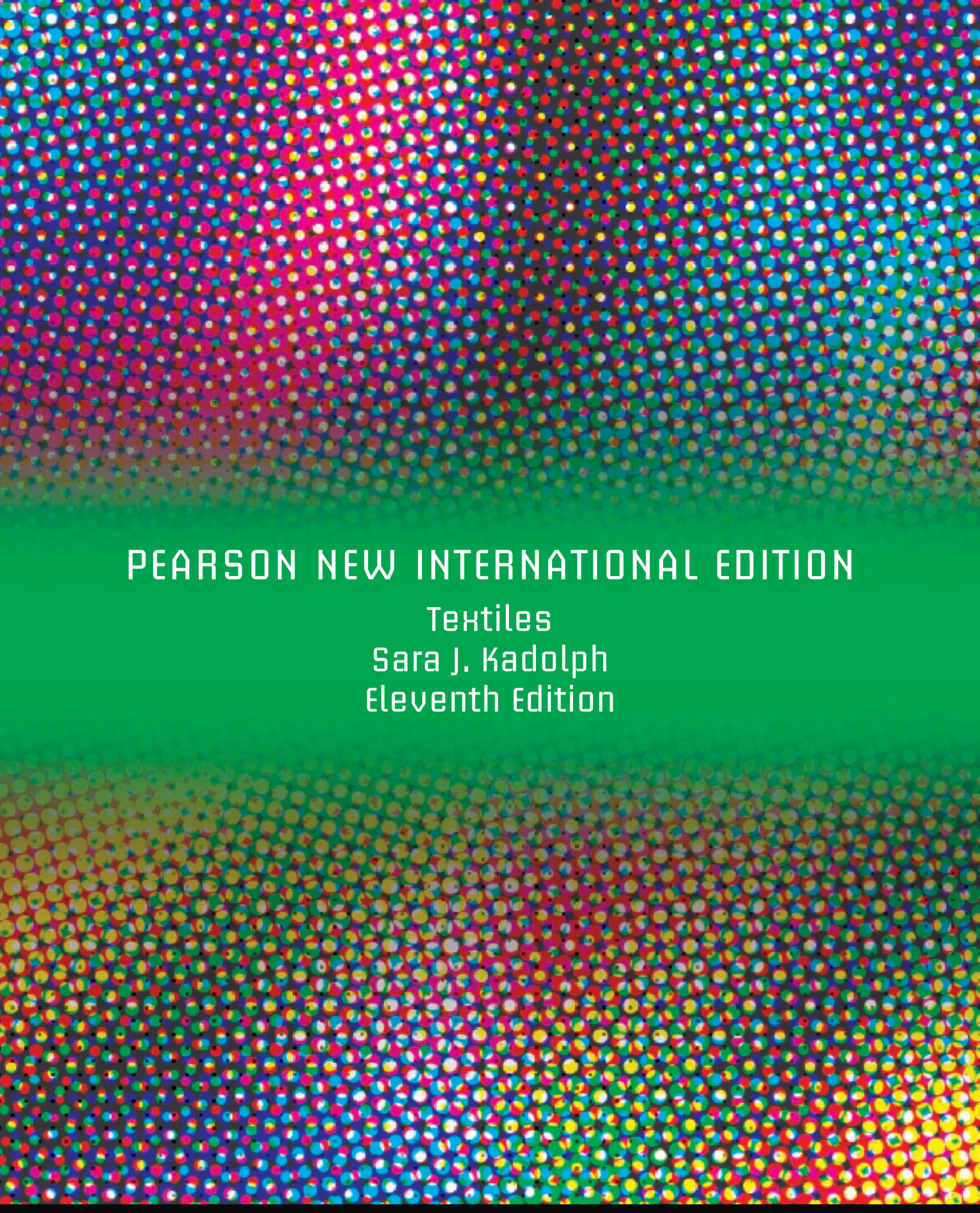

PEARSON NEW INTERNATIONAL EDITION

Textiles

Sara J. Kadolph

Eleventh Edition

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Table 15 Summary of the Performance of Olefin in Apparel and Interior Textiles

Aesthetic	Variable
Luster	Medium
Durability	High
Abrasion resistance	Very good
Tenacity	High
Elongation	Variable
Comfort	Moderate
Absorbency	Poor
Thermal retention	Good
Appearance Retention	Excellent
Resiliency	Excellent
Dimensional stability	Excellent
Elastic recovery	Excellent
Recommended Care	Machine-wash, dry at low temperature (apparel)
	Dry extraction (interior textiles)

An acid-dyeable olefin is available, but dyed olefins comprise a tiny fraction of the market. Polypropylene is used in apparel, interiors, and technical products.

