1977

THE ADHESIVES INDUSTRY TO 1985

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DELPHI MARKETING SERVICES, INC.
400 EAST 89th STREET, NEW YORK, N.Y. 10028

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INTRODUCTION

The adhesives industry touches upon practically every aspect of the economy. From about $640 million in 1970, shipments have grown to about $1,280 million in 1976, a growth rate of 12.3 percent annually. Adhesives compete with many other type of fasteners, such as nails, solder, bolts, and hinges. The total fasteners industry accounted for about $3.1 billion of shipments in 1976 (see Table 1), a 11-percent annual growth rate since 1970.

TABLE 1

U.S. Fastener Industry Shipments, 1960-1985
(millions of dollars)

Year	Value
1960	$1,045
1965	1,480
1970	1,658
1975	2,980
1976	3,100
1980	4,100
1985	5,000

Source: Census of Manufactures, 1972; U.S. Industrial Outlook; estimates by Delphi Marketing Services, Inc.

An adhesive is any substance that produces a bond between two or more similar or dissimilar substrates. The term "adhesive" has now become generic, and also includes within its definition glue, paste, and cement. The adhesives industry is difficult to define because many substances with adhesive properties are used in applications where the bonding function is secondary to other functions.

This study will limit itself to the adhesives industry, and will discuss those materials that are specifically formulated for their adhesive properties. There are a large number of different formulated

adhesives based on a wide variety of different bonding substances and used in many different applications. The study discusses the various types of adhesives as well as the markets for each by type and by end-use. Also included will be a description of the industry structure and a detailed description of the major adhesives companies. The information for this marketing study was compiled from various sources. Government sources included the Census of Manufactures and the Annual Survey of Manufactures. Information was also obtained from various trade associations, trade journals, and company annual reports and prospectuses.

Nature and Scope of the Adhesives Industry

The adhesives industry is extremely complex and diverse. Its growth, because of the diverse nature of its end-uses, can be related to Gross National Product. Production of adhesives is reported by the Bureau of the Census in SIC category 2891 entitled "Adhesives and Sealants". This excludes adhesives manufactured from captively produced materials within the plant which are found in SIC category 2891. Production of elastomers (excluding rubber cement) are found in SIC category 2911; fillers and extenders are in SIC category 2851.

The data reported by the Bureau of the Census are believed to be somewhat low, perhaps representing 85 to 90 percent of the annual volume consumed. Adhesives are classified in several ways:

- By the raw material origin
- By form
- By type of bonding agent

Adhesives are often grouped into those of natural and synthetic origins. Adhesives of natural origin in turn are broken down into those of animal, protein, vegetable, and mineral. Materials of animal origin are derived from either animal hides or bones. Protein-adhesives are produced from casein, soybean, blood, albumen and fish. Those of vegetable origin are primarily starch and dextrin. Mineral types of adhesives include sodium silicate, ceramic pastes and asphalt.

Synthetic adhesives consist of both thermosetting and thermoplastic resins. Rubber-base adhesives may be derived from either natural or synthetic rubber. All of the major adhesives are described in detail in the demand section of the report.

Adhesives have many diverse applications. The major outlets, which are described in greater detail in subsequent sections of this report, include:

- Primary Wood Products
- Packaging and Converted Paper Products
- Construction
- Textiles
- Foundry Binders
- Transportation
- Gummed Products

Other important uses are in the manufacture of coated and bonded abrasives, friction materials, printing and publishing, footwear, appliances and furniture.

Many of the adhesives have several end-use applications, while others have only one or two. The most versatile of the adhesives is polyvinyl acetate, which finds application in such areas as packaging, consumer products, and the furniture industry.

SUMMARY

The adhesives industry is quite diverse and highly competitive. In 1976 consumption of adhesives amounted to about 3.8 billion pounds of materials, on a non-formulated dry basis weight, worth about $1.3 billion. Table S1 shows the shipments of adhesives by type of material since 1960. Consumption is projected to increase to about 6.0 billion pounds in 1985 for an annual growth rate of five percent. Much of this growth will come from thermoplastics.

The adhesives market is analyzed according to the following sections of this report.

- Industry Structure
- Demand by Type of Material
- Demand by End-Use Markets
- Marketing Characteristics
- New Developments
- Outlook

Industry Structure

The adhesives industry is a diffuse and complex industry because the raw materials are produced from a number of different sources. There are a large number of formulators as large capital investments are not required, and there are many small customers. The industry has both large and small producers. The four largest producers (National Starch and Chemical Company, Borden, Inc., H. B. Fuller and E.I. du Pont de Nemours) account for about 19 percent of the market. The larger companies offer a broad line of adhesives on a national distribution basis and that may or may not be a significant part of their total sales. The smaller companies usually restrict themselves to one or two types of adhesives and/or to fairly narrow end-use markets.

Both backward and forward integration is occurring in the adhesives industry. Since 1970, there have been over 40 mergers and acquisitions. Formulators have been attempting to acquire consumer market distribution. Several companies, such as Borden, captively use their resin to produce adhesives. Captive usage is expected to increase for 12 percent of the produced materials in 1976 to 18 percent in 1985.

TABLE S1

U.S. Shipments of Total Adhesive Materials, 1960-1985
(millions of pounds[1])

Year	Natural Resins	Elastomers	Synthetics *	Total Adhesives
1960	702	157	677	1,536
1961	714	181	747	1,642
1962	742	199	877	1,818
1963	814	207	948	1,969
1964	811	223	1,074	2,108
1965	756	241	1,227	2,224
1966	755	263	1,337	2,355
967	724	317	1,381	2,422
968	743	328	1,581	2,652
969	741	342	1,732	2,815
970	760	353	1,796	2,909
971	759	377	2,057	3,193
972	763	411	2,389	3,563
973	779	419	2,500	3,698
974	787	249	2,541	3,577
975	794	441	2,294	3,529
976	806	452	2,591	3,849
980	832	500	3,475	4,807
985	859	565	4,588	6,012

[1] Dry weight basis is the total weight of the material including resin and coloring agents, extenders, fillers, plasticizers and other additives (except water and other liquid diluents).

