5. Applications of Cellulose Acetate

5.1 Cellulose Acetate in Textile Application

Rachel C. Law

Celanese Acetate, 2300 Archdale Drive, Charlotte, NC 28210, USA
E-mail: Rachel.Law@CelaneseAcetate.com

Summary: The first cellulose acetate fiber, commonly referred to as acetate, was produced in Europe in 1918 and on a large scale in the United States of America in 1924 making acetate the second man-made fiber to be produced.[1] The usage of acetate worldwide peaked at a consumption of approximately 400 kilotons in the early 1970's.[2] In the past three decades the use of acetate fiber has declined as fabric manufacturers moved to lower costs manmade fibers such as polyester. Manufacturers of acetate have worked aggressively to reduce their cost while maintaining product quality. These efforts have had some reward, leading to acetate's categorization as a niche fiber. As such, cellulose acetate represents less than one percent of the world's total fiber consumption as compared to cotton at over a third[3] of the world's consumption and polyester at around a fourth.[4]

Acetate has been used and continues to be used in many different textile applications because of its attributes and good textile processing performance. It is used in woven fabrics, knits and braids. It is found in multiple applications including medical gauze, ribbons, coffin linings, home furnishings, woven velvets, tricot knits, men's linings, circular knits, woven satins, woven fashion, women's linings. It is found in a variety of deniers, lusters, colors, finishes, compactions types and package sizes. It is often blended with other fibers to make combination yarns.

Keywords: biodegradable; blends; extrusion; fibers; processing

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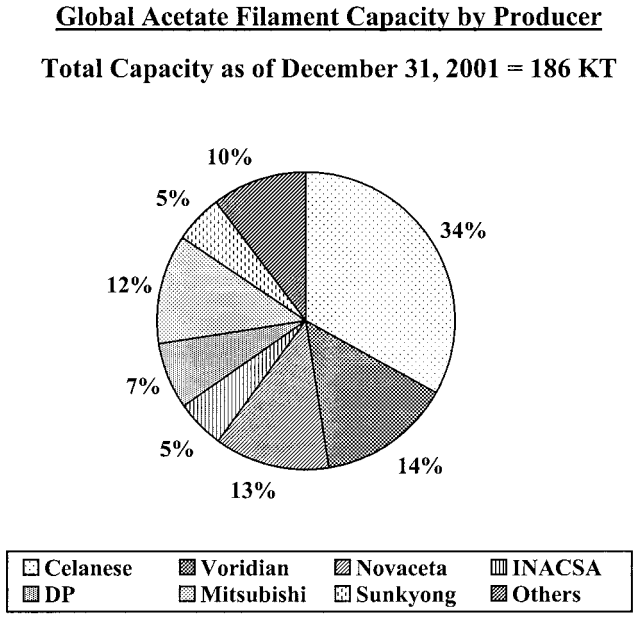
Market Perspective

• World Supply and Demand

Market Perspective

World-wide fiber consumption (2001) was 130.5 billion pounds or 59,000 kilotons (kt). Cotton fiber represents over a third of the world's total fiber consumption and polyester around a fourth of the total.[5] Having reached a high of over 400 kt in the 1970's, consumption of cellulose acetate filament, the second oldest man-made fiber, was 300 million pounds in 2001or 136 kt, less than 1 percent of the total synthetic fiber market.[6] Capacity utilization in 2001 was 73 percent. Market decline is attributed mostly to the availability of other synthetic fibers at substantially lower prices. Acetate is a niche fiber with fiber attributes that have remained desirable even in a declining market. It runs well on most textile equipment and can be easily blended with other fibers.

