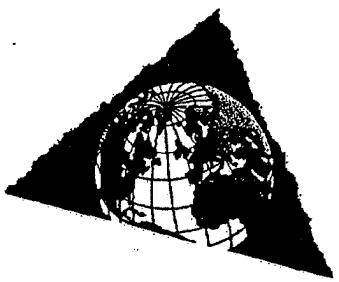
An Overview of Titanium Dioxide Uses in the Specialties Applications Segment

March 11, 1991

MR#: 91-5

Paul C. Gundersen
DuPont Chemicals Marketing Research



MARKETING RESEARCH
FOR BUSINESSES
DUPONT CHEMICALS

Table of Contents

Listing of Tables

Listing of Figures

Executive Summary

A Historical Perspective

As the worldwide supply of titanium dioxide expands throughout the next several years, excess supply will become available. As supply becomes more available, titanium dioxide suppliers must find additional avenues to sell their products.

Historically, DuPont has enjoyed good sales in the major industries; however, the company has had relatively low market share in the Specialty markets. Now that the worldwide shortage is over, DuPont can seek new areas to place excess titanium dioxide. Specialty markets provide avenues for DuPont to grow.

The Market Today

Despite DuPont being the world's largest supplier of TiO2 (with 26% of world capacity), its participation in the specialties market is relatively modest. DuPont's role and image in the market are greatly enhanced by its global strength. DuPont is one of the top four worldwide suppliers along with Tioxide, Kronos, and SCM.[1] The overall market for TiO2 is about 3000 M tonnes per year. The specialties segment consumes roughly 300 M tonnes per year, or 10% of the total market volume. Figure 1 shows the overall TiO2 market.

Objectives

The primary objective of this report is to characterize the worldwide market for titanium dioxide use in the Specialty applications segment. This report characterizes specialties by reviewing the following information.

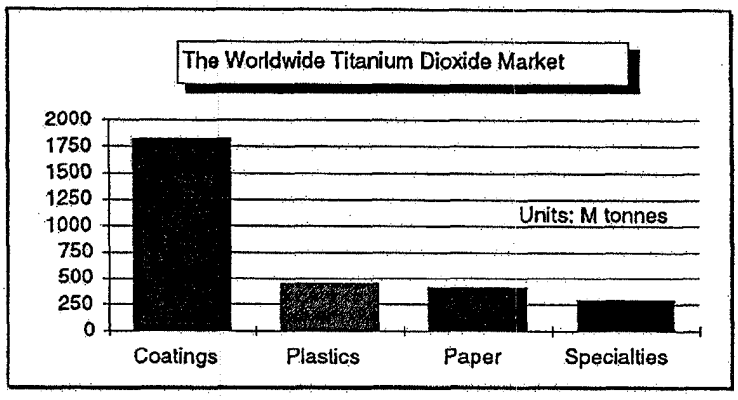
- *Segment size*
- *Segment growth rate*
- *Crystalline forms used*
- *Competitive grades.*

Method of Study

Information was gathered through a number of primary and secondary sources in a worldwide context. Overall, over 200 segment contacts were made. This included contacts to industry and trade associations as well as users in each segment. Contacts were made inside and outside of DuPont. Study of the European segment is filed under DuPont Chemicals Marketing Research MR#:91-4

Figure - 1

The Worldwide Titanium Dioxide Market



Overview

The Worldwide Market for Titanium Dioxide

The titanium dioxide market is a worldwide market with annual consumption of 3000 M tonnes. The market is segmented into four basic groups. Table 1 shows the breakdown of the worldwide titanium dioxide market.

Table - 1

The Worldwide Titanium Dioxide Market

Coatings	61%
Plastics	15%
Paper	14%
Specialties	10%
TOTAL	100%

This document focuses on the fourth segment, Specialties.

The Specialties segment consumes about 300 M tonnes TiO2 per year.

The specialties segment is divided among several major industries and numerous minor applications. Table 2 lists the industries and their titanium dioxide consumption per year.

The remainder of this document discusses each segment in detail. The segments are reviewed in order of worldwide TiO2 consumption from highest to lowest.

Conventions

The chemical formula TiO2 is often used in this document. This formula represents the chemical name for Titanium Dioxide.

Throughout this document references are made to TiO2 consumption. The units are always in *THOUSANDS OF METRIC TONNES* (M tonnes) unless otherwise noted. The term "tonne" refers to one metric tonne.

1 metric tonne = 2204.6 pounds.

The term "ton" refers to one short ton.

1 short ton = 2000 pounds.

For each segment, there is a table in the "Market Size, Structure, & Growth section. These tables sometimes have the abbreviation "NR" listed. This indicates "Not Reported."

Table - 2

TiO2 consumed in Specialties

Worldwide Summary by Segment (M tonnes)

Segment	TiO2 Consumed	Percent of Total
Inks	78	26.0%
Rubbers/Elastomers	66	21.3%
Floor Coverings	36	12.0%
Textile Fibers	32	10.6%
Adhesives/Sealants	25	8.3%
Ceramics	22	7.3%
Leather	15	5.0%
Roofing Granules	9	3.0%
Correction Fluid	7	2.3%
Electronics	5	1.7%
Cosmetics	3	1.0%
Segment Total	294	
Misc Applications	6	2.0%
Specialties Worldwide	300	100%

Anatase Versus Rutile

Table 3 itemizes the anatase/rutile TiO_2 breakdown in the specialties segment. The column indicating "% Anatase/Rutile" was taken from the European study. The general proportions of Anatase/Rutile are believed to be similar in other regions of the world based on feedback from DuPont contacts in Asia Pacific, Latin America, and the United States.

Table - 3

Summary of TiO_2 Anatase/Rutile Requirements by User Sector

Segment	Anatase Verses Rutile	% Anatase vs. Rutile	Potential for Conversion to Rutile
Inks	Rutile grades are used where abrasion is not an issue. In gravure printing, anatase grades are used exclusively.	10/90	Rutile forms of TiO_2 are used widely in this segment in all but the gravure process.
Flooring	North America: Rutile grades are being used because of their relative opacity and performance properties. Europe: Anatase is used because of historical usage.	10/90	
Adhesives & Sealants	In this segment, anatase has no significant technical advantage. Anatase grades often suffice.	25/75	Better as rutile prices drop closer to anatase prices.
Rubbers & Elastomers	Tires and Athletic Shoes: Rutile grades can be used. Anatase has no significant advantage.	40/60	In this segment, anatase has no significant advantage. Potential is better as rutile prices drop closer to anatase prices.
Leathers	Some anatase is used where softness is an issue.	30/70	Not having anatase in the leather segment may prove a slight handicap.

Table (Continued)

Summary of TiO_2 Anatase/Rutile Requirements by User Sector

Textile Fibers	Anatase is essential because abrasiveness is an issue.	90/10	No potential unless DuPont developes an anatase grade.
Cosmetics	Anatase grades are preferred for their softness and purity.	90/10	No potential unless DuPont develops an anatase grade or meets government regulation and/or seeks approval.
Correction Fluids	Because hiding is very important in this segment, Rutile grades are the only ones used.	0/100	DuPont already dominates in the United States.
Ceramics		80/20	
Electronics	Anatase grades are used today. Rutile grades with no surface treatment will work. Purity is an issue.		Fair if DuPont can offer a grade of TiO_2 with low Al_2O_3 content.
Roofing			

TiO2 Specialties Markets

Overview

The worldwide specialties market consumes 300 M tonnes TiO2 each year. In this segment, each region consumes the following:

Latin America	*16 M tonnes (4%)*
North America	*117 M tonnes (39%)*
Europe	*85 M tonnes (28%)*
Asia Pacific	*76 M tonnes (25%)*

Table 4 shows the worldwide breakdown of the Specialties market by region and segment.

Table - 4

A Worldwide Overview of the Specialties Marketplace by Segment and Region

	Latin America	North America	Europe	Asia Pacific	Total	Percent of Total	Growth Rate
Inks	6	23	25	24	78	26.0	2-3%
Rubbers/Elastomers	4	29	8	23	64	21.3	1-2%
Floor Coverings	0	14	20	2	26	8.6	1%
Textile Fibers	2	6	7	17	32	10.6	Decline
Adhesives/Sealants	0	14	9	0	25	8.3	2-3%
Ceramics	2	11	7	2	22	7.3	2-4%
Leather	1	5	5	4	15	5.0	5%
Roofing Granules	0	9	0	0	9	3.0	Flat
Correction Fluid	0	4	1	2	7	2.3	3-5%
Electronics	0	2	2	1	5	1.7	5-8%
Cosmetics	0	1	1	1	3	1.0	5-8%
	16 5.3%	117 39.0%	85 28.0%	76 25.7%	294	98.0	
				Other Applications	6	2.0%	
				Specialties Worldwide	300		

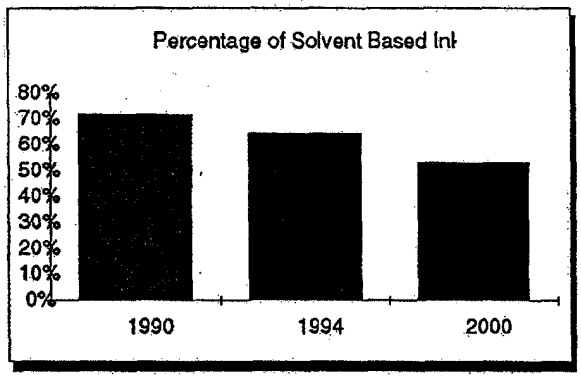
Printing Inks

Introduction

The printing inks segment has undergone considerable changes throughout the past several years. The worldwide focus on the environment has moved the print segment from solvent based waste streams towards hazardous free waste streams. Printing ink manufacturers and commercial printers are trying to minimize the use of all hazardous components in printing materials. They are also attempting to maximize the use of substrates, inks, and printing plates. Their overall goal is to shift from solvent-based inks to waterborne inks. [2] Waterborne inks are expected to make steady gains in the years ahead. Frost and Sullivan predict that solvent-based inks will decline rapidly between 1994 and the year 2000. Figure 2 depicts the decrease in solvent based inks.

