Industry & Trade Summary

Saturated Polyesters in Primary Forms

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PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on saturated polyesters in primary forms covers the period 1988-92 and represents one of approximately 250 to 300 individual reports to be produced in this series during the first half of the 1990s. Listed below are the individual summary reports published to date on the chemicals and textiles sectors.

USITC publication number	*Publication date*	*Title*
Chemicals:		
2458	November 1991	Soaps, Detergents, and Surface–Active Agents
2509	May 1992	Inorganic Acids
2548	August 1992	Paints, Inks, and Related Items
2578	November 1992	Crude Petroleum
2588	December 1992	Major Primary Olefins
2590	February 1993	Polyethylene Resins in Primary Forms
2598	March 1993	Perfumes, Cosmetics, and Toiletries
2736	February 1994	Antibiotics
2739	February 1994	Pneumatic Tires and Tubes
2741	February 1994	Natural Rubber
2743	February 1994	Saturated Polyesters in Primary Forms
Textiles and apparel:		
2543	August 1992	Nonwoven Fabrics
2580	December 1992	Gloves
2642	June 1993	Yarn
2695	November 1993	Carpets and Rugs
2702	November 1993	Fur Goods
2703	November 1993	Coated Fabrics
2735	February 1994	Knit Fabric

[1] The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

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INTRODUCTION

This report covers saturated polyesters in primary forms for the 5-year period 1988-92. The commodities in this summary are contained in standard industry classification (SIC) grouping 2821, along with other plastics resins in primary forms. Saturated polyester resins are part of a larger group of plastics known as thermoplastics. Thermoplastics are plastics capable of being repeatedly resoftened by increases in temperature. This summary contains information about the major saturated polyesters—polyethylene terephthalate (PET) and polybutylene terephthalate (PBT), and other small volume saturated polyesters—polycyclohexylenedimethylene terephthalate (PCT), polyethylene naphthalate (PEN), liquid crystal polymers (LCP), and polyarylates. These resins are in primary forms, meaning that the material has not been fabricated or formed into a product. This summary does not include polyester for fiber use.

Polyesters are a family of plastics that contain repeating ester linkages (-COO-) in the skeletal long-chain structure. This summary specifically covers the saturated[1] polyesters, which are thermoplastic in nature, and not the unsaturated polyesters, which are typically thermosetting[2] in nature. Because the two types of polyesters are different in chemical structure, they are utilized in different applications and comprise different markets. The term 'polyesters' will be used throughout this report and refers to the saturated-type polyester resins.

The first commercialization of saturated polyesters in the United States came in 1953, when PET was introduced as a textile fiber. Carothers and Hill had produced fiber forming polyesters in the early 1930s, but it was not until the work of Winfield of the Calico Printers Laboratories in England in 1941 that PET was recognized as a useful synthetic fiber material. E. I. du Pont de Nemours and Co., Inc. (DuPont) acquired the U.S. patent rights in 1948 and began fiber production in 1953, followed by PET film production soon after.[3]

PET is the largest volume and most commercially important saturated polyester currently produced in the United States, with domestic production amounting to 1.44 million metric tons in 1991.[4] In addition to the original application as a textile fiber, PET has entered the film, beverage bottle, sheeting, and engineering application markets. The other polyester of significant importance is PBT, which has grown steadily in engineering applications since introduced commercially in 1970. PBT also has applications in the automotive and appliance industries.

In 1992, the United States was the world's largest producer country of PET, with total production capacity reported at 996,000[5] metric tons, or about 45 percent of world capacity.[6] The Far East has built up PET capacity in recent years and had a reported 530,000 metric tons on line in 1992.[7] The United States has an increasing trade surplus of PET and exported 13.2 percent of production in 1991. This trend is likely to diminish during the 1990s as Western Europe builds local capacity to satisfy demand. During the past 2 years, approximately 40 percent of U.S. exports were destined for the European Union (EU).

U.S. INDUSTRY PROFILE

Product Description and Attributes

The materials covered in this summary, saturated polyesters in primary forms (figure 1), include commodity resins, which are produced in large volume with low unit value, and specialty engineering grade resins, which possess unique properties that allow them to enter specialized markets traditionally reserved for metals, ceramics, and alloys. Although PET is commonly referred to as a commodity plastic, it also is used in engineering applications when compounded with glass fiber or other reinforcing agents.

Many of the specialty engineering resins are compounded with metals, glass fiber, or chemicals[8] to provide added strength and higher heat resistance. These high-performance materials command a large price differential compared with commodity PET and uncompounded grades. In addition, some resins are copolymers or blends with other polyesters. These resin mixtures are formulated to achieve the desirable qualities of each resin; for example, a high heat resistant resin may be blended with one with high optical clarity.

The engineering resin PCT is often utilized as a copolyester or blend. PCT has numerous applications in a wide range of markets because various properties can be achieved by blending different types of materials. For example, PCTG is a glycol-modified polyester which is capable of being extruded or injection molded into a variety of products such as catheter systems and high impact resistant face shields.

PET is reported to account for approximately 89 percent of the volume of the saturated polyesters consumed in North America; PBT accounts for about 9 percent; and the remaining 2 percent is accounted for by specialty polyesters such as PCT and LCP.[9] PEN, a specialty resin targeted for high-performance niche markets, is not currently produced in the United States. ICI Americas is introducing a PEN film in the U.S. market; PEN is made in its Dumfries, Scotland, plant. Long term expectations are to produce the

[1] Refer to app. A for glossary of industry terms.

[2] Thermosetting plastics are not capable of being remolded or shaped when exposed to heat.

[3] Kirk-Othmer, *Encyclopedia of Chemical Technology*, (New York: John Wiley & Sons, Inc., 1968), vol. 16, pp. 143 and 159.

[4] U.S. International Trade Commission, *Synthetic Organic Chemicals: United States Production and Sales, 1991*, USITC Publication 2607, 1993.

[5] Includes one production facility in Toronto, Canada.

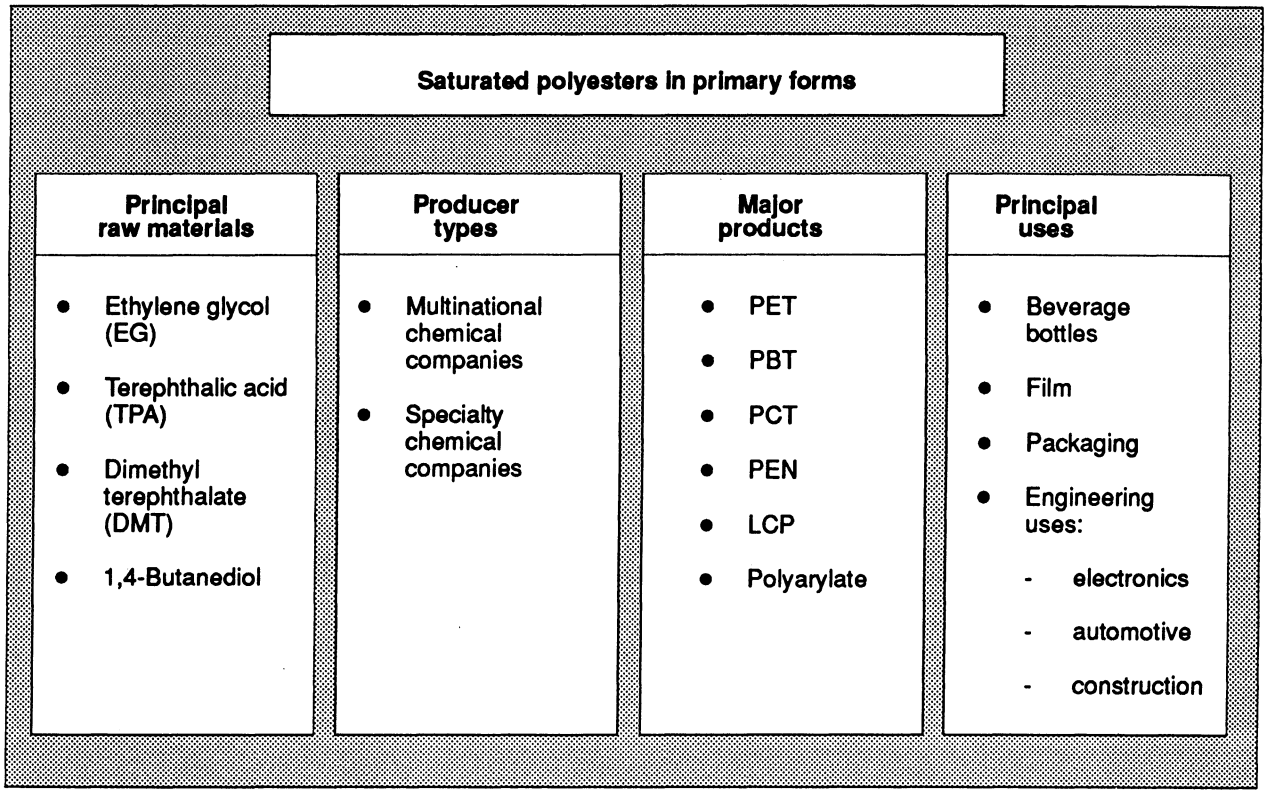
[6] 'Bottle-Grade PET: The Only News is Good News,' *Chemical Week*, Apr. 21, 1993, p. 38.

[7] Ibid.

[8] Chemicals such as flame retardants are often added to improve resin qualities, especially in high-temperature applications such as electronics.

[9] "North American Thermoplastic Polyester Consumption," *Hydrocarbon Processing*, Nov. 11, 1991, p. 35.

Figure 1
U.S. saturated polyester resins: Principal raw materials, producer types, major products, and principal uses



Source: Compiled by the USITC staff from various sources.

material in the United States if the product is acceptable in the marketplace.[10]

Demand for LCPs, a relatively new type of engineering resin, is predicted to grow during the 1990s. Since introduction in 1985, U.S. demand for LCPs stood at approximately 4,000 tons in late 1991; demand is expected to triple by 1995 and then double to approximately 24,000 tons by the year 2000. Growth in electronic/electrical applications will be the determining factor.[11]

Most U.S. producers sell their resins by trade name. Some of the common trade names of polyester resins and the corresponding producing companies are shown in table 1. The use of trade names has increased in recent years as companies tailor their resins and resin blends to specific markets and uses. New technology and developments in the polymerization and blending processes have allowed companies to produce a wider range of resins with specific properties.

[10] "PEN Film Business Emerges As ICI Slates Production," *Chemical Marketing Reporter*, Mar. 16, 1992, p. 5.

