FIBER)

COMPOSITION

LARGELY PROTEIN

PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE

    LAYER OF SCALES ON OUTER SURFACE

    LAYER UNDER SCALES ARE SOFT AND SPONGY WHICH ABSORBS WATER AND DYES.

2. LENGTH

    1 - 20 INCHES, MOST BEING 1 - 8 INCHES

    1 - 3 INCH FIBERS IN WOOLEN YARNS

    4-8 INCH FIBERS IN WORSTED YARNS

3. COLOR

    VARYING DEGREES OF WHITENESS

    SOME GRAY, BROWN, AND BLACK WOOL

4. LUSTER

    POORER GRADES OF WOOL HAVE HIGHER LUSTER

5. STRENGTH

    MUCH LESS THAN COTTON

    LOSES 10-20% OF ITS STRENGTH WHEN WET

6. ELASTICITY

    VERY ELASTIC

    CAN BE STRETCHED 30% WITHOUT WEAKENING

7. RESILIENCY

SPRINGS BACK IF CREASED OR CRUSHED

8. MOISTURE ABSORPTION

16% AT 65% RELATIVE HUMIDITY AND 70°F

9. WATER

BOILING WATER BREAKS DOWN WOOL IF BOILED FOR A LONG TIME

LUSTER AND STRENGTH IS REDUCED

10. HEAT

LOSES MOISTURE WHEN HEATED IN DRY AIR AT 212 TO 230°F FOR OVER A PERIOD OF TIME BECOMING HARSH WITH LOSS OF STRENGTH

IN MOIST AIR AT 212°F, WOOL BECOMES PLASTIC

11. FLAMMABILITY

BURNS SLOWLY AND IS SELF-EXTINGUISHING

12. ELECTRICAL CONDUCTIVITY

POOR CONDUCTOR

13. SPECIFIC GRAVITY

1.34 (COMPARATIVELY LIGHT)

CHEMICAL PROPERTIES

NOT EASILY DAMAGED BY ACIDS

VERY EASILY ATTACKED BY ALKALIES

SUNLIGHT BREAKS DOWN AND WEAKENS WOOL

SILK

(A PROTEIN ANIMAL FIBER)

A VERY TOUGH FIBER

STAPLE - short length
Filament - 450 yards long for silk (continuous)

NATURAL FILMANT

COMPOSITION

PROTEIN

PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE
2. LENGTH
   1300 - 2000 FT.
3. COLOR
   YELLOW TO GRAY
4. LUSTER
   VERY HIGH
5. STRENGTH
   STRONGEST OF THE ANIMAL FIBERS
6. ELASTICITY
   HIGH - 20% OF ORIGINAL LENGTH
7. RESILIENCY
   RANKS NEXT TO WOOL
8. MOISTURE ABSORPTION
   11%
9. SPECIFIC GRAVITY
   1.25 (LESS DENSE THAN COTTON, LINEN, AND WOOL)

CHEMICAL PROPERTIES

GOOD RESISTANCE TO MOST ACIDS
MORE RESISTANT TO ALKALIES THAN WOOL
NOT VERY RESISTANT TO STRONG LIGHT

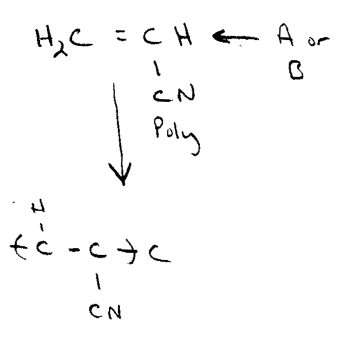
MAN MADE FIBERS

AND

THEIR PROPERTIES

Important to know fiber properties

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.
AZLON	REGENERATED NATURALLY OCURRING PROTEINS
GLASS	GLASS
MODACRYLIC	LESS THAN 85% BUT AT LEAST 35% ACRYLONITRILE UNITS
NOVOLOID	AT LEAST 85% CROSS-LINKED NOVOLAC
NYLON	POLYAMIDE IN WHICH LESS THAN 85% OF THE AMIDE LINKAGES ARE DIRECTLY ATTACHED TO TWO AROMATIC RINGS
NYTRIL	AT LEAST 85% LONG CHAIN POLYMER OF VINYLIDENE DINITRILE WHERE THE LATTER REPRESENTS NOT LESS THAN EVERY OTHER UNIT IN THE CHAIN
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 PARA-SUBSTITUTED 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 ALCHOL UNITS AND AT LEAST 85% TOTAL VINYL ALCOHOL AND ACETAL UNITS
VINYON	AT LEAST 85% VINYL CHLORIDE UNITS



- Extrusion of synthetic fibers

THREE SPINNING TECHNIQUES

WET SPINNING

- Slow
- Deposits impurities on fiber

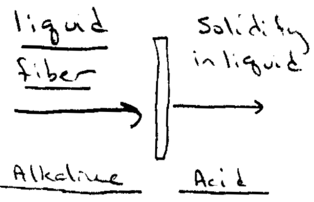
TYPICAL WET SPUN FIBERS

VISCOSE

ACRILAN

CRESLAN

DYNEL



creates alot of pollution (wet spinning rayon)

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

	dissolve in:
ACETATE	(ACETONE SOLVENT)
TRIACETATE	(METHYLENE CHLORIDE)
ORLON	(DIMETHYL FORMAMIDE)
SPANDEX (SOME)	(DTMETHYL FORMAMIDE)
	solidify in hot dry air

