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INDUSTRIAL PROCESS PROFILES FOR ENVIRONMENTAL USE: Chapter 11. The Synthetic Fiber Industry

Industrial Environmental Research Laboratory
Office of Research and Development
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INDUSTRIAL PROCESS PROFILES

FOR ENVIRONMENTAL USE

CHAPTER 11

THE SYNTHETIC FIBER INDUSTRY

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SYNTHETIC FIBER INDUSTRY

INDUSTRY DESCRIPTION

Synthetic fibers are defined as noncellulosic fibers of synthetic origin. The category includes manufactured fibers in which the fiber-forming substance is a long-chain, organic synthetic polymer. Cellulosic fibers such as rayon and acetate and the inorganic fibers such as boron, fiberglass, and graphite are excluded. Synthetic fiber industry activities start with a synthetic, long-chain polymer and terminate with the formation of a marketable filament or threadlike material.

The major raw material for the synthetic fiber industry is bulk polymer obtained from the plastics and resins industry. For descriptive purposes it was assumed that the polymer is received by the synthetic fiber industry in the form of polymer chips. In actuality, however, some processes use molten or dissolved polymer directly from the polymerization vessel.

The processes involved in the manufacture of synthetic fibers are melt spinning, dry-spinning, wet spinning, lubrication, drawing, and fiber modification. A flow diagram has been prepared which illustrates the sequence in which these processes are combined to produce a marketable product.

The synthetic fiber industry employs 97,000 people in 149 plants. Most of the production is from a few large plants with capacities from 50 to 150 Gg per year. $(55-165 \times 10^3$ T$)$ There are many small specialty plants in which products are captively consumed. Capacities of these plants are from 0.5 to 5 Gg per year. Capacities are approximate because equipment may be used to produce more than one product and producers may shift product lines depending on market conditions.

Synthetic fibers comprise about 43 percent of the total fiber production in the United States with 2700 Gg produced in 1975. Of this total more than 99 percent was either acrylic, nylon, olefin, or polyester. Production data for 1975 are summarized in Table 1.

Of the 149 plants in operation on January 1, 1976, 85 are located in the states of North Carolina, South Carolina, Virginia, and Tennessee. Another 44 are located in seven adjoining mid-atlantic and southern states. The remaining 20 are scattered throughout 11 states and Puerto Rico. Table C-2 in the appendix shows the number of plants in each state and the fiber produced. Several of these plants are associated with polymerization processes in the plastics and resins industry or with downstream industries such as the textile or tire producing industries. Table 2 lists the ten largest producers and their major products. These ten companies account for 85 percent of the total production capacity.

Table 1. 1975 PRODUCTION OF SYNTHETIC FIBERS

Fiber	Production, Gg (10^6 lbs)	
Polyester	1360	(2995)
Nylon	843	(1857)
Acrylic	238	(525)
Olefin	226	(497)
Other	5	(11)
TOTAL	2672	(5885)

Source: C & EN's Top 50 Chemical Products and Producers. Chemical and Engineering News, 54(19): 33-39, May 3, 1976.

Production Fell, Often Sharply, Last Year for Almost All Major Chemical Products. Chemical and Engineering News, 54(24): 35, June 7, 1976.

Table 2. TEN LARGEST SYNTHETIC FIBER PRODUCERS

	Major Products			
Producer	Acrylic	Nylon	Olefin	Polyester
Akzona, Inc.		x		x
Allied Chemical Corporation		x		x
American Cyanamid Company	x			x
American Hoechst Corporation				x
Celanese Corporation		x		x
Dow Badische Company	x	x		x
E. I. duPont de Nemours & Co., Inc.	x	x		x
Eastman Kodak Company	x			x
Monsanto Company	x	x		x
Phillips Petroleum Company		x	x	x

Source: Directory of Chemical Producers, 1976.

A decline in production of synthetic fibers started in 1973 and resulted in substantial losses for fiber producers during 1975. Despite increased fiber demand production dropped to only 72 percent of existing capacity because of stocks accumulated by textile companies as a hedge against anticipated shortages and price rises. Price increases in raw materials and utilities also affected producers, and many smaller companies were forced out of business. However, by late 1975 production was almost back to full capacity and the outlook for 1976 is optimistic, especially for polyester. Plant capacities are expected to increase 22 percent to 4200 Gg by 1980, although growth rates of per capita fiber consumption are expected to taper off.

Fiber demand is closely tied to a variety of complex market conditions such as disposable income levels (apparel), housing starts (home furnishings) and automobile sales (tire cord). Thus, the major influences on future fiber growth are population increases and continued replacement of natural and cellulosic fibers. Energy requirements for the synthetic fibers industry for 1971 are summarized in Table 3.

Table 3. FUELS & ELECTRICAL ENERGY CONSUMED BY COMPANIES IN SIC CODE 2824 in 1971

Purchased fuels	
Coal (Gg)	2883
Fuel Oil (Mm^3)	702
Natural Gas (Gm^3)	1160
Purchased Electrical Energy (GWh)	4843
Generated Electrical Energy (GWh)	1528
Total Energy Consumed (TWh equiv.)	43.4

Source: U. S. Bureau of Census. Census of Manufacturers, 1972. Industries Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers. MC72(2)-28B. Washington, D. C., GPO, 1974.

Raw Materials

Relatively pure materials are required in the fibers industry because of the deleterious effect of impurities on the properties of the fiber. The primary raw material used in the synthetic fiber industry is bulk polymer obtained either directly from the polymerization process or indirectly in the form of dried polymer chips. The polymers used and their chemical compositions are summarized in Table A-1 in the appendix. Table 4 gives 1974 industry consumption figures for major raw materials.

Many additives are blended with the polymer before fiber production. Examples are delustrants, pigments, dyeing assistants, dye receptors, optical brighteners, heat stabilizers, antioxidant stabilizers, and light stabilizers. Ordinarily, the total amount of additives does not exceed five percent. Materials added to the fiber to enhance product utility include lubricating agents, bacteriostats, humectants, anti-static agents, and other similar additives. Both organic solvents and aqueous solutions of inorganic salts are used in some processes. Tables A-2 and A-3 in the appendix list some of these raw materials.

The synthetic fiber industry, like the plastics and resins industry, is dependent on basic petrochemicals as feedstocks for production. The major chemical feedstocks used directly to produce polymers for fiber raw materials are benzene, butadiene, ethylene, propylene, and xylene. The shortage of these raw materials has affected fiber producers in a variety of ways. At present, feedstocks seem ample to meet demand.

Table 4. RAW MATERIAL CONSUMPTION FOR PRODUCTION OF SYNTHETIC FIBERS BY COMPANIES IN SIC CODE 2824 in 1971.

Raw Material	Consumption, Gg
Acrylonitrile	290
Acrylates and methacrylates	12
Caprolactam	347
Glycols	518

Source: U. S. Bureau of Census. Census of Manufacturers, 1972. Industries Series: Plastics Materials, Synthetic Rubber, and Man-made Fibers. MC72(2)-28B. Washington, D. C., GPO, 1974.

Products

Synthetic fibers have been grouped into nine classes by the Federal Trade Commission. The accepted generic names for the synthetic fibers produced in the United States are acrylic, modacrylic, nylon, aramid, olefin, polyester, saran, spandex, and vinyon. Definitions of these classes are found in Table 5. Other fibers which are now being produced but have not yet been assigned generic names are fluorocarbon, polycarbonate, and novoloid (phenolic) fibers. Table B-1 in Appendix B gives a complete product list and properties of major products are given in Table B-2.

Fibers are generally marketed as yarn, staple, or tow. Other forms are monofilament, split film, fiberfill, and nonwoven fabrics. The major uses of synthetic fibers are summarized in Table 6. Over 80 percent of the fiber used in home furnishings is for rugs, carpets, and carpet backing. Most of the remainder is used for draperies and upholstery. The major industrial use (70 percent) for synthetic fibers is for automobile tire cord. Other uses of synthetic fibers are automobile seat covers; belting; electrical wire insulation; hose; recreational surfaces (Astroturf); roofing; rope and twine; sewing thread; tents, parachutes, sails, etc.; tarp; and webbing for outdoor furniture.

Table 5. GENERIC NAMES OF SYNTHETIC FIBERS

Generic Name	Definition
*Acrylic	At least 85 percent acrylonitrile by weight
*Modacrylic	35-85 percent acrylonitrile by weight
*Nylon	Polyamide with less than 85 percent of the amide linkages attached to two aromatic rings.
Aramid	Polyamide with at least 85 percent of amide linkages attached to two aromatic rings.
*Olefin	At least 85 percent ethylene, propylene, or other olefin units by weight.
*Polyester	At least 85 percent by weight of an ester of a substituted aromatic carboxylic acid, including but not limited to the ester of a dihydric alcohol and terephthalic acid.
Saran	At least 80 percent vinylidene chloride by weight.
Spandex	At least 85 percent of a segmented polyurethane.
Vinyon	At least 85 percent vinyl chloride

*These classes account for 99 percent of production.

Table 6. END USES OF SYNTHETIC FIBERS, 1973[1] CONSUMPTION (Gg)

	Apparel	Home Furnishings	Industrial & Other	Total
Acrylic and Modacrylic	165	84	5	254
Nylon	192	356	205	753
Olefin[2]	< 1	121	49	170
Polyester	898	234	280	1412
TOTAL	1255	795	539	2589

[1]Includes imports
[2]1972 figures

Sources: Harper, C. A. Handbook of Plastics and Elastomers. N.Y., McGraw-Hill, 1975.

Wallace, P. T. Fibers-Introduction, and Fibers-Synthetic. In: Chemical and Economics Handbook. Menlo Park, California, Stanford Research Inst., August and December 1974, 541.1000A-541 1000K; 543.1000-543.1400E; 543.3521J.