Source: Delphi Marketing Services, Inc.

* PVAc IS INCLUDED IN THESE TOTALS

Demand by Type of Resin

Adhesives are produced for natural materials, elastomers and thermosetting and thermoplastic resins. Thermosetting resins account for the largest market share as shown in Table S2 and Figure 1. Thermoplastics*, while smaller in size, are increasing at a faster rate of growth.

*(PVAc IN THIS MARKET)

TABLE S2

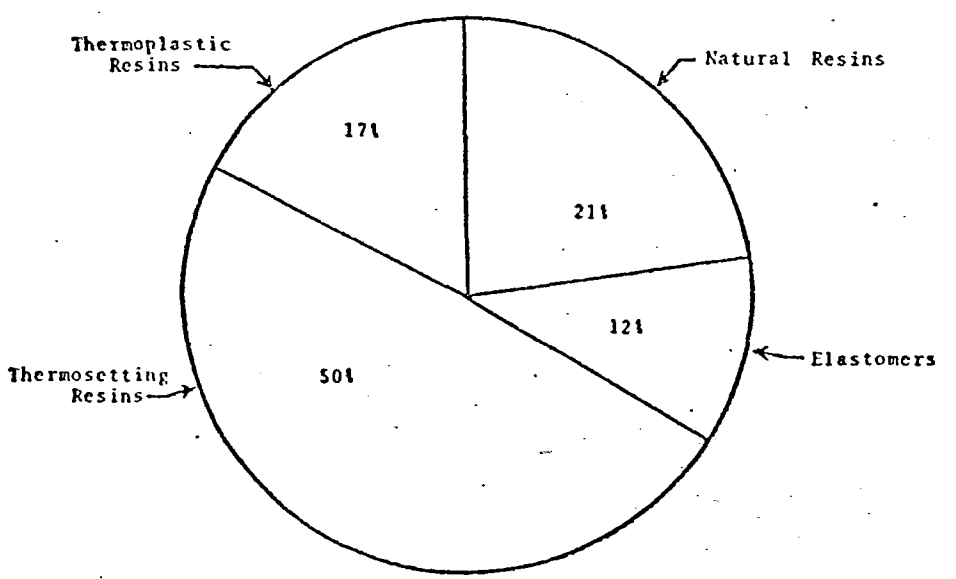
Adhesive Shipments By Type of Resin, 1976
(millions of pounds)

Type of Resin	Quantity	Percent	Growth 1970-1975
Natural Resins	806	20.9%	0.9%
Elastomers	452	11.7	5.0
Thermosets	1,919	49.9	7.5
Thermoplastics	672	17.5	12.1
Total	3,849	100%	5.4%

Source: Delphi Marketing Services, Inc.

FIGURE S1

Domestic Shipments of Adhesives By Type, 1976
(percent)



Source: Delphi Marketing Services, Inc.

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Many of the older adhesives were based on natural materials. Asphalt/bituminous resins are the largest in size with shipments of 354 million pounds in 1976, or 44 percent of the market. Vegetable glues rank second in size with about 40 percent. Animal and protein-based adhesives are decreasing in importance. In 1960 they accounted for about 60 percent of all natural-based adhesives, but in 1976 they accounted for only about 16 percent.

Elastomer-based adhesives accounted for about 12 percent of the market in 1976. Most elastomers are in combination with other rubber and synthetic resins. In 1976, about 452 million pounds worth about $213 million were utilized. Elastomers are used in rubber cements which are mostly solvent-based. About 335 million pounds of rubber in combination with other resins were consumed.

Thermosetting resins are the resins most frequently used in adhesives, with about 50 percent of the market. Of these resins, phenolics is the oldest and largest with about 45 percent of the thermoset market. Amino resins are the second largest with shipments of about 820 million pounds.

Thermoplastic resins account for about 17 percent of the market (dry basis weight) and are growing about 12 percent annually. About 48 percent of the thermoplastics include some form of vinyl, such as polyvinyl acetate. Hot-melts, while not specific resins, account for 38 percent of the thermoplastics.

Demand by End-Use Markets

Information on the end-use markets for adhesives are difficult to obtain and are at best estimates. Table S3 and Figure S2 show consumption of adhesives by major end-use categories. Primary wood products is the largest with 31 percent of the market, followed by packaging and converted paper products (19 percent) and construction (15 percent).

Marketing Characteristics

Distribution chemicals for adhesives depend on the end-use, type adhesive, quantity and technical service required, and size of producer. Adhesives may be sold directly to large industrial or related consumers, or directly through formulators, wholesalers, and jobbers. There are over 500 adhesive formulators, most of which are

TABLE S3

Identified End-Use Markets for Adhesives, 1976
(millions of pounds)

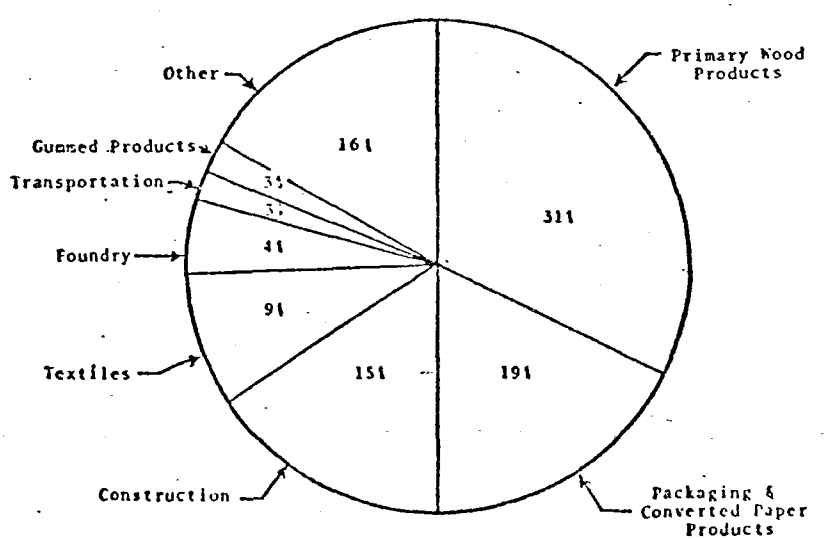
End-Use Markets	Quantity	Percent
Primary Wood Products	1,211	31%
✓ Packaging & Converted Paper Products	745	19
✓ Construction	590	15
✓ Textiles	362	9
Foundry	170	4
Transportation	110	3
Gummed Products	108	3
✓ Other (Printing & Publishing, Consumer Products, Footwear, Furniture, Appliances & Electrical Equipment, Friction Materials, and Bonded Adhesives)	553	16
Total	3,849	100%