DISADVANTAGES

FLAMMABLE SOLVENT HAZARDS

SOLVENT RECOVERY

SLOW (?) (200 - 400 YDS/MIN)

- Needs to be enclosed to control emissions

ADVANTAGES

- YARN DOES NOT REQUIRE PURIFICATION
- Faster than wet spinning

MELT SPINNING

<u>TYPICAL MELT SPUN FIBERS</u>

NYLONS (second most used)

POLYESTER (most used)

POLYPROPYLENE
- sports wear apparel
- carpet

<u>DISADVANTAGES</u>

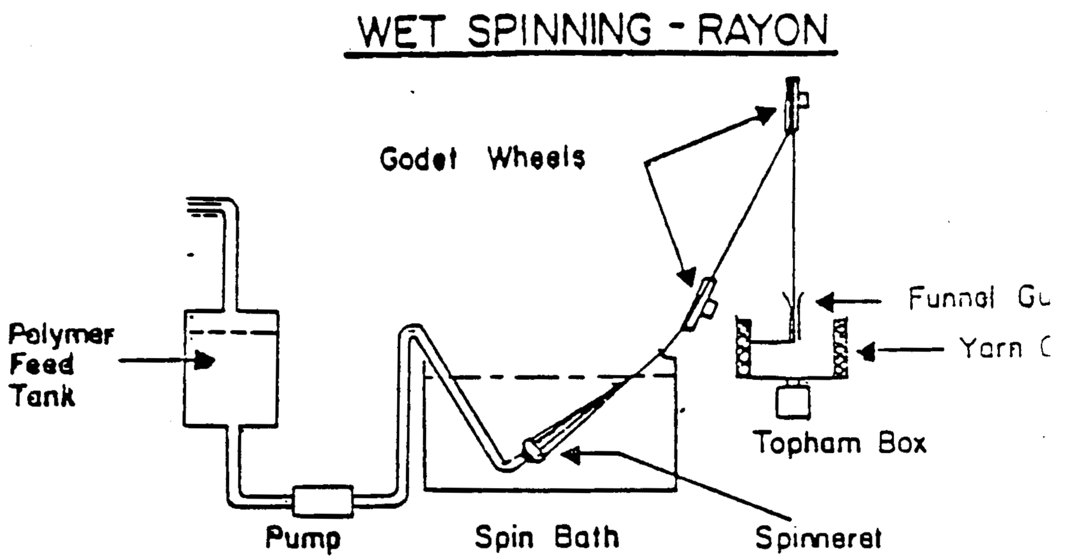
- SEPARATE DRAWING STEP
  (UNLESS SPIN DRAW)
- Not everything is melt spinnable

<u>ADVANTAGES</u>

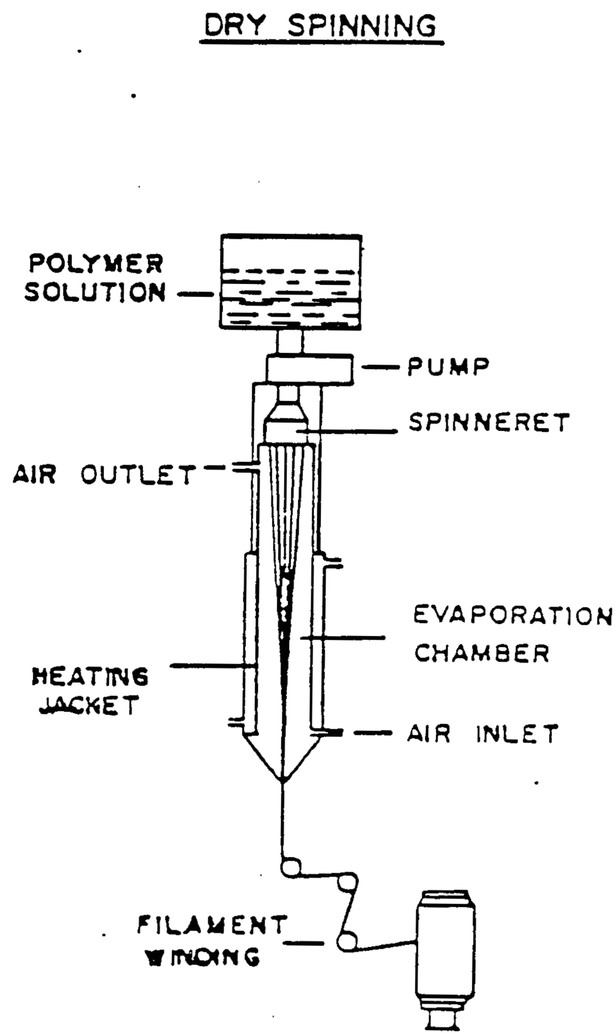
- HIGH SPEED (275 TO 1500 YDS/MIN)
  (4000 YDS/MIN SPIN DRAW)
- NO SOLVENTS
- NO PURIFICATION PROBLEMS
- Cheapest & least cumbersome

EXTRUSION OF MAN-MADE FIBERS
(SPINNING METHODS)