Companies

As of 1 January 1976 there were 61 companies which comprised the synthetic fibers industry. The companies operated 149 plants in 22 states and Puerto Rico. Table 7 lists the 10 largest companies and the production capacity of each along with the combined capacity of the other 51 companies. A complete listing of all plants, by company, is given in Appendix C. Production capacities were not available for some plants which produce low-volume specialty items. As is evident from the company list, many of the fiber producers are also major synthetic polymer producers. Fiber plants are generally not located near polymer plants although the trend in newer plants is toward integration of these two industries.

Table 7. CAPACITY OF TEN LARGEST SYNTHETIC FIBER PRODUCERS

Company	Number of Plants	Capacity (Gg/yr)
E. I. duPont de Nemours & Co., Inc.	16	>1169 (1387)*
Celanese Corporation	5	382
Monsanto Company	9	> 373 (433)*
Eastman Kodak Company	3	195 (308)*
Akzona, Inc.	5	135
Allied Chemical Corporation	4	129 (143)*
American Hoechst Corporation	2	116 (127)*
Dow Badische Company	2	100
Phillips Petroleum Company	3	91
American Cyanamid Company	2	80
All Others	98	506
	149	3276 (3748)*

*Planned increases for 1976

Environmental Impact

Relatively little data were available on the environmental impact of the synthetic fibers industry. It can be assumed that the industry produces all three types of waste (gaseous, solid, and liquid) in varying degrees. Aqueous emissions appear to represent the largest potential source of pollution.

In general, the polymer raw materials are not toxic or otherwise hazardous unless heated to temperatures at which decomposition can occur. Emissions from the fiber industry usually arise from mechanical treatment of the polymer or are associated with solvents, additives, lubricants, or finishes used in processing. Companies which use integrated polymerization spinning systems produce waste which contains unreacted monomer.

The major sources of gaseous emissions are from cooling chambers, conditioning chambers, solvent removal chambers, and from solvent make-up. The use of hot solvents in several processes results in the entrainment of solvent by the fibers. Solvent may be subsequently emitted as vapor during processes such as drawing or heat-setting.

Particulate emissions of the solid polymer are possible from most of the processes but primarily from the cutting, winding, crimping, and baling process steps. Other solid wastes result from disposal of sub-standard material, filter solids, and water treatment sludge. Some four percent of fiber produced is of sub-standard quality. This waste fiber may be buried, incinerated, reprocessed, or sold depending on supply and demand.

Liquid emissions generally are termed "spin-finish wastes." Included in this category are water used for purging the spinning baths and washing the filaments, lubricants used in finish applications, and solvent wastes from dry and wet spinning. Other liquid effluents arise from wash water in filtration steps, solvent spills, and drawing baths. Periodic cleaning of process equipment also contributes significantly to the total wastewater load. Sanitary wastes resulting from the large number of people employed at fiber plants are a significant portion of the total effluent load. Cooling water blowdown also contributes to the liquid effluent from melt spinning.

Wastewater emissions from some operations have been classified according to waste load and treatability. This information is summarized in Table 8. Analysis of samples from a settling pond at an acrylic fibers production facility indicated the presence of acrylonitrile (100 mg/ℓ), 2,3-dibromo-1-propanol (0.5 mgl/ℓ), an isomer of dibromopropene, and 2,4-dimethyldiphenylsulfone.

Table 8. SUMMARY OF WASTEWATER DATA FOR SELECTED FIBERS

Fiber	Wastewater Loading (m^3/kkg)	Raw Waste Loads (kg/kkg) BOD_5	COD	SS
Nylon	1.3-30.9	0.1-60	0.2-90	0.1-6
Olefin[1]	8.3-14.2	0.4-1.1	1.8-2.6	0.2-2.2
Spandex	-	20[2]	40[2]	-

[1]polypropylene
[2]estimated

EPA Source Classification Codes for the synthetic fibers industry are summarized in Table 9.

Table 9. SOURCE CLASSIFICATION CODES FOR SYNTHETIC FIBERS

Operation	Code
Nylon General	3-01-024-01
Dacron General	3-01-024-01
Orlon	3-01-024-03
Elastic	3-01-024-04
Teflon	3-01-024-05
Polyester	3-01-024-06
Nomex	3-01-024-08
Acrylic	3-01-024-12
Tynex	3-01-024-12
Olefins	3-01-024-14
Others	3-01-024-99

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INDUSTRY ANALYSIS

Data for the analysis of the fiber industry are presented in six process modules. There are three processes describing filament formation and three which describe fiber treatment. Variations on these processes occur both in order of processing and in operating conditions. The processes are presented graphically in Figure 1. They have been numbered consecutively from 1 to 6. The numbers assigned to the modules on the flow sheet correspond to process description numbers.

Some data were available on operating parameters for the spinning and drawing processes, but not for all fibers. Waste stream data were available mainly in the form of general comments about the production of a particular fiber. Data on utilities were unavailable. The data given should be viewed as being generally representative of industry and not descriptive of the variation in waste management practices from company to company.

Synthetic Fiber Processing

Synthetic fibers are formed by three different processes: melt spinning (Process No. 1), wet spinning (Process No. 2), and dry spinning (Process No. 3). The choice of method depends primarily on several simple polymer characteristics such as melting point, melt stability, and solubility in organic solvents. The spinning processes accomplish the extrusion of the polymer in liquid form through fine orifices called spinnerets. The processes differ in the manner in which the polymer is liquefied, which in turn determines the manner in which the extruded filaments are solidified.

Melt spinning uses heat to melt the polymer and then uses cool air to solidify the extruded liquid stream. In dry spinning, solidification of the fiber occurs by evaporation of the solvent used to dissolve and extrude the polymer. In wet spinning, the liquid polymer is spun (extruded) into a liquid coagulating bath. The essential feature of this process is the mass transfer of the organic solvent or inorganic salt solution from the polymer to the coagulating bath. The fiber thus formed can be wound on a bobbin at either constant speed or constant tension to give "continuous filament yarn" or it can be cut into small pieces called "staple" which may be processed into bundles called "tow."

The yarn, staple, or tow must be lubricated (Process No. 4) to reduce the friction encountered in the processing machinery and to reduce the static electric charge on the fiber. The lubricated fiber is then drawn (Process No. 5) to give orientation and increase strength and modified (Process No. 6) by a variety of process steps to give a finished product.

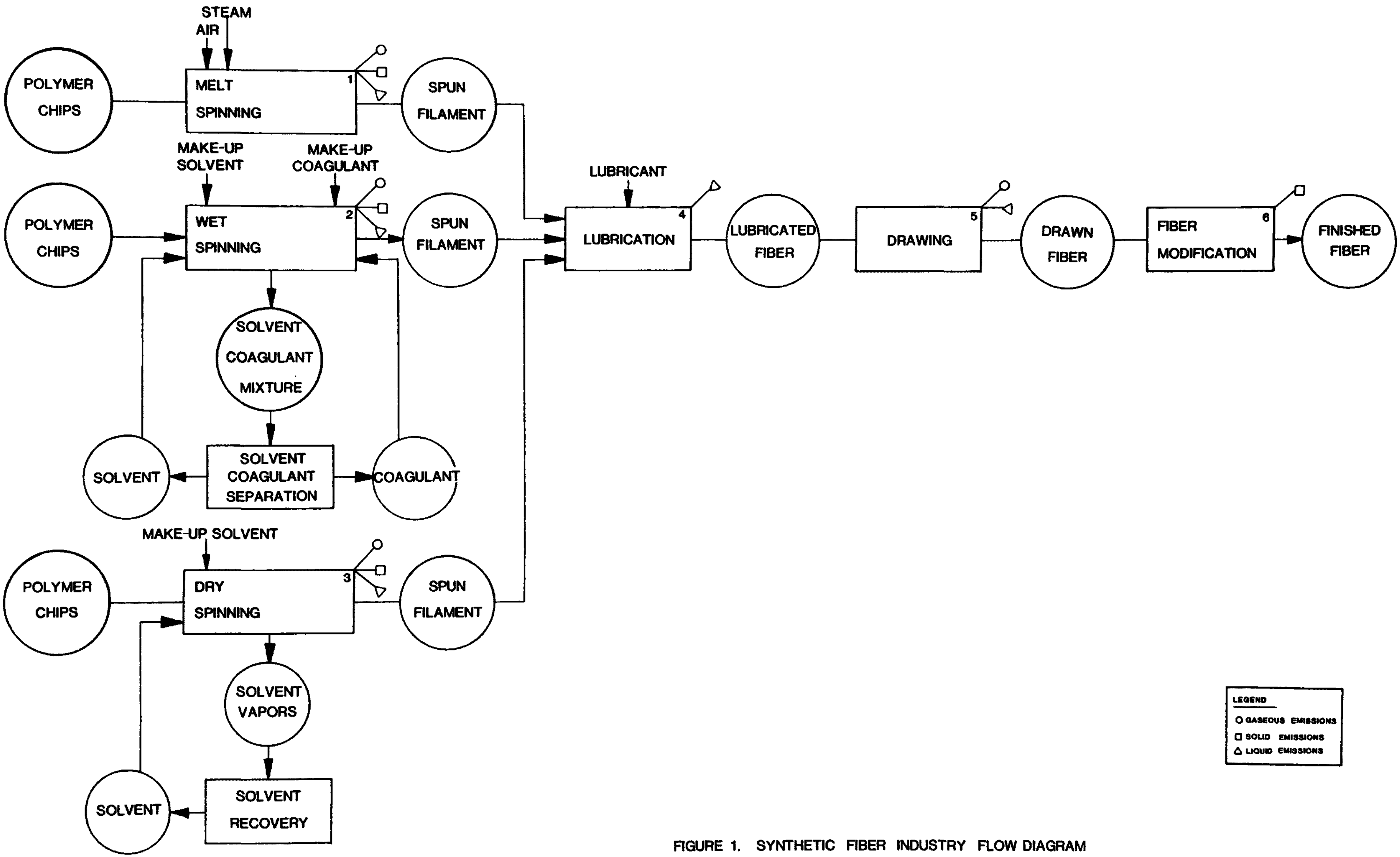

FIGURE 1. SYNTHETIC FIBER INDUSTRY FLOW DIAGRAM

Melt Spinning

1. Function - Melt spinning is used to convert polymer chips into synthetic fibers called filaments. This process is used for polymers which can be melted under reasonable conditions without degradation of the polymer and thus is used mainly for the production of nylon, polyester, olefin, and saran filaments.