[11] "Liquid crystal polymer demand in the United States will triple through 1995 to 25 million pounds, with subsequent growth to 50 million pounds and $250 million in the year 2000," *Chemical Marketing Reporter*, Dec. 23, 1991, p. 19.

Production Processes

Polyesters are produced by condensation reactions of dicarboxylic acids (or their esters) with dihydroxy alcohols (diols). For example, PET is produced by reacting either dimethyl terephthalate (DMT) or terephthalic acid (TPA) with ethylene glycol (EG). In the commercial production of PET, a continuous melt-phase polymerization process, typically using an antimony catalyst, is utilized. The production of bottle-grade PET includes an additional step known as solid-stating, which further polymerizes the PET from the first reaction, increasing the molecular weight of the polymer. The molecular weight, as measured by intrinsic viscosity (IV) is usually greater than 0.7 dl/g for bottle-grade resins.[12]

About 62 percent of ethylene glycol production and nearly all of DMT/TPA production is reported to be used for polyester production (both resins and fiber).[13] Other monomers used to produce polyesters include 1,4-butanediol for PBT, and 1,4-cyclohexane dimethanol for PCT, and 2,6-dimethylnaphthalate for PEN.

[12] Ehrig, R.J., *Plastics Recycling: Products and Processes*, (New York: Hanser Publishers, 1992), pp. 47-48.

[13] Ibid., pp. 185 and 344.

Table 1
Trade names of saturated polyester resins in primary forms

Trade name	Type	Company
Petra	PET, reinforced	Allied Signal
Xydar	LCP	Amoco
Dalar	PET	DuPont
Rynite	PET	DuPont
Kodapak	PET	Eastman
Kodar	PETG	Eastman
Tenite	PET	Eastman
Ektar	PET and PCT, reinforced	Eastman
Valox	PBT and PCT alloy	General Electric
Xenoy	PBT alloy	General Electric
Cleartuf	PET	Goodyear
Celanex	PBT	Hoechst Celanese
Impet	PET	Hoechst Celanese
Vandar	PBT alloy	Hoechst Celanese
Vectra	LCP	Hoechst Celanese
Thermocomp	PBT, reinforced	ICI Americas
Petlon	PET, reinforced	Miles
Pocan	PBT, modified	Miles
Aspect	PET, reinforced	Phillips
Tetrafil	PET	Thermofil

Source: *Modern Plastics Encyclopedia '93*, vol. 69, no. 13 (New York: McGraw-Hill, 1992); and *Hawley's Condensed Chemical Dictionary*, 11th ed. (New York: Van Nostrand Reinhold Company, 1987).

After polymerization of the monomers, the polymer usually undergoes some type of compounding to aid in processibility and utility. The following materials are commonly added to the resin: extenders, fillers, colorants, flame retardants, and antioxidants. The polymer may take many forms after production depending on its intended use. The most common forms are powder, flake, solution, or extruded pellets.

Polyester resins are often further processed by the producing company to film or sheet after compounding, because the resins are hygroscopic[14] and require careful drying and molding conditions to achieve maximum crystallinity and minimum polymer breakdown. Aside from film extrusion, processes used to form polyesters include injection molding and stretch-blow molding.

Markets

Non-engineering grade PET has broad applications in numerous industry segments. As shown in figure 2, the largest market is soft-drink bottles, followed by film, custom bottles[15], sheeting, magnetic film, strapping, oven-ready trays, and coating. In recent years, the packaging market has been a source of growth for PET. Soft-drink companies have turned to PET instead of glass for a number of reasons: liability is reduced because PET bottles are shatterproof; PET's light weight reduces transportation costs; and PET's strength can accommodate carbonation pressures in the larger 2- and 3-liter bottles. PET packaging for food, distilled spirits, and toiletries also has increased as companies switch from glass and metal containers for their products. PET's clarity is important to many purchasers who want to present their products in a clear container.

The market for PET film has experienced growth due to increases in video tape, computer tape, and audio tape sales. PET film is also used in photographic film and X-ray film. Other significant markets for PET include strapping for industrial containers, wire coating, and oven-ready food trays.

Markets for PET, PBT, and PCT engineering polyesters are shown in figure 3. These resins possess excellent heat resistance, strength, and chemical resistance, which make them ideally suited for the electronics, automotive, and industrial machinery markets. Electrical end uses include lamp sockets, connectors, switches, fuse holders, and coil bobbins. These resins have a variety of applications in automobiles; structural items like luggage racks, door hardware, and grille panels use PET and PBT, while under-the-hood applications for PBT and PCT include distributor caps, pressure sensors, and alternator armatures. Lower-volume applications for these resins include sunglasses, utility vehicle hoods and fenders, pedestal bases, chair arms, circuit boards, and appliance housings and parts. Table 2 outlines major U.S. markets and applications for saturated polyester resins in 1992.

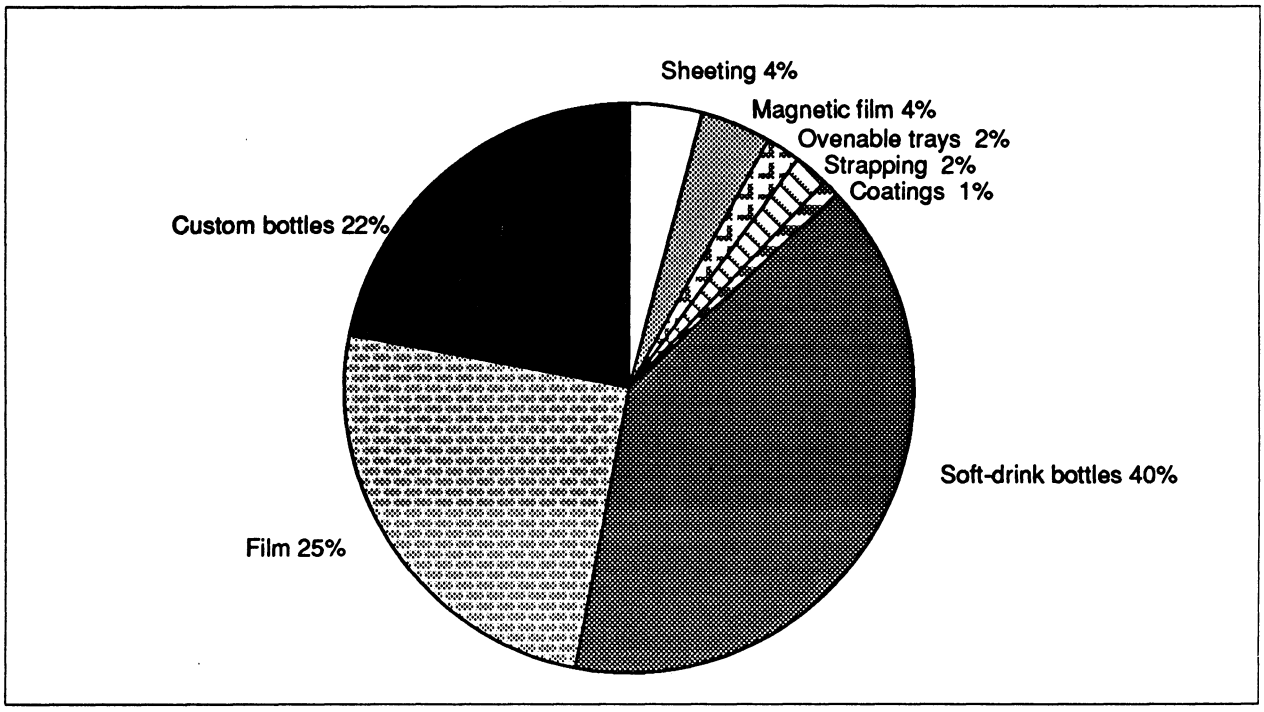
Market Structure

Polyester resins are produced in the United States by multinational chemical companies and by specialty chemical companies. Engineering grade resins are sometimes compounded by smaller independent companies. Polyester resins are sold by the producer in compounded and uncompounded form directly to a fabricator, funneled through a compounding or distributing intermediary before reaching the fabricator, used internally for derivative products, or further processed by the producer into film, sheet, or

[14] Hygroscopic refers to resins that have a tendency to absorb moisture from the air.

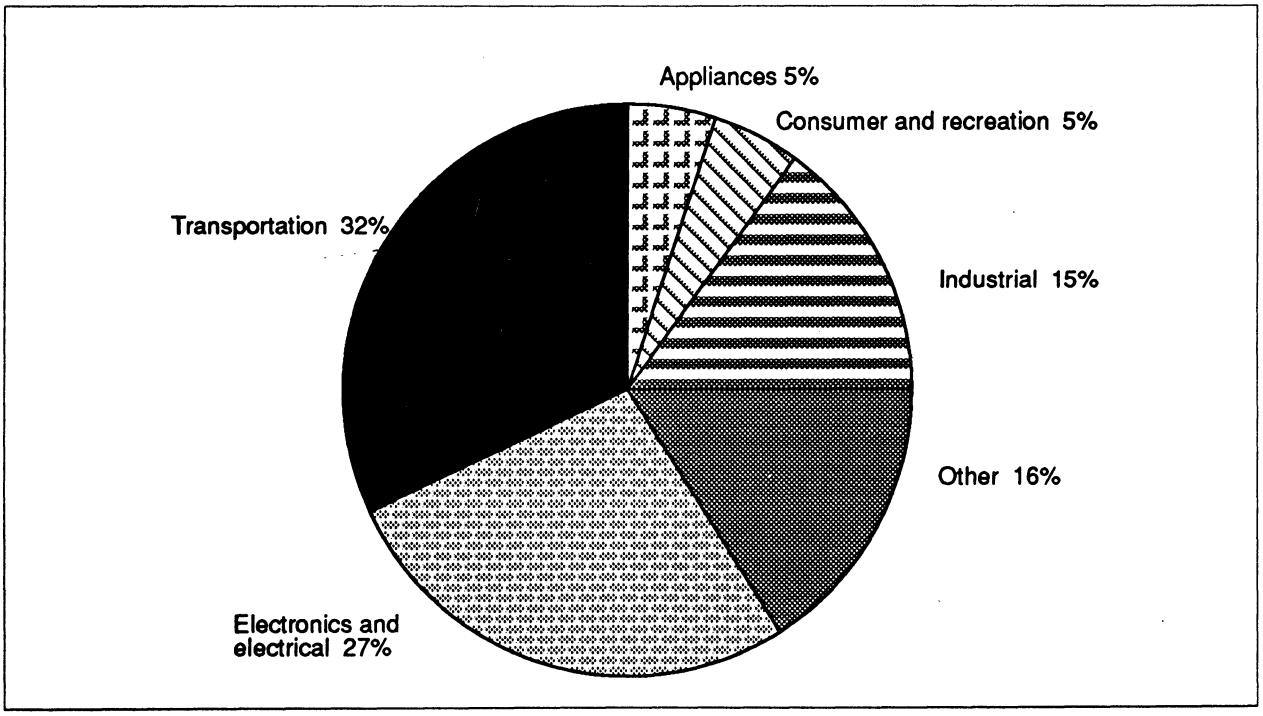
[15] Includes bottles for cosmetics, toiletries, pharmaceuticals, food, and liquor.

