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INTRODUCTION

Spandex. Acrylic. Nylon. Lyocell. Olefin. Polyester. Have you heard these names? You might have noticed them on the tags sewn into your clothing and household textiles or in catalog copy describing a product. You might have seen them in stain-removal guides, on your iron, or in the cautions on the back of a bleach bottle. Your washing machine instructions may use these names in sorting and cycle selection information. They are generic fiber names for common textile fibers. Do you know what performance to expect from items made of these fibers? Do you know how to care for each fiber type?

You might be more familiar with the names Lycra, Creslan, Cordura, Tencel, Thinsulate, and Dacron. These are some well-known brand names for the same fibers. People are often familiar with advertised brands and may request fiber brands when shopping for sports apparel, for instance, without knowing what fiber they are actually requesting. Wouldn't it be useful to know that fabric containing spandex should have the same properties as fabric containing Lycra? Haven't you ever wondered what Thinsulate is really made from? Or whether recycled polyester is different from other polyester? Do you realize that many fibers are petroleum derivatives? Do you assume that all knitting yarn is the same and that it is alright to mix acrylic and wool in the same item?

This book is designed to answer those questions. It provides basic information on fiber origin, production, characteristics, brand names and producers, and care and cautions for the fibers most commonly found in clothing, home furnishings, linens, and outdoor and sports gear.

ACETATE AND TRIACETATE

The Beauty Fiber and its Cousin

Acetate and triacetate are related fibers made from cellulose acetate, originally used to seal the fabric wings of early aircraft. A surplus of cellulose acetate after World War I spurred research into new uses, culminating in the discovery of a method of creating fibrous cellulose. Acetate fiber reached the market in the United States in 1924, the second man-made fiber available. Triacetate was manufactured in the United States from 1954 until 1986, and is still imported.

Acetate is a luxurious fiber with an attractive sheen that has made it popular for taffeta, brocade, satin, and velvet fabrics used for formal wear. The most important use of acetate is as a lining for suits, coats, draperies, and caskets. Acetate is found in choir and graduation robes and in drapery fabrics, particularly antique satins. It is often used for labels sewn into clothing and for decorative ribbons. Acetate fiber is used in cigarette filters as well.

Triacetate is found primarily in women's apparel fabrics such as velour and suede-like fabrics for robes and dresses. It is used in tricot knits, sharkskins, and various woven dress fabrics.

ACETATE MANUFACTURE

Acetate is defined by the Textile Fiber Products Identification Act as "a manufactured fiber in which the fiber-forming substance is cellulose acetate." Like rayon, acetate is made from cellulose; but it is a chemical derivative of cellulose, whereas rayon is pure cellulose reshaped as a fiber.

Acetate fiber production begins with purified and bleached cellulose, either wood pulp or cotton fiber too short to spin. The cellulose is shredded and treated with acetic acid and other chemicals to break up the cellulose molecules and substitute acetyl groups for hydroxyl groups. Acid is then removed from the resulting cellulose acetate compound. The cellulose acetate is dissolved in acetone to create a clear solution that can be spun into fiber. The acetone solvent evaporates during spinning. The acids and acetone used in acetate manufacture are largely recovered for reuse.

Acetate can be modified by adding compounds to the cellulose acetate solution or by variations in spinning processes. Low-luster fibers can be produced with the addition of titanium oxide, although the additive reduces fiber durability. Acetate can be made in a flame-

retardant variant to meet fire codes for institutional drapes and upholstery. Variation in fiber cross section can be made by changing the shape of spinneret openings. A Y-shape provides additional loft to allow acetate to be used as a fiberfill. Air blown onto yarns as they are being spun can produce fancy textures, often used in knitwear.

Antimicrobial acetate is a recent product, produced under the name Microsafe by Celanese Acetate. Microsafe inhibits the growth of a broad range of microorganisms. It can be laundered several hundred times without losing its properties. Because the structure of acetate allows the antimicrobial agent to migrate throughout a fabric, a small amount of Microsafe can be blended with other fibers to control odor, bacteria, and mildew in the entire fabric. It is now incorporated into pillows and other bedding items for hospitals and homes, and used for medical products, high performance gear, and furnishings.

Acetate yarn is generally used in filament form—that is, as long, continuous yarns—to show off the natural fiber luster. It can be cut into shorter staple-length fibers for blending with other fibers. Acetate is blended with many types of fibers, often to enhance fabric softness.

Triacetate is also a cellulose acetate fiber, different from acetate in that at least 92 percent of the hydroxyl groups of the cellulose molecule have been replaced by acetate groups. Having mostly acetyl side groups instead of a combination of acetyl and hydroxyl means that triacetate fibers can pack together more than acetate, making them more crystalline and affecting fiber properties. Solvents used to spin triacetate are methylene chloride and methanol rather than acetone.

WHY ACETATE?

- Acetate is known for its luxurious appearance and feel—hence, it is labeled "the beauty fiber." Fabrics are often shiny and have a smooth texture.
- Acetate drapes, or hangs, beautifully. It bends easily, so will move with the body, but has sufficient firmness and springiness to give shape to a garment or drapery. Some acetate fabrics, such as taffeta, are crisp and rustle when moved.
- It feels comfortable next to the skin due to a combination of smooth texture and moderate moisture absorption.
- White acetate remains white, unlike silk, which yellows over time. Acetate dyes in myriad rich colors. Special dyes had to be developed for acetate, which does not accept dyes used for cellulosic fibers. Solution-dyed acetate, or acetate dyed before spinning, has excellent colorfastness.
- Acetate is resistant to moths, mildew, and bacteria.

It does not build up static.

- Acetate does not pill.

SOME CAUTIONS ABOUT ACETATE

- Acetate is chosen for aesthetic appeal, not durability. It is a weak fiber, especially when wet. It is not abrasion resistant. If elongated, acetate fiber has poor elastic recovery. Acetate is sometimes blended with nylon to increase strength or with spandex to improve elastic recovery.
- Acetate wrinkles easily during wear because it has poor resiliency.
- Some acetate is susceptible to fume

fading, or change in color when exposed to atmospheric fumes. This depends on the type of dye used.

- Acetate degrades more readily than most fibers if exposed to continuous sunlight, a consideration for home furnishings.
- It is thermoplastic, meaning that it softens when heat is applied, but unlike other thermoplastic synthetic fibers, it cannot be heat set to give permanent shape, such as pleats or embossed texture, to fabrics.
- Acetate will dissolve in acetone, the primary component of nail polish remover and an ingredient in nail polish. Acetone solubility can be used to identify acetate fiber, because it is the only soluble fiber.

WHAT IS DIFFERENT ABOUT TRIACETATE?

Tiacetate, like acetate, is soft and silky and not terribly durable. It has similar resistance to insects, molds, and mildew, and to ultraviolet light. Triacetate does not dissolve in acetone, but otherwise exhibits reactions to chemicals like those of acetate. There are some major differences between the fibers, attributed to the greater crystallinity of triacetate. Some of those differences follow:

- Triacetate can be heat set to put permanent creases, pleats, or embossing into the fabric.
- Triacetate is resilient and does not wrinkle during wear.
- Triacetate fabrics can be machine washed and dried, without changing dimensions or wrinkling.
- Triacetate has low moisture absorbency, more similar to polyester than acetate.

FABRIC CARE

Dry-cleaning is recommended for most acetate fabrics because the fiber absorbs water and swells, is weaker when wet, and is easily pulled permanently out of shape when wet. If acetate is washed, it should be washed by hand in warm water. It can be bleached with chlorine or oxygen bleaches. Agitate very gently, and do not twist or wring to remove water. Roll in a towel to absorb excess water. Drip dry or lay flat to dry. Due to temperature sensitivity, wrinkles are set easily by using too hot a dryer. Always follow care label instructions.

Acetate can be pressed while damp on the back side with a cool iron. A press cloth should be used to press on the right side. Acetate will soften, stick to the iron, and shrink at about 350 degrees F.

Triacetate may be machine washed and tumble dried. It will not shrink or wrinkle in the dryer. If pressing is necessary, the wool setting on the iron should be used, and no press cloth is needed. Permanently pleated or creased triacetate fabrics may retain their shape best if hand washed and drip dried.

Triacetate may be bleached. Triacetate fabrics will not pick up color or soil from laundry water, so whites retain their whiteness.

ACETATE MANUFACTURERS

Acetate is produced by two companies in the United States. Celanese manufactures under the brand names Celanese Acetate and MicroSafe. Eastman produces Estron and Chromspun brands. These companies can be contacted for further information. Triacetate is not currently produced in the United States, but imported triacetate is available in the U.S.

Celanese Acetate
3 Park Avenue
New York, NY 10016-5902
212-251-8000

Eastman Chemical Company
P.O. Box 431
Kingsport, TN 37662-5370
615-229-2000

REFERENCES

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Celanese Acetate Filament Company

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

ACRYLIC AND MODACRYLIC

Warmth without Weight

Acrylic to many people is the fiber for machine-washable, nonallergenic winter knits. Acrylic is often made into a soft, bulky yarn used for sweaters, hats, and mittens; sweatshirt fleece; socks; pile fabrics; blankets; and craft yarns for knitting, crocheting, and crewel embroidery. Acrylic is much more versatile than that, however. It is a fiber whose properties can be designed to suit a particular need by varying fiber components and manufacturing conditions. It is used for cotton-like apparel fabrics; for upholstery, lawn furniture, awnings, and sail covers; and even for asbestos replacement. Acrylic is often the precursor fiber for carbon fibers, as well.

Modacrylic, a closely related fiber with many similar properties, is no doubt most familiar to consumers as pile coats or linings, simulated furs, wigs, and hair pieces. Modacrylic is in fact also found in blankets, awnings, rugs, filters, paint rollers, stuffed toys, and flame-resistant draperies and curtains.

Both acrylic and modacrylic are produced from acrylonitrile, a petroleum derivative that was first used as a component in synthetic rubber during World War II. DuPont introduced Orlon acrylic in 1950. Today several manufacturers produce many varieties of acrylic fibers, although DuPont discontinued Orlon production in 1990. Sterling Performance Fibers manufactures Creslan, MicroSupreme, BioFresh, and WeatherBloc acrylics. Solutia makes Acrilan, Sayelle, Wear-Dated, Bounce-Back, Wintuk, and DuraSpun Smart Yarns. Modacrylic entered the United States market in 1949 as Dynel, manufactured by Union Carbide. Currently Solutia is the only company in the United States producing modacrylic, under the name SEF, for self-extinguishing fiber.

FIBER PRODUCTION

The Federal Trade Commission defines acrylic as "a manufactured fiber in which the fiber-forming substance is any long-chain synthetic polymer composed of at least 85 percent by weight of acrylonitrile units." Pure acrylonitrile is very difficult to dye due to the polymeric structure, so most acrylics are made as copolymers, or combinations, of acrylonitrile with up to 15 percent additives. Additives provide a more open structure that will allow dye to be absorbed into the fiber. Multiple additives may be used to provide additional reactive sites for dyes or to impart flame resistance to the

fiber. The exact additives used are proprietary, and variation in additives will produce varied fiber characteristics.

Modacrylic is also composed of acrylonitrile units, less than the 85 percent by weight contained in acrylic, but at least 35 percent. So, in fact, the bulk of the modacrylic molecule may consist of one or more copolymers. Common copolymers for modacrylic are vinyl chloride, vinylidene chloride, or vinyl bromide.

Acrylic and modacrylic are usually wet spun, meaning that fibers are formed by extruding polymer solution through spinnerets into a chemical bath where the fibers solidify, then removing the solvent. Acrylic may also be dry spun, which involves extruding polymer into hot gas to harden the resulting filaments and evaporate solvents. The fiber cross section varies according to the method of fiber formation. Dry spinning produces a dog-bone cross section, whereas wet spinning gives a round or lima-bean shape. These cross-sectional differences do affect fiber properties—e.g., the dog-bone shape is more flexible and results in a softer fiber.

Most acrylic fiber is crimped to add bulk, stretch, and resiliency. Crimp is imparted by rolling fibers over heated gears or stuffing them into a box when warm, then cooling them into a new shape. Both acrylic and modacrylic are cut into staple, or short, lengths for spinning into yarns like wool or cotton. Crimped fibers entangle with one another, forming yarns more easily than straight fibers. Staple fibers are easily blended with other fibers to make yarns; acrylic is blended with many other fibers.

High-bulk acrylic yarn for use in knitwear or pile fabrics is made in two ways. One means uses two variants of acrylic side by side in a single fiber, a bicomponent fiber. One of the variants shrinks when exposed to heat, causing the yarn to crimp. The other means of making high-bulk yarns uses high-shrinkage acrylic fibers blended into yarns with ordinary acrylic. After the yarn is spun, it is heated, causing the high-shrinkage yarns to shrink and pulling the regular acrylic into loops and crimps.