The polymer chips can be melted in a variety of ways. The trend is towards extrusion of the polymer chips in an electrically heated screw extruder. The molten polymer is processed in a nitrogen atmosphere and metered through an accurately machined gear pump to a filter assembly consisting of either a series of metal gauzes or layers of graded sand. The filtered molten polymer is then extruded at a constant rate, under high pressure, through a nickel or stainless steel spinneret. The extruded liquid polymer streams are cooled using an air stream and the solid filaments thus formed converge at a guide to give a "spun yarn." For fibers such as nylon 66 the filaments pass through a steam conditioning tube before converging.

After the fiber is converged it is given further treatments which are dictated by the end use. These treatments probably include drawing and lubrication. Crimping, heat-setting, winding, cutting, or twisting may also be done.

2. Input Materials - The polymers treated in melt spinning and their chemical composition are summarized in Table 10.

Table 10. INPUT POLYMERS FOR MELT SPINNING

Fiber	Generic Type	Input Polymer
Nylon 66	Nylon	Poly(hexamethylene adipamide)
Nylon 6	Nylon	Polycaprolactam
Nylon 610	Nylon	Poly(hexamethylene sebacamide)
Dacron	Polyester	Poly(ethylene terephthalate)
Kodel	Polyester	Poly(1,4 dimethyl dicyclohexyl terephthalate)
Polypropylene	Olefin	Polypropylene
Polyethylene	Olefin	Polyethylene
Saran	Saran	Poly(vinylidene chloride)

The input polymer may contain other copolymers, dyes, or additives as listed in Table A-2 in the appendix. Other input materials in the process include air, nitrogen and steam.

3. Operating Parameters - Operating parameters for the melt spin processing of major fibers are given in Table 11.

Table 11. TYPICAL MELT SPINNING OPERATING PARAMETERS

Fiber	Spin Temperature (°C)	Pressure (MPa)	Spinneret Hole Diam. (μm)	Spin Speed (m/min)
Nylon	270-290	-	200-300	600-1200
Polyester	280-300	7-35	-	500-1000
Olefin	250-360	-	>100	-
Saran	175	-	-	-

4. Utility Requirements - Quantitative data were not found in the sources consulted for this study.

5. Waste Streams - Gaseous emissions resulting from the use of air to solidify the filament and steam to condition nylon could contain unreacted monomer or other volatile hydrocarbon species. Solid wastes resulting from filtering the molten polymer are disposed of by landfill. Water used for rinsing the spinneret and other process equipment contributes to the spin-finish wastes which have high BOD and oil and grease contents. Large quantities of water are used for cooling and air conditioning. Liquid effluents arise from cooling tower blowdown.

6. EPA Source Classification Code - See industry description.

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Wet Spinning

1. Function - Wet spinning is also used to produce filaments from polymer chips. This process is used for polymers which can be dissolved in solvents. Wet spinning requires slower spinning speeds than either melt or dry spinning. This production method is usually reserved for the manufacture of heavy tow, which also requires slow speeds for downstream processing steps. This method is used primarily to produce acrylic, modacrylic and spandex tow.

Equipment required for wet spinning includes a solution vessel, a metering pump, a filter, a spinneret, and a coagulant tank. Products which require "aging" of the polymer solution before spinning employ a holding tank and all processes include a recovery system to separate the coagulant and solvent.

As in melt spinning, the extruded filaments are further processed in a variety of ways depending on end use. Wet spinning requires a washing step immediately after extrusion to remove solvent and other impurities. This washing step can occur either continuously or by a batch method.

2. Input Materials - The main input materials include polymer, solvent, and coagulant. Some examples are summarized in Table 12. Although water is generally used to clean the fibers, aqueous ammonia is sometimes used for filaments spun from inorganic salt solutions.

Table 12. INPUT MATERIALS FOR WET-SPINNING

Fiber	Polymer	Solvent	Coagulant
Acrylic	Polyacrylonitrile	Dimethylacetamide (DMAc)	Aqueous DMAc
		Aqueous $ZnCl_2$	Aqueous $ZnCl_2$
		Aqueous NaSCN	Aqueous NaSCN
Modacrylic	Polyacrylonitrile-poly(vinyl chloride) copolymer	Acetonitrile	Aqueous Acetonitrile
		Acetone	Water
Spandex	Polyurethane	Dimethylformamide (DMF)	Water

3. Operating Parameters - The important variables affecting fiber properties are concentration and temperature of the polymer solution (dope) and spin-bath composition, concentration, and temperature. The values for these variables differ from fiber to fiber and solvent to solvent but should be within the range given below.

Spinneret:	1,000 to 12,000 holes, 50 to 100 μm diameter. May be made of platinum or tantalum if corrosive liquids are used.
Coagulate Bath Temperature:	-15 to 10°C
Concentration of Polymer:	10 to 30 %
Wind-Up Speed:	15 to 60 m/min
Spinning Speeds:	50 to 100 m/min
Spin Temperature:	0 to 200°C

Specific operating parameters for wet-spinning of some acrylic fibers are summarized in Table 13.

Table 13. OPERATING SUMMARY OF PARAMETERS FOR PRODUCTION OF ACRYLIC FIBERS BY WET SPINNING

Fiber	Producer	Solvent Composition	Polymer Concentration (wt. %)	Coagulent Bath Temp. (°C)	Coagulent Bath Composition (wt %)
Acrilan-16	Monsanto	DMAc	25	20 to 32	45-65% DMAc
Acrilan-1656	Monsanto	DMAc	19	20	66% DMAc
Creslan 61	American Cyanamid	45-50% NaSCN	10 to 13	-5 to +5	10% NaSCN
Creslan 58	American Cyanamid	45-50% NaSCN	10 to 13	-5 to +5	10% NaSCN
Zefran	Dow Badische	60% $ZnCl_2$	10	10 to 25	43-47% $ZnCl_2$
Zefran	Dow Badische	60% $ZnCl_2$	10	15 to 30	32-39% $ZnCl_2$
Zefran	Dow Badische	54-60% $ZnCl_2$	10	15 to 30	32-39% $ZnCl_2$

4. Utilities - No data were found in the sources consulted for this study.

5. Waste Streams - Gaseous emissions may result from solvent evaporation. Solid wastes resulting from filtration of the polymer solution and from the solvent recovery unit may be incinerated or sent to landfill. Sub-standard fiber, often termed spinning waste, is also either incinerated or sent to landfill. Gaseous emissions are produced from polymer incineration. Liquid effluents are produced from cooling water discharge and blowdown and a once

through cooling system with discharge to a storm sewer is employed at one plant. Regeneration wastes are generated by the deionizing unit used to provide spin bath make-up water. The spin-finish waste includes water used to clean the fibers and rinse water used to clean out various pieces of equipment.

A wet spinning process variation termed reaction or chemical spinning is employed by one company to produce spandex fiber. Effluent from fiber washing is a mixture of water, toluene, and ethylene/diamine. Toluene and water are separated in a continuous decanter. The waste water has a faint odor of toluene and is discharged to a municipal sewage system. The toluene is purified by distillation. Still bottoms are drummed and sent to landfill. Nitriles (acrylic fiber), cyanides (spandex fiber), vinyl chloride (modacrylic fiber), or thiocyanates could be present in waste waters from other processes. Wastes from the solvent purification and recycle process contains inorganic salts or organic solvents which contribute significantly to the total waste load.

6. EPA Source Classification Code - See Industry Description.

7. References -

(1) Billmeyer, F. W., Jr. Fiber Technology. In: Textbook of Polymer Science. N.Y., Interscience Publishers, 1962.

(2) Chaney, David W. Acrylic and Modacrylic Fibers. In: Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Ed., Vol. I. Anthony Standen, ed. N.Y., Wiley, 1968, p. 313-338.

(3) Davis, C. W. and Paul Shapiro. Acrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 1. H. F. Mark, ed. N.Y., Wiley, 1964, p. 342-73.

(4) Environmental Protection Agency, Effluent Guidelines Division. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Synthetic Polymers Segment of the Plastics and Synthetic Materials Manufacturing Point Source Category. EPA 440/1-75/036-b. Washington, D. C., Jan. 1975.

(5) Kennedy, R. K. Modacrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 812-39.

(6) McIntyre, J. E. Man-Made Fibers, Manufacture. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 374-404.

(7) Wallace, P. T. Acrylic and Modacrylic Fibers. In: Chemical Economics Handbook. Menlo Park, California, Stanford Research Institute, October 1975.

(8) Work, R. W. Man-Made Textile Fibers. In: Reigel's Handbook of Industrial Chemistry, 7th Ed. J. A. Kent, ed. N.Y., Van Nostrand Reinhold, 1974, p. 323-330.

Dry Spinning

1. Function - Dry spinning is the third process used for converting polymer chips into filaments. A polymer solution is extruded into a zone of heated gas or vapor. The volatile solvent readily evaporates, leaving a solidified filament which is then further processed. This process is used for easily dissolved polymers such as acrylonitrile, poly(vinyl chloride), or polyurethane. Dry spinning is generally used to make continuous filament yarn because of the higher spinning speeds possible.