Figure - 2

The Decline of Solvent Based Inks in the United States



The printing inks segment is also heavily impacted by crude oil prices. Nearly 80% of its raw materials are petrochemicals. [3] As a result, printing ink manufacturers are very concerned with the price performance of their products.

Market Structure, Size, and Growth

The worldwide printing inks segment consumes over 74 M tonnes of TiO2. Table 5 shows the TiO2 volume in the printing inks segment. Europe, Asia Pacific, and North America comprise over 95% of the printing inks market.

Table - 5

TiO2 Consumed in Printing Inks

	Consumption (M tonnes)	Growth Rate
Latin America	6	NR
North America	23	2-3%
Europe	25	3%
Asia Pacific	24	7%
World	78	2.7%

A positive factor for the printing segment is the creation of the European common currency in 1992. This may have an important effect on U.S. exports of printed materials particularly at the current exchange rate on the dollar. [4]

The Graphic Arts Technology Foundation forecasted United States sales growth in the publishing and printing industries of 7-8% in 1990. At that rate, the 1994 market for printing inks would be the equivalent of $ 4 billion US dollars. With inflation expected to be around 5%, the real growth in this segment would be 2-3%. [5] Although overall growth of the United States printing ink segment is relatively slow, a few sectors that are growing fast. Waterbased inks used in packaging are growing at an annual rate of 10-15%. The newspaper flexographic segment is growing at 20-30%. [6]

The United States printing ink segment is comprised of over 38 thousand establishments. Figure 3 shows the overall structure of the United States printing ink segment.

A vast majority of these firms (84%) have fewer than 20 employees. The segment has experienced a strong shift from letterpress, dominant into the 1970's, to lithography, a process lending itself to computer composition and the economical use of color.

The largest printing ink manufacturers are:

- *Dainippon Ink & Chemicals (Japan)*
- *BASF (Parsippany, New Jersey)*
- *Flint Ink (Detroit, Michigan)*
- *Sinclair & Valentine.*

These four manufacturers account for over 45% of the world market share. Their share of TiO2 consumption is somewhat less than their share of ink production. This phenomenon is caused by the majority of their production lines generating commodity black inks.[7] Other ink manufacturers include:

France	United Kingdom
- SICPA	- Coates
- Lorrilleux	(Lorrilleux)
- Branchet	- Mander Kidd
Germany	Holland
- Siegwerk	- Kroda
- Schmidt	
- Hartmann	Italy
- Huber	- Colorama
	- Baglini

The projected worldwide growth for the printing inks segment is expected to be 2.7% for the next several years.[8] By printing process, the worldwide printing inks segment is segmented as shown in Table 6.

Table - 6

The Worldwide Printing Industry

Segment	$ MM	Growth Rate
Lithography	835	5%
Gravure	529	6%
Flexography	411	10%
Letterpress	175	8%
Other	320	9%
Overall	~2300	7%

Gravure Printing

Gravure technology continues to be used where high quality and longer print runs are desirable. Gravure print is used in the following types of applications:

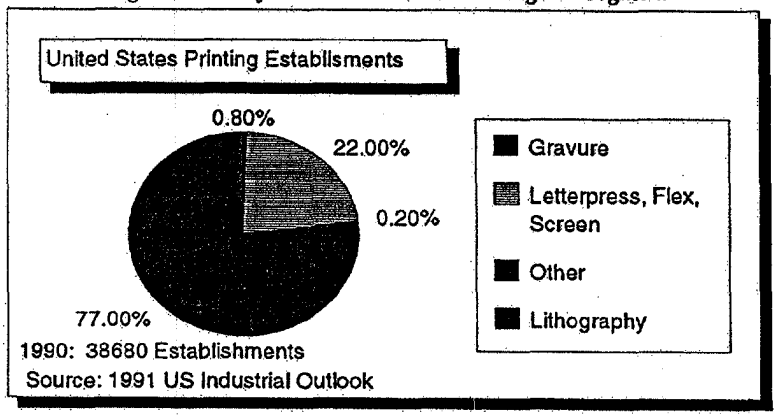
- *cigarette packaging*
- *detergents*
- *magazines*
- *cereal boxes*
- *foil for insulation*
- *diaper bags.*

Gravure printing is normally used for extremely long print runs where high print resolution is desired.

Lithographic Printing

Figure - 3

Segmentation of the United States Printing Ink Segment



The most popular of the four major printing processes, lithography, uses the planographic method. The image and non-printing areas are essentially on the same plane of a thin metal plate, and the distinction between them is maintained chemically. There are two basic differences between lithography and other processes:

- It is based on the principle that oil and water do not mix
- The ink is offset first from the plate to a rubber blanket, and then from the blanket to the paper.

Flexographic Printing

Flexography continues to be used where lower quality and shorter runs are desirable. Flexographic printing is used in the manufacture of:

- *craft bags*
- *bleached bags*
- *food packaging*
- *flexible packaging*
- *narrow web applications (i.e., tissue, paper towels).*

Inks containing TiO2 are most often used in packaging, particularly flexible packaging such as polyethylene food wrap. Other uses include metal cans and other publications.

Packaging ink worldwide is a $500 MM market. The average packaging ink price is $1.10-$1.20 per pound. Of all packaging inks, 7-10% are white.[9] TiO2 is typically loaded in white inks .2-.25% by weight to produce the desired opacity.[10] Based on these figures, the worldwide packaging segment consumes 2-4 M tonnes each year.

Letterpress Printing

Letterpress is the oldest and most versatile method of printing. It can be used for short, medium, or long runs. The letterpress method is the only process which can use type directly. Printing is done from a cast metal type or plates on which the image or printing areas are raised above the non-printing areas. Ink rollers touch only the top surface of the raised areas; the surrounding (non-printing) areas are lower and do not receive ink.[11] Typical letterpress applications include:

- *commercial printing,*
- *books,*
- *newspapers,*
- *magazines,*
- *packaging,*
- *various specialty printing applications.*

General Requirements

There are many parallels between the printing ink segment and coatings segment.

- A given ink manufacturer has many ink grades -- each one many require special TiO2 properties.
- Technical support is needed just as in coatings.
- Ink manufacturers use several grades of TiO2 and two or three TiO2 suppliers.
- Most sales to the ink segment are direct.[12]

While considerations are similar to those in the coatings segment, there are additional considerations like:

- *Oil or water absorbancy*
- *Dispersibility*
- *Viscosity*

In the United States, the industry standards for TiO2 are Kemira OR-580 and Kronos 2090.[13] In Europe, Tioxide grades tend to set the standard, notably RHD2, RDI, and RXL. Other grades noted in the European study include: Bayer R-FD-I and Kronos 2044. These products have the following characteristics:

- *low oil absorption*
- *easy dispersion*
- *low abrasion*
- *high TiO2 content.*

DuPont R-931 is sometimes used when opaqueness and hold-out are important.

DuPont needs to offer a product like Kemira OR-580 to be successful in this segment.

The improved product should be less yellow, lower in abrasion, and should have the same or higher gloss.[14]

In Japan, the following TiO2 grades and properties were reported as shown in Table 7.[15]

Table - 8

TiO2 Grades Used in Printing Inks

DuPont	
R-960	Hiding
R-900	Surface Smoothness
R-931	Hiding
R-902	Surface Smoothness, Non-Fogging
Ishihara	
CR-90	Hiding, Surface Smoothness, Non-Fogging
R-930	Hiding, Surface, Non-Fogging
R-820	Surface Smoothness, Non-Fogging
R-630	Surface Smoothness, Non-Fogging

Customers primary concerns with TiO2 are price and abrasion.[16] As the printing inks segment turns towards waterborne inks, the need for a higher gloss TiO2 is even more critical. As water content increases, gloss levels tend to decrease.

Gravure Printing

The gravure printing process uses what is known as a "doctor blade" to remove excess ink from "engraved cylinder." Through time, the doctor blade and the engraved cylinder wear down. In this process, overall wear increases as the inks' abrasion increases. Physically, the ink must be finely ground and free from any hard particles which could result in scratching the engraved cylinder or "nicking" of the doctor blade.[17] Gravure printing uses anatase grades of TiO2 . Rutile forms of TiO2 are too abrasive and cause premature cylinder wear. As a result, conversion to rutile grades is highly unlikely.

Flexographic Printing

In the past mostly anatase TiO2 was used for the printing segment. Today, the flexographic printing uses predominantly rutile grades. This change has accelerated as inks have moved from solvent based to waterborne processes.