Figure 2
Polyethylene terephthalate (PET): U.S. consumption, 1992



Source: "U.S. Resin Sales by Process and Market," *Modern Plastics,* Jan. 1993, p. 86.

Figure 3
Engineering polyesters—PET, PBT, PCT: U.S. consumption, 1992



Source: "U.S. Resin Sales by Process and Market," *Modern Plastics,* Jan. 1993, p. 86.

Table 2
Saturated polyester resins: Major U.S. markets, 1992

(1,000 metric tons)

Type	Polyester	Reinforced Polyester	Total
Appliances	4	40	44
Building			
Glazing and skylights	(1)	12	12
Panels and siding	(1)	49	49
Pipes, fittings, conduit	(1)	55	55
Plumbing	4	43	47
Total	4	159	163
Electrical/Electronics	24	24	48
Packaging			
Coatings	6	(1)	6
Containers			
Blow molded	609	(1)	609
Thermoformed	68	(1)	68
Total	677	(1)	677
Transportation[2]			
Cars, vans, light trucks	23	(1)	23
Other	5	(1)	5
Total	28	(1)	28

[1] Separate statistics not provided for this application.
[2] Includes Canada.

Source: "U.S. Resin Sales to Major Markets," *Modern Plastics*, Jan. 1993, pp. 89-90.

other forms. Some producers of PET are integrated backward to produce PET raw materials—EG, DMT, and TPA; other companies are forward-integrated to produce film or other fabricated polyester products.

Establishments

Currently there are four major U.S. producers of PET commodity resins (table 3). The Eastman Chemical Co. presently possesses over 50 percent of the total U.S. capacity and is the world's largest PET producer for packaging applications. During 1991-92 Eastman announced that it would increase its PET capacity worldwide by 140,000 metric tons per year. This expansion includes the construction of a 60,000 metric ton facility in Mexico, a 20,000 metric ton facility in the United Kingdom, and a 60,000 metric ton facility in southern Europe.[16] The second largest U.S. producer, Shell Chemical, recently acquired Goodyear Tire & Rubber Co.'s facility in Point Pleasant, WV; a 35-percent capacity increase is scheduled in the first quarter of 1994.[17] Hoechst Celanese Corp. has also announced capacity increases in its three U.S. plants. The company will add about 180,000 metric tons of capacity during the next 4 years. A new market entrant, Wellman Inc., reportedly intends to bring a 35,000 metric ton plant on stream in late 1993, and an additional 55,000 metric ton capacity in 1995.[18]

Other types of polyesters are produced by a variety of companies in addition to the major producers mentioned above. The Commission's report, *Synthetic Organic Chemicals: U.S. Production and Sales, 1991*, lists a dozen more polyester producers. These companies range from large multinationals, such as Allied Signal Inc. and BASF Corp., to much smaller entities, such as McWhorter and Insulating Materials, Inc.

Geographic Distribution

Geographic distribution of U.S. PET producers is concentrated in the southern States as shown in figure 4. The accumulation of producers in North and South Carolina is largely attributed to the large number of textile establishments in these states.[19] A large market for PET is extruded polyester fiber used in textile applications. Close geographic proximity between supplier and purchaser is believed to be advantageous to this commodity-type industry. The geographic distribution of other polyester resin producers is widely dispersed throughout the country.

Employment

Employment statistics for saturated polyester resins are not available because of aggregation of all plastics resins in primary forms into one SIC code. Table 4 shows total employment and production worker

[16] "PET: Sitting Pretty as Growth Goes On," *European Chemical News*, June 21, 1993, p. 20; and "Bottle-Grade PET: The Only News is Good News," *Chemical Week*, Apr. 21, 1993.
[17] Ibid.
[18] Ibid.
[19] North and South Carolina are the first and fifth ranking states in terms of number of textile mill facilities. U.S. Department of Commerce, *County Business Patterns 1989-90*.

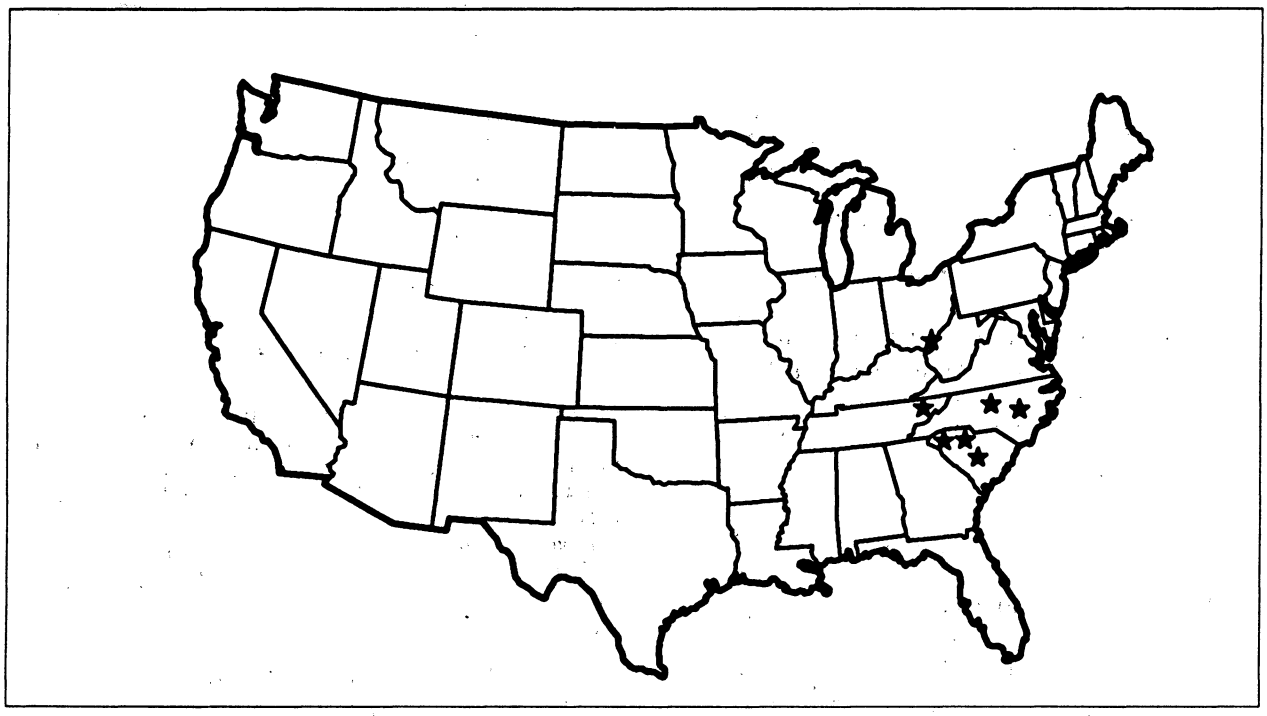
Table 3
Polyethylene terephthalate (PET): U.S. capacity, 1993

Company	Annual Capacity
	metric tons
Eastman Chemical[1]	570
Shell Chemical	205
Hoechst Celanese	160
ICI Americas	65
Total	1,000

[1] Includes Eastman's Toronto, Canada facility.

Source: "Chemical Profile," *Chemical Marketing Reporter*, May 3, 1993.

Figure 4
Geographic distribution of polyethylene terephthalate (PET) producers



Source: "Bottle-Grade PET: The Only News is Good News," *Chemical Week*, Apr. 21, 1993, p. 38; and Collins World Atlas, New Edition 1990 (Glasgow: William Collins Sons & Co. Ltd. 1990), p. 41.

employment for 1986 through 1990,[20] based on Commission staff estimates from U.S. Department of Commerce, Bureau of the Census, data. This industry is not labor-intensive; therefore employment, labor, and productivity factors are of minor significance.

Pricing

Market prices of polyester resins vary significantly from the low-priced commodity PET resins to the highly specialized engineering polyesters. In 1992, market prices for bottle-grade PET were 64-67 cents per lb., while LCP (non-compounded) was $12-$22 per lb.[21] PET pricing reflects that of raw materials—EG, TPA, and DMT. Supply and demand factors influence market prices of these materials. Ethylene glycol producers have been squeezed lately by an oversupplied market, new capacity coming on stream, and rising costs.[22] Polyester prices are inherently tied to crude petroleum and natural gas prices because their raw materials are derived from these feedstocks.

[20] Data for 1991 and 1992 are not available from the U.S. Department of Commerce, Bureau of the Census.

[21] Plastics Technology, Dec. 1992.

[22] 'EG Trade Bumps Along the Bottom,' *Chemical Marketing Reporter*, Aug. 10, 1992, p. 3.

Table 4
Saturated polyester resins in primary forms: U.S. employment, 1986-90

Year	Total employment	Production workers
1986	1,264	788
1987	1,734	1,075
1988	1,755	1,084
1989	2,300	1,402
1990	2,315	1,406

Source: Estimated by Commission staff, based on official statistics of the U.S. Department of Commerce.

Consumer Characteristics and Factors Affecting Demand

The demand for polyester resins has grown considerably during 1988-92. Derivative products such as recording tapes have experienced growth, and packaging applications such as beverage bottles have taken market share from other materials, such as glass and metal.

New resin blends and improved properties have propelled engineering resins to a variety of new end uses. Plastics applications in automobiles have increased in recent years, as producers strive for greater fuel efficiency through weight reduction.[23] Promising applications for LCP resins in electronic applications such as computer connectors should promote growth for these new resins.

PET bottles have replaced other types of resins such as polyethylene and polyvinyl chloride (PVC) in the packaging industry during 1988-92. PET's advantages over these two resins are twofold: PET is a clear resin, unlike polyethylene, which is cloudy or white, and PET does not pose the health and disposal problems that has created concern over PVC use.

Increased environmental concerns by the public in recent years may have a significant impact on future demand for virgin PET. As recycling rates continue to escalate, more of the virgin market may be eroded.

Environmental Considerations and Recycling

The plastics industry has been increasingly involved in recycling as communities, municipalities, industry, and citizens look for alternatives to disposing of wastes. Since 1970, approximately 75 percent of operating landfills in the United States have closed because of stricter environmental regulations and reductions in landfill capacity.[24] These closings have contributed to escalating landfill costs, which have prompted communities to look for alternative methods of disposal. Recycling has become the most popular alterative because other options, such as incineration, are held to have adverse effects on the environment.