The equipment used for dry spinning is the same as that used for wet spinning up to the spinneret. After leaving the spinneret the solution passes through a spinning cell which consists of a cabinet about 25 feet long. Hot, solvent-lean gas or vapor enters at one end and solvent-rich gas or vapor emerges from the other.

The solidified filament is further treated by the processes listed in melt spinning. An efficient solvent recovery system is required.

2. Input Materials - The two major input materials, polymer and solvent, are summarized in Table 14 for the various fibers.

Table 14. INPUT MATERIALS FOR DRY SPINNING

Fiber	Polymer	Solvent
Acrylic	Polyacrylonitrile	DMF, DMAc tetramethylene sulfone
Modacrylic	Polyacrylonitrile/ poly(vinyl chloride)	acetone
Spandex	polyurethane	DMF, DMAc

The gas used to evaporate the solvent may be air, inert gas (nitrogen or carbon dioxide), superheated steam, or superheated solvent vapor.

3. Operating Parameters - The major operating parameters are summarized below:

Spinneret:	25 to 200 μm diameter holes
Gas temperature:	80 to 130°C for low boiling solvents 200 to 400°C for higher boiling solvents (DMF, DMAc) The cell walls may be heated to 500°C
Polymer concentration:	10 to 30%
Yarn wind-up speed:	500 to 1200 m/min

4. Utilities - No data were found in the sources consulted for this study.

5. Waste Streams - Gaseous emissions probably include solvent vapors. Filtration of the polymer solution (dope) feed to spinning produces solid wastes which are either incinerated or sent to landfill.

Liquid effluents include waste solution from the solution preparation step, waste from solvent purification and cooling water discharge. The waste stream from the solution preparation step is incinerated, while the waste from solvent purification and equipment washing is sent to biological treatment. Waste polymer and unrecovered solvent are termed "spinning wastes" and are either incinerated or added to the spin-finish waste stream.

6. EPA Source Classification Code - See Industry Description

7. References -

(1) Billmeyer, F. W., Jr. Fiber Technology. In: Textbook of Polymer Science. N.Y., Interscience Publishers, 1962.

(2) Chaney, David W. Acrylic and Modacrylic Fibers. In: Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Ed., Vol. I. Anthony Standen, ed. N.Y., Wiley, 1968, p. 313-338.

(3) Davis, C. W. and Paul Shapiro. Acrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 1. H. F. Mark, ed. N.Y., Wiley, 1964, p. 342-73.

(4) Environmental Protection Agency, Effluent Guidelines Division. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Synthetic Polymers Segment of the Plastics and Synthetic Materials Manufacturing Point Source Category. EPA 440/1-75/036-b. Washington, D. C., Jan. 1975.

(5) Environmental Protection Agency, (Office of Air and Water Program, Effluent Guidelines Div.). Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Synthetic Resins Segment of the Plastics and Synthetic Materials Manufacturing Point Source Category. EPA 440/1-74-010-a. Washington, D. C. 1974.

(6) Kennedy, R. K. Modacrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 812-39.

(7) McIntyre, J. E. Man-Made Fibers, Manufacture. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 374-404.

(8) Wallace, P. T. Acrylic and Modacrylic Fibers. In: Chemical Economics Handbook. Menlo Park, California, Stanford Research Institute, October 1975, 543.3522G.

(9) Work, R. W. Man-Made Textile Fibers. In: Reigel's Handbook of Industrial Chemistry, 7th Ed. J. A. Kent, ed. N.Y., Van Nostrand Reinhold, 1974, p. 323-330.

Lubrication

1. Function - The three main functions of lubrication (spin finishing) are surface lubrication, plasticizing action and static protection. The application of a lubricant immediately after filament formation improves subsequent handling and processing.

For melt spun and dry spun yarns, the lubricant is applied before winding on a spin bobbin. In staple finishing the lubricant may be applied by passing through a bath or by spraying. For wet spun fibers the lubricant is usually added after the cleaning step.

Most applications occur at the spinning stage. The lubricant is contacted with the filament immediately after spinning by means of a ceramic wheel. An aqueous solution or emulsion of the lubricant is pumped to a holding or storage tank. From this tank, the lubricant is circulated into feeding trays where it contacts the ceramic applicator.

2. Input Materials - The input materials to the process are the spun filament from Process 1, 2, or 3, the antistatic lubricant, and water. Typical antistatic lubricants are polyoxyethylene attached to aliphatic hydrocarbon chains, long-chain alkyl quarternary ammonium salts, hydroxyalkylamine salts of long-chain fatty acids, high-boiling aliphatic esters, hydrocarbon oils, and fluid silicones. The lubricant is applied as a solution or emulsion in water.

3. Operating Parameters - Both the composition of the lubricant and the amount applied to the fiber depend on the chemical composition of the fiber and on the end use. The application is made at ambient pressure and temperature. The application speed is the same as the yarn wind-up speed.

4. Utilities - No data were found in the sources consulted for this study.

5. Waste Streams - Spent lubricant is the major contributor to spin-finish waste streams. Occasional cleaning of spin finish tanks also adds to the total plant waste load in the form of oil and grease. At one plant these waste streams are sent to municipal sewage treatment plants. In-plant biological treatment is employed at another plant.

6. EPA Source Classification Code - See Industry Description

7. References -

(1) Billmeyer, F. W., Jr. Textbook of Polymer Science, 2nd Ed. N.Y., Wiley, 1971.

(2) Environmental Protection Agency, Effluent Guidelines Division. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Synthetic Polymers Segment of the Plastics and Synthetic Materials Manufacturing Point Source Category. EPA 440/1-75/036-b. Washington, D. C., Jan. 1975.

(3) Environmental Protection Agency, (Office of Air and Water Programs, Effluent Guidelines Div.). Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Synthetic Resins Segment of the Plastics and Synthetic Materials Manufacturing Point Source Category. EPA 440/1-74-010-a. Washington, D. C., 1974.

(4) McIntyre, J. E. Man-Made Fibers, Manufacture. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 374-404.

Drawing

1. Function - The function of drawing (stretching) is to introduce molecular orientation to the spun fiber and thus produce a stronger fiber. An optimum draw ratio exists for each type of fiber as shown in Table 15. Yarns and tows are drawn by stretching between two rolls, one to feed the undrawn yarn and the other, moving at a faster velocity, to collect the drawn yarn. The ratio of the surface speeds of the feed and draw rolls is defined as the draw ratio.

Many fibers are drawn as an integral part of the spinning process. In other cases it is preferable to store the fibers or carry out some other operation first. The drawing process may be aided by heating the fiber either through direct metal-to-fiber contact or by passing the fiber through a bath containing a heated plasticizing liquid or other solution. In these cases drawing may be combined with other processes such as cleaning or lubrication. The drawn fiber may be wound, cut into tow, or modified by further treatment depending on end use.

2. Input Materials - The input material is the lubricated fiber or tow from Process 4. Superheated steam, hot water, or hot inert liquids may be used depending on drawing arrangement.

3. Operating Parameters - The operating parameters are summarized in Table 15.

Table 15. OPERATING PARAMETERS FOR SYNTHETIC FIBER DRAWING

Fiber	Draw Ratio	Draw Temperature (°C)	Percent Elongation
Modacrylic	-	-	400 to 1400
Acrylic	-	70 to 110	300 to 1000
Polyester	3 to 6	75 to 100	400
Nylon	3 to 6	15	250 to 600
Polypropylene	5 to 8	100 to 120	-
Polyethylene	4 to 10	-	-

Yarn and tow are drawn at different speeds. Drawing speeds vary from 100 to 1500 m/min.

4. Utilities - No data were found in the sources consulted for this study.

5. Waste Streams - Possible emissions from drawing include vapors of solvents entrained in the fiber or waste liquids used in drawing baths.

6. EPA Source Classification Code - See Industry Description

7. References -

(1) Billmeyer, F. W., Jr. Textbook of Polymer Science, 2nd Ed. N.Y., Wiley, 1971.

(2) Davis, C. W. and Paul Shapiro. Acrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 1. H. F. Mark, ed. N.Y., Wiley, 1964, p. 342-73.

(3) Erlich, Victor L. Olefin Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 9. H. F. Mark, ed. N.Y., Wiley, 1968, p. 403-40.

(4) Farrow, G. and E. S. Hill. Polyester Fibers. In: Kirk-Othmer Encyclopedia of Chemical Technology, 2nd Ed., Vol 16. Anthony Standen, ed. N.Y., Wiley, 1968, p. 143-58.

(5) Kennedy, R. K. Modacrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 812-39.

(6) Mark, H. F., S. M. Atlas and E. Cernia, eds. Man-Made Fibers, Science and Technology, Vol 2. N.Y., Wiley Interscience, 1968.

(7) Snider, O. E. and J. Richardson. Polyamide Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 10. H. F. Mark, ed. N.Y., Wiley, 1969, p. 347-460.

Fiber Modifications

1. Function - The function of these process steps is to modify the fiber into a marketable product. Modifications include twisting to produce interfilament cohesion, heat setting or heat relaxation to produce dimensional stability, crimping to add bulk and resilience, and cutting to produce staple products similar to natural fibers. Other processing steps such as dyeing; sizing; treating with water-repellant, fire-retardant, or other finishes; or blending different fibers may be done by the fiber manufacturer but are usually performed after manufacture and sale of the fiber.

The procedure used by a particular plant to transform the drawn fiber into a marketable product depends on the end use. The following processing steps are those used most often.

False-twist Texturing: This method of adding twist to yarns has replaced many of the other twisting procedures because of the high speed (300,000 to 700,000 rpm) of operation. In this procedure the yarn is heated close to the melting point, twisted to 28 to 40 turns per centimeter and then cooled and unwound.