✓ PVAc MARKETS

Source: Delphi Marketing Services, Inc.

FIGURE S2

Domestic Consumption By End-Use Market, 1976
percent)



Source: Delphi Marketing Services, Inc.

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small and specialize in specific end-use markets. On a weight basis they account for about 30 percent of the market, but more on a dollar basis.

Adhesive producers are distributed in almost every state, although some areas have a greater concentration. The midwest and northeast have close to 70 percent of the adhesive establishments. Prices vary according to the adhesive binder. Many of the industrial adhesives are customer formulated and the prices are arrived at through negotiated contracts.

New Developments

New developments in the adhesive industry have been mostly in the type of materials utilized and their methods of bonding. Most have been in response to specific customer needs and among these are:

- More types of adhesives will be developed to meet specific customer needs, such as mending and mounting tapes that are used at room temperature. Adhesives are also, for example, being developed for textile interlinings and fusible webs for nonwovens.
- The development and modification of new resins such as cyanoacrylate and anaerobics. One-component, moisture-curing systems are expected to gain wider usage.
- New methods of curing, such as U.V., high-frequency radiation and electromagnetic bonding are being developed for specific end-use markets.
- The development of hot-melt pressure-sensitive adhesives for tapes and labels instead of solvent-based rubber cements.
- Hot-melts are being developed for non-packaging product assembly line application. Copolymers are being used to extend the performance range of the resins.
- Easier methods of application are being developed. Micro-encapsulated adhesives, for example, cure when broken under pressure.
- Catalysts are being developed that require less energy and cure time for adhesives.

Outlook

Total adhesive consumption (dry basis weight) is expected to reach a level of about 6.0 million pounds by 1985, for a ten-year annual growth rate of about 5.3 percent (see Table S4). Synthetic adhesives are increasing faster than those based on natural resins or elastomers and are expected to account for about 74 percent of the market.

TABLE S4

U.S. Consumption of Adhesives, 1960-1985

	Quantity (millions of pounds)	Value (millions of dollars)	Growth Rates
1960	1,536	$384	
1965	2,224	511	7.7%
1970	2,909	641	5.5
1975	3,529	1,160	4.0
1980	4,807	1,630	6.0
1985	6,012	2,200	4.6

Source: Delphi Marketing Services, Inc.

Market shares for most end-uses are expected to remain about the same. Greater than average growth is expected in such potential markets as primary wood products, construction, textiles, and foundry binders.

Hot-melt adhesives are expected to be the fastest growing resin. Demand is expected to increase from about 250 million pounds in 1976 to about 550 million pounds in 1985. They are expected to penetrate the pressure-sensitive market and replace solvent-based rubber adhesives.

INDUSTRY STRUCTURE

Introduction

The adhesives industry is diffuse and complex. Part of the reason stems from the fact that the raw materials for adhesives are produced from a number of different sources. For instance, naturally occurring materials for adhesives are produced by vegetable processors and meat packers, while the chemical industry produces synthetic resins and plastics for adhesives production. Also, because of the wide variety of formulations being produced for specific needs, products are not uniform. In addition, many products are used secondarily for their adhesive function and primarily for other functions.

Another reason for the disperse nature of this industry lies in the fact that there are literally hundreds of thousands of customers for adhesives, many of whom are extremely small and buy many different types of formulations. This has fostered a fragmented industry.

Industry Concentration

The industry can be divided into formulators and raw material suppliers. At the same time there are a number of companies that manufacture adhesives from resins produced captively in their plants. The Adhesives Redbook lists over 1,000 suppliers of adhesives and, according to the 1972 Census of Manufactures, there were 463 establishments actually involved in the adhesives and gelatin industry. It is estimated that there are probably 700 formulators in the adhesives industry. Table 3 lists the number of suppliers by the major types of adhesives produced.

The four largest adhesive companies account for about 19 percent of the market; the 50 largest account for about 76 percent as shown in Table 2. Table 4 shows the concentration of adhesive establishments by number of employees.

TABLE 2

Market Share by Size of Adhesive Company, 1972
(percent)

Size	% of Shipments
4 largest companies	19%
8 largest companies	31
20 largest companies	52
50 largest companies	76

Source: U.S. Bureau of Census.