In 1990, plastics accounted for approximately 8 percent of the weight of all landfill material and 21 percent of the volume.[25] Separate landfill statistics for polyesters are not available.

Recycling of plastics has increased dramatically in the last 2 years. PET has the highest recycling rate among all plastics—24 percent in 1991.[26] This high rate can be attributed to the infrastructure in place to return beverage bottles. Many States have legislated "bottle bills" which provide the consumer with an economic incentive to return their bottles. In addition, many communities have commenced curbside recycling programs; in 1991 there were 1,900 curbside programs and 3,150 drop-off centers. According to a recent study, one out of every three PET soft drink bottles produced in 1991 was recycled.[27]

Table 5 provides a list of U.S. recyclers of PET and their present capacities. Industry estimates project a 36 percent rate of PET recycling by 2000.[28] Recycled PET is used in many products including fiberfill, carpet fiber, and non-food containers. The price differential between virgin and recycled PET provides an incentive to use the recycled material. Figure 5 provides a historical view of the relationship between virgin and recycled PET prices.

FOREIGN INDUSTRY PROFILE

Overview

Annual world PET resin capacity was reported to be 2.2 million metric tons in 1992.[29] The United States is the single largest producing country, with almost half the world supply, or nameplate capacity of 996,000 metric tons per year (tpy), followed by East Asia with 530,000 tpy, and Europe with 550,000 tpy. Most industrialized countries of the world have PET capacity.

[23] Modern Plastics Encyclopedia, (New York: McGraw Hill, 1991), p. 44.
[24] R.J. Ehrig, *Plastics Recycling*, p. 3.
[25] U.S. Environmental Protection Agency, *Characterization of Municipal Solid Waste in the United States: 1992 Update*, EPA publication 530-S-92-019, EPA, 1992.
[26] "PET Recycling Grows," *Chemical Marketing Reporter*, June 1, 1992, p. 5.
[27] Ibid.
[28] "BCC: Plastics Recycling to Surge," *Packaging*, Nov. 1991, p. 25.
[29] "Bottle-Grade PET," *Chemical Week*, Apr. 21, 1993, p. 38.

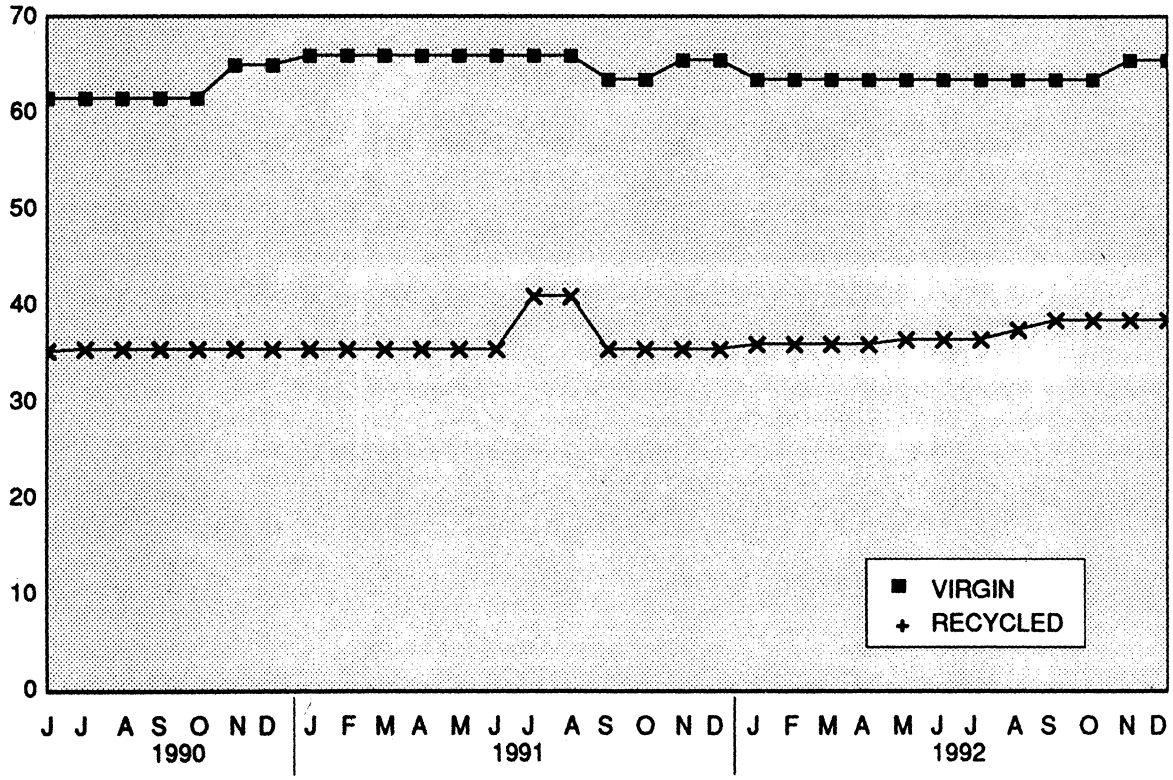
Table 5
Polyethylene terephthalate (PET): U.S. recycling capacity, 1992

Company	Location	Capacity
		1,000 tons per year
Martin Color-Fi	Sumter, Trenton, SC	54
Wellman	Johnsonville, SC	[1]50
Plastics Recycling Alliance	Philadelphia, PA/Chicago, IL	[1]36
MA Industries	Peachtree City, GA	[1]27
Nicon Plastics	Long Island City, NY	[1]17
Day Products	Bridgeport, NJ	16
wTe Recycling	Albany, NY	[1]14
Johnson Controls	Novi, MI	[1]9
Envirothene	Chino, CA	[1]8
St. Jude Polymer	Frackville, PA	8
Pepsi/Goodyear	Pt. Pleasant, WV	6
Orion Pacific	Odessa, TX	[1]5
Pure Tech	Springfield, MA	5
Polymer Resource Group	Rosedale, MD	[1]1
Total		[1]256

[1] Includes polyethylene and PET capacity.

Source: "1992 Plastics Yellow Pages," *Plastics World*, Jan. 1992, p. 138.

Figure 5
Polyethylene terephthalate (PET): Virgin and recycled prices[1], by months, 1990-92



[1] Prices refer to average published prices for the month. Recycled PET is clean flaked.

Source: "Bulk Market Prices," *Plastics Technology*, numerous issues; and *Trends in End-Use Markets for Plastics*, various issues.

The United States and the Far East are net exporters of polyesters, while Europe and the rest of the world require imports to meet local demand. In 1992, the United States exported 273,000 metric tons of polyester, or approximately 15 percent of total production. Approximately 40 percent of U.S. exports went to the EU (mainly the Netherlands and United Kingdom) countries during the past 2 years. Imports remain minimal compared with exports, but reached 50,000 metric tons in 1992. The EU supplied about half of U.S. imports of polyester resins. Imports from Canada constituted the largest single source of total U.S saturated polyester resin imports; these imports amounted to 34 percent of the volume, but only 19 percent of the value in 1992. These trading patterns are explained, in part, by intercompany transfers among multinationals.

Major world polyester producers include large multinational conglomerates, multinational chemical companies, and state-owned enterprises. Table 6 lists major world producers, country affiliation, and type of polyester produced.

Europe

The United States has a strong presence in the European PET market. The United States is the source of about 90 percent of European PET imports. Current European capacity stands at 550,000 tpy.[30] This trend is predicted to change in the future as European producers announce capacity increases and new plant construction. If announced plans materialize, additional European capacity of 200,000 tpy will be added by the mid 1990s, creating an oversupply of PET.[31] As a result, U.S. exports would most likely diminish. The largest U.S. producer, Eastman Chemical Co., has plans to increase foreign capacity during the 1990s which will have an effect on U.S. polyester exports. Eastman Chemical Co. sells 40 percent of their products outside the United States, but only 6 percent of world production is outside the United States. Corporate planning announced 40-50 percent PET production increases in the United Kingdom, Mexico, and the former Soviet Union during the next decade.[32]

European PET demand grew 12 percent in 1991 as soft drink and mineral water bottles propelled the rise. Projections through 1998 indicate that PET will show a minimum 8 percent annual growth rate, resulting from inroads in the packaging and electronic recording industries.[33]

Japan

The market for PET and PBT resins in Japan has grown rapidly in recent years. In 1992, production for non-fiber-use PET reached 467,588 metric tons, an increase of 13 percent over 1988 levels.[34] During 1988-91, PBT production increased by 36 percent amounting to 55,520 tons in 1991.

Japan's PET market is highly dependent on the electronics industry where 68 percent of PET is consumed for magnetic tape. The other main PET markets in Japan include bottles (food and non-food uses) with approximately 29 percent of the resin market and the remaining 3 percent is utilized in engineering applications. The growth of the electronics and automotive industries is reported to have propelled PBT growth; the electronics market accounts for approximately 50 percent of PBT consumption, automotive use accounts for 35 percent, and 8 percent is exported.[35]

Former Soviet Union

The former Soviet Union has limited polyester capacity but that is projected to change. Production capacity was reported at 1,300 tpy, with production at 1,000 tpy, in 1990. Eastman Chemical Co. has announced a joint venture operation with Pepsi and two Russian companies to build a 25,000 tpy PET plant in Russia which is scheduled to begin production in late 1992. This capacity reportedly will be used to produce Pepsi bottles for the Russian market and the remainder will be exported for hard currency. This market is seen as having growth potential as the former Soviet countries can currently only supply 35 percent of demand.[36]

[30] "PET Producers Pin Hopes on Improving Margins," *European Chemical News*, Dec. 9, 1991.

[31] "Hoechst and ICI Vie to Hike European PET Capacity," *European Chemical News*, June 24, 1991; and "PET Producers Pin Hopes on Improving Margins," *European Chemical News*, Dec. 9, 1991.

[32] "Eastman Chemical Develops a Worldwide Picture," *Chemical Week*, April 22, 1992, p. 22.

[33] "PET: Sitting Pretty," *European Chemical News*, June 21, 1993.

[34] *Plastics Industry News*, Apr. 1992 through Mar. 1993 issues.

[35] "Japan-1991 PBT Consumption Forecast," *Modern Plastics International*, Jan. 1, 1992, p. 48; and "PBT on Steady Increase," *Plastics Industry News*, Sept. 1991, p. 131.

[36] Hunt, Julian, *Packaging Week*, June 24, 1992, p. 13.