Properties of Olefin

Olefin's performance in apparel and interior fabrics is summarized in Table 15.

Aesthetics Olefin is usually produced with a medium luster and smooth texture, but the luster and texture can be modified depending on the end use. Many sizes of olefin fibers are available. Smaller fibers are available for interiors and apparel. Finer-denier fibers produce a softer, more natural drape.

Olefin has a waxy hand; crimped fibers with modified cross sections have a much more attractive hand and are most often used for apparel and interior textiles. Drape can be varied relative to end use by selection of fiber modification, fabric construction method, and finish.

Current olefins do not look artificial, as the early olefins did. Contemporary olefins are modified easily by changing cross section, fiber size, crimp, and luster. Olefin fibers are most often solution-dyed; many producers provide a wide variety of color choices for olefins designed for interiors or apparel. Some interior designers prefer olefin to most other fibers because of its attractive appearance and other positive performance aspects, coupled with its relatively low price as compared with similar products made from different fibers.

Durability Olefins may be produced with different strengths suited to the end use. The tenacity of polypropylenes ranges from 3.5 to 8.0 g/d; that of polyethylenes, from 1.5 to 7.0 g/d. Wet strength is equal to dry strength for both types. An ultra-high-strength olefin, Spectra by Honeywell, has a tenacity of up to 30 g/d and is used in technical products. Fibers produced for less demanding end uses have tenacities ranging from 4.5 to 6.0 g/d. Olefin fibers have very good abrasion resistance. Elongation varies with the type of olefin. For olefins normally used in apparel and interior textiles, the elongation is 10 to 45 percent, with excellent recovery. Upholstery and commercial carpets of olefin and olefin blends combine excellent performance with low cost.

Olefin products are durable and strong. With olefin's low density, it is possible to produce highly durable, lightweight products. Resistance to abrasion and chemicals is excellent. This combination of characteristics and low cost means that olefin is very competitive with other fibers with equal or superior durability. Olefin is ideal for end uses for which durability, low cost, and low density are critical, such as ropes and cables of great size or length.

Comfort Olefins are nonabsorbent, with a moisture regain of less than 0.1 percent. Because of this, most olefin fibers are mass-pigmented or solution-dyed. However, when modified nanoclay particles are incorporated in composite olefin fibers, it can be dyed. Olefins are nonpolar in nature and are not prone to static electricity. Because of its excellent wicking abilities, olefin is used in some active sportswear, socks, and underwear, and as a cover stock in disposable diapers. It does not absorb moisture and minimizes leakage. In cold-weather wear and active sportswear, olefin keeps the skin dry by wicking moisture away from the skin's surface.

Olefin has good heat retention. It is also the lightest of the textile fibers. Polypropylene has a specific gravity of 0.90 to 0.91; polyethylene, 0.92 to 0.96. This low specific gravity provides more fiber per pound for better cover. As producers learned to deal with its low softening and melting temperatures, difficulty in dyeing, and unpleasant hand, olefin is used in warm, lightweight sweaters and blankets. It takes 1.27 pounds of nylon or 1.71 pounds of cotton to cover the same volume as 1 pound of olefin.

An inner-layer barrier fabric of olefin is used in activewear. The barrier fabric combines wind resistance with air permeability and a good moisture vapor transport rate. **Moisture vapor transport rate (MVTR)** measures how quickly moisture vapor, such as evaporated perspiration, moves from the interior side of the fabric, next to the body, to the exterior. A high MVTR describes a fabric with good comfort characteristics, especially when the wearer is active.

Lastol, an elastic olefin, is a generic subclass fiber with superior stretch and recovery properties compared to other olefin fibers. Lastol has low levels of crystallinity, a different molecular structure, more resistance to solvents, and more tolerance of a wider range of temperatures. It is used in easy-care stretch apparel.

With modifications of cross section, crimp, and fiber size, olefin upholstery fabrics can be extremely comfortable. In upholstery, olefins with deniers of 1.7 to 2.0 produce comfortable textures. Olefin fibers with a similar small denier are used in apparel. Soft and lightweight olefin fibers with excellent wicking are prized by both amateur and professional athletes for the edge they contribute to performance.