Heat Treating: Heat treating procedures are carried out by passing the fiber through an oven or over a heated roll. If the fiber is under tension, the procedure is called heat setting; if the procedure is carried out under little or no tension it is called heat relaxation. Heat setting procedures are often combined with texturizing process steps in order to "set" the crimp or twist.

Crimping: Staple or yarn is crimped by mechanically distorting the fiber. Crimping may be done at various stages during fiber production but is usually done during or immediately after the drawing process. Crimping procedures include gear crimping, edge crimping, and stuffer-box crimping.

Gear crimping is accomplished by passing the yarn through a pair of meshed gears. The permanency of the crimp depends on the yarn temperature during crimping and the setting temperature thereafter. In edge crimping the yarn is passed over a blunt knife edge. The distortions and strains which develop are retained by passing the yarn over a cooling roll. Stuffer-tube crimping of yarn or stuffer-box crimping of tow are accomplished by forcing the yarn into an electrically-heated, thermostatically controlled tube or box. The yarn pushes up on a weighted insert which is free to rise and fall in the vessel. The crimped yarn is pulled from the tube at constant speed. The temperature of the oven and the yarn residence time control the amount of crimp.

Cutting: Continuous filament or tow is chopped into staple using cutting machines. The fiber can be cut by rotating knives as it advances on rollers or it can be advanced by centrifugal force and cut by stationary knives as it advances.

2. Input Materials - Synthetic filament or tow is the only input material to this process.

3. Operating Parameters - Roller speeds approximate the speeds used in spinning and drawing. Heat setting temperatures are generally close to the melting point of the fiber.

4. Utilities - No data were found in the sources consulted for this study.

5. Waste Streams - Emissions from fiber modification processes are primarily particulate wastes resulting from physical manipulation of the fiber. Heat treatment of fibers could release gaseous emissions of entrained solvent.

6. EPA Source Classification Code - See Industry Description

7. References -

(1) Kennedy, R. K. Modacrylic Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 812-39.

(2) Mark, H. F., S. M. Atlas and E. Cernia, eds. Man-Made Fibers, Science and Technology, Vol 1. N.Y., Wiley Interscience, 1967.

(3) McIntyre, J. E. Man-Made Fibers, Manufacture. In: Encyclopedia of Polymer Science and Technology, Vol 8. H. F. Mark, ed. N.Y., Wiley, 1968, p. 374-404.

(4) Snider, O. E. and J. Richardson. Polyamide Fibers. In: Encyclopedia of Polymer Science and Technology, Vol 10. H. F. Mark, ed. N.Y., Wiley, 1969, p. 347-460.

APPENDIX A

RAW MATERIALS LISTS

Table A-1. FIBER RAW MATERIALS

Generic Name and Trade Name	Polymer Raw Materials
Acrylic	acrylonitrile with 7 to 8% neutral acrylate comonomers
Aramid[1]	
Nomex	m-phenylene diamine and isophthaloyl chloride
Fiber B (Kevlar)	p-phenylene diamine and terephthaloyl chloride
Qiana	trans, trans-bis-(4 aminocyclohexyl)-methane and dodecanoic acid
Tajmir	2-pyrrolidone
Fluorocarbon	tetra fluoroethylene and fluorinated ethylene-propylene copolymers
Modacrylic	acrylonitrile and vinyl chloride or other comonomers
Nylon	
Nylon 6[2]	hexamethylenediamine and adipic acid
Nylon 66[2]	caprolactam
Nylon 610	hexamethylenediamine and sebacic acid
Nylon 612	hexamethylene diamine and dodecanoic acid
Olefin	ethylene, propylene, or other olefin
Polyester	
Dacron/Fortrel	dimethyl terephthalate or terephthalic acid and ethylene glycol
Kodel	dimethylterephthalate and 1, 4 cyclo hexylene diglycol
Saran[1]	vinylidene chloride and vinyl chloride
Spandex[1]	diisocyanates, polyester, polyester glycols diamines
Vinyon[1]	vinyl chloride and vinyl acetate

[1]These fibers represent less than 2% of total fiber production
[2]Nylon 6 and 66 represent 99% of nylon production

Sources: Wallace, P. T. Fibers - Introduction, and Fibers - Synthetic. In: Chemical and Economic Handbook. Menlo Park, California. Stanford Research Inst., August and December 1974, 541.1000A-541.1000K; 543.1000-543.1400E; 543.3521J.

Table A-2. TYPICAL ADDITIVES USED IN FIBER PRODUCTION

Delustrants -	Usually titanium dioxide
Optical Brighteners -	Stiblene Phenyl coumarin derivatives
Antioxidant Stabilizers -	Alkylated phenols p-cresols mixed with sulfides Thio compounds such as dilauryl or distearyl thio dipropionate
Light Stabilizers -	Long-chain alkyl derivatives of hydroxy benzophenones
Dyeing assistants -	2-methyl-5-vinyl pyridine 2-vinyl pyridine p-vinyl-benzene sulfonic acid Sulphocinamic acid
Lucricants and Other Finishes -	Polyoxyethylene attached to aliphatic hydrocarbon chains Long-chain alkyl quartenary ammonium salts Hydroxyalkyl amine salts of fatty acids Aliphatic esters Hydrocarbons Fluid silicones

Table A-3. SOLVENTS USED IN FIBER PRODUCTION

Dimethyl acetamide
Dimethylformamide
Acetonitrile
Acetone
Aqueous $ZnCl_2$
Aqueous NaSCN
Tetramethylene sulfone

APPENDIX B

PRODUCTS

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
A-Acrilan	acrylic	Monsanto	FST	AHI
Acrilan	acrylic	Monsanto	F (solution dyed)	AH
Acrilan Plus	acrylic	Monsanto	S	H
Acrilan 2000+	acrylic	Monsanto	F (solution dyed)	H
Actionwear	nylon	Monsanto	F (producer-textured)	A
Amco Polyethylene	olefin	American Mfg.	M (incl. slit film)	I
Amco Polypropylene	olefin	American Mfg.	M (incl. slit film)	I
American Polyethylene	olefin	American Mfg.	M (incl. slit film)	I
American Polypropylene	olefin	American Mfg.	M (inc. slit film)	I
Anso	nylon	Allied Chemical	F, S	H
Anso-X	nylon	Allied Chemical	F, S	H
Antron	nylon	DuPont	FST	AH
AstroTurf	nylon	Monsanto	Ribbon	I
Autowine	olefin	Indian Head	Slit Processed high modulus	R
Avlin (fiber 200)	polyester	FMC	FS	AH
Beaunit Nylon	nylon	El Paso Natural Gas	F (multibobal), S	HITC
Beaunit Polyester	polyester	El Paso Natural Gas	FST	TCA
Bi-Loft	acrylic	Monsanto	S (bi-component) T	A
Blue "C"	nylon, polyester	Monsanto	FS	AHI, TC
Cadon, C-Cadon	nylon	Monsanto	F (multilobal) S	H
Camalon	nylon	Camac Corp.	F	AH
Cantrece	nylon	DuPont	FM (bi-component)	A
Caprolan	nylon, polyester	Allied Chemical	FMS	AHITC
Celanese Nylon	nylon	Celanese	F	AHITC
Chadolene	olefin	Diversified Ind.	F (fibrillated)	HIS
Chadolon	nylon	Chadbourn Ind.	FM	A
Cordura	nylon	DuPont	F	LI
Courtaulds Nylon	nylon	Courtaulds	F	A
Crepeset	nylon	Akzona	M (inherent crepe effect built in during manufacture)	A
Crepeset Anti-Cling	nylon	Akzona	M (inherent crepe and anti-cling properties built in during manufacture	A
Creslan	acrylic	American Cyanamid	ST	AHI
C-Cumuloft	nylon	Monsanto	F (textured)	H
Cumuloft	nylon	Monsanto	F (textured)	H

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY (CONTINUED)

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
Dacron	polyester	DuPont	FST	AHITC
DLP 17 Polyethylene	olefin	Thiokol	M (round shrinker yarn)	I
DLP 21 Polyethylene	olefin	Thiokol	M (round)	I
DLP 31 Polyethylene	olefin	Thiokol	M (ribbon)	AHI
DLP 40 Polypropylene	olefin	Thiokol	M (round & flat)	HI
DLP 47 Polypropylene	olefin	Thiokol	M (round & flat)	HI
DLP 50 Polypropylene	olefin	Thiokol	M (round & flat)	HI
DLP 57 Polypropylene	olefin	Thiokol	M (round & flat)	HI
DLP 61 Polypropylene	olefin	Thiokol	M (round, hi-tenacity	I
DLP 70 Polypropylene	olefin	Thiokol	M (ribbon)	I
DLP 77 Polypropylene	olefin	Thiokol	M (ribbon)	HI
DLP 90 Polypropylene	olefin	Thiokol	F (round)	HI
DuPont nylon	nylon	DuPont	FSTM	AHITC
Ektafill	polyester	Eastman	S (fiberfill)	H
Elura	modacrylic	Monsanto	T	Wigs
Encron	polyester	Akzona	FS	AHITC
Encron 8	polyester	Akzona	F (multilobal cross section, reduces sparkle in outer-wear fabrics)	A
Encron Golden Touch	polyester	Akzona	F (high filament count)	A
Encron Plyloc	polyester	Akzona	F (producer-textured two-ply stretch)	A
Enkaloft TWIX	nylon	Akzona	F (bulked, multilobal; space differential, normal, cationic, light dyeing types) S (crimpset or non-crimpset, normal cationic, dyeing types)	H
Enkaloft Stria	nylon	Akzona	F (bulked, modified twist, plied; cationic and light dyeing types; random pattern effect)	H
Enkaloft Super Bulk	nylon	Akzona	F (high bulk)	H
Enkaloft TWIX	nylon	Akzona	F (bulked, modified twist, plied; cationic, light dyeing types; tweed pattern effect	H
Enkalure	nylon	Akzona	F (multilobal, delayed soiling)	AH
Enkalure II	nylon	Akzona	F (bulked, multilobal, soil hiding) S (multilobal), crimpset or non-crimpset)	H