There are several specialty acrylic variations. MicroSupreme, a very fine fiber, is on the market in products such as golf shirts, thermal underwear, and pile fabrics. Acrylic that has been modified to become more moisture absorbent has cotton-like properties. Antistatic and antipill variants are both available. If copolymers, each with an affinity for a different type of dye, are used to make an acrylic yarn or fabric, they can be simultaneously dyed in two colors to produce heather yarns or patterned fabrics. Flame-resistant acrylic fibers are made for carpeting and draperies. A high-temperature, heat-resistant acrylic is used to protect welders and steel workers from molten metal. Antimicrobial acrylic fibers control fungi, bacteria, viruses, and yeasts. They have been widely used in socks, shoe liners, bathroom rugs and shower curtains, and hospital bedding and gowns. An acrylic fiber with ion-exchange ability is used in kidney dialysis.

CHARACTERISTICS OF ACRYLIC

- Acrylic fibers are soft and flexible. Textured acrylic imitates the soft, resilient bulk of wool better than any other synthetic fiber.
- Acrylic is quite lightweight, so it is warm without being heavy.
- It can be dyed in very bright colors and has excellent color fastness.
- Acrylic fibers do not absorb much moisture. They are considered moderately comfortable because the characteristic uneven surface of the fiber allows moisture to wick from the skin to the outside of a fabric for evaporation, leaving the fiber dry. This stay-dry property plus its soft bulk make acrylic popular for socks.
- The fibers are sufficiently resilient to resist wrinkling during wear and care. Bulky acrylic yarns are particularly resilient, meaning that yarns do not mat and compress, but spring back to original shape.
- Acrylic has excellent resistance to sunlight degradation, which makes it ideal for outdoor furniture, awnings, boat covers, and automobile upholstery.
- Acrylic has medium strength and resistance to abrasion, making it more like wool than like some of the other synthetic fibers.
- It has good resistance to organic solvents and oxidizing agents, dilute acids, and dilute alkalis. It can be dissolved by concentrated acids and will be damaged by chlorine bleach.
- Acrylic is resistant to moths, oils, and chemicals.
- It cannot be permanently heat set to shape like polyester or nylon because rather than melting when heated, it decomposes. Pleats durable to wear or cleaning can be pressed in, but they are easily removed with excessive temperatures during drying or ironing.
- Acrylic will build up static electricity.
- Pills sometimes form on the surface of acrylic fibers.

CHARACTERISTICS OF MODACRYLIC

- Modacrylic has many characteristics similar to acrylic.
- Modacrylic softens at very low temperatures, allowing it to be stretched, embossed, or molded into shape easily. Fibers with different heat shrinkage characteristics can be mixed in a pile fabric so that after heat is applied, the fibers are at varying lengths like natural fur.
- Modacrylic is inherently fire retardant, being difficult to ignite, self-extinguishing if ignited, and dripless if burned at all. It has been used for children's sleepwear and is used for institutional draperies to meet fire codes.

CARE OF ACRYLIC AND MODACRYLIC

Be sure to follow care label instructions for acrylic and modacrylic. There are many types of acrylic, requiring different care. In general, acrylic and modacrylic are machine or hand washable, but some fabrics have water-soluble finishes on them and must be dry cleaned. Dry cleaning is generally recommended for high-pile fabrics, such as imitation furs.

Launder acrylic fabrics in warm or cool water with gentle agitation. Hot water causes stretching and may leave the garment distorted. Do not bleach acrylic with chlorine.

Many woven or firmly woven knitted acrylic garments may be drip-dried. Drip-drying is preferable for pleated garments, because dryer heat may remove pleats. Machine dry other acrylic garments at a low temperature and remove them promptly to avoid wrinkling. Acrylic sweaters do not need to be laid out and blocked to shape as do wool sweaters. In fact, some acrylic sweaters containing a particular type of textured yarns must be machine dried to regain their shape and will be very large and misshapen if dried another way. A sweater of this type that is mistakenly air dried may be returned to shape by rewashing and machine drying.

Acrylic garments may be ironed with a moderately warm iron if necessary. Steam should not be used, because the combination of heat and steam may stretch and distort a garment.

Modacrylic must be cleaned with care. The fiber shrinks at 250 degrees F., and stiffens at temperatures over 300 degrees F. A warm-water wash and a low dryer setting should be used. The lowest ironing setting is required. Many deep-pile garments require dry cleaning or fur cleaning. Be sure to check care labels.

FURTHER INFORMATION

Additional information on acrylic and modacrylic may be obtained by contacting one of the following:

The Acrylic Council, Inc.
1285 Avenue of the Americas
New York, NY 10019
212-554-4042

Sterling Performance Fibers
5 Garret Mountain Plaza
West Patterson, NJ 07424
201-357-3100

Solutia, Inc.
1460 Broadway
New York, NY 10018
212-382-9600

REFERENCES

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

Solutia, Inc.

The Acrylic Council

COTTON

World's Most Popular Fiber

Cotton is all around you. It is the fiber used for your favorite soft T-shirts and blue jeans. Your underwear, socks, shirts, and khaki pants may be cotton too, as are the baby's diapers. Your furniture may be covered in cotton, and your sheets and towels are mostly cotton. Many medical supplies, sewing thread, book bindings, and other common items are cotton.

Light and heavy fabrics can be made from cotton. The fiber is commonly used for denim, corduroy, slack-weight twills, flannel, percale, poplin, terry cloth, seersucker, chintz, and knits of many kinds. Cotton is also blended with other fibers, particularly polyester. Polyester adds strength and durability as well as improved wrinkle resistance.

ADVANTAGES OF COTTON

Cotton has several desirable properties:

- Cotton fibers are soft. There are no known cases of skin irritation or contact allergy to cotton.
- Cotton is highly absorbent. This means that cotton absorbs perspiration and keeps the body cool, especially in hot weather. This trait also makes cotton ideal for towels. But if completely saturated, cotton is slow to dry, making jeans a bad choice for a hike on a wet day.
- Cotton does not build up a static charge—its moisture content prevents this.
- Cotton is moderately strong when dry. Strength increases when the fibers are wet, so cotton can be laundered with no special precautions.
- Cotton can be boiled and sterilized, making it useful for medical uses when control of infection is a concern.
- Cotton accepts dyes easily, so it can be dyed in a wide range of colors.
- Cotton is biodegradable.

WHERE DO WE GET COTTON?

Cotton fibers are harvested from the seed of the cotton plant, called a boll. Chemically, the fibers are composed of cellulose, as are other plant products. Under a microscope, cotton fibers resemble a flat, twisted ribbon. Cotton is a staple fiber, which means that many short fibers must be spun together to form yarn.

Cotton is classified according to fiber length. Short-staple cotton consists of fibers of 3/4 inch or less in length. Indian and Asian cotton is generally short staple. Intermediate-length cotton is 13/16 to 1-1/4 inches. American Upland, the most commonly grown cotton in the United States, is intermediate length.

Long-staple cotton is 1-1/2 to 2-1/2 inches long and is often identified on labels because it is considered premium cotton. The longer fibers make smoother yarns with greater luster. Some varieties of long-staple cotton are Pima, Sea Island, and Egyptian.

Cotton fibers are generally creamy white. The whiter the cotton, the higher the grade of the fiber. Cotton that is not pure white is often bleached during processing. Cotton can be grown in tan, brown, or green, then used in these colors without chemical bleaching and dyeing. Cotton sold under the name Foxfibre is naturally colored.

Cleaned cotton fibers are straightened into parallel rows before they are spun using a process called carding. For production of very fine cotton fabrics, an additional step, called combing, removes short fibers and impurities.

CHEMICALS MODIFY COTTON'S PROPERTIES

Cotton is sometimes chemically modified to make it more desirable for particular uses. Textile products may carry labels or hangtags identifying some of the following modifications:

- Mercerized indicates that the cotton has been treated with an alkali to swell the fibers. This improves strength, sheen, and dye receptivity and reduces shrinkage.
- Preshrunk means that a fabric has been treated to remove the tension introduced during manufacturing—i.e., relaxation shrinkage has already taken place, so very minimal shrinkage should occur during laundering. Garments labeled Sanforized, Sanfor-Knit, or Sanfor-Set have been preshrunk. Sanfor-Set garments also will retain a smooth appearance without ironing.
- Stone-washed garments have been washed with pumice stones to soften the fabric surface. This look can also be achieved with use of cellulase enzyme in addition to or instead of stones, giving rise to the term "enzyme-washed." "Acid-washed" garments have been softened using stones and an oxidizing agent.
- Wrinkle-resistant garments have been treated with chemical resins to enable them to resist wrinkles during wear, and to hold creases during wear and laundering. Untreated woven cotton wrinkles easily during wear and requires ironing after laundering. Recent improvements in resins have greatly increased the availability of wrinkle-resistant garments.
- Water-resistant fabrics can be constructed of cotton woven so tightly that the natural tendency of the fiber to swell in water will fill the fabric pores and block penetration of liquid water. A water-repellent finish will cause water to bead up on the fabric surface.
- Flame-retardant fabrics have been chemically treated to slow ignition and cause flames to self-extinguish. Cotton is naturally flammable, burning with an odor like that of burning paper. Cotton smolders, meaning that a fire might break out hours after ignition, a problem if cigarettes are dropped on mattresses or upholstered furniture stuffed with cotton batting. Flame-retardant treatments enable cotton to meet flammability standards for products such as children's sleepwear, protective clothing, and upholstery.

ORGANIC COTTONS

The cotton plant is susceptible to attack by a wide range of insects and diseases. As a result, cotton is grown with extensive use of synthetic insecticides, herbicides, and fertilizers. Cotton also is often bleached during processing, then dyed with chemical dyes. There is a small but growing movement toward more organic cotton production. Cotton products labeled "natural" are cotton textiles that have not been bleached or dyed during processing. FoxFibre cottons are one example of "natural" cottons, but others are available in creamy white shades. "Organic" cotton is cotton grown without the use of artificial chemicals in the field for at least three years and processed without use of synthetic chemical products. It may be dyed with natural dyes such as indigo or cochineal.

LONG HISTORY

Cotton is one of the oldest fibers known to humans. There is some evidence that cotton cloth may have been used as early as 12,000 B.C. in Egypt. Good-quality cotton fabrics are known to have been woven by 1500 B.C. in India. The Pima Indians were growing cotton when Columbus arrived in the New World. The earliest European colonists cultivated it in Virginia, and by the American Revolution, cotton was widely cultivated in the Colonies. Eli Whitney's invention in 1794 of the cotton gin, to mechanically separate cotton fibers from seeds, was one major factor that began the Industrial Revolution in the United States. Cotton cloth was a major export from the United States until the Civil War. Today, cotton is cultivated across the southern United States. The United States, countries of the former Soviet Union, China, and India are the major world producers of cotton, but cotton is grown in many other warm countries as well.

USING AND STORING COTTON

- Cotton will yellow and degrade when exposed to prolonged sunlight, so window coverings or outdoor furniture covers in white cotton will eventually yellow. Moisture and acidic air pollutants will speed the process.
- Cotton is susceptible to mildew and bacteria. Do not store damp cotton items.
- Silverfish will eat cotton, especially if it is starched. Store cotton unstarched.
- Although cotton can withstand hot ironing temperatures, too much heat will cause scorching. Cotton will ignite and burn if it is in contact with open flames.
- Cotton is damaged by strong acids. Because sulfuric acid is an air pollutant, cotton items should be wrapped in acid-free tissue paper for long-term storage.

CARE AND CLEANING OF COTTON

Cotton as a fiber requires no special care when cleaning. It can be machine washed in hot water with vigorous agitation, using either detergent or soap. Soil is easily released from cotton, although fruit juice and other acidic stains should be treated with cold water before laundering, preferably as soon as they occur. Cotton can be bleached with either chlorine or oxygen bleach if it is not left too long in the bleach and is thoroughly rinsed. Cotton can also be dry cleaned. Cotton garments can be ironed on a high setting; wrinkle removal will be easier if garments are ironed slightly damp or using a steam iron.

It is important to check the care labels on garments and hangtags on other cotton items. Although care procedures just described are appropriate for the cotton fiber, cotton items that have not been preshrunk may shrink during washing. Some cotton fabrics may fade, depending on the dyes used. There may be other design or construction features that require gentler handling. The care label contains care instructions the manufacturer has determined will give good results.

THE COTTON SEAL

The Cotton Seal is the registered trademark of Cotton Incorporated. Pure cotton items bearing this symbol have met performance criteria established by Cotton Incorporated. Cotton Incorporated conducts research on cotton and provides technical assistance to manufacturers, retailers, and importers to enable them to offer the best cotton products possible.

THE FABRIC OF OUR LIVES®

FURTHER INFORMATION

For further information on cotton, contact:

Cotton Incorporated
488 Madison Avenue
New York, NY 10022
212-586-1070
www.cottoninc.com

The National Cotton Council of America
198 North Parkway
Memphis, TN 38112

REFERENCES

"An American Patriot Yesterday, Today, and Tomorrow," National Cotton Council of America, August 1987.

Green Alternatives, February/March 1994, pp. 26-36.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

"No Wrinkles in Basics and Beyond," *Bobbin*, March 1995, pp. 90-98.