TABLE 3

Number of Suppliers of the Major Types of Adhesives, 1976

Natural-based Adhesives	Number of Suppliers
Animal Glue	68
Blood Glue	6
Casein Glue	58
Fish Glue	18
Soybean Glue	10
Edible Gelatin	1
Linseed Glue	1
Flexible Glue	2
Silica Base Cement	1
Dextrin	96
Starch	95
Natural Gums	7
Guar Gum	7
Furcelleran	1
Agar	1
Alginates	1
Gelatin	6
Gum Arabic	12
Wheat Wallpaper Paste	1
Cross Linking Acrylic	1
Rubber-based Adhesives	
Butadiene-Styrene Rubber	195
Butyl Rubber	114
Chlorinated Rubber	109
Natural Rubber	196
Polychloroprene	127
Polyurethane Rubber	119
Thermoplastic Adhesives	
Acrylate-Vinyl Acetate Copolymer	152
Cellulose Nitrate	117
Polyamide	104

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TABLE 3 (Continued)

Number of Suppliers of the Major Types of Adhesives, 1976

Thermoplastic Adhesives (Cont.)	Number of Suppliers
Polyester	88
Polystyrene	61
Polyvinyl Acetate	139
Polyvinyl Alcohol	116
Polyvinyl Chloride	135
Thermosetting Adhesives	
Epoxy	264
Melamine Formaldehyde	30
Phenol Formaldehyde	40
Phenolic	62
Polyester	83
Silicone Resins	45
Urea Formaldehyde	47
Two-Polymer Adhesives	
Neoprene-Phenolic	120
Nitrile-Phenolic	88
Nylon-Epoxy Resins	41
Polyvinyl-Phenolic	40
Miscellaneous Adhesives	
Bitumen-Asphaltic	74
Ceramic	22
Lacquer	63
Shellac	15
Silicates (Soluble)	24

Source: Delphi Marketing Services, Inc.

Very few companies offer a broad line of adhesives. Most strict themselves to one or two types of adhesives and/or restrict emselves toward a fairly narrow end-use market. The number of mpanies supplying the major types are listed in the Marketing aracteristics Section. Appendix B of this report provides a more mplete list of the types of adhesives by supplier.

In the synthetic resins portion of the adhesives industry, it s estimated that approximately 250 companies manufacture synthetic ihesives. Here again, a very few firms account for probably half of ie total sales in this portion of the industry.

dhesive Suppliers

The adhesives industry comprises both large and small manufacturers ho in turn sell to formulators, supplying both synthetic and natural ased adhesives in many different forms. At the same time, many ormulators have integrated backward to manufacture their own resins.

Approximately seven percent of the establishments, those with 10 or more employees, accounted for 35 percent of the industry shipments in 1972. This concentration of establishments and shipments has not varied significantly from the data shown in the 1963 and 1967 Census as shown in Table 4.

The top 39 merchant adhesive formulators are ranked according to size of sales in Table 5. National Starch and Borden are the two largest suppliers. National Starch is relatively concentrated in two market areas: packaging and paper converting. Adhesives are an important percent of its total sales. Borden, in comparison, is a very large formulator of a more general line of synthetic adhesives. Its adhesive sales are a small percentage of its total sales. They also supply monomer raw materials to other adhesives manufacturers and are well-known for their consumer line of "Elmer's Glue".

H.B. Fuller is the third largest supplier. Its sales are in the industrial adhesives area, with major emphasis on the packaging and paper converting markets.

The Loctite Corporation, while smaller in dollar sales, is rhaps the most highly specialized company. It supplied specialty anaerobics to the transportation industry.

TABLE 5

Sales of the Top Adhesive Formulators, 1976
(millions of dollars)

Company	Total Sales	Adhesives	Formulated Adhesives Sales
National Starch & Chemical Corp.	$339	40.0%	$110
Borden Inc.	338	3.0	103
H. B. Fuller Co.	168	58.0	98
3M Company	3,514	2.0	70
E. I. du Pont de Nemours & Company	8,361	0.6	47
Loctite Corp.	86	50.0	43
Monsanto Co.	4,270	1.0	42
Ashland Oil Inc. (Inland Chemical Co.)	4,348	0.9	40
IMC (International Minerals & Chemical Corp.)	1,260	2.7	34
United States Gypsum Co.	963	3.0	29
Champion International (Roberts Consolidated Inc.)	2,911	0.9	25
Estech Inc. (Swift Chemical Co.)	5,301	0.4	20
Armstrong Cork Company	981	2.0	20
Hooker Chemicals & Plastics Corp.	761	2.5	19
W. R. Grace & Co.	3,615	0.5	17
CPC International (Acme Resin Division)	2,696	0.6	17
Lord Corp. (Hughson Chemical Co.)	64	26.0	17
B. F. Goodrich Co. (Chemical Div.)	1,996	0.8	17
Eastman Chemical Products, Inc. (Div. of Eastman Kodak)	124	1.3	16
Pratt & Lambert, Inc. (Pierre & Stevens Chemical Corp.)	78	19.4	15
Products Research & Chemical Corp.	40	38.0	15
W. W. Henry Co.	N.A.	-	15
Findley Adhesives, Inc.	N.A.	-	14
Peter Cooper Corp.	30	43.0	13
Philip Morris (Polymer Ind.)	4,293	0.3	12
Celanese Corp. (Polymer Specialties Division)	2,123	0.6	12
Allied Chemical Co.	2,630	0.4	12
Emhart Corp. (USM Corp.)	1,106	1.0	11
Gulf Corp. (Chemical Division)	18,403	0.1	10
Franklin Glue Co.	10	100.0	10
United Resin Products Inc.	-	-	10
Union Oil of California (Amsco Division)	5,780	0.2	9
Dexter (Hysol Div.)	189	5.0	9
National Casein Co.	-	-	9
American Cyanamid Co.	2,094	0.4	8
Morton-Norwich (Morton Chemical)	564	1.4	8
Essex Chemical Corp.	63	13.0	8
Miracle Adhesives	9	93.0	8
Koppers Co.	1,189	0.5	6

Source: Delphi Marketing Services, Inc.

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The industry also consists of a large number of medium-sized and smaller adhesive companies. Of the 463 establishments involved in the adhesives industry in 1972, only 33 had more than 100 employees; 154 had 20 to 99 employees, and 276 had 1 to 19 employees. The last group, which compiled nearly two-thirds of the total number of establishments, accounted for only 17 percent of industry shipments.

There are a number of companies, probably on the order of 25 to 35, whose sales range from $1 to $5 million a year who account for approximately 20 percent of the total adhesive sales. These companies derive most of their revenues from adhesives and have relatively narrow product lines. They also tend to operate in regional markets rather than national markets, although there are exceptions to this rule. The companies that do market nationally confine themselves to a relatively small group of customers in a definite field.