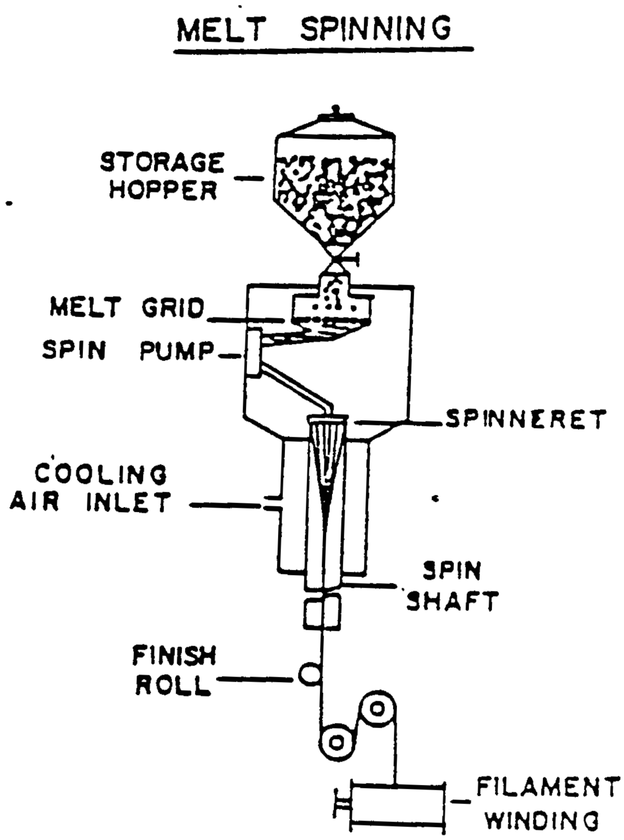
a. Wet Spinning



b. Dry Spinning



c. Melt Spinning



- Different varieties of polyester can dye differently

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."

1. **Primary Properties**

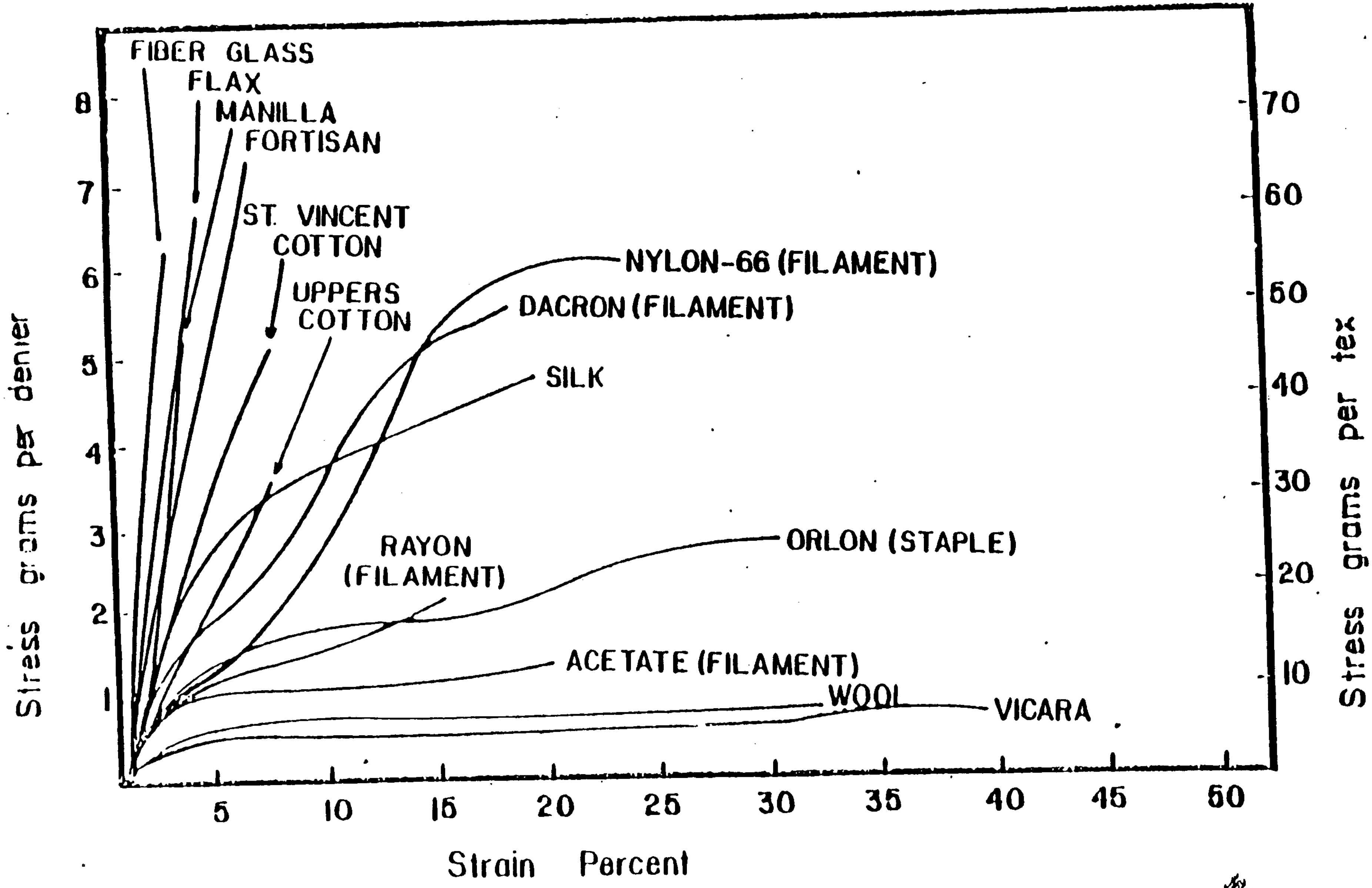
    a. Length; length-width ratio
    b. Tenacity (strength)
    c. Flexibility (pliability)
    d. Acceptable Extensibility for processing
    e. Cohesion
    f. Uniformity of properties

