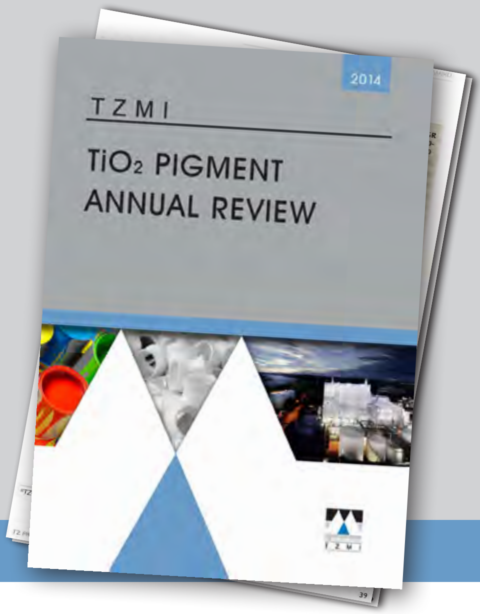

TiO_2 PIGMENT ANNUAL REVIEW *SAMPLE*

NEW EDITION TO BE RELEASED Q2 2014

PROPOSED TABLE OF CONTENTS*

* minor changes may be made to this outline prior to publication

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SAMPLE OF 2013 EDITION

INTRODUCTION TO TiO2 PIGMENT AND PIGMENT INDUSTRY

TiO2 PIGMENT

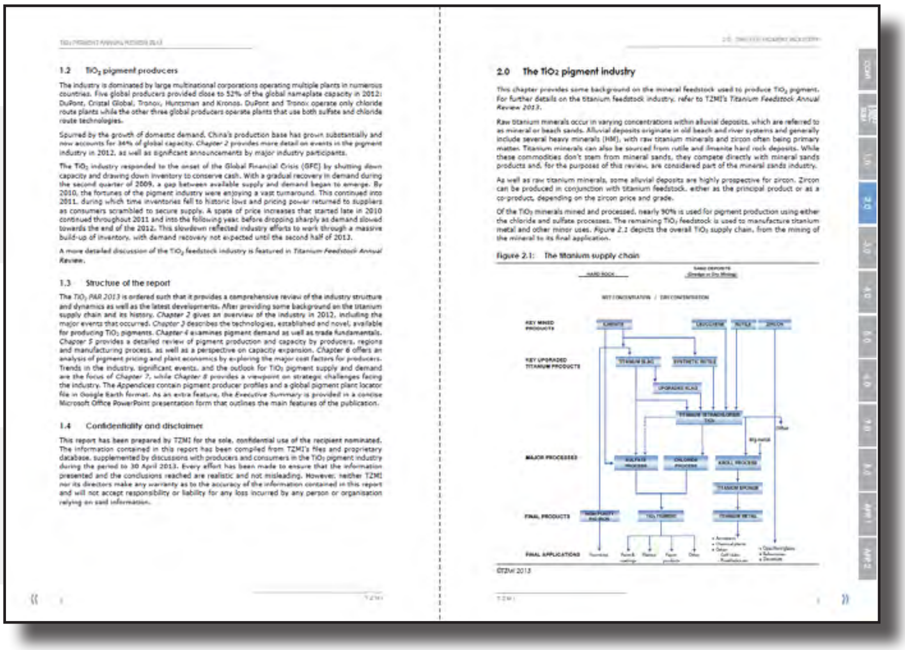
Overview of characteristics, supply chain and producers.

HISTORY OF TiO2 PIGMENT

Historical perspective and overview of markets from 2008 to 2011.

2012

TiO_2 markets and major events.



1.2 TiO_2 pigment producers

The industry is dominated by large multinational corporations operating multiple plants in numerous countries. Five global producers provided close to 52% of the global nameplate capacity in 2012: DuPont, Cristal Global, Tronox, Huntsman and Kronos. DuPont and Tronox operate only chloride route plants while the other three global producers operate plants that use both sulfate and chloride route technologies.

Spurred by the growth of domestic demand, China's production base has grown substantially and now accounts for 34% of global capacity. *Chapter 2* provides more detail on events in the pigment industry in 2012, as well as significant announcements by major industry participants.

The TiO_2 industry responded to the onset of the Global Financial Crisis (GFC) by shutting down capacity and drawing down inventory to conserve cash. With a gradual recovery in demand during the second quarter of 2009, a gap between available supply and demand began to emerge. By 2010, the fortunes of the pigment industry were enjoying a vast turnaround. This continued into 2011, during which time inventories fell to historic lows and pricing power returned to suppliers as consumers scrambled to secure supply. A spate of price increases that started late in 2010 continued throughout 2011 and into the following year, before dropping sharply as demand slowed towards the end of the 2012. This slowdown reflected industry efforts to work through a massive build-up of inventory, with demand recovery not expected until the second half of 2013.

A more detailed discussion of the TiO_2 feedstock industry is featured in *Titanium Feedstock Annual Review*.

1.3 Structure of the report

The *TiO_2 PAR 2013* is ordered such that it provides a comprehensive review of the industry structure and dynamics as well as the latest developments. After providing some background on the titanium supply chain and its history, *Chapter 2* gives an overview of the industry in 2012, including the major events that occurred. *Chapter 3* describes the technologies, established and novel, available for producing TiO_2 pigments. *Chapter 4* examines pigment demand as well as trade fundamentals. *Chapter 5* provides a detailed review of pigment production and capacity by producers, regions and manufacturing process, as well as a perspective on capacity expansion. *Chapter 6* offers an analysis of pigment pricing and plant economics by exploring the major cost factors for producers. Trends in the industry, significant events, and the outlook for TiO_2 pigment supply and demand are the focus of *Chapter 7*, while *Chapter 8* provides a viewpoint on strategic challenges facing the industry. The *Appendices* contain pigment producer profiles and a global pigment plant locator file in Google Earth format. As an extra feature, the *Executive Summary* is provided in a concise Microsoft Office PowerPoint presentation form that outlines the main features of the publication.

1.4 Confidentiality and disclaimer

This report has been prepared by TZMI for the sole, confidential use of the recipient nominated. The information contained in this report has been compiled from TZMI's files and proprietary database, supplemented by discussions with producers and consumers in the TiO_2 pigment industry during the period to 30 April 2013. Every effort has been made to ensure that the information presented and the conclusions reached are realistic and not misleading. However, neither TZMI nor its directors make any warranty as to the accuracy of the information contained in this report and will not accept responsibility or liability for any loss incurred by any person or organisation relying on said information.

2.0 The TiO2 pigment industry

This chapter provides some background on the mineral feedstock used to produce TiO_2 pigment. For further details on the titanium feedstock industry, refer to TZMI's *Titanium Feedstock Annual Review 2013*.