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY (CONTINUED)

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
Enkalure III	nylon	Akzona	F (inherent anti-cling properties built in during manufacture)	A
Enka Nylon	nylon	Akzona	MFS (type 6)	AHITC
Enka Polyester	polyester	Akzona	FS	AHITC
Enkasheer	nylon	Akzona	M (producer modified torque yarn)	A
Esterweld	polyester	American Cyanamide	F (treated)	I
Fibrilawn	olefin	Fibron	F (fibrillated)	H, I
Fibrilon	olefin	Fibron	F (fibrillated)	HI
Firestone nylon	nylon	Firestone	MF	ITC
Firestone polyester	polyester	Firestone	F	TCI
FMC Vinyon	vinyon	FMC	F or S (modified)	AH
Fortrel	polyester	Cleanese	FST	AHITC
Fortrel 5	polyester	Celanese	F	A
Fortrel 7	polyester	Celanese	T	AH
Fortrel PCP	polyester	Celanese	S (producer-colored)	H
Glospan/Cleerspan	spandex	Globe	F (fused)	AHI
Goldcres	olefin	Shuford Mills	M (flat)	AHI
			F (fibrillated)	AHI
Goodyear Polyester	polyester	Goodyear Tire	F	TC
Hamlon	olefin	ACS Industries	F	HI
Hanover Nylon	nylon	Falk Fibers & Fabrics	MF	AI
Hanover Polyester	polyester	Falk Fibers & Fabrics	MF	AHI
Herculon	olefin	Hercules	F (bulked) FST	AHI
Herculon IV	olefin	Hercules	FS	H
Hoechst Polyester	polyester	Amer. Hoechst	SF (high tenacity, low pilling for cotton, woolen & worsted systems)	AHI
Kevlar	aramid	DuPont	F	TC
Kevlar 29	aramid	DuPont	F	I
Kevlar 49	aramid	DuPont	F	I
Kodel	polyester	Eastman	FS (several types available)	AHI
Kynar	fluorocarbon	Monofilaments	M	I
Kynol	novoloid	Carborundum	S	AHI
Lo-Pic	olefin	Fibron	M (flat)	HI

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY (CONTINUED)

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
Lycra	spandex	DuPont	F	A
Marvess	olefin	Phillips	FS	AHI
Marvess III	olefin	Phillips	F (BCF, modified cross-section, high luster, solution dyed.)	AH
Marvess CG	olefin	Phillips	S (heavy-denier sol. dyed)	H
Montrel	olefin	Wellington	(low shrinkage, very high modulus)	HI
Monvelle	biconstituent nylon/ spandex	Monsanto	M,F	A (Hosiery)
Multisheer	nylon	Akzona	F (stretch yarns)	A
MX6020	polyester	Shakespeare	M-Round, reg., med. & low shrink	I
MX6020-H	polyester	Shakespeare	M-Round, hydrolysis resistant, Reg., med. & low shrink	I
MX108	nylon	Shakespeare	M-Round opaque, HM	I
Newton Polyester	polyester	Albany Inter.	F	I
NM1000	nylon	Monofilaments	M (clear melt-dyed)	AHI
NM1103	nylon	Monofilaments	M (clear melt-dyed)	AHI
NM1200	nylon	Monofilaments	M (clear melt-dyed)	AHI
NM1400	nylon	Monofilaments	M (clear melt-dyed)	AHI
NM1500	nylon	Monofilaments	M (clear melt-dyed)	A
Nomex	aramid	DuPont	FS	AHI
Numa	spandex	Ameliotex	F	AHI
Nylon by Amtech	nylon	Amtech	M (round)	I
Nypel Halar	fluorocarbon	Allied Chem.	M	I
Nypel Nylon	nylon	Allied Chem.	M	I
Nypel Polyester	polyester	Allied Chem.	M	I
Nypel Polypro	olefin	Allied Chem.	M	I
Olefin	olefin	Waltrich	M	AHI
Olefin	olefin	Indian Head	Slit-film, high mod.	I
Oletex	olefin	Poncar	M	IR
Orlon	acrylic, modacrylic	DuPont	ST	AH
Parapro	olefin	Wall	F	H
Patlon	olefin	Standard Oil Co. (Ind.)	F	H
PE3100	polyester	Monofilaments	M (clear melt-dyed)	AHI
Phillips 66 Nylon	nylon	Phillips	F	AHI
PolarGuard·	polyester	Celanese Corp.	F,T	AI
Polycarbonate	polycarbonate	Monofilaments Inc.	M	AI
Polyester	polyester	American Cyanamide	F	TC

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY (CONTINUED)

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
Polyester by Amtech	polyester	Amtech	M (round)	IH
Polyethylene by Amtech	olefin	Amtech	M (round)	I
Polyloom I	olefin	Standard Oil Co. (Calif.)	F (fibrillated)	HI
Polyloom II	olefin	Standard Oil Co. (Calif.)	F (fibrillated)	HI
Polypropylene by Amtech	olefin	Amtech	M (round and flat)	IH
Polywrap	olefin	Indian Head	Slit processed high modulus	R
Poncar	olefin	Poncar	M	IR
Pro-Tuft	olefin	Bemis	P (ribbon)	HIT
Qiana	nylon	DuPont	M	AH
Quintess	polyester	Phillips	F	AH
Random-set	nylon	Rohm and Haas	Twisted and heat-set	H
Random-tone	nylon	Rohm and Haas	Heat-set and dyed	H
Ruvea	nylon	DuPont	M (ribbon)	AHI
S-3	nylon	Shakespeare	M (clear, melt-dyed)	I
Saran by Amtech	saran	Amtech	M (round and flat)	IH
SEF	modacrylic	Monsanto	S (flame retardant)	AH
Shakespeare Nylon	nylon	Shakespeare	M (round)	I
Shakespeare Polyester	polyester	Shakespeare	M	I
Shareen	nylon	Courtaulds	M, F	A (Hosiery)
Shoeflex	nylon	Shakespeare	M (clear, melt-dyed)	I
Shurti	olefin	Shuford Mills	F (fibrillated)	R
Sooflex	nylon	Shakespeare	M (clear, melt-dyed)	I
Spectran	polyester	Monsanto	S	A
Starbrite	nylon	Star Fibers	S	AHI
Strialine	polyester	Akzona	F (thick & thin, color contrast dyeing)	AH
Stryton	nylon	Phillips	F (undulating variable cross-section)	AH
Synflex-N	nylon	Wall Industries	M	H
Synthetic Ind	olefin	Diversified Ind.	Slit Film	IH
Tango	nylon	Allied Chemical	F	A
Teflon	fluorocarbon	DuPont	FM	I
Textura	polyester	Rohm and Haas	Producer textured	A
Travira	polyester	Amer. Hoechst	FS (high tenacity)	AHI
TW 6208	olefin	Fibron	F	R
Ty EZ	olefin	Indian Head	Slit processed high modulus	R

Table B-1. PRODUCTS OF THE SYNTHETIC FIBERS INDUSTRY (CONTINUED)

Trademark	Generic Name	Producer	Types and Special Characteristics[1]	End-Use Areas[2]
Tytite	olefin	Indian Head	Slit processed high modulus	R
Uitron	nylon	Monsanto	F	A
Unifil	olefin	Wall	M	H
Vectra	olefin	Vectra	FS	AIH
Verel	modacrylic	Eastman	S (assorted types for specialized uses)	AHI
Voplex	olefin	Voplex	M (round or flat polypropylene and polyethylene)	I
Voplex	vinyon	Voplex	M (flat)	I
Vylor	nylon	DuPont	M	I
Wall Polypropylene	olefin	Wall	M	I
Waltrich Polypropylene	olefin	Waltrich	M and ribbon	IH
Wellene	polyester	Wellman		HI
Wellon	nylon	Wellman	S	AHI
Wellstrand	nylon & polyester (heavy den.)	Wellman	S (monofil)	HI
WSF PE	olefin	Wellington	M (round, high tenacity (slit film)	I
WSF PP	olefin	Wellington	M (round, high tenacity) (slit) F (fibrillated)	I
X-static	nylon	Rohm and Haas	F (anti-static modified)	AH
Zefran	acrylic	Dow	S (dyeable copolymer, producer - colored homopolymer)	AHI
Zefran	nylon	Dow	FS	AH
Zefran	polyester	Dow	F	A

[1]Type: M=monofilament; F=multifilament; S=staple fiber; T=tow.
[2]Identification of end-use areas: A=apparel; H=carpets, home furnishings; l=industrial fabrics: TC=tire cord; R=twine

Source: Directory of Chemical Producers - U.S.A. Directory Information Services, Menlo Park, California, Stanford Research Institute, 1976.