2. **Secondary Properties**

    a. Physical shape (cross-section, surface contour, etc.)
    b. Specific Gravity (influence weight, cover, etc.)
    c. Moisture Regain and Moisture Absorption (comfort, static electricity, etc.)
    d. Elastic character - tensile and compression
    e. Thermoplasticity (softening point and heat-set character)
    f. Dyeability
    g. Resistance to solvents, corrosive chemicals, micro-organisms, and environmental conditions
    h. Flammability
    i. Luster

Note: Cost is always a factor to consider.

TYPICAL STRESS-STRAIN CURVES OF VARIOUS FIBERS

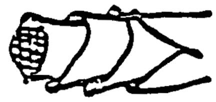


Key Fiber Properties Determined by Polymer Composition and Structure

1. Melting Point
2. Modulus
3. Elasticity and Recovery from Strain
4. Tensile Strength
5. Density
6. Moisture Absorption
7. Dyeability
8. Comfort

EXAMPLES OF FIBER SHAPES

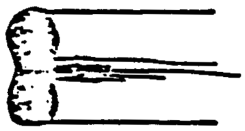
FLAT OVAL,
LUMEN
CONVOLUTIONS
COTTON



OVAL TO
ROUND, OVER-
LAPPING
SCALES,
MEDULLA
WOOL

TRIANGULAR,
ROUND EDGES,
UNIFORM IN
MAN-MADES
SILK, NYLON
TYPE 90 DACRON
TYPE 62

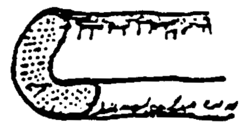
CIRCULAR,
UNIFORM IN
DIAMETER
NYLON, DACRON
CUPRAMMONIUM
RAYON



DOG-BONE
ORLON,
VEREL,
LYCRA

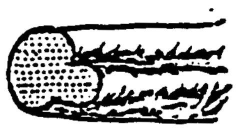
LOBULAR
LENGTHWISE
STRIATIONS
ACETATE

Y-SHAPED
CELACLOUD
TYPE 20
ACETATE
CUMULOFT NYLON

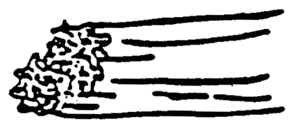


RIBBON-SHAPED
DYNEL

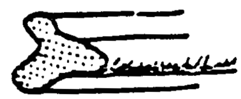
CIRCULAR,
SERRATED,
LENGTHWISE
STRIATIONS
VISCOSE RAYON



MUSHROOM
(BICOMPONENT)
ORLON SAYELLE



LIMA BEAN,
SERRATED
AVRIL RAYON



TRILOBAL
ANTRON
NYLON

COLLAPSED TUBE,
HOLLOW CENTER
AVLIN RAYON,
VINAL SF

NCSU TEXTI

KC2 — Tx 101

DENSITY AND SPECIFIC GRAVITY*

Fiber	Density (g/cc)
Natural Fibers	
Cotton	1.52
Flax	1.52
Silk	1.25
Wool	1.32
Man-made Fibers	
Acetate	1.32
Acrylic	1.17-1.18
Aramid	1.38-1.44
Flurocarbon	2.2
Glass	2.49-2.73
Modacrylic	1.30-1.37
Novoloid	1.25
Nylon	1.14
Nylon Qiana	1.03
Olefin	0.91
Polyester	1.22 or 1.38
Rayon	1.50-1.52
Saran	1.70
Spandex	1.20-1.22
Vinyon	1.33-1.35

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

ABSORBENCY

Fiber	Moisture Regain*
Natural Fibers	
Cotton	7-11
Flax	12
Silk	11
Wool	13-18
Man-made Fibers	
Acetate	6.0
Arnel triacetate	3.2
Acrylic	1.3-2.5
Aramid	4.5
Flurocarbon	0
Glass	0-0.3
Modacrylic	0.4-4.0
Novoloid	5.5
Nylon	4.0-4.5
Nylon Qiana	2.5
Olefin	0.01-0.1
Polyester	0.4-0.8
Rayon	15
Rayon HWM	11.5-13
Saran	0.1
Spandex	0.75-1.3
Vinyon	0.5

*Moisture regain is expressed as a percentage of the moisture-free weight at 70° Fahrenheit and 65% relative humidity.

HEAT AND TEXTILE MATERIALS

IMPORTANT CRITERIA TO CONSIDER

1. SOFTENING, MELTING, OR DECOMPOSITION TEMPERATURES,
2. TENDENCY OF THE FIBER AND FABRIC TO SHRINK WHEN HEAT-RELAXED, OR STRETCH WHEN HEATED AND TENSIONED,
3. ABILITY OF THE FABRIC TO BE HEAT SET,
4. ABILITY OF THE FABRIC TO FUNCTION PROPERLY AT ELEVATED TEMPERATURES IN ONE TIME OR REPEATED USE,
5. 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.