Raw titanium minerals occur in varying concentrations within alluvial deposits, which are referred to as mineral or beach sands. Alluvial deposits originate in old beach and river systems and generally include several heavy minerals (HM), with raw titanium minerals and zircon often being primary matter. Titanium minerals can also be sourced from rutile and ilmenite hard rock deposits. While these commodities don't stem from mineral sands, they compete directly with mineral sands products and, for the purposes of this review, are considered part of the mineral sands industry.

As well as raw titanium minerals, some alluvial deposits are highly prospective for zircon. Zircon can be produced in conjunction with titanium feedstock, either as the principal product or as a co-product, depending on the zircon price and grade.

Of the TiO_2 minerals mined and processed, nearly 90% is used for pigment production using either the chloride and sulfate processes. The remaining TiO_2 feedstock is used to manufacture titanium metal and other minor uses. *Figure 2.1* depicts the overall TiO_2 supply chain, from the mining of the mineral to its final application.

Figure 2.1: The titanium supply chain

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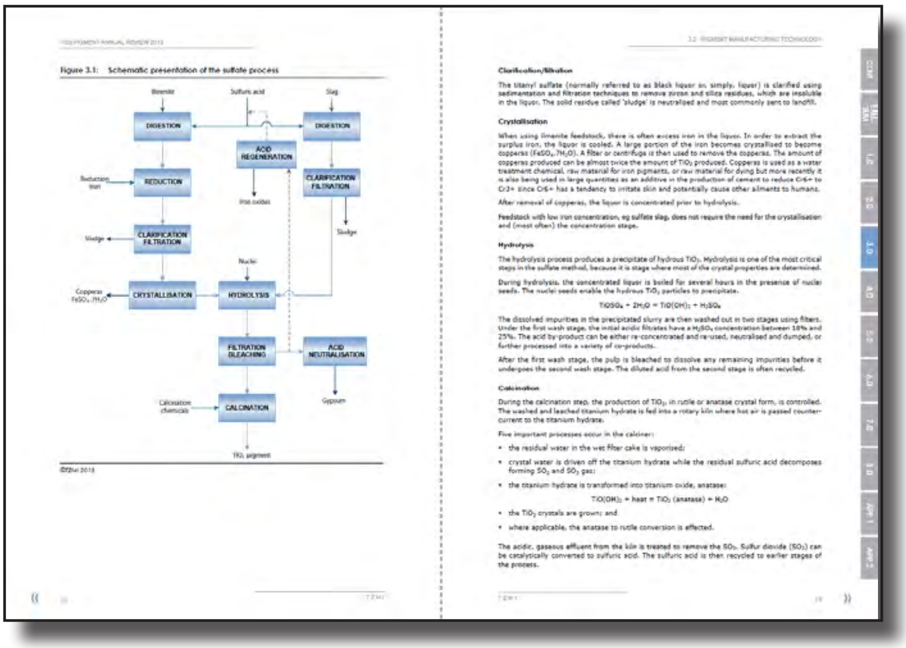
PIGMENT MANUFACTURING TECHNOLOGY

Detailed explanation (including flowsheets) of the chloride and sulfate processes, finishing and alternative processes used to manufacture pigment.



TiO2 PIGMENT ANNUAL REVIEW 2013

Figure 3.1: Schematic presentation of the sulfate process

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3.0 PIGMENT MANUFACTURING TECHNOLOGY

Clarification/filtration

The titanyl sulfate (normally referred to as black liquor or, simply, liquor) is clarified using sedimentation and filtration techniques to remove zircon and silica residues, which are insoluble in the liquor. The solid residue called 'sludge' is neutralised and most commonly sent to landfill.

Crystallisation

When using ilmenite feedstock, there is often excess iron in the liquor. In order to extract the surplus iron, the liquor is cooled. A large portion of the iron becomes crystallised to become copperas ($FeSO_4.7H_2O$). A filter or centrifuge is then used to remove the copperas. The amount of copperas produced can be almost twice the amount of TiO_2 produced. Copperas is used as a water treatment chemical, raw material for iron pigments, or raw material for dying but more recently it is also being used in large quantities as an additive in the production of cement to reduce Cr6+ to Cr3+ since Cr6+ has a tendency to irritate skin and potentially cause other ailments to humans.

After removal of copperas, the liquor is concentrated prior to hydrolysis.

Feedstock with low iron concentration, eg sulfate slag, does not require the need for the crystallisation and (most often) the concentration stage.

Hydrolysis

The hydrolysis process produces a precipitate of hydrous TiO_2. Hydrolysis is one of the most critical steps in the sulfate method, because it is stage where most of the crystal properties are determined.

During hydrolysis, the concentrated liquor is boiled for several hours in the presence of nuclei seeds. The nuclei seeds enable the hydrous TiO_2 particles to precipitate.

$$TiOSO_4 + 2H_2O = TiO(OH)_2 + H_2SO_4$$

The dissolved impurities in the precipitated slurry are then washed out in two stages using filters. Under the first wash stage, the initial acidic filtrates have a H_2SO_4 concentration between 18% and 25%. The acid by-product can be either re-concentrated and re-used, neutralised and dumped, or further processed into a variety of co-products.

After the first wash stage, the pulp is bleached to dissolve any remaining impurities before it undergoes the second wash stage. The diluted acid from the second stage is often recycled.

Calcination

During the calcination step, the production of TiO_2, in rutile or anatase crystal form, is controlled. The washed and leached titanium hydrate is fed into a rotary kiln where hot air is passed counter-current to the titanium hydrate.

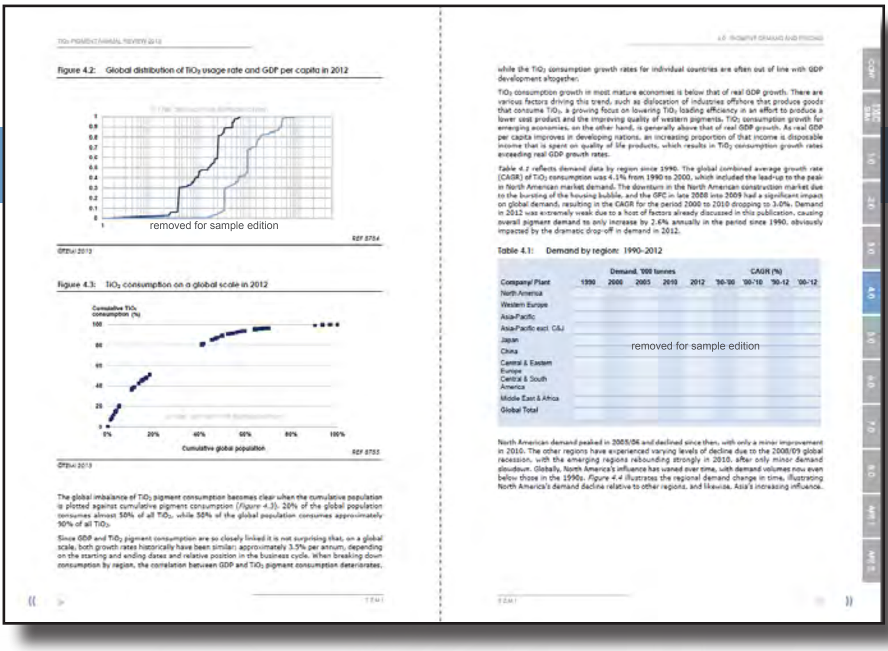
Five important processes occur in the calciner:

- the residual water in the wet filter cake is vaporised;
- crystal water is driven off the titanium hydrate while the residual sulfuric acid decomposes forming SO_2 and SO_3 gas;
- the titanium hydrate is transformed into titanium oxide, anatase:

$$TiO(OH)_2 + heat = TiO_2 \text{ (anatase)} + H_2O$$

- the TiO_2 crystals are grown; and
- where applicable, the anatase to rutile conversion is effected.

The acidic, gaseous effluent from the kiln is treated to remove the SO_3. Sulfur dioxide (SO_2) can be catalytically converted to sulfuric acid. The sulfuric acid is then recycled to earlier stages of the process.



TiO2 PIGMENT ANNUAL REVIEW 2013

Figure 4.2: Global distribution of TiO_2 usage rate and GDP per capita in 2012

REF 8754

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Figure 4.3: TiO_2 consumption on a global scale in 2012

REF 8755

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The global imbalance of TiO_2 pigment consumption becomes clear when the cumulative population is plotted against cumulative pigment consumption (*Figure 4.3*). 20% of the global population consumes almost 50% of all TiO_2, while 50% of the global population consumes approximately 90% of all TiO_2.

Since GDP and TiO_2 pigment consumption are so closely linked it is not surprising that, on a global scale, both growth rates historically have been similar; approximately 3.5% per annum, depending on the starting and ending dates and relative position in the business cycle. When breaking down consumption by region, the correlation between GDP and TiO_2 pigment consumption deteriorates, while the TiO_2 consumption growth rates for individual countries are often out of line with GDP development altogether.

4.0 PIGMENT DEMAND AND PRICING

TiO_2 consumption growth in most mature economies is below that of real GDP growth. There are various factors driving this trend, such as dislocation of industries offshore that produce goods that consume TiO_2, a growing focus on lowering TiO_2 loading efficiency in an effort to produce a lower cost product and the improving quality of western pigments. TiO_2 consumption growth for emerging economies, on the other hand, is generally above that of real GDP growth. As real GDP per capita improves in developing nations, an increasing proportion of that income is disposable income that is spent on quality of life products, which results in TiO_2 consumption growth rates exceeding real GDP growth rates.

Table 4.1 reflects demand data by region since 1990. The global combined average growth rate (CAGR) of TiO_2 consumption was 4.1% from 1990 to 2000, which included the lead-up to the peak in North American market demand. The downturn in the North American construction market due to the bursting of the housing bubble, and the GFC in late 2008 into 2009 had a significant impact on global demand, resulting in the CAGR for the period 2000 to 2010 dropping to 3.0%. Demand in 2012 was extremely weak due to a host of factors already discussed in this publication, causing overall pigment demand to only increase by 2.6% annually in the period since 1990, obviously impacted by the dramatic drop-off in demand in 2012.

Table 4.1: Demand by region: 1990–2012

	Demand, '000 tonnes					CAGR (%)			
Company/ Plant	1990	2000	2005	2010	2012	'90-'00	'00-'10	'90-'12	'00-'12
North America									
Western Europe									
Asia-Pacific									
Asia-Pacific excl. C&J									
Japan									
China									
Central & Eastern Europe									
Central & South America									
Middle East & Africa									
Global Total									

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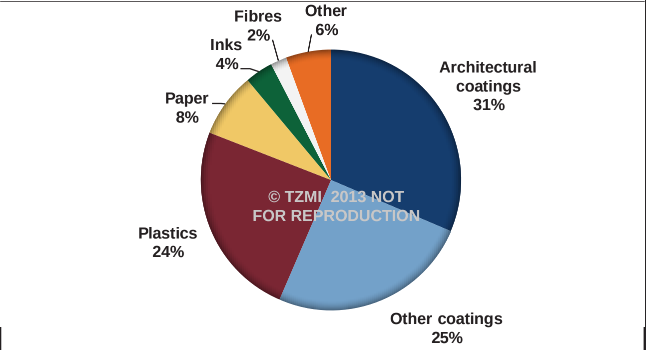
North American demand peaked in 2005/06 and declined since then, with only a minor improvement in 2010. The other regions have experienced varying levels of decline due to the 2008/09 global recession, with the emerging regions rebounding strongly in 2010, after only minor demand slowdown. Globally, North America's influence has waned over time, with demand volumes now even below those in the 1990s. *Figure 4.4* illustrates the regional demand change in time, illustrating North America's demand decline relative to other regions, and likewise, Asia's increasing influence.

PIGMENT DEMAND AND PRICING

Discussion of GDP links to TiO2 consumption, demand by region and end-use applications.

1st tier products represent 65–70% of global demand

Globale TiO2 demand by end-use sector in 2012



CHINA

2000	2012
11%	27%

(% global demand TiO2 pigment)