Figure 1: Acetate Filament Capacity



Source: SRI International – CEH Marketing Research Report, *Cellulose Acetate and Triacetate Fibers;* July 2002

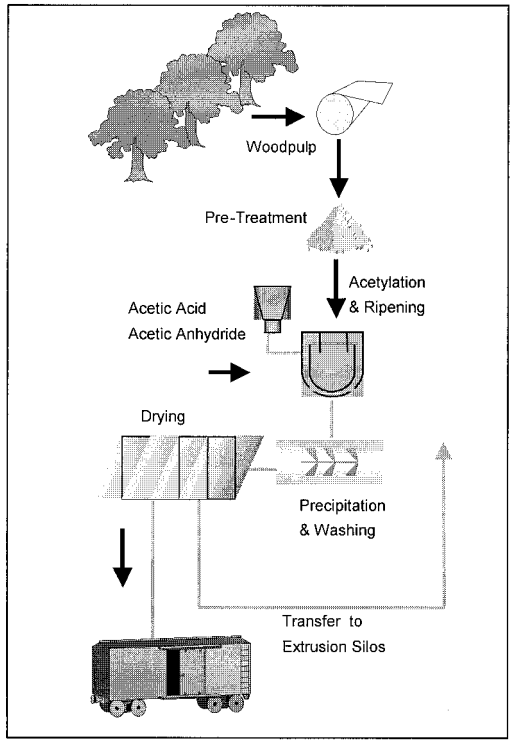
Table 1: Supply and Demand

World Supply Demand for Cellulose Acetate Textile Fibers – 2001 (thousands of metric tons)				
	Annual Capacity	Production	Net Exports	Apparent Consumption
North America				
United States	64	50	19	31
Canada	--	--	-2	2
Mexico	12	12	4	8
South America	6	4	-1	5
Western Europe	38	28	-4	32
Eastern Europe	13	9	6	3
Asia				
China	--	--	-6	6
Japan	33	23	9	14
Other Asia	20	10	-24	34
Rest of the World	0	0	0	0
Total	186	136	0	136

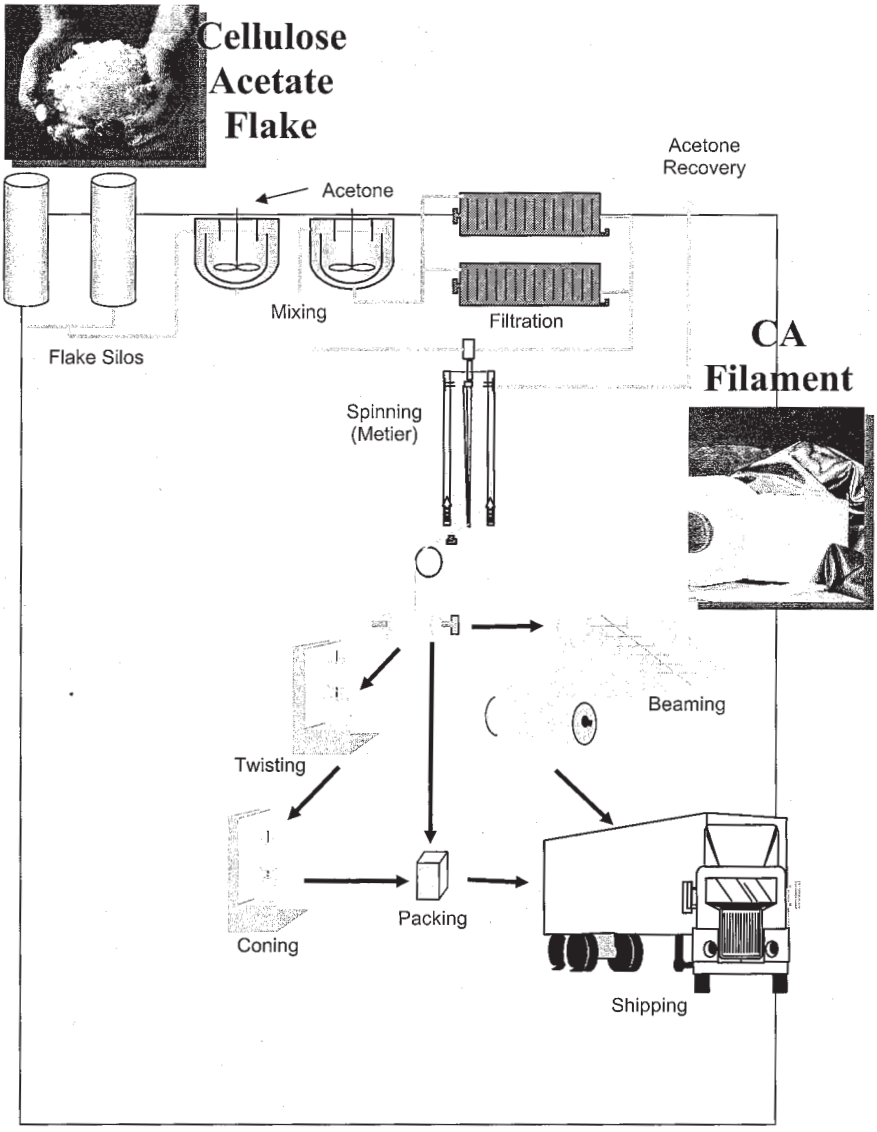
Source: SRI International – CEH Marketing Research Report, *Cellulose Acetate and Triacetate Fibers;* July 2002