KASWELL

THERMAL PROPERTIES

Fiber	Melting Point °F	Melting Point °C	Softening Sticking Point °F	Softening Sticking Point °C	Safe Ironing Temperature* °F	Safe Ironing Temperature* °C
Natural Fibers						
Cotton	Nonmelting				425	218
Flax	Nonmelting				450	232
Silk	Nonmelting				300	149
Wool	Nonmelting				300	149
Man-made Fibers						
Acetate	446	230	364	184	350	177
Arnel Triacetate	575	302	482	250	464	240
Acrylic			400-490	204-254	300-350	149-176
Aramid	Does not melt, carbonizes above 800° F					
Glass			1400-3033			
Modacrylic	410	210	300	149	200-250	93-121

THERMAL PROPERTIES (Cont.)

Fiber	Melting Point		Softening Sticking Point		Safe Ironing Temperature*	
	^{0}F	^{0}C	^{0}F	^{0}C	^{0}F	^{0}C
Novoloid	Nonmelting					
Nylon 6	414	212	340	171	300	149
Nylon 66	482	250	445	229	350	177
Olefin	275	135	260	127	150 (lowest possible)	66
Polyester PET	480	249	460	238	325	163
Polyester PCDT	550	311	490	254	350	177
Rayon	Nonmelting				375	191
Saran	350	177	300	149	Do not iron	
Spandex	446	230	347	175	300	149
Vinyon	285	140	200	93	Do not iron	

* Lowest setting on irons: 185-225^0 F.

COMPARATIVE FIBER PROPERTIES - EFFECT OF ACIDS

ACRYLIC	Resistant to most acids
MODACRYLIC	Resistant to most acids
POLYESTER	Resistant to most mineral acids; disintegrated by 96% sulfuric
RAYON	Disintegrates in hot dilute and cold concentrated acids
ACETATE	Soluble in acetic acid, decomposed by strong acids
TRIACETATE	Similar to acetate

<u>COMPARATIVE FIBER PROPERTIES - EFFECT OF ACIDS</u>

NYLON (66)	Decomposed by strong mineral acids, resistant to weak acids
OLEFIN	Very resistant
GLASS	Resists most acids. Etched by hydrofluoric acid and hot phosphoric acid
COTTON	Similar to rayon
WOOL	Destroyed by hot sulfuric, otherwise unaffected by acids

COMPARATIVE FIBER PROPERTIES - EFFECTS OF ALKALIES

ACRYLIC	Destroyed by strong alkalies at a boil. Resists weak alkalies
MODACRYLIC	Resistant to alkalies
POLYESTER	Resistant to cold alkalies. Slowly decomposed at a boil by strong alkalies
RAYON	No effect by cold, weak alkalies. Swells and loses strength in concentrated alkalies
ACETATE	Saponified. Little effect from cold weak alkalies
TRIACETATE	Not effected up to pH 9.8, 205^{0}F. Better than acetate

COMPARATIVE FIBER PROPERTIES - EFFECTS OF ALKALIES

NYLON (66)	Little or no effect
OLEFIN	Very resistant
GLASS	Attacked by hot weak alkalies and concentrated alkalies
COTTON	Swells when treated with caustic soda but is not damaged
WOOL	Attacked by weak alkalies, destroyed by strong alkalies

COMPARATIVE FIBER PROPERTIES - EFFECT OF ORGANIC SOLVENTS

ACRYLIC	Unaffected
MODACRYLIC	Soluble in warm acetone, otherwise unaffected
POLYESTER	Soluble in some phenolic compounds, otherwise unaffected
RAYON	Unaffected
ACETATE	Soluble in acetone, dissolved or swollen by many others
TRIACETATE	Soluble in acetone, chloroform and swollen by others

COMPARATIVE FIBER PROPERTIES - EFFECT OF ORGANIC SOLVENTS

NYLON (66)	Generally unaffected, soluble in some phenolic compounds
OLEFIN	Soluble in chlorinated hydrocarbons above 160^{0}F.
GLASS	Unaffected
COTTON	Resistant
WOOL	Generally resistant

COMPARATIVE FIBER PROPERTIES - EFFECT OF SUNLIGHT

ACRYLIC	Little or no effect
MODACRYLIC	Highly resistant, some loss of strength and discoloration after constant exposure.
POLYESTER	Some loss of strength, no discoloration, very resistant behind glass.
RAYON	Generally resistant. Loses strength after long exposure.
ACETATE	Approximately same as rayon.
TRIACETATE	Resistant. Loses strength after long exposure.
NYLON (66)	No discoloration. Strength loss after long exposure.

COMPARATIVE FIBER PROPERTIES - EFFECT OF SUNLIGHT

OLEFIN	Very resistant. Retains 95% strength after 6 mos. exposure
GLASS	None
COTTON	Strength loss on long exposure
WOOL	Strength loss, dyeing is affected.