Appearance Retention Olefin has excellent resiliency and recovers quickly from wrinkling. Shrinkage resistance is excellent as long as it is not heated. It also has excellent elastic recovery. Olefin retains its attractive appearance for years. Since the fiber can be heat-set, wrinkles are minimal. Crimp and other three-dimensional effects are permanent. The fiber does not react with most chemicals, so it does not soil or stain readily. Designers find olefin carpeting and upholstery fabrics ideal for a wide variety of end uses.

Care Olefins have easy-care characteristics that make them suited to a number of end uses. They dry quickly after washing. Dry cleaning is not recommended because olefins are swollen by common dry-cleaning solvents such as perchloroethylene (perc or PCE). Petroleum-based dry-cleaning solvents are acceptable for cleaning olefins, but if perc is used, the damage cannot be reversed.

Since olefin is not absorbent, waterborne stains are not a problem. The fiber does not pick up color from stains or items that bleed in the wash. The major problems with olefin relate to its oleophilic and heat-sensitive nature. Oily stains are extremely difficult to remove. Exposure

to oil may cause the fiber to swell. Exposure to excess heat causes the fiber to shrink and melt. Interior items of olefin should never be treated with soil-removal agents that contain perc since this solvent will alter the appearance of any treated areas.

Olefins have excellent resistance to acids, alkalis, insects, and microorganisms. They are affected by sunlight, but stabilizers can be added to correct this disadvantage. Outdoor carpeting made of olefin fibers can be hosed off.

Olefins have a low melting point (325 to 335°F), which limits their use in apparel. Warm or cold water should be used for spot cleaning or washing. Olefin fabrics should be air-dried. Olefins should be dried and ironed at low temperatures.

Environmental Concerns and Sustainability of Olefin Many environmental issues discussed with nylon also apply to olefin. See the earlier discussion in this chapter. Olefin is an easier fiber to recycle than most other fibers. It is extensively used in a basic unmodified form to protect bales of fiber and rolls of fabrics used in apparel and interior textiles. Many packaging materials and technical products used in other industries are also used in a basic form that can be melted and reused with minimal effort to purify and process them back into fiber form. Tyvek Protective Wear by DuPont Performance Materials is an example of a product made of 25 percent postconsumer recycled polyethylene.

Since olefin is seldom dyed, the environmental problems related to dyeing are minimal. Because olefin can be engineered for specific end uses, the problems related to recycling or disposing of finishing chemicals are of little concern.

Probably one of the most significant impacts of olefin on the environment is its use in products that protect the environment. Erosion-control fabrics used in landscaping and along highways protect newly seeded areas and prevent soil erosion. Weed-barrier fabrics and protective covers for vegetables and flowers minimize the use of herbicides and insecticides by farmers, gardeners, and homeowners. Hazardous-waste-transport containers are lined with Tyvek, an olefin product by DuPont Performance Materials.

Uses of Olefin The American Polyolefin Association (APA) promotes the use of olefin and a positive image of the fiber. Olefin is found in an ever-widening array of end uses. In apparel, it is used for underwear, socks, sweaters, glove liners, and active sportswear. A fine-denier olefin is used in blends for pantyhose, saris, and swimwear. A microdenier olefin is used as a wind-, water-, and cold-barrier layer in active and outdoor wear. Thinsulate is a low-bulk, ultra-fine-microdenier fiberfill of olefin produced by 3M and used in footwear, ski jackets, and other outerwear for which a slim silhouette is desired.

In interior textiles, olefin is used by itself and in blends with other fibers in carpeting as face yarns; as nonwoven, needle-punched carpets and carpet tiles; and as upholstery, draperies, and slipcovers. Olefin has almost completely replaced jute in carpet backing because of its low cost, easy processing, excellent durability, and suitability for a wide variety of face yarns, end uses, and finishing procedures. It is used for nonwoven fabrics for furniture webbing because it is versatile, efficient, easy to handle, and economic. Antimicrobial and antifungal olefins are also used in woven mattress covers and contract floor coverings.

It is in technical applications that olefin really proves itself. Olefin's popularity is due to its versatility, serviceability, and low cost in a wide array of applications. Olefin makes an ideal *geotextile*—textiles that are used in contact with the soil. It is used to produce roadbed-support fabrics, like Petromat and Petrotak, that provide a water and particle barrier between road surfaces and the underlying soil foundation. Roadbed-support and stabilizer fabrics are used on roadways, rail lines, and parking lots to extend their life.