Manufacturing of Cellulose Acetate Fibers

General Process Diagram



The Cellulose Acetate Process



- **Spinning Process**

An acetate polymer commonly called acetate flake is dissolved in an acetone and water solution to form a concentrated solution of roughly 20 to 30 percent solids. The viscous solution is referred to as dope. This dope solution is filtered to remove the slightest impurities and extruded through microscopic holes in metal spinnerets. The number of orifices (holes) in a spinneret will vary based on the desired yarn denier. Round holes yield filaments with an approximately round, but crenulated filament.[7] Different hole shapes are used to produce other cross sections and fiber properties. In this dry spinning process a threadline passes through heated cabinets called metiers to remove acetone. The solvent evaporates and a dry filament is formed. Greater than 99 percent of this solvent is recovered and reused. The filament yarns removed from the bottom of the cabinet are lubricated with finish oils. A typical acetate filament yarn contains from 20 to 160 filaments and is wound on to bobbins, cheese packages (packages that look much like a large round of cheese) or other yarn package suitable for textile processing.

Acetate filament is available in two lusters - "bright" or "dull". The bright fiber contains no additional additives; the dull fiber is produced with titanium dioxide as a delusterant. Both bright and dull packages can be transferred onto beams for distribution to customers.

- **Shipping Packages**

Acetate yarns packaged on tubes, cones, or cheese packages with individual weights of 1.3 to 9 kg depending on package type are cartoned or wound onto large beams (113-680 kg) for shipment to customers. Beam yarns are used solely for warp yarns, while other package types are used for warp, filling or circular knits.

- **Other Aspects of Manufacturing**

Yarn that is produced that is not suitable for customer shipments can be redissolved, blended with pure dope solution, and reused to make product. Quality control at all levels of the fiber spinning process minimizes the amount of rework or the amount of product available as sub-quality material.

Attributes

Acetate filament is soft with a silk-like hand. It has a good drape, is comfortable to wear, and absorbs moisture. Its amorphous open-pore structure allows moisture to be transported away from the body, making the wearer feel cooler and more comfortable. It is safe to be used in a variety of applications that touch the skin. Fabric aesthetics are excellent and acetate fabrics have no static cling. Acetate dyes to bright clear colors at low temperatures. It is versatile, blending easily with other fibers such as rayon, silk, nylon, cotton, polyester, etc. This allows for the use of acetate in many different textile applications. Textile processing performance for acetate is good. Made from natural, renewable resources it is environmentally friendly. It can be composted or incinerated, making it ideal for durable goods and disposables.