Table 6
Major international producers of saturated polyester resins in primary forms

Company	Resin Type	Country
Eastman Chemical	PET, PBT, PCT	United States
EniChem	PET	Italy
Hoechst Celanese	PET, PBT	Germany
ICI	PET, PEN	United Kingdom
Mitsubishi Kasei	PET, PBT	Japan
Shell Chemical	PET	Netherlands
Toray Industries	PET, PBT, LCP	Japan

Source: Compiled by USITC staff from various industry publications.

U.S. TRADE MEASURES

Tariff Measures

Table 7 shows the rates of duty as of January 1, 1993, for imports of polyester resins in primary forms under the U.S. Harmonized Tariff Schedule (HTS). The table shows the column 1 rates of duty for countries that have most-favored-nation (MFN) status, as well as rates of duty for countries qualifying for special tariff programs.[37] The column 1 general rate of duty for the products covered in this summary was 3.1 cents per kilogram plus 9 percent ad valorem in 1992.

Saturated polyesters are eligible for duty free treatment under the Generalized System of Preferences (GSP), Caribbean Basin Economic Recovery Act (CBERA), United States-Israel Free Trade Area Implementation Act of 1985, and the Andean Trade Preference Act. Imports of polyester from Canada currently have duty-free status; non-PET polyesters received duty-free status in January 1993 after a 5-year duty reduction schedule.

During 1988, the United States classified imports under the Tariff Schedule of the United States (TSUS). This system classified items more broadly than under the HTS (saturated polyester resins). PET was not identified separately from saturated polyester resins; therefore, separate trade data for polyester resins are suppressed for 1988.

Nontariff Measures and U.S. Government Trade-Related Investigations

The U.S. International Trade Commission has conducted only one investigation, under the U.S. antidumping law, with respect to derivative PET products. In that investigation, the Commission determined that a domestic industry was materially injured by reason of imports of PET film, sheet, and strip products from Japan and the Republic of Korea that the U.S. Department of Commerce had determined were being sold in the United States at less than fair value (dumped).[38] Commerce subsequently issued an antidumping duty order and imports subject to that order are currently subject to antidumping duties in an amount equal to the margin of dumping (if any). There are no known domestic nontariff import restrictions.

[37] Refer to app. B for explanation of tariff and trade agreement terms.

FOREIGN TRADE MEASURES

Tariff Measures

The duty rates for saturated polyester in primary forms vary considerably for the various countries throughout the world. The tabulation at the bottom of the page lists the corresponding duty rates for the major U.S. trading partners (in percent).[39]

There are no known nontariff measures that affect U.S. exports of polyester resins in primary forms.

U.S. MARKET

Consumption

U.S. consumption of polyester resins in primary forms during 1988-92 is shown in table 8. Consumption of polyester resins, in terms of value, amounted to $2,633 million in 1991 and was almost totally accounted for by U.S. production. The increase in consumption in 1991 compared to 1988 can be attributed to growing markets for PET, most importantly, food and beverage packaging. The only imports of significance are from Canada and are believed to be intracompany transfers to the U.S. parent firm. In 1991, total polyester imports accounted for only 2.6 percent of U.S. consumption.

[38] *Polyethylene Terephthalate Film, Sheet, and Strip from Japan and the Republic of Korea*, inv. Nos. 731-TA-458 and 459 (Final), USITC Publication 2383, May 1991. Under the U.S. antidumping law (19 U.S.C. 1673 et seq.), petitions are filed with the Department of Commerce and the Commission. If Commerce finds sales at less than fair value (dumping) and the Commission finds that a domestic industry is materially injured or threatened with material injury, or that the establishment of an industry is materially retarded, by reason of such LTFV sales, Commerce then issues an antidumping duty order and collects antidumping duties in an amount equal to the margin of dumping.

[39] Information obtained from country tariff schedules and U.S. Department of Commerce.

Nation/Area	Average rate of duty on saturated polyesters in primary forms
Canada	10 percent most-favored-nation rate Free for U.S. imports (1993 rate)
Mexico	10-15 percent
European Union	8 percent
Japan	4.6 percent
Australia	10-15

Table 7
Saturated polyester resins in primary forms: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1993; U.S. exports, 1992; and U.S. imports, 1992

HTS subheading	Description	Col. 1 rate of duty as of Jan. 1, 1993		U.S. exports, 1992	U.S. imports, 1992
		General	Special[1]		
				Million dollars	
3907.60.00	Polyethylene terephthalate	3.1¢/kg + 9%	Free (A,CA,E,IL,J)	320	33
3907.60.0010	Bottle-grade resins			(2)	2
3907.60.0050	Other			(2)	31
	Other polyesters:				
3907.99.00	Other	3.1¢/kg + 9%	Free (A,CA,E,IL,J)	136	54
3907.99.0010	Polybutylene terephthalate			(2)	10
3907.99.0050	Other			(2)	44

[1] Programs under which special tariff treatment may be provided, and the corresponding symbols for such programs as they are indicated in the "Special" subcolumn, are as follows: Generalized System of Preferences (A); Automotive Products Trade Act (B); Agreement on Trade in Civil Aircraft (C); United States-Canada Free-Trade Agreement (CA); Caribbean Basin Economic Recovery Act (E); United States-Israel Free Trade Area (IL); and Andean Trade Preference Act (J).

[2] Export statistics are only available at the 8-digit level.

Source: Harmonized Tariff Schedule of the United States, and import and export data were compiled from official statistics of the U.S. Department of Commerce.

Table 8
Saturated polyester resins in primary forms: U.S. producers' shipments, exports of domestic merchandise, imports for consumption, and apparent consumption, 1988-92

Year	U.S. Production	U.S. Exports	U.S. Imports	Apparent U.S. consumption	Ratio of imports to consumption
	Million dollars				*Percent*
1988	3,066	121	23	2,968	0.8
1989	2,265	252	51	2,064	2.5
1990	2,925	339	66	2,652	2.5
1991	2,972	408	69	2,633	2.6
1992	(1)	456	88	(2)	(2)

1 Production data for 1992 are not available.

2 Not available.

Source: Production data compiled from USITC, *Synthetic Organic Chemicals, U.S. Production and Sales, 1988-91.* Import and export data are compiled from official statistics of the U.S. Department of Commerce.

Production

U.S. production of polyester in primary forms during 1987-91 is shown in table 9. During this period, U.S. production increased from 1.2 million metric tons in 1987 to 1.7 million metric tons in 1991, or by over 40 percent. U.S. production is predicted to increase as all major U.S. producers have announced their intentions to expand capacity during the next few years. If reported capacities come on stream as scheduled through 1995, U.S. capacity will increase by 252,000 tpy.[40]

Imports

Although imports of polyester resins in primary forms account for less than 3 percent of domestic consumption, they increased slightly in each of the previous 5 years. Table 10 shows the principal sources of U.S. imports during 1988-92. The majority of U.S. imports were shipped from Canada and were over 95 percent PET (refer to appendix C for classification of imports by type). In contrast to Canada, the second largest import source—Germany, provided mainly (98 percent) non-PET polyester materials. U.S. imports from Canada and Japan experienced the largest increases during this period.

Imports of polyester resins in primary forms entered the U.S. duty-free under a number of preferential trade agreements. Table 11 shows the composition of these imports. In 1992, approximately 30 percent of U.S. imports of polyester resins entered duty-free; countries under the Generalized System of Preferences (GSP) accounted for 10 percent of total imports.

[40] 'Eastman will double resins,' *Chemical Week*, Apr. 15, 1992, p. 32; and 'Goodyear to Sell PET Unit To Shell in Debt Reduction,' *Chemical Marketing Reporter*, Mar. 30, 1992, p. 5.

FOREIGN MARKETS

Foreign Market Profile

Traditionally the United States has exported the majority of polyester resins to the EU. The Netherlands is the single largest destination for U.S. exports. As stated above, firms producing in the EU are planning large capacity increases in the upcoming years, which will probably limit future U.S. exports. Other potential markets include South American countries such as Brazil, Colombia, Venezuela, which have relatively little production capacity.

U.S. Exports

During 1988-92, U.S. exports of polyester resins in primary forms increased from $121 million in 1988 to $456 million in 1992, or by over 375 percent, as shown in table 12. The United States has exported an average of 12 percent of production during the last 2 years. The largest increase has been in exports destined for the Netherlands, Canada, and Mexico. Combined exports to those three countries increased from $105 million in 1989 to $271 million in 1992. The majority of U.S. exports of polyester resins is destined for European countries, mainly the Netherlands and the United Kingdom.

U.S. TRADE BALANCE

The United States has traditionally had a substantial trade surplus of saturated polyester resins in primary forms. Table 13 depicts the balance of trade for polyester in the top ten countries. The United States has maintained a trade deficit with Germany during 1988-92. A large and growing trade surplus has developed during this period with a high of $368 million recorded in 1992. The majority of this trade is believed to be intercompany transfers among affiliates of multinational companies. Figure 6 shows the trends in imports and exports during this period.

Table 9
Saturated polyester resins in primary forms: U.S. production by major categories, 1987-91[1]
(Metric tons, dry weight basis[2])

Description	1987	1988	1989	1990	1991
Polyethylene terephthalate (PET)	860,790	957,136	1,211,704	1,347,638	1,441,972
All other, including polybutylene terephthalate (PBT)	333,895	294,707	323,710	250,747	246,534
Total	1,194,686	1,251,844	1,535,414	1,598,385	1,688,506

[1] Data for 1992 are not available at this time.

[2] Dry weight basis is the total weight of the materials including resin and coloring agents, extenders, fillers, plasticizers, and other additives, but excluding water and other liquid diluents unless they are an integral part of the materials.

Note.—Because of rounding, figures may not add to the totals shown.

Source: USITC, *Synthetic Organic Chemicals, U.S. Production and Sales, 1987-91.*

Table 10
Saturated polyester resins in primary forms: U.S. imports for consumption, by principal sources, 1988-92[1]

Source	1988	1989	1990	1991	1992
			Quantity *(1,000 kilograms)*		
Canada	(2)	352	13,106	12,478	16,971
Germany	(2)	3,227	2,840	3,880	3,859
Japan	(2)	219	2,579	4,167	5,832
Luxembourg	(2)	4,048	4,249	3,333	2,786
Mexico	(2)	2,212	3,083	5,897	6,998
Taiwan	(2)	2,151	2,434	1,209	4,164
Belgium	(2)	1,818	1,574	1,023	1,696
Switzerland	(2)	1,118	644	1,101	2,176
United Kingdom	(2)	593	738	879	1,106
Netherlands	(2)	597	858	421	1,211
All other	(2)	3,378	1,969	2,110	2,943
Total	11,688	19,713	34,073	36,498	49,742
			Value *(1,000 dollars)*		
Canada	(2)	587	15,514	14,281	16,765
Germany	(2)	10,180	8,117	13,400	14,613
Japan	(2)	1,894	5,951	10,003	14,158
Luxembourg	(2)	15,404	13,753	10,940	10,723
Mexico	(2)	2,912	3,567	5,179	5,784
Taiwan	(2)	3,976	3,635	1,700	5,436
Belgium	(2)	4,450	4,416	2,666	4,226
Switzerland	(2)	3,087	1,564	2,307	3,713
United Kingdom	(2)	1,922	2,475	3,043	3,693
Netherlands	(2)	1,697	2,658	1,389	3,652
All other	(2)	4,951	4,109	4,489	4,932
Total	22,893	51,039	65,780	69,396	87,695
			Unit value *(dollars per kilogram)*		
Canada	(2)	1.67	1.18	1.14	0.99
Germany	(2)	3.15	2.86	3.45	3.79
Japan	(2)	8.65	2.31	2.40	2.43
Luxembourg	(2)	3.81	3.24	3.28	3.85
Mexico	(2)	1.32	1.16	0.88	0.83
Taiwan	(2)	1.85	1.49	1.41	1.31
Belgium	(2)	2.45	2.81	2.61	2.49
Switzerland	(2)	2.76	2.43	2.10	1.71
United Kingdom	(2)	3.42	3.35	3.46	3.34
Netherlands	(2)	2.76	3.10	3.30	3.02
All other	(2)	1.47	2.09	2.13	1.68
Average	1.96	2.59	1.93	1.90	1.76

[1] U.S. trade with East Germany is included in "Germany".

[2] Country-level detail is provided only for years in which there are actual trade data under the Harmonized Tariff Schedule of the United States (HTS).

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 11
Characterization of U.S. imports for consumption, 1992

Type of trade	Value of imports	Share of total imports
	1,000 dollars	*Percent*
Total imports	87,695	100.0
Dutiable imports	62,492	71.3
Duty-free imports under GSP	8,241	9.4
Duty-free imports under other provisions[1]	16,962	19.3

[1] Includes United States-Canada Free-Trade Agreement, Caribbean Basin Economic Recovery Act, and United States-Israel Free Trade Area.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 12
Saturated polyester resins in primary forms: U.S. exports of domestic merchandise, by principal markets, 1988-92

Market	1988	1989	1990	1991	1992
			Quantity *(1,000 kilograms)*		
Netherlands	(1)	29,913	70,964	76,110	88,625
Canada	(1)	30,068	49,075	51,311	57,494
Japan	(1)	10,099	14,469	20,817	21,689
Australia	(1)	14,943	17,798	24,720	20,687
Mexico	(1)	2,936	4,153	8,217	15,769
Israel	(1)	3,278	6,864	8,949	12,653
United Kingdom	(1)	5,510	17,340	11,426	8,632
Argentina	(1)	1,075	1,418	4,192	8,086
Colombia	(1)	247	37	1,839	5,815
Chile	(1)	1,578	652	663	5,222
All other	(1)	55,503	28,768	32,758	28,501
Total	72,596	155,152	211,538	241,001	273,174
			Value *(1,000 dollars)*		
Netherlands	(1)	53,093	112,412	130,893	151,919
Canada	(1)	46,088	82,218	84,311	94,319
Japan	(1)	16,683	24,014	37,778	37,333
Australia	(1)	20,842	23,612	34,741	28,753
Mexico	(1)	6,210	8,155	14,229	25,191
Israel	(1)	5,352	8,608	11,752	15,756
United Kingdom	(1)	9,796	25,687	21,468	14,577
Argentina	(1)	1,630	1,859	6,530	12,547
Colombia	(1)	524	132	2,762	8,670
Chile	(1)	2,132	809	1,021	7,690
All other	(1)	89,640	51,294	62,737	59,460
Total	120,788	251,990	338,799	408,223	456,214
			Unit value *(dollars per kilogram)*		
Netherlands	(1)	1.77	1.58	1.72	1.71
Canada	(1)	1.53	1.68	1.64	1.64
Japan	(1)	1.65	1.66	1.81	1.72
Australia	(1)	1.39	1.33	1.41	1.39
Mexico	(1)	2.12	1.96	1.73	1.60
Israel	(1)	1.63	1.25	1.31	1.25
United Kingdom	(1)	1.78	1.48	1.88	1.69
Argentina	(1)	1.52	1.31	1.56	1.55
Colombia	(1)	2.12	3.57	1.50	1.49
Chile	(1)	1.35	1.24	1.54	1.47
All other	(1)	1.62	1.78	1.92	2.09
Average	1.66	1.62	1.60	1.69	1.67

[1] Country-level detail is provided only for years in which there are actual trade data under the new Schedule B (based on the Harmonized Tariff Schedule of the United States).

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table 13
Saturated polyester resins in primary forms: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1988-92[1]

(Million dollars)

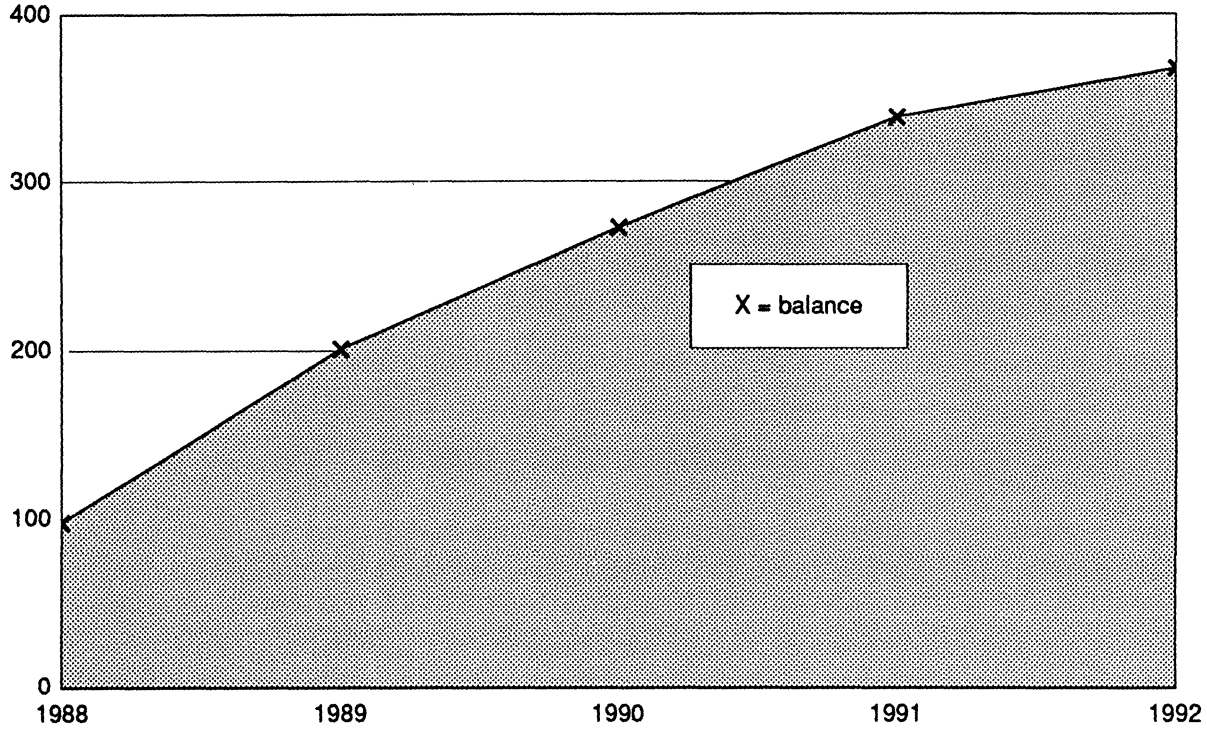
Item	1988	1989	1990	1991	1992
U.S. exports of domestic merchandise:					
Netherlands	(2)	53	112	131	152
Canada	(2)	46	82	84	94
Japan	(2)	17	24	38	37
Mexico	(2)	6	8	14	25
Australia	(2)	21	24	35	29
United Kingdom	(2)	10	26	21	15
Germany	(2)	7	3	3	2
Israel	(2)	5	9	12	16
Argentina	(2)	2	2	7	13
Belgium	(2)	4	6	6	8
All other	(2)	81	43	57	66
Total	121	252	339	408	456
EU-12	(2)	81	157	170	184
OPEC	(2)	5	3	6	8
ASEAN	(2)	4	4	4	4
CBERA	(2)	3	2	3	4
Eastern Europe	(2)	0	0	0	0
U.S. imports for consumption:					
Netherlands	(2)	2	3	1	4
Canada	(2)	1	16	14	17
Japan	(2)	2	6	10	14
Mexico	(2)	3	4	5	6
Australia	(2)	0	0	0	0
United Kingdom	(2)	2	2	3	4
Germany	(2)	10	8	13	15
Israel	(2)	0	0	0	0
Argentina	(2)	0	0	0	0
Belgium	(2)	4	4	3	4
All other	(2)	19	23	20	25
Total	23	51	66	69	88
EU-12	(2)	35	33	33	38
OPEC	(2)	0	0	0	0
ASEAN	(2)	0	0	0	0
CBERA	(2)	0	0	0	0
Eastern Europe	(2)	0	0	0	0
U.S. merchandise trade balance:					
Netherlands	(2)	51	109	130	148
Canada	(2)	45	66	70	77
Japan	(2)	15	18	28	23
Mexico	(2)	3	4	9	19
Australia	(2)	21	24	35	29
United Kingdom	(2)	8	24	18	11
Germany	(2)	-3	-5	-10	-13
Israel	(2)	5	9	12	16
Argentina	(2)	2	2	7	13
Belgium	(2)	0	2	3	4
All other	(2)	62	20	37	41
Total	98	201	273	339	368
EU-12	(2)	46	124	137	146
OPEC	(2)	5	3	6	8
ASEAN	(2)	4	4	4	4
CBERA	(2)	3	2	3	4
Eastern Europe	(2)	0	0	0	0

[1] Import values are based on customs value; export values are based on f.a.s. value, U.S. port of export. U.S. trade with East Germany is included in "Germany" but not "Eastern Europe."

[2] Country-level detail is provided only for years in which there are actual trade data under the Harmonized Tariff Schedule of the United States and under the new Schedule B.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Saturated polyester resin in primary forms: U.S. trade balance, 1988-92



Source: Compiled from official statistics of the U.S. Department of Commerce.

APPENDIX A
GLOSSARY OF INDUSTRY TERMS

GLOSSARY OF INDUSTRY TERMS

Antioxidant	A substance incorporated in a material for the purpose of inhibiting oxidation at normal or elevated temperatures.
Blow Molding	The process of forming hollow articles by expanding a hot plastic element against the internal surfaces of a mold.
Catalyst	A substance that causes or accelerates a chemical reaction when added to the reactant in minor amount, without being permanently affected by the reaction.
Chain Transfer Agent	An agent capable of stopping the growth of a molecular chain by yielding an atom to the active radical at the end of the growing chain, but also in turn being left as a radical that can initiate the growth of a new chain.
Cold Forming	A group of processes by which sheets or billets of thermoplastic materials are formed into three-dimensional shapes at room temperature by processes used in the metalworking industry such as forging, brake press bending, deep drawing, stamping, heading, and coining.
Colorant	Dyes or pigments that import color to plastics.
Copolymer	This term usually denotes a polymer of two chemically distinct monomers.
Dielectric	A material with electrical conductivity less than one millionth of a reciprocal ohm per centimeter, thus so weakly conductive that different parts of its surface can have a different electrical charge.
Environmental Stress Cracking	The formation of external or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength, when such strength has been reduced by aging or exposure to some environmental condition.
Extender	A substance added to the mixture to reduce its cost.
Extrusion	The process of forming continuous shapes by forcing a molten plastic material through a die.
Filler	A relatively inert substance added to plastic compound to reduce its cost and/or to improve physical properties, particularly hardness, stiffness, and impact strength.
Film	Film is distinguished from sheet in the plastic and packaging industries only according to thickness. A web under 10 mils thick is usually called a film.
Flame Retardants	Materials that reduce the tendency of plastics to burn.
Homopolymer	The polymer resulting from the polymerization of a single monomer: a polymer consisting substantially of a single type of repeating unit.

GLOSSARY OF INDUSTRY TERMS—*Continued*

Impact Strength	The ability of a material to withstand shock loading.
Initiator	An agent that causes a chemical reaction to start and becomes a part of the resultant compound.
Injection Molding	The method of forming objects from granular or powdered plastics, most often of the thermoplastic type, in which the material is fed from a hopper to a heated chamber in which it is softened, after which a ram or screw forces the material into a mold.
Intrinsic Viscosity	In dilute solution viscosity measurements, intrinsic viscosity is the limit of the reduced and inherent viscosities as the concentration of the polymeric solute approaches zero and represents the capacity of the polymer to increase viscosity.
Liquid Crystal Polymers	A wholly aromatic copolyester that exhibits a highly ordered structure in both the melt and solid states. Properties include high tensile and flexural properties, UV radiation stability, and are transparent to microwaves.
Melt Index	The amount, in grams, of a thermoplastic resin that can be forced through an orifice of 0.0825 inch diameter when subjected to a force of 2,160 grams in 10 minutes at 190 °C. The test is performed by an extrusion rheometer described in ASTM D 1238.
Molecular Weight	The sum of the atomic weights of all atoms in molecule.
Monomer	A relatively simple compound, usually containing carbon and of low molecular weight, that can react to form a polymer by combination with itself or with other similar molecules or compounds.
Plasticizer	A substance or material incorporated in a material (usually a plastic or an elastomer) to increase its flexibility, workability or distensibility.
Polyarylate	Polymers that are aromatic polyesters derived from aromatic dicarboxylic acids and diphenols. They are heat-resistant thermoplastics with excellent toughness, UV stability, flexural recovery, dimensional stability, flame retardance, and electrical properties.
Polybutylene Terephthalate	A member of the polyalkyleneterephthalate family, similar to polyethylene terephthalate in that it is derived from a polycondensate derived from terephthalic acid whose diol component is butanediol rather than glycol. Properties include high strength, dimensional stability, low moisture absorption, good electrical characteristics and resistance to heat and chemicals when suitably modified.

GLOSSARY OF INDUSTRY TERMS—*Continued*

Polycyclohexylenedimethylene Terephthalate	A high-temperature, semicrystalline, thermoplastic polyester produced by reacting 1,4-cyclohexane dimethanol with dimethyl terephthalate. The resin has high heat deflection temperature values, low moisture absorption, and outstanding chemical resistance.
Polyethylene Naphthalate	A material developed by Teijin Ltd., described as having a naphthalene core chemical structure which includes two additional benzene nuclei.
Polyethylene Terephthalate	A saturated, thermoplastic polyester resin made by condensing ethylene glycol and terephthalic acid, used for fibers, films, and molded parts. It is extremely hard, wear-resistant, dimensionally stable, resistant to chemicals, and has good dielectric properties.
Polymer	The product of a polymerization reaction.
Polymerization	A chemical reaction in which the molecules of a simple substance (monomer) are linked together to form large molecules whose molecular weight is a multiple of that of the monomer.
Resins	The term resin is defined by ASTM (D 883-75a) as a solid or pseudosolid material, often of high molecular weight, that exhibits a tendency to flow when subjected to stress, usually has a softening or melting range, and usually fractures conchoidally. A note added to this ASTM definition explains that in a broad sense, the term is used to designate any polymer that is a basic material for plastics.
Saturation	The state in which all available valence bonds of an atom (especially carbon) are attached to other atoms.
Sheet	Sheet is distinguished from film in the plastic and packaging industry only according to thickness. A web over 10 mils is usually called a sheet.
Shore D Hardness	The hardness of a material as determined by either the size of an indentation made by an indenting tool under a fixed load, or the load necessary to produce penetration of the indenter to a predetermined depth.
Tensile Strength	The maximum tensile stress sustained by the specimen during a tension test. The result is usually expressed in pounds per square inch, the area being that of the original specimen at the point of rupture rather than the reduced area after break.
Thermoforming	The process of forming a thermoplastic sheet into a three-dimensional shape by clamping the sheet in a frame, heating it to render it soft and flowable, then applying differential pressure to make the sheet conform to the shape of a mold or die positioned below the frame.

Unsaturation	The state in which not all the available valence bonds along the alkyl chain are satisfied; in such compounds the extra bonds usually form double or triple bonds (chiefly with carbon).

Source: *Whittington's Dictionary of Plastics, Hawley's Condensed Chemical Dictionary,* and *Modern Plastics Encyclopedia.*

APPENDIX B
EXPLANATION OF TARIFF AND TRADE AGREEMENT TERMS

TARIFF AND TRADE AGREEMENT TERMS

The ***Harmonized Tariff Schedule of the United States*** (HTS) replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989. Chapters 1 through 97 are based upon the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description, with additional U.S. product subdivisions at the 8-digit level. Chapters 98 and 99 contain special U.S. classification provisions and temporary rate provisions, respectively.

Rates of duty in the ***general*** subcolumn of HTS column 1 are most-favored-nation (MFN) rates; for the most part, they represent the final concession rate from the Tokyo Round of Multilateral Trade Negotiations. Column 1-general duty rates are applicable to imported goods from all nonembargoed countries except those enumerated in general note 3(b) to the HTS plus Serbia and Montenegro, whose products are dutied at the rates set forth in ***column 2***. Goods from Albania, Armenia, Belarus, Bulgaria, the People's Republic of China, the Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Mongolia, Poland, Romania, Russia, Slovakia, Turkmenistan, Ukraine, and Uzbekistan are currently eligible for MFN treatment, as are the other republics of the former Socialist Federal Republic of Yugoslavia. Among articles dutiable at column 1-general rates, particular products of enumerated countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the **special** subcolumn of HTS column 1. Where eligibility for special tariff treatment is not claimed or established, goods are dutiable at column 1-general rates.

The ***Generalized System of Preferences*** (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 and renewed in the Trade and Tariff Act of 1984, applies to merchandise imported on or after January 1, 1976 and before September 30, 1994. Indicated by the symbol "A" or "A*" in the special subcolumn of column 1, the GSP provides duty-free entry to eligible articles the product of and imported directly from designated beneficiary developing countries, as set forth in general note 4 to the HTS.

The ***Caribbean Basin Economic Recovery Act*** (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984; this tariff preference program has no expiration date. Indicated by the symbol "E" or "E*" in the special subcolumn of column 1, the CBERA provides duty-free entry to eligible articles, and reduced-duty treatment to certain other articles, which are the product of and imported directly from designated countries, as set forth in general note 7 to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free Trade Area Implementation Act*** of 1985 (IFTA), as provided in general note 8 to the HTS. Where no rate of duty is provided for products of Israel in the special subcolumn for a particular provision, the rate of duty in the general subcolumn of column 1 applies.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn of column 1 followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the ***Andean Trade Preference Act*** (ATPA), enacted in title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 11 to the HTS.

Preferential rates of duty in the special subcolumn of column 1 followed by the symbol "CA" are applicable to eligible goods of Canada, and those followed by the symbol "MX" are applicable to eligible goods of Mexico, under the **North American Free Trade Agreement**, as provided in general note 12 to the HTS, effective January 1, 1994.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), goods covered by the ***Automotive Products Trade Act*** (APTA) (general note 5) and the ***Agreement on Trade in Civil Aircraft*** (ATCA) (general note 6), and ***articles imported from freely associated states*** (general note 10).

The ***General Agreement on Tariffs and Trade*** (GATT) (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) is a multilateral agreement setting forth basic principles governing international trade among its signatories. The GATT's main obligations relate to most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national (nondiscriminatory) treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, antidumping and countervailing duties, and other measures. Results of GATT-sponsored multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX.

Officially known as "The Arrangement Regarding International Trade in Textiles," the ***Multifiber Arrangement*** (MFA) provides a framework for the negotiation of bilateral agreements between importing and producing countries, or for unilateral action by importing countries in the absence of an agreement. These bilateral agreements establish quantitative limits on imports of textiles and apparel, of cotton and other vegetable fibers, wool, man-made fibers and silk blends, in order to prevent market disruption in the importing countries—restrictions that would otherwise be a departure from GATT provisions. The United States has bilateral agreements with many supplying countries, including the four largest suppliers: China, Hong Kong, the Republic of Korea, and Taiwan.

APPENDIX C
STATISTICAL TABLES

Table C-1
Polyethylene terephthalate: U.S. exports of domestic merchandise, by principal markets, 1989-92[1]

Market	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Netherlands	23,880	53,958	57,393	66,203
Canada	18,994	37,612	40,429	44,632
Australia	14,781	17,592	24,462	20,431
Japan	7,116	11,977	17,456	16,252
Mexico	802	642	2,757	10,927
Israel	3,227	6,728	8,856	12,436
United Kingdom	4,980	15,689	10,503	8,213
Argentina	1,033	1,357	4,046	7,802
Colombia	200	0	1,757	5,704
Chile	1,546	635	648	5,179
All other	41,894	19,355	22,417	20,655
Total	118,453	165,545	190,724	218,435
	Value (1,000 dollars)			
Netherlands	42,149	80,156	92,025	106,691
Canada	27,714	49,721	52,987	57,150
Australia	20,394	23,069	33,987	27,850
Japan	10,280	16,134	25,606	22,586
Mexico	1,714	1,368	4,150	15,363
Israel	4,766	8,150	11,528	15,269
United Kingdom	7,821	20,676	19,473	12,987
Argentina	1,459	1,663	6,088	11,791
Colombia	361	0	2,543	8,328
Chile	2,065	762	972	7,552
All other	65,094	30,048	37,160	34,881
Total	183,818	231,748	286,519	320,448
	Unit value (dollars per kilogram)			
Netherlands	1.77	1.49	1.60	1.61
Canada	1.46	1.32	1.31	1.28
Australia	1.38	1.31	1.39	1.36
Japan	1.44	1.35	1.47	1.39
Mexico	2.14	2.13	1.51	1.41
Israel	1.48	1.21	1.30	1.23
United Kingdom	1.57	1.32	1.85	1.58
Argentina	1.41	1.23	1.50	1.51
Colombia	1.80	0	1.45	1.46
Chile	1.34	1.20	1.50	1.46
All other	1.55	1.55	1.66	1.69
Average	1.55	1.40	1.50	1.47

[1] Comparable data for 1988 are not available.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-2
Other polyesters: U.S. exports of domestic merchandise, by principal markets, 1989-92[1]

Market	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Netherlands	6,033	17,006	18,717	22,422
Canada	11,074	11,463	10,882	12,861
Japan	2,983	2,491	3,361	5,437
Mexico	2,134	3,511	5,460	4,842
Belgium	1,620	1,385	1,791	1,384
France	1,162	1,085	1,948	689
Taiwan	338	429	621	1,276
South Korea	1,214	1,016	1,299	998
Brazil	200	330	518	460
United Kingdom	530	1,651	923	419
All other	9,410	5,626	4,758	3,951
Total	36,698	45,993	50,278	54,739
	Value (1,000 dollars)			
Netherlands	10,944	32,256	38,868	45,228
Canada	18,374	32,496	31,324	37,169
Japan	6,403	7,880	12,171	14,747
Mexico	4,496	6,787	10,079	9,828
Belgium	2,697	4,982	4,658	5,917
France	2,814	3,603	3,920	2,872
Taiwan	944	767	1,223	2,766
South Korea	1,798	2,312	3,610	2,488
Brazil	701	1,291	2,339	1,871
United Kingdom	1,975	5,011	1,995	1,590
All other	17,026	9,667	11,516	11,291
Total	68,172	107,051	121,704	135,766
	Unit value (dollars per kilogram)			
Netherlands	1.81	1.90	2.08	2.02
Canada	1.66	2.83	2.88	2.89
Japan	2.15	3.16	3.62	2.71
Mexico	2.11	1.93	1.85	2.03
Belgium	1.67	3.60	2.60	4.28
France	2.42	3.32	2.01	4.17
Taiwan	2.79	1.79	1.97	2.17
South Korea	1.48	2.27	2.78	2.49
Brazil	3.51	3.92	4.51	4.07
United Kingdom	3.73	3.03	2.16	3.80
All other	1.81	1.72	2.42	2.86
Average	1.86	2.33	2.42	2.48

[1] Comparable data for 1988 are not available.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-3
Polyethylene terephthalate, bottle-grade resins: U.S. imports for consumption, by principal sources, 1989-92[1] [2]

Source	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Taiwan	0	0	0	951
Canada	0	179	165	542
Netherlands	0	2	0	178
South Korea	0	0	36	179
United Kingdom	2	14	0	81
Germany	4	0	([3])	30
Colombia	0	0	0	19
Mexico	102	92	3	5
Pakistan	0	0	0	19
Italy	0	6	8	1
All other	68	41	3	4
Total	176	334	215	2,010
	Value (1,000 dollars)			
Taiwan	0	0	0	1,084
Canada	0	151	105	471
Netherlands	0	3	0	148
South Korea	0	0	38	107
United Kingdom	4	15	0	48
Germany	7	0	12	28
Colombia	0	0	0	14
Mexico	115	49	7	7
Pakistan	0	0	0	6
Italy	0	10	3	5
All other	83	22	2	8
Total	210	251	168	1,925
	Unit value (dollars per kilogram)			
Taiwan	0	0	0	1.14
Canada	0	0.84	0.64	0.87
Netherlands	0	1.82	0	0.83
South Korea	0	0	1.05	0.60
United Kingdom	2.00	1.07	0	0.59
Germany	1.67	0	39.62	0.92
Colombia	0	0	0	0.72
Mexico	1.12	0.53	2.48	1.42
Pakistan	0	0	0	0.29
Italy	0	1.59	0.40	5.12
All other	1.23	0.55	0.80	1.82
Average	1.19	0.75	0.78	0.96

[1] U.S. trade with East Germany is included in "Germany".

[2] Comparable data for 1988 are not available.

[3] Less than 500 kilograms.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-4
Polyethylene terephthalate, other than bottle-grade resins: U.S. imports for consumption, by principal sources, 1989-92[1] [2]

Source	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Canada	196	12,693	12,107	16,112
Japan	52	1,724	2,929	4,274
Mexico	244	1,956	5,117	5,467
Brazil	1,759	1,022	1,103	1,434
Taiwan	9	0	81	1,727
United Kingdom	2	2	0	273
Belgium	17	292	187	62
Germany	288	28	102	94
France	200	24	9	49
Venezuela	0	0	0	120
All other	643	1,475	693	284
Total	3,408	19,217	22,328	29,895
	Value (1,000 dollars)			
Canada	94	14,554	13,502	15,584
Japan	186	2,427	4,801	7,071
Mexico	439	2,088	4,266	4,397
Brazil	2,461	1,485	1,479	1,758
Taiwan	9	0	53	1,428
United Kingdom	16	15	0	270
Belgium	52	598	695	237
Germany	928	260	236	235
France	299	83	25	90
Venezuela	0	0	0	54
All other	2,338	3,300	1,320	182
Total	6,822	24,811	26,376	31,304
	Unit value (dollars per kilogram)			
Canada	0.48	1.15	1.12	0.97
Japan	3.61	1.41	1.64	1.65
Mexico	1.80	1.07	0.83	0.80
Brazil	1.40	1.45	1.34	1.23
Taiwan	1.07	0	0.65	0.83
United Kingdom	9.02	6.64	0	0.99
Belgium	3.07	2.04	3.72	3.83
Germany	3.22	9.41	2.32	2.50
France	1.50	3.51	2.95	1.83
Venezuela	0	0	0	0.45
All other	3.63	2.24	1.90	0.64
Average	2.00	1.29	1.18	1.05

[1] U.S. trade with East Germany is included in "Germany".

[2] Comparable data for 1988 are not available.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-5
Polybutylene terephthalate: U.S. imports for consumption, by principal sources, 1989-92[1] [2]

Source	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Germany	1,426	1,221	1,533	2,039
Japan	48	197	288	441
Netherlands	106	209	76	217
Belgium	553	21	0	206
Luxembourg	480	0	167	373
Taiwan	18	0	0	78
United Kingdom	15	18	12	25
Canada	1	0	0	2
France	0	0	0	6
All other	25	58	2	284
Total	2,672	1,724	2,078	3,387
	Value (1,000 dollars)			
Germany	4,027	3,179	4,189	5,676
Japan	344	742	1,046	1,767
Netherlands	348	763	339	1,051
Belgium	1,544	53	0	825
Luxembourg	659	0	335	751
Taiwan	32	0	0	199
United Kingdom	89	92	27	119
Canada	2	0	0	10
France	0	0	0	3
All other	36	189	2	0
Total	7,081	5,019	5,939	10,402
	Unit value (dollars per kilogram)			
Germany	2.82	2.60	2.73	2.78
Japan	7.14	3.77	3.64	4.01
Netherlands	3.28	3.65	4.46	4.85
Belgium	2.79	2.54	0	4.02
Luxembourg	1.37	0	2.01	2.01
Taiwan	1.81	0	0	2.54
United Kingdom	5.74	5.18	2.25	4.78
Canada	1.78	0	0	4.62
France	0	0	0	0.48
All other	1.41	3.27	1.00	0
Average	2.65	2.91	2.86	3.07

[1] U.S. trade with East Germany is included in "Germany".

[2] Comparable data for 1988 are not available.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Table C-6
Other polyesters: U.S. imports for consumption, by principal sources, 1988-92[1] [2]

Source	1989	1990	1991	1992
	Quality (1,000 kilograms)			
Luxembourg	3,568	2,940	2,661	2,413
Germany	1,509	1,591	2,245	1,696
Japan	119	655	950	1,116
Switzerland	839	628	981	2,170
United Kingdom	574	704	867	728
Belgium	1,248	1,261	836	1,429
Taiwan	2,125	2,434	1,128	1,408
Netherlands	149	508	345	796
Mexico	1,867	1,035	777	1,526
Austria	87	103	262	277
All other	1,372	941	826	893
Total	13,457	12,799	11,878	14,450
	Value (1,000 dollars)			
Luxembourg	14,745	11,127	9,594	9,972
Germany	5,218	4,678	8,962	8,675
Japan	1,354	2,773	4,156	5,317
Switzerland	1,844	1,414	2,130	3,705
United Kingdom	1,812	2,352	3,015	3,257
Belgium	2,853	3,765	1,971	3,164
Taiwan	3,935	3,635	1,647	2,726
Netherlands	358	1,453	1,049	2,427
Mexico	2,358	1,430	906	1,380
Austria	193	265	580	901
All other	2,255	2,809	2,902	2,542
Total	36,927	35,700	36,913	44,064
	Unit value (dollars per kilogram)			
Luxembourg	4.13	3.78	3.61	4.13
Germany	3.46	2.94	3.99	5.12
Japan	11.43	4.23	4.37	4.77
Switzerland	2.20	2.25	2.17	1.71
United Kingdom	3.16	3.34	3.48	4.48
Belgium	2.29	2.99	2.36	2.21
Taiwan	1.85	1.49	1.46	1.94
Netherlands	2.40	2.86	3.05	3.05
Mexico	1.26	1.38	1.17	0.90
Austria	2.20	2.58	2.21	3.25
All other	1.64	2.99	3.51	2.85
Average	2.74	2.79	3.11	3.05

[1] U.S. trade with East Germany is included in "Germany".
[2] Comparable data for 1988 are not available.
Source: Compiled from official statistics of the U.S. Department of Commerce.