Regional Information

NORTH AMERICA

1989 consumption of TiO2 for printing inks was about 22.7 M tonnes.[18] Table 8 shows the approximate TiO2 consumption by printing process.

Hull and Company estimated the following TiO2 usage by printing process.

Table - 8

TiO2 Consumed by Printing Process (1990 Estimate)[19]

Solvent Flexo	6.3
Water Flexo	5.9
Screen Inks	4.8
Lithographic	2.6
Gravure	2.7
Letterpress	.13
TOTAL	22.4

DuPont reaches the ink market almost exclusively through its distributor. TiO2 is most often sold in LTL quantities.

United States: 1989 TiO2 consumption in inks was estimated at 20-22 M tonnes.[20] This represents 90% of the North American total.

The printing inks segment grew slightly more than 4% in 1989 with sales of $2.5 billion. The segment is expecting to return to the long-term trend of about 5% annual growth.[21]

JAPAN

In 1989, TiO2 growth was 6.6% to Japan's printing ink segment.[22] Japan consumed 38,500 tons of TiO2 in printing inks.[23] The ink segment is very important in Japan because the major ink customers are also major customers in the plastics segment. The implication of this relationship is that salespeople on plastics accounts can call on ink customers at the same time.

Toyo Ink, Dainichi Seika, and Sakata Inx have good penetration into the gravure segment.

The Japan TiO2 Segment Association provides information about Japanese TiO2 consumption by segment. Imports, which are not reported by the associating, account for 20% of Japan's total TiO2 demand. Table 9 below shows the associations' estimates for ink and an estimate (which includes imports) of Japan's total TiO2 demand in the ink segment.

Ishihara is very strong in the Japanese ink segment. They offer grades like CR-90, R-930, R-820, and R-630.

EUROPE

The market for printing inks is expected to grow by 3.3%/year to reach 618 tons of ink produced by 1993.[24]

The ink segment is very important in Europe because many of the major ink customers are also major customers in the paint segment. The implication of this relationship is that salespeople on paint accounts can call on ink customers at the same time.

Table 9

Estimated Japanese TiO2 Consumption in Inks

(Units: Tonnes)

Metric Tons	Rutile	Anatase	1989 Total	% vs. 1988
Ink (w/o imports)	34977	3500	38477	110
Ink (w/ imports -- estimate)	41972	4200	46172	

Rubbers & Elastomers

Introduction

TiO2 pigments are used in virtually all rubber compounds that are non-black. This includes grey as well as white rubber.[25] The Rubbers and Elastomers segment depends on petroleum products for 80% of its raw materials. As a result, raw materials pricing is of major importance to segment producers. Throughout the past several years, environmental concerns have become increasingly important to rubbers and elastomers producers.

The two largest elastomer markets are white sidewalls for passenger tires (estimated to account for two-thirds of the entire market) and rubber footwear.[26] Other applications include wire and cable coating, and housewares. Houseware products include items such as drain boards, storage container lids, and rubber trim on the inside of refrigerator doors.[27] TiO2 is the prime white pigment used in all light colored rubber products.

TiO2 suppliers to this segment include:

- *DuPont*
- *Kemira*
- *Kerr-McGee*
- *NL Chemicals*
- *SCM*
- *Tioxide*

The suppliers are produce a mixture of rutile and anatase grades for rubber applications.

Market Structure, Size, and Growth

The worldwide Rubbers & Elastomers segment consumes roughly 63 M tonnes TiO2 per year. The largest markets for TiO2 are in North America and Asia Pacific. Table 10 shows the TiO2 consumption in each region of the world for Rubbers & Elastomers.

Table - 10

TiO2 Consumption in Rubbers & Elastomers

	TiO2 consumption (M tonnes)	Growth Rate
Latin America	4	NR
North America	29	1%
Europe	8	2%
Asia Pacific	23	4%
World	64	

The rubbers and elastomers segment consists of a number of compounders who produce components on a sub-contract basis for incorporation into end products like:

- *Automotive components*
- *Athletic shoes*
- *Appliances*
- *Clothing elastic*

This segment is highly fragmented. Most compounders purchase TiO2 through distributors.

NORTH AMERICA: Soft key construction markets and general economic sluggishness caused demand in the North American region to slow in 1989. Although the industrial consumer goods segment will increase in size, the overall decrease in tire manufacturing has caused a low growth rate in this segment. Growth in the North American Rubber and Elastomers segment is predicted to be 0.6% over the next several years.[28] Slow growth is expected because fewer whitewall tires are being produced. Whitewall tires are common in the United States but are seldom seen overseas. The only TiO2 consumption Europe reported in tires was in bicycle tires. North American growth in this segment should be attributed to a slight increase in the consumer products segment.[29]

EUROPE: In Europe, the Rubbers and Elastomers segment is made up of two tiers:

Compounders -- supply rubber compounds to final producers.

Moulders -- who either buy compound or prepare it.

These producers create a variety of end-use products. In Europe, there are over 200 users of TiO2. This segment receives its TiO2 supply through distributors. Overall, European growth trends are modest, with a predicted growth rate of 2%.[30]

TiO2 Properties in the Rubbers and Elastomers Segment

Overall Product Use

In North America, anatase grades are the primary grades used in this segment.[31] Products like DuPont's R101 and Kemira's O-110 are commonly used in rubber manufacturing. In Europe, rutile is more widely used. A great deal of anatase is still used in this sector -- individual companies show a strong preference for one or the other. Table 11 lists the various TiO2 grades preferred in the Rubbers & Elastomers segment.

Users are looking for dispersibility, consistency, color fastness in light and heat, and stability in contact with oil or solvents.[32]

Table - 11

TiO2 Grades Used in the Rubbers & Elastomers Segment

Supplier	*Product Code*
DuPont	R-101
Kemira	O-110, O-220, OR-450, OR-460
Kronos	1000
SCM	RGM, HSS, RCS-3
Tioxide	R-CR2, R-FC6, A-LF2, A-HR

Tires

Six producers account for over 75% of the entire world rubber tire market. They are:

- *Michelin*
- *Goodyear*
- *Bridgestone*
- *Continental*
- *Sumitomo (Dunlop)*
- *Pirelli.*

Figure - 4

A View of the Worldwide Tire Market

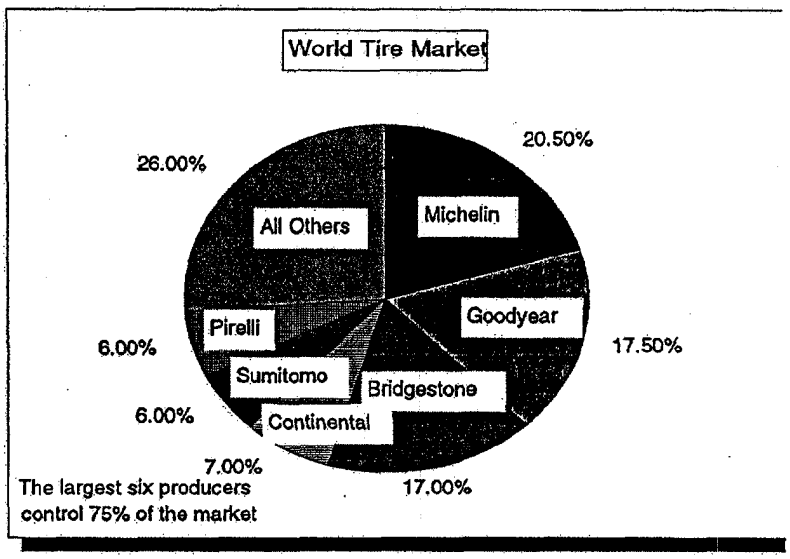


Figure 4 shows the top six producers with their relative worldwide marketshare.

Blackwall tires are becoming the predominant type of tire in the marketplace. Some whitewall tire production still exists. This decline is causing an overall decrease in TiO2 use in this segment.[33]

Tire manufacturers say they expect no surprises in the segment over the next several years -- slow growth (about 2%)[34]*, and continued growth of radial and performance tires.*[35] *Table 12 shows the projected growth of the worldwide tire segment.*

Table - 12

A View of the Global Tire Market

Region	Percent of World	Growth Rate
North America	39%	2.5%
Europe	30%	3.9%
Latin America	6%	0.0%
Asia/Africa	25%	4.0%
World	100%	3.1%

TiO2 Properties Needed in Tires

In tire production, anatase forms of TiO2 are commonly used. Some rutile grades are used; however, some tires containing rutile grades have been known to crack. Anatase TiO2 provides a good buff texture and whiteness. Chaulking grades are preferred. Anatase producers to this segment include:

- *SCM*
- *Kronos*
- *Kemira*
- *Tioxide.*

Because TiO2 does not contribute to the strength of material, loading levels are kept to a minimum. On average 1-1.15 pounds of white compound are used per whitewall tire. TiO2 loading in the white compound is typically 15-20% by weight.[36]

Products like DuPont's R-101 and Kemira's Unitane O-110 are commonly used in tire production.

Athletic Shoes

Introduction

The largest athletic shoe manufacturing operations are located in Asia Pacific and Latin America. Manufacturers will be looking for more lightweight and durable materials throughout the 1990's.[37]

Market Structure Size and Growth

The United States imports over 60% of all its rubber athletic footwear. Lower cost overseas labor, particularly in Asia Pacific has attracted producers to overseas locations.