1975 Man-made Fiber Deskbook. Modern Textiles 1975 (March), 17.

Table B-2. CHEMICAL AND PHYSICAL PROPERTIES OF SOME TEXTILE FIBERS[1]

Fiber	Specific Gravity	Tenacity[2] (grams per denier)	Tenacity (Wet)[2] (grams per denier)	Moisture Regain (percent)	Extensibility[3] (percent)	Elasticity[4] (percent)
Acrylic						
Acrilan	1.17	2-2.7	1.6-2.2	1.5	34-50	99(2) 89(5)
Creslan	1.18	2-3	1.6-2.7	1-1.5	35-45	55-65(3) 40-60(5)
Orlon	1.16	2.2-2.6	1.8-2.1	1.5	20-28	-
Modacrylic						
Dynel	1.3	3.5-4.2	3.5-4.2	0.4	14-34	100(2) 98(5)
Verel	1.33-1.37	2-2.8	2-2.7	3-4.25	25-43	88(4) 55(10)
Nylon 6						
regular monofilament	1.14	4-7	3.7-6.2	2.8-5	17-45	99-100(2-100)
staple	1.14	3.8-5.5	-	2.8-5	37-50	100(2)
Nylon 66						
regular monofilament	1.14	3-6	2.6-5.2	4.2-4.5	25-65	100(5) 99-100(10)
staple and tow	1.14	3.5-7.2	3-6.1	4.2-4.5	16-66	-
Nomex	1.38	4-5.3	3-4.1	6.5	22-32	-
Olefin						
Polypropylene-isotatic						
monofilament	0.9-0.91	3.5-7	3.5-7	0.01-0.1	14-30	98(5) 95(10)
staple and tow	0.9-0.91	3-6.5	3-6.5	0.01-0.1	20-80	97-100(2) 94-100(5)
Polyesters, regular tenacity						
Avlin, staple	1.38	3.5-5	3.5-5	0.4	35-50	90-95(2) 55-65(5)
Blue C, staple	1.39	4.6	4.5	0.4	40-50	92(2) 75(5)
Dacron, staple	1.38	2.2-6	2.2-6	0.4-0.8	12-55	100(1)
Encron, filament	1.38	4.4-5	4.4-5	0.4	27-36	55-65(5)
Fortrel, staple	1.38	4.8	4.8	0.4	45-55	75-80(5)
Kodel, staple	1.38	4.5-5.5	4.5-5.5	0.4	35-45	75-85(2) 35-45(5)
Quintess, staple	1.38	4.5-5.5	4.5-5.5	0.4	40-50	-
Trevira, staple	1.38	3.1-6.6	3.1-6.6	0.4	18-55	67-86(2) 57-74(5)
Vycron, staple	1.38	3.8-5.8	3.8-5.8	0.6	22-67	44(5) 33(10)

Table B-2. CHEMICAL AND PHYSICAL PROPERTIES OF SOME TEXTILE FIBERS[1] (CONTINUED)

Fiber	Specific Gravity	Tenacity[2] (grams per denier	Tenacity (Wet)[2] (grams per denier	Moisture Regain (percent)	Extensibility[3] (percent)	Elasticity[4] (percent)
Saran	1.7	up to 1.5	up to 1.5	None	15-25	-
Spandex						
Fulflex	1.41	0.34	-	<0.5	600-625	97(50)
Glospan	1.2	0.7	0.6-0.9	<1	600-700	99(50) 98(200)
Lycra	1.21	0.7-0.9	-	1.3	444-555	97(50)
Numa	1.2	0.6-0.9	-	1	500-600	98(300)
Unel	1.2	0.55-0.85	-	1.3	500-700	96-98.5(50)
Vyrene	1.2	-	-	0.3	650-700	98(600)
Fluorocarbon						
Teflon, staple	2.1	1.2-1.4	1.2-1.4	-	15-33	-
Teflon, monofilament	2.1	0.5	0.5	-	52	-
Biconstituent Fiber						
Source-AC0001	1.22	up to 9	-	2.7	45 maximum	100(4)

[1]Because natural fibers inevitably vary in properties and man-made fibers may be produced in various forms, values given should be interpreted as indicating order of magnitude of the fibers as used in textile applications.
[2]Tested at 21°C (70°F) with relative humidity 65 percent.
[3]Percentage of elongation at 65 percent relative humidity.
[4]Percentage of recovery from strain indicated.

Source: American Home Economics Association. Textile Handbook, 4th Ed., Washington, D. C., 1970.

APPENDIX C

PRODUCERS

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
ACS Industries	Walthourville, Ga.	Olefin (P)	Y,F	na	
	Woonsocket, R.I.	Olefin	Y,F	na	
Akzona Inc.					
American Enka Co., Div	Central, S.C.	Nylon	Y,F,S	7	
	Enka, N.C.	Nylon	Y,F,S	34	
	Lowland, Tenn.	Nylon	Y,F,S	45	
	Central, S.C.	Polyester	Y,S	59	
	Lowland, Tenn.	Polyester	Y,S		
Albany International Corp.					
Albany Felt Co., Div.					
Newton Line Co., Inc.	Homer, N.Y.	Fluorocarbon	F	na	
	Homer, N.Y.	Nylon	F	1	
	Homer, N.Y.	Polyester	F	<.5	
	Homer, N.Y.	Olefin (E&P)	F	na	
Allied Chem. Corp.					
Fibers Div.	Chesterfield, Va.	Nylon	Y,F,S	59	
	Irmo, S.C.	Nylon	Y,F,S	45	
	Irmo, S.C.	Polyester	Y,S	9	Experimental Capacity
	Moncure, N.C.	Polyester	Y,S	16 (14)[2]	
Nypel, Inc., Subsid.	West Conshohocken, Pa.	Nylon	F	na	
Alrac Corp.	Stamford, Conn.	Nylon	Y,S	>1(23)[2]	Pilot
Ameliotex, Inc.	Rocky Hill, N.J.	Spandex	F	<.5	
American Cyanamid Co.					
Fibers Div.	Milton, Fla.	Acrylic and modacrylic	S,T	57	
IRC Fibers Co. Subsid.	Painesville, Ohio	Polyester	Y	23	
American Hoechst Corp.					
Film Div.	Delaware City, Del.	Polyester	Y,F,S,T	2	
Hoechst Fibers Indust. Div.	Spartanburg, S.C.	Polyester	Y,F,S,T	114 (11)[2]	
American Mfg. Co. Inc.	Homesdale, PA	Olefin (E&P)	F,O	na	
St. Louis Cordage Mills Div.	St. Louis, MO	Olefin (E&P)	F,O	na	
AMTECH, Inc.	Odenton, Md.	Nylon	F	5	
	Odenton, Md.	Olefin (E&P)	F,O	na	
	Odenton, Md.	Polyester	F	0.5	
	Odenton, Md.	Saran	F	na	

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
Arlin Mfg. Co., Inc.	Lowell, Mass.	Olefin (E&P)	F,O	na	
Bemis Co., Inc.	St. Louis, Mo.	Olefin (P)	F,O	na	
	Talladega, Ala.	Olefin (P)	F,O	na	
Berkley & Co., Inc.	Spirit Lake, Iowa	Olefin (E&P)	F	na	Captive Use
	Spirit Lake, Iowa	Nylon	F	0.5	
Camac Corp.	Bristol, Va.	Nylon	Y	5	
	Bristol, Va.	Olefin		na	
The Carborundum Co. Polymers Venture	Niagra Falls, N.Y.	Novoloid		na	
Celanese Corp. Fiber Industries, Inc., Subsid.	Greenville, S.C.	Nylon	Y,S	40	
	Florence, S.C.	Polyester	Y,S,T	45	
	Greenville, S.C.	Polyester	Y,S,T	30	
	Salisbury, N.C.	Polyester	Y,S,T	57	
	Shelby, N.C.	Polyester	Y,S,T	210	
Chadbourn, Inc. Chadbourn Indust. Div. Chadol Div.	Gainesville, Ga.	Nylon	Y,F	2	
Columbian Rope Co. The Cordage Group Div.	Auburn, N.Y.	Olefin (E&P)	F,O	na	
Courtalds North America, Inc.	LeMoyne, Ala.	Nylon	Y,F	2	
Andrew Crowe & Sons, Inc. Crowe Rope Co., Div.	Warren, Me.	Olefin (P)	F	na	
Deering Milliken, Inc. Indust. Div.	Laurens, S.C.	Nylon	F	0.5	Captive Use
	Laurens, S.C.	Olefin	F	na	
	Spartanburg, S.C.	Olefin		na	
Dow Badische Co.	Williamsburg, Va.	Acrylic and modacrylic	S,T	33	
	Anderson, S.C.	Nylon	Y,S	39	
	Anderson, S.C.	Polyester	Y	28	

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
Diversified Indust. Inc.					
Synthetic Indust. Inc., Subsid.	Chickamauga, Ga.	Olefin (P)	O	na	Captive Use
Tennessee Fibers, Subsid.	Pecatur, Tenn.	Olefin (P)	O	na	Captive Use
E.I. duPont de Nemours & Co., Inc.					
Textile Fibers Dept.	Camden, S.C.	Acrylic and Modacrylic	S,T	138	
	Waynesboro, Va.	Acrylic	S,T		
	Richmond, Va.	Flurocarbon	Y,F,S,T	na	
	Richmond, Va.	Aramid		(23)[2]	
	Camden, S.C.	Nylon	Y,F,S,T		
	Chattanooga, Tenn.	Nylon	Y,F,S.T	>450 (70)[2]	
	Martinsville, Va.	Nylon	Y,F,S.T		
	Richmond, Va.	Nylon	Y,F,S,T		
	Seaford, Del.	Nylon	Y,F,S,T		
	Camden, S.C.	Polyester	Y,S,T		
	Cape Fear, N.C.	Polyester	Y,S,T	570 (115)[2]	
	Chatanooga, Tenn.	Polyester	Y,S,T		
	Kinston, N.C.	Polyester	Y,S,T		
	Old Hickory, Tenn.	Polyester	Y,S,T		
	Waynesboro, Va.	Spandex	F	5	
Plastic Products & Resins Dept.	Parkersburg, W. Va.	Nylon	F	11	
Eastman Kodak Co.					
Eastman Chem. Products, Inc., Subsid.					
Carolina Eastman Co. Div.	Columbia, S.C.	Polyester	Y,S	177 (113)[3]	
Tennessee Eastman Co., Div.	Kingsport, Tenn.	Polyester, Acrylic & Modacrylic	S	18	
El Paso Natural Gas Co.					
Beaunit Corp., Subsid.					
Beaunit Fibers Div.	Elizabethton, Tenn.	Nylon	S,T	4	
	Etowah, Tenn.	Nylon	Y,S	33	
	Elizabethton, Tenn.	Polyester	Y,T	29	
		Olefin (P)		(9)[2] (27)[3]	
Falk Fibers & Fabrics Inc.					
Hanover Mills, Inc., Subsid.	Yanceyville, N.C.	Nylon	Y,F	2	
Universal Polymer Products, Co. Subsid.	Fuquay-Varina, N.C.	Polyester	Y,F	5	
FIBRON, Inc.	Chatanooga, Tenn.	Olefin (P)		na	
The Firestone Tire & Rubber Co.					
Firestone Synthetic Fibers Co., Div.	Hopewell, Va.	Nylon	Y,F	25	Captive Use
		Polyester	Y	14	