PIGMENT SUPPLY

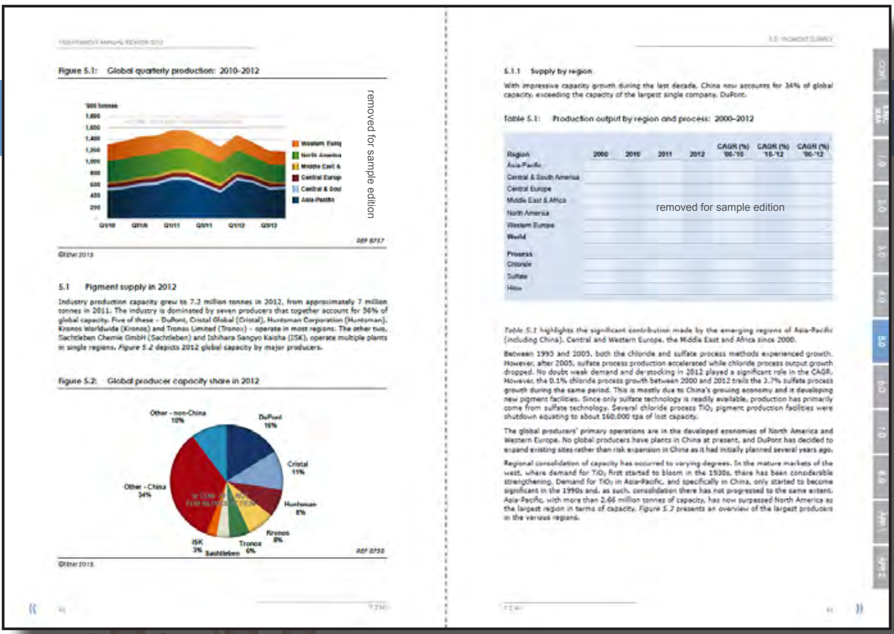


Figure 5.1: Global quarterly production: 2010–2012

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5.1 Pigment supply in 2012

Industry production capacity grew to 7.2 million tonnes in 2012, from approximately 7 million tonnes in 2011. The industry is dominated by seven producers that together account for 56% of global capacity. Five of these – DuPont, Cristal Global (Cristal), Huntsman Corporation (Huntsman), Kronos Worldwide (Kronos) and Tronox Limited (Tronox) – operate in most regions. The other two, Sachtleben Chemie GmbH (Sachtleben) and Ishihara Sangyo Kaisha (ISK), operate multiple plants in single regions. *Figure 5.2* depicts 2012 global capacity by major producers.

Figure 5.2: Global producer capacity share in 2012

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5.1.1 Supply by region

With impressive capacity growth during the last decade, China now accounts for 34% of global capacity, exceeding the capacity of the largest single company, DuPont.

Table 5.1: Production output by region and process: 2000–2012

Region	2000	2010	2011	2012	CAGR (%) '00-'10	CAGR (%) '10-'12	CAGR (%) '00-'12
Asia-Pacific							
Central & South America							
Central Europe							
Middle East & Africa							
North America				removed for sample edition			
Western Europe							
World							
Process							
Chloride							
Sulfate							
Hitox							

Table 5.1 highlights the significant contribution made by the emerging regions of Asia-Pacific (including China), Central and Western Europe, the Middle East and Africa since 2000.

Between 1995 and 2005, both the chloride and sulfate process methods experienced growth. However, after 2005, sulfate process production accelerated while chloride process output growth dropped. No doubt weak demand and de-stocking in 2012 played a significant role in the CAGR. However, the 0.1% chloride process growth between 2000 and 2012 trails the 3.7% sulfate process growth during the same period. This is mostly due to China's growing economy and it developing new pigment facilities. Since only sulfate technology is readily available, production has primarily come from sulfate technology. Several chloride process TiO_2 pigment production facilities were shutdown equating to about 160,000 tpa of lost capacity.

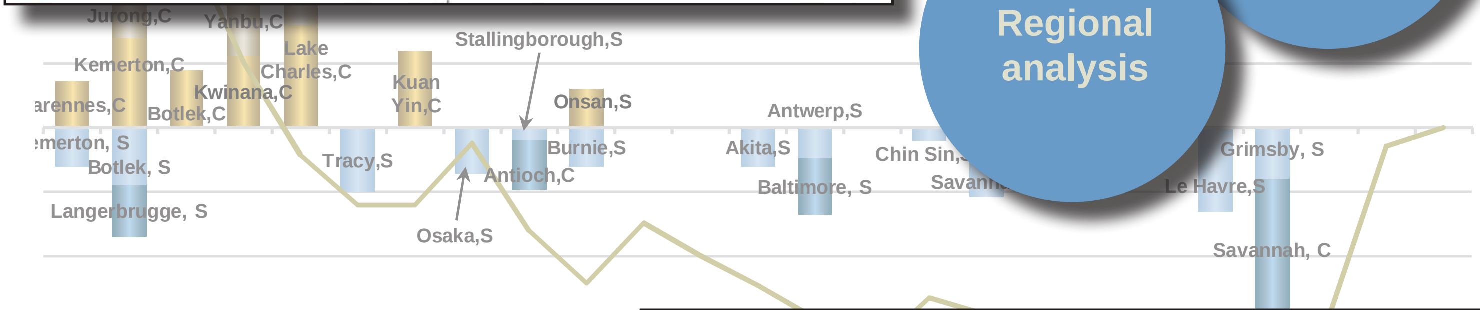
The global producers' primary operations are in the developed economies of North America and Western Europe. No global producers have plants in China at present, and DuPont has decided to expand existing sites rather than risk expansion in China as it had initially planned several years ago.

Regional consolidation of capacity has occurred to varying degrees. In the mature markets of the west, where demand for TiO_2 first started to bloom in the 1930s, there has been considerable strengthening. Demand for TiO_2 in Asia-Pacific, and specifically in China, only started to become significant in the 1990s and, as such, consolidation there has not progressed to the same extent. Asia-Pacific, with more than 2.66 million tonnes of capacity, has now surpassed North America as the largest region in terms of capacity. *Figure 5.3* presents an overview of the largest producers in the various regions.

Supply developments

Major producers

Regional analysis



PIGMENT PLANT ECONOMICS

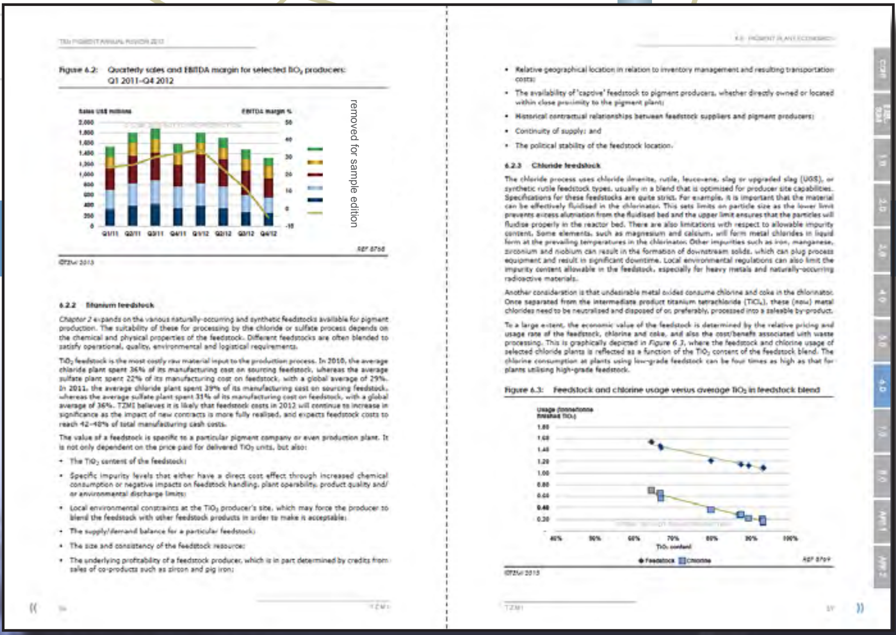


Figure 6.2: Quarterly sales and EBITDA margin for selected TiO_2 producers: Q1 2011–Q4 2012

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6.2.2 Titanium feedstock

Chapter 2 expands on the various naturally-occurring and synthetic feedstocks available for pigment production. The suitability of these for processing by the chloride or sulfate process depends on the chemical and physical properties of the feedstock. Different feedstocks are often blended to satisfy operational, quality, environmental and logistical requirements.

TiO_2 feedstock is the most costly raw material input to the production process. In 2010, the average chloride plant spent 36% of its manufacturing cost on sourcing feedstock, whereas the average sulfate plant spent 22% of its manufacturing cost on feedstock, with a global average of 29%. In 2011, the average chloride plant spent 39% of its manufacturing cost on sourcing feedstock, whereas the average sulfate plant spent 31% of its manufacturing cost on feedstock, with a global average of 36%. TZMI believes it is likely that feedstock costs in 2012 will continue to increase in significance as the impact of new contracts is more fully realised, and expects feedstock costs to reach 42–48% of total manufacturing cash costs.

The value of a feedstock is specific to a particular pigment company or even production plant. It is not only dependent on the price paid for delivered TiO_2 units, but also:

- The TiO_2 content of the feedstock;
- Specific impurity levels that either have a direct cost effect through increased chemical consumption or negative impacts on feedstock handling, plant operability, product quality and/or environmental discharge limits;
- Local environmental constraints at the TiO_2 producer's site, which may force the producer to blend the feedstock with other feedstock products in order to make it acceptable;
- The supply/demand balance for a particular feedstock;
- The size and consistency of the feedstock resource;
- The underlying profitability of a feedstock producer, which is in part determined by credits from sales of co-products such as zircon and pig iron;
- Relative geographical location in relation to inventory management and resulting transportation costs;
- The availability of 'captive' feedstock to pigment producers, whether directly owned or located within close proximity to the pigment plant;
- Historical contractual relationships between feedstock suppliers and pigment producers;
- Continuity of supply; and
- The political stability of the feedstock location.

6.2.3 Chloride feedstock

The chloride process uses chloride ilmenite, rutile, leucoxene, slag or upgraded slag (UGS), or synthetic rutile feedstock types, usually in a blend that is optimised for producer site capabilities. Specifications for these feedstocks are quite strict. For example, it is important that the material can be effectively fluidised in the chlorinator. This sets limits on particle size as the lower limit prevents excess elutriation from the fluidised bed and the upper limit ensures that the particles will fluidise properly in the reactor bed. There are also limitations with respect to allowable impurity content. Some elements, such as magnesium and calcium, will form metal chlorides in liquid form at the prevailing temperatures in the chlorinator. Other impurities such as iron, manganese, zirconium and niobium can result in the formation of downstream solids, which can plug process equipment and result in significant downtime. Local environmental regulations can also limit the impurity content allowable in the feedstock, especially for heavy metals and naturally-occurring radioactive materials.

Another consideration is that undesirable metal oxides consume chlorine and coke in the chlorinator. Once separated from the intermediate product titanium tetrachloride ($TiCl_4$), these (now) metal chlorides need to be neutralised and disposed of or, preferably, processed into a saleable by-product.

To a large extent, the economic value of the feedstock is determined by the relative pricing and usage rate of the feedstock, chlorine and coke, and also the cost/benefit associated with waste processing. This is graphically depicted in *Figure 6.3*, where the feedstock and chlorine usage of selected chloride plants is reflected as a function of the TiO_2 content of the feedstock blend. The chlorine consumption at plants using low-grade feedstock can be four times as high as that for plants utilising high-grade feedstock.

Figure 6.3: Feedstock and chlorine usage versus average TiO_2 in feedstock blend

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Costs of production

Comparisons between regions

Sulfate & chloride process economics

> “ Profitability of TiO2 pigment producers declined during 2012, with the 5% increase in price more than offset by rapidly rising input costs. ”

Image courtesy Sachtleben

TRENDS AND OUTLOOK

Trends observed in 2012 analysed and assessed for impact on the TiO_2 pigment sector. Historical and two-year forecasts for demand and supply provided.

Table 7.1: Demand by region: 2008–2014
'000 tonnes

								CAGR (%)	
Region	2008	2009	2010	2011	2012	2013f	2014f	2008-2012	2008-2014f
Asia-Pacific ex China & Japan									
China									
Japan									
Central & South America									
Central Europe									
Middle East & Africa									
North America									
Western Europe									
Global total									

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f=forecast

While effective growth rates in 2013 and 2014 appear to be very high, 13% and 7% respectively, the rates must be taken in context of the substantial downturn in 2012. Demand in 2013 is below levels experienced in both 2010 and 2011; demand in 2014 is the first year in which demand should exceed 2011 demand. *Table 7.1* provides TZMI's historical and forecast demand volumes for 2008–2014.

The Americas

In North America, the majority of TiO_2 demand is driven by the construction sector, with a majority of the TiO_2 use in the paints and coatings segment. For this reason, TZMI closely tracks housing related indices, as well as indices for consumer confidence, consumer spending, population growth, and a host of macroeconomic indicators such as GDP and industrial production.

In 2012, many housing-related indicators improved, although TiO_2 demand remained weak. TZMI believes that this was a result of de-stocking and some substitution at the customer level, due to concerns about the regional and global economy. Housing starts improved steadily during 2012, with new home inventory values declining steadily and prices increasing steadily at a rate exceeding inflation. Housing starts in 2012 rebounded to 781,000 from the low of 554,000 units in 2009; while the recovery is substantial, housing starts figures remain well below normal cycle lows, especially when adjusting for population. Independent projections are for 2013 housing starts to increase above 1 million for the first time since 2007. *Figure 7.2* illustrates the dramatic decline in housing starts during the GFC and the years that immediately followed.

Central and South America demand is heavily reliant on the economies of Brazil and Mexico for growth, which together account for more than 60% of the region's demand. Brazil faces headwinds in expected high inflation, as the country appears to be determined to support growth through high fixed investment and stimulus programs in combination with expansionary fiscal and monetary measures. Brazil's GDP is expected to grow at 3.0% in 2013 and 4.6% in 2014. Mexico's GDP is expected to grow at 3.6% in 2013 and 5% in 2014. *Figure 7.3* provides the macroeconomic data underpinning to TZMI's forecast.

Figure 7.2: US Housing Starts: 1959–2012

REF 6773

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Figure 7.3: Macroeconomic historical and forecast data for Central & South America: 2008–2014

©TZMI 2013

f=forecast

Central and South American demand declined in 2012 after a very strong 2011. Like many other regions of the world, the demand decline was a result of overheated buying patterns in 2011 and the resulting de-stocking in 2012, plus substitution due to persistently high pricing for TiO_2 products. TZMI only expects demand in the region to recover to 2011 levels by 2014, with 2013 demand a partial recovery from the 16% year-on-year decline experienced in 2012.