United States TiO2 use in athletic shoes is estimated in Table 13. In the athletic shoe segment, estimating the total TiO2 consumption was very difficult. The estimate provided below is based on the following assumptions.

- 3 billion pair of rubber soled footwear per annum imported to the United States.
- The percentage of non-black range from 25-50%.

Table - 13

United States TiO2 Used in Athletic Shoes

(Tonnes)

TiO2 Content	Minimum 25% non-black	Mid-Range 33% non-black	Maximum 50% non-black
2%	6000	7920	12000
3%	9000	11880	18000
4%	12000	15840	24000
5%	15000	19800	30000

Source: Shoe Allied Trades Research Association

- All non-black contains some TiO2
- Sole weight -- 0.4 kg/pair[38]

For the purposes of this report, a mid-range value of ~13,860 tonnes is being used.

Nike, Reebok and LA Gear are the major suppliers to the athletic shoe segment.[39] Other producers include Brooks, K Swiss, Stride Rite (Keds Division), Converse, and Etonic.

TiO2 Properties Needed in the Athletic Shoes

Hiding power, whiteness, and durability are the most important TiO2 properties in this segment. In white compounds, 5% loading is normal for TiO2. But up to 10% loading is used in very dense whites. For buff, sand or cream colored rubbers, 2% loading is normal. Loadings depend on the color of the base polymer.

As rutile prices drop, the potential conversion from anatase grades to rutile grades is more likely. Rutile grades offer a better price/performance ratio. The improved hiding power of DuPont's R-103 makes this grade a good candidate in the Athletic segment.[40]

Regional Information

WORLDWIDE

By the year 2000, nine thousand tons of TiO2 will be consumed worldwide by rubber product manufacturers.

Most manufacturing takes place in Asia Pacific and South America because of low labor costs.

NORTH AMERICA

Kemira held a 30% market share in the North American segment in 1989.[41]

United States: Consumption of TiO2 in the manufacture of elastomeric products was 18-20 thousand tons in 1989.[42]

JAPAN

Use in rubber was 3661 m tons in 1989.[43]

KOREA

The Korean athletic shoe market is a $5 billion marketplace. TiO2 use in this segment/region is estimated at 9,000 tonnes. TiO2 consumption in Korea is 95% anatase grades.[44] The potential for conversion to rutile grades is good as rutile prices come down closer to anatase prices.

Floor Coverings

Introduction

This segment includes TiO2 consumed in resilient floor tiles and sheet goods. Typically, these floor coverings contain 2-4% by weight, although some products have a much lower content. [45]

There are five basic types of flooring. TiO2 is used in all types except wood flooring.

- *Rubber*
- *Ceramic Tile*
- *Vinyl*
- *Wood*
- *Linoleum*

Wood, carpet, and ceramics producers are the major competitors to the vinyl flooring segment. [46]

Market Structure, Size, and Growth

The total TiO2 demand in the flooring marketplace is approximately 37 M tonnes per year. Table 14 shows the TiO2 use in each of these segments.

In the United States, the market has remained flat throughout the past several years. This flatness is caused by a slowdown in key construction markets. In Europe, average annual growth is estimated at 1%.

Table 14

TiO2 Use in Flooring

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	
North America	14	0%
Europe	20	1%
Asia Pacific	2	
Total	36	

The top producers in the floor coverings segment are:

- *Armstrong*
- *Tarkett*
- *Cognoleum*
- *Mannington Mills.*

In North America, Armstrong, the leading producer in flooring, sole sources 100% of their TiO2 needs from DuPont. Armstrong has an estimated 50-55% market share in this segment. Because other floor covering manufacturers are privately held companies, little information is available about their market share and growth rates. [47] In the United States, the overall market has remained relatively flat throughout the past several years.

TiO2's use in the floor coverings segment is heavily dependent on fashion trends. The shift from darker colors to lighter colors has caused an increase in TiO2 use; however, the slow growth in key construction markets has caused overall growth to remain flat. [48]

TiO2 Properties in the Floor Coverings Segment

Properties particularly important in this segment are:

- *Covering capacity*
- *Dispersability*
- *Low viscosity*
- *Color stability.*

Currently, 90% of the consumption is rutile. Rutile grades are used for their opacity and tint strength. Rutile grades also provide better protection from ultra-violet radiation. Table 15 lists the grades being used in this segment.

Table - 15

TiO2 Grades Used in Flooring

Producer	Grade
DuPont	R100, R101, R900
Thann & Mulhouse	RL11-A
Tioxide	R-SM2, R-HD2, R-FC2
SCM	RCL-472
Bayer	RFDK-1

Textile Fibers

Introduction

Hardly any innovations have so greatly contributed to the expansion of synthetic fibers in the textile segment as delustering and spin coloring. Both synthetic and semi-synthetic fibers are produced more or less as transparent materials. They both exhibit an unpleasant, hazy luster which is unattractive particularly for articles of clothing. The undesirable luster of man-made fibers is removed by the process of delustering while spinning with TiO2.[49] TiO2 is added to a fiber by mixing it in a slurry form with molten fiber prior to spinning the fiber.

Market Structure, Size, and Growth

The worldwide fiber market demand was about 32 billion pounds in 1989.[50] Table 16 shows the TiO2 consumption in this segment.

Table 16

TiO2 Use in Fibers

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	2	
North America	6	
Europe	7	Decline
Asia Pacific	17	
Total	32	

Overall, TiO2 consumption is expected to fall in the man-made fibers segment. As finer and finer yarns are used, TiO2 will cause blockages in the spinerettes. Also, companies buying fibers are increasingly aware of the environmental impact of the sulphate process. [51]

The segment is divided among five basic product lines:

- *Acrylics*
- *Nylons*
- *Polyesters*
- *Rayon*
- *Acetate.*

Sachtleben is the primary producer of TiO2 to the fibers segment. Sachtleben produces about 25,000 tons of anatase TiO2 for use in fibers. TiO2 and are trying to gain share in this segment. The Japanese supply to this segment is improving.[52]

As a general rule, 0.2% TiO2 is used per pound of fibers production.[53]

TiO2 Properties in the Textile Fibers Segment

Anatase TiO2 is the predominant form of TiO2 used in the Fibers segment. Anatase grades represent nearly 90% of the total TiO2 consumption. Some rutile grades are claimed to be softer than anatase grades. However, as a general rule, rutile grades are rarely used in fibers applications because they disperse poorly and are very abrasive. The key needs for TiO2 in fibers applications are dispersion, brightness, and opacity. Dispersion is one of the most often discussed characteristics. TiO2 must disperse very well in the liquid polymer before it passes through the spinerette. [54] In this segment gloss is not an issue. [55] Table 17 lists the various grades most commonly used in fibers applications.

Table - 17

TiO2 Grades Used in Fibers Applications

Supplier	Grades
Sachtleben	LW-S, LW-S-U
Kronos	1071, 1072
Tioxide	A-PP2, A-HR
Kemira	OR520

Sachtleben grades used in fibers applications include LWSU for Dacron, and LWSU for Polyester. Other Sachtleben grades used in fibers are LWS, FFS, and LOCLS. *Kemira* OR520 is also used.[56]

Sachtleben produces TiO2 for most fibers applications world wide.

Adhesives and Sealants

Introduction

The worldwide Adhesives and Sealants segment is a highly fragmented segment. There are at least 750 producers making thousands of products world wide. The majority of producers in this segment would normally seek TiO2 supply through distributors. This segment has seen considerable consolidation worldwide. The driving forces behind consolidation are snowballing R&D costs and environmental compliance. [58]

UNITED STATES: The United States adhesives and sealants segment is a relatively small segment with just over $6 billion in merchant shipments. The segment is extremely complex in its products, specifications, and competition. [59] This segment has over 500 merchant producers operating some 750+ plants.

EUROPE: This segment is very attractive to DuPont. It is 90% rutile and one of the largest European segments. While the segment is highly fragmented, if DuPont can be successful through good distributor relationships.

Market Structure, Size, and Growth

The worldwide adhesives and sealants segment is a highly fragmented segment. This segment has over 750 producers worldwide. In the United States alone, there are over 550 producers. This segment is mature and has thousands of products, end uses, and technology.

TiO2 requirements was extremely difficult. Table 18 depicts TiO2 use in each region of the world. Kline's 1988-1989 Extenders and Fillers report indicated that 13-14 M tonnes TiO2 were consumed in the United States. The European Study reported that 9 M tonnes were consumed. Assuming that Asia Pacific figures closely relate to those of the United States and Europe, the estimated consumption in Asia Pacific is approximately 11 M tonnes per year.