RAYON

(A CELLULOSIC MAN-MADE FIBER)

COMPOSITION

REGENERATED CELLULOSE

PHYSICAL PROPERTIES

1.	MICROSCOPIC APPEARANCE	- STRIATIONS SEEN IN VISCOSE AND HIGH-STRENGTH RAYON. IF DELUSTERED, SCATTERED SPECKS OF PIGMENT CAN BE SEEN.
2.	LENGTH	- FILAMENT AND STAPLE
3.	COLOR	- TRANSPARENT UNLESS DULLED BY PIGMENTS
4.	LUSTER	- HIGH UNLESS DELUSTERING PIGMENT ADDED
5.	STRENGTH	- FAIR TO EXCELLENT REGULAR RAYON HAS FAIR STRENG HIGH TENACITY TYPES HAVE GOOD TO EXCELLENT STRENGTH
6.	ELASTICITY	- REGULAR RAYON IS LOW HIGH STRENGTH RAYON IS GOOD
7.	RESILIENCY	- HIGH WET-STRENGTH RAYON IS BETTER
8.	MOISTURE ABSORPTION	- HIGHER THAN NATURAL CELLULOSE FIBERS SWELL IN WATER WEAKER WHEN WET
9.	HEAT	- LOSES STRENGTH ABOVE 300°F DECOMPOSES BETWEEN 350 AND 400°F
10.	FLAMMABILITY	- BURNS RAPIDLY UNLESS TREATED
11.	ELECTRICAL CONDUCTIVITY	- FAIR - STATIC CHANGE CAN BE REDUCED WITH SPECIAL FINISHES
12.	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

ACETATE

(A CELLULOSIC MAN-MADE FIBER)

COMPOSITION

ACETATE ESTER OF CELLULOSE.

PHYSICAL PROPERTIES

1.	MICROSCOPIC APPEARANCE	- STRIATIONS FARTHER APART THAN VISCOSE RAYON. LOBED CROSS-SECTION
2.	LENGTH	- FILAMENT AND STAPLE
3.	COLOR	- TRANSPARENT UNLESS DULLED BY PIGMENTS
4.	LUSTER	- BRIGHT, SEMIBRIGHT, OR DULL
5.	STRENGTH	- MODERATE. LESS THAN RAYON WHEN WET.
6.	ELASTICITY	- NOT VERY HIGH. SIMILAR TO RAYON
7.	RESILIENCY	- POOR
8.	MOISTURE ABSORPTION	- 6%, LITTLE STRENGTH LOSS WHEN WET
9.	HEAT	- IRONING TEMPERATURES OF 275°F ARE SATISFACTORY
10.	FLAMMABILITY	- SLOWLY COMBUSTIBLE
11.	ELECTRICAL CONDUCTIVITY	- GOOD
12.	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.

ACRYLIC
(A WOOL-LIKE FIBER)

COMPOSITION

ACRYLONITRILE AND SMALL AMOUNTS OF OTHER MONOMERS

PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE
   UNIFORM AND SMOOTH SURFACE
   IRREGULAR SPACED STRIATIONS
2. LENGTH - MAINLY A STAPLE FIBER
3. COLOR - WHITE TO OFF-WHITE
4. LUSTER - BRIGHT, SEMIDULL, OR DULL
5. STRENGTH - FAIR TO GOOD STRENGTH
6. ELASTICITY - GOOD
7. RESILIENCE - GOOD
8. WATER ABSORPTION - 1-3%
9. HEAT - YELLOWING MAY OCCUR ABOVE 300°F
   SOFTENING OR STICKING ABOUT 450°F
10. FLAMMABILITY - BURNS WITH YELLOW FLAME
11. ELECTRICAL CONDUCTIVITY - FAIR TO GOOD
12. 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 - CAPROLACTUM

PHYSICAL PROPERTIES

1.	MICROSCOPIC APPEARANCE	- VERY SMOOTH AND EVEN
2.	LENGTH	- FILAMENT AND STAPLE
3.	COLOR	- OFF WHITE
4.	LUSTER	- HIGH NATURAL LUSTER CAN BE CONTROLLED
5.	STRENGTH	- EXCEPTIONALLY HIGH (60,000 - 108,000) POUNDS PER SQUARE INCH
6.	ELASTICITY	- EXCEPTIONALLY HIGH
7.	RESILIENCY	- VERY GOOD
8.	MOISTURE ABSORPTION	- 3.8%
9.	HEAT	- HIGH RESISTANCE. MELTS AT 482°F
10.	FLAMMABILITY	- MELTS SLOWLY DOES NOT SUPPORT COMBUSTION
11.	ELECTRICAL CONDUCTIVITY	- LOW, GENERATES STATIC
12.	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 DIMETHYL TEREPHTHALATE AND ETHYLENE GLYCOL

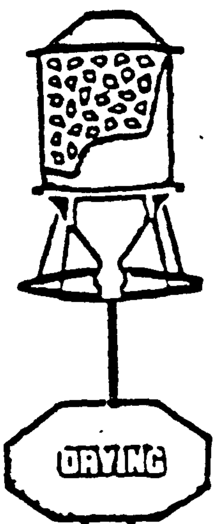
PHYSICAL PROPERTIES

1. MICROSCOPIC APPEARANCE - SMOOTH, EVEN, RODLIKE, DIFFERENT CROSS-SECTIONAL SHAPES
2. LENGTH - FILAMENT AND STAPLE
3. COLOR - WHITE
4. LUSTER - BRIGHT OR DULL
5. STRENGTH - GOOD TO EXCELLENT
6. ELASTICITY - FAIR TO GOOD, GREATER THAN COTTON OR RAYON
7. RESILIENCY - EXCELLENT
8. MOISTURE ABSORPTION - LESS THAN 1%
9. HEAT - SOFTENING OR STICKING TEMPERATURE IS ABOVE 400°F (THERMOPLASTIC)
10. FLAMMABILITY - BURNS SLOWLY
11. ELECTRICAL PROPERTIES - ACCUMULATES STATIC CHANGES
12. SPECIFIC GRAVITY - TYPICALLY 1.38

CHEMICAL PROPERTIES

GOOD RESISTANCE TO MOST ACIDS
GOOD RESISTANCE TO MOST ALKALIES
GOOD SUNLIGHT RESISTANCE

PRODUCTION OF POLYESTER



POLYMERIZATION

The raw material used to form a man-made fiber is known as the polymer and the chemical process of manufacturing the polymer is called polymerization.

There are two polymerization processes: batch and continuous. In the batch process, the polymer is made up in batches, then sent into the spinning process. In the continuous process, polymer is made continuously and spun continuously. To make the polyester polymer, dimethyl terephthalate is reacted with ethylene glycol at a temperature range of 150-210°C, in the presence of a catalyst. A monomer (dihydroxydiethyl terephthalate) is created and transferred to a polymerization autoclave, where the temperature is raised to about 280°C.

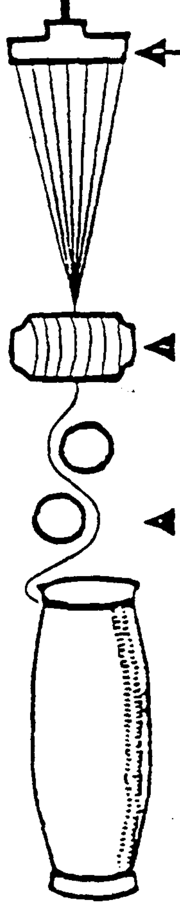
DRYING

When the desired viscosity is reached, the polymer is extruded, cooled and formed into chips. All moisture must be removed to prevent irregularities.

MELT SPINNING

Polymer chips are melted under high temperatures (280-270°C), then the syrupy solution is forced through the tiny holes of a spinneret or jet. The basic difference between filament and staple spinning is the number of holes in the spinneret.

For filament, the number of holes determines the size of the yarn. Thus, a 150 denier/36 filament yarn is extruded through one spinneret with 36 holes, and each hole produces an individual filament of 4.1 denier (150 ÷ 36). By contrast, the spinneret for staple spinning is larger. Typically it has 300 to 400 holes.



UNDRAWN YARN

At this stage the filament yarn is easily elongated and pulled apart. If heat-set, it would be very brittle. It is then brought into the drawing stage to increase its strength.

DRAWING

Filament is drawn out to give it high strength, tenacity and resilience. This is done on heated draw rolls by a draw ratio of 3 to 4, much the same as tow. Drawn filament is not dried or heat-set like tow, however. After drawing, it is wound on bobbins or on flat-wound packages. The flat-wound package gathers the filament at a higher speed.

FILAMENT YARN

1 DRAWING TOW

After the molten tow is quickly cooled or quenched, it is dropped or loosely coiled into "sub-tow" cans like rope. Many sub-tows are creeled up or gathered in a parallel run, then drawn on heated tension rollers which actually elongate the tow by a draw ratio of 3-4 times (typically 3.6 times). Drawing the tow increases its strength three fold, since random molecules are all drawn into a parallel formation, also increasing resilience.

2 CRIMPING

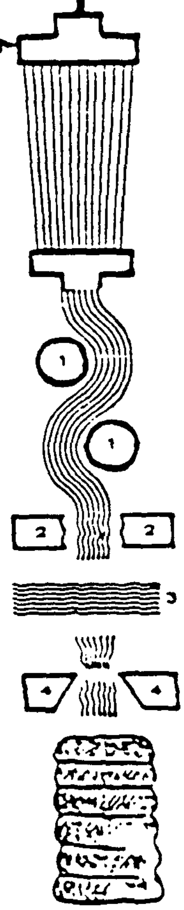
The tow comes into compression boxes, forcing the fiber to buckle back on itself like an accordion, 9-16 crimps per inch. Crimping holds the fiber together, giving it coherence during the yarn spinning stage. Crimping is the mechanical equivalent of what nature does to cotton.

3 DRYING/HEAT SETTING

The crimped tow is dried at 100-150°F to set the crimp. Some of the crimp is lost in yarn spinning later on, which is why fiber companies try to achieve a balance of properties during the drawing and crimping stage by applying finish to hold fibers together and to overcome static.

4 CUTTING

The crimped and heat-set tow is cut into lengths, determined by eventual end-use. Fiber companies generally cut the tow into lengths of 1¼ inches (for blending with combed cotton), 1½ inches (carded cotton) and 2 inches (rayon) under the cotton system. An outside contractor will cut tow into longer lengths of 3 to 6 inches on the Pacific Converter for worsted processing, thence bales.



STAPLE FIBER

SOURCE: *ENCYCLOPEDIA OF TEXTILES*, 2nd EDITION BY EDITORS OF AMERICAN FABRICS MAGAZINE © 1960, 1972 BY DORIC PUBLISHING COMPANY PUBLISHED BY PRENTICE-HALL, INC., ENGLEWOOD CLIFFS, NEW JERSEY.