Table 2: Physical Properties of Filament Yarns[8]

Physical Properties of Filament Yarns

Property	Acetate	Triacetate	Polyester	Nylon 66	Viscose Rayon
Tenacity (g/d)	1.2 to 1.4	1.2 to 1.3	2.8 to 5.6	2.3 to 6.0	1.9 to 2.3
Elongation at Break (%)	25 to 35	25 to 35	24 to 42	25 to 65	20 to 25
Boiling Water Shrinkage (%)	2.0 to +0.5	0.5 to 2.0	5 to 14	6 to 10	1.3
Specific Gravity	1.32	1.3	1.38	1.13 to 1.14	1.48 to 1.54
Moisture Regain (%)	6.5	3.2	0.4	4.0 to 4.5	11
Sticks/Softens (°C)	176 to 190	232	204 to 229	229	148*
Melting Point (° C)	260	300	250	249 to 250	162*
Dye Affinity	Disperse	Disperse	Disperse	Disperse and Acid	Direct and Fiber React
Structure	Amorphous	Crystalline	Crystalline	Crystalline	Amorphous
Heatset	No	Yes	Yes	Yes	No
Effect of Hot Water	Stretches	Shrinks	Shrinks	Shrinks	Shrinks

*Note: Rayon loses strength @ 148oC, and decomposes @ 162oC

Types of Cellulose Acetate Yarns

Numerous variations of acetate yarns are produced. These variations include differences in deniers, number of filaments, luster, colors, finishes, compaction levels, package sizes and types. Denier ranges of 40 to 600 are typical of filament yarns. Fifteen to 600 filament ends will make up a single threadline. Acetate yarn lusters range from bright or natural yarn to dull yarn with titanium dioxide pigment added. Acetate yarns may be produced in a variety of colors, but natural, black and ingrain are the dominant colors produced as acetate is readily dyed. It is also produced with various internal and external finishes, compaction and twisting to enhance yarn processing. Package sizes range from 1.3 kg cheese packages to 680 kg weaving beams.

Properties of Acetate Yarns

Dyeing acetate fabrics

Acetate fabrics are dyed by using jigs, jets and winch machines. Dyeing temperatures range between 85 and 95 degrees centigrade. In blends with polyester and nylon 66 dyeing temperatures can be increased to 110 to 112°C. No dye carriers are needed. After dyeing fabrics are dried and framed on stenter frames at temperature ranging from 120 to 190°C. No strength loss or glazing occurs up to a temperature of 193°C. Disperse dyes are used for dyeing acetate fabrics. Colorfastness is controlled by careful selection of dyes. Acetate dyers use low energy disperse dyes. To obtain dark shades temperature and cycle times are increased. Excessive amounts of dye should not be used and a surface dye is removed in a reduction clear process.

Durability

Acetate fibers resist the effect of microorganisms and insects including attack by molds, mildew, fungi and other microorganisms. The effect of sunlight on strength retention of acetate fibers is similar to rayon and cotton. For fabrics with frequent exposure to sunlight such as window fabrics, dull acetate yarns are recommended to avoid fabric deterioration. As acetate fibers are biodegradable, these fibers lose physical integrity after prolonged exposure to soil and water.

Chemical resistance

Acetate fibers are unaffected by weak acids, but strong acids cause deterioration. Strong alkalis saponify acetate, converting it to regenerated cellulose. Saponification of acetate is prevented by

avoiding temperatures greater than 85°C and solutions with a pH greater than 9.5. This is of importance when scouring of the fibers occurs. Precautions are required with bleaching as well. It is recommended that near neutral peroxide bleaching be used for acetate/cotton blends. Acetate fibers are soluble in acetone, and other low boiling ketones, methylene chloride, and methyl acetate. Some alcohols swell acetate fibers. Percholoroethylene is recommended for dry cleaning acetate fabrics and garments. Acetate is insoluble in petroleum ether, ethyl ether, benzene, gasoline, and toluene.

End Use Applications of Acetate Filament Yarns

Wovens

The properties of cellulose acetate, primarily comfort, drape and dyeability, have led to their largest use in apparel linings[9] for business suits, skirts and pants. Acetate fabrics usually require dry-cleaning which has limited their use in many applications. However, it is found in a very broad range of woven and knit fashion fabrics such as crepes, satins, taffetas, jacquards, jerseys, and raschels, plus twills and taffetas for apparel linings.