Table 18

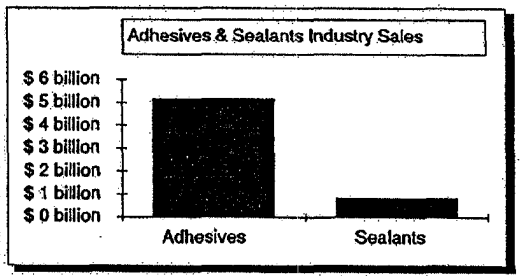
TiO2 Use in Adhesives & Sealants

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	
North America	14	2%
Europe	9	5%
Asia Pacific	0	
Total	23	

In the United States, 1988 sales to the adhesives segment were $5.7 billion. Figure 5 shows United States adhesives and sealants sales. The ten leading producers accounted for over 40% of the US total market share. The remaining 500 accounted for the remaining 60% market share. In Europe, the combined adhesives and sealants marketplace totalled almost $4 billion (adhesives/$3 billion, sealants $1 billion). [60] The European market structure is similar with over 200 producers.

Figure - 5

Adhesives and Sealants Sales in the United States



Three of the top producers in this segment are:

- *National Starch & Chemical (New Jersey, USA)*
- *3M (St. Paul, Minnesota)*
- *Henkel (Dusseldorf, Germany)*

Adhesives, in short, are chemical compounds capable of bonding themselves to a dissimilar materials. [61] *Adhesives* includes:

- *cements*
- *pastes*
- *mucilage*
- *glues.*

Sealants includes sealants and caulks. While sealants must adhere to one or more surfaces, their application is designed to prevent the passage of a liquid or gas between the surfaces. [62]

TiO2 Properties in the Adhesives/Sealants Segment

TiO2 is used in virtually all uses of sealants which are visible and white. The overall use of TiO2 is relatively low – typical loadings are 1-2% by weight. The most important product properties in this segment are dispersability and ultra-violet stability.[63] In Europe, the main grades discussed in this segment are:

- *SCM AG-WDB*
- *Tioxide TR92 and RFC5.*

Anatase grades are the predominant grades used in this segment today. The potential for conversion to rutile will be much greater as rutile prices drop.

TiO2 is used in nitrile rubber cements at levels between 5 and 25 particles per hundred to add whiteness, promote tack, and extend storage life. [64] In sealants, some rutile grades are added at levels up to 22% by weight to reinforce rubber in polysulfide sealants and at lower levels as a whitener in polybutene and silicone based sealants. [65]

Regional Information

EUROPE:

Adhesives and Sealants producers have a sense of neglect. They typically purchase small TiO2 quantities direct from the supplier. Because quantities are small, users have encountered indifference.

Ceramics

Introduction

TiO2 is used as a component of porcelain enamels and glazes for metals, ceramics, and specialty glasses. Non-pigmentary grades are often used because of their larger particle size. [66]

The United States ceramics segment has experienced a decline since the 1973. This decline coincided with the development of other metal coatings and techniques for applying thinner ceramic surfaces.

The ceramics segment is divided into two segments: Frits and Glazes. Frits are used in many porcelain applications. Glazes are used in bathroom tile and cookware applications. [67]

Market Structure, Size, and Growth

The worldwide ceramics business (frits and glazes) consumes approximately 22.3 M tonnes TiO2 per year. Table 19 shows the TiO2 usage by region.

Table 19

TiO2 Use in Ceramics

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	2	
North America	11	2%
Europe	7	5%
Asia Pacific	2	
Total	22	

The ceramic wall and floor tile segment experienced record shipment levels of about 505 million square feet in 1989. The 3 percent increase over 1988 shipments primarily reflected the growing popularity of ceramic tile for many applications in new and existing residential and non-residential buildings. [68]

Growth in the North American segment is likely to be slow. The level of TiO2 consumption in 1989 was, 11-12 M tonnes.[69]

Ferro is a major player in the Frits and Glaze marketplace. In the United States, they use 1500-2000 tons of non-pigmentary TiO2. Other manufacturers in this marketplace are Mobay, Chivey, and General Color. [70]

The United States ceramics segment has decreased in size by 50% in the past 5 years. This decline has been heavily influenced by the shift in use of porcelain enamel frit to powder coatings. [71] Major producers to the ceramics segment are:

- *Ferro*
- *Bobay*
- *Chivet*
- *General Color.*[72]

Ferro has between 33-50% of the market share in ceramics worldwide.[73]

TiO2 Properties in the Ceramics Segment

Anatase is the preferred form of TiO2 in ceramic frit applications. While rutile grades are preferred in many nonceramic applications, in titania enamels, appreciable rutile gives rise to objectionable color. [74] The segment standard grade of TiO2 in the ceramics segment is SCM's non-pigmentary TiO2. It is typically shipped and imported to the United States. This grade of TiO2 has a 9-10 micron particle size. [75]

Frit Applications: Care must be exercised in selecting TiO2 for ceramics. Grades produced especially for ceramic applications flow freely in dry state and eliminate sticking. These properties are not characteristic of pigmentary TiO2.

Glaze Applications: TiO2 is used in glazes to affect acid resistance, color, and texture. To glass, nonpigmentary TiO2 imparts a high refractive index. It also intensifies and brightens colored transparent glasses, especially those using ceria as a colorant. [76]

The most important product attribute is particle size -- typical 9-10 microns. SCM currently has a product capable of meeting producers' needs. The product is shipped to the United States in bulk quantities. DuPont success in the marketplace is dependent on making TiO2 with a large enough particle size.

Regional Information

WORLD

Tile is produced in Mexico, Brazil, Italy, and Taiwan.[77]

UNITED STATES

Growth of the ceramics market in the United States is flat. The major reason for the flatness is that there is has been an increased use of powder coatings in appliance applications.

ITALY AND BRAZIL

These two countries consume the most tile per capita. These are the largest ceramics markets in the world.[78]

MEXICO

The standard grade of TiO2 is R-110. Mexico uses this grade because of a legalized monopoly in the country.[79]

Leathers

Introduction

The leather tanning and finishing segment consists of establishments primarily engaged in tanning, currying, and finishing raw or cured hides and skins into leather. The segment also includes converters and dealers who buy hides and skins or leather and contract with tanners or finishers to process these products. Overall, this segment is highly fragmented. All tanneries use TiO2 for finishing or surface coating of leather. The industry term for what a layman might call "spray paint" is "dope." Most producers purchase TiO2 in an aqueous paste form supplied by leather pigment manufacturers.

TiO2 is used in many types of leather products. It is typically found in colored items where a white or pastel color is desired. The segment has two segments:

- consumer products (i.e., shoes, handbags, and accessories)
- automotive upholstery. [80]

Market Structure, Size, and Growth

Bayer, BASF, Henkel, Earnshaw, and ICI all supply this segment with TiO2.[81] In this segment, the TiO2 producers are also the major suppliers of pigments to the leather industry. Consequently, these companies represent the majority of the TiO2 consumption in leather goods manufacturing.

Table 20 lists TiO2 consumption figures for the leather segment.

The long-term outlook for the worldwide leather tanning and finishing segment is brighter than it has been. The hide supply will begin to increase in late 1990, and process should decline thereafter.

Worldwide growth in the leather segment will be about 5%/year.[82]

Environmental problems will remain a concern, but new technology and equip ment will help the segment remain the most cost-com petitive and highly productive of any in the world.[83]

Throughout the past ten years, the North American leather segment has been in a depression because many production operations have moved overseas.

Table 20

TiO2 Use in Leathers

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	1	NR
North America	4	2%
Europe	4	3%
Asia Pacific	4	14%
Total	15	5%

In addition to the labor shortage, car builds in the automotive segment have declined. [84] Inexpensive labor rates have driven these markets overseas. [85] The fastest growing and potentially largest markets in the United States today are those for automotive and furniture upholstery leather.

The North American leather segment experienced considerable contraction and consolidation between 1982 and 1987. The number of companies declined from 342 in 1982 to 308 in 1987. By 1989, only about 130 establishments of significant size were directly tanning raw hides and skins into leather. The footwear segment is the tanning segment's largest market, consuming an esti mated 55 percent of leather shipments in 1989.

TiO2 Properties in the Leathers Segment

In the leathers segment, both anatase and rutile grades of TiO2 are used; however, rutile grades are preferred for their hiding power. Anatase is typically used in lower quality applications. The properties typically sought after are much the same as those in the coatings industry. [86]

In North America, leather manufacturers obtain their TiO2 supply through distributors. In Europe, leather finishing chemical suppliers are often large chemical companies themselves. At least 90% of all TiO2 consumed in this segment is used for coloring purposes. It is used mainly in finishing, or the "dry" end, but to some extend in pre-coloring, or the "wet" process.[87]

Dupont's R-900 and R-902 are used in the segment.[88] TiO2 is typically loaded at levels of 1-2% by weight. TiO2 is also used in leather finishing (15-25% by weight).[89]

Regional Information

WORLDWIDE:

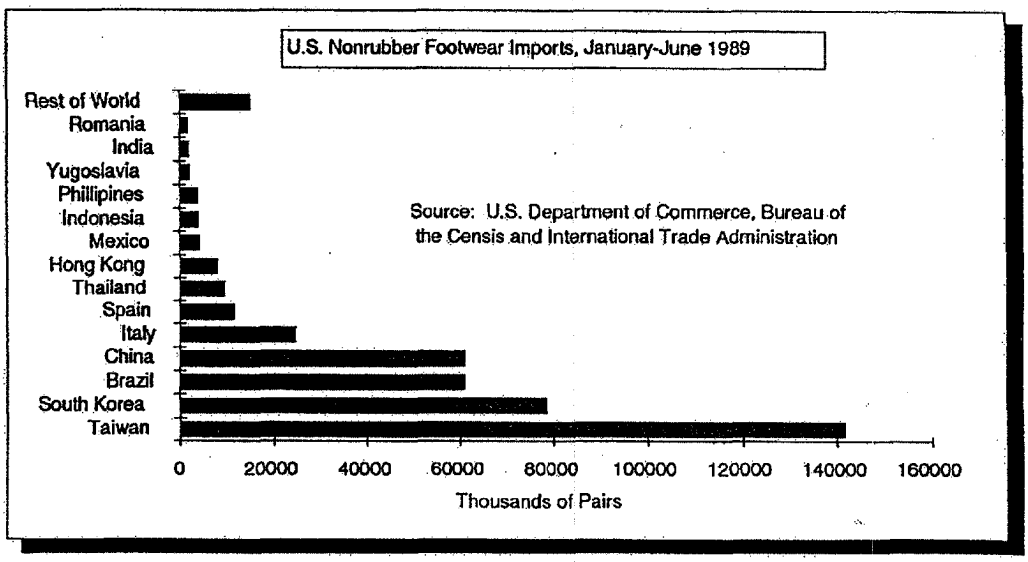
There is no technical barrier to DuPont entering this industry. The similarities to the coatings industry will help DuPont gain success in this segment.