Table 16 Types and Kinds of Olefin Fibers

Heat-stabilized	Acid-dyeable
Light-stabilized	Solution-dyed
Modified cross section	Bicomponent
Pigmented	Fibrillated
Antimicrobial and antifungal	Soil-blocking
Flame-retardant	

Table 17 Comparison of Melt-Spun Fibers

	Nylon	Polyester	Olefin
Breaking tenacity, g/d	2.3–9.8 filament 2.9–7.2 staple	2.8–9.5 filament 2.4–7.0 staple	3.5–8.0 filament
Specific gravity	1.14	1.22 or 1.38	0.91
Moisture regain %	4.0–4.5	0.4–0.8	Less than 1
Melting point	482 or 414°F	540 or 482°F	325–335°F
Safe ironing temp	270–300°F	325–350°F	250°F to lowest setting
Effect of light	Poor resistance	Good resistance	Poor resistance

Learning Activity 11

Olefin is not a common apparel fiber, but it is used for interiors and technical products. Use Fabric #96 and list three technical end uses that would be appropriate for this textile. Describe the properties of olefin that make it a good choice for these end uses.

Olefin is used in some car interiors for floor coverings, upholstery, headliners, sun visors, instrument panels, arm rests, package-shelf fabric, door and side panels, and carpeting in trunks and cargo areas. It is also a popular fiber in boats for interiors and finishing fabrics and as surface coverings on docks and decks. It is found in dye nets, cover stock for diapers, filter fabrics, laundry bags, sandbags, banners, substrates for coated fabrics, ropes, and twines. Tyvek is used in wall-panel fabrics, envelopes, and protective apparel. Table 16 lists modifications of olefin. Table 17 compares the characteristics of nylon, polyester, and olefin, the three melt-spun fibers discussed in this chapter.

Acrylic

Acrylonitrile, the substance from which **acrylic** fibers are made and from which the generic name is derived, was first made in Germany in 1893. The marketing of acrylic fibers frequently takes advantage of their wool-like characteristics. Terms like *virgin acrylic*, *mothproof*, and *moth-resistant* appeal to consumers but do not convey anything significant, since acrylics are inherently moth-resistant and are not currently recycled.

Production of Acrylic

Some acrylic fibers are dry- or solvent-spun and others are wet-spun. In **dry spinning**, the polymers are dissolved in a suitable solvent, such as dimethyl formamide,

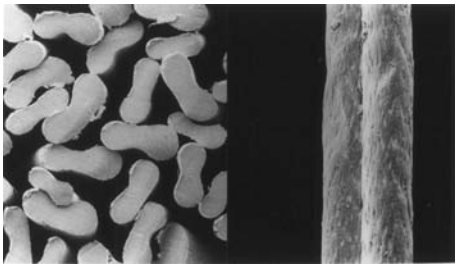


Figure 14 Photomicrographs of acrylic: cross-sectional view (left) and longitudinal view (right).
SOURCE: Courtesy of the British Textile Technology Group.

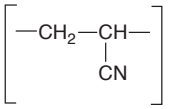
extruded into warm air, and solidified by evaporation of the solvent. After spinning, the fibers are stretched hot, 3 to 10 times their original length, crimped, and marketed as cut staple or tow. In **wet spinning**, the polymer is dissolved in solvent, extruded into a coagulating bath, dried, crimped, and collected as tow for use in the high-bulk process or cut into staple and baled.

Physical Structure of Acrylic The cross-sectional shape of acrylic fibers varies as a result of the spinning method used to produce them (Figure 14). Dry spinning produces a dog-bone shape. Wet spinning imparts a round or lima bean shape to some fibers. Differences in cross-sectional shape affect physical and aesthetic properties and thus can be a factor in determining appropriate end use. Round and lima bean shapes have a higher bending stiffness, which contributes to resiliency, and are appropriate for bulky sweaters and blankets. Dog-bone shape gives the softness and luster desirable for other uses.

All the production of acrylic fibers in the United States is staple fiber and tow. Staple fiber is available in deniers and lengths suitable for all spinning systems. Acrylic fibers also vary in shrinkage potential. Bicomponent fibers were first produced as acrylics. Some filament-yarn acrylic fabrics are imported, mostly in window treatments. MicroSupreme is a trade name for an acrylic microfiber made by Sterling Fibers Inc.

Chemical Composition and Molecular Arrangement of Acrylic

Acrylic fibers—manufactured fibers in which the fiber-forming substance is any long-chain synthetic polymer composed of at least 85 percent by weight acrylonitrile units.



—Federal Trade Commission

Fibers of 100 percent polyacrylonitrile have a compact, highly oriented internal structure that makes them virtually undyeable. They are an example of a **homopolymer**, a fiber composed of a single substance. Schematically, a homopolymer could be diagrammed:

X X X X X X X X X X X X X X X X Homopolymer

Most acrylics are produced as **copolymers**, with up to 15 percent of the repeating units something other than acrylonitrile. This produces a more open structure and permits dye to be absorbed into the fiber. The other repeating units furnish dye sites that can be changed for specific dye classes so that cross dyeing is possible. The percentages of other repeating units and their arrangement in relation to each other will vary. Copolymer fibers are composed of two or more compounds and could be diagrammed:

XXXOXXXXXXOXXXXXXOXXX Copolymer

In **graft polymer** acrylics, the other repeating unit does not become a part of the main molecular chain. It is a side chain attached to the backbone chain of the molecule. These molecular chains have a more open structure, less crystallinity, and better dye receptivity.

Some fibers have molecules with chemically reactive groups; others are chemically inert. A chemically inert molecule can be made reactive by grafting reactive groups onto the backbone. It could be diagrammed:

X X X X X X X X X X X X X X X X X X X X
C C C
Graft polymer

Copolymer acrylics are not as strong as the homopolymers or graft polymer acrylics. Since acrylics are used mostly in apparel and interiors, the reduced strength is not a major concern.

Acrylic is a manufactured fiber in which the fiber-forming substance is any long-chain synthetic polymer composed of acrylonitrile units.

Table 18 Summary of the Performance of Acrylic in Apparel and Interior Textiles

Aesthetics	Wool-like
Durability	Moderate
Abrasion resistance	Moderate
Tenacity	Moderate
Elongation	Moderate to high
Comfort	Moderate
Absorbency	Poor
Thermal retention	Moderate
Appearance Retention	Moderate
Resiliency	Moderate
Dimensional stability	Moderate
Elastic recovery	Moderate
Recommended Care	Machine-wash; follow care label (apparel)
	Dry-clean or dry-extraction method (interior textiles)

Properties of Acrylic

Acrylic fibers are soft, warm, lightweight, and resilient. They make easy-care fabrics. Because of their low specific gravity and high bulk, the acrylics have been called the "warmth without weight" fibers. Acrylics have been successful in end uses, such as sweaters and blankets, that had been dominated by wool. They are superior to wool in their easy-care properties and are nonallergenic. Bulky acrylic yarns are popular in socks, fleece and fake-fur fabrics, and craft yarns. Table 18 summarizes the performance characteristics of acrylic.

Aesthetics Acrylic fibers possess favorable aesthetic properties. They are attractive and have a soft, pleasant hand. Bulky spun yarns are usually textured to be wool-like. Indeed, acrylic fabrics imitate wool fabrics more successfully than any of the other manufactured fibers.

Apparel and interior items of all acrylic or acrylic blends are attractive. Their luster is matte as a result of delustering, the irregular cross-sectional fiber shape, and fiber crimp. Since these products are almost always staple fibers, their wool-like appearance is maintained. Bulky yarns and bicomponent fibers also contribute to the wool-like appearance and texture.

Durability Acrylics are not as durable as nylon, polyester, or olefin fibers, but in apparel and interior textiles, the strength of acrylics is satisfactory. Dry tenacity is moderate, ranging from 2.0 to 3.0 g/d. Abrasion resistance is also moderate. The breaking elongation is 35 percent. Elongation increases when the fiber is wet. The overall durability of acrylic fibers is moderate, similar to that of wool and cotton.

Interior textiles made from acrylics or acrylic blends are durable. They provide reasonable resistance to abrasion for upholstery fabrics. They are sufficiently strong to withstand laundering, dry cleaning, and dry-extraction cleaning, depending on the product. Pilling can be noticeable with staple fiber fabrics. However, low-pilling fiber modifications are available, and some fabric finishes reduce pilling.