CCM Data & Business Intelligence

Survey of Titanium Dioxide in China

The Eleventh Edition

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Executive summary

Recent years, China's titanium dioxide (TiO_2) industry has been developing steadily. The period of 2019–2021 saw consecutive growth of TiO_2 capacity and output. In 2021, domestic TiO_2 capacity grew to 4.30 million t/a and the output came to nearly 3.81 million tonnes. With increasing concentration of the industry and manufacturers to obtain better production technology, it is estimated that TiO_2 production capacity in China will exceed 8 million t/a by 2026 and the output will grow to about 5 million tonnes.

So far, chloride process TiO_2 is at the nascent stage in China, while sulfate process still dominates. Although some major domestic manufacturers have already built or are building chloride process projects, technical barriers, product quality and high cost of related facilities make the process unreachable to most producers. The upgrading of China's TiO_2 production techniques still has a long way to go.

The domestic price curve of TiO_2 in 2019–H1 2022 showed a "down-up-fluctuation" pattern; the price went down from Jan. 2019 to July 2020, then followed by a upward trend all the way to June 2021, and after that fluctuated at high level till June 2022.

With high foreign demand and the continuous improvement in quality of domestic TiO_2, the exports kept strong in 2019–2021, and China exported 1,311,626 tonnes of TiO_2 in 2021, the volume expanding at a CAGR of 15.69% during 2019–2021. The import volume of TiO_2 to China also followed an uptrend in the same period, coming to 191,914 tonnes in 2021.

As one of the largest TiO_2 consumers worldwide, China sees its consumption grow year by year. In 2019–2021, domestic TiO_2 consumption increased from 2,303,518 tonnes to 2,646,584 tonnes, with a CAGR of 7.19%. Coating, plastics and papermaking industries remain the largest downstream markets for TiO_2, accounting for 60.56%, 18.26% and 12.32% of the total in 2021. It is expected that in the next five years, these three industries will continue to lead the way in TiO_2 consumption.

Methodology

Survey of Titanium Dioxide in China is CCM's eleventh edition report on China's titanium dioxide industry, finished in Dec. 2022.

The report is drafted by diverse methods as follows:

1) Desk research
The sources of desk research are various, including published magazines, journals, government statistics, industrial statistics, customs statistics, association seminars as well as information from the Internet. A lot of work has gone into compilation and analysis of the obtained information. Where necessary, checks have been made with Chinese suppliers regarding market information such as key producers, key end users, production, export and demand and so on.

2) Telephone interview
CCM has carried out extensive telephone interviews in order to survey the actual market situation of titanium dioxide industry in China.

Interviewees cover:
- Key producers
- Key end users
- Key traders
- Material suppliers
- Some associations
- Experts

3) Site visit
CCM has visited some industry experts in order to obtain the experts' thorough views and investment suggestion.

4) Network
CCM adopts network to contact with players in this industry by B2B website and software.

5) Questionnaire
In order to confirm some information and obtain more experts' views for China's titanium dioxide industry development trend, CCM adopts questionnaire for some key producers, end users, traders and experts.

Data processing and presentation
The data collected and compiled were sourced from:
- CCM's ValoTracer database
- Published articles from periodicals, magazines and journals, the third database
- Statistics from governments and international institutes
- Telephone interviews with domestic producers, joint ventures, service suppliers, government
- Questionnaire
- Third-party data providers
- Custom statistics
- Comments from industrial experts
- Professional database from other sources
- Information from the Internet

The data from various sources have been combined and cross-checked to make this report as precise and scientific as possible. Throughout the process, a series of internal discussions took place in order to analyse the data and draw conclusions from it.

Unit

RMB: currency unit in China, also called Yuan
USD: currency unit in the US
tonne: ton, equals to metric ton in this report
/t: per tonne
t/a: tonne/annum or tonne/year

Glossary

CAGR: Compound annual growth rate
GDP: Gross domestic product
TiO_2: Titanium dioxide
MIIT: Ministry of Industry and Information Technology of the People's Republic of China
CNCIA: China National Coatings Industry Association
MOFCOM: Ministry of Commerce of the People's Republic of China
SAT: State Administration of Taxation
GACC: General Administration of Customs of the People's Republic of China
NDRC: National Development and Reform Commission
NBS: National Bureau of Statistics
IPO: Initial public offering
REACH: Registration, Evaluation, Authorization and Restriction of Chemicals
USGS: United States Geological Survey

Table null-1 Exchange rate USD/CNY, Jan. 2019–Nov. 2022

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
2019	6.8482	6.7081	6.6957	6.7193	6.7344	6.8896	6.8716	6.8938	7.0883	7.0726	7.0437	7.0262	**6.8826**
2020	6.9614	6.9249	6.9811	7.0771	7.0690	7.1315	7.0710	6.9980	6.8498	6.7796	6.7050	6.5921	**6.9284**
2021	6.5408	6.4623	6.4754	6.5584	6.4895	6.3572	6.4709	6.4660	6.4680	6.4604	6.4192	6.3693	**6.4615**
2022	6.3794	6.3580	6.3014	6.3509	6.5672	6.6651	6.6863	6.7467	6.8821	7.0992	7.2081	-	**-**

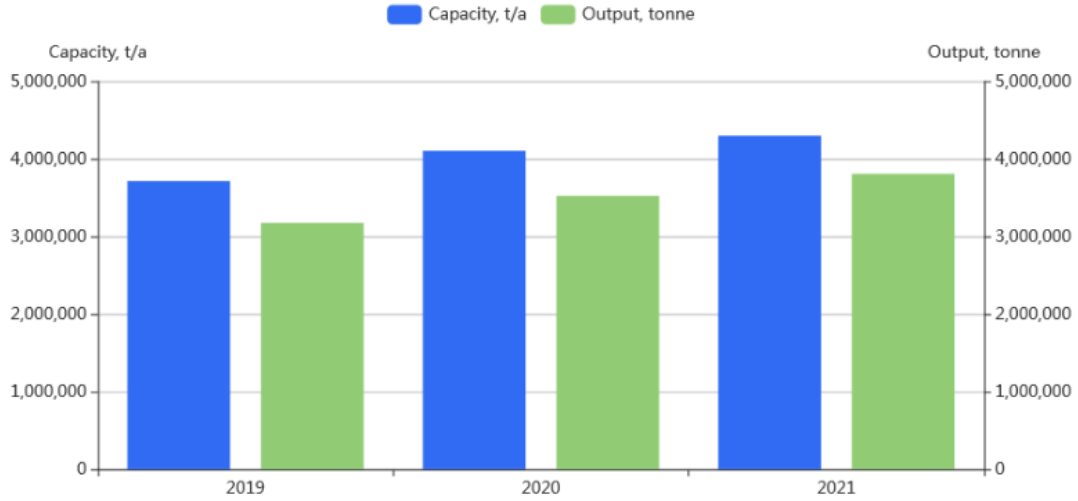
Source: The People's Bank of China

1 Titanium dioxide production in China

1.1 Titanium dioxide production information, 2019–2021

The period of 2019–2021 saw consecutive growths of TiO_2 capacity and output in China.

Figure 1.1-1 Capacity and output of titanium dioxide in China, 2019–2021



Source: CCM

In 2021, the capacity of TiO_2 in China increased to 4,298,000 t/a and the output reached 3,806,600 tonnes. The operating rate of the industry was 88.57%.

In 2019–2021, there were some new entrants and expansion projects of TiO_2. Production lines of Yibin Tianyuan Haifeng Hetai Co., Ltd., Guizhou Sunward Fuquan Chemicals Co., Ltd. and Guangxi Xilong Chemical Co., Ltd. were finished and put into trial production in 2019. LB Group Co., Ltd. (LB Group) and CNNC Hua Yuan Titanium Dioxide Co., Ltd. expanded their capacity in 2020. In 2021, Guangdong Huiyun Titanium Industry Co., Ltd., Yibin Tianyuan Haifeng Hetai Co., Ltd. and Shandong Lubei Chemical Co., Ltd. expanded their capacity to 110,000 t/a, 100,000 t/a and 200,000 t/a respectively.

However, Henan Luohe Xingmao Titanium Industry Co., Ltd. exited this industry in 2019 as it went bankrupt.

The export volume of TiO_2 from China has expanded constantly these years and China's TiO_2 products have enjoyed greater recognition and popularity for their improved quality and advantageous prices. Growing export market has not only broadened business and sales destinations for Chinese producers, but also effectively consumed their inventories, which has driven up their productivity for more engagement in international trade.

1.2 Top 40 titanium dioxide manufacturers, 2019–2021

In 2019, of all the domestic full-process TiO_2 manufacturers that maintained normal production, 11 manufacturers had their output exceeding 100,000 tonnes. The output of these 11 enterprises altogether was some 2.15 million tonnes, about 68% of the total output. In particular, the output of LB Group was 629,900 tonnes, slightly below 20% of the total, and came as the largest TiO_2 manufacturer in China.

In 2020, all the production activities worldwide were somehow affected by COVID-19. However, with China outperforming other countries in response to this public health incident, Chinese TiO_2 manufacturers were able to maintain normal production throughout the year in general, and managed to fulfill more orders from home and abroad. In 2020, of all the domestic TiO_2 manufacturers, 12 manufacturers crossed the 100,000-tonne-line in output, of which Panzhihua Taihai Technology Co., Ltd. entered this group for the first time. Output of these 12 enterprises totaled about 2.54 million tonnes, over 70% of the national total. LB Group alone achieved 817,200 tonnes, over 23% of the total, retaining the No.1 position in China.

In 2021, the output of TiO_2 in China reached a record high, encouraged by improved demand at home and abroad. Overseas TiO_2 capacity has not been effectively increased for many years. Moreover, affected by the COVID-19, operating rates in foreign enterprises were at a low level. As a result, the volume of TiO_2 exported from China increased year by year. The increase in export volume stimulated China's TiO_2 manufacturers to increase their operating rates. In 2021, of all the domestic full-process TiO_2 manufacturers that maintained normal production, 10 manufacturers achieved 100,000-tonne-above output. The output of these 10 enterprises altogether reached about 2.52 million tonnes, accounting for more than 66% of the total output. In particular, the largest Chinese TiO_2 producer LB Group produced 902,200 tonnes of TiO_2.

Table 1.2-1 Titanium dioxide production of top active 40 manufacturers in China, 2019–2021

No.	Producer	Location	Capacity, t/a			Output, tonne		
			2021	2020	2019	2021	2020	2019
1	LB Group Co., Ltd.	Henan	1,010,000	1,010,000	630,000	902,200	817,200	629,900
2	CNNC Hua Yuan Titanium Dioxide Co., Ltd.	Gansu	300,000	300,000	200,000	324,200	317,600	255,600
3	Pangang Group Vanadium & Titanium Resources Co., Ltd.	Sichuan	235,000	235,000	235,000	224,400	235,500	233,900
4	GPRO Investment Holding Group Co., Ltd.	Jiangsu	260,000	260,000	180,000	204,000	187,600	145,200
5	Shandong Doguide Group Co., Ltd.	Shandong	220,000	220,000	220,000	189,100	170,000	168,000
6	Shandong Lubei Chemical Co., Ltd.	Shandong	200,000	100,000	100,000	153,400	133,500	107,500
7	China National Chemical Co., Ltd.	Beijing	170,000	170,000	170,000	174,500	135,400	169,800
8	Shandong Dawn Titanium Industry Co., Ltd.	Shandong	100,000	100,000	100,000	123,600	113,500	123,500
9	Guangxi Jinmao Titanium Co., Ltd.	Guangxi	100,000	100,000	100,000	112,900	113,100	104,600
10	Yunnan Dahutong Industrial & Trade Co., Ltd.	Sichuan	120,000	120,000	120,000	96,000	110,500	106,800
11	Ningbo Xinfu Titanium Dioxide Co., Ltd.	Zhejiang	120,000	120,000	120,000	99,700	100,000	110,000
12	Guangdong Huiyun Titanium Industry Co., Ltd.	Guangdong	110,000	65,000	65,000	82,300	69,200	64,300
13	Yibin Tianyuan Haifeng Hetai Co., Ltd.	Sichuan	100,000	50,000	50,000	35,100	24,400	13,000
14	Panzhihua Taihai Technology Co., Ltd.	Sichuan	80,000	80,000	80,000	114,000	108,200	87,700
15	Anhui Annada Titanium Industry Co., Ltd.	Anhui	80,000	80,000	80,000	84,300	85,300	77,300
16	Panzhihua Haifengxin Chemical Industry Co., Ltd.	Sichuan	60,000	60,000	60,000	96,300	64,200	56,700
17	CITIC Titanium Industry Co., Ltd.	Liaoning	60,000	60,000	60,000	68,300	68,700	60,000
18	Guangxi Shunfeng Titanium Industry Co., Ltd.	Guangxi	60,000	60,000	60,000	52,300	52,700	53,700
19	Wuhan Fangyuan Titanium Dioxide Co., Ltd.	Hubei	60,000	60,000	60,000	27,600	27,600	26,100
20	Guizhou Sunward Fuquan Chemicals Co., Ltd.	Guizhou	50,000	50,000	50,000	51,000	30,000	5,000
21	Jiangxi Tikon Titanium Co., Ltd.	Jiangxi	50,000	50,000	50,000	50,000	46,700	47,700

No.	Producer	Location	Capacity, t/a			Output, tonne		
			2021	2020	2019	2021	2020	2019
22	Panzhihua Xingzhong Titanium Industry Co., Ltd.	Sichuan	50,000	50,000	50,000	47,500	52,000	45,500
23	Shanghai Pengbo Titanium Dioxide Co., Ltd.	Shanghai	50,000	50,000	50,000	19,000	19,300	19,000
24	Kunming Donghao Titanium Co., Ltd.	Yunnan	45,000	45,000	45,000	45,000	41,500	45,000
25	Panzhihua Tianlun Chemical Co., Ltd.	Sichuan	40,000	40,000	40,000	29,500	25,000	24,000
26	Huai'an Feiyang Titanium Dioxide Manufacturing Co., Ltd.	Jiangsu	36,000	36,000	36,000	11,600	15,800	18,000
27	Denox Advanced Materials Co., Ltd.	Anhui	30,000	30,000	30,000	39,800	20,000	10,500
28	Panzhihua Hengtong Titanium Co., Ltd.	Sichuan	30,000	30,000	30,000	30,000	30,500	30,000
29	Panzhihua Taidu Chemicals Co., Ltd.	Sichuan	30,000	30,000	30,000	29,300	24,000	24,300
30	Suzhou Hongfeng Titanium Industry Co., Ltd.	Jiangsu	30,000	30,000	30,000	26,000	28,700	30,000
31	Panzhihua Zhengyuan Technology Co., Ltd.	Sichuan	30,000	30,000	30,000	25,700	13,000	7,000
32	Nexttech Materials Co., Ltd.	Anhui	30,000	30,000	30,000	24,000	22,600	23,200
33	Guangxi Xilong Chemical Co., Ltd.	Guangxi	30,000	30,000	30,000	23,000	15,800	8,000
34	Fumin Longteng Titanium Industry Co., Ltd.	Yunnan	30,000	30,000	30,000	18,100	25,800	30,000
35	Alfa Full (Guangxi Tengxian) Titanium Dioxide Co., Ltd.	Guangxi	25,000	25,000	25,000	12,600	20,000	25,800
36	CNMC (Guangxi) Pgma Co., Ltd.	Guangxi	25,000	25,000	25,000	20,300	21,800	21,000
37	Guangxi Detian Chemical Cycle Co., Ltd.	Guangxi	20,000	20,000	20,000	18,400	18,200	18,800
38	Guangxi Baihe Chemical Co., Ltd.	Guangxi	20,000	20,000	20,000	18,900	14,100	23,000
39	Yumen Jingyang Titanium Pigment Manufacturing Co., Ltd.	Gansu	20,000	20,000	20,000	6,000	6,300	6,000
40	Hunan Chuangda Yutu Chemcial Co., Ltd.	Hunan	15,000	15,000	15,000	14,700	14,500	13,600
Others			167,000	167,000	337,000	82,000	82,800	106,000
Total			**4,298,000**	**4,103,000**	**3,713,000**	**3,806,600**	**3,522,600**	**3,175,000**

Source: CCM

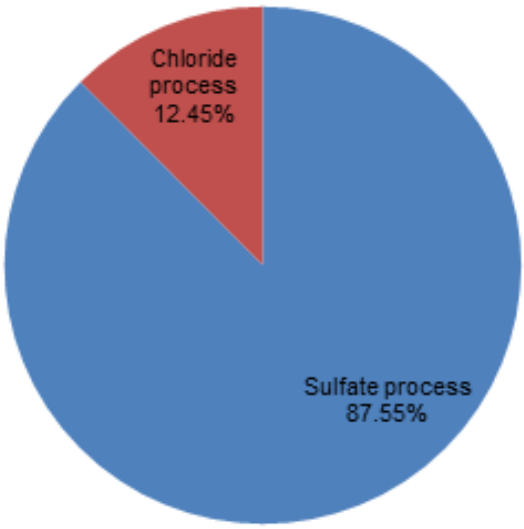
During 2019–2021, sulfate process TiO_2 still dominated the domestic market; at the same time, chloride process TiO_2, the future of the industry, developed steadily. Generally, current domestic chloride process technique is far from mature yet, and stable mass production waits for improvement. The next five years may see a fast growth of chloride process as it is encouraged in the course of the 14th Five-Year Period (2021–2025). There will be a shift to chloride process in years to come, but sulfate process would still remain the mainstream, though seeing shrinking share in the industry.

Table 1.2-2 Production situation of chloride process titanium dioxide in China, 2020–2021

No.	Producer	Capacity, t/a		Output, tonne	
		2021	2020	2021	2020
1	LB Group Co., Ltd.	360,000	360,000	256,200	212,500
2	Yibin Tianyuan Haifeng Hetai Co., Ltd.	100,000	50,000	35,100	24,400
3	CITIC Titanium Industry Co., Ltd.	60,000	60,000	68,300	68,700
4	Pangang Group Vanadium & Titanium Resources Co., Ltd.	15,000	15,000	16,400	13,300
Total		**535,000**	**485,000**	**376,000**	**318,900**

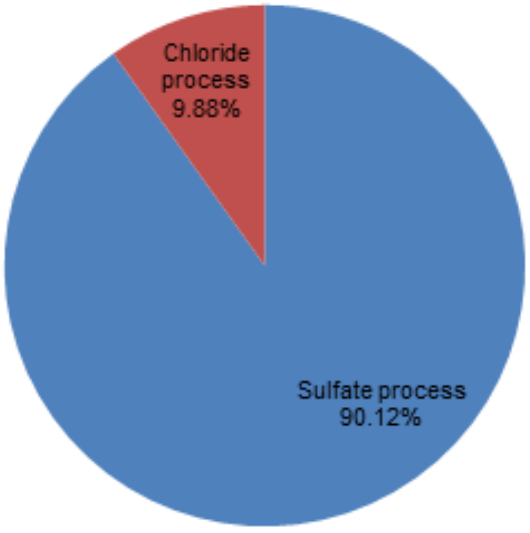
Source: CCM

Figure 1.2-1 Share of capacity of titanium dioxide by process in China, 2021



Source: CCM

Figure 1.2-2 Share of output of titanium dioxide by process in China, 2021



Source: CCM

1.3 Titanium dioxide production distribution, 2021

Domestic TiO_2 manufacturers are mainly distributed in 17 provinces, municipalities and autonomous regions. In particular, many TiO_2 manufacturers congregated in Sichuan, Guangxi, Shandong, Jiangsu and Anhui. The largest TiO_2 producer in China is headquartered in Henan Province, having production bases in Sichuan, Hubei and Yunnan.