UNITED STATES:

United States imports of leathers rose about 13 percent in 1990 to an estimated $14 billion. Over 80 percent all imports came from developing and newly industrialized countries like Tiawan and Korea.[90] Figure 6 shows the total pairs of non rubber imports to the United States. Taiwan, South Korea, Brazil, and China are the largest producers of leather products.

Figure - 6

Leather Footwear Imports to the United States



Roofing

Introduction

The roofing granule segment is a predominantly United States segment. This segment creates two types of products.

- *roofing granules*
- *sheeting.*

TiO2 is used in roofing granules for lighter colored roofing.

Market Structure, Size, and Growth

Growth in the roofing segment is directly related to GNP growth.[91] This segment has remained stagnant since 1973. Prices have remained the same since 1973 and the market shows little growth. The only way for a granule producers to increase earnings is to cut production costs or increase volume.[92] Cost is a predominant concern in this segment.[93]

The roofing segment is a relatively small segment and is a predominantly North American in orientation. Overall TiO2 consumption was estimated at 8.5 M tonnes (shown in Table 21).

Table 21

TiO2 Use in Roofing

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	N/A
North America	9	0%
Europe	0	N/A
Asia Pacific	0	N/A
Total	9	

About 60% of the roofing market is new housing starts, and the balance is repair and replace ment markets.[94] GAF and 3M are the major producers of roofing granules, 3M being the largest. The largest producer of roofing products is 3M. Experts estimate that 3M has 50% of the market share.[95] Overall, about 3000 M tons of roofing granules are produced each year.

DuPont supplies 3M with approximately 55% of their total TiO2 requirements (SCM and Kerr-McGee supply the rest). 3M's estimated annual requirement is 4700 tons.

TiO2 Properties in the Roofing Segment

Roofing granules are normally required to be highly opaque (less than 1% light transmitted).[96] Black and grey granules of various shades are typically made of natural basalt (no TiO2 content). Other colors are basalt granules that are coated with a ceramic layer containing TiO2 and other pigments. Typically, granule producers purchase pigmented products containing TiO2 from distributors. They then fire the coated basalt particles to produce the finished granule.[97] Typical loadings are less than 5% by weight.

Granule producers are most interested in TiO2 opacity.[98] The most prominent TiO2 grades used in this segment are:

- *DuPont R100 and R101*
- *SCM's RCL9 and RCL4*
- *Kemira's OR-342 and OR580.*

Regional Information

NORTH AMERICA

Gangrit (a roofing granule producer) purchases color formulations already containing TiO2 from distributors such as Van, Waters & Rodgers.

DuPont is the sole supplier of TiO2 to GS Roofing. They use two grades -- R901 and R101.[99]

Correction Fluid

Introduction

Correction Fluid is a highly opaque fluid that is used to "paint" over typewritten or handwritten mistakes on paper. It is sold in small bottles about the size of a bottle fingernail polish. The correction fluid segment is predominantly North American.

Market Structure, Size, and Growth

North America is the largest consumer of office papers in the world. Overall, consumption of correction fluid is directly related to that of office papers. The correction fluid segment is a predominantly North American marketplace. Over 80% of all correction fluids consumed worldwide are sold in North America.[100] The Paper Mate Company (a subsidiary of Gillette), St. Paul, Minnesota, is the major producer in this segment with over 50% market share. Table 22 shows the TiO2 consumption in this segment.

Table 22

TiO2 Use in Correction Fluid

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	NR
North America	4	4%
Europe	1	NR
Asia Pacific	2	NR
Total	7	

Overall, about 7.1 M tonnes of TiO_2 are consumed in this segment worldwide. In North America approximately 80% or 4.0 M tonnes TiO_2 are used in this application.

Throughout the 1980's businesses computerized their offices and turned to word processing rather than conventional typewriters. Experts initially felt that the correction fluids segment would decrease as wordprocessing became more popular and the number of typewritten documents decreased. Surprisingly, the correction fluid segment continues to increase. The segment has increased because people continue using correction fluid to correct their mistakes after printing computer generated documents. This segment continues to grow at 3-5% annually.

TiO_2 Properties in the Correction Fluids Segment

The Paper Mate Company purchases 100% of their TiO_2 supply from DuPont. Currently R-901 is used because of its dry-flat hiding ability and its relative opacity. TiO_2 is loaded at levels of up to 30% by weight in correction fluid. Kronos 2160 is also used widely in Europe.

Paper Mate is in the process of reformulating their correction fluid products because VOC's have become a concern. By 1992, producers will shift TiO_2 grades to DuPont's R-931.

Electronics

Introduction

"Miniaturization" is a predominant theme in the electronics segment. The goal of miniaturization is to create smaller, higher performing devices. As the segment matures, TiO2 requirements will decrease because less TiO2 is required for each device produced.[101] The most important requirements for the electronics segment are:

- *purity of raw materials*
- *increasing yield to permit lower pricing*
- *decreasing production costs*
- *mass production.*[102]

In the electronics segment, TiO2 is used for piezoelectric devices, dielectric layers in capacitors, and titanates. The major ceramic capacitor applications are in mainframe computers, telephones, microcom puters, and consumer electronics.[103]

In the United States market, the predominant TiO2 suppliers are TAM (a subsidiary of Cookson pigments) and National Lead.[104] These two producers account for over 80% market share in the ceramic powders market. TAM produces TiO2 by mixing TiCl with H_2O. This TiO2 is known for its large particle size and poor dispersion characteristics. Regardless, electronics manufacturers use TAM TiO2 because it is pure (contains no AL_2O_3).[105]

Market Structure, Size, and Growth

Table 23 shows the TiO2 consumption in the high performance electronics segment.

Companies involved with one or more facets of the advanced ceramics segment may range in size from the job shop to huge, multinational corporations.

In the electronics segment TiO2 is found in high-tech ceramics. TiO2 opportunities are limited to selective niches requiring fine powder feedstock.

Table 23

TiO2 Use in Electronics

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	
North America	2	
Europe	2	
Asia Pacific	1	
Total	5	

The market is small with about 5000 tons of TiO2 consumed worldwide.

On average, TiO2 consumption in the United States is 2.2 M tonnes.[106] In Japan, Fuji and Toho are the major suppliers of high performance TiO2. They supply 400-500 tons per year of aluminum-free product.[107] The segment is growing worldwide at 8% per year. Asia is a major player in this segment.[108] In this market, TiO2 sells from $5.00-15.00 per pound. The high purity needed dictates the higher price.

Atomergic Chemicals Corp, Bay State Abrasives, Kraft Chemical Company, TAM, Superior Technical Ceramics, and Whittaker, Clark, and Daniels all supply the high purity TiO2 business.[109]

TiO2 Properties in the Electronics Segment

Dielectric Applications: Only rutile TiO2, which decomposes at 1640 is used in dielectric purposes. Rutile grades are used in either pure form or with minor additions of various materials.

Barium Titanate: BaTiO3 (m.p. >1500C) has widespread used in the electronics segment because of its high dielectric constant and piezoelectric properties. Since anything that will affect the crystal lattice of barium titanate will alter its dielectric properties, it is important that impurities (SiO2, Al2O3, etc.) be controlled and maintained at comparatively low levels. Barium titanate ceramic products are used for applications in underwater sonar, guide missiles, acoustic mines,

ultrasonic cleaning, measuring instruments, accelerometers, sound reproduction, etc. The most important TiO2 product characteristics in this segment are particle size and purity. Aluminum content is detrimental to manufacturing success in the high performance electronic segment.

In barium titanate applications, the type of TiO2 (rutile or anatase) is not as important as its purity, aggregation, and dispersion characteristics. [110] DuPont TiO2 is not suitable for electronics applications today because if its Al_2O_3 content; however, DuPont does have the ability to produce aluminum-free TiO2 that could be used in this segment. [111]

DuPont needs to produce a high purity, low Al_2O_3 content TiO2 to be successful in the electronics segment.[112]

Regional Information

UNITED STATES AND CANADA

TAM and DuPont supply TiO2 to this segment.