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
FMC Corp.					
Chem. Group					
Fiber Div.	Front Royal, Va.	Polyester	Y,S	20	
	Lewistown, Pa.	Polyester	Y,S	23	
	Meadville, Pa.	Vinyon	S	2	
FNT Indust. Inc.	Menominee, Mich.	Olefin (E)	F	na	
Georgia Synthetics, Inc.	Elberton, Ga.	Olefin (P)	O	na	
Globe Mfg. Co.	Fall River Mass.	Spandex	F	0.7	
	Gastonia, N.C.	Spandex	F	0.9	
The Goodyear Tire & Rubber Co.					
Chem. Div.	Point Pleasant, W. Va.	Polyester	F,Y	6.5	Captive Use
	Scottsboro, Ala.			14	
Hercules Inc.					
Polymers Dept.					
Fibers Div.	Covington, Va.	Olefin (P)	Y,S,T	45[4]	
	Oxford, Ga.				
Film Div.	Covington, Va.	Olefin (P)	O	na	
Indian Head, Inc.					
Indian Head Yarn & Thread, Div.	Blue Mountain, Ala.	Olefin (P)	O	na	
Kayser-Roth Corp.					
Yarn Processing Div.	Creedmoor, N.C.	Nylon	Y,F	5	Captive Use
Lambeth Corp.	New Bedford, Mass.	Olefin (P)	F	na	
Clarence L. Meyer & Co.					
Meyers Fibers, Inc.	Ansonville, N.C.	Polyester		5	
Monofilaments, Inc.	Waynesboro, Va.	Nylon	F	<.5	
	Waynesboro, Va.	Polyester	F	<.5	
	Waynesboro, Va.	Polycarbonate	F	na	

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
Monsanto Co.					
Monsanto Textiles Co.	Decatur, Ala.	Acrylic and Modacrylic	S,T	120 (30)[2]	
	Pensacola, Fla.	Nylon-Spandex	Y		Biconstituent fiber, pilot
	Decatur, Ala.	Nylon	Y,F,S	11	
	Greenwood, S.C.	Nylon	Y,F,S	91	
	Pensacola, Fla.	Nylon	Y,F,S	68	
	Sand Mountain	Nylon	Y,F,S	10	
	Decatur, Ala.	Polyester	Y,S	43	
	Sand Mountain, Ala.	Polyester	Y,S	30 (30)[2]	
The Osterneck Co.	Lumberton, N.C.	Olefin (P)	O		Captive Use
Phillips Petroleum Co.					
Phillips Fibers Corp., Subsid.	Rocky Mount, N.C.	Polyester	Y	23	
	Spartanburg, S.C.	Olefin (P)	Y,S,T	25[4]	
Fibers International Corp., Subsid.	Guayama, P.R.	Nylon	Y	29	
	Guayama, P.R.	Polyester	Y	14	
Plataril Co.	Birdsboro, Pa.	Nylon	F	1	
Poncar Plastic Corp.	Miami, Fla.	Olefin (P)	F	na	
Rohm and Haas Co.					
Rohm and Haas N.C. Inc., Subsid.	Fayetteville, N.C.	Nylon	Y,F,T	18	
	Fayetteville, N.C.	Polyester	Y,T	30 (30)[2]	
Shakespeare Co.					
Monofilament Div.	Columbia, S.C.	Nylon	F	2	
	Columbia, S.C.	Polyester	F	1	
Shuford Mills, Inc.	Hickory, N.C.	Olefin (P)	F	na	
Standard Oil Co. of California					
Chevron Chem. Co., Subsid.	Dayton, Tenn.	Olefin (P)	O	5[4]	

Table C-1. SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
Standard Oil Co. (Indiana)					
Amoco Chems. Corp. Subsid.					
Amoco Fabrics Co., Subsid.					
Patchogue Plymouth Co. Div.	Bainbridge Ga.	Olefin (P)	O	na	
	Hazelhurst, Ga.	Olefin (P)	O	18[4]	
	Nashville, Ga.	Olefin (P)	O	na	
Star Fibers, Inc.	Edgefield, S.C.	Nylon	S	6	
Texfi Indust., Inc.					
Texfi Yarn and Fibers Group	Asheboro, N.C.	Polyester	Y	8	
	New Bern, N.C.	Polyester	Y	11	
Thiokol Corp.					
Fibers Div.	Waynesboro, Va.	Olefin (E&P)	Y,F,O	14[4]	
Tubbs Cordage Co.	Orange, Calif.	Olefin (P)	F	na	
Uniroyal, Inc.					
Uniroyal Fiber & Textile Div.	Winnsboro, S.C.	Nylon	F	<.5	
	Winnsboro, S.C.	Olefin	F,S	9[4]	
Voplex Corp.					
Canadaigua Plastics Div.	Canadaigua, N.Y.	Olefin (E&P)	F	na	
	Canadaigua, N.Y.	Vinyon	F	0.5	
Well Indust., Inc.	Beverly, N.J.	Olefin (E&P)	F	na	
Waltrich Plastic Corp.	Tennet, N.J.	Olefin (P)	F	na	
Wellington Computer Graphics, Inc.					
Wellington Synthetic Fibers, Inc. subsid.					
Montair Div.	Pilot Mountain, N.C.	Olefin (E&P)	F,O	na	
Plastic Woven Products Div.	Leesville, S.C.	Olefin (P)	F	na	
Poly Fibers Div.	Trusville, Ala.	Olefin (P)	F,O	na	

Table C-1 SYNTHETIC FIBER PRODUCERS, PLANT LOCATIONS, PRODUCTS, AND CAPACITIES (CONTINUED)

Company	Location	Products[5]	Form[5]	Capacity (Gg/Yr)[1]	Remarks
Wellman, Inc.					
Wellman Indust., Inc., Subsid.					
Man-Made Fiber Div.	Johnsonville, S.C.	Nylon	S,T	14	
	Johnsonville, S.C.	Polyester	S,T	16	

[1] On-line 1 January 1976 unless otherwise noted. Capacity data from 1976 Directory of Chemical Producers unless otherwise noted.
[2] Capacity increase scheduled in 1976
[3] Capacity increase under construction or planning
[4] Capacity data from 1975 Directory of Chemical Producers

[5] ABBREVIATIONS: P-polypropylene, E-polyethylene, Y-yarn, F-filament, mono or multi, S-staple, T-tow, O-other, na-not available

Sources: Man-Made Fiber Producers' Directory. Textile Organon, 65(9), 1974.

Directory of Chemical Producers, 1976.

TABLE C-2

LOCATION OF U.S. SYNTHETIC FIBER PRODUCING PLANTS

STATES AND AREA	ACRYLIC	NYLON	OLEFIN	POLYESTER	OTHER	TOTAL
New England		1	4		1	6
Connecticut		1				1
Maine			1			1
Massachusetts			2		1	3
Rhode Island			1			1
Mid-Atlantic		5	8	4	6	23
Delaware		1		1		2
Maryland		1	2	1	1	5
New Jersey			2		1	3
New York		1	3	1	3	8
Pennsylvania		2	1	1	1	5
Piedmont	3	23	12	28	5	71
N. Carolina		4	3	11	1	19
S. Carolina	1	11	5	11		28
Virginia	2	7	4	4	4	21
W. Virginia		1		2		3
South	3	13	16	9	1	42
Alabama	1	3	3	3		10
Florida	1	2	1		1	5
Georgia		1	7			8
Tennessee	1	6	5	5		17
Puerto Rico		1		1		2
Midwest & West		1	5	1		7
California			1			1
Iowa		1	1			2
Michigan			1			1
Missouri			2			2
Ohio				1		1
TOTAL	6	43	45	42	13	149

Sources: Textile Organon
1976 Ch. P.D.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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16. ABSTRACT

The catalog of Industrial Process Profiles for Environmental Use was developed as an aid in defining the environmental impacts of industrial activity in the United States. Entries for each industry are in consistent format and form separate chapters of the study. Synthetic fibers are defined as noncellulosic fiber of synthetic origin. The category includes manufactured fibers in which the fiber-forming substances is a long-chain, organic synthetic polymer. Cellulosic fibers such as rayon and acetate and the inorganic fibers such as boron, fiberglass, and graphite are excluded. Synthetic fiber industry activities start with a synthetic, long-chain polymer and terminate with the formation of a marketable filament or thread-like material. One process flow sheet and six process descriptions have been prepared to characterize the industry. Three of the process descriptions are involved with filament formation and three describe fiber treatment. Within each process description available data have been presented on input materials, operating parameters, utility requirements and waste streams. Data related to the subject matter, including company and product data, are included as appendices.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Air Pollution Control	07C
Synthetic Fibers	Water Pollution Control	11E
Organic Synthetic Polymer	Solid Waste Control	13C
Polymerization	Textile Industry	
Process Description	Synthetic Fibers	

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