Table 1.3-1 Distribution of top 40 titanium dioxide manufacturers by province/municipality/autonomous region in China, 2021

Province/Municipality/Autonomous Region	Capacity, t/a	Output, tonne	Company number
Henan	1,010,000	902,200	1
Sichuan	775,000	727,800	10
Shandong	520,000	466,100	3
Jiangsu	326,000	241,600	3
Gansu	320,000	330,200	2
Guangxi	280,000	258,400	7
Beijing	170,000	174,500	1
Anhui	140,000	148,100	3
Zhejiang	120,000	99,700	1
Guangdong	110,000	82,300	1
Yunnan	75,000	63,100	2
Liaoning	60,000	68,300	1
Hubei	60,000	27,600	1
Guizhou	50,000	51,000	1
Jiangxi	50,000	50,000	1
Shanghai	50,000	19,000	1
Hunan	15,000	14,700	1

Source: CCM

Sichuan Province is a famous TiO_2 production base in China, with 10 manufacturers concentrated there in 2021. Particularly, Panzhihua City boasts abundant titanium ore resources and the local government aims to turn the city into a renowned TiO_2 production base by granting many preferential policies regarding water and electricity, which stimulates the development of local TiO_2 industry.

The manufacturers in Guangxi Zhuang Autonomous Region are mainly located in Wuzhou City (including Tengxian County) and Liuzhou City where titanium ore resources are rich. With less strict local regulations on environmental protection there, many manufacturers adopt sulfate process to produce TiO_2. Moreover, Guangxi can easily make full use of overseas resources because it borders Vietnam, an important titanium ore import origin for China. Most manufacturers in Guangxi only produce anatase TiO_2 or non-pigment TiO_2 for ceramics, enamel and welding rod.

TiO_2 production in Shandong Province is controlled by Shandong Doguide Group Co., Ltd., Shandong Lubei

Chemical Co., Ltd. and Shandong Dawn Titanium Industry Co., Ltd.

In Jiangsu Province, GPRO Investment Holding Group Co., Ltd. now controls nearly 80% of the total TiO_2 production capacity there, being the controlling shareholder of both GPRO Titanium Industry Co., Ltd. and Jiangsu Taibai Group Co., Ltd.

LB Group Co., Ltd. (with 1,010,000 t/a in 2021 in total) has TiO_2 production lines in Henan, Yunnan, Sichuan and Hubei provinces, of which the latter two, with abundant ilmenite resources, provide the company with easy access to raw materials. Therefore, real capacity in Henan Province is much lower.

CNNC Hua Yuan Titanium Dioxide Co., Ltd. takes the lion's share of TiO_2 production in Gansu Province. It also has production bases in Anhui and Jiangsu provinces. It is notable that its Jiangsu base, Wuxi Haopu Titanium Dioxide Co., Ltd., was shut down in 2018 due to the local government's adjustment to industrial planning and the production facilities were taken over by another subsidiary Anhui Gold Star Titanium Dioxide (Group) Co., Ltd.

1.4 Domestic titanium dioxide expansion projects

Since 2010, domestic TiO_2 capacity has been increasing at a much slower pace, which is mainly attributed to the government limitation of the production with sulfate process for the process is less clean. While restricting expansion of sulfate process, the government also encourages the advancement and application of chloride process to produce TiO_2. However, due to technical barriers and blockade of core technologies imposed by the overseas TiO_2 giants, enterprises that intend to apply chloride process can only explore by themselves and accumulate experience little by little. Only a few well-capitalized chemical enterprises with enough technology accumulation have carried out chloride process projects. Nevertheless, with all things improved in the past few years, China's TiO_2 industry is likely to see accelerating capacity expansion in both processes in the near future.

Table 1.4-1 List of projects in China expected to be built up and put into operation in the near future

Company	Capacity in 2021, t/a	Expansion, t/a	Expected finish time	Technology	Note
CNNC Hua Yuan Titanium Dioxide Co., Ltd.	300,000	400,000	2022	Sulfate	1. Its subsidiary Anhui Gold Star Titanium Dioxide (Group) Co., Ltd. is building a 100,000 t/a post-processing project, which is expected to be completed by the end of 2022. 2. Its subsidiary Gansu Dongfang Titanium Dioxide Co., Ltd. is building a 300,000 t/a sulfate process project, which is expected to be completed by the end of 2022.
Shandong Lubei Chemical Co., Ltd.	200,000	60,000	2022	Chloride	Its subsidiary Shandong Xianghai Titanium Resources Technology Co., Ltd.'s 60,000 t/a chloride process project has been put into production since April 2022.
Guangdong Huiyun Titanium Industry Co., Ltd.	110,000	50,000	2022	Sulfate	The Phase II (50,000 t/a) of its 80,000 t/a post-processing project is expected to be completed by the end of 2022.
CITIC Titanium Industry Co., Ltd.	60,000	60,000	2022	Chloride	Its 60,000 t/a chloride process TiO_2 production line was put into trial production in Jan. 2022.
Panzhihua Haifengxin Chemical Industry Co., Ltd.	60,000	30,000	2022	Sulfate	Its 30,000 t/a post-processing project will be finished by the end of 2022.
LB Group Co., Ltd.	1,010,000	1,100,000	2022 & 2023 & 2024 & 2025	Chloride & sulfate	1. Its subsidiary Yunnan Metallurgical Xinli Titanium Co., Ltd. is building a 200,000 t/a chloride process project, which is expected to be completed by the end of 2022. 2. Its subsidiary Henan Billions New Material Co., Ltd. is pushing ahead with a 100,000 t/a chloride process expansion project, which is expected to be completed by 2022 and it is going to convert a 60,000 t/a chloride process device into a 30,000 t/a titanium sponge device by 2024. 3. Its subsidiary Gansu Xingbai Titanium Industry Co., Ltd. is building a 400,000 t/a sulfate process project, which is expected to be completed by 2023.

Company	Capacity in 2021, t/a	Expansion, t/a	Expected finish time	Technology	Note
					4. Its subsidiary LB Xiangyang Titanium Industry Co., Ltd. is building a 200,000 t/a post-processing project, which is expected to be completed by 2023. 5. Its subsidiary LB Sichuan Mining & Metallurgy Co., Ltd. is building a 200,000 t/a chloride process project, which is expected to be completed by 2025.
Guizhou Sunward Fuquan Chemicals Co., Ltd.	50,000	130,000	2022 & 2023	Sulfate	The company is building a 130,000 t/a sulfate TiO_2 project, of which the Phase I (50,000 t/a) was finished in June 2022 and the Phase II (80,000 t/a) is expected to be completed by 2023.
Hunan Chuangda Yutu Chemcial Co., Ltd.	15,000	100,000	2022 & 2025	Sulfate	Its subsidiary Hunan Yutu Titanium Industry New Material Co., Ltd. is pushing ahead with the 100,000 t/a sulfate process project, of which the Phase I (50,000 t/a) is expected to be finished by the end of 2022 and the Phase II (50,000 t/a) by 2025.
Fujian Kuncai Material Technology Co., Ltd.	0	500,000	2022 & 2025	Hydrochloric acid extraction process	Its 200,000 t/a hydrochloric acid extraction process TiO_2 production line was put into production in Feb. 2022. Its 300,000 t/a project is expected to be completed by 2025.
Hebei Jicheng New Material Co., Ltd.	0	480,000	2023 & 2025	Chloride	The company is building a 480,000 t/a chloride process TiO_2 project, of which the Phase I (160,000 t/a) is expected to be completed by 2023 and the Phase II (320,000 t/a) by 2025.
Guangxi Xilong Chemical Co., Ltd.	30,000	30,000	2023	Sulfate	/
Guocheng Resources (Inner Mongolia) Co., Ltd.	0	200,000	2023	Sulfate	/
Inner Mongolia Dadi Yuntian Chemical Co., Ltd.	0	100,000	2023	Sulfate	/
Pangang Group Vanadium & Titanium Resources Co., Ltd.	235,000	60,000	2024	Chloride	Its subsidiary Pangang Group Titanium Industry Co., Ltd. is building a 60,000 t/a chloride process line, which is expected to be completed by 2024.
Anhui Annada Titanium Industry Co., Ltd.	80,000	50,000	2024	Sulfate	Its 50,000 t/a post-processing project is expected to be completed by 2024.
Guangxi Shunfeng Titanium Industry Co., Ltd.	60,000	120,000	2024	Sulfate	The company is going to relocate its production capacity and expand it to 120,000 t/a with the relocation project.
Guangdong Dinglong Industrial Group Co., Ltd.	0	500,000	2026	Chloride	/

Source: CCM

Of all the projects above, it is eye-catching that Fujian Kuncai Material Technology Co., Ltd. developed a set of hydrochloric acid extraction process TiO_2 with independent intellectual property rights.

According to relevant literature, main procedures for the hydrochloric acid extraction process TiO_2 are as follows:

- Acidolysis: hydrochloric acid is added to dissolve ilmenite, and then the solid is separated to obtain the titanium oxychloride solution.
- Reduction: the titanium oxychloride solution is reduced by iron powder to remove ferric ion.
- Crystallization: after cooling, ferrous chloride in the solution crystallizes, and titanium oxychloride solution without iron is obtained.
- Extraction: add organic extractant to the iron-free solution to remove impurities.
- Hydrolysis: the titanium oxychloride solution is then sprayed and hydrolyzed to obtain amorphous TiO_2.
- Salt treatment: add salt treatment agent to increase the color and luster and porosity of TiO_2.

● Calcining: after high-temperature dehydration and calcination, the primary product of granular TiO_2 is obtained.
● Crushing: the granular TiO_2 is rolled and milled to obtain TiO_2 powder.

The process has both advantages and disadvantages, specifically:
● Advantages: hydrochloric acid and extractant can be recycled and reused, and the by-products ferrous chloride and ferric chloride can be converted into iron oxide for reuse after hot water hydrolysis. In addition, the hydrochloric acid extraction method has not high requirements for raw materials, generates less industrial wastewater and residues, and consumes less energy.
● Disadvantages: Expensive extractant, high requirements on equipment, high conditions for hydrochloric acid dissolving ilmenite all pose some threats to the promotion of this process. Also, concentration of titanium oxychloride is difficult to guarantee.

Domestic titanium dioxide capacity expansion is mainly based on the following favorable factors:
● Firstly, demand from downstream industries is increasing, especially from the coating and plastics industries.
● Secondly, demand from overseas markets gives domestic manufacturers room to expand further.
● Thirdly, policies and regulations are helpful to the capacity expansion in regard to production through chloride process, so such projects are progressing faster than before.
● Fourthly, sulfate process has also improved in terms of pollutant disposal, so there are such ongoing projects too.

1.5 Development of chloride process

Chloride process used to develop slowly in China, with projects promoted in a steady way only by experienced big players in TiO_2 industry.

Since 2019, however, more influential companies, some even from other chemical sectors, joined in the development of chloride process. For instance, Yibin Tianyuan Haifeng Hetai Co., Ltd., a wholly-owned subsidiary of Yibin Tianyuan Group Co., Ltd., built up a 50,000 t/a chloride process TiO_2 production line and started trial run in 2019. The company's another 50,000 t/a expansion project had been put into production by the end of 2021. Similarly, Hebei Jicheng New Material Co., Ltd., a subsidiary of Tangshan Yanshan Iron & Steel Co., Ltd., announced to enter into this industry in 2020 and has planned a 480,000 t/a chloride-process project, of which the first phase will deliver 160,000 t/a production capacity.

Guidance Catalogue for Industrial Structure Adjustment (2019 version) given by National Development and Reform Commission (NDRC) stipulates that addition of sulfate-process TiO_2 capacity is restricted, while building chloride-process projects with capacity of 30,000 t/a per production line or above is encouraged. And this development direction of TiO_2 industry shall not change in many years to come.

Therefore, during the 14th Five-Year Plan period (2021–2025), China's TiO_2 industry is to witness fast growth in chloride-process TiO_2 capacity and welcome many new players. Often these new producers come with ambitious chloride-process projects, yet it remains unknown that how many proposed capacity can be built up and put into operation in the next few years. Generally, China's TiO_2 industry is not to expect a chloride process-dominant future in the short term.

It is also noteworthy that the faster development of chloride process in China does not mean it serves as a substitute for sulfate process as reported by the media. In fact, as long as enterprises bear in mind environmental protection and comprehensive utilization of wastes and by-products, sulfate process would still be the mainstream for quite a long time.

1.6 Titanium dioxide feedstock situation, 2019–2021

According to the *Mineral Commodity Summaries 2022* offered by the United States Geological Survey (USGS), ilmenite consumption takes up 90% of titanium ore consumption around the world. As of the end of 2021, global titanium ore resources exceeded 2 billion tonnes (calculated by TiO_2 equivalent) and reserves were about 750 million tonnes, about 93% of which were ilmenite reserves (about 700 million tonnes). Except in Antarctica, titanium ore resources are found abundant in the other six continents, more specifically, scattering in 29 countries. Among them, Australia holds the most titanium ore resources. Reserves in the top 15 countries

account for about 97% of the global total.

Table 1.6-1 Ilmenite & rutile reserves of major titanium resources suppliers

No.	Country	2021 output, '000 tonne			Reserve, '000 tonne			Share to global total reserve
		Ilmenite	Rutile	Total	Ilmenite	Rutile	Total	
1	China	3,000	N/A	3,000	230,000	N/A	230,000	30.70%
2	Australia	480	200	680	160,000	31,000	191,000	25.49%
3	India	180	11	191	85,000	7,400	92,400	12.33%
4	Brazil	66	N/A	66	43,000	N/A	43,000	5.74%
5	Norway	440	N/A	440	37,000	N/A	37,000	4.94%
6	South Africa	1,000	90	1,090	30,000	6,500	36,500	4.87%
7	Canada	600	N/A	600	31,000	N/A	31,000	4.14%
8	Mozambique	970	9	979	26,000	890	26,890	3.59%
9	Madagascar	310	10	320	22,000	400	22,400	2.99%
10	Ukraine	430	95	525	5,900	2,500	8,400	1.12%
11	The US	100	N/A	100	2,000	N/A	2,000	0.27%
12	Vietnam	220	N/A	220	1,600	N/A	1,600	0.21%
13	Kenya	190	71	261	390	170	560	0.07%
14	Senegal	360	10	370	N/A	N/A	N/A	N/A
15	Sierra Leone	N/A	120	120	N/A	490	490	0.07%
Others		67	13	80	26,000	N/A	26,000	3.47%
World total		**8,413**	**629**	**9,042**	**699,890**	**49,350**	**749,240**	**100.00%**

Note:
1. Ilmenite & rutile output and reserves are calculated based on equivalence to titanium dioxide content.
2. The rutile output and reserves data of the United States are included with in ilmenite data.
3. The data are estimated.
Source: Mineral Commodity Summaries 2022 by the USGS

According to the China Mineral Resources Report 2022 issued by the Ministry of Natural Resources of the People's Republic of China in Oct. 2022, 223.83 million tonnes of titanium ores (calculated by TiO_2 equivalent) had been recorded as of 2021, up by 11.27% over 2020. But high-quality ores only account for a very small proportion, about 1% of the total. Primary rutile ores of lower grade account for 86% of the domestic rutile ores, and the rest 14% are placers. The other 99% titanium reserves are ilmenites, of which primary ilmenite (magnetite) ores and ilmenite placers take up 93% and 7% respectively.

By 2021, this basic situation has rarely changed, titanium ore resources had been found in 15 provinces (regions) in China, mainly in Sichuan, Yunnan, Shandong, Hubei and Hebei provinces. Specifically, some 91% of domestic titanium ores (about 210 million tonnes calculated by TiO_2 equivalent) were found in Yunnan and Sichuan provinces.

Though China is rich in titanium resources, its ore grade is relatively lower than that of many other titanium-rich countries. Primary ilmenite rock ores, with average content of only 5%, are concentrated in Sichuan Province and Hebei Province; ilmenite placers are found in Yunnan Province, Guangxi Zhuang Autonomous Region,

Hainan Province and Guangdong Province. Besides ilmenite, there are some other titanium resources in Henan Province, Hubei Province, and Shanxi Province, but the content of their rutile resources is even lower than 5%.

Absolute majority of associated primary rock-type ilmenite ores with low titanium content and only a tiny bit of easy-to-exploit-and-utilize rutile ores make China depend on import, at least in terms of high-quality titanium ores. At present, domestic ilmenite enterprises mostly produce low-grade products with underdeveloped purification technology and limited equipment scale.

The content of the domestic titanium concentrate ore is generally lower than 45%, while that of the imported one is above 50% in the majority. So a number of the domestic titanium dioxide manufacturers prefer to use imported titanium concentrate ore in their production.

In 2019–2021, there was a significant rise in titanium ore import, mainly because of an increased demand for China's TiO_2 and other titanium products from home and abroad. In 2021, Mozambique, Vietnam and Kenya were the major providers of titanium ores to China.

Table 1.6-2 China's import volume of ilmenite by month, 2019–2021

Month	Volume, tonne		
	2019	2020	2021
Jan.	230,248	300,342	277,839
Feb.	165,309	249,244	352,761
March	260,524	233,388	395,760
April	122,310	231,508	367,164
May	171,774	320,038	226,630
June	162,266	198,631	357,775
July	362,664	216,261	250,197
Aug.	185,255	222,934	262,223
Sept.	124,799	202,740	349,740
Oct.	270,414	285,911	185,637
Nov.	245,423	252,854	528,063
Dec.	297,619	300,547	242,968
Total	**2,598,605**	**3,014,397**	**3,796,756**

Source: China Customs

Table 1.6-3 Top 10 import origins of ilmenite to China, 2021

No.	Origin	Volume, tonne
1	Mozambique	1,463,275
2	Vietnam	418,807
3	Kenya	287,765
4	Norway	255,502
5	Australia	253,206
6	South Africa	182,616
7	South Korea	127,107
8	India	117,423
9	The US	115,559
10	Sri Lanka	95,866
Others		479,631
Total		**3,796,756**

Source: China Customs

Table 1.6-4 Output of titanium concentrate in China, 2019–2021

Production area (Province/Municipality/Autonomous Region)	Volume, tonne		
	2019	2020	2021
Sichuan	3,998,000	4,340,000	4,595,000
Hebei	166,000	320,000	353,000
Yunnan	190,000	323,000	311,000
Xinjiang	312,000	274,000	296,000
Shandong	120,000	271,000	78,000
Others	229,000	219,000	192,000
Total	**5,015,000**	**5,747,000**	**5,825,000**

Source: CCM

Both the capacity and output of titanium slag in China have been increasing in recent years. In TiO_2 production, titanium slag approach has lesser pollutants emitted compared with titanium concentrate ore approach.

Table 1.6-5 Output of titanium slag (74%–76%) in China by month, 2019–2021

Month	Volume, tonne		
	2019	2020	2021
Jan.	32,860	33,800	43,100
Feb.	29,600	29,600	40,400
March	37,100	36,000	41,500
April	37,800	27,100	40,000
May	34,400	31,400	40,600
June	31,900	37,500	38,800
July	33,100	35,000	39,050
Aug.	34,050	34,960	42,000
Sept.	38,750	36,400	46,800
Oct.	33,800	44,700	51,130
Nov.	34,000	42,800	45,000
Dec.	35,500	41,400	48,100
Total	**412,860**	**430,660**	**516,480**

Source: CCM

Table 1.6-6 Output of titanium slag (90%–92%) in China by month, 2019–2021

Month	Volume, tonne		
	2019	2020	2021
Jan.	14,600	23,000	23,300
Feb.	10,900	17,950	19,000
March	15,300	24,350	21,600
April	18,050	24,700	22,500
May	18,460	20,150	23,500
June	18,960	17,550	24,300
July	21,200	22,250	19,800
Aug.	24,700	22,060	22,250
Sept.	26,300	20,840	13,830
Oct.	25,100	22,100	7,670
Nov.	26,650	19,500	18,300
Dec.	26,200	20,500	17,800
Total	**246,420**	**254,950**	**233,850**

Source: CCM

Under mounting pressure of environmental protection from the government, basically more and more enterprises chose to use acid-soluble titanium slag or mixture of acid-soluble titanium slag and titanium concentrate ore to produce TiO_2. At the same time, growing demand for high quality TiO_2 forces manufacturers to use more acid-soluble titanium slag for better product quality.

Thus, the scale of titanium slag production in China has grown larger driven by the huge demand from downstream product sectors (also including $TiCl_4$, titanium sponge). However, titanium slag still does not have cost advantage compared with titanium concentrate ore in TiO_2 production, which impedes a fast growth of titanium slag consumption.