JAPAN

The key Japanese TiO2 suppliers to this marketplace are: Titan Kogyo and Toho Titanium. Other suppliers include: Fuji Titanium, Furukawa Mining, Ishihara Sangyo, and Teikoku Kako.[113] *The key suppliers of Barium Titanate are: Kyoritsu Yogyo, and Fuji Titanium.*

Cosmetics

Introduction

The Food and Drug Administration has defined cosmetic products as

> "articles intended to be rubbed, poured, sprinkled on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering appearance." [114]

Although one of the best self-regulated industries in the past, the cosmetics segment, in cooperation with the Food and Drug ad ministration, is placing even more emphasis on self-regulation. As a result, evaluation of ingredients is improving as is the safe and optimum use of cosmetics and hair care products. [115]

The need for TiO2 in cosmetics is heavily dependent upon fashion trends. All cosmetics have a degree of transparency or translucently depending the current fashion trend. [116] Current fashion trends are moving towards more translucent cosmetics. [117] TiO2 usage will decrease as a result of this shift.

TiO2 is used in a multitude of cosmetic products. Just to name a few: foundation, mask, mascara, cream concealer, lipstick, lip gloss, eye color, cheek color, loose powder, pressed powder, nail cover remover, etc. [118] Table 24 lists selected cosmetic products and their TiO2 content by weight. In the products listed below, TiO2 is loaded at levels between 1% and 46%.

Table 24

TiO2 Used in Selected Cosmetics Products

Cosmetic Product	TiO2 Use by Weight
Caster Oil-Free Lipstick	6%
Long-Wearing Creamy Lipstick	11%
Basic Lipstick	6%
Soft Frost Eye-Shadow	30%
Compacted Eyeshadow	2%
Waterproof Iridescent Eyeliner	10%
Waterproof Special-Effects Mascara	1%
Waterproof Mascara	6%
Pressed Powder Rouge	46%
Cover Stick	6%
Pigmented Cover Cream	2%
Pearly Foundation Cream	10%
Face Mask	4%
Copper Suntan Cream	5%

Market Structure, Size, and Growth

Table 25 lists the TiO2 consumption in the cosmetics segment.

Table 25

TiO2 Use in Cosmetics

	TiO2 Consumption (M tonnes)	Growth Rate
Latin America	0	
North America	1	
Europe	1	
Asia Pacific	1	
Total	3	

During 1987 the worldwide sales of cosmetics and toilitries amounted for $70 billion at retail selling prices. The United States is the biggest single market with 30% of the world total. Japan is the second largest consumer of cosmetics and toiletries, representing 14% of the world market. Table 26 shows a worldwide breakdown of cosmetics consumption.

Table - 26

Cosmetics Consumed by Country

Country	Percent of All Cosmetics Purchased
United States	30%
Japan	14%
France	9%
West Germany	8%
Italy	6%
United Kingdom	6%
Rest of World	27%

Source: Cosmetics & Toiletries, Volume 103, September 1988, p. 98.

The cosmetics segment consists of three major categories: cosmetics, fragrances, and toiletries. In the United States, the value of product shipments in 1989 is estimated at $16.7 billion, up 5.8 percent from 1988.[119] The skin- and hair-care markets are the largest segments in the cosmetics segment. The ethnic market for products designed specifically for darker skin and special hair care is growing faster than the rest of the cosmetics segment. Table 27 shows breakdown of growth in the United States cosmetics segment.

Table - 27

Growth in the United States Cosmetics Segment

Growth/Sales in the Cosmetics Segment		
	Growth	Total Sales
Skin Care	12.0%	$3 billion
Sun Care	16.0%	$205 million
Hair Care	8.0%	$4 billion
Ethnic Segment	12.0%	$2 billion
Source: 1990 US Industrial Outlook		

Three major suppliers service the cosmetics segment:

- *Whittaker, Clark, & Daniels*
- *Warner Jenkins*
- *H. Kohnstam.*

TiO2 Properties in the Cosmetics Segment

Cosmetics are becoming high-tech products. Research and development is aimed primarily at skin care and protection as well as minimizing allergic response to ingredients.[120] Anatase grades of TiO2 are predominant in the cosmetics segment. Opacity is the most important property in this segment. Average loading for most products is 3-6%.[121]

The cosmetics segment has very strict guidelines for TiO2 use. The guidelines are outlined in United States Pharmacopeia (1990 Edition, Volume 22) and 21 CFR 73.575. All TiO2 is quality tested against these specifications. Table 28 summarizes TiO2 requirements in the United States.

Table - 28

Food & Drug Administration Specifications for TiO2 in Cosmetics.

99-100% pure by US Pharmacopeia standards.
Less than .1% Lead content
Less than 2ppm Antimony
Less than 1ppm Mercury
Must conform to 21CFR 73.575

Regional Information

ASIA PACIFIC

Korea: Growth in the cosmetics has been limited in South Korea due to governmental requirements and restrictions. The Korean government only allows production for a limited number of products, such as eyebrow pencils and soft capsule preparations. As a result, there are only 56 cosmetic manufacturers in South Korea.[122]

Sources

Overall

DuPont Chemicals

A. M. Baker -- Devoted numerous hours to this study by providing project guidance, technical expertise, draft review, and training.

Hubbard and Lutz, TiO2 Minor Markets Update, April 1979. DuPont Chemicals Marketing Research MR#: 7901

E. A. Bonanni, TiO2 Minor Markets Update, November 1983. DuPont Chemicals Marketing Research MR#: 8311

B. A. Murphy -- Literature Searches

Business Information Center

C. F. Brown -- Literature Searches
A. M. Grillo -- Multi-client Studies

Specialty Segments (listed alphabetically)

Adhesives and Sealants

People
- DuPont Chemicals
  - Marty McKenzie -- Marshall Lab
- National Starch & Chemical
  - John O'Rourke

Professional Organizations
- Adhesives and Sealants Council
  - (703)841-1112
- Adhesives Manufacturing Association
  - (312)644-6610

Publications
- Rubbers & Plastics News
- Adhesives Age
- Chemical Week
- Kline -- Extender and Filler Materials -- North America.

Major Companies
- US Chemicals and Plastics
- Marson Marble

Ceramics

People
- DuPont Chemicals
  - Gerald K. Campbell -- (216) 752-0211
  - Charlie Booth - Ex Station
    - Ducom 695-2843
  - John Deitz
  - Carl Chen - Jackson Labs
    - Ducom 540-3175

Professional Organizations
- Institute of Ceramic Engineers
  - (614)890-4700

Publications
- Ceramics Industry Update
- Chemicals Business

Cosmetics

Professional Organizations
- Cosmetic Industry Buyers and Suppliers Association (516)679-9120
- American Beauty Association (305)736-7897
- Kolmar Laboratories, Bill Hogan (914)856-5311

Publications
- Journal of the Society of Cosmetic Chemists
- Cosmetics and Toiletries
- Household and Personal Products Industry

Major Companies
- Mary Kay

Correction Fluids

People
- John Imes -- DuPont Chemicals

Electronics

People
- DuPont Chemicals
  - John Deitz - Jackson Labs
    - Ducom 540-3253
  - Howard ("Jake") Jacobsen - Exp Station
    - Ducom 540-4294

Professional Organizations
- Association of Electronics Manufacturers
  - (202)475-4900

Publications
- Ceramics Industry

Floor Coverings

People
- DuPont Chemicals
  - Joe Battin - DuPont Rep for Armstrong
  - John Birmingham

Professional Organizations

Wood & Synthetic Flooring Institute
(312) 449-2933
Resilient Floor Coverings Institute
(301)340-8580
National Floor Products Company
(205) 766-0234
Publications
Handbook of Contract Floor Covering
Major Companies
Armstrong -- Robert Trees (717) 397-0611

Leathers

Professional Organizations
Leather Industries of America --
Frank Rutland
Publications
U.S. Industrial Outlook -- Leathers
Leather Industries of America -- Membership
Directory and Buyers Guide
Major Companies
Rohm & Haas -- Nick DiCandelo

Printing Inks

People
Cookston Pigments
Bill Dusch -- (704) 588-2020
Joe Loughney -- (800) 932-0765
Ralph Edelman
DuPont Chemicals
Jim McNutt
Horacio Ojeda
Mary Gardner
Ed Wandersee
Harry Coker -- x 49619
Carl Landerl -- (714) 583-1677
Professional Organizations
Lehigh University
National Association of Printing Inks
Manufacturers
Gravure Technical Association
DuPont Boothwyn Printing Operation
Publications
Kline Guide to Printing Inks
American Ink Maker Magazine
The Printing Ink Handbook
Printing World
Chemical Marketing Reporter
Major Companies
Sun Chemicals -- Sam Gilbert
(708)562-0550
BASF - Howard Ramsey

Roofing

People
DuPont Chemicals
John Imes
Steve Leung
Rich Hinchman
Publications
Roofing, Siding, & Insulation
(212)888-4354
Major Companies
3M (Source asked not to be identified)

Rubbers and Elastomers

Tires
Professional Organizations
Rubber Manufacturing Association
(202)682-4860
National Tire and Retread Association
(202)789-2300
International Tire re Association
(203)677-7782
Akron Rubber Group
Allen Gatzman -- (216) 798-2237
Abdul Hadi -- (216) 798-2236
Publications
Chemical and Engineering News
Rubber World (216)846-2122
Rubber & Plastics News
Rubber & Plastics News II
(202)662-7200
Elastomerics
Athletic Shoes
Professional Organizations
Footwear Industries of America
(202) 789-1420
Lee McKinely (technical information
and industry contacts).
Tracy Hoeffel (statistics on footwear
production)
International Footwear Association
(202)737-5660
Shoe and Allied Trades Research
Association (Europe)
Steve Abott
011 44 536 410000
Bryan Blackwell
011 44 536 410000
Publications
Footwear News -- (212) 741-4010

Textile Fibers

- People
  - DuPont Fibers
    - Dick Goodly
    - Jim Sherrer
    - Rita Cappell
    - Chris Smith
    - Myron Richardson
    - Bob King
  - DuPont Chemicals
    - Becky Craft
  - DuPont Imaging
    - Ray Work -- Ducom 992-2011
- Professional Organizations
  - Textile Research Institute (609)924-3150
  - Textile Fibers By-Products Association (704)527-5593
  - American Association of Textile Chemists (919)549-8141
- Publications
  - DuPont Chemicals Marketing Research MR#:91-4,
  - Screen Printing Magazine
- Major Companies
  - DuPont

Footnotes

[1]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study

[2]American Ink Maker, Selected articles from 1990.