In addition to these first two groups of companies, there are many formulators. Estimates range up to a thousand of these formulators, who account for perhaps $100 to $200 million of sales. These companies are usually very small. They offer a very small number of adhesives and have very few customers. Most of these formulators make very simple formulations and are competitive strictly on a price and service basis, with relatively low price margins. There are exceptions, however, with a few small companies deriving most of their sales from specialty adhesives.

Integration

In order to strengthen product lines, increase direct sales, and provide better distribution facilities, there has been a definite movement toward integration in the adhesives industry. A number of companies have acquired other adhesive companies, while industrial formulators have been attempting to acquire consumer distribution. Table 6 lists the mergers and acquisitions of the U.S. adhesive companies since 1976. In terms of acquisitions, H. B. Fuller, Loctite, and National Starch and Chemical Corporation have been the most active. A number of companies have also attempted to enter the manufacture of consumer type adhesives, with its higher profit margins. Raw material suppliers are integrating forward to become formulators and formulators have been integrating backward to sources of raw materials.

III. END-USE DEMAND BY TYPE OF MATERIAL

In 1976, shipments of adhesive materials on a dry basis weight were about 3.8 billion pounds worth an estimated $1.3 billion dollars. Dry basis weight, in this study, refers to the total weight of the material including resin and coloring agents, extenders, fillers, plasticizers and other additives; it does not include water or other solvents. By 1985, shipments are expected to reach a level of 6.0 billion pounds, worth about $2.2 billion. The average annual growth rate on a weight basis is expected to be about 5.0 percent.

Adhesive shipments are reported by the Census of Manufactures and are shown in Table 10. The data is not a complete representation of the total market.

Table 11 shows total estimated adhesive shipnents for the period 1960-1985. Synthetic resins have experienced the highest rate of growth and account for about 67 percent of the total market. Natural-based adhesives, in contrast have remained fairly level. Figure 2 hows the relative importance of each of the major types of adhesives.

The major types of adhesives are discussed in this section according to the following categories:

- Natural-Base Adhesives
- Rubber-Base Adhesives
- Synthetic Resins (thermosetting and thermoplastic)

Natural Base Adhesives

Natural adhesives include animal, protein, vegetable and mineral based materials. In 1976, about 806 million pounds were utilized and accounted for about 21 percent of the adhesives market. By 1985, usage is expected to increase to a level of about 859 million pounds for an annual growth rate of less than one percent. Table 12 shows the relative importance of these glues since 1960.

TABLE 11

U.S. Shipments of Total Adhesive Materials, 1960-1985

(millions of pounds[1])

ear	Natural Resins	Elastomers	Synthetics	Total Adhesives
960	702	157	677	1,536
961	714	181	747	1,642
962	742	199	877	1,818
963	814	207	948	1,969
964	811	223	1,074	2,108
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1969	741	342	1,732	2,815
1970	760	353	1,796	2,909
971	759	377	2,057	3,193
1972	763	411	2,389	3,563
1973	779	419	2,500	3,698
1974	787	249	2,541	3,577
1975	794	441	2,294	3,529
1976	806	452	2,591	3,849
1980	832	500	3,475	4,807
1985	859	565	4,588	6,012

[1]Dry weight basis is the total weight of the material including resin and coloring agents, extenders, fillers, plasticizers and other additives (except water and other liquid diluents).

Source: Delphi Marketing Services, Inc.

Synthetic Resins

In 1976, 2,591 million pounds of synthetic adhesives were utilized, as shown in Table 33. The synthetic resin-base materials have been growing rapidly until they now dominate adhesives production. In 1958 the synthetic based resins accounted for 47 percent of the adhesives production; in 1967, 59 percent, and in 1976, 67 percent. Growth of synthetic resins is shown in Figure 5 on the following page.

Although the plastics and resins industry is very important to the adhesives industry, adhesives consumption of plastics and resins is not relatively important to the plastics industry as a whole, having accounted for approximately 10 percent of the plastics industry output last year. However, among certain individual resins adhesives consumption is much higher. For instance, adhesives accounted for 83 percent of amino resins consumption last year and 66 percent of phenolic resin consumption.

Specialty resin adhesives have generally experienced the most rapid growth of the synthetics through 1975 and are higher priced than large volume synthetics. Specialty resins can be formulated to provide higher strength, increased durability, and allow more bond flexibility. The two types of synthetic resins are:

- Thermosetting
- Thermoplastics

Thermosetting

The main types of synthetics are:

- Phenolics
- Amino Resins
- Resorcinol
- Furan Resins
- Polyesters
- Polyurethanes
- Epoxies
- Other (Thermosetting Adhesives)

TABLE 33

Shipments of Synthetic Adhesives By Type, 1960-1985
(millions of pounds[5])

Year	Phenolics	Amino Resins	Resorcinol	Furan Resins	Polyesters	Polyurethane	Epoxies	Other[1]	Acrylic Resins	Polyvinyl Acetate	Polyvinyl Chloride	Polyvinyl Alcohol	Other Vinyl[2]	Polyamides	Hot-melts[4]	Other[3]	Total
1960	334	159	-	10	-	10	-	20	-	74	26	-	29	-	-	15	677
1961	349	194	-	13	-	11	-	23	-	79	30	-	30	-	-	18	747
1962	385	222	-	17	-	13	5	21	11	94	35	-	31	-	-	19	844
1963	429	246	-	23	-	15	6	23	13	109	39	-	32	-	-	13	943
1964	496	277	-	30	-	17	6	26	15	111	47	-	33	-	-	16	1,074
1965	564	319	9	40	12	19	6	10	18	122	51	-	34	-	14	9	1,227
1966	622	365	10	44	14	21	7	11	20	116	40	-	34	7	22	4	1,337
1967	576	400	11	47	16	24	7	11	22	129	54	-	35	8	35	6	1,351
1968	655	460	12	51	18	27	8	12	30	147	62	-	36	8	47	8	1,591
1969	695	540	14	56	20	30	9	14	35	137	63	-	37	9	60	10	1,732
1970	690	580	15	60	22	32	10	14	41	136	64	9	38	9	72	4	1,795
1971	824	680	16	63	25	38	11	17	50	149	31	10	33	10	90	4	2,057
1972	946	770	17	66	28	43	11	20	55	203	44	15	40	11	115	5	2,383
1973	957	820	18	71	31	48	13	20	65	220	54	20	41	11	145	6	2,500
1974	859	840	20	73	34	53	16	19	80	225	62	25	42	12	175	5	2,541
1975	752	740	16	71	37	57	15	17	69	186	52	17	37	12	210	6	2,294
1976	864	820	20	74	40	62	19	20	75	198	68	20	42	13	250	6	2,591
1980	1,100	1,120	25	110	55	85	24	25	100	250	75	35	46	16	400	9	3,475
1985	1,475	1,400	29	160	80	120	33	33	145	330	105	45	52	19	550	12	4,588

[1] Includes cyanoacrylates, anaerobics, rubber modified resins.

[2] Includes polyvinyl butyral and polyvinyl formal and ethylene vinyl acetate (non hot melt).

[3] Includes polyethylene (non-hot melts), copolymers, modified resins.

[4] Includes ethylene vinyl acetate, polyethylene, polypropylene, nylon.

[5] Dry basis weight is the total weight of the material including resin and coloring agents, extenders, fillers, plasticizers and other additives (except water and other liquid diluents).

Source: Synthetic Organic Chemicals, International Trade Commission (1950-1970); SPI monthly statistical data, as compiled by Ernst & Ernst (1970-1976); estimates by Delphi Marketing Services, Inc.

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Thermoplastics

In 1976, thermoplastic resins accounted for 672 million pounds, or about 17 percent of the total adhesive market. By 1985, shipments are expected to reach a level of about 1,260 million pounds for an annual growth rate of 7.9 percent. Figure 9 shows the shipments of thermoplastic resins since 1960.

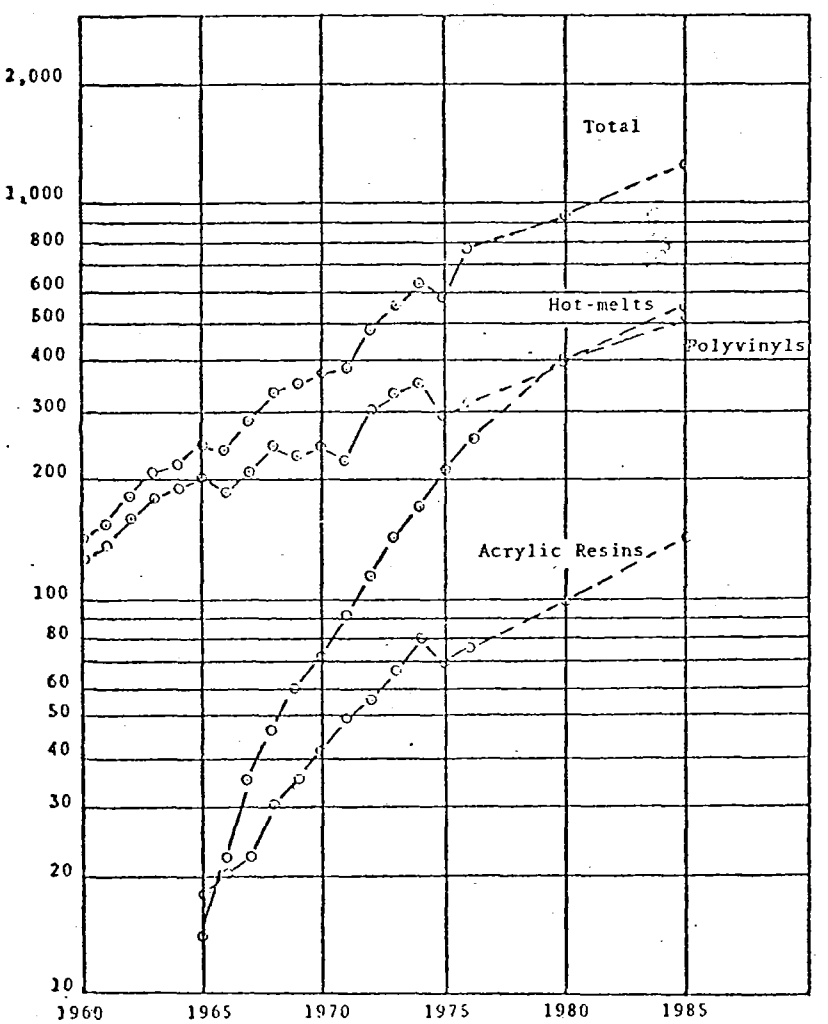
The main types of thermoplastics are:

- Acrylic Resins
- Polyvinyls
- Polyamides
- Hot-Melts
- Other Thermoplastics

FIGURE 9

U.S. Shipments of Thermoplastic Adhesives, 1960-1985

(millions of pounds)



Source: Delphi Marketing Services, Inc.

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Polyvinyls

Polyvinyl resins are the least expensive synthetic adhesives and much of their growth has been at the expense of natural resins for converted paper products. The vinyl-based adhesives are comprised of the following resins:

- Polyvinyl acetate
- Polyvinyl chloride
- Polyvinyl alcohol
- Other vinyl adhesive resins (polyvinyl butyl, polyvinyl formal, ethylene-vinyl acetate)

Polyvinyl Acetate

Polyvinyl acetate is the largest synthetic volume resin utilized in adhesives. It is one of the most versatile adhesives and is the principal vinyl resin used in water-based emulsions. The most notable example of polyvinyl acetate is the well-known white glue; typified by Borden's Elmer's Glue-All, which accounts for the majority of the total consumer adhesive sales.