2 Titanium dioxide and raw material prices

2.1 Raw material price, 2019–H1 2022

- Ilmenite

In 2019, ex-works price of ilmenite was relatively stable in China, with little fluctuation, but big jumps in the price were witnessed in 2020–H1 2021. From July 2021 to June 2022, the price fluctuated at a high level.

- 2019: Ex-works price was relatively flat overall with some more obvious ups in Q4. The highest point occurred in Nov., with an average price of USD208.87/t; the lowest point came in Jan., with the average price being USD193.95/t.
- 2020: The price dipped in Q2 but then rebounded and reached for new high since June.
- 2021–H1 2022: The price kept increasing in H1 2021, and from
- H2 2021 to H1 2022, the prices in some major production regions in China went through several rounds of up and down.

Jan. 2019–Aug. 2019

In Q1–Q3 2019, the market did not change significantly, despite minor ups and downs in the price. Downstream demand grew around the Spring Festival and the price rose slightly in Q1. In March, as the operating rates of ilmenite producers in Panzhihua-Xichang Area increased, the market supply of ilmenite was sufficient with slight price increase. Starting from May, the overall market fell again, but the price only dropped a bit due to the support of its cost.

Sept. 2019–March 2020

The price went up, and main reasons are:

- The supply of raw materials reduced due to transportation disruption caused by COVID-19. Starting from Oct. 2019, some ilmenite manufacturers were in routine maintenance, which caused the output reduction of ilmenite. Around the Spring Festival, downstream manufacturers increased inventories, stimulating certain price increase.
- The decline in foreign ilmenite output and restricted export of ilmenite in India and Vietnam led to tight supply of ilmenite imported, along with high import price.

April 2020–May 2020

In late March, the supply of ilmenite in Panzhihua-Xichang Area returned to normal, and the inventory in manufacturers increased. However, the operating rate of downstream manufacturers failed to come normal because of the aftermath of COVID-19, thus the downstream demand was weak, which drove the price of ilmenite down.

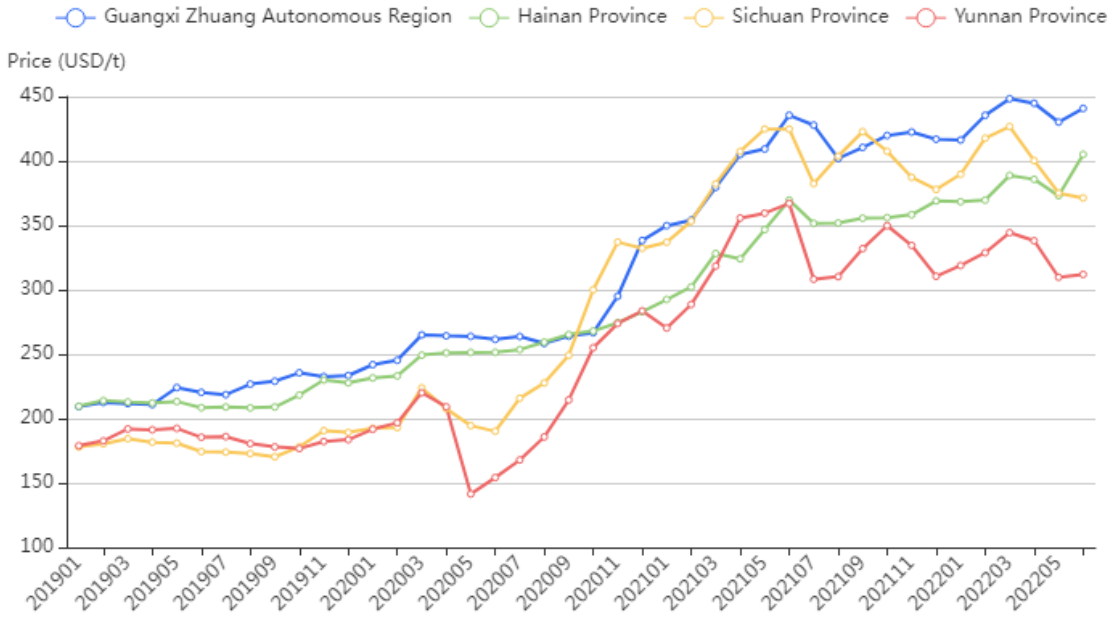
June 2020–June 2021

The price showed an upward trend in this period owing to shrinking supply of ilmenite. Besides, in H2 2020, due to sharp increases in the price of domestic ilmenite, demand for imported ilmenite has increased. However, as the exchange rate of USD to RMB declined, overseas manufacturers raised their prices continuously.

July 2021–June 2022

The price witnessed frequent fluctuations as demand changed during this period.

Figure 2.1-1 Monthly ex-works price of ilmenite in China by region, Jan. 2019–June 2022



Note: Ilmenite grading: 45%–47% in Yunnan Province, 40%–46% in Sichuan Province, 45%–54% in Hainan Province and 50%–52% in Guangxi Zhuang Autonomous Region
Source: CCM

- Titanium slag

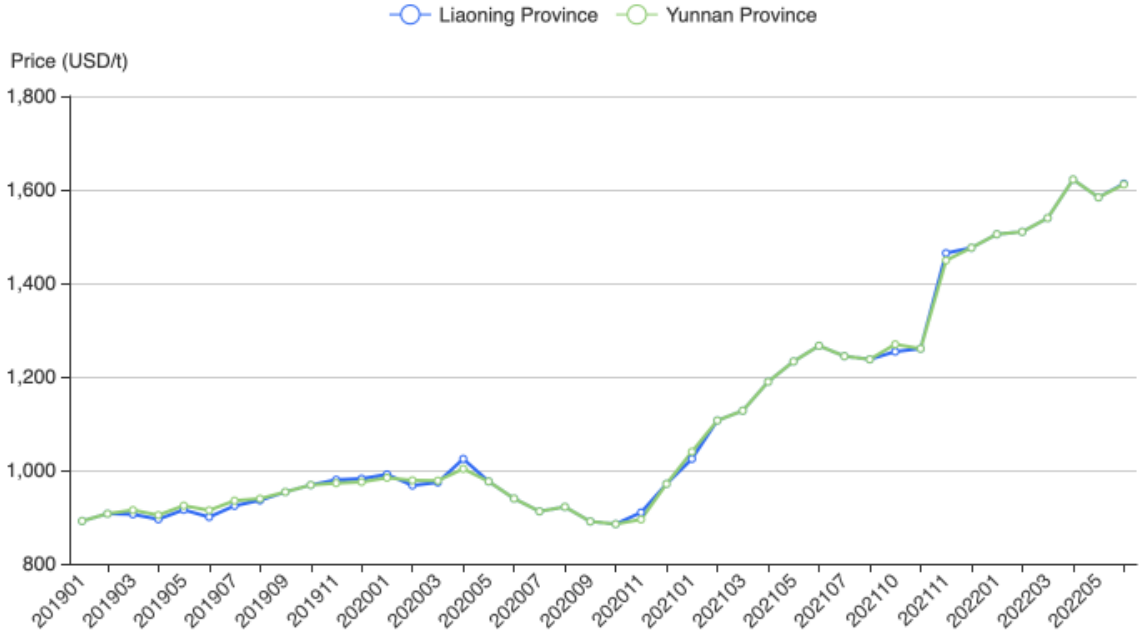
Jan. 2019–Dec. 2019
In 2019, the supply of titanium slag was relatively stable, the overall market price increased, except tax reduction in April and weak downstream demand in June driving prices down. Rising downstream demand and insufficient supply of raw materials drove the market price of titanium slag up in general.

Jan. 2020–Oct. 2020
The price of titanium slag witnessed an overall downward trend. Due to the aftermaths of COVID-19, the downstream demand became weak, leading the price of titanium slag down. And many titanium slag manufacturers chose to suspend production or cut production because of low profits.

Nov. 2020–June 2022
The price of titanium slag went up significantly. Main reasons are as follow:

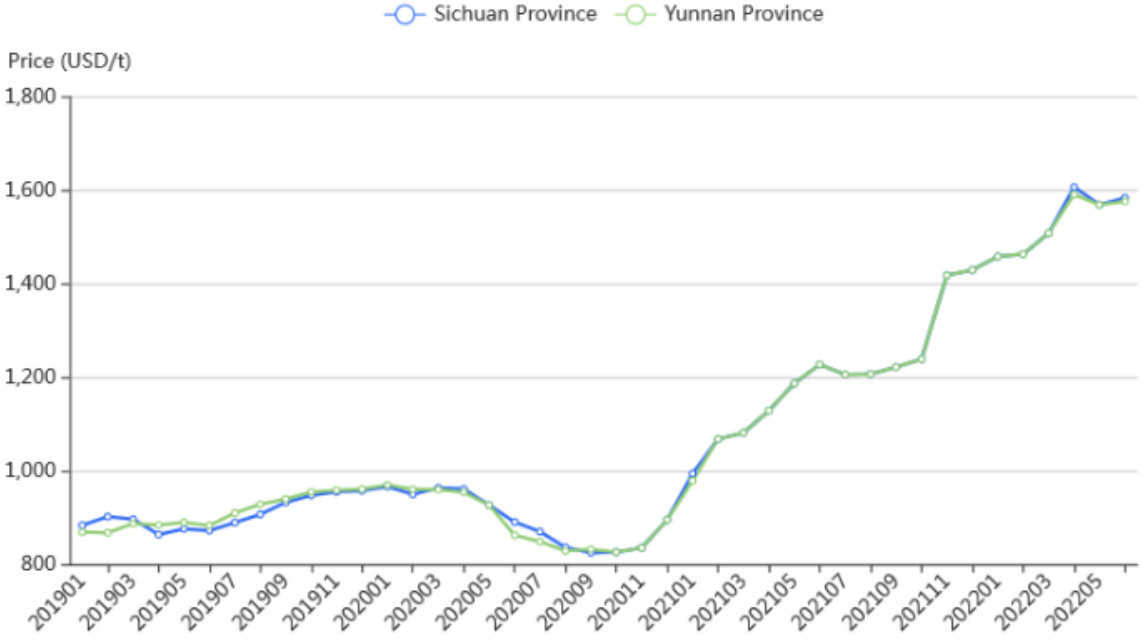
- Limited supply: The shortage of high quality titanium ore in China and the reduction of supply from some miners led to limited supply in the overall market.
- Strong downstream demand: The demand for titanium slag increased as operating rates of chloride process TiO_2 and titanium sponge remained at a high level.
- High costs: The import price of high quality titanium ore continued to rise, resulting in increased costs for titanium slag producers.

Figure 2.1-2 Monthly ex-works price of titanium slag (92%) in China by region, Jan. 2019–June 2022



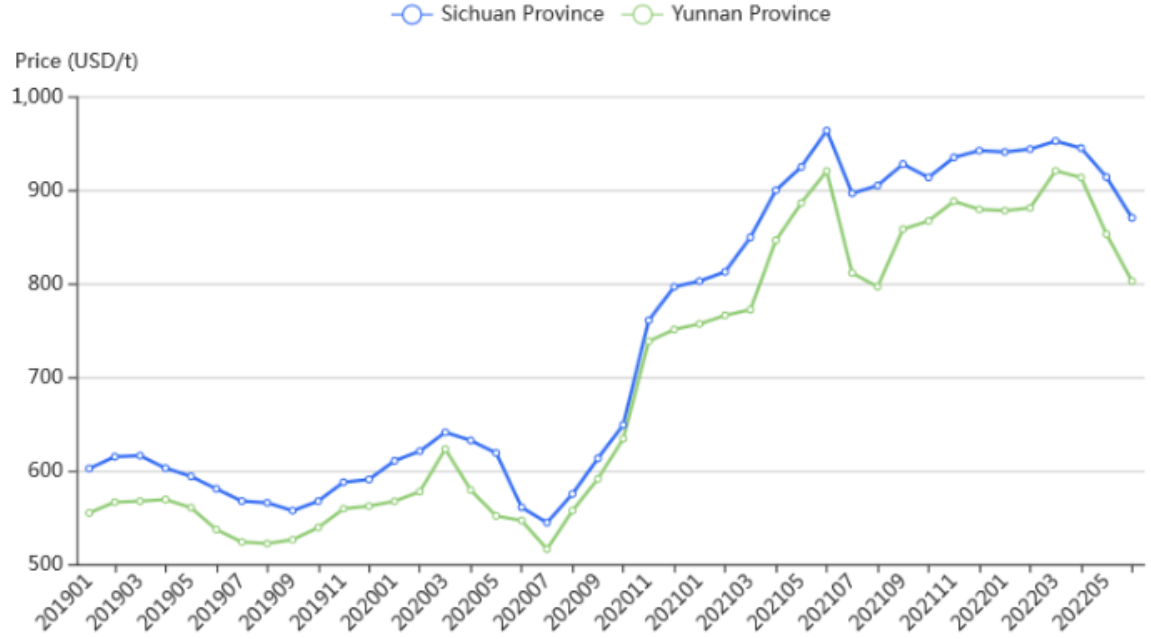
Source: CCM

Figure 2.1-3 Monthly ex-works price of titanium slag (90%) in China by region, Jan. 2019–June 2022



Source: CCM

Figure 2.1-4 Monthly ex-works price of titanium slag (74%–76%) in China by region, Jan. 2019–June 2022



Source: CCM

2.2 Titanium dioxide price, 2019–H1 2022

The domestic price curve of TiO_2 in 2019–H1 2022 showed a "down-up-fluctuation" pattern, in which the price went down and hit the bottom in June or July 2020, then followed a upward trend till June 2021, and after that fluctuated at a relatively high level.

Jan. 2019–Dec. 2019

There was a year-long price descent in this period. TiO_2 price fluctuated and slipped lower in China. The price decline is mainly attributed to a sluggish domestic TiO_2 market and an overstock in the whole industry. Specifically:

- On the demand side:

Downstream producers were also affected by environmental inspections. Operating rates of most downstream producers saw a decline trend this year. And in Q4 2019, North China and East China were frequented by hazy days.

- On the supply side:

The TiO_2 industry lacked vitality in demand, and an overstock trend became increasingly obvious in this period. Notably, operating rates of TiO_2 manufacturers in Shandong, Anhui, Sichuan, Liaoning, Hubei and Jiangsu provinces were relatively low, affected by strict environmental inspections along the Yangtze River and "Look Back" inspections by central government officials. Since the SCO Qingdao Summit was held in Shandong Province in June 2018, major TiO_2 manufacturers there such as Shandong Dawn Titanium Industry Co., Ltd., Shandong Doguide Group Co., Ltd. had to cut or suspend production till the end of 2019.

Jan. 2020–July 2020

The price of TiO_2 rose for a short while but then declined in this period. The outbreak of COVID-19 in late Jan. restricted the production of some TiO_2 manufacturers in the early stage and the spot supply was tightened, which drove the prices up. In Q2 2020, the price began to drop mainly due to sluggish demand as the downstream manufacturers were affected by COVID-19, especially the foreign ones.

Aug. 2020–June 2021

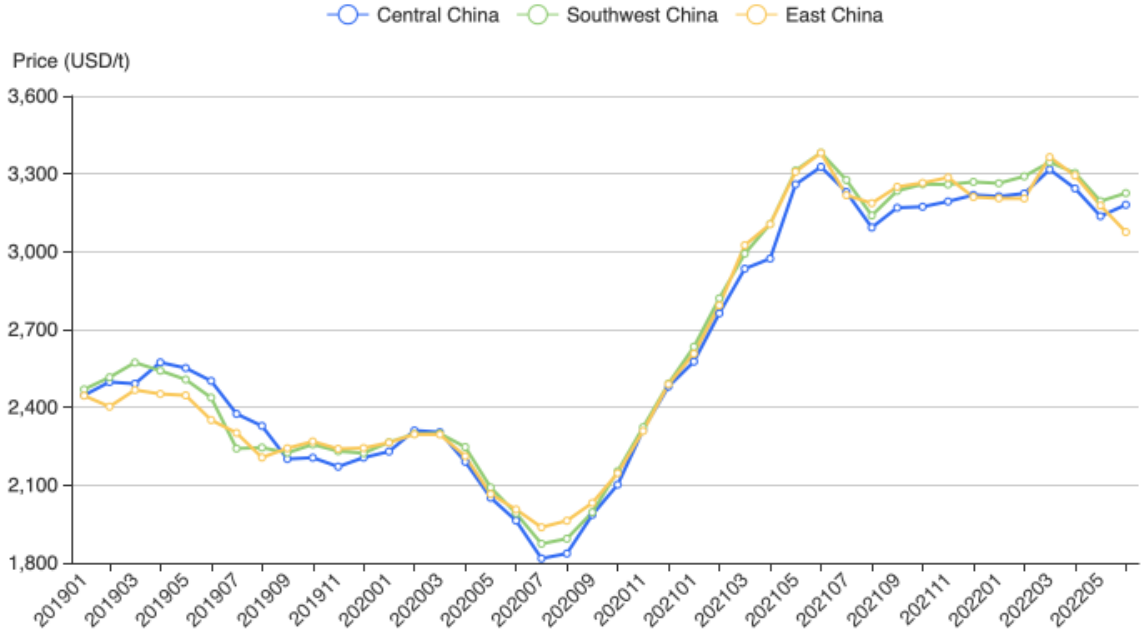
In this period, the world came back on the right track under eased COVID-19 situation with recovering economy. Demand for China's TiO_2 from home and abroad was revitalized, plus rising cost of ilmenite lending support to TiO_2 price for most of the time. This two factors were strong to keep the TiO_2 price soaring.

July 2021–June 2022

In this period, TiO_2 price basically fluctuated at high level. Main reasons for this are:

- Prosperous export market supported the domestic market strongly. Thus domestic demand, though had seasonal variations, was basically good enough to maintain the TiO_2 price at a high level.
- The prices of ilmenite and sulfuric acid, materials of TiO_2, stayed at a high level, which supported the price of TiO_2.

Figure 2.2-1 Monthly ex-works prices of rutile titanium dioxide in China by region, Jan. 2019–June 2022



Source: CCM

Figure 2.2-2 Monthly ex-works prices of anatase titanium dioxide in China by region, Jan. 2019–June 2022

Source: CCM

3 Mainstream titanium dioxide manufacturers, 2019–2021

3.1 Overview

Traditional first-tier TiO_2 manufacturers in China are LB Group Co., Ltd. (LB Group), CNNC Hua Yuan Titanium Dioxide Co., Ltd. (CNNC Hua Yuan), Pangang Group Vanadium & Titanium Resources Co., Ltd. (Pangang Group), GPRO Investment Holding Group Co., Ltd. (GPRO Group) and Anhui Annada Titanium Industry Co., Ltd. (Anhui Annada). They not only have large production scale, but also, as listed companies, enjoy more financing channels which makes them backbone forces for future development of chloride-processed TiO_2 in China. With faster development and deeper upgrading of China's TiO_2 industry, there will be more to join them.

Statistics show that in 2021, over 40 domestic large-scale full-process TiO_2 manufacturers maintained normal production, of which 10 boasted TiO_2 output exceeding 100,000 tonnes. Of these 10 enterprises, LB Group, CNNC Hua Yuan, Pangang Group and GPRO Group are the front runners and expected to lead domestic TiO_2 industry.