[3]Chemical Marketing Reporter, Inks and Dyes: Kaleidoscopic Change, September 24, 1990.

[4]American Ink Maker, September 1990, p. 13.

[5]American Ink Maker, September 1990, p. 13.

[6]American Ink Maker, September 1990, p. 13.

[7]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003F.

[8]Paint and Coatings Industry, The Global Market for Titainim Dioxide, August 22, 1990, p. 528, 538.

[9]Bill Dusch, Sun Chemical (??????) Check this reference to be sure. Ask Connie Hubbard.

[10]Carl Landerl, (714) 583-1677.

[11]Pocket Pal -- A Graphic Arts Production Handbook. International Paper Company, pp. 24-30.

[12]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study

[13]Bill Dusch

[14]Bill Dusch

[15]DuPont Japan -- Ryo Kuroda

[16]DuPont Chemicals (Mexico) -- Horacio Ojeda

[17]The National Association of Printing Ink Manufactureers(NAPIM), The Printing Ink Handbook, 4th Edition, p. 37.

[18]Kline, 1989 Extenders and Filler Minerals, Volume 2, p. 309.

[19]Hull & Company

[20]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003F.

[21]American Ink Maker, State of the Industry, August 1990, p. 62.

[22]Japan Chemical Week, May 17, 1990.

[23]Farbe & Lack (German), Japan: Rekord fuer TiO2-Absatz, May 1990, p. 376.

[24]Informations Chimie, Encres d'imprimerie: Maintenir le Cap, July 1990, p. 84/

[25]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study

[26]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003C.

[27]Elastomerics, TiO2 in Rubber Goods to Hit 9,000 Tons, May 1989, p. 19.

[28]Kline, 1987 Extender and Filler Materials -- North America, p. 363.

[29]Elastomerics, TiO2 in Rubber Goods to Hit 9,000 Tons, May 1989, p. 19.

[30]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study

[31]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003C.

[32]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study

[33]Akron Rubber Group, Allan Gatzman (216) 798-2237.

[34]Rubber & Plastics News, 1990s Supply, Demand Changing the Tire Industry, April 30, 1990, p. 9.

[35]Rubber & Plastics News, '90s May Begin Specialty Polymers Era, January 22, 1990, p. 15.

[36]Akron Rubber Group, Abdul Hadi (216) 798-2336.

[37]Rubber & Plastics News, '90s May Begin Specialty Polymers Era, January 22, 1990, p. 15.

[38]Bryan Blackwell -- SATRA

[39]Lee McKinely -- Footwear Industries of America

[40]I.K. Park -- DuPont Chemicals

[41]Kline, 1989 Extender and Filler Materials -- North America, p. 314.

[42]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003D.

[43]Japan Chemical Week, Production, Deliveries of Titanium in Fiscal '89 Set Record, May 31, 1990, p. 2.

[44]I. K. Park -- DuPont Chemicals

[45]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003G.

[46]Robert Trees -- Armstrong World, Inc.

[47]The Floor Covering Institute

[48]Robert Trees -- Armstrong World, Inc.

[49]Kronos Guide to ti10 Use.

[50]Chemical Week, Soft Markets Bring Hard Times to Fibers, November 7, 1990, p. 23.

[51]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[52]Jim Sherrer -- DuPont Fibers
[53]Jim Sherrer -- DuPont Fibers
[54]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[55]Samuel Taylor (DuPont Chemicals) and Mike DelCamp (Van Waters & Rogers)
[56]Jim Sherrer -- DuPont Fibers
[57]Chemical Engineering Progress, The Chemical Industry: Past and Future Performance, July 1988, p. 56-66.
[58]Chemical Week, Adhesives & Sealants. A Dynamic Industry Meets New Demands, March 14, 1990, p. 20.
[59]The Rauch Guide to the U.S. Adhesives and Sealants Industry. p. 1.
[60]Chemical Week, Adhesives & Sealants. A Dynamic Industry Meets New Demands, March 14, 1990, p. 20.
[61]The Rauch Guide to the U.S. Adhesives and Sealants Industry. p. 2.
[62]The Rauch Guide to the U.S. Adhesives and Sealants Industry. p. 3.
[63]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[64]Kline, 1987 Extender and Filler Materials -- North America, p. 368.
[65]Kline, 1987 Extender and Filler Materials -- North America, p. 368.
[66]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003E.
[67]DuPont Chemicals -- Gerald K. Campbell
[68]U.S. Industrial Outlook for Construction Materials - 1990, Chapter 7, p. 13.
[69]F. Alan Ferguson and Barbara Heydorn, Titanium Dioxide Pigments, May 1986, p. 788.5003E.
[70]Gerald K. Campbell -- DuPont Chemicals
[71]Gerald K. Campbell -- DuPont Chemicals
[72]Gerald K. Campbell -- DuPont Chemicals
[73]Gerald K. Campbell -- DuPont Chemicals
[74]Ceramic Industry, A Guide to Products and Services, January 1990, p. 116.
[75]Gerald K. Campbell -- DuPont Chemicals
[76]Chemical Week, Adhesives & Sealants. A Dynamic Industry Meets New Demands, March 14, 1990, p. 20.
[77]Dwight Holzen -- DuPont Chemicals
[78]Gerald K. Campbell -- DuPont Chemicals
[79]DuPont Chemicals (Mexico) -- Horacio Ojeda
[80]Nick DiCandalo -- Rohm & Haas
[81]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[82]Frank Rutland -- Leather Industries of America
[83]United States Department of Commerce, US Industrial Outlook, p. 37-4.
[84]Nick DiCandalo -- Rohm & Haas
[85]Nick DiCandalo -- Rohm & Haas
[86]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[87]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[88]DuPont Chemicals (Mexico) -- Horacio Ojeda
[89]DuPont Chemicals (Mexico) -- Horacio Ojeda
[90]U.S. Industrial Outlook 1991 -- Leather and Leather Products, Chapter 35, p. 1.
[91]John Imes -- DuPont Chemicals
[92]Steve Leung -- DuPont Chemicals
[93]John Imes -- DuPont Chemicals
[94]John Imes -- DuPont Chemicals
[95]John Imes -- DuPont Chemicals
[96]Steve Leung -- DuPont Chemicals
[97]Steven J. Leung -- DuPont Chemicals -- Chestnut Run.
[98]John Imes -- DuPont Chemicals
[99]G. M. Pettyjohn -- DuPont Chemicals
[100]John Imes -- DuPont Chemicals
[101]Jake Jacobsen -- DuPont Chemicals -- Jackson Lab
[102]Advanced Ceramics, Advanced Ceramics: '90's Global Business Outlook, April 1990, p. 53-57.
[103]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[104]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[105]John Deitz -- DuPont Chemicals
[106]John Deitz -- DuPont Chemicals
[107]Jake Jacobson -- DuPont Chemicals -- Jackson Lab
[108]Advanced Ceramics, Advanced Ceramics: '90's Global Business Outlook, April 1990, p. 54.

[109]Ceramic Industry, September 15, 1990, p. 77.
[110]John Deitz -- DuPont Chemicals
[111]Jake Jacobsen -- DuPont Chemicals
[112]John Deitz -- DuPont Chemicals
[113]DuPont Chemicals Marketing Research MR#:91-4 European TiO2 Study
[114]Mary Kay Consumer Guide to Cosmetic Ingredients.
[115]United States Department of Commerce, US Industrial Outlook, p. 37-4.
[116]Tony Mentlick -- Mary Kay Cosmetics
[117]Bill Hogan -- Kolmar Labs, Port Jervis, New York
[118]Mary Kay Consumer Guide to Cosmetic Ingredients.
[119]United States Department of Commerce, US Industrial Outlook, p. 37-4.
[120]United States Department of Commerce, US Industrial Outlook, p. 37-4.
[121]Bill Hogan -- Kolmar Labs, Port Jervis, New York
[122]Cosmetics & Tioletries, Cosmetic Market in Korea, Volume 103, September 1988, p. 118.