LINEN, RAMIE, AND HEMP

From Plant Stems to Fine Fabrics

Linen is ancient, in use for at least 10,000 years. Linen fragments dating to 8,000 B.C. have been found in Swiss lake dwellings. Egyptian mummies were wrapped in linen. Linen historically has been viewed as a fiber of purity and cleanliness, often used for religious purposes. It was also used for ropes and sails for ships.

Linen could be cultivated in the climate of northern Europe where cotton could not, so prior to development of world trade in silk and cotton, linen and wool were the daily textiles in Europe. In the United States, flax was cultivated until the 18th century. It was woven with wool into linsey-woolsey cloth. The invention of the cotton gin in the 18th century made less expensive cotton widely available, supplanting linen for many uses. Linen remained as the fabric of choice for fine bedding, clothing, and furnishings. The term "linens" is used for tablecloths, napkins, sheets, and towels because these items were originally always made of linen.

WHERE DO WE GET LINEN?

Linen is more correctly the name for fabrics, not fibers. The fiber used to make linen fabrics comes from inside the stem of the flax plant, also the source of linseed used for oil. Fibers extracted from the stems of plants are referred to as bast fibers. Linen is the most widely used bast fiber in the western hemisphere. Almost three quarters of the world's flax is cultivated in Russia and Eastern Europe. Flax is also cultivated in France, Belgium, the Netherlands, and New Zealand.

Harvesting and processing flax plants to extract the textile fiber is done by methods used for thousands of years. The methods are labor intensive, contributing to the high cost of fine linen, but ecological, involving chemicals only for bleaching. The plants are harvested by pulling them out of the ground rather than cutting, to preserve the greatest length of fiber. Plants are dried in the field, then seeds are combed from the stalk. Extraction of the fiber from the stalk begins with a process called retting, or soaking in water or on wet ground to decompose the bark and the pectins that hold the fibers together. A mechanical operation called scutching follows. Scutching breaks the rotted straw away from the fiber bundles in the interior of the stem.

The separated fibers are combed to separate long fibers, called line fibers and averaging about 20 inches long, from the

short tow fibers, only 4 to 6 inches long. The finest yarns are made from line fibers, whereas tow is spun into less expensive yarns used for candle wicks, mops, rope, and canvas for painting. Flax is also a component of fine papers, as in those used for currency.

Once made into yarn, linen can be woven or knitted. Fibers may be bleached, dyed, or printed. Finishes for crease resistance, stain repellence, or flame retardance can be applied. Linen can be lacquered, brushed, embossed, or glazed to create different effects. It may be blended with almost any other fiber. Some names for classic linen fabrics are crash, a coarse plain fabric; damask, a textured weave with a reversible pattern often used for table linens; handkerchief linen, a very fine, sheer linen; and huck linen, a thick fabric in honeycomb weave used for towels. Irish linen is a trade name used on quality linens from the Irish Linen Guild. It is usually a fine, plain weave. Moygashel linen is a trade name for Irish linens made by one company.

PROPERTIES OF LINEN/FLAX

Chemically, flax is composed of cellulose, like cotton. The flax fiber contains a longer cellulose polymer and is both more crystalline in structure and has more of the polymers aligned than cotton. These differences mean that cotton and flax react the same way to chemicals but have different physical properties.

- The characteristic irregularities of linen fabrics are caused by the bundles of primary fibers that make up the substructure of the fiber. Bundles vary in size. Periodic cross markings similar to the joints on corn stalks occur along the length of the fibers.
- Linen fabrics feel cool because the length and smoothness of the flax fiber allows fabrics to lie close to the skin. Flax fibers do not lint, so this smoothness is retained. This is one reason linen dish towels are used for fine glassware.
- Flax absorbs moisture, as does cotton, but it absorbs more and dries more quickly than cotton. This makes linen fabric comfortable to wear and makes it ideal for towels.
- One of the appealing things about linen fabrics is the luster, which increases with cleaning as natural waxes wear off. Flax has more luster than cotton because the fibers are longer and straighter.
- Flax dyes easily and retains color well if dyed properly. Poor dyeing procedures can weaken a fabric and cause exceptionally fast abrasion at garment folds and edges. Certain dark colors rub off during wear.
- Flax is the strongest natural fiber, so it was used whenever strength was required prior to the advent of synthetic fibers. The fiber is stronger wet than dry.
- Flax has good abrasion resistance and good light fastness, making it attractive for upholstery and draperies. Some sizings or finishes applied to linens to increase wrinkle resistance will lower abrasion resistance.
- Flax is a stiff fiber. This means that linen fabrics wrinkle and crease easily. It also means that linen fabrics tend to be less drapable and crisper than others.
- Flax fibers elongate very little and have good elastic recovery for the low elongation. As a result, linen fabrics retain their shape well when laundered.
- Linen fabrics have some natural soil resistance. The smooth surface and antistatic properties of the fiber do

not invite soil adhesion, and the fiber structure does not allow dirt to penetrate the fiber.

- Flax is more resistant to rotting and weathering than cotton, possibly due to the harder fiber surface. When dry, flax will not mildew. This explains the ancient linen fragments found still intact in Egyptian tombs.
- Flax is nonallergenic.

CERTIFICATION OF LINEN

Masters of Linen is a linen promotional organization financed by the European Community. Linen producers located in Western Europe who buy from members of a growers and processors organization and agree to abide by quality criteria may use the Masters of Linen trademark label to identify pure linen, minimum 50 percent linen, or union linen, made with a pure cotton warp and a pure linen weft. But consumers should not be concerned if linen products do not carry a Masters of Linen tag, because nearly 80 percent of the world's fiber flax plants are grown in Russia and Eastern Europe, which are not included in the Masters of Linen program. Advertising by the Masters of Linen group raises consumer awareness of the benefits of any linen.

OTHER BAST FIBERS

Ramie and hemp are bast fibers also found in apparel and home furnishing textiles in the United States. Ramie comes from a relative of the nettle plant native to the Far East. It is grown primarily in China, the Philippines, and Brazil. Ramie and ramie–cotton apparel appeared in the United States in the 1980s when import quotas limited cotton imports. Ramie was not subject to quotas at the time, although it is now. Recent development of a mechanical method for extracting fiber from the plant stem had lowered the costs and improved the quality of ramie. Ramie fibers are even longer, stronger, and more lustrous than linen fibers, and have many similar properties. The fiber is coarser than linen and is more stiff and brittle, with low elasticity. Consequently, ramie is most successful used in blends in which the other fiber contributes elasticity and flexibility.

Hemp is a very old fiber, like flax. It was widely used for hemp cloth beginning thousands of years ago in China. It was used by the Romans, and its production was so important in Tudor England that farmers were fined for not growing it. Hemp was important for fine fabrics but also for canvas sails and marine cordage. It was grown in the United States until the end of World War II for ropes and other military uses. Hemp fell into disfavor because the fiber comes from stems of the cannabis plant, whose leaves and seeds are harvested as marijuana. Hemp varieties containing low levels of the drug THC are cultivated legally in Australia, Canada, China, and many Western European countries, although not in the United States. Hemp products may be imported, however, and a wide and increasing variety of hemp clothing and household textiles has come onto the U.S. market.

Hemp fiber resembles flax in appearance and properties, although it is longer, coarser, and less flexible. It is strong like flax and does not rot easily when exposed to water. It can be made into very fine textiles, indistinguishable from fine linen. Hemp is easily grown in many conditions without chemicals, making it less

expensive than linen and more environmentally friendly than cotton.

CARE OF LINEN AND OTHER BAST FIBERS

Linen fabrics may be laundered unless a care label indicates otherwise. Linings, trims, type of dye, or special finishes may cause a manufacturer to recommend dry cleaning for a linen item. Linen fabrics do not shrink or lose shape in the laundry. When laundering, warm to hot water is recommended. Gentle agitation is also recommended to avoid breaking fibrils loose in a process called cottonizing. Oxygen bleach is best, but chlorine bleach may be used on white linens. Rinse linen well to avoid age spots, caused by oxidation of cellulose. Avoid wringing out hand-washed linen to prevent excessive wrinkling.

Linen may be line or machine dried. Line drying in the sun helps keep white linen white. Remove linen from the dryer when slightly damp to ease ironing. It is much more effective to iron damp linen than to steam iron dry linen. Damp linen can be stored in a plastic bag in the refrigerator or freezer for 6 to 24 hours before ironing to make it easier to iron. The cool temperatures prevent mildew. Linen is ironed on hot settings. Spray starch may be used to provide extra crispness. Iron dark linens on the wrong side only to avoid bringing out sheen. Iron embroidered linen on the wrong side over a soft towel to keep embroidery raised.

Spots and stains in colored linen fabrics should not be rubbed or dried while wet, because this may cause dye rub-off. It is best to blot stains. Consult a professional dry cleaner about a difficult stain.

Linen fabrics should not be folded repeatedly in the same place or ironed with a fold. High fiber stiffness, low elasticity, and low elongation mean that repeated stress will eventually cause a split in the fabric. Rolling large tablecloths around a tube is a good storage technique.

Store linen fabrics in acid-free tissue or old sheets and place them in a cool, dry, well-ventilated area. Avoid plastic bags, cedar chests, unvarnished wooden chests, and cardboard, because acids or fumes from these materials can cause yellowing. Always store linen clean.

Care of fabrics made from the other bast fibers should be similar to linen, although be sure to consult care labels.

FURTHER INFORMATION

Contact the following organizations for additional information:

Masters of Linen/USA
200 Lexington Ave., Suite 225
New York, NY 10016
212-685-0424

North American Industrial Hemp Council, Inc.
PO Box 259329
Madison WI 53725-9329
608-258-0243
www.naihc.org

REFERENCES

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

"Hemp—A Fibre for the Future?" *Textiles Magazine*, Autumn 1994, pp. 15–17.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

International Fabricare Institute

Masters of Linen, U.S.A.

LYOCELL

Luxury and Performance from Wood Pulp

Lyocell is a new fiber, the first broad-use apparel fiber to be developed in more than 30 years. Tencel is the trademark for lyocell manufactured by Courtaulds Fibers, currently the only lyocell on the market in the United States. It has been available in the United States since 1992, and use has been growing steadily. A competitive product, Lenzig Lyocell, is expected to debut soon. Lyocell is widely used in Japan already.

Lyocell is described by Courtaulds as a natural luxury fiber. Like other cellulosic fibers, it is absorbent and comfortable and takes dyes easily. It also has strength and easy-care properties more like petroleum-based synthetic fibers.

WHAT IS LYOCELL?

The Federal Trade Commission defines lyocell as a cellulose fiber obtained by a spinning process that uses an organic solvent. Lyocell is a close cousin to rayon, and like rayon, is a manufactured fiber made from wood pulp, a renewable resource. The means of dissolving the wood cellulose and re-forming it into textile fiber differs for the two, producing fibers with different properties. The Federal Trade Commission determined in 1996 that lyocell was sufficiently different to be designated as a new generic fiber type.

The production method for lyocell is the most environmentally friendly means of producing cellulosic fibers thus far. Wood pulp is dissolved in an organic, nonhazardous solvent, then extruded to form fibers in such a way that virtually all of the solvent is recovered and reused. Use of water and energy is low, and chemical effluent is kept to a minimum in this direct spinning process. One of the unique features of the lyocell fiber is the ability to produce fine hairs on the fiber surface. The length and density of these hairs can be controlled to achieve different surface effects ranging from smooth to silky to peach fuzz to woolly. Lyocell is used in staple form—short lengths that must be spun together into yarns suitable for knitting or weaving. It can be blended easily with other fibers, natural and synthetic, to enhance yarn and fabric characteristics. Lyocell can be dyed and finished with the same chemicals used for other cellulosics such as cotton and rayon, but less dyestuff is required to achieve the same colors in lyocell. Lyocell's high strength allows it to withstand a wide variety of finishing processes to produce varying textures and surface effects.

LYOCELL'S UNIQUE PROPERTIES

- Lyocell is inherently soft and smooth, but controlled formation of fibrils on the fiber surface allows manufacture of a wide range of fabrics, from denim to suede to a fabric similar to washed silk.
- Lyocell fabrics drape and flow with the body.
- The fiber can be dyed or printed to create rich, vibrant colors.
- It is highly moisture absorbent, making it comfortable to wear and eliminating static cling.
- Lyocell is naturally wrinkle resistant.
- It is abrasion resistant.
- The fiber is incredibly strong, dry or wet, allowing a great variety of processing techniques to be used and permitting it to be machine washed and tumble dried.
- It will not shrink.
- Lyocell may be ironed safely at temperatures approaching those of cotton. It will not melt.
- Lyocell production is environmentally friendly, both because the solvent is recyclable, reducing emissions into waterways or air, and because less dye and finishing chemicals are required for equal results on lyocell than on other cellulosic fibers.
- It is biodegradable.

WHERE CAN YOU FIND LYOCELL?