Table 3.1-1 List of domestic titanium dioxide producers with more than 100,000-tonne output, 2021

No.	Producer	Note
1	LB Group Co., Ltd.	Including LB Sichuan Titanium Industry Co., Ltd., LB Xiangyang Titanium Industry Co., Ltd., Henan Billions New Material Co., Ltd. and Yunnan Metallurgical Xinli Titanium Co., Ltd.
2	CNNC Hua Yuan Titanium Dioxide Co., Ltd.	Including Anhui Gold Star Titanium Dioxide (Group) Co., Ltd., Gansu Hecheng Titanium Dioxide Co., Ltd. and Gansu Dongfang Titanium Dioxide Co., Ltd.
3	Pangang Group Vanadium & Titanium Resources Co., Ltd.	Including Pangang Group Chongqing Titanium Industry Co., Ltd., Panzhihua Dongfang Titanium Industry Co., Ltd. and Pangang Group Titanium Industry Co., Ltd.
4	GPRO Investment Holding Group Co., Ltd.	Including GPRO Titanium Industry Co., Ltd. (with subsidiaries Nanjing Titanium Dioxide Chemical Co., Ltd. and Xuzhou Titanium Dioxide Chemical Co., Ltd.) and Jiangsu Taibai Group Co., Ltd. (with subsidiaries Jiangsu Zhentai Chemical Co., Ltd. and Zhenjiang Taibai Chemical Co., Ltd.)
5	Shandong Doguide Group Co., Ltd.	Including itself and Shandong Jinhong Titanium Dioxide Chemicals Co., Ltd., Shandong Suntiox Industrial Co., Ltd.
6	China National Chemical Co., Ltd.	Including Jinan Yuxing Chemical Co., Ltd. and Guangxi Bluestar Dahua Chemical Co., Ltd.
7	Shandong Lubei Chemical Co., Ltd.	Including Shandong Jinhai Titanium Resources Technology Co., Ltd. and Shandong Xianghai Titanium Resources Technology Co., Ltd.
8	Shandong Dawn Titanium Industry Co., Ltd.	/
9	Guangxi Jinmao Titanium Co., Ltd.	/
10	Panzhihua Taihai Technology Co., Ltd.	/

Source: CCM

3.2 LB Group Co., Ltd.

- Company profile

LB Group Co., Ltd. (LB Group, 002601), previously known as Lomon Billions Group Co., Ltd. and Henan Billions Chemicals Co., Ltd., is headquartered in Jiaozuo City, Henan Province. In September 2016, it invested USD1.35 billion to acquire 100% stake of Sichuan Lomon Titanium Industry Co., Ltd. Up to now, LB Group has five titanium dioxide production bases in four provinces, including two bases in Jiaozuo City (Henan Province), and one each in Mianzhu City (Sichuan Province), Xiangyang City (Hubei Province) and Kunming City (Yunnan Province). Its titanium dioxide capacity reached 1,010,000 t/a in 2021, ranking first in Asia and third in the world. LB Group has established subsidiaries outside mainland China, such as Billions (Hong Kong) Co., Ltd., Billions Europe Ltd. and Billions America Corporation, to expand its business in export markets.

Table 3.2-1 Major subsidiaries of LB Group in titanium dioxide business, 2021

No.	Subsidiary	Business location	Business	Shareholding ratio	Obtain method
1	Henan Billions New Material Co., Ltd.	Jiaozuo City, Henan Province	Titanium dioxide production and sale	100.00%	Establish
2	Yunnan Metallurgical Xinli Titanium Co., Ltd.	Kunming City, Yunnan Province	Titanium dioxide production and sale	99.58%	Controlling shareholder
3	LB Sichuan Titanium Industry Co., Ltd. (previously known as Lomon Billions Sichuan Titanium Industry Co., Ltd. and Sichuan Lomon Titanium Industry Co., Ltd.)	Mianzhu City, Sichuan Province	Titanium dioxide production and sale	100.00%	Purchase
4	LB Xiangyang Titanium Industry Co., Ltd. (previously known as Lomon Billions Xiangyang Titanium Industry Co., Ltd.)	Xiangyang City, Hubei Province	Titanium dioxide production and sale	100.00%	Purchase
5	Billions America Corporation	Illinois, United States	Titanium dioxide sale	100.00%	Establish
6	Billions Europe Ltd.	United Kingdom	Chemical product sale	100.00%	Establish
7	Billions (Hong Kong) Co., Ltd.	Hong Kong, China	Chemical product sale	100.00%	Establish
8	Gansu Xingbai Titanium Industry Co., Ltd.	Jinchang City, Gansu Province	Titanium dioxide production and sale	100.00%	Purchase
9	LB Sichuan Mining & Metallurgy Co., Ltd.	Panzhihua City, Sichuan Province	Ilmenite production and sale	100.00%	Controlling shareholder

Source: CCM & LB Group Co., Ltd.

- Production

Table 3.2-2 Capacity and output of titanium dioxide in LB Group, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	630,000	629,900
2020	1,010,000	817,200
2021	1,010,000	902,200

Source: CCM & LB Group Co., Ltd.

The capacity of TiO_2 of LB Group reached 1,010,000 t/a in 2020 and remained the same in 2021, with 650,000 t/a sulfate process TiO_2 and 360,000 t/a chloride process TiO_2. The output saw significant increases in 2019–2021.

Table 3.2-3 Major events of LB Group's production, 2019–2021

Time	Major event
June, 2019	LB Group acquired Yunnan Metallurgical Xinli Titanium Co., Ltd.
Dec., 2019	LB Group acquired 15.66% equity of Guangdong Orient Zirconic Ind Sci & Tech Co., Ltd.

Time	Major event
April, 2020	Lufeng Xinli Titanium Industry Co., Ltd.'s (Lufeng Xinli) 200,000 t/a chloride process TiO_2 project was approved by Chuxiong Ecological Environment Bureau. A 100,000 t/a production line of the project was completed and successfully put into trial production in Q3 2022, and the another 100,000 t/a production line is expected to be completed by the end of 2022.
May, 2020	LB Xiangyang Titanium Industry Co., Ltd. issued the environmental impact report of the 150,000 t/a rutile TiO_2 technological transformation and expansion project. The company plans to increase its TiO_2 capacity from 100,000 t/a to 150,000 t/a through this project.
May, 2020	LB Group signed a technical cooperation contract with Ti-Cons Technology Consulting GmbH to improve its TiO_2 production technology and management. Chloride process TiO_2 capacity in its subsidiary Henan Billions New Material Co., Ltd. will benefit from this and gradually increase its capacity to 100,000 t/a.
Aug. 2021	LB Sichuan Mining & Metallurgy Co., Ltd. planned to build 7 million t/a green and efficient mineral processing project. Upon completion, 1.6 million t/a iron ore concentrate, 400,000 t/a ilmenite and 15,000 t/a sulfur cobalt concentrate processing capacity will be added. The project is expected to be completed in 2024.
Aug. 2021	LB Group announced that its subsidiary Henan Billions New Material Co., Ltd. would expand chloride process TiO_2 by 100,000 t/a. The project will be finished in 2022.
Oct. 2021	LB Group announced that its subsidiary LB Sichuan Mining & Metallurgy Co., Ltd. planned to invest in the construction of 200,000 t/a chloride process TiO_2, and rare metals (vanadium and scandium included) comprehensive recovery demonstration project, which at the same time is supported with 1 million t/a high-salinity wastewater treatment facilities. The project is expected to be completed by 2025.

Source: CCM & LB Group Co., Ltd.

As for the company's development plan in the 14th Five-Year Period (2021–2025), LB Group plans a performance target of annual revenue over RMB50 billion by 2025 from businesses such as titanium dioxide, titanium products, mineral products, and new energy. The company will continue to focus on the TiO_2 business and try to enrich its product portfolio through technological innovation, transformation, and upgrading.

- TiO_2

LB Group has found a way to reduce production cost of chloride process TiO_2 and hence will further expand capacity. It will also acquire some small-sized factories, integrate the original sulfate process TiO_2 into the industry through technological transformation and upgrades, or launch new sulfate process project recycling waste and by-product resources such as carbide slag and sulfur, to further strengthen its influence.

- Raw material

In order to ensure the supply of raw materials for chloride process TiO_2, in 2019, LB Group invested in an innovative upgrade and transformation project in Panzhihua City, which can convert 500,000 tonnes of ilmenite to chloride titanium slag per year. In 2020, the company also considered a titanium slag project in Yunnan to upgrade domestic ilmenite to chloride titanium slag on a large-scale basis. In 2021, LB Group proposed the 7 million t/a green and efficient mineral processing project to ensure the supply of titanium ore.

- Derivatives

LB Group sticks to product diversification. The company will focus on the development of titanium tetrachloride, titanium sponge, and high-end titanium alloy. It also tries to expand to derivative businesses of zirconium, iron, and scandium products. In 2021, its capacity of sponge titanium was 15,000 t/a. In addition, both the 30,000 t/a titanium sponge project (phase I, 15,000 t/a) in Yunnan Province and the 30,000 t/a sponge titanium technology upgrading project in Gansu Province were under equipment installation.

- Industrial chain

LB Group, particularly the Jiaozuo base, has achieved co-production of sulfuric acid, TiO_2, ferrous sulfate, iron oxide black, and scandium oxide. It has built 600,000 t/a sulfuric acid, 100,000 t/a iron pigment, 100,000 t/a scandium oxide, and 600,000 t/a gypsum production lines, which maximizes resources utilization rate and cuts pollution discharge.

Table 3.2-4 Financial figures of LB Group's major businesses, 2019–2021

Category	Sales, USD			YoY change, %			Operating cost, USD			YoY change, %			Gross profit margin			YoY change, percentage point		
	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019
By industry																		
Chemicals and raw material manufacturing	3,081,594,614	1,996,467,105	1,621,242,461	43.95	23.96	8.93	1,777,957,217	1,288,135,318	936,822,991	28.72	38.42	7.05	42.30%	35.48%	42.22%	6.82	-6.74	1.02
By product																		
TiO_2	2,352,201,604	1,580,588,299	1,271,368,703	38.79	25.15	-0.17	1,293,162,267	1,011,789,704	724,023,156	19.2	40.68	0.88	45.02%	35.99%	43.05%	9.03	-7.07	-0.59
Mineral	326536399.9	275,036,662	202,143,597	10.72	9.43	92.62	167,932,590	154,863,563	101,615,665	1.13	11.12	57.06	48.57%	43.69%	49.73%	4.88	-0.86	11.38
Zirconium products	151,249,587	4,008,284	9,586,794	3,419.14	-57.91	-14.03	119,384,881	3,526,200	7,587,731	3,057.5	-53.22	-8.41	21.07%	12.03%	20.85%	9.04	-8.83	-4.86
Sponge titanium and titanium tetrachloride	200,004,870	117,316,732	/	58.99	433.52	/	155,225,499	103,408,185	/	39.99	558.47	/	22.39%	11.86%	/	10.53	-16.73	/
Others	51,602,154	19,517,128	138,143,366	146.58	-69.84	39.95	42,251,980	14,547,666	103,596,438	170.87	-70.18	22.65	18.12%	25.46%	25.01%	-7.34	0.85	10.58
By region																		
Domestic	1,833,884,063	1,075,298,593	916,262,950	59.05	18.14	17.12	1,092,888,562	729,428,522	546,868,004	39.73	34.27	13.35	40.41%	32.17%	40.32%	8.24	-8.15	1.98
Overseas	1,247,710,551	921,168,512	704,979,511	26.32	31.54	-0.14	685,068,654	558,706,796	389,954,987	14.35	44.23	-0.69	45.09%	39.35%	44.69%	5.74	-5.34	0.31

Note: The financial figures of sponge titanium and titanium tetrachloride were included in "Others" in 2019.
Source: CCM & LB Group Co., Ltd.

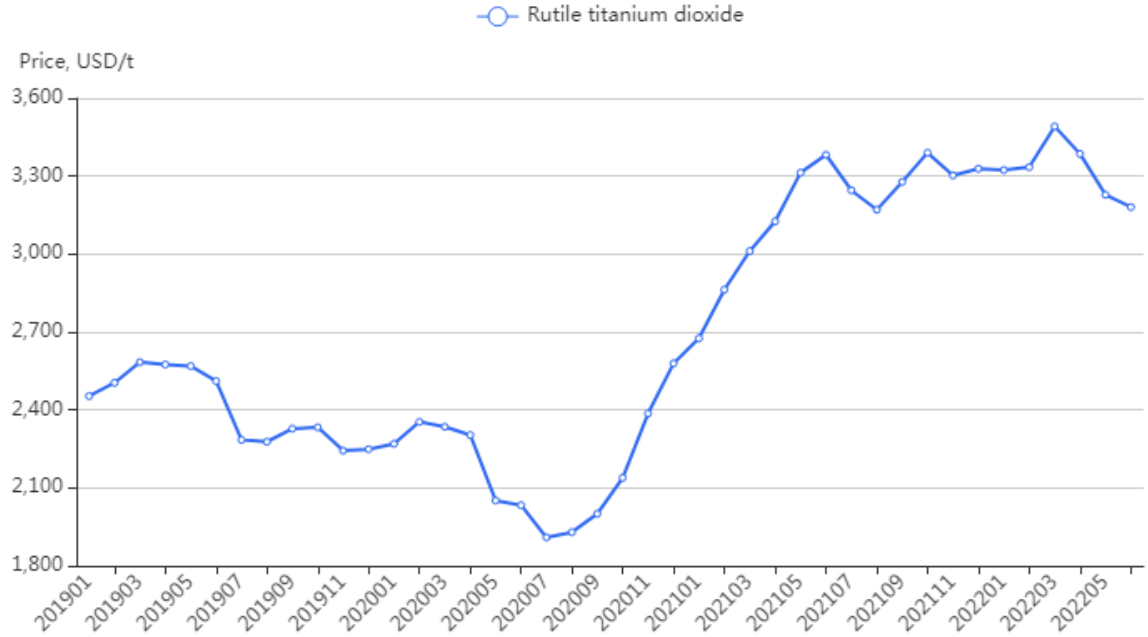
Table 3.2-5 Operating costs of LB Group's titanium dioxide business, 2019–2021

Item	2021		2020		2019	
	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %
Feedstock	815,853,664	63.08	646,220,875	63.87	453,467,494	62.63
Energy	260,760,051	20.16	213,362,899	21.09	135,575,702	18.73
Labor	52,966,962	4.10	46,820,704	4.63	33,611,919	4.64
Depreciation	65,883,543	5.09	65,123,327	6.44	47,762,399	6.60
Freight	39,857,314	3.08	N/A	/	N/A	/
Others	58,012,574	4.49	40,261,899	3.98	53,605,642	7.40
Total	**1,293,334,109**	**100**	**1,011,789,704**	**100**	**724,023,156**	**100**

Source: CCM & LB Group Co., Ltd.

- Price

Figure 3.2-1 Ex-works price of titanium dioxide of LB Group, Jan. 2019–June 2022



Source: CCM

3.3 CNNC Hua Yuan Titanium Dioxide Co., Ltd.

- Company profile

CNNC Hua Yuan Titanium Dioxide Co., Ltd. (CNNC Hua Yuan, 002145) is headquartered in Jiayuguan City, Gansu Province. As the second largest TiO_2 producer in China, it has three TiO_2 production bases: Anhui Gold Star Titanium Dioxide (Group) Co., Ltd., Gansu Hecheng Titanium Dioxide Co., Ltd. and Gansu Dongfang Titanium Dioxide Co., Ltd. In addition, CNNC Hua Yuan takes Jiangsu Province as its purchasing center and Shanghai as a sales center.

Table 3.3-1 Major subsidiaries of CNNC Hua Yuan, 2021

No.	Subsidiary	Business location	Business	Shareholding ratio	Obtain method
1	Wuxi CNNC Hua Yuan Titanium Dioxide Co., Ltd.	Wuxi City, Jiangsu Province	Procurement	100%	Establish
2	Anhui Gold Star Titanium Dioxide (Group) Co., Ltd.	Ma'anshan City, Anhui Province	Manufacturing	100%	Purchase
3	Gansu Dongfang Titanium Dioxide Co., Ltd.	Baiyin City, Gansu Province	Manufacturing	100%	Purchase
4	Gansu Hecheng Titanium Dioxide Co., Ltd.	Jiayuguan City, Gansu Province	Manufacturing	100%	Establish
5	Gold Star Titanium Dioxide (Hong Kong) Co., Ltd.	Hong Kong, China	Trading	100%	Establish
6	Shanghai Sicheng Titanium Dioxide Co., Ltd.	Shanghai Municipality	Sales	100%	Establish
7	Anhui Goldstar Titanium Dioxide Sales Co., Ltd.	Ma'anshan City, Anhui Province	Sales	100%	Establish
8	Guangzhou Tioxhua Co., Ltd.	Guangzhou City, Guangdong Province	Sales	100%	Establish

Source: CCM & CNNC Hua Yuan Titanium Dioxide Co., Ltd.

- Production

Table 3.3-2 Capacity and output of titanium dioxide in CNNC Hua Yuan, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	200,000	255,600
2020	300,000	317,600
2021	300,000	324,200

Source: CCM

The TiO_2 products of CNNC Hua Yuan are all sulfate-processed. In 2020–2021, its capacity of TiO_2 remained at 300,000 t/a, ranked second in China. The output of TiO_2 increased from 255,600 tonnes in 2019 to 324,200 tonnes in 2021, with a CAGR of 12.62%.

Table 3.3-3 Major events of CNNC Hua Yuan's production, 2019–2021

Time	Major event
Aug., 2020	CNNC Hua Yuan signed a cooperation agreement with the People's Government of Baiyin City. CNNC Hua Yuan will build a 500,000 t/a resources comprehensive utilization project with clean production process in Yindong Industrial Park of Baiyin High Tech Zone. Upon completion, it will form 200,000 t/a crude titanium dioxide and 300,000 t/a finished titanium dioxide production capacity.
Oct., 2020	Xinjiang Desheng New Material Technology Co., Ltd. (Xinjiang Desheng), a subsidiary of CNNC Hua Yuan, signed a framework agreement on investment with Xinjiang Hami Municipal People's Government. Xinjiang Desheng will invest in a 2 million t/a high-quality titanium-rich material resources deep processing project, which is divided into three phases, and the first 1 million t/a production lines are scheduled to be finished before 2026. This project will guarantee the company's raw material supply for TiO_2 production.
Jan. 2021	CNNC Hua Yuan announced that Anhui Gold Star Titanium Dioxide (Group) Co., Ltd.'s 200,000 t/a post-processing project (phase II) would be postponed to Dec. 2021. However, in Nov. 2021, CNNC Hua Yuan announced that the project was expected to be completed and put into operation in Dec. 2022.
Feb. 2021	Subsidiary Gansu Dongfang Titanium Dioxide Co., Ltd. planned a 200,000 t/a crude TiO_2 production line and supporting auxiliary project, which will be finished by 2023. At the same time, the subsidiary planned to build 300,000 t/a finished TiO_2 production lines, which is expected to be completed in 2022.

Source: CCM & CNNC Hua Yuan Titanium Dioxide Co., Ltd.

Regarding the future development, CNNC Hua Yuan aims to build two major TiO_2 production bases in Gansu and Anhui provinces. It will integrate the resources of the industry chain, enhance its core competitiveness, and improve the production, sale and R&D capabilities of TiO_2. At the same time, the company will orderly promote the implementation of the 200,000 t/a crude TiO_2 and 300,000 t/a finished TiO_2 projects in Gansu Dongfang Titanium Dioxide Co., Ltd.

Table 3.3-4 Financial figures of CNNC Hua Yuan's major businesses, 2019–2021

Category	Sales, USD			YoY change, %			Operating cost, USD			YoY change, %			Gross profit margin			YoY change, percentage point		
	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019
By industry																		
Fine Chemicals	822,477,071	532,912,942	483,541,882	43.94	10.94	13.17	530,531,269	391,219,426	329,961,499	26.47	19.35	10.74	35.50%	26.59%	31.76%	8.91	-5.17	1.49
By Product																		
TiO_2	822,477,071	532,912,942	483,541,882	43.94	10.94	13.17	530,531,269	391,219,426	329,961,499	26.47	19.35	10.74	35.50%	26.59%	31.76%	8.91	-5.17	1.49
By region																		
Domestic	422,094,009	313,755,798	297,949,491	25.46	6.01	14.55	269,632,969	231,755,878	204,852,774	8.5	13.89	12.32	36.12%	26.13%	31.25%	9.99	-5.12	1.36
Overseas	400,383,062	219,157,144	185,592,392	70.38	18.87	11.02	260,898,299	159,463,548	125,108,726	52.58	28.31	8.25	34.84%	27.24%	32.59%	7.60	-5.35	1.72

Source: CCM & CNNC Hua Yuan Titanium Dioxide Co., Ltd.