TiO_2 pigment production down in 2012

De-stocking has major impact on markets in 2012

In 2012, China continued to out-produce domestic needs

STRATEGIC CHALLENGES FOR THE INDUSTRY

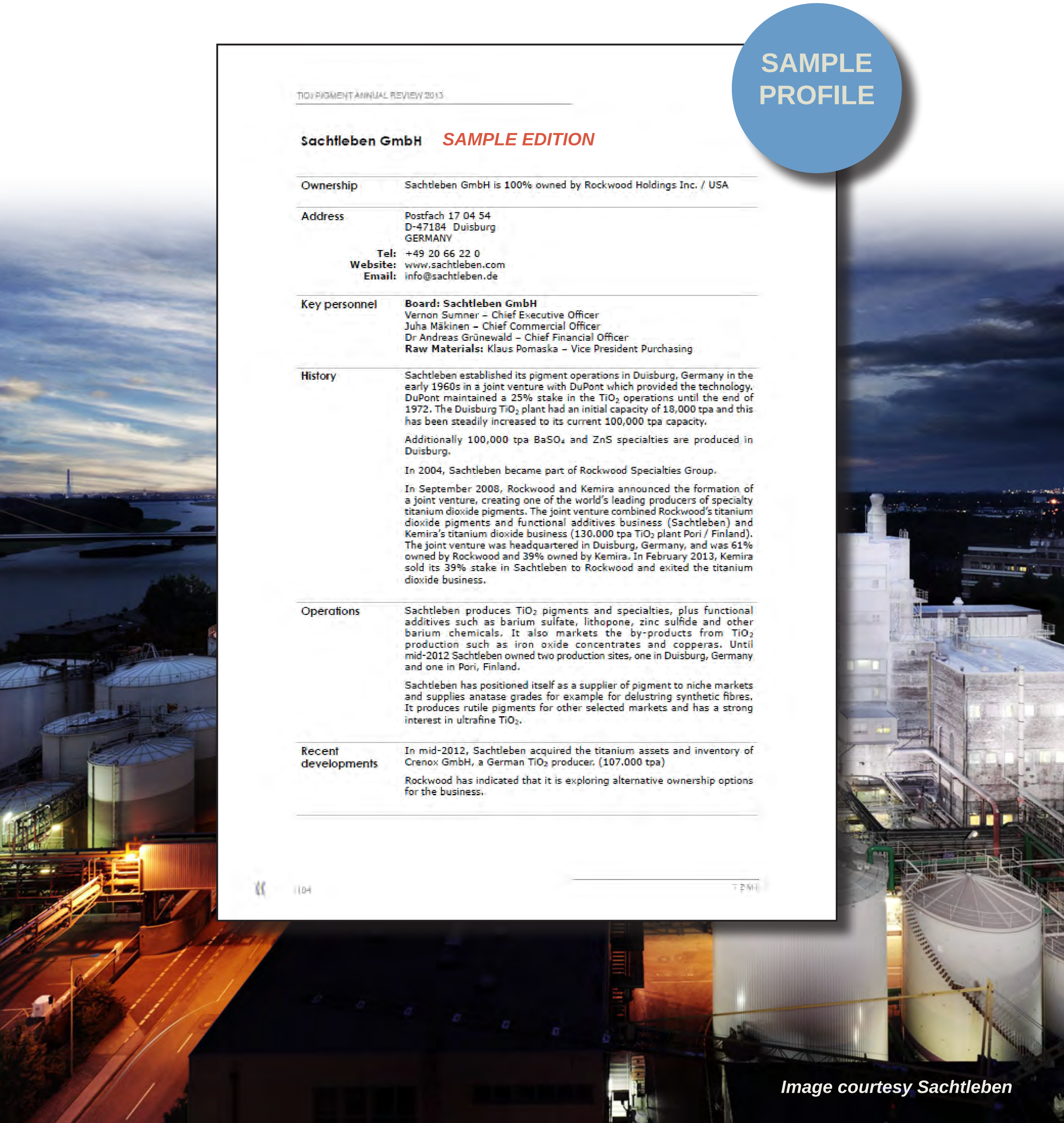
> “After experiencing a rocky end to 2012, the TiO_2 pigment sector continued to struggle with the market bottoming out during the first three months of 2013 and into the June quarter. With the worst of the slump hopefully behind it, the TiO_2 pigment market still faces some challenges in its attempt to regain lost ground.”

This section discusses the challenges faced over recent years, and emerging themes for TiO_2 pigment producers.

APPENDIX 1 *Pigment producer profiles*

APPENDIX 2 *Pigment plant locator*

This KMZ file allows the user to locate major pigment plants using the program Google Earth.



SAMPLE PROFILE

TiO₂ PIGMENT ANNUAL REVIEW 2013

Sachtleben GmbH SAMPLE EDITION

Ownership	Sachtleben GmbH is 100% owned by Rockwood Holdings Inc. / USA
Address	Postfach 17 04 54 D-47184 Duisburg GERMANY **Tel:** +49 20 66 22 0 **Website:** www.sachtleben.com **Email:** info@sachtleben.de
Key personnel	**Board: Sachtleben GmbH** Vernon Sumner – Chief Executive Officer Juha Mäkinen – Chief Commercial Officer Dr Andreas Grünewald – Chief Financial Officer **Raw Materials:** Klaus Pomaska – Vice President Purchasing
History	Sachtleben established its pigment operations in Duisburg, Germany in the early 1960s in a joint venture with DuPont which provided the technology. DuPont maintained a 25% stake in the TiO_2 operations until the end of 1972. The Duisburg TiO_2 plant had an initial capacity of 18,000 tpa and this has been steadily increased to its current 100,000 tpa capacity. Additionally 100,000 tpa $BaSO_4$ and ZnS specialties are produced in Duisburg. In 2004, Sachtleben became part of Rockwood Specialties Group. In September 2008, Rockwood and Kemira announced the formation of a joint venture, creating one of the world's leading producers of specialty titanium dioxide pigments. The joint venture combined Rockwood's titanium dioxide pigments and functional additives business (Sachtleben) and Kemira's titanium dioxide business (130.000 tpa TiO_2 plant Pori / Finland). The joint venture was headquartered in Duisburg, Germany, and was 61% owned by Rockwood and 39% owned by Kemira. In February 2013, Kemira sold its 39% stake in Sachtleben to Rockwood and exited the titanium dioxide business.
Operations	Sachtleben produces TiO_2 pigments and specialties, plus functional additives such as barium sulfate, lithopone, zinc sulfide and other barium chemicals. It also markets the by-products from TiO_2 production such as iron oxide concentrates and copperas. Until mid-2012 Sachtleben owned two production sites, one in Duisburg, Germany and one in Pori, Finland. Sachtleben has positioned itself as a supplier of pigment to niche markets and supplies anatase grades for example for delustring synthetic fibres. It produces rutile pigments for other selected markets and has a strong interest in ultrafine TiO_2.
Recent developments	In mid-2012, Sachtleben acquired the titanium assets and inventory of Crenox GmbH, a German TiO_2 producer. (107.000 tpa) Rockwood has indicated that it is exploring alternative ownership options for the business.