Polyvinyl acetate is produced by the polymerization of vinyl acetate, yielding a water emulsion with a solids content of 50-55 percent. Commercial development began in the 1930's primarily as a homopolymer, but more recently polyvinyl acetates have been used in copolymers, hot-melts and solutions. Homopolymers are still the most important resin form and account for about 65 percent of the market as shown in Table 55.

Polyvinyl acetates are often combined in copolymers with n-butyl acrylate, 2-ethylhexyl acrylate, ethylene, dibutyl maleate and dibutyl fumarate. Additives and extenders are used, the most popular are polyvinyl alcohol and starch.

Polyvinyl acetate adhesives provide moderate bond strength, are low in cost and are odorless, tasteless, and non-toxic. The advantages are summarized on the following page.

Advantages

- Odorless
- Tasteless
- Nontoxic
- Unaffected by ultraviolet light or air
- Absorb small quantities of water without serious effect of the bond
- Heat stable
- Burn slowly
- Colorless
- Readily dissolve in many organic solvents
- Water mixable
- Moderate bond strength

In 1976, about 198 million pounds of polyvinyl acetate were used in adhesives as shown in Table 56. The usage of polyvinyl acetate polymers are reported by the International Trade Commission and SPI, and the data is not directly comparable. Industry sources believe the International Trade Commission data represents 80 to 90 percent of actual usage; SPI data is believed to be 90 to 94 percent of actual usage. By 1985, about 330 million pounds of polyvinyl acetate resins are expected to be used in adhesives, for an annual growth rate of 6.0 percent. Since most markets are mature, only moderate growth is expected.

The largest end-use market for polyvinyl acetate adhesives is in packaging and labeling applications (see Table 57). Because they are water-based emulsions and can be remoistened, they have largely replaced natural resins for paper bags, cardboard cartons and tubes.

Polyvinyl acetate resins are also used in construction for smoothing of gypsum board tape joints in wallboard lamination and in cement additives where quick binding and crack free surfaces are essential. They are also used in textiles for nonwovens and interlinings for luggage, handbags, purses and other leather goods. In the production of saturated felts, polyvinyl acetate is almost always used in copolymer form.

There are more than 50 merchant and captive producers of polyvinyl acetate. The five major suppliers of monomer for adhesives are:

TABLE 55

Types of Polyvinyl Acetate Resin, 1976

(percent)

Resin Type	Percent
Homopolymer Emulsions	65%
Copolymer Emulsions	9
Hot-melts & Solutions	26
Total	100%

Source: Delphi Marketing Services, Inc.

TABLE 56

Shipments of Polyvinyl Acetate in Adhesives, 1960-1985
(millions of pounds)

Year	Total Polyvinyl Acetate			Adhesives Sales & Use	Adjusted Adhesives Sales & Use
	Merchant	Captive[1]	Sales & Use		
1960	N.A.	N.A.	133.1	62.0e	74
1961	N.A.	N.A.	142.0	66.2e	79
1962	N.A.	N.A.	182.9	85.3	94
1963	194.6	41.3	235.9	99.3	109
1964	228.2	51.4	279.6	100.9	111
1965	220.4	62.9	283.3	111.1	122
1966	231.4	74.0	305.4	105.4	116
1967	251.2	59.3	310.5	117.0	129
1968	306.2	51.9	358.1	133.6	147
1969	332.4	62.4	394.8	124.7	137
1970	365.3	17.2	382.5	124.0	136
1971	359.0	58.1	417.1	135.5	149
1972	487.9e	86.1e	574.0	187.9	203
1973	491.3e	86.7e	578.0	208.4	220
1974	499.8e	88.2e	588.0	212.0	225
1975	381.5e	67.3e	448.8	175.9	186
1976	406.0	71.8	477.8	187.2	198
1980	510.0	90.0	600.0	236.0	250
1985	680.0	120.0	800.0	312.1	330

[1]Includes inventory adjustment from 1960-1971.

Source: Synthetic Organic Chemicals (1960-1971); SPI data as compiled by Ernst & Ernst (1972-1975); estimates by Delphi Marketing Services, Inc.

DSW 587261

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Borden Inc.
National Starch & Chemical Co.
Air Products
Celanese (Stein-Hall Division)
du Pont de Nemours

The major producers of adhesives are National Starch and Chemical Co., H. B. Fuller, W. R. Grace, National Casein, and Celanese (Stein-Hall Division). Captive usage is common among the major producers, such as Borden, National Starch and Chemical Company, Celanese, H. B. Fuller, Morton Chemical, Staley, and Franklin Glue.

TABLE 57

Polyvinyl Acetate Adhesive End-Use Markets, 1976
(percent)

End-Use	Percent
Packaging & labeling	38%
Emulsions (20%)	
Hot-Melts and Solutions (18%)	
Construction	28
Gypsum board (17%)	
Wallboard Laminations (3%)	
Cement Additives (3%)	
Other (6%)	
Textile	11
Nonwoven Binder (6%)	
Felt Saturation (1%)	
Hot-Melts (4%)	
Consumer Uses	13
Furniture	5
Bookbinding	3
Miscellaneous	2
Total	100%

Source: Delphi Marketing Services, Inc.

DSW 587262

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Polyvinyl Chloride

Polyvinyl chloride adhesives are used in the form of plastisols, solution or latex. Plastisols account for an estimated 65 percent of the volume. They are a dispersion of powdered resin in a plasticizer which is stable and viscosous at room temperature. When the temperature is raised, the plasticizer solubilizes the resin and fuses to form a continuous film.

Solutions of polyvinyl chloride are also used, and typical solvents include cyclohexanane, tetrahydrofuran, methyl ethyl ketone, and diisobutyl ketone.

In 1976, about 68 million pounds of polyvinyl chloride were utilized in adhesives as shown in Table 59. By 1985, an estimated 105 million pounds of resin are expected to be used, for an annual growth rate of 4.9 percent.

Adhesives based on polyvinyl chloride resins are used in specialized segments of the industry. As a plastisol, it finds application in the automotive area and to a very small extent in carpet backing. As a latex it is used in nonwovens as a binder because of its chemical resistance and flame retardancy. Solutions are used in pipe cements. Table 58 shows the major end-use areas for 1976.

TABLE 58

Polyvinyl Chloride Adhesive End-Uses, 1976
(percent)

End-Use	Percent
Automotive	26%
Textiles (carpet backing, tie coats, nonwoven, flocking, interlining)	24
Construction (pipe, cements)	3
Furniture	2
Other (appliance, packaging laminates)	45
Total	100%

Source: Delphi Marketing Services, Inc.

TABLE 59

Polyvinyl Chloride Usage in Adhesives, 1960-1985
(millions of pounds)

Year	Adhesives & Other Coatings[1]	Adhesives Usage[2]
1960	35	26
1961	40	30
1962	47	35
1963	52	39
1964	63	47
1965	68	51
1966	54	40
1967	72	54
1968	83	62
1969	84	63
1970	85	64
1971	41	31
1972	59	44
1973	72	54
1974	83	62
1975	70	52
1976	90	68
1980	100	75
1985	140	105

[1]Synthetic organic chemicals and Society of Plastics Industry.

[2]Assumes 75 percent of total adhesives and coatings.

Source: Delphi Marketing Services, Inc.

There are 20 U.S. producers of polyvinyl chloride. The top eight account for about 75 percent of capacity and include:

B. F. Goodrich
Robintech Inc.
Borden Inc.
Firestone Tire & Rubber
Conoco Chemicals
Diamond Shamrock Chemical Co.
Stauffer Chemical Co.
Union Carbide

Polyvinyl Alcohol

Polyvinyl alcohol is produced from polyvinyl acetate by hydrolysis and the degree of hydrolysis affects the resins physical properties such as water solubility, solvent resistance, and adhesive strength.

The major advantages of polyvinyl alcohol adhesives are their:

- Odorlessness
- Nontoxic ability
- Improved solubility, tack and viscosity

In 1976 about 20 million pounds of polyvinyl alcohol were utilized in adhesives. Adhesives account for about one-third of total domestic consumption of polyvinyl alcohols as shown in Table 60. By 1985, usage is expected to reach a level of about 45 million pounds.

TABLE 60

Shipments of Polyvinyl Alcohol in Adhesives, 1970-1985
(millions of pounds)

Year	Production	Domestic Sales & Use	Adhesives
1970	48.8	39.6	9
1971	57.7	45.6	10
1972	62.4	67.2	15
1973	95.9	90.3	20
1974	142.0	114.0	25
1975	118.4	78.9	17
1976	128.0	85.0	20
1980	225.0	150.0	35
1985	300.0	200.0	35

Source: Delphi Marketing Services, Inc.

DEMAND BY MARKET END-USE

Introduction

Information on markets for adhesives by end-use is difficult to obtain since the only data reported by the U.S. Government are in the Census of Manufactures, which appears on an average of every four to five years. These data are reported only by type of adhesive and are supplemented annually by the Annual Survey of Manufactures, which gives the total figures in dollars for that particular year.

Table 67 and Figure 10 show the types of resins by end-use. In 1976 the total market for adhesives was 3.8 billion pounds; it is forecast to grow to 6.0 billion pounds by 1985, an annual rate of 5.1 percent. Primary Wood Products is the largest category and accounted for 31 percent of the total adhesives market which was about 1.2 billion pounds. Packaging and converted paper products is the second largest end-use and accounted for an estimated 745 million pounds of materials. Construction is the third largest. While it is smaller in size, it is expected to have a greater annual growth rate through 1985.

Adhesives are utilized in many different markets; however, seven end-use categories account for about 85 percent of the materials used in 1976. The major end-use adhesive markets are:

- Primary Wood Products
- Packaging & Converted Paper Products
- Construction
- Textiles
- Foundry
- Transportation
- Gummed Products
- Other (Printing and Publishing, Consumer Products, Footwear, Furniture, Appliances and Electrical Equipment, Friction Materials, and Coated and Bonded Abrasives)

These categories can be subdivided into a number of subcategories.

TABLE 67

Types of Adhesives By End-Use, 1976
(millions of pounds)

Types of Adhesives	Primary Wood Products (Forest Products)	Packaging & Converted Paper Products	Construction	Textile	Foundry	Transportation	Bonded Products	Printing & Publishing	Consumer	Footwear	Furniture	Other & Unknown	Total
Natural													
Animal Glue		24					16	6				19	65
Protein Glues (Casein & Other)		17	50										67
Vegetable Glues (Starch, Dextrin & Other)		266					35					19	320
Mineral Glues (Asphalt/ Bituminous, Silicates)		142	188		10							10	350
Elastomers													
Rubber Cement		1		4		2	29		3	2		2	43
Rubber & Synthetic Resin Combinations		11	11	240		26	13			1	2	53	355
Other						1						53	54
Thermosetting													
Phenolics	435		207		69							153	864
Amino Resins	771										14	35	820
Resorcinol	5					14						1	20
Furan Resins					70							4	74
Polyesters					17	15				1	2	5	40
Polyurethanes		31	2	13						9	4	3	62
Epoxies			9			1					2	5	17
Other												20	20
Thermoplastics													
Acrylic Resins			3	56			15					1	75
Polyvinyl Acetate		75	55	22				3	28		10	7	195
Polyvinyl Chloride			2	13		15						26	56
Polyvinyl Alcohol		14	4								1	1	20
Other Vinyl (Polyvinyl butyral, Polyethylene)			5	1		35						1	42
Polyamides		4		1						3		5	13
Hot-melts		150		10				23		8	5	54	250
Other											-	6	6
Unknown		19	54	2	4	1	-	-	17	-	1	N.A.	18
Total	1,211	745	590	362	170	110	108	32	46	24	41	N.A.	3,849

Source: Delphi Marketing Services, Inc.

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