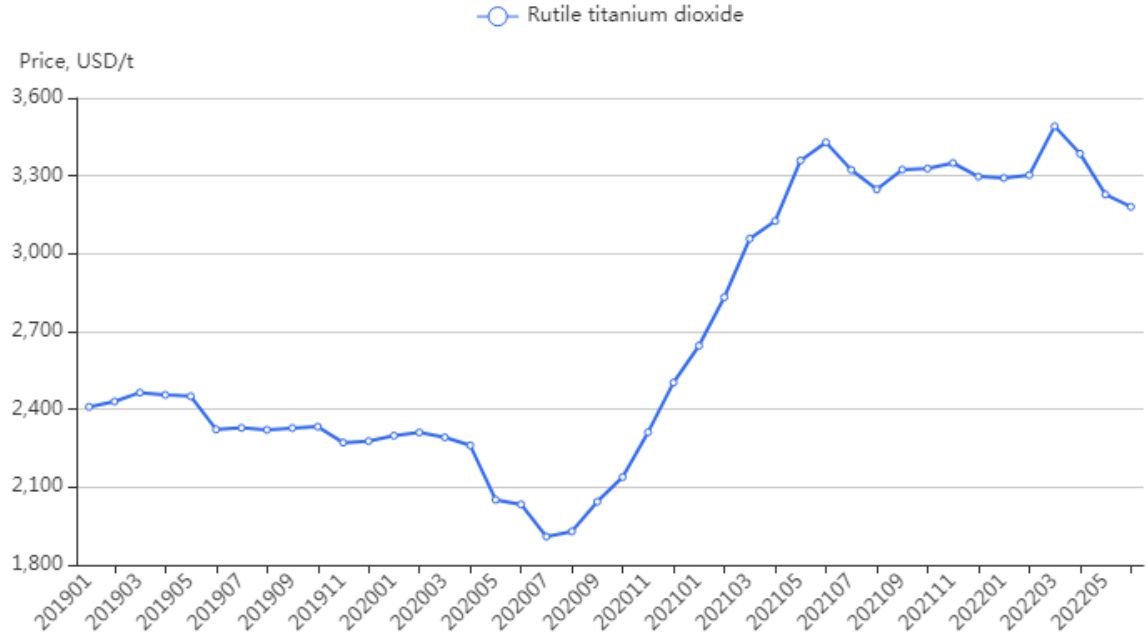
Table 3.3-5 Operating costs of CNNC Hua Yuan's TiO_2 business, 2019–2021

Item	2021		2020		2019	
	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %
Feedstock	360,649,431	67.98	243,472,335	62.23	207,671,779	62.94
Energy	80,782,423	15.23	69,603,026	17.79	62,019,203	18.80
Labor	12,284,511	2.32	10,318,964	2.64	9,694,418	2.94
Manufacturing, depreciation and others	76,814,904	14.48	67,825,101	17.34	50,576,099	15.33
Total	**530,531,269**	**100**	**391,219,426**	**100**	**329,961,499**	**100**

Source: CCM & CNNC Hua Yuan Titanium Dioxide Co., Ltd.

- Price

Figure 3.3-1 Ex-works price of titanium dioxide of CNNC Hua Yuan, Jan. 2019–June 2022



Source: CCM

3.4 Pangang Group Vanadium & Titanium Resources Co., Ltd.

- Company profile

Pangang Group Vanadium & Titanium Resources Co., Ltd. (Pangang Group, 000629) was established in 1993 and headquarters in Panzhihua City, Sichuan Province. Its main businesses cover vanadium, titanium and electricity. Specifically, it is the biggest producer of vanadium products and a top five TiO_2 producer by production scale in China. Vanadium and titanium are Pangang Group's focuses for further development.

Table 3.4-1 Subsidiaries of Pangang Group, 2021

No.	Subsidiary	Business location	Business	Shareholding ratio	Obtain method
1	Pangang Group Titanium Industry Co., Ltd.	Panzhihua City, Sichuan Province	Titanium products production	100%	Establish
2	Pangang Group Chongqing Titanium Industry Co., Ltd.	Chongqing Municipality	Titanium dioxide production	100%	Establish
3	Panzhihua Dongfang Titanium Industry Co., Ltd.	Panzhihua City, Sichuan Province	Titanium dioxide production and sale	65%	Purchase
4	Panzhihua Guotai Science & Technology Co., Ltd.	Panzhihua City, Sichuan Province	Titanium slag production	51%	Purchase
5	Pangang Group Beihai Special Ferroalloy Co., Ltd.	Beihai City, Guangxi Zhuang Autonomous Region	Steel processing	100%	Establish
6	Pangang Group Chongqing Vanadium Titanium Science & Technology Co., Ltd.	Chongqing Municipality	Trading	100%	Establish
7	Pangang Group Chengdu Vanadium Titanium Resource Development Co., Ltd.	Chengdu City, Sichuan Province	Trading	100%	Establish
8	Pangang Group Xichang Vanadium Products Technology Co., Ltd.	Liangshan Yi Autonomous Prefecture, Sichuan Province	Vanadium products production	100%	Acquisition

Source: CCM & Pangang Group Vanadium & Titanium Resources Co., Ltd.

- Production

Table 3.4-2 Capacity and output of titanium dioxide in Pangang Group, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	235,000	233,900
2020	235,000	235,500
2021	235,000	224,400

Source: CCM

As China's third largest producer of TiO_2 (by output), Pangang Group is one of the few companies in China that can produce TiO_2 through both sulfate and chloride processes. In 2019–2021, Pangang Group's TiO_2 production capacity maintained at the same level, with 220,000 t/a sulfate process TiO_2 and 15,000 t/a chloride process TiO_2 capacity. Its output fluctuated slightly in this period.

Table 3.4-3 Major events of Pangang Group's production, 2019–2021

Time	Major event
May, 2019	Pangang Group signed a cooperation agreement with Sichuan Desheng Group Vanadium & Titanium Co., Ltd. The two sides have established a strategic partnership in the sale of vanadium products.
Nov. 2020	Pangang Group signed a cooperation agreement with Western Metal Materials Co., Ltd. In 2021, the two formed a strategic partnership in production, marketing, research and service to promote the sharing of cooperation results of special purpose small-grain titanium, ultra-soft titanium and titanium materials.
Oct. 2021	Pangang Group acquired 100% shares of Pangang Group Xichang Vanadium Products Technology Co., Ltd.

Source: CCM & Pangang Group Vanadium & Titanium Resources Co., Ltd.

Table 3.4-4 Financial figures of Pangang Group's major businesses, 2019–2021

Category	Sales, USD			YoY change, %			Operating cost, USD			YoY change, %			Gross profit margin			YoY change, percentage point		
	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019
By industry																		
Vanadium products	698,785,738	544,335,666	905,519,262	21.02	-39.49	-23.64	485,679,969	465,674,964	657,406,182	6.25	-28.69	-11.71	30.50%	14.45%	27.40%	9.66	-12.95	-9.81
Titanium products	1,051,614,396	612,152,796	632,692,776	60.21	-2.60	2.18	865,072,451	543,622,120	540,331,077	44.01	1.28	11.13	17.74%	11.20%	14.60%	9.26	-3.40	-6.88
Electricity	291,825,684	276,654,566	268,326,937	-1.62	3.79	-6.85	258,758,533	250,218,815	237,196,334	-3.56	6.19	-9.06	11.33%	9.56%	11.60%	1.77	-2.04	2.14
By product																		
Vanadium products	698,785,738	544,335,666	905,519,262	21.02	-39.49	-23.64	485,679,969	465,674,964	657,406,182	6.25	-28.69	-11.71	30.50%	14.45%	27.40%	9.66	-12.95	-9.81
Titanium slag	171,174,267	109,221,756	90,486,441	46.16	21.51	4.73	142,584,246	92,731,270	80,458,840	42.66	16.02	/	16.70%	15.10%	11.08%	2.04	4.02	/
TiO_2	630,321,493	392,587,648	442,686,995	49.74	-10.73	1.81	479,918,017	352,683,286	372,296,911	24.09	-4.64	14.62	23.86%	10.16%	15.00%	15.74	-5.74	-9.40
Electricity	291,825,684	276,654,566	268,326,937	-1.62	3.79	-6.85	258,758,533	250,218,815	237,196,334	-3.56	6.19	-9.06	11.33%	9.56%	11.60%	1.77	-2.04	2.14
By region																		
Domestic	1,827,785,188	1,403,956,222	1,676,700,953	27.87	-15.71	-13.02	1,459,884,881	1,237,835,387	1,328,373,419	18.02	-6.20	-2.26	20.13%	11.83%	20.77%	6.67	-8.94	-8.72
Overseas (including Hong Kong, Macao and Taiwan Province)	348,222,520	122,934,807	235,173,880	72.72	-47.38	-14.56	282,634,601	111,379,776	205,617,238	51.21	-45.47	-13.46	18.84%	9.40%	12.57%	11.54	-3.17	-1.11

Source: CCM & Pangang Group Vanadium & Titanium Resources Co., Ltd.

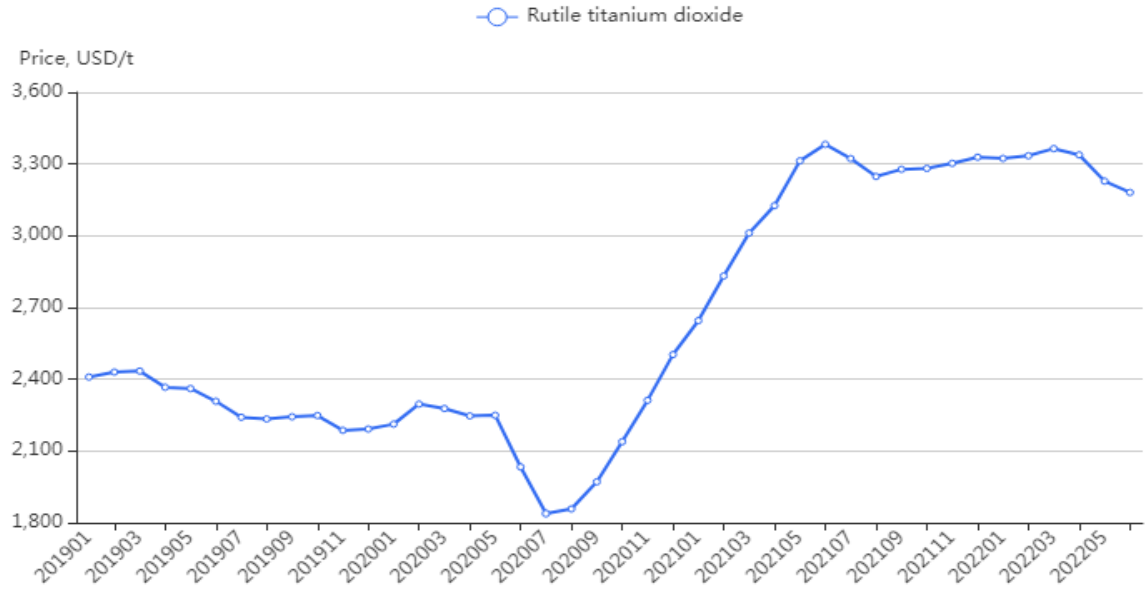
Table 3.4-5 Operating costs of Pangang Group's titanium dioxide business, 2019–2021

Item	2021		2020		2019	
	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %
Raw materials and energy	388,002,645	80.85	291,317,817	82.60	306,780,278	82.40
Others	91,915,372	19.15	61,365,469	17.40	65,516,634	17.60
Total	**479,918,017**	**100**	**352,683,286**	**100**	**372,296,911**	**100**

Source: CCM & Pangang Group Vanadium & Titanium Resources Co., Ltd.

- Price

Figure 3.4-1 Ex-works price of titanium dioxide of Pangang Group, Jan. 2019–June 2022



Source: CCM

3.5 Shandong Doguide Group Co., Ltd.

- Company profile

Established in 2002, Shandong Doguide Group Co., Ltd. (Shandong Doguide) has a registered capital of RMB100 million. Headquartered in Zibo City, Shandong Province, Shandong Doguide is mainly dedicated to the production and sale of titanium dioxide, sulfuric acid, purifying agent, etc. And it is one of the large-scale sulfate process TiO_2 producers in China.

Table 3.5-1 Major subsidiaries of Shandong Doguide in titanium dioxide business, 2021

No.	Subsidiary	Business location	Business	Shareholding ratio	Obtain method
1	Shandong Jinhong Titanium Dioxide Chemicals Co., Ltd.	Zibo City, Shandong Province	Titanium dioxide production	58.50%	Controlling shareholder
2	Shandong Suntiox Industrial Co., Ltd.	Zibo City, Shandong Province	Chemical fiber grade titanium dioxide production	58.00%	Purchase

Source: CCM

- Production

Table 3.5-2 Capacity and output of titanium dioxide in Shandong Doguide, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	220,000	168,000
2020	220,000	170,000
2021	220,000	189,100

Source: CCM

3.6 GPRO Investment Holding Group Co., Ltd.

- Company profile

Headquartered in Nanjing City, Jiangsu Province, GPRO Investment Holding Group Co., Ltd. (GPRO Group)'s main businesses cover manufacturing, real estate, financial, tourism, and food industries.

GPRO Titanium Industry Co., Ltd. (GPRO Titanium, 000545), a holding subsidiary of GPRO Group, is a listed company. It is a large-scale sulfate process TiO_2 producer in China, with rutile TiO_2 and anatase TiO_2 as main products. Its TiO_2 production bases are Nanjing Titanium Dioxide Chemical Co., Ltd. (Nanjing Titanium) and Xuzhou Titanium Dioxide Chemical Co., Ltd. (Xuzhou Titanium). Specifically, Nanjing Titanium produces rutile TiO_2 and Xuzhou Titanium produces both rutile and anatase TiO_2.

Jiangsu Taibai Group Co., Ltd. (Jiangsu Taibai), another subsidiary of GPRO Group, is also a main domestic TiO_2 manufacturer. It produces both rutile and anatase TiO_2, with rutile TiO_2 accounting for about 90%. In March 2020, 100% equity of Jiangsu Taibai was transferred to GPRO Group.

Table 3.6-1 Main subsidiaries of GPRO Group, 2021

No.	Subsidiary	Business location	Business
1	GPRO Titanium Industry Co., Ltd.	Jilin City, Jilin Province	Manufacturing and trading
2	Nanjing Titanium Dioxide Chemical Co., Ltd.	Nanjing City, Jiangsu Province	Manufacturing
3	Xuzhou Titanium Dioxide Chemical Co., Ltd.	Xuzhou City, Jiangsu Province	Manufacturing
4	Nanjing Titanium Industry International Co., Ltd.	Nanjing City, Jiangsu Province	Trading
5	Nanjing GPRO Supply Chain Management Co., Ltd.	Nanjing City, Jiangsu Province	Service
6	Nanjing GPRO Commercial Factoring Co., Ltd.	Nanjing City, Jiangsu Province	Commercial factoring
7	GPRO (USA) Development Co., Ltd.	United States	Trading
8	Jiangsu Taibai Group Co., Ltd.	Zhenjiang City, Jiangsu Province	Manufacturing and trading
9	Jiangsu Zhentai Chemical Co., Ltd.	Zhenjiang City, Jiangsu Province	Manufacturing and trading

Source: CCM & GPRO Investment Holding Group Co., Ltd.

- Production

Table 3.6-2 Capacity and output of titanium dioxide in GPRO Group, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	180,000	145,200
2020	260,000	187,600
2021	260,000	204,000

Note: The capacity and output of Jiangsu Taibai are consolidated into GPRO Group since 2020.
Source: CCM

Table 3.6-3 Major events of GPRO Group's production, 2019–2021

Time	Major event
July 2019	GPRO Titanium's plan to acquire Zhejiang Guxiandao New Materials Co., Ltd., a leader in China's polyester filament industry, was rejected by the China Securities Regulatory Commission.
Jan. 2020	Nanjing Titanium Dioxide Chemical Co., Ltd. (Nanjing Titanium Dioxide), a subsidiary of GPRO Titanium, and Nippon Paint (China) Holdings Co., Ltd. signed a cooperation agreement on the supply and application of titanium dioxide.
March 2020	GPRO Group announced to acquire 100% shares of Jiangsu Taibai Group Co., Ltd. (Jiangsu Taibai), and would promote GPRO Titanium to acquire Jiangsu Taibai within 36 months after Jiangsu Taibai completed the industrial and commercial change registration.
March 2021	Nanjing Titanium Dioxide signed a cooperation agreement with Jiangsu Jiuwu Hi-Tech Co., Ltd. The latter would help dispose of titanium gypsum solid wastes for Nanjing Titanium Dioxide.

Source: CCM & GPRO Investment Holding Group Co., Ltd.

- GPRO Titanium

Table 3.6-4 Financial figures of GPRO Titanium's major businesses, 2019–2021

Category	Sales, USD			YoY change, %			Operating cost, USD			YoY change, %			Gross profit margin			YoY change, percentage point		
	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019
By business																		
TiO_2	390,587,727	251,569,343	263,715,313	44.80	-3.97	0.59	316,793,124	236,923,636	223,436,538	24.70	6.74	3.55	18.89%	5.82%	15.27%	13.07	-9.45	-2.43
Supply chain	7,016,023	5,884,361	3,955,022	11.20	49.77	101.14	N/A	N/A	3,328,362	/	/	102.06	N/A	N/A	15.84%	/	/	-0.38
Commercial factoring	7,894,909	7,267,362	6,190,929	1.31	18.17	16.40	0	0	0	0	0	0	100.00%	100.00%	100.00%	0	0	0
By product																		
Rutile TiO_2	307,953,749	200,436,186	208,619,044	43.29	-4.41	3.04	250,520,109	187,656,037	173,995,891	24.50	8.57	5.05	18.65%	6.38%	16.60%	12.27	-10.22	-1.59
Anatase TiO_2	70,879,574	49,137,003	52,602,700	34.53	-5.97	0.98	56,235,247	47,700,362	47,190,304	9.95	1.75	8.29	20.66%	2.92%	10.29%	17.74	-7.37	-6.05
Commercial factoring	7,894,909	7,267,362	6,190,929	1.31	18.17	16.40	0	0	0	0.00	0.00	0.00	100.00%	100.00%	100.00%	0	0	0
Others	18,770,427	7,880,514	6,448,590	122.14	23.02	-32.76	N/A	N/A	5,578,706	/	/	-31.98	N/A	N/A	13.49%	/	/	-0.99
By region																		
Domestic	310,586,480	209,375,432	233,449,504	38.38	-9.72	-1.90	245,301,965	190,224,451	193,025,896	20.26	-0.80	0.65	21.02%	9.12%	17.32%	11.90	-8.20	-2.09
Overseas	94,912,180	55,345,634	40,411,761	59.78	37.87	28.28	77,172,409	51,920,692	33,739,005	38.62	54.91	31.57	18.69%	6.28%	16.51%	12.41	-10.23	-2.10

Source: CCM & GPRO Titanium Industry Co., Ltd.