TEXTILE FIBER PROPERTIES

	Specific Gravity	Tenacity gpd	Tenacity (wet) gpd	Moisture regain (per cent)	Elongation (per cent)	Softening Melting Point (F°)
COTTON	1.5 - 1.55	3.0 - 4.9	3.3 - 6.4	7 - 8	3 - 7	none
ACETATE	1.32	1.3 - 1.5	1.2 - 1.4	6	23 - 24	(s) 400°F - 445° (m) 500°F
ACRYLIC	1.16-1.18	2.0 - 3.6	1.6 - 2.9	1.5 - 2.5	35 - 39	(s) 420°F
GLASS	2.50-2.55	9.6 - 19.9	6.7 - 19.9	none	3.1 - 5.3	(s) 1350-1560°F
NYLON 66	1.14	3.0 - 7.2	2.6 - 6.1	4.2 - 4.5	16 - 66	(s) 445°F (m) 480°F-500°F
POLYESTER	1.38	2.2 - 6.6	2.2 - 6.6	0.4 - 0.8	12 - 67	(s) 445°F (m) 482°F
RAYON, HT	1.50 - 1.53	3.0 - 5.7	1.9 - 4.3	13	9 - 26	DNM Decomposes 350°F-400°F
WOOL	1.31	1 - 1.5	-----	16	30 - 40	DNM De. 310-350
SILK	1.25	3 - 5	-----	11	25	DNM 350-400

SUMMARY OF PROPERTIES DESIRED FOR TEXTILE FIBERS

APPAREL AND DOMESTIC REQUIREMENTS

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

INDUSTRIAL REQUIREMENTS

1. Tenacity: 7 - 8 grams/denier.
2. Elongation at break: 8 - 15%.
3. Modulus of elasticity: 80 grams/denier or more conditioned, 50 grams denier wet.
4. Zero strength temperature: 250°C or above.

EEH - Fiber Science II.

FIBER PROPERTIES AFFECTING FABRIC PROPERTIES

FIBER PROPERTY	CONTRIBUTES TO FABRIC PROPERTY
Abrasion resistance is the ability of a fiber to withstand the rubbing or abrasion it gets in every day use.	Durability Abrasion resistance Resistance to splitting
Absorbency or moisture regain is the percentage of moisture a bone-dry fiber will absorb from the air under standard conditions of temperature and moisture.	Comfort, warmth, water repellency, absorbency, static buildup Dyeability, spotting Shrinkage Wrinkle resistance
Aging resistance	Storing of fabrics
Chemical reactivity is the effect of acids, alkali, oxidizing agents, solvents	Care required in cleaning--bleaching, ability to take acid or alkali finishes
Cohesiveness is the ability of fibers to cling together during spinning. Not important in contnuous filament.	Resistance to ravel
Cover is the ability to occupy space for concealment or protection.	Warmth in fabric Cost--less fiber needed
Creep is delayed elasticity. Recovers gradually from strain	Streak dyeing and shiners in fabric
Density--see *Specific Gravity*	
Dyeability is the fibers' receptivity to coloration by dyes	Aesthetics and colorfastness
Elastic recovery is the ability of fibers to recover from strain *Elasticity* is the ability of a stretched material to return immediately to its original size.	Processability of fabrics Resiliency Delayed elasticity or creep

Fiber Property	Contributes to Fabric Property
Fiber properties . . . . (*cont.*)	
Electrical conductivity is the ability to transfer electrical charges	Poor conductivity causes fabric to cling to the body, electric shocks
Elongation is the ability to be stretched, extended, or lengthened. Varies at different temperatures and when wet or dry.	Increases tear strength Reduces brittleness Provides "give" and stretchiness
Feltability refers to the ability of fibers to mat together	Fabrics can be made directly from fibers Special care required furing washing
Flammability is the ability to ignite and burn	Fabrics burn
Hand is the way a fiber feels: silky, harsh, soft, crisp, dry	Hand of fabric
Heat conductivity is the ability to conduct heat away from the body	Warmth
Heat sensitivity is the ability to soften, melt, or shrink when subjucted to heat.	Determine safe washing and ironing temperatures
Hydrophilic, hygroscopic--see absorbency.	
Luster is the light reflected from a surface. More subdued than shine: light rays are broken up	Luster
Loft or compressional resiliency is the ability to spring back to original thickness after being compressed	Springiness, good cover Resistance to flattening
Mildew resistance	Care during storage
Moth resistance	Care during storage

Fiber Property	Contributes to Fabric Property
Pilling is the balling up of fiber ends on the surface of fabrics.	Pilling Unsightly appearance
Specific gravity and density are 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	Warmth without weight
Stiffness or rigidity is the opposite of flexibility. It is the resistance to bending or creasing.	Body of fabric Resistance to insertion of yarn twist
Strength is defined as the ability to resist stress and is expressed as tensile strength (pounds per square inch) or as tenacity (grams per denier).	Durability, tear strength, sagging, pilling Sheerer fabrics possible with strong fine fibers
Sunlight resistance is the ability to withstand degradation from direct sunlight.	Durability of curtains and draperies, outdoor furniture, outdoor carpeting
Toughness	Resists rupture from deformation, gives frictional resistance
Wicking is the ability of a fiber to transfer moisture along its surface.	Makes fabrics comfortable

FIBER BLENDS - SOME REASONS FOR BLENDING

TO FACILITATE PROCESSING

TO IMPROVE PROPERTIES:

a. ABRASION RESISTANCE

b. STRENGTH

c. ABSORBENCY

d. ADD BULK AND WARMTH

e. HAND

f. DIMENSIONAL STABILITY

g. RESISTANCE TO WRINKLING

TO PRODUCE MULTI-COLOR FABRICS

TO REDUCE COST