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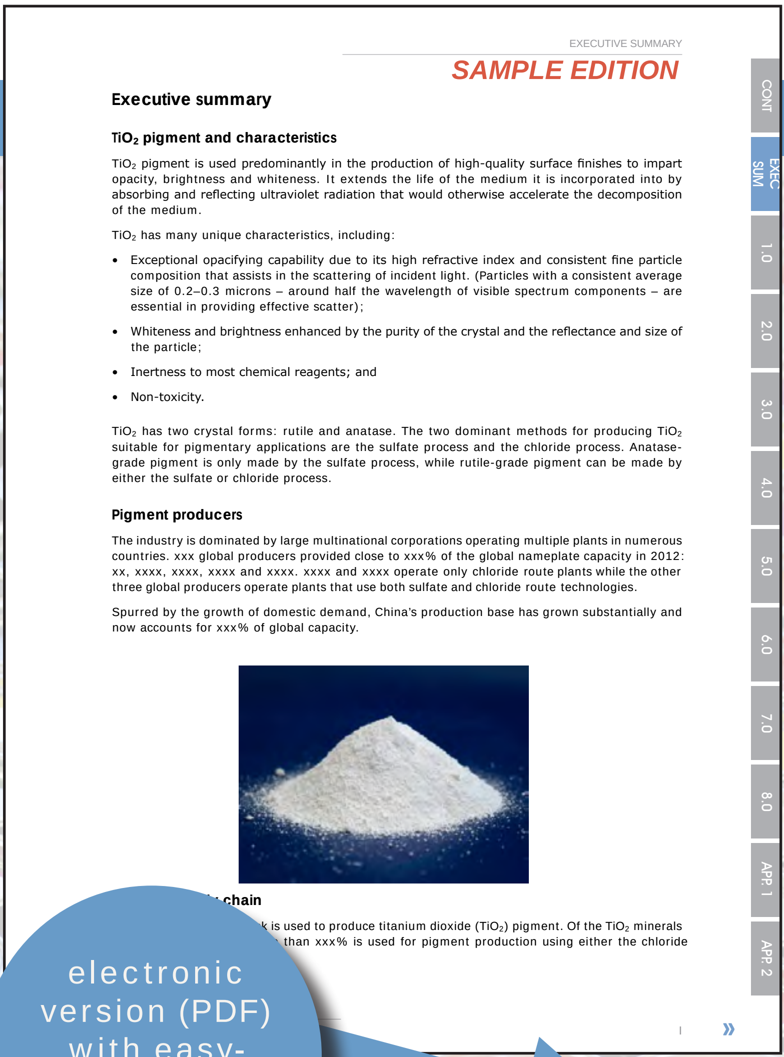
Image courtesy Sachtleben

SAMPLE PAGES

Includes
90
pages, plus
26
company
profiles

49
easy-to-read charts, images and detailed tables

electronic version (PDF) with easy-to-navigate buttons



EXECUTIVE SUMMARY

SAMPLE EDITION

Executive summary

TiO_2 pigment and characteristics

TiO_2 pigment is used predominantly in the production of high-quality surface finishes to impart opacity, brightness and whiteness. It extends the life of the medium it is incorporated into by absorbing and reflecting ultraviolet radiation that would otherwise accelerate the decomposition of the medium.

TiO_2 has many unique characteristics, including:

- Exceptional opacifying capability due to its high refractive index and consistent fine particle composition that assists in the scattering of incident light. (Particles with a consistent average size of 0.2–0.3 microns – around half the wavelength of visible spectrum components – are essential in providing effective scatter);
- Whiteness and brightness enhanced by the purity of the crystal and the reflectance and size of the particle;
- Inertness to most chemical reagents; and
- Non-toxicity.

TiO_2 has two crystal forms: rutile and anatase. The two dominant methods for producing TiO_2 suitable for pigmentary applications are the sulfate process and the chloride process. Anatase-grade pigment is only made by the sulfate process, while rutile-grade pigment can be made by either the sulfate or chloride process.

Pigment producers

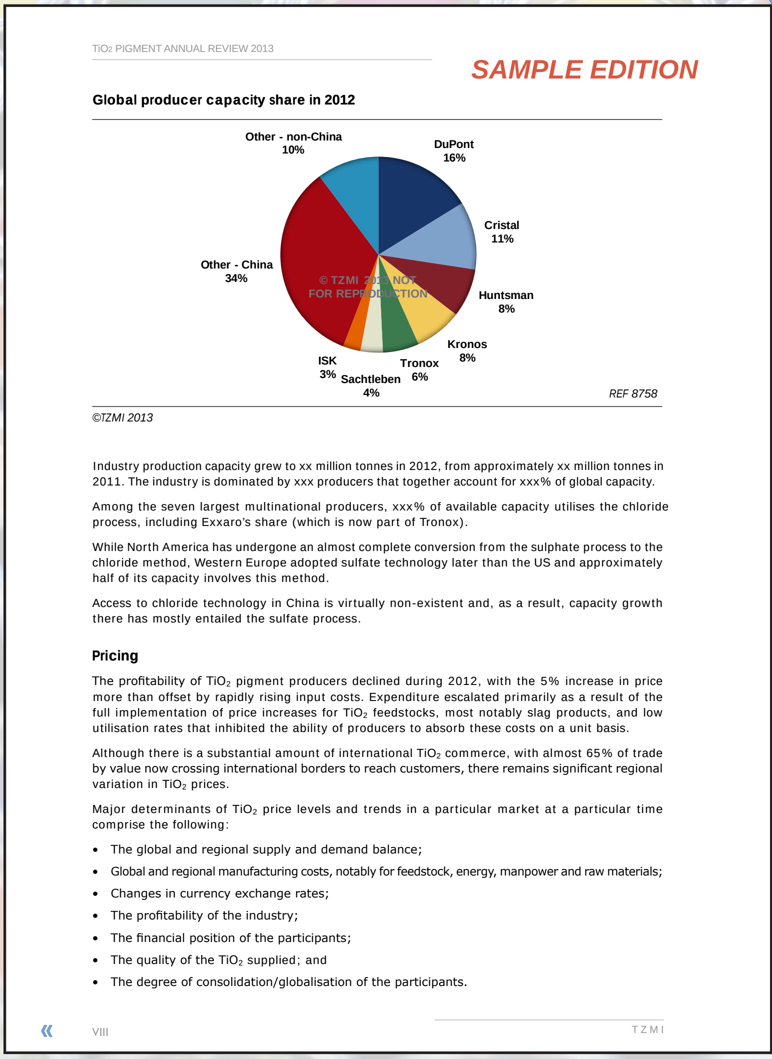
The industry is dominated by large multinational corporations operating multiple plants in numerous countries. xxx global producers provided close to xxx% of the global nameplate capacity in 2012: xx, xxxx, xxxx, xxxx and xxxx. xxxx and xxxx operate only chloride route plants while the other three global producers operate plants that use both sulfate and chloride route technologies.