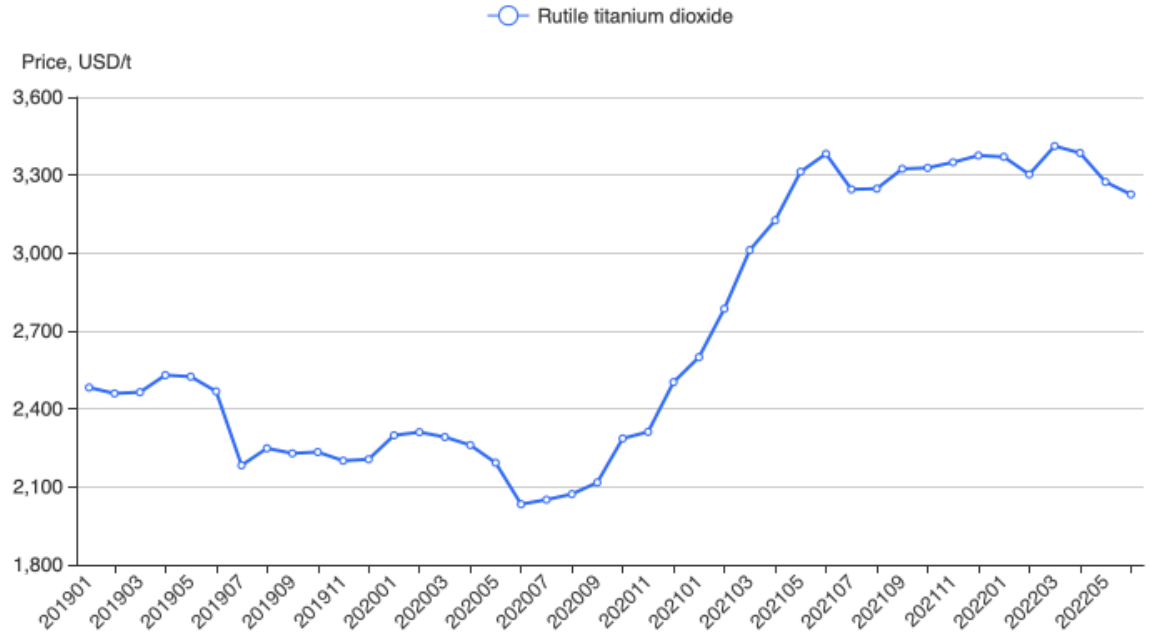
Table 3.6-5 Operating costs of GPRO Titanium's titanium dioxide business, 2019–2021

Item	2021		2020		2019	
	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %
Feedstock	193,598,717	63.11	130,823,170	55.59	131,671,578	58.94
Energy	64,639,588	21.07	59,823,241	25.42	55,094,320	24.66
Labor	16,042,902	5.23	13,031,852	5.54	12,342,463	5.52
Depreciation	13,594,038	4.43	16,098,185	6.84	12,355,121	5.53
Others	18,880,110	6.15	15,579,952	6.62	11,934,680	5.34
Total	**306,755,356**	**100**	**235,356,399**	**100**	**223,398,163**	**100**

Note: Due to rounding, the total may not equal 100.00%
Source: CCM & GPRO Titanium Industry Co., Ltd.

- Price

Figure 3.6-1 Ex-works price of titanium dioxide of GPRO Titanium, Jan. 2019–June 2022



Source: CCM

3.7 Anhui Annada Titanium Industry Co., Ltd.

- Company profile

Anhui Annada Titanium Industry Co., Ltd. (Anhui Annada, 002136), headquartered in Tongling City, Anhui Province, is also one of the large-scale sulfate process TiO_2 producers in China. Anhui Annada itself is mainly involved in the production and sale of TiO_2 and its subsidiary specializes in iron phosphate business.

Table 3.7-1 Subsidiary of Anhui Annada, 2021

Subsidiary	Business location	Business	Shareholding ratio	Obtain method
Tongling Nayuan Material Science and Technology Co., Ltd.	Tongling City, Anhui Province	Production and sale of iron phosphate products	66.64%	Establish

Source: CCM & Anhui Annada Titanium Industry Co., Ltd.

- Production

Table 3.7-2 Capacity and output of titanium dioxide in Anhui Annada, 2019–2021

Time	Capacity, t/a	Output, tonne
2019	80,000	77,300
2020	80,000	85,300
2021	80,000	84,300

Source: CCM

TiO_2 products of Anhui Annada are all sulfate-processed. In 2019–2021, TiO_2 capacity of Anhui Annada maintained at 80,000 t/a, with about 20,000 t/a of anatase TiO_2 and 60,000 t/a of rutile TiO_2. Output of its TiO_2 fluctuated in this period and it decreased slightly to 84,300 tonnes in 2021.

Table 3.7-3 Major events of Anhui Annada's production, 2019–2021

Time	Major event
Sept. 2019	Anhui Annada announced that Anhui Chuang'gu New Materials Co., Ltd. and Tongling Chemical Industry Group Co., Ltd. signed a capital increase agreement. At the same time, Anhui Annada's controlling shareholder was still Tongling Chemical Industry Group Co., Ltd.
Dec. 2020	Anhui Ananda issued the EI report of the 50,000 t/a of rutile TiO_2 for plastics and inks upgrading project. The project is expected to be completed in 2024.

Source: CCM

Table 3.7-4 Financial figures of Anhui Annada's major businesses, 2019–2021

Category	Sales, USD			YoY change, %			Operating cost, USD			YoY change, %			Gross profit margin			YoY change, percentage point		
	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019	2021	2020	2019
By industry																		
Chemicals and raw material manufacturing	313,947,261	160,489,760	149,785,289	82.44	7.86	0.07	263,350,492	141,159,542	129,646,461	73.99	6.34	2.33	16.12%	N/A	13.45%	4.07	/	-1.90
By product																		
TiO_2	249,905,936	141,790,182	138,277,831	64.37	3.22	-3.20	213,238,183	125,834,100	120,120,401	58.04	6.34	-0.73	14.54%	N/A	13.13%	3.43	/	-2.16
Iron phosphate	64,041,324	18,699,578	11,507,458	219.40	63.58	68.45	50,942,400	15,478,409	9,526,060	206.94	63.57	67.42	22.26%	N/A	17.22%	3.15	/	0.51
By region																		
Domestic	254,256,773	126,454,046	119,769,994	88.15	6.28	6.38	213,526,974	111,125,860	103,905,092	79.20	7.66	8.66	16.20%	N/A	13.25%	4.18	/	-1.82
Overseas	59,690,488	34,461,494	30,015,295	61.54	15.58	-19.07	50,280,447	30,270,533	25,741,369	54.91	18.38	-17.16	15.76%	N/A	14.24%	3.60	/	-1.97

Note: The financial figures were applicable to industries, products or regions where the company's operating income or operating profit is more than 10%.
Source: CCM & Anhui Annada Titanium Industry Co., Ltd.

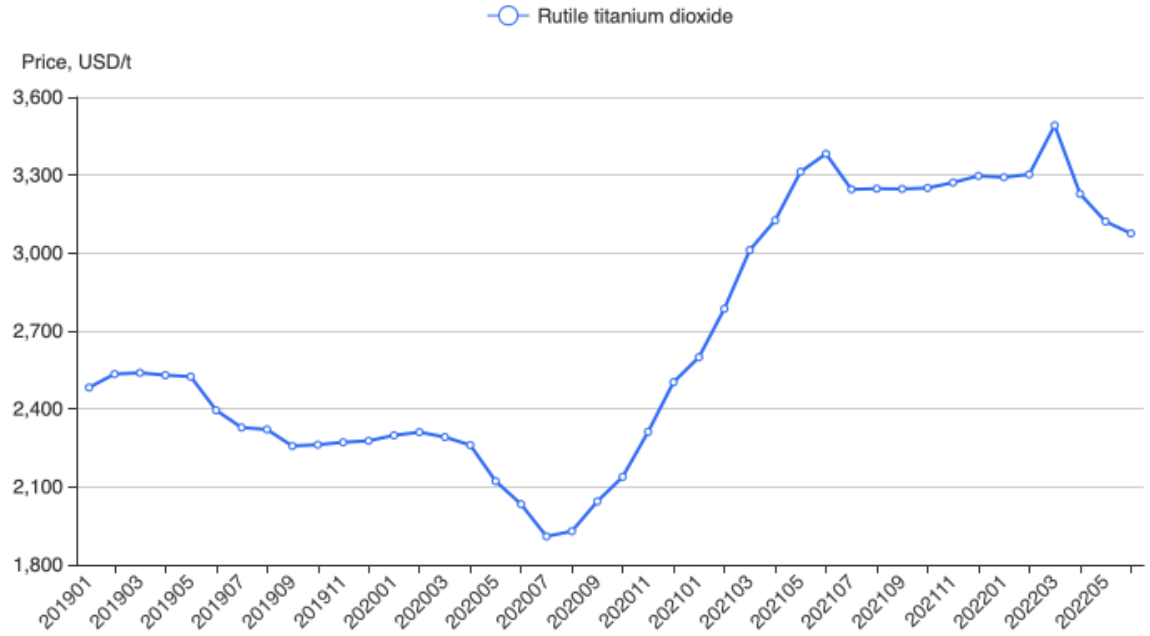
Table 3.7-5 Operating costs of Anhui Annada's chemicals and raw material manufacturing business, 2019–2021

Item	2021		2020		2019	
	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %	Value, USD	Proportion to total operating cost, %
Raw material, fuel and energy	219,554,075	83.37	106,765,151	75.64	95,142,549	73.39
Manufacturing	27,322,245	10.37	21,577,239	15.29	21,760,833	16.78
Labor	9,448,276	3.59	6,489,865	4.60	6,353,498	4.90
Depreciation	7,025,895	2.67	6,324,770	4.48	6,389,581	4.93
Total	**263,350,492**	**100**	**141,157,025**	**100**	**129,646,461**	**100**

Source: CCM & Anhui Annada Titanium Industry Co., Ltd.

- Price

Figure 3.7-1 Ex-works price of titanium dioxide of Anhui Annada, Jan. 2019–June 2022



Source: CCM

4 Highlighted cases

4.1 Enterprise dynamics during 2019–2021

After the sluggish market in 2012–2015, prices of China's main titanium products including titanium ore, titanium slag, titanium sponge and TiO_2 began to rise from the bottom in 2016 and reached a relatively high level in 2017; after that they generally fell at different rates and came to a lower level in 2019. Meanwhile, output of these titanium products generally showed an upward trend. It is fair to say that China's titanium industry had come to a phase where the increasing demand could be satisfied at lower costs. As the market turned better but competition became fiercer year by year, investment in the titanium industry grew heavier. Some projects shelved due to previous market downturn started construction again at the end of 2016. What's more, there came a new wave of listing plans and M&A activities in the industry.

Domestic enterprises made restructuring and asset acquisitions mainly through the following three ways these years:

- Big enterprises acquire small ones to expand their production scale.
- Merge with another company of similar size to meet the requirements of the industry policy.
- Some enterprises acquire listed titanium dioxide companies, in order to help themselves get listed in the stock exchange.

Here is the dynamics of some enterprises which attracted much attention during 2019–2021.

Table 4.1-1 Events of titanium dioxide producers in China, 2019–2021

Time	Event	Status	Note
27 May, 2019	LB Group Co., Ltd. acquired Yunnan Metallurgical Xinli Titanium Industry Co., Ltd.	Finished	By the end of 2019, LB Group Co., Ltd. has acquired 98.39% shares of Yunnan Metallurgical Xinli Titanium Industry Co., Ltd., whose 60,000 t/a chloride process TiO_2 capacity was just back to production in Dec. 2019 after years of suspension.
16 Nov., 2019	Shandong Lubei Chemical Co., Ltd. announced to acquire 100% shares of both Shandong Jinhai Titanium Resources Technology Co., Ltd. and Shandong Xianghai Titanium Resources Technology Co., Ltd.	Finished	Shandong Jinhai Titanium Resources Technology Co., Ltd. had 200,000 t/a TiO_2 capacity in 2021. Besides, Shandong Xianghai Titanium Resources Technology Co., Ltd.'s 60,000 t/a chloride process TiO_2 line was put into production in April 2022.
21 March, 2020	GPRO Investment Holding Group Co., Ltd., controlling shareholder of GPRO Titanium Industry Co., Ltd., announced to acquire 100% shares of Jiangsu Taibai Group Co., Ltd.	Finished	There is horizontal competition between GPRO Titanium Industry Co., Ltd. and Jiangsu Taibai Group Co., Ltd. after the acquisition. GPRO Investment Holding Group Co., Ltd. has promised to fix that in 36 months.

Note: Events above mainly focus on stock exchange information.
Source: CCM

In addition to horizontal mergers and acquisitions, TiO_2 enterprises also make full use of the surrounding environment and create conditions for co-production to reduce wastes and achieve resources recycling. For example, LB Group, CNNC Hua Yuan and Anhui Annada have entered lithium battery industry; Guangdong Huiyun Titanium Industry Co., Ltd. has built a "sulfur—titanium—iron—calcium" industry chain.

4.2 Policy and legislation

Environmental protection is a basic national policy in China and it is playing an increasingly important role in Chinese industries. The establishment of the Ministry of Environmental Protection in 2008 demonstrated China's determination to reduce pollution and achieve sustainable development.

In 2018, the State Council reformed its subordinate institutions. The Ministry of Environmental Protection was revoked and replaced by the Ministry of Ecology and Environment (MEE), whose main responsibilities are to formulate and implement eco-environmental policies, plans and standards, to take the charge of ecological environment monitoring and law enforcement, to supervise and manage pollution prevention and treatment activities, as well as to organize the environmental protection inspection. The establishment of the MEE highlights the Chinese government's commitment to environmental protection.

Recent years, with increasing attentions being paid to environmental protection by government departments, the

TiO_2 industry in China faced with unprecedented pressure as an industry of high pollution, high energy consumption, and high water consumption. During this period, the most influential actions upon China's TiO_2 industry were the central environmental protection inspections starting from Dec. 2015.

Central inspection teams were formed under the leadership of the Ministry of Environmental Protection in Jan. 2016. These teams were scheduled to head altogether to 31 provinces/municipalities/autonomous regions through several batches. The inspection work had not a day off; local environmental protection authorities were also required to conduct appropriate inspections and supervise rectification work before and after the inspections by the central government. Such inspections are unprecedented in terms of both time spent and regions covered. Major TiO_2 production bases were all affected for quite a time. The majority of TiO_2 manufacturers had to suspend or cut production given the stricter requirements and meticulous inspection.

After the first round of central inspection, on 29 March, 2018, the spokesperson of MEE stated that the Ministry planned to carry out the second round during 2018–2021. It aims to establish a dual-inspection system with central government and provincial governmental complementing each other to improve the long-term mechanism for environmental protection.

In addition, before the official announcement of a planned second round, the first round was still ongoing in certain regions, teams of central inspection launched environmental protection reviews now and then to check the implementation of the rectification plans. At the same time, environmental protection actions against severe air pollution were conducted in Beijing-Tianjin-Hebei Region.

Major impacts of the environmental protection inspections upon domestic TiO_2 industry are:

First, environmental protection cost grows ever higher. Since 2016, environmental protection policies have become stricter in China. Once deemed unqualified, those companies would suffer environmental protection penalties, production suspension for rectification, which involuntarily drives up the cost of pollution treatment. Currently, most domestic TiO_2 production goes through sulfate process and the waste water treatment cost accounts for more than 10% of the production cost.

Second, the living space of small- and medium-sized producers has been narrowed. According to laws and regulations, environmental protection facilities must be designed, constructed and put into operation simultaneously with the production lines. For sulfate process TiO_2 production, however, requirements for resources utilization and environmental protection facilities are higher than those in chloride process TiO_2 production, because of extra treatment of by-products. Therefore, the sulfate process TiO_2 producers face greater pressure on environmental protection investment and operation. Particularly, small- and medium-sized producers have greater risks of being eliminated due to their weaknesses in capital and technology.

In order to effectively utilize titanium resources, reduce pollution and energy consumption, regulate market order and upgrade the industry, a series of policies has been put forward to regulate China's titanium dioxide industry. These policies point out four orientations in future regulatory work:
- Firstly, restrain expansion of currently dominant sulfate process technology.
- Secondly, encourage the development of chloride process.
- Thirdly, push TiO_2 producers to improve environmental protection technology.
- Fourthly, promote industry integration.

Table 4.2-1 Relevant policies & legislations on Chinese titanium dioxide industry, 2012–2021

Issue time	Document	Issued by	Content
July 2012	*12th Five-Year Plan for Comprehensive Utilization of Vanadium & Titanium Resources*	NDRC	Weed out backward TiO_2 production lines in 2015, including: the sulfate process production line with capacity less than 20,000 t/a; the chloride process production line with capacity less than 15,000 t/a.
April 2016	*Draft of Negative List for Market Access (pilot version)*	NDRC	Forbid the construction of new TiO_2 projects with the sulfate process. The pilot areas were Tianjin, Shanghai, Fujian and Guangdong provincial level administration regions. Full coverage across China was officially implemented in Dec. 2018.
Jan. 2017	*Notice of the Ministry of Finance and the State Administration of Taxation on Comprehensively Promoting the Reform of Resource Tax*	SAT	Reduce resource tax on eligible cut-and-fill mining and mines at the stage of exhaustion. Encourage the exploitation of low-grade minerals and waste slag.
Oct. 2019	*Guidance Catalogue for Industrial Structure Adjustment (2019 version)*	NDRC	New capacity of sulfate process TiO_2 is listed in the Restricted Catalogue, while chloride process project with a capacity of over 30,000 t/a (included) per production line is listed in the Encouraged Catalogue.
Dec. 2020	*Catalogue of Prohibited Commodities in Processing Trade*	MOFCOM and GACC	TiO_2 was removed from the Catalogue from 1 Dec., 2020.
March 2021	*Guiding Opinions on the Comprehensive Utilization of Bulk Solid Wastes in the 14th Five-Year Plan (2021–2025)*	NDRC	To scale up high-value utilization of industrial by-product gypsum. To explore ways to recycle industrial by-product gypsum such as titanium gypsum and fluorgypsum.
Nov. 2021	*14th Five-Year Plan for Green Industrial Development*	MIIT	To promote large-scale comprehensive utilization of industrial solid wastes. To promote efficient and collaborative utilization of natural resources, and strengthen the development of coexisting and associated mineral resources such as vanadium and titanium resources in vana-titano magnetite ores.

Source: Above-mentioned issuing departments & CCM

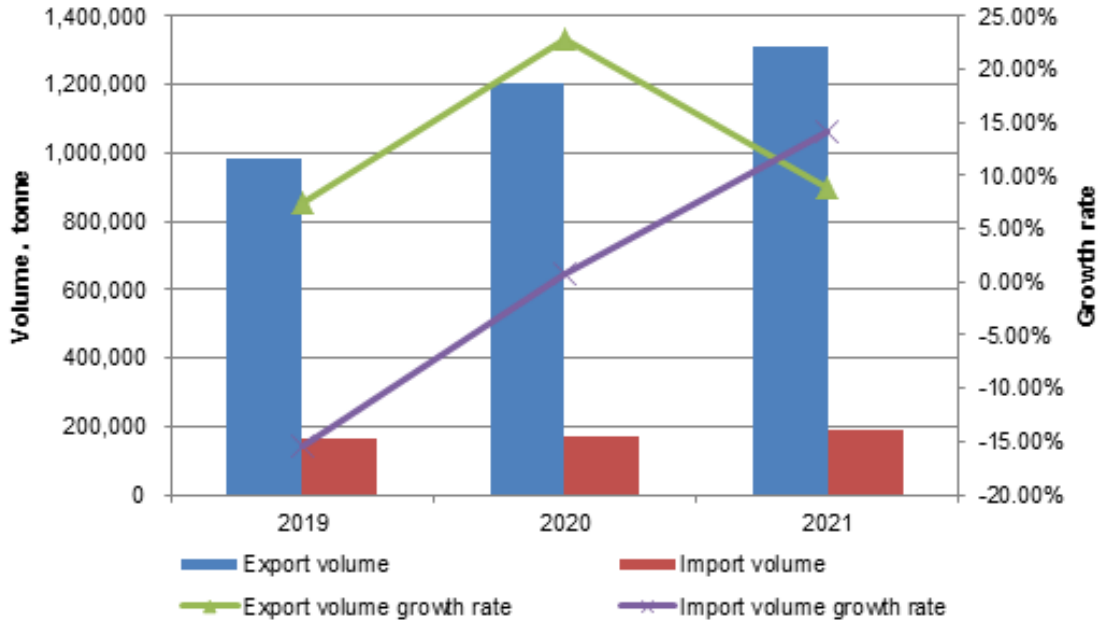
5 Import and export analysis

5.1 Overview 2019–2021

The export volume of TiO_2 from China continued to reach a new high in 2019–2021, along with improvement of product quality and contraction of TiO_2 production capacity overseas. With TiO_2 export exceeding 1,300,000 tonnes in 2021, China has been playing an increasingly important role in the international TiO_2 market.