Fabrics made from acetate filament yarns are used in a variety of other woven fabrics. Applications include party dresses, ball gowns, bridal wear, home furnishings, window fabrics, bed covers, medical, surgical tape, athletic tape, decorative fabrics, ribbons, artificial flowers, lamp shades, velvets, women's apparel, coffin linings. Acetate is used in fashion fabrics and blends with rayon, nylon, silk, spandex, etc. Some of these blends are washable and comfortable and retain the shape characteristic of the other fibers.

Knits

Warp knits made from acetate filament are used in fashion fabrics, active sportswear, medical bandages and tape, fleece robe wear fabrics, and decorative fabrics such as lace and crochet. Circular knits made from acetate include fashion fabrics such as slinky materials and blends with polyester and nylon.

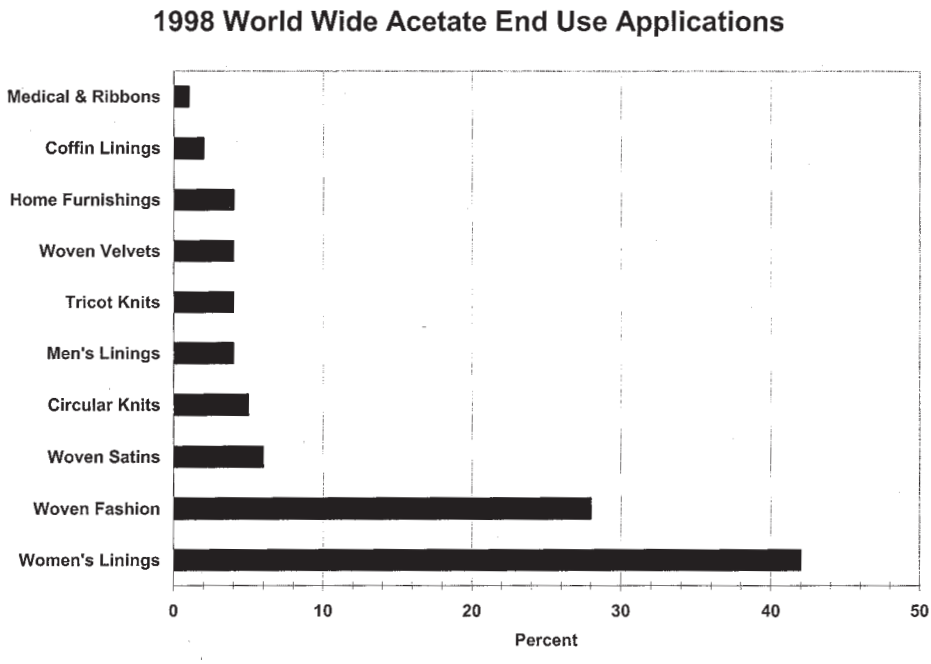
Cut Fiber and Nonwovens

Cut acetate fiber can be used in carded, air laid and wet laid constructions for many applications, such as wound dressings, personal hygiene cover stocks and cores, wipes, and specialty papers. It blends well with other fibers and can be converted into a broad array of structures.

Other

Braid and chainette decorative trims are also made from acetate fabrics.

Figure 2: End Use Applications[10]



Recent New Products

Although acetate filament is a mature product line, development efforts continue on new product applications. Some of the newer developments are as follows. Antimicrobial agents have been incorporated into the fiber to protect fibers from bacteria that cause odor. These yarns provide new opportunities for cellulose acetate fabrics used for sports and underwear.[11] Solution-dyed yarns such as black and ingrain products are used as a styling tool for cross-dye effects and improved color fastness properties. Low total denier and low denier per filament yarns are used to improve aesthetics, drape, and touch. Combination yarns such as acetate/nylon blends are used as a styling tool for cross-dye effects and to improve strength and heat settability.

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