Lyocell has been used mostly in premium products because it costs somewhat more than either rayon or cotton at present. Manufacturers predict a bright future for lyocell because of its performance characteristics, which allow easier processing and care than rayon, and also because the production method is more environmentally friendly. The first lyocell products in the United States were denim; lyocell denim is naturally soft like worn cotton denim. Lyocell is used in a wide variety of fabrics, primarily for women's sportswear and dresses. It is both woven and knitted, used alone or blended with wool, cotton, spandex, or linen and rayon.

CAUTIONS WITH LYOCELL

- Like all cellulosic fibers, lyocell will burn if exposed to flame. It requires topical finishing to make it flame retardant.
- It will mildew if kept in damp conditions.
- Lyocell could be attractive to insects such as crickets and silverfish.

CARE AND CLEANING OF LYOCELL

Lyocell fiber is machine washable, one of the main features differentiating it from rayon, which often requires dry cleaning due to low fiber strength. Ordinary laundry detergents work fine for lyocell. It is not damaged by bleach, although dyes might not be colorfast. Lyocell will not shrink, even in hot water. It can be tumble dried, and if removed promptly from the dryer, will not wrinkle. It also can be hang dried.

Always follow garment care label instructions. A garment's label may say "dry clean only" because of trim, lining, or other hidden factors. Lyocell dry cleans very well.

Lyocell can be ironed at medium to high temperatures, just under the temperature suggested on the iron dial for cotton. It will scorch if the iron is too hot or is left too long in one place.

LYOCELL PRODUCERS

For further information on lyocell, contact one of these companies manufacturing lyocell, or preparing to manufacture lyocell, in the United States:

Acordis Cellulosic Fibers., Inc.
111 West 40th Street
New York, NY 10018
212-944-7400

Lenzig Fibers Corporation
6100 Fairview Road
Charlotte, NC 28210
704-551-1400

REFERENCES

Courtaulds Fibers, Inc.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Lenzig Fibers Corporation

Smith, Joyce A.; and Pitts, Norma, "Rayon—the Multifaceted Fiber," Extension Fact Sheet, The Ohio State University Extension, 1993.

The International Fabricare Institute

NYLON

The Miracle Fiber

Nylon was the first synthetic fiber created from chemicals, introduced to the public for women's hosiery in 1939. It was termed the "miracle fiber" for several years because it was unlike any other fiber available in the 1940s. Nylon's fine properties and versatility have made it popular for a wide range of uses. Nearly three quarters of all nylon fiber in the United States is used for carpeting. The remaining quarter is used for industrial products such as tire cord, tents, parachutes, luggage, and ropes; for accessories such as umbrellas; and for clothing. Clothing uses of nylon include hosiery, underwear and nightwear, windbreakers and rain jackets, skiwear, activewear, lace, and pile fabrics.

WHY NYLON?

- Nylon is a tough fiber. It has very high tenacity (breaking strength), making it the fiber of choice for automobile seat belts. By weight, nylon is stronger than steel wire. It is also the most abrasion resistant of common fibers, which accounts for its popularity for carpets, luggage, and backpacks. Nylon fiber has high flexibility, meaning it can withstand repeated bending. Furthermore, nylon is highly resistant to puncture.
- It maintains its appearance well. This is because it elongates, or stretches, more than any fiber other than rubber or spandex. Once elongated, it recovers its shape easily, allowing it to retain its original appearance. This feature has made nylon the fiber for hosiery. Nylon is also highly resilient, springing back after compression as a carpet springs up after being stepped on. This resilience also helps prevent wrinkling of garments.
- Nylon is very lightweight. The combination of low weight and high strength make nylon important for parachutes and ideal for camping equipment.
- The fibers are very smooth and can be packed tightly together to weave fabrics with low permeability for ski garments and other wind-resistant clothing.
- Nylon is a thermoplastic fiber. It softens with application of heat and can be shaped while soft, then will cool permanently into that configuration. This means that yarns can be curled and shaped to add bulk, or that permanent creases or pleats can be put in garments.
- Nylon was the first "easy care" fiber. Nylon maintains its shape during laundering, dries quickly, and does not wrinkle if washing instructions are followed. Nylon does not shrink.

• Nylon is resistant to both insects and fungi.

HOW DO WE MAKE NYLON?

Nylon is the result of basic research at the DuPont Company in the 1930s about the way small molecules unite to form large molecules, or polymers. Nylon is a polymer synthesized from organic petroleum derivatives. It is defined by the Federal Trade Commission as a "manufactured fiber in which the fiber-forming substance is any long-chain synthetic polyamide in which less than 85 percent of the amide linkages are attached to two amide rings." Amide linkages occur in natural protein fibers such as wool and silk, as well. They are characterized by the chemical grouping -C-N-.

Variations in the starting chemicals used to manufacture nylon produce fibers with differing properties. The different nylon types are named according to the number of carbon atoms present in the starting compounds. Tags on nylon items sometimes identify the variant, such a s nylon 6,6, the most common type.

Nylon production involves blending the organic ingredients in a complex series of steps to form viscous nylon polymer, which is then extruded through spinnerets to form filament fibers. Fibers of varying diameter and cross-sectional shape can be extruded, depending on the desired properties. Processing can be adjusted to change the balance of strength versus elongation desired in the final fiber as well. About 200 variants of nylon are manufactured. Variations are predominately in fiber diameter, cross section, and texture.

Originally, nylon fibers were extruded as smooth, round filaments, like finer versions of monofilament fishing line. Engineers discovered that other shapes could reduce fiber luster and help hide soil on carpets. Fiber engineers further discovered that adding texture to nylon yarns greatly improved the air and moisture-vapor permeability of fabrics made from them by increasing air space around fibers and preventing the fabric from laying flat against the skin. Textured yarns also feel warmer and softer and have reduced luster. Crimped, or curled, yarns have good recovery from elongation as they spring back into the shape set in place with heat during manufacture. Hosiery yarns and stretch yarns used for activewear are crimped.

Developments in microfiber, or very fine-diameter, nylons including Microsupplex, Tactel, and Silky Touch, finer even than silk, have permitted development of fluid, drapable fabrics. Microfibers also permit waterproof, breathable fabrics to be made, because spaces between the very fine yarns in fabrics are too small for rainwater to penetrate but large enough for water vapor to pass through. The attractive features of fine nylons have meant increased use of nylon for sportswear and dresses.

Nylon is blended with other fibers to add strength and durability. It is often found in small percentages in wool fabrics, or cotton or acrylic socks. New blends of wool, rayon, or cotton with nylon microfibers combine the lightweight strength and easy care of nylon with the soft feel and moisture-absorbing properties of the other fibers. Nylon knits for activewear may be blended with spandex to give additional stretch.

Nylon is produced by many different companies. Companies manufacturing

nylon fiber for consumer end uses often register a trademark for each type of nylon manufactured and advertise the trademarks to consumers. AlliedSignal uses the trademarks Patina, Caprolan, Captiva, and Hydrofil, among others. BASF Corporation manufactures Crepeset, Matinesse, Shimmereen, Silky Touch, and Zeftron. Among DuPont's better-known trademarks are Antron, Cordura, Supplex and Microsupplex, and Tactel. Solutia is known for carpet yarns with the brand name Ultron.

SPECIAL FABRICS MADE OF NYLON

Nylon clothing is often made from knitted fabrics. The combination of the flexible knit structure and nylon's natural stretch and resilience creates fabrics that move with the body. Knitted fabrics have an open structure which allows air and moisture permeability to ensure wearer comfort. Lingerie, women's hosiery, tights, leotards, and women's bathing suits are garments most often made of nylon knits sometimes combined with spandex for even greater stretch.

Nylon also is the most frequently used fiber for windbreakers, parkas, and skiwear. For those garments, woven nylon taffeta or ripstop is generally preferred. Fine, smooth nylon fibers form tightly woven fabrics with few open spaces for wind penetration. The fabrics are water repellent due to nylon's low absorbency and the lack of spaces between yarns. The smooth fabrics also have no loose yarns to snag. Ripstop and tightly woven taffeta are considered downproof fabrics; that is, down and feathers will not work their way out between the yarns. Both fabrics are lightweight, but ripstop is generally the lighter. It is characterized by a heavy thread every few threads, in both lengthwise and crosswise directions, giving it a grid-like appearance, whereas taffeta is totally smooth.

NYLON'S DRAWBACKS

- Nylon has low moisture absorbency compared to cellulosic fibers such as cotton and rayon, or compared to wool and silk. But it is the most absorbent of the synthetic fibers and will absorb water vapor from the skin surface and diffuse it to the outer surface of the fabric for evaporation.
- Nylon fibers develop static electricity easily in dry conditions. This is the cause of static cling in clothing and static shocks on carpets. Static also attracts dirt particles. Antistatic treatments can be applied to nylon and are generally used for carpeting and lingerie.
- Nylon has low resistance to ultraviolet light. Extended exposure to sunlight causes decomposition. Polluted air accelerates the decomposition. There are variants of nylon engineered for increased ultraviolet resistance.
- Prolonged exposure to heat will reduce the strength of nylon fibers and induce yellowing.
- Nylon melts when exposed to flame.
- It stains easily with oil-borne soils and with chemical compounds commonly used in food dyes. This is the reason many nylon carpets have been treated with soil-repellent and stain-resistant finishes. Brand names such as Stainmaster by DuPont indicate a nylon designed to repel many common stains.
- Nylon attracts soil and color particles in laundry water, which is why white

nylon discolors so easily. It is virtually impossible to clean discolored nylon.

• Nylon fiber is easily damaged by acids. The weak sulfuric acid formed from air pollutants in large cities will cause nylon stockings to "run."

CARE AND CLEANING OF NYLON

Laundering is the best way to remove soil from nylon fabrics, although they are not harmed by dry-cleaning solvents. Nylon should be laundered in warm water at a permanent press setting to avoid setting in wrinkles. If hot water is necessary to remove oily soil, rinse in cool water before spinning to prevent wrinkling.

White nylon should be washed alone or with other white items, so that there is no colorant in the wash water. White nylon should not be washed with heavily soiled items either, to prevent discoloration from redeposition of the soil.

Oxygen bleaches may be used to remove stains. Chlorine bleaches will yellow and degrade nylon fibers.

Low dryer temperatures are best for nylon. Permanent wrinkles can be induced by overly hot drying temperatures, and commercial dryers on hot settings can melt nylon. Fabric softeners can alleviate static cling induced by drying. Nylon also hangs dry quickly.

Nylon should be ironed at low temperatures. Dry ironing is recommended. Ironing will not press out wrinkles acquired in washing, nor can permanent creases be pressed into nylon at home.

FURTHER INFORMATION

For further information on nylon, contact

DuPont
1430 Broadway, 4th Floor
New York, NY 10018
212-512-9200
www.dupont.com

BASF Corporation
Fiber Products Division
4824 Parkway Plaza Blvd., Suite 300
Charlotte, NC 28217
704-423-2000

AlliedSignal, Inc.
Textile Nylon Business Group
1411 Broadway
New York, NY 10018
212-391-5000

REFERENCES

"ATI Fiber Glossary," The Acrylic Council, Inc., New York, N.Y., 1995.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; Textiles, Macmillan Publishing Company, New York, N.Y., 1988.

Rudie, Raye, "Synthetics: A Sure Thing," *Bobbin*, May 1996, pp. 20–23.

"Style Savvy Foresight," *DuPont Magazine*, May/June 1996, pp. 23–25.

"The Nine Lives of Cordura," *DuPont Magazine*, November/December 1995, pp. 8–11.

OLEFIN

Moisture Resistant and Chemically Inert

Olefin may not be a familiar fiber name because olefin products are often referred to as polyolefin or by the chemical names polypropylene or polyethylene, or simply by brand names. Olefin is widely used in many familiar products, however.

Olefin is a common choice for functional apparel items such as athletic clothing, socks, thermal underwear, and glove liners. Many disposable protective or medical garments are made of olefin. Artificial turf is olefin, as is indoor-outdoor carpeting. And most new carpet is tufted onto an olefin backing. Nontear envelopes and housewraps used to seal out moisture and wind are made of nonwoven olefin. It is a popular choice for upholstery and is widely used in automobile interiors. Ropes, burlap bags, and geotextiles (used for road construction, soil containment, and agriculture) may be olefin. It is also used to make the liner layer next to the skin for disposable diapers and sanitary products.

For many of the end uses just mentioned, olefin is formed into nonwoven fabrics rather than used as a yarn for knitting or weaving. The process of making nonwovens, which are random webs of fibers similar to paper, is quick and inexpensive. Webs of olefin are formed in several manners, depending on the end use. Heat, pressure, acrylic adhesives, and needle entangling may be used to hold either continuous filament or cut staple fibers together in nonwoven configurations. Tyvek, for instance, is a spun-bonded nonwoven, made by spinning olefin fibers randomly onto a fast-moving belt. The fibers are soft and semimolten as they emerge from the spinnerets, causing them to fuse together wherever they overlap as they cool.

Use of olefin as a fashion apparel fiber is increasing, particularly since the introduction of Telar, a very fine filament olefin produced by Filament Fiber Technology, Inc. Olefin is produced from a chemical solution, which is pushed through spinnerets as continuous, smooth filaments and cooled to retain that shape. Most olefin is cut into short, staple length pieces, which are spun together to make yarns. Telar differs in that it is left in filament form, and it is a much finer filament. Telar is stronger by weight than a comparable spun yarn. A further advantage of the Telar filament is an increase in fiber softness. Coarser olefins sometimes have a waxy feel many people find objectionable for clothing.

WHAT IS OLEFIN?

Olefin is produced from raw materials that are by-products of the petroleum industry, available in large quantities at very low cost. Production is very clean, with very little waste or by-products. The Federal Trade Commission defines olefin as a long-chain synthetic polymer composed of at least 85 percent by weight of ethylene or propylene. In practice, more textile products are made from the polypropylene variant, which permits formation of finer fibers and has a somewhat higher melting point.

While olefin has been available in the United States since 1962, problems with heat and light sensitivity limited its use until the 1980s, when a means of stabilizing the fiber was found. Today, agents for stabilizing heat and ultraviolet light sensitivity are added to the olefin in solution form before it is extruded into fibers. Characteristics of olefin fibers can be varied by the nature and quantity of additives, the choice of polypropylene or polyethylene, and by changes in processing conditions.

Olefin fibers are chemically inert, lacking polar groups for dyes or detergents to react with the polymer. This makes dyeing olefin a challenge. Therefore, most olefin is solution dyed, which involves putting dye pigment into the chemical solution prior to extrusion. Solution dyeing is done early in the production cycle, making it a limitation for fiber destined for the capricious fashion fabric market, requiring frequent color changes. In compensation, solution-dyed fibers are uniform in coloration and highly colorfast.

Olefin is currently manufactured by several companies. Filament Fiber Technology, Inc. produces fine filament yarns for apparel, both Telar and Salus, an antimicrobial olefin. Fiber Visions manufactures a range of olefin fibers, among them Herculon, widely used in home furnishings. DuPont manufactures the familiar Tyvek spun-bonded olefin, used for nontear envelopes and for wind and moisture barriers in housing construction. Amoco Fabrics and Fibers markets olefin fibers for apparel carpet backings, furnishings, automotive uses, marine carpeting, wall coverings, and geotextiles for roads, parking lots, and runways. Amoco's brand names include Alpha, Condesa, Essera, Impressa, Innova, Marvess, Propex, Protel, and Trace.

SPECIAL PROPERTIES OF OLEFIN

- Olefin is the lightest-weight fiber available. It is actually lighter than water, a quality desirable for suits for competitive swimmers. Light weight also means the fiber provides greater bulk and warmth for a given weight.
- It absorbs almost no moisture, but is able to transport moisture along the fiber to the fabric surface for evaporation. This makes olefin ideal for socks and athletic apparel, because sweat is moved away from the skin for rapid evaporation, and the garments remain dry. This property is also the reason for using olefin as diaper or sanitary pad liners. Olefin also dries quickly if wetted or laundered.
- Olefin does not fade. Dyes are impregnated into the fiber, so they cannot wear off or react with wash water or detergent.
- The fibers have excellent resistance to many chemicals, including acids, alkalis, and chlorine, which makes them ideal for protective clothing, industrial products, and bathing suits.

• Olefin does not build up static charge as do most nonabsorbent synthetic fibers, making it popular for carpets and upholstery.
• It does not absorb or retain odors. Most odors rely on moisture absorption to penetrate the fiber.
• Olefin is resistant to microbiological and insect attack, thus will not deteriorate when used for outdoor geotextiles.
• The fibers are strong and abrasion resistant.
• Olefin is resilient, enabling it to recover from wrinkling and from compression.
• It has low thermal conductivity, making it valuable as insulation.
• Olefin is thermoplastic, meaning that it softens when heated and can be shaped, pleated, creased, etc. while soft, and then will cool into that position. The shaping will remain so long as washing, drying, and ironing temperatures do not exceed the softening point of olefin, which is very low.

SPECIALTY OLEFIN PRODUCTS

A fiber named Salus, by Filament Fibers, is a very fine olefin fiber containing AM Microstop antimicrobial agent, added prior to fiber extrusion. The antimicrobial agent migrates throughout the yarns. It is used for medical purposes, such as odor-resistant cast liners, and in outdoor uses where mold and fungus can be problems. It is also being used in apparel fabrics, and for competitive swimwear and athletic apparel to reduce odors and growth of yeast and bacteria. Fleece for bike seat covers is another use for antimicrobial olefin.

Thinsulate insulation, manufactured by 3M Corporation, is made of olefin or olefin/polyester microfibers, ten times smaller in diameter than human hair. Given olefin's low conductivity, Thinsulate is very warm for its weight, so that less of it is required to provide comparable insulation to higher-bulk fiberfills. As a result, Thinsulate is widely used as insulation when low bulk is necessary, such as in footwear, gloves, and fitted outerwear. Bulkier versions of Thinsulate are used for sleeping bags and bedding.

HIGH PERFORMANCE POLYETHYLENE

Research by Allied-Signal, Inc. on polyethylene fibers led to the development in 1985 of a long-chain polyethylene, trademarked Spectra. It is very strong, requiring more force to break than any other fiber. In fact, it is ten times stronger than steel and twice as strong as Kevlar per weight. This makes it very attractive for protective clothing such as bullet-proof vests and gloves. Spectra cables secure oil drilling platforms to sea bottom anchors. Spectra is also used to replace tendons and ligaments in the human body. Fabrics made of Spectra and steel are laminated to vinyl to create slash-proof seating for public transportation.

CARE AND CLEANING OF OLEFIN

Care of olefin is influenced by its unique properties. Because olefin does not absorb water, it is quite resistant to waterborne stains. Soil can often be wiped off upholstery or carpets with a damp cloth. Stains may be spot treated with lukewarm water and detergent. Olefin attracts oily stains, though, and removal

can be difficult. The hydrophobic characteristics that make olefin resistant to waterborne stains make it resist detergent solutions as well. Very hot water, which could help remove oily stains, is not recommended because of the low softening and melting points of olefin. The fiber may shrink or wrinkles may be set in place with use of very hot laundering water.

- Olefin is always colorfast, because the color is pigment-impregnated into the fiber, not dye-absorbed on the surface of the fiber. Light and dark garments can be safely washed together, and stripes will not bleed or run onto lighter areas of a garment. Bleach, either chlorine or oxygen, may be used to remove stains from olefin fabrics.
- Olefin dries very rapidly, so it may be line dried or tumble dried in home dryers on permanent press or low heat. Large commercial dryers should not be used because they often heat to temperatures that might melt olefin. Avoid ironing olefin garments because the fiber is sensitive to high temperatures. It will melt at 325–335 degrees F. Olefin does not wrinkle easily, so should not need ironing anyway.

Dry cleaning is not recommended for olefin, because perchlorethylene, a common dry-cleaning solvent, swells and weakens olefins. Petroleum dry-cleaning solvents are acceptable, but must be specially requested.

FURTHER INFORMATION

Further information on olefin can be obtained by contacting

American Polyolefin Association
302-475-1450
http:/www.apa-polyolefin.com

Amoco Fabrics and Fibers Company
9000 Circle 75 Parkway, Suite 550
Atlanta, GA 30339
770-956-9025

Filament Fiber Technology Corp. (FFT)
571 West Lake Avenue
Bay Head, NJ 08742
732-295-5900

REFERENCES

American Fiber Manufacturers Association

American Polyolefin Association, Inc.

Filament Fiber Technology, Inc.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph S., *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

3M Corporation

POLYESTER

Most Widely Used Synthetic

Polyester has been a favorite since its introduction in 1951—in a man's suit that had been worn for 67 days, machine laundered, but never pressed, and still looked presentable. It is a very versatile fiber which blends well with other fibers, contributing good properties to the blend without destroying the desirable properties of the other fiber. Polyester is sold in four basic forms: filament fiber, short "staple" fibers for blending, fiberfill, and nonwoven fabric structures made at the time of fiber production.

Polyester is the most widely used fiber in the United States, and is second only to cotton in world use. The major use for polyester fiber is apparel; in 1990, 40 percent of all polyester fiber was used in clothing of all types. Almost as much polyester is used in industrial and consumer textiles for end uses ranging from cover fabrics for disposable diapers and fiberfill in pillows to synthetic arteries and tire reinforcement cord. Polyester is used extensively in interior textiles such as bed and bath linens, draperies, upholstery, and blankets and is used less extensively for carpets.

WHY POLYESTER?

- Polyester does not wrinkle during wear, owing to its exceptional resilience to small stresses. The fiber snaps back into shape after bending and crushing.
- It is a durable fiber due to its high tenacity (resistance to breaking) whether wet or dry, and to its abrasion resistance.
- Polyester will not stretch or bag, because the fiber elongates only slightly even at stresses that would break a cotton fiber. It recovers quickly from such stresses.

Polyester dries quickly.

- It is nonallergenic.
- Polyester has high resistance to damage from molds, fungus, moths, and beetles.
- Polyester is highly resistant to both ultraviolet rays and acids, giving it high "weather resistance" to sunlight and polluted air.

MANUFACTURE OF POLYESTER

The Federal Trade Commission defines polyester as a manufactured fiber in which the fiber-forming substance is a long-chain polymer composed of at least 85 percent by weight of an ester of a substituted aromatic carboxylic acid. This polymer contains ester linkages and

benzene ring structures. Many possible variations of this generic group are possible, but most polyester produced today is polyethylene terephthalate (PET), synthesized from petroleum derivatives ethylene glycol (familiar as antifreeze) and terephthalic acid. PET is also used to make beverage bottles and other food containers.

Polyester is produced by melt spinning. That is, the ingredients are blended into a viscous polymer soup, which is then extruded through spinnerets to form filament fibers. The fibers are able to retain the shape of the spinneret hole, so fibers may be not only round in cross section but lobed, triangular, star shaped, or hollow. Cross-section shape and size are chosen based on desired end-use characteristics. Extruded fibers are stretched to align molecular crystals for increased strength. The degree of alignment can be specified.

Polyester is a thermoplastic fiber—i.e., it softens with application of heat and cools into the position assumed when soft. This means that fibers can be curled, crimped, twisted, or flattened into different shapes to add bulk, texture, and stretch. Finished fibers are heat set into position and retain a memory for that shape. Wear and laundering of polyester items will not change a heat-set shape.

Filament fibers are cut into shorter ends called staple for spinning into cotton-like yarns, either alone or blended with other fibers including cotton, wool, rayon, linen, and acrylic. Polyester offers increased strength and durability, but especially improved wrinkle resistance and appearance retention, to such blends.

Approximately 200 variants of polyester fiber are produced. Polyester lends itself to chemical and physical variations, allowing it to be tailored to an end use. The fiber can be extruded in different cross-sectional shapes, with hollow core or not, and in different diameters. Additives such as antibacterial agents or flame retardants can be added to the polymer before the fibers are formed, or surface chemical treatments can be applied to reduce static or increase flame retardance.

Many polyester brand names are well known to consumers because the brands are heavily promoted by fiber producers. DuPont manufactures Dacron, Micromattique, Coolmax, and Thermax, among others. Brands by Wellman include Fortrel, ComFortrel, Fortrel MicroSpun, and Fortrel EcoSpun.

SPECIALIZED POLYESTERS

Use of recycled PET beverage containers as raw material has made polyester something of a "green" fiber. Wellman's EcoSpun polyester is 100 percent recycled. Ten beverage bottles will yield one pound of polyester. Recycled polyester is identical in quality to polyester made directly from petroleum products. Recycled polyester was first marketed in outdoor products to people who might be concerned with the environment, but its use is now widespread.

Microdenier, or ultra-fine, polyester fibers half as fine as silk allow production of soft, drapable fabrics because microfibers are individually less rigid than larger-diameter fibers. Fabrics made of microfibers tend to be more comfortable to wear than conventional polyesters, because use of multiple fine fibers increases the surface area available for moisture transport away from the skin.

Prints on microfiber fabrics tend to have exceptional clarity as well.

A major use of polyester fiber in recent years has been for fleece fabrics, most often used for outerwear. Not all fleece fabrics are polyester; fleece refers to the pile structure of the fabric. Polyester fleece is popular for its lightweight warmth, softness, and quick drying abilities. Fleece is available in different weights, in stretch and nonstretch, with a windproof inner layer, and treated for water repellency.

Polyester fiberfill is the most widely used insulation and padding in the United States. It is used in pillows, comforters, mattress pads, sleeping bags, winter outerwear, and stuffed toys. Fiberfill, like pile, is popular for lightweight, quick-drying warmth. For padding, fiberfill provides a nonallergenic resilient pad. For outerwear or sleeping bags, the ability to insulate even when wet and to dry quickly is highly desirable. Fiberfill is made of textured, bulky polyester, either made as batts of continuous filament or as shorter staple yarns. Some yarns for fiberfill are made with hollow cores or channels within the fiber to trap more air and thereby provide more insulation. Microfibers are also used for fiberfill in clothing where insulation without bulk is desired.

POLYESTER IS NOT PERFECT

- Polyester is not absorbent, and the fiber itself does not wick moisture away from the skin. This accounts for the wearing discomfort of some polyester garments. Changing the shape of the fiber has enabled polyester manufacturers to improve this problem. DuPont's Coolmax fiber has a peanut-shaped cross section that forms channels along the surface of the fiber for moisture transport, therefore permitting evaporation of perspiration.
- Polyester is susceptible to pilling when used in staple form, and the strength of the fiber holds the pills on the fabric.
- It builds up static electricity, which causes clothing to cling and attracts lint and soil to fabric surfaces.
- Polyester attracts oil, and oil in turn attracts dirt, causing "ring around the collar" and other oily stains. These stains can hold tenaciously to the fabric surface.
- Soil build-up will cause bacterial odor on polyester, hence the common perception that polyester retains perspiration odor. Complete removal of soil from the fiber will remove any odor.
- Polyester is flammable. It melts and drips when exposed to flame. A flame-resistant variant of polyester is manufactured and is used for children's sleepwear and other applications where flame resistance is required.
- Polyester exhibits low compression resilience under heavy loads, meaning that polyester is not an ideal carpet fiber because it will flatten permanently under furniture or in heavy traffic areas.

CARE AND CLEANING OF POLYESTER

Polyester items may be laundered with vigorous agitation. Because polyester retains oily soil, pretreating soiled areas using a detergent with a soil-release ingredient and laundering in hot water may be necessary for complete soil removal. Although polyester may be bleached, bleaching is not usually necessary because water-borne stains are easily removed by detergents. Polyester fabrics do not shrink or fade during laundering, nor will they pick up soil or colorant particles from wash water.

Permanent-press laundering and drying cycles are recommended to reduce wrinkling in polyester. Polyester should require little ironing if it is laundered in this way and removed promptly from the dryer. If ironing is required, a low temperature must be used to prevent melting. Wrinkles that have been set into polyester fabrics during laundering are best removed by re-laundering in hot water to soften the wrinkles, then cooling down and removing promptly.

Fabric softeners are useful for reducing static cling in polyester fabrics.

FURTHER INFORMATION

Additional information on polyester can be obtained from

DuPont
1430 Broadway, 4th Floor
New York, NY 10018
212-572-9200

Wellman, Inc.
1450 Broadway, 8th Floor
New York, NY 10018
212-703-9040

REFERENCES

"ATI Fiber Glossary," The Acrylic Council, Inc., New York, N.Y., 1995.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

The DuPont Company, Wilmington, Del.

Hoechst, New York, N.Y.

Hollen, Norma, Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

"It's So Fine," *DuPont Magazine*, July/August 1995, pp. 1–3.

"Kerchoos Gotcha?" *DuPont Magazine*, September/October 1996, pp. 1–3.

McCurry, John W.; and Isaacs, McAllister III; "Stretch, Durability, and Style Among Fiber Trends," *Textile World*, August 1996, pp. 39–46.

Rudie, Raye, "Synthetics: A Sure Thing," *Bobbin*, May 1996, pp. 20–23.

"The Long and Winding Road," *DuPont Magazine*, January/February 1994, pp. 18–21.

Wellman, Inc., New York, N.Y.

RAYON

Natural or Synthetic?

Rayon is a much maligned fiber, frequently misunderstood by consumers. It is not a natural fiber like cotton, nor is it a petroleum-based synthetic like polyester. Rayon is extremely versatile and has been called "the great imitator" for its ability to mimic other fibers, making it difficult to characterize. Rayon has frequently been used in inexpensive, poorly constructed garments that have given it a bad reputation. Contributing to the confusion, two major types of rayon with totally different care requirements coexist in the marketplace.

Rayon is widely found in apparel, primarily women's. It is often used in dressy fabrics such as velvet and taffeta, as well as challis. Many decorative ribbons and trims are made of rayon. Rayon is blended with other fibers, often with polyester, in blends that mimic cotton, wool, or linen. In fact, cotton and rayon directly compete with one another in blends, and use depends largely on relative price and availability. Rayon once dominated the tire cord market and is still used for industrial purposes as a reinforcement. Rayon is widely used in upholstery and draperies. Another major market for rayon is absorbent wipes, medical supplies, diapers, and sanitary products.

WHAT IS RAYON?

Rayon is the first manufactured fiber, developed in the late 19th century after years of research into a means of creating silk from plants. Rayon became commercially available in the United States in 1910 and was widely known as "artificial silk." Stigma attached to the word "artificial"; and confusion over a proliferation of names made wide consumer acceptance difficult, so in 1926 the industry adopted the name rayon, short for ray of light.

Rayon is made from wood pulp, an available and renewable source of cellulose. To make a textile fiber from wood pulp, the cellulose is converted to a viscous solution, pushed through spinnerets, and hardened in filament form. The resulting fiber contains shorter molecular chains and is less crystalline than cotton and linen but exhibits many similar properties. Rayon can be varied through choice of chemicals, temperature and time of processing, type of spinneret, and additives to the cellulose solution. The Federal Trade Commission allows replacement of up to 15 percent of the hydrogen in the hydroxyl groups of the cellulosic molecule in rayon.

Rayon manufacture is a complicated process with high energy and labor requirements and extensive use of chemicals, resulting in high air and water pollution control costs. One type of rayon, cuprammonium rayon, is no longer produced in the United States because of environmental difficulties, although it is produced abroad and imported to the United States. Bemberg or cupra rayon is of this type.

Rayon produced in the United States is viscose rayon, named for the syrupy solution from which the fiber is spun. Two major variations of viscose rayon dominate the market:

- Regular viscose rayon currently is the most widely used. It has very low strength when wet and may stretch out of shape if tension is applied when wet, or shrink as much as 10 percent in ordinary laundering. Dry cleaning is recommended for regular rayon.
- High Wet Modulus Rayon (HWM) is viscose rayon modified to increase wet strength. It can be machine laundered and will perform much like cotton. Terms used to describe HWM rayon include "polynosic" and high performance (HP). Lenzig markets HWM rayon under the brand name Modal.

Viscose rayon is modified to create high-tenacity rayon, used for reinforcement of tire cord, belting, automobile hoses, and other industrial uses. It retains its strength well if coated or rubberized. Super-absorbent rayon is a viscose used for medical and sanitary products. It will absorb up to 380 percent of its dry weight, far more than cotton. A flame-retardant rayon is made for interior furnishing use. An interesting use of rayon is as the raw material for carbon fibers employed in high-temperature applications such as space shuttle heat shield tiles.

Either regular or HWM rayon can be modified to change appearance and texture. Delustered rayon has the sheen removed to give it a cotton-like appearance. Crimped rayon is made bulky during processing to make it more wool-like in texture. Rayon also is manufactured in microfiber form, which means that it is extruded in very fine diameter to make silk-like fabrics.

Rayon is used in both filament form, which is in continuous strands that can be used to make yarns, and in staple form, which has been cut to shorter lengths for spinning with other fibers to make blended yarns. Filament forms more closely resemble silk, while staple rayon can imitate cotton, wool, and linen in appearance and texture.

RAYON'S UNIQUE PROPERTIES

- Rayon is highly moisture absorbent, even more so than cotton. This makes it comfortable to wear in warm weather, but slow to dry once wet.
- Rayon is easily dyed in vivid colors.
- Rayon is very soft against the skin.
- It has a natural silk-like sheen, although rayon can be produced without luster.
- Rayon fabrics are known for their beautiful drape, hence the popularity of rayon challis dress fabrics which flow easily over the body.

It does not build up static cling.

- Rayon can be ironed safely on medium to high temperatures close to those used for cotton. It will scorch rather than melt if pressed with too hot an iron.
- Rayon is moderately resistant to acids and alkalis.

- It is quite versatile and blends easily with other fibers to add luster, softness, or absorbency, or to reduce cost. HWM rayon can be finished for shrink resistance and permanent press.
- Rayon is biodegradable.

SPECIAL CONCERNS WITH RAYON

- Regular rayon is characterized by low wet strength, allowing severe shrinkage and/or stretching out of shape when wet. HWM rayon overcomes this difficulty.
- Regular rayon fabrics often spot if food or beverages spill on them or raindrops splash them. This is due to moisture sensitivity in dyes or in sizings and starches applied during manufacturing to give body and shape and control shrinkage. Moisture-induced spots or rings are difficult to remove without wetting the entire garment, which can further damage garments. A dry cleaner must also use water-based cleaning methods for non-oily stains and steam when pressing, so dye and sizing disturbances can occur during dry cleaning as well. Such moisture-sensitive sizings and dyes are not generally used on HWM rayons, which can be machine washed safely.
- Rayon fabrics may become limp over time from abrasion or loss of commercially applied sizing during cleaning.
- It will wrinkle, as do other cellulosic fibers.
- Rayon has only moderate abrasion resistance, so it is preferred for fashion apparel rather than products such as children's and work clothing.
- Rayon burns like other cellulosics. Flame retardants can be used.
- It will mildew if kept in damp conditions.
- Rayon may be attacked by silverfish and sometimes termites.
- Prolonged exposure to ultraviolet light will damage rayon.

CARE AND CLEANING OF RAYON

Care labels should always be followed when cleaning rayon. Consumers often find it difficult to know whether a rayon item is made from regular or HWM rayon. Even HWM rayon garments may have linings or trims that are not washable. Many regular rayons require dry cleaning for fabric stability and to protect dyes and sizings. Consumers who do not follow care instructions have no recourse with manufacturers should damage occur during laundering.

HWM rayon items can generally be machine washed and dried without special care. Remove them from the dryer while slightly damp, smooth, and hang to reduce wrinkling. Use care in hang drying heavy HWM rayon items. They should be well supported to avoid stretching or loss of shape.

Regular rayons require care during wear. They should be protected from contact with moisture and food spills as much as possible. Blot spills immediately to remove moisture. Dye migration problems increase the longer an item remains wet. Take stained garments to the dry cleaner for stain removal, but be aware that rings and shading changes may be permanent. Rayon can be bleached, although some dyes used for regular rayon are sensitive to bleach.

Regular rayons that can be hand washed should be handled with care to avoid stretching them out of shape. Support wet fabrics. Gently squeeze moisture

out without wringing or twisting, then roll in a towel. Lay flat to dry.

Rayon can be pressed at medium to high temperatures. Press on the wrong side or use a press cloth on the right side to avoid shine or iron imprints. Be careful of spitting steam irons to avoid water spots. When ironing rayon/synthetic blends, use the temperature appropriate for the synthetic to avoid melting the synthetic.

RAYON PRODUCERS

For further information on rayon, contact one of the three companies manufacturing rayon in the United States:

Acordis Cellulosic Fibers, Inc.
111 West 40th Street
New York, NY 10018
212-944-7400

Lenzig Fibers Corporation
6100 Fairview Road
Charlotte, NC 28210
800-727-2966

North American Rayon
500 5th Ave.
New York, NY 10110
212-840-2592

REFERENCES

"A Special Report on the Cellulosics Rayon and Acetate Fibers and Fabrics," *American Fabrics and Fashions Magazine*, 1979.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Lenzig Fibers Corporation

Smith, Joyce A.; and Pitts, Norma; "Rayon—the Multi-Faceted Fiber," Extension Fact Sheet, The Ohio State University Extension, 1993.

The International Fabricare Institute

SILK

Queen of Fibers

Silk is synonymous with luxury. It is soft, smooth, and fluid with a lustrous sheen. Silk has a unique combination of properties not possessed by any other fiber. In fact, the manufactured fiber industry was begun in an effort to reproduce those properties, because silk was scarce and expensive.

- Silk has the finest texture of any natural fiber. This allows production of very fine, lightweight fabrics.
- Silk has a soft luster with an occasional sparkle once the natural gum coating has been removed.
- It is very smooth to the touch and feels cool and soft.
- Silk drapes very fluidly and moves with the body.
- Silk can absorb water up to one-third of its weight without feeling wet to the touch. This is an important factor in the wearing comfort of silk.
- It is moderately elastic, which gives it flexibility to move with the body, reduces creasing, and lets it easily shed wrinkles when a garment is hung in a steamy bathroom.
- Silk has excellent strength relative to its fineness when dry. It loses up to 20 percent of its strength when wet, though.
- Silk itself does not shrink, although certain fabric constructions such as crepe may shrink.
- Silk accepts dyes readily to create vibrant, rich shades.
- Silk is a natural fiber and is biodegradable.

WHAT IS SILK?

Silk is a protein fiber spun by an insect called a silkworm to form its cocoon. Cultivated silk is produced under carefully controlled conditions by feeding bombyx moth larvae fresh mulberry leaves until they have formed cocoons. Completed cocoons are softened in hot water and unwound. Each cocoon yields approximately 1,000 yards of continuous, fine, white filament desirable for the finest silk fabrics. Filament from as many as 1500 cocoons can be required to make one dress. The filament can be woven, knitted, or made into lace.

Douppioni silk is produced when two cultivated silkworms spin their cocoons together, creating a thick and thin yarn. The resultant fabric has a rougher texture than plain filament silk.

Broken filaments and silk from cocoons where the moth was allowed to mature and break out yield shorter silk fibers which are spun together to make

yarns suitable for fabrics. The shortest silk fibers, left over from spinning longer fibers, are often spun into noil yarn, a nubby textured yarn. Spun silk fabrics have a slightly brushed appearance and a dull sheen because the short fiber ends protrude from the yarns. They are not as strong and elastic as the much longer, smoother filament silk fabrics.

Wild silk, or tussah silk, comes from the cocoons of other species of silkworms. The silkworms feed on oak and cherry leaves which color their silk brown, yellow, orange, or green. The filaments are coarser and less regular in appearance than those from cultivated silkworms. Wild silk is harvested after the moths have matured, so it is used as spun silk.

The silkworm coats silk with a natural gum, called sericin, to help glue the cocoon together. Sericin helps protect the silk during processing, but it is generally removed before the fabric is dyed. Raw silk is silk which still retains the coating of sericin. It is less shiny and soft than degummed silk. Either cultivated or wild silk can be sold as raw silk.

SPECIAL TREATMENTS FOR SILK

The surface of a silk fabric may be treated to soften it and make it more casual. Sandwashed silk is washed with sand or pebbles to create a worn or faded appearance, just as denim jeans are treated.

Sueded silks are spun silks with a slight surface nap produced with textured rollers. They have a very soft hand and a chalky appearance.

Both sueded and sandwashed silks have a limited wear life because their surfaces have been damaged to create the soft hand and highlighted surface.

Pigment-dyed silks resemble sandwashed silks in their dull, chalky appearance. They are found most often in sportswear. Color may rub off the surface of pigment dyed silks.

Washed silk has been laundered to achieve a crinkled look. It must be dry cleaned to preserve the crinkles. It is distinct from "washable" silk.

Washable silk fabrics have been chemically treated with a water-insoluble additive so that they can be washed. Some can be machine washed. The treatment alters the appearance of the silk fabric as well, making it softer and more worn. Washable silk is used in more casual garments.

Weighted silk has been treated with metallic salts, such as tin, to replace some of the weight lost by seracin removal and make the silk drape more stiffly. Weighted silks deteriorate over time and are especially prone to breakage at folds. Historic items often exhibit disintegration, an irreversible condition known as "shattered silk."

A SERENDIPITOUS DISCOVERY

Silk has been treasured as a luxury fabric since its accidental discovery about 2600 B.C. by a young Chinese empress. Legend has it that she dropped a cocoon into her cup of tea. The hot liquid dissolved the sticky sericin gum so that the cocoon unraveled into one long fiber. China held a monopoly on silk production for 3000 years, guarding the secret so closely that death could be the penalty for disclosure to a foreign power.

Alexander the Great is credited with the introduction of silk to Europe in the 4th century B.C. Silk fabrics were transported by caravan from China to the

Mediterranean via the 6000 mile "Silk Road." Silk has always been the fabric of royalty, wealth, and power. Julius Caesar restricted use of silk to himself and a handful of other officials. During the Crusades, it was sought by European royalty at a great price.

Production eventually spread to other countries, but China still produces more than half of the world's raw silk. India, Japan, Brazil, South Korea, and Thailand are other silk-producing countries. Italy is an important source of fine silk fabrics, woven from imported raw silk.

SELECTING SILK

Silk is widely available in both expensive luxury garments and popularly priced sportswear. It has become one of the major fibers in the apparel market. Very dressy fabrics such as chiffon, georgette, taffeta, satin, and charmeuse are often made of silk. These fabrics are generally found in expensive garments and will most often require dry cleaning. Many of these dressy fabrics are Chinese raw silk, sometimes woven in Italy or France. Tussah silks are often woven into pongee or shantung fabrics appropriate for suits and blazers. Silk noil, China silk, crepe de chine, sandwashed, sueded, or washed silks are found more often in popularly priced sportswear.

When buying silk garments, check for tightly woven fabrics and be sure that color does not rub off when you rub a tissue against an inconspicuous spot. Read care labels because silk sportswear may be washable. Silk is sometimes blended with cotton for blouse and shirt fabrics or with wool, linen, or synthetics in suiting fabrics.

Silk is also knitted into sweaters, socks, gloves, and underwear. It is so fine and lightweight that silk long underwear will fit comfortably under street clothes. It feels cool and dry to the touch.

USING AND STORING SILK

Follow these guidelines to maintain silk's beauty:

- Silk is easily degraded by mineral acids. This means that perspiration, which is acidic, causes discoloration and weakening of silk. Clean silks immediately after soiling to avoid staining.
- Aluminum chloride, a common ingredient in deodorants and antiperspirants, will stain silk. Let deodorants dry thoroughly before putting on a silk garment.
- Alcohol may bleed the dye in silk. Apply perfume before putting on silk garments. Clean alcoholic beverage spills immediately.
- Alkaline substances often cause dyes used on silk to change color. Take care not to get soap, toothpaste, shampoos, and other alkaline toiletries on silk garments because they may irreversibly spot silk.
- Silk is the most sensitive of any fiber to ultraviolet light. Protect silk from prolonged direct exposure to sunlight and to artificial ultraviolet light.
- Do not bleach silk with chlorine bleaches.
- Silk deteriorates over time with exposure to oxygen in the air, a problem for conservation of historic silk textiles. Store silk in acid-free paper in dry, cool, dark conditions.
- Insects, especially carpet beetles, may be attracted to silk, even more so if it is soiled. Moths will not attack silk. Store silk clean.
- The sericin gum on silk may absorb

environmental odors. These will disappear with sufficient airing or cleaning.

CARE AND CLEANING OF SILK

Care instructions on silk items depend more on the nature of the dyes and finishes, the yarn structure, or the garment construction than on the fiber content. Follow care label instructions carefully. All matching pieces of an ensemble should be cleaned together to avoid variance in texture or color between pieces. Silk items with no care labels should be tested for dye loss by wetting an inconspicuous spot or a snip from a seam, then blotting between paper towels. If color "bleeds" onto the paper towels, dry clean the item.

Dry cleaning is the most commonly recommended care for silk garments, especially those with elaborate details, such as pleats, ruffles, embroidery, covered buttons, or linings. Crepe fabrics should be dry cleaned to prevent shrinkage. Many dyes used on silk are water soluble, so items containing those dyes must be dry cleaned. Be sure to point out stains to the dry cleaner before cleaning, because even the sugars in colorless drinks can cause yellow stains if exposed to heat.

If washed, silk must be handled gently. Prolonged soaking often causes dye bleeding. Wash items of different colors separately. Neutral laundry detergents recommended for delicate items are best; strongly alkaline detergents will cause yellowing. Chlorine bleaches should be avoided. Hydrogen peroxide and oxygen bleaches can be used to remove spots from white silks.

Hand wash silk in mild detergent or soap with gentle agitation. Do not rub or stretch silk. Squeeze water out; do not wring. Roll the garment in a towel to remove excess water and hang dry indoors away from heat and sunlight.

Silk may be machine washed if it is labeled washable. It should be washed on a short gentle cycle using warm or cool water. Colors should be washed separately. Spin dry without heat or hang to dry. Silk labeled specifically "washable" should not be dry cleaned.

Silk should be ironed when damp. Keep silks damp by wrapping them in a towel or plastic bag and storing in the refrigerator if they cannot be ironed immediately. Iron on the wrong side of the garment using a moderate setting.

REFERENCES

Hatch, Kathryn, *Textile Science*, West Publishing Co., St. Paul, Minn., 1993.

International Fabricare Institute Bulletins, May 1989, November 1990, January 1992, September 1993, International Fabricare Institute, Silver Spring, Md.

Rheinberg, Leslie, "Silk, the Continuous Filament Natural Fiber, Part One," *Textiles*, 1991, Issue No. 4, pp. 6–10.

Rheinberg, Leslie, "Silk, the Continuous Filament Natural Fiber, Part Two," *Textiles*, 1992, Issue No. 1, pp. 6–8.

"Silk," *Consumer Connection*, Volume 7, Number 1, January/February 1992, Maytag Consumer Education.

"Silk: a Natural Wonder," *Cleanliness Facts*, The Soap and Detergent Association, November 1985, pp. 13–15,

"Silk," International Fabricare Institute, 1989.

"Silk," The Silk Institute, Clifton, N.J.

SPANDEX

Stretch for Comfort and Fit

Spandex is the fiber that allows you to wear close-fitting exercise clothing yet still have freedom of movement. It is the fiber that holds up your socks. It prevents pants and leggings from bagging at the knees. It provides "power stretch" for foundation or support garments and allows just a little bit of "comfort stretch" in other clothing. Spandex is a hidden fiber that is never used alone, but adds stretch and flexibility to the properties of other fibers it is combined with. The name spandex was actually derived from the word "expand," which describes its performance well.

Spandex, the first manufactured elastic fiber, was developed by DuPont in 1959. It was an immediate success in foundation garments, surgical-support garments, swimsuits, and other garments requiring power stretch for support and body shaping. Spandex was stronger and more durable and offered several times more restraining power for weight than the rubber fibers used before that time. The combination of spandex with textured nylon enabled production of "support" or "control" pantyhose in very sheer styles.

Interest in fitness and sports in the United States created demand for comfortable, lightweight clothing that moves with the body. Use of spandex in ski pants, aerobics wear, bicycle pants, and other sports clothing allowed a trim, close fit, which returned immediately to shape after stretching with movement. As people became accustomed to comfort and freedom of movement in active sports clothing, they looked for it in daily wear. Today an examination of hangtags will show that dresses, slacks, jackets, knit tops, jeans, and many other garments, either knit or woven, may contain spandex for comfort and shape retention. Demand for spandex is increasing as more and more people discover the benefits of a little stretch in a fabric.

SPANDEX MANUFACTURE

Spandex is a petroleum-based manufactured fiber that the Federal Trade Commission defines as a long-chain synthetic polymer composed of at least 85 percent of a segmented polyurethane. Spandex fiber is elastomeric—capable of stretching repeatedly to at least twice its original length and returning to approximately the original length immediately and forcefully once force or stress is removed. This capability is achieved in

spandex by a fiber structure that alternates rigid and flexible segments: the rigid segments provide the fiber framework and the flexible segments straighten when force is applied, then spring back into a coiled position when the force is removed. The amount of stretch can be controlled by varying the proportions of rigid and flexible segments within the fiber. Spandex usually elongates at least 400 percent and can elongate as much as 700 percent over original size. There are chemical variants of spandex made to meet various end-use requirements and differing somewhat in resistance to detergents or body oils. Spandex fibers can be made in a wide range of diameters, from very fine for hosiery to very heavy for power-restraining purposes.

Spandex is blended with other fibers because it is sufficiently strong so that there is little need for fabric made of all spandex. Also, spandex absorbs very little moisture, making it uncomfortable next to the skin. It is blended with more absorbent fibers to provide a combination of next-to-the-skin comfort and stretch. Spandex can be spun into yarns with other fibers as a bare filament and is often used this way with nylon for foundation garments, lingerie, swimsuits, and pantyhose. Spandex may also be a component of covered or core-spun yarns.

Covered yarns encase the spandex yarn in a wrapping of yarn made of another fiber. This can protect spandex from body oils and other degrading agents. Covered yarns can also restrict elongation of the spandex core and increase the resistance required to stretch at all, creating power stretch yarns suitable for support garments. Foundation garments and swimsuits may contain 15 to 40 percent spandex. Nylon is commonly used to cover spandex.

Core-spun yarns are spun with a sheath of other fibers wrapped around a spandex core. Cotton yarns with a spandex core are used to make stretch denim or corduroy, cotton swimsuits, or ribbing for cuffs and collars on knit garments. Any fiber may be used for the outer sheath surrounding the spandex. Smaller amounts of spandex are used in these fabrics, often 1 percent to 10 percent, and the fabric feel and appearance are most like the covering fiber. Wool, acetate, rayon, silk, nylon, polyester, and lyocell are blended with spandex to make a variety of wovens and knits, from suiting fabrics to sueded knits and satins.

Spandex is a thermoplastic fiber, meaning that it softens with application of heat and will ultimately melt if exposed to high enough temperatures. This property means that it can be heat-set, or shaped permanently, by softening it nearly to the melting point, then holding it in a desired configuration until it is cool. It will retain this shape unless it is brought nearly to the melting point again. Fabrics containing spandex are sometimes heat-set to smooth or to texture them and to set the desired amount of stretch into the final fabric. Since spandex will return to its original configuration, it won't bag during wear and will help fabrics such as cotton or acetate knits retain garment shape.

Spandex is perhaps most recognizable by the brand name Lycra, the heavily promoted DuPont spandex. Spandex is also manufactured by Globe Manufacturing Company, with the brand names Cleerspan and Glospan, and by Bayer, under the trade name Dorlastan.

BEST FEATURES OF SPANDEX

- Spandex can usually be stretched more than 500 percent without breaking. It can be stretched repeatedly and still return to the original shape or very close to it.
- The fiber is very supple and flexible.
- It provides sufficiently powerful stretch and recovery so that small quantities achieve results. This means that even powerful control garments can be made lightweight.
- Spandex dyes easily, eliminating "show through" of elastic yarns when a garment is stretched.
- The fiber is just as strong wet as it is dry, making it ideal for swimwear and easy to wash.
- Spandex dries immediately, because it does not absorb water.
- It is unaffected by saltwater.
- Spandex does not shrink in cleaning, nor does it stretch out of shape with wear.
- It does not deteriorate with age.
- Spandex is resistant to deterioration by sunlight, body oils, perspiration, or cosmetics.

CARE AND CLEANING OF SPANDEX

Always read garment care labels. Spandex itself may be machine washed or dry cleaned. The choice depends on what is appropriate for the fiber blended with spandex to make the fabric. If laundering, don't use chlorine bleach on fabrics containing spandex. Machine drying is acceptable. Low-temperature drying is best. Spandex requires an ironing temperature similar to that of wool and silk (on the lower end of the iron dial).

Spandex deteriorates with exposure to chlorine bleach, but the concentration of chlorine used in swimming pools does not affect spandex. Sunlight might cause spandex to yellow but not to degrade. Spandex will not mildew.

FURTHER INFORMATION

Additional information on spandex can be obtained by contacting

DuPont(producers of Lycra)
1430 Broadway, 4th Floor
New York, NY 10018
1-800-645-9272

Globe Manufacturing Company (producers of Glospan and Cleerspan)
456 Bedford Street
Fall River, MA 02720
508-674-3585

Bayer, Inc., Fibers Division (producers of Dorlastan)
P.O. Box 118088
Charleston, SC 29423
888-336-4377

REFERENCES

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

Hollen, Norma; Saddler, J.; Langford, A.; Kadolph, S.; *Textiles*, Macmillan Publishing Company, New York, N.Y., 1988.

L'eggs Web Page

Rudie, Raye, "Fabrics Stretch into the Future," *Bobbin*, August 1995, pp.28–34.

WOOL

Nature's Wonder Fiber

Wool is hair from the sheep or lamb, angora goat (mohair), cashmere goat, camel, alpaca, llama, and vicuna. Like human hair, wool is a protein fiber that grows continuously from follicles in the skin. Nature designed wool to protect animals from cold, heat, rain, wind, and sun. Humans have taken advantage of those protective abilities for thousands of years while enjoying wool's beauty. You may have wool rugs, blankets, upholstery, sweaters, suits, coats, hats, and other wool items in your home.

WHAT MAKES WOOL SPECIAL?

Wool's many useful properties result from its unique layered structure. The thin outermost layer absorbs moisture vapor, such as humidity or perspiration, through microscopic pores, giving wool the unique ability to "breathe." Larger liquid water droplets cannot penetrate the pores, so they tend to bead up and roll off, making wool naturally water repellent.

Inside the porous sheath is a layer of overlapping scales resembling tiny roof shingles. The shingle structure gives wool its slightly rough texture and enables wool to felt, or to lock fibers together permanently, forming tight fiber mats. Controlled felting produces hats, yard goods, pool table tops, sound-absorbing materials for acoustical purposes, and many industrial items.

The central core of wool allows the fiber to absorb moisture up to 30 percent of its own weight and still feel dry. This means that in cold, wet conditions, wool will soak up exterior moisture until it is saturated, but leave the wearer comfortable. As the moisture held within wool evaporates, sufficient heat is given off to prevent the wearer from chilling. In hot, dry weather, wool absorbs perspiration, leaving a dry layer next to the body. The perspiration evaporates very gradually from the wool, holding enough moisture near the skin to prevent dehydration.

The moisture content of the fiber core affects conductivity of electrical charges. Under humid conditions, wool resists static well. Very dry conditions will cause garment cling and static shocks on wool carpets.

A combination of moisture content and chemical composition makes wool flame resistant. It is slow to ignite, burns slowly, and self-extinguishes when the source of flame is removed. Chemical treatment renders wool sufficiently flame resistant to meet rigid standards.

Wool has another special quirk: its natural crimp. Wool fibers grow with a permanent curl like a powerful spring. The coiled fibers stretch easily and can be twisted and flexed many times without breaking (up to 20,000 times as compared to 3,200 bends for cotton). Stretched fibers are able to spring back to their original positions. This resilience means that wool fabrics do not wrinkle easily, and wrinkles that do occur are easily removed.

Wool has an insulative ability because pockets of air are trapped around the crimped fibers. Up to two-thirds of a wool fabric may be air. A bulky wool yarn with lots of crimp provides lightweight warmth.

Wool absorbs unpleasant odors and deactivates them, so that wool garments do not hold perspiration or smoke odors. Wool also readily absorbs oils, such as spills or body oils, but releases them easily during cleaning. Oily stains are thus less of a problem for wool than for many synthetic fibers.

WHERE DO WE GET WOOL?

Wool was one of the first fibers to be spun and woven into cloth. Wool garments were worn as early as 4000 B.C. in Babylon. Sheep and wool were carried throughout the Mediterranean world by traders. The finest wool-bearing sheep in the world, the merino sheep, was developed by the Romans in Spain about 45 A.D. Wool trade accounted for much of the wealth of Spain and England during the Renaissance and beyond. Resentment over British limitations on Colonial American wool trade helped fuel the American Revolution.

Today Australia is the single largest source of wool, producing 30 percent of the world total. Russia and New Zealand together account for another 19 percent. China, Argentina, Eastern Europe, South Africa, Uruguay, Turkey, Britain, and the United States also produce significant quantities of wool. There are at least 200 different commercial breeds of sheep and almost as many varieties of wool.

TERMS TO KNOW ABOUT WOOL

Federal legislation requires that the amount and type of wool in a garment be identified. Virgin wool or new wool is wool that has never been processed in any way before. Recycled wool is obtained by converting a previously manufactured wool product, such as scraps left from garment cutting or used garments, to fibers that are then processed the same way as new wool. Quality depends more on the quality of the raw wool that on whether the wool is virgin or recycled.

The Woolmark is a quality symbol, denoting a pure wool item tested by the Woolmark Company, an organization devoted to wool research and promotion. The Woolblend Mark certifies that an item contains at least 60 percent wool and meets Woolmark standards.

A specialty fiber name may be used in lieu of the word "wool" and often appears on premium products. Examples are cashmere, mohair, alpaca, camel's hair, and vicuna. Sheep variety such as merino or shetland may be identified as well.

Wool clipped from sheep less than eight months old is termed lamb's wool. It is finer and softer because it is the first shearing and the fiber has only one cut end.

PURE NEW WOOL

WOOLMARK

WOOL RICH BLEND

WOOLBLENDMARK

Wool that retains much of the natural sheep lanolin is termed oiled wool. It has enhanced natural water repellency and is often used for heavy sweaters.

There are two types of wool yarns: woolen and worsted. Woolen yarns are spun from short wool fibers that have been somewhat straightened but are still entangled. Fabrics made of woolen yarns are textured because many fiber ends protrude. Examples of woolen fabrics are flannel, tweed, and melton. Sweaters are usually knit of woolen yarns. Worsted yarns are spun from long fibers that have been combed until they lie straight and parallel to each other. Worsted yarns are more tightly spun than woolens and produce smooth fabrics such as gabardine, crepe, and serge. Tailored clothing is likely to be worsted wool.

SPECIAL CONCERNS WITH WOOL

- Many people believe that they are allergic to wool. In fact, wool is chemically identical to human hair and not a common allergen. What is actually occurring is skin irritation from contact with coarse fibers. Any coarse fiber could cause the same reaction. Very fine wool, such as merino or cashmere, and smooth worsted wools are unlikely to irritate the skin.
- Wool will felt if laundered in warm water with sufficient agitation. Felting causes irreversible shrinkage. Read care labels and treat wool gently.
- Moth larvae and carpet beetles attack wool. They are especially attracted to wool with food stains, body oils, and other soils.
- Bleach, particularly chlorine bleach, decomposes wool fibers. Do not bleach wool.
- Prolonged exposure to sunlight causes wool to yellow because oxidation degrades the fiber.
- Wool fibers swell in water, causing internal bonds to break. Wet wool is therefore weaker and less resilient than dry wool. Do not stretch wet wool.
- Wool scorches easily when ironed. Dry heat causes wool to become brittle. Wool should be pressed at low temperatures, preferably with moist heat.
- Soft wools sometimes mat or pill on the surface during wear. These pills are easily brushed off pure wool but may cling to wool-synthetic blend fabrics because the synthetic fibers are quite strong.

MODIFICATIONS TO A NATURAL PRODUCT

Wool is sometimes blended with other fibers. Polyester may be blended with wool to promote wrinkle resistance and crease retention. Nylon may be added for increased durability. Synthetic yarns are sometimes blended with wool to lower the price. Wool and cotton are blended to make a very soft fabric.

Special treatments are used to control felting and to allow machine washing of wool. These treatments either alter the chemical structure of wool or coat wool so the scales cannot interlock. Brand names such as Superwash indicate machine-washable wool. A new treatment for wool jersey was introduced in the United States in 1996. It allowed machine washing in warm water on a gentle cycle and air drying.

Much of the wool available today is moth-proofed by application of chemicals, none of which are known to be toxic to humans. No mothproofing formula is 100 percent effective, but all deter moths. A dry cleaner can apply mothproofing to wool items.

Attempts have been made to make wool hold creases better. Durable-press wool has been treated with polymers which will set in position with application of heat. Permanent-set wool fabrics have been modified using a process like a permanent wave to fix them into a particular configuration.

Worsted wool fabrics are sometimes labeled London-shrunk or "Genuine London Process." These fabrics have been treated with moisture to reduce relaxation shrinkage during cleaning and improve the feel of the fabric.

CARE AND CLEANING OF WOOL

Spills should be removed promptly from wool. Beverages containing sugars and acidic dyes may oxidize with time, making permanent yellow stains.

Most wool articles require hand washing or dry cleaning. Some specially treated items are labeled machine wash. Read care labels carefully. Mild soaps and detergents are recommended because prolonged exposure to strong detergents can weaken wool.

To handwash wool, use cool water. Gently squeeze the wash water through the fabric. Rinse until the water is clear. Always support wool items from underneath when lifting out of the water. Do not wring water from wool but gently squeeze it out, then roll the item in a towel to remove remaining water. Lay flat to dry, patting gently into shape. Do not dry in the sun or near direct heat.

Machine-washable wool items may be washed on the gentle cycle and tumble-dried until just dry. Other knits or blankets may be machine washed on the gentle cycle in cool water if the agitation cycle is very short. Knits should be dried flat in the same way hand-washed items are dried. Blankets may be tumble-dried on high heat with a load of clean towels to absorb the moisture.

Wrinkles can be removed from wool by hanging a garment in a warm moist environment such as a steamy bathroom. Refresh a wool garment after wearing by brushing it with a soft brush, then hanging it.

Use care in ironing wool. Wool should always be pressed with moist heat, either a steam iron or a damp press cloth. A press cloth helps avoid a shine on the

wool surface. Wool fabrics can be molded to shape, creased, or pleated easily with steam heat.

Wool garments should be thoroughly cleaned before storing. Store wool in a closed container in an insect-free area. Mothballs will help keep insects away, but be cautious with them, because they are an indoor air pollutant. Air garments outdoors after removing from mothball storage. Cedar chests are appropriate for storing wool only because they are sealed containers. Cedar itself will not deter insects, so cedar balls placed in garment bags are not sufficient to prevent moth damage.

FURTHER INFORMATION

Additional information on wool is available from

The Woolmark Company
330 Madison Ave.
New York, NY 10017-5001
www.woolmark.com

The American Wool Council
Division of the American Sheep Industry Association, Inc.
6911 South Yosemite St.
Englewood, CO 80112-1414

REFERENCES

Fact Sheets 1–8, American Wool Council, Denver, Colo. 1987.

Freeman, R. C., Letter to Eleanor Young, The Wool Bureau, Inc., 1983.

Hatch, Kathryn, *Textile Science*, West Publishing Company, St. Paul, Minn., 1993.

McLean, Jean, *Wondrous Wool*, Cornell Cooperative Extension, 1982.

Rudie, Raye, "Of Things to Come," *Bobbin*, March 1996, pp.14-78.

Washable Silk, Rayon, and Wool, International Fabricare Institute Bulletin, International Fabricare Institute, Silver Springs, Md., 1989.

Wool. From Fiber to Fabric, The Wool Bureau, New York, N.Y., 1981.

RAYON. NYLON. SPANDEX. TENCEL. THINSULATE. DACRON. Have you seen these names on clothing tags and on household furnishings? Which are fibers and which are brand names? What do you need to know to make informed shopping decisions and to clean and store your garments and household items?

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