In contrast, China's annual TiO_2 import has kept below 200,000 tonnes in this period. Although China's TiO_2 production technology has been improved and the quality elevated, China still has to rely on high-end TiO_2 import to meet domestic demand. During these three years, annual import of high-end TiO_2 to China stayed above 150,000 tonnes.

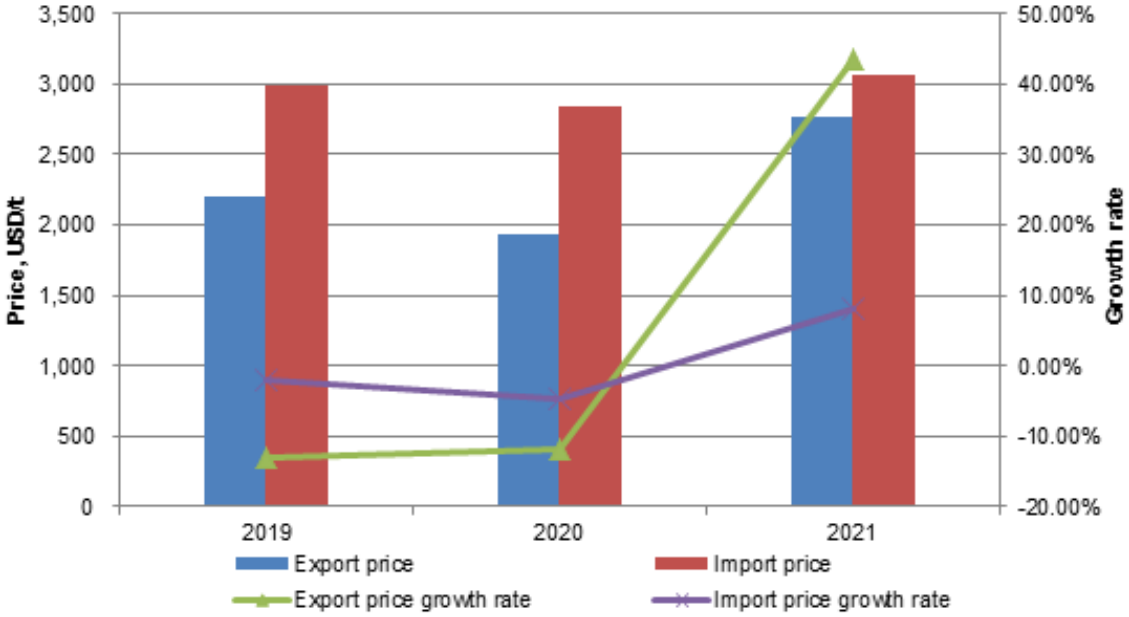
Figure 5.1-1 China's import and export volume of titanium dioxide, 2019–2021



Source: CCM & China Customs

With regard to the TiO_2 import and export prices, the price gap between imported and exported TiO_2 was significant and even broadened in 2019–2020, indicating that the majority of export products from China were just mid- to low-end ones. However, in 2021, the price gap narrowed significantly, mainly due to the increases in overseas demand and freight costs.

Figure 5.1-2 China's import and export prices of titanium dioxide, 2019–2021



Source: CCM & China Customs

5.2 Import analysis 2019–2021

The import volume of TiO_2 to China picked up from 167,091 tonnes in 2019 to 191,914 tonnes in 2021. The annual average import price went down to USD2,986/t in 2019 and further down to USD2,844/t in 2020, but recovered to USD3,072/t in 2021.

In 2019–2021, dependency on TiO_2 imports in China was 5.26%, 4.78%, 5.04%, respectively; the dependency ratio kept at a low level mainly came from the following factors:

Breakthrough of domestic chloride process technology
At present, four domestic producers have mastered the chloride process technology. In 2021, the capacity and output of chloride process TiO_2 in China reached 535,000 t/a and 376,000 tonnes, respectively. The output of chloride process TiO_2 accounted for 9.88% of the national total, an increase of 3.32 percentage points from 6.56% in 2019.

Released capacity and increasing output in China
Domestic output increased from 3,175,000 tonnes in 2019 to 3,806,600 tonnes in 2021, at a CAGR of 9.50%.

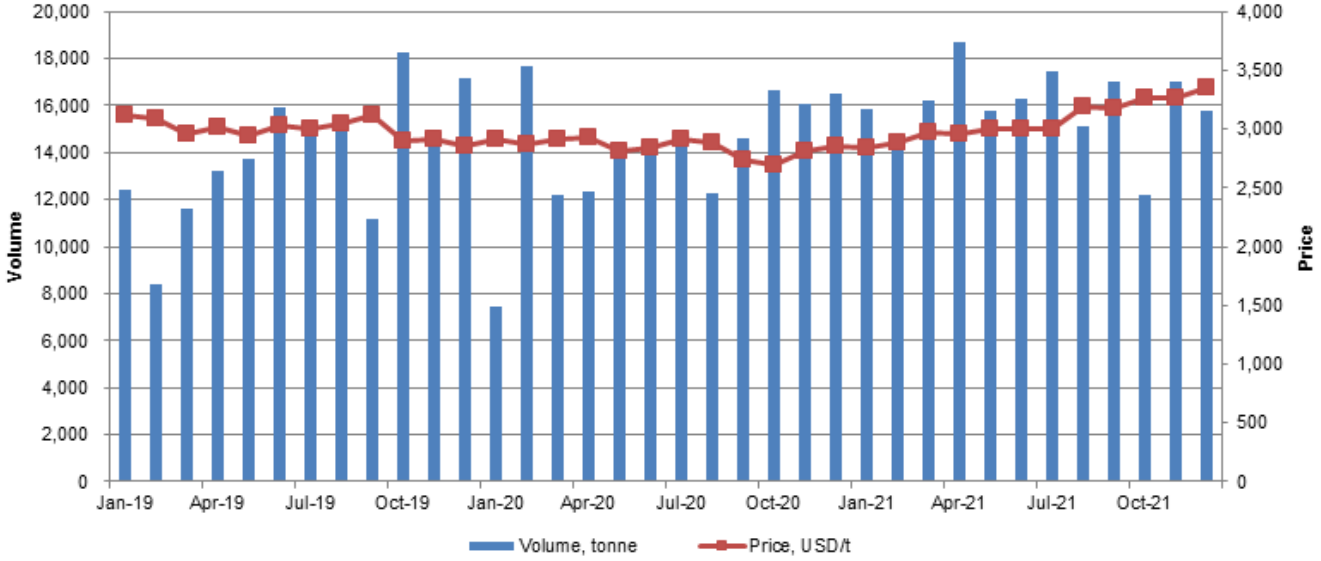
High import price
In the past three years, the exchange rate fluctuated a lot, and import price of TiO_2 was greatly affected. Since most of the imported TiO_2 is produced with chloride process, these high-end products came at high price.

In 2019, the import price still kept at high level, but the total import volume fell 15.37% year on year. In Feb., the import volume stood at 8,419 tonnes, the lowest of the year.

In 2020, the price fell below USD3,000/t, and hit the bottom in Oct. at USD2,701/t. China's monthly TiO_2 import remained above 12,000 tonnes all the year except Jan. It is fair to say that COVID-19 barely affected the import volume of TiO_2.

In 2021, the import price of TiO_2 showed an obvious upward trend triggered by price hike globally. During this period, world-renowned TiO_2 suppliers raised their prices multiple times amid the prosperous global TiO_2 market.

Figure 5.2-1 China's import volume and price of titanium dioxide, Jan. 2019–Dec. 2021



Source: CCM & China Customs

5.3 Export analysis 2019–2021

China exported 980,008 tonnes in 2019, 1,203,975 tonnes in 2020 and 1,311,626 tonnes in 2021, which showed an obvious upward trend with a CAGR of 15.69% during this period.

China's export volume of TiO_2 kept increasing mainly for the follow reasons:

- Lower price of TiO_2 from China
- Improved quality of TiO_2 made in China
- Surging demand in overseas markets

The top 10 export destinations in 2021 took up 54.49% of the total TiO_2 export, and the share was 52.30% in 2020 and 52.65% in 2019. China's TiO_2 export market is diverse, involving more than 140 countries. In 2019–2021, China's TiO_2 was mainly exported to some developing countries such as India, Brazil, Vietnam, Turkey and Indonesia. It is worth noting that TiO_2 exports to India continued to grow because of rigid demand for infrastructure there.

Table 5.3-1 China's top 10 export destinations of titanium dioxide, 2019–2021

No.	Country	2021		Country	2020		Country	2019	
		Quantity, tonne	Country		Country	Quantity, tonne		Quantity, tonne	Price, USD/t
1	India	168,884	2,752	India	135,810	1,879	India	126,936	2,172
2	Brazil	89,021	2,703	Brazil	99,277	1,907	Brazil	72,583	2,186
3	South Korea	85,233	2,837	South Korea	73,149	2,008	South Korea	62,632	2,227
4	Turkey	74,592	2,756	Vietnam	62,696	1,992	Vietnam	52,767	2,238
5	Vietnam	62,617	2,812	Turkey	59,377	1,916	Indonesia	49,701	2,158
6	Indonesia	62,477	2,775	Indonesia	49,657	1,940	Turkey	38,126	2,174
7	United Arab Emirates	56,453	2,753	Malaysia	38,729	1,944	Malaysia	32,580	2,178
8	Malaysia	44,181	2,770	Canada	38,324	1,852	United Arab Emirates	31,247	2,182
9	France	36,810	2,746	Egypt	37,525	1,996	Thailand	25,109	2,204
10	Thailand	34,481	2,782	France	35,087	1,916	France	24,302	2,228
Others		**596,878**	**2,785**	**Others**	**574,346**	**1,938**	**Others**	**464,025**	**2,200**
Total/Average		**1,311,626**	**2,775**	**Total/Average**	**1,203,975**	**1,933**	**Total/Average**	**980,008**	**2,195**

Source: CCM & China Customs

Asia-Pacific region, Europe and South America were the core regions for China's TiO_2 export in this period.

Table 5.3-2 China's titanium dioxide export volume by region, 2019–2021

Region	Export volume, tonne			Share		
	2021	2020	2019	2021	2020	2019
Africa	97,115	84,322	66,264	7.40%	7.00%	6.76%
Asia	547,905	473,320	425,224	41.77%	39.31%	43.39%
Central and Eastern Europe	150,896	127,065	92,455	11.50%	10.55%	9.43%
Middle East	117,977	103,183	79,261	8.99%	8.57%	8.09%
USMCA (NAFTA)	39,409	67,138	44,834	3.00%	5.58%	4.57%
Oceania	12,610	14,113	11,283	0.96%	1.17%	1.15%
South America	147,580	157,342	118,757	11.25%	13.07%	12.12%
West Europe	198,133	177,492	141,930	15.11%	14.74%	14.48%
Total	**1,311,626**	**1,203,975**	**980,008**	**100.00%**	**100.00%**	**100.00%**

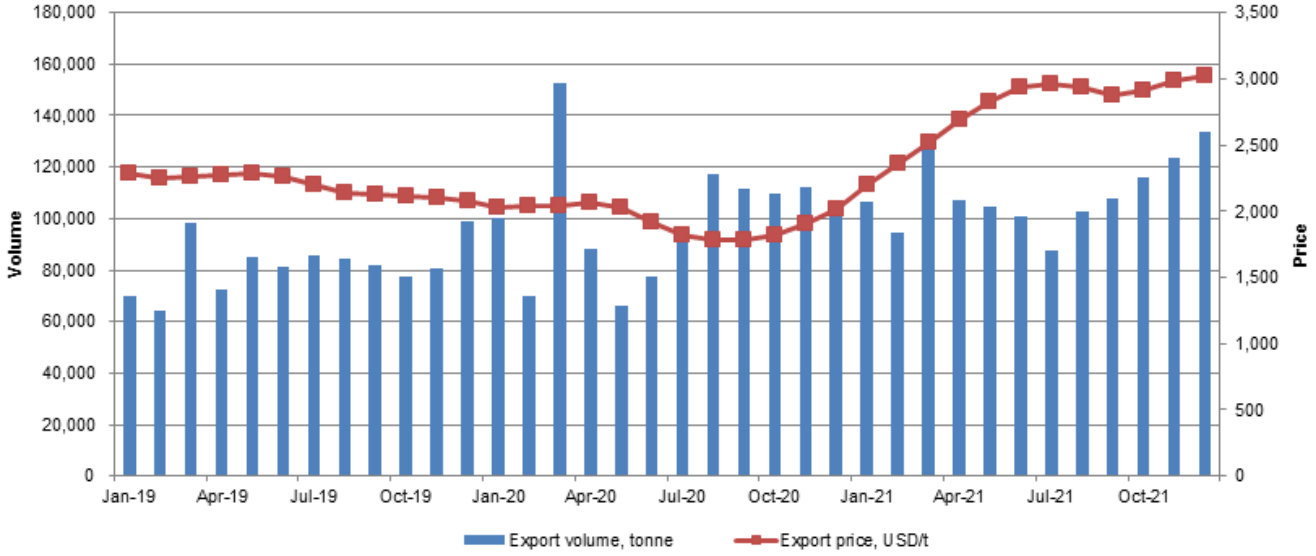
Note: Due to rounding, the total may not equal 100.00%.
Source: CCM & China Customs

The export price of TiO_2 in China witnessed a slightly downtrend during 2019–2020, dropped from USD2,280/t in

May 2019 to USD1,785/t in Sept. 2020. However, the situation was reversed from Oct. 2020, the price jumped quickly because of increased demand.

In 2021, the export volume of TiO_2 in China increased by 8.94% year on year; except Feb. and July, monthly export volume exceeded 100,000 tonnes.

Figure 5.3-1 China's export volume and price of titanium dioxide, Jan. 2019–Dec. 2021



Source: CCM & China Customs

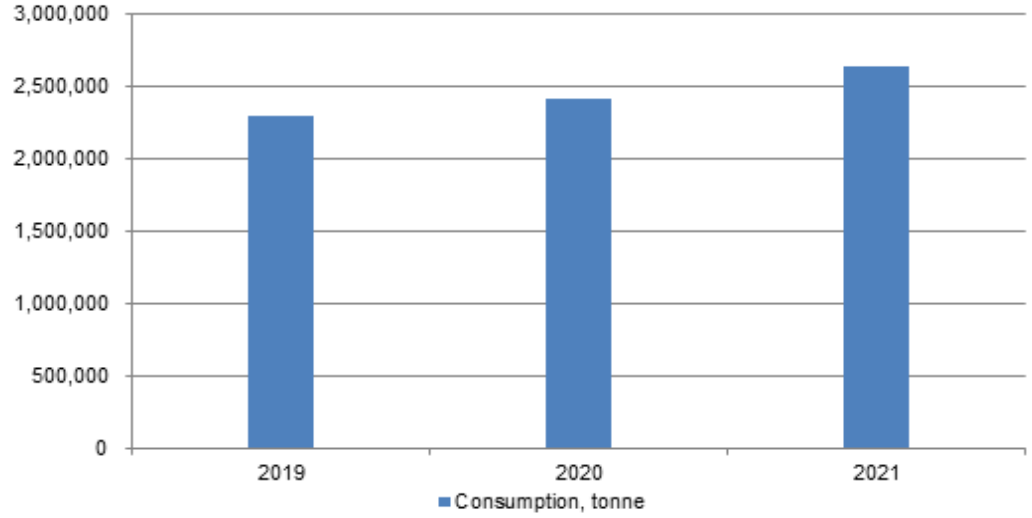
6 Consumption

6.1 Titanium dioxide consumption in China, 2019–2021

China, as an industrial power, is not only a producing powerhouse, but also a big consumer of TiO_2. In 2019–2021, annual domestic consumption of titanium dioxide was 2,303,518 tonnes, 2,414,878 tonnes and 2,646,584 tonnes respectively, increasing with a CAGR of 7.19%.

Downstream application fields of TiO_2 are mainly coating, plastics, papermaking and chemical fiber, occupying the top four positions in China's TiO_2 consumption fields. In 2021, 60.56% of China's TiO_2 was used in coating, followed by plastics and papermaking, accounting for 18.26% and 12.32% of the total respectively.

Figure 6.1-1 Consumption volume of titanium dioxide in China, 2019–2021



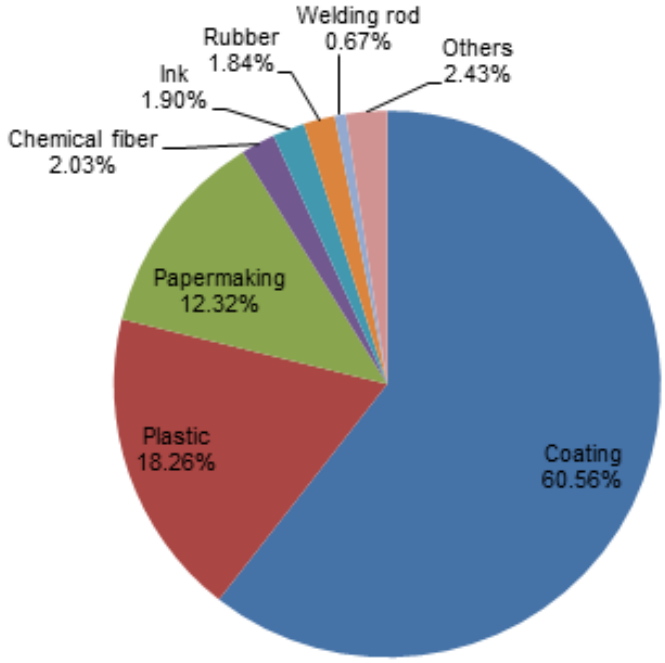
Source: CCM

Table 6.1-1 Consumption volume of titanium dioxide by major end use segment in China, 2019–2021

Industry	Consumption volume, tonne		
	2019	2020	2021
Coating	1,363,534	1,470,815	1,602,722
Plastics	502,089	459,000	483,273
Papermaking	236,830	270,240	326,014
Chemical fiber	47,622	49,012	53,668
Ink	47,400	48,900	50,340
Rubber	44,028	44,388	48,702
Welding rod	18,360	18,084	17,676
Others	43,655	54,439	64,189
Total	**2,303,518**	**2,414,878**	**2,646,584**

Source: CCM

Figure 6.1-2 Consumption pattern of titanium dioxide in China, 2021

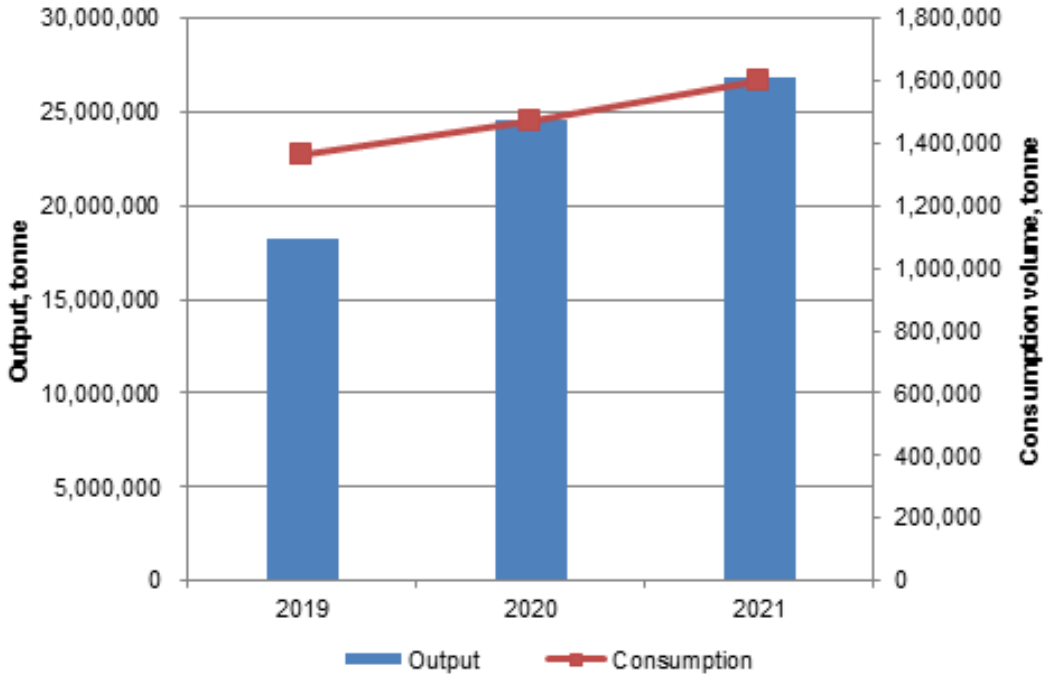


Note: Due to rounding, the total may not equal 100.00%.
Source: CCM

6.1.1 Coating

Coating is the largest TiO_2 downstream sector in China. In 2019–2021, the TiO_2 consumption in coating was 1,363,534 tonnes, 1,470,815 tonnes and 1,602,722 tonnes respectively, with a CAGR of 8.42%. In the same period, the output of coating continued to grow. In coating industry, architectural coating consumed about half of the TiO_2 for this sector, followed by industrial protective coating with a share of 26.55%.