Spurred by the growth of domestic demand, China's production base has grown substantially and now accounts for xxx% of global capacity.

chain

k is used to produce titanium dioxide (TiO_2) pigment. Of the TiO_2 minerals than xxx% is used for pigment production using either the chloride

I »



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Global producer capacity share in 2012

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Industry production capacity grew to xx million tonnes in 2012, from approximately xx million tonnes in 2011. The industry is dominated by xxx producers that together account for xxx% of global capacity.

Among the seven largest multinational producers, xxx% of available capacity utilises the chloride process, including Exxaro's share (which is now part of Tronox).

While North America has undergone an almost complete conversion from the sulphate process to the chloride method, Western Europe adopted sulfate technology later than the US and approximately half of its capacity involves this method.

Access to chloride technology in China is virtually non-existent and, as a result, capacity growth there has mostly entailed the sulfate process.

Pricing

The profitability of TiO_2 pigment producers declined during 2012, with the 5% increase in price more than offset by rapidly rising input costs. Expenditure escalated primarily as a result of the full implementation of price increases for TiO_2 feedstocks, most notably slag products, and low utilisation rates that inhibited the ability of producers to absorb these costs on a unit basis.

Although there is a substantial amount of international TiO_2 commerce, with almost 65% of trade by value now crossing international borders to reach customers, there remains significant regional variation in TiO_2 prices.

Major determinants of TiO_2 price levels and trends in a particular market at a particular time comprise the following:

- The global and regional supply and demand balance;
- Global and regional manufacturing costs, notably for feedstock, energy, manpower and raw materials;
- Changes in currency exchange rates;
- The profitability of the industry;
- The financial position of the participants;
- The quality of the TiO_2 supplied; and
- The degree of consolidation/globalisation of the participants.

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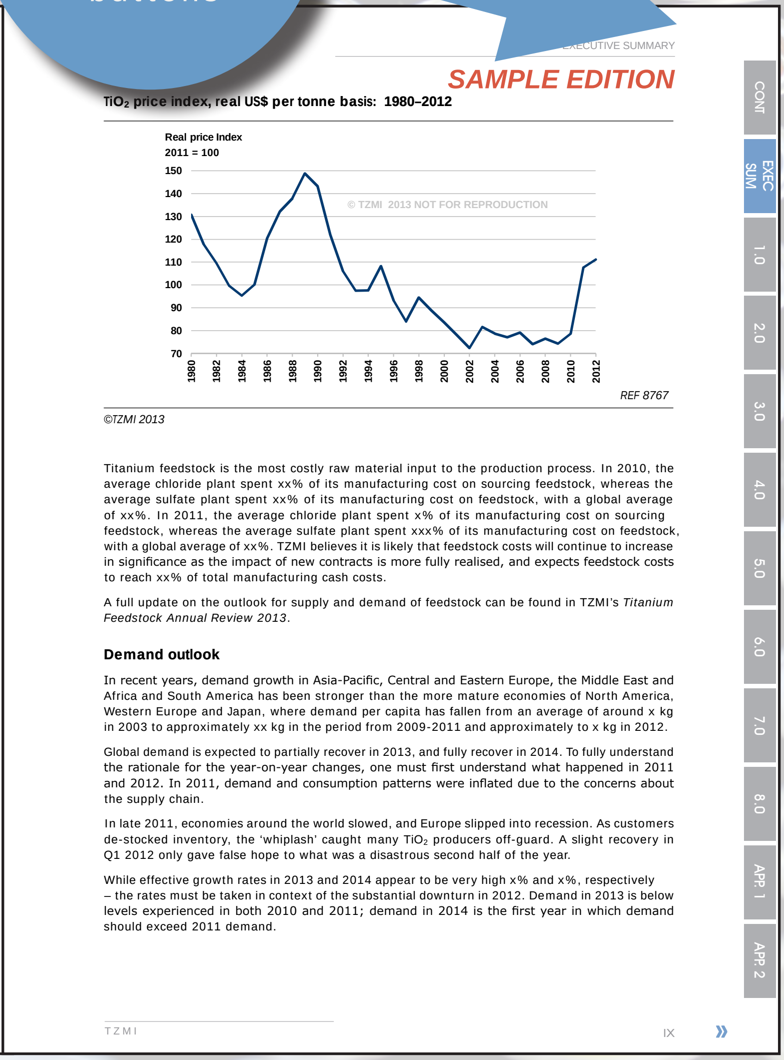

EXECUTIVE SUMMARY

SAMPLE EDITION

TiO_2 price index, real US$ per tonne basis: 1980–2012

REF 8767

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Titanium feedstock is the most costly raw material input to the production process. In 2010, the average chloride plant spent xx% of its manufacturing cost on sourcing feedstock, whereas the average sulfate plant spent xx% of its manufacturing cost on feedstock, with a global average of xx%. In 2011, the average chloride plant spent x% of its manufacturing cost on sourcing feedstock, whereas the average sulfate plant spent xxx% of its manufacturing cost on feedstock, with a global average of xx%. TZMI believes it is likely that feedstock costs will continue to increase in significance as the impact of new contracts is more fully realised, and expects feedstock costs to reach xx% of total manufacturing cash costs.

A full update on the outlook for supply and demand of feedstock can be found in TZMI's *Titanium Feedstock Annual Review 2013*.

Demand outlook

In recent years, demand growth in Asia-Pacific, Central and Eastern Europe, the Middle East and Africa and South America has been stronger than the more mature economies of North America, Western Europe and Japan, where demand per capita has fallen from an average of around x kg in 2003 to approximately xx kg in the period from 2009-2011 and approximately to x kg in 2012.

Global demand is expected to partially recover in 2013, and fully recover in 2014. To fully understand the rationale for the year-on-year changes, one must first understand what happened in 2011 and 2012. In 2011, demand and consumption patterns were inflated due to the concerns about the supply chain.

In late 2011, economies around the world slowed, and Europe slipped into recession. As customers de-stocked inventory, the 'whiplash' caught many TiO_2 producers off-guard. A slight recovery in Q1 2012 only gave false hope to what was a disastrous second half of the year.

While effective growth rates in 2013 and 2014 appear to be very high x% and x%, respectively – the rates must be taken in context of the substantial downturn in 2012. Demand in 2013 is below levels experienced in both 2010 and 2011; demand in 2014 is the first year in which demand should exceed 2011 demand.

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