Figure 6.1.1-1 Titanium dioxide consumption in the coating industry and output of coating in China, 2019–2021



Source: CCM

- Architectural coating

In 2019–2021, the output of architectural coating grew steadily, mainly driven by the real estate industry and renovation of old houses. The demand for architectural coating has kept strong. For one thing, due to large number of houses in China and the advancement of renovation of old house, demand for architectural coatings increases continuously; for another, growths in population and urbanization rate, infrastructure construction and the real estate industry have brought greater market demand for architectural coatings.

- Real estate industry

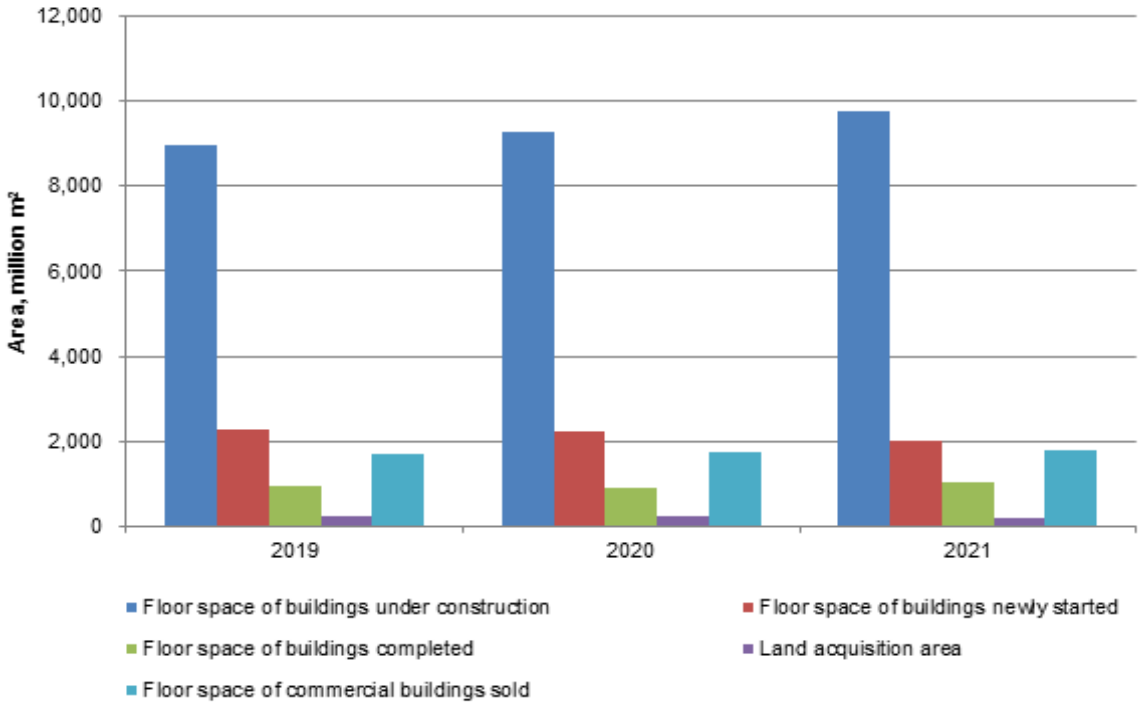
The real estate industry in China has a great demand for coating. Therefore, how the real estate industry fares greatly affects the demand for coating and thus the consumption of TiO_2. At present, the real estate market in China is still huge.

In 2021, the real estate industry entered an adjustment period. The investment in real estate development increased by some 4% year on year to USD2,284.35 billion (RMB14,760.20 billion), but the growth rate reduced 2.60 percent point year on year. The floor space of buildings under construction was about 9,754 million m^2 and the floor space of buildings completed was 1,014 million m^2, increased by 5.20% and 11.20% compared with the figures in 2020, and the floor space of commercial buildings sold increased by 1.90% year on year to over 1,794 million m^2, indicating an increase in TiO_2 consumption in real estate industry. However, floor space of houses newly started and land acquisition area of real estate development enterprises had two-digit year-on-year decline, indicating that real estate developers held weakened confidence in this market.

- Renovation of old houses

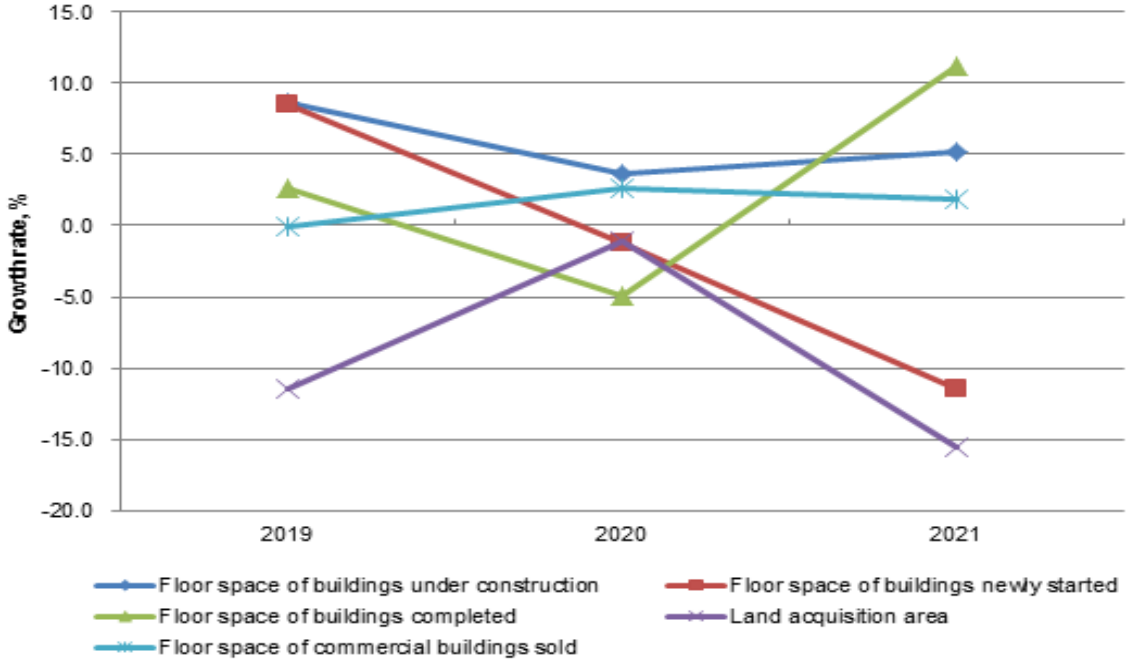
According to the Ministry of Housing and Urban-Rural Development of the People's Republic of China, there were about 160,000 old communities in China in 2019, involving more than 42 million households and a construction area of about 4 billion m^2, with an average construction area of 25,000 m^2 each community. If calculated on the ratio of external wall area to building area of 0.7, the external wall area of each community is 17,500 m^2. Assuming that 50% of the external wall area needs renovating with coating usage of 5 kg per square meter, and 25,000 old communities are renovated every year, there will be about 1.09 million tonnes of coating used in old house renovation each year. In 2021, 55,600 communities were renovated in China.

Figure 6.1.1-2 Brief analysis of the economic operation of real estate industry



Source: National Bureau of Statistics (NBS)

Figure 6.1.1-3 Growth rate of real estate development and sales in China, 2019–2021



Source: NBS

On the whole, affected by factors such as the downward-going macroeconomy, bouts of COVID-19 resurgence, and government policy change, the real estate industry has been facing growing pressures since 2020, and the situation is likely to continue in the next two years. As a result, the growth rate of architectural coating consumption in China will slow down.

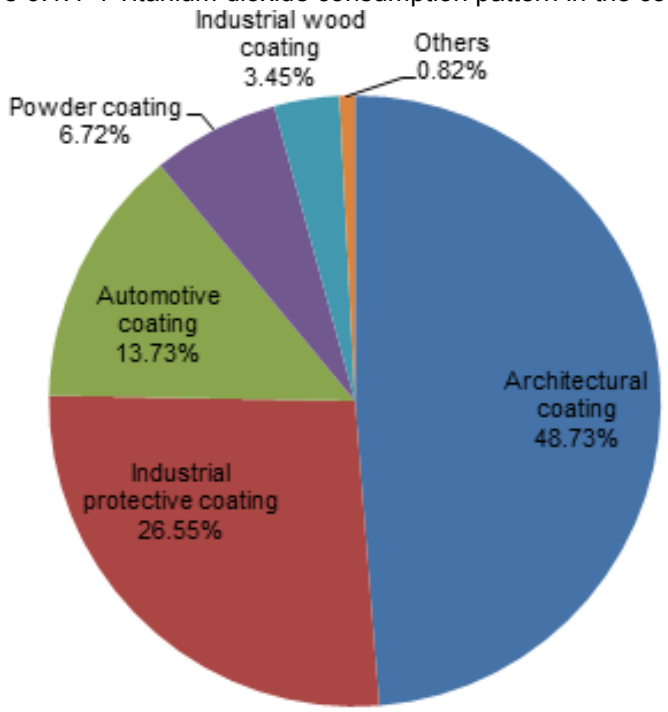
- Industrial protective coating

Industrial protective coating took up the second largest proportion of TiO_2 consumption. In China, industrial protective coating covers marine, container and other anti-corrosion coating.

The booming shipbuilding and ship repair industries have driven up the demand for marine coating. According to China Association of the National Shipbuilding Industry, in 2021, the accomplished shipbuilding output increased 3.00% year on year to 39.70 million DWT (dead weight tonnage), and a total of 7,731 ship repair and modification projects were completed.

According to the China Container Industry Association, China's container production output reached a record high in 2021, at about 6.53 million TEU (twenty-feet equivalent unit). The increase in container output also drove up the market demand for container coating.

Figure 6.1.1-4 Titanium dioxide consumption pattern in the coating industry in China, 2021



Source: CCM

TiO_2 used in the coating industry requires good application performance in terms of chroma, hiding force, tinting strength and dispersity to ensure the quality of the coating. As a common practice, the rutile type is widely applied in architectural coating, because exterior wall coating requires excellent weatherability.

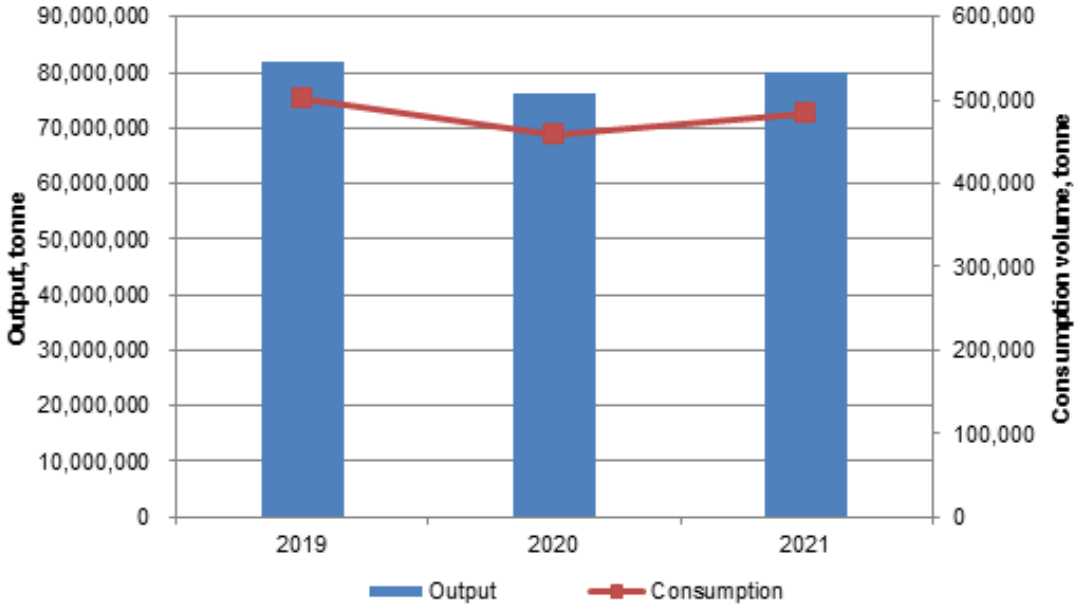
Rutile TiO_2 is also welcomed in industrial coating, which is mainly used on the surface of industrial products. And TiO_2 with better performance is required in this field. For example, the product used in automobile production must have good covering ability, anti-corrosion performance and sound weatherability. Coil coating and wood coating, used in household appliances and furniture, have looser requirements on weatherability. Powder coating requires only good covering ability and chroma, and both anatase and rutile types can meet the requirement.

6.1.2 Plastics

China is the world's largest producer of plastics and plastics is China's second largest consumption field of TiO_2. In 2019–2021, China's consumption volumes of TiO_2 in plastics industry were 502,089 tonnes, 459,000 tonnes and 483,273 tonnes respectively.

In the past three years, yearly output of plastics was 81,841,700 tonnes, 76,032,000 tonnes and 80,040,000 tonnes respectively. Generally, TiO_2 consumption in plastics goes hand in hand with the output of plastics. In 2021, daily plastic product and plastic pipe were the top two TiO_2 consuming sub-sectors in the plastics industry, taking up 19.16% and 16.66% respectively.

Figure 6.1.2-1 Titanium dioxide consumption in the plastic industry and output of plastics in China, 2019–2021

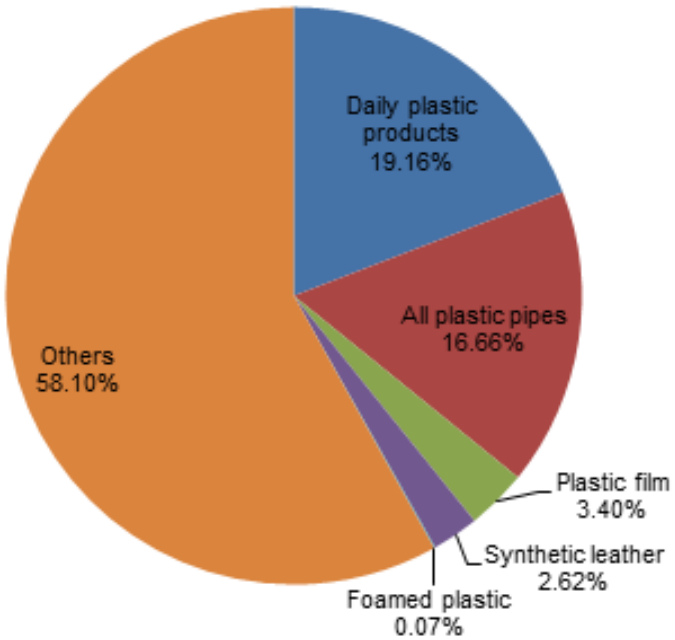


Source: CCM

The amount of TiO_2 added in plastics varies with variety and application, generally ranging between 0.5%–5.0%. Daily plastic products consume the most of TiO_2; usually, average addition amount of TiO_2 in these products is about 30 kilograms per tonne. As the output of daily plastic products increased in 2019–2021, TiO_2 consumption in this sector also climbed up in general.

Another big consumption sector in the industry is all plastic pipes. The output of all plastic pipes increased from 16,060,000 tonnes in 2019 to 16,770,000 tonnes in 2021, thanks to the development of real estate industry, old house renovation and the construction of urban pipelines.

Figure 6.1.2-2 Titanium dioxide consumption pattern in the plastics industry in China, 2021



Note: Due to rounding, the total may not equal 100.00%.
Source: CCM

TiO_2 is used as colorant and reinforcer in the plastics industry, which requires high hiding power, good achromic

ability, weatherability and surface-treatment effect. Rutile type is applied more widely than anatase type in plastics used in outdoor.

As to TiO_2 addition volume in plastic products, it varies according to type and quality. It can be mixed with resin powder or plasticizer. It can also be processed into master batch first, which is a concentrated mixture of pigments and/or additives encapsulated during a heat process into a carrier resin, which is then cooled and cut into a granular shape. The master batch can be used by mixing with plastic resin in certain ratio according to different process requirements of the plastics and injection molds.

During the 14th Five-Year Period (2021–2025), three development goals for the plastics processing industry have been put forward, including:

- Scale development: to keep steady growth in the output, revenue, operating profit and export value of plastic products.
- Technological innovation: R&D investment of key enterprises shall be no less than 3.20% of their revenue. Superior resources should be better integrated.
- Green development: to promote the application of new technologies for energy conservation, emission reduction and low-carbon & clean production, and to promote the use of new energy and adopt environment friendly new materials, processes & technologies to reduce energy consumption.

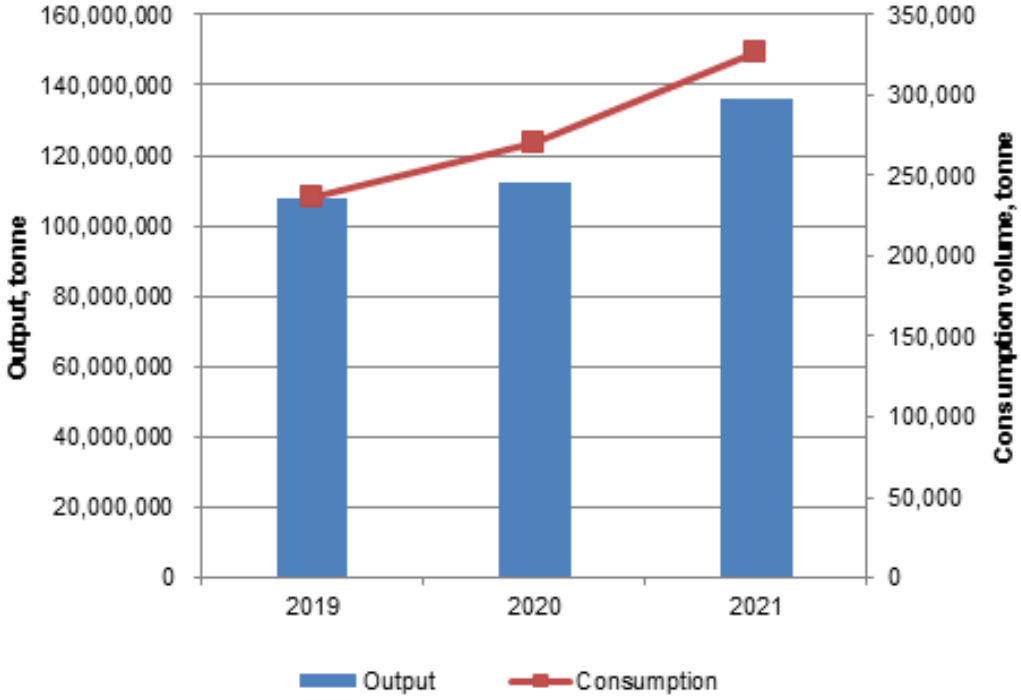
It is foreseeable that the production of and demand for plastics will continue to grow in the next few years. Therefore, demand for TiO_2 from this sector will also increase.

6.1.3 Papermaking

Papermaking is the third largest TiO_2 consumption field in China, which accounted for about 12.32% of the total consumption volume in 2021.

In 2019–2021, the consumption volume of TiO_2 in the papermaking industry increased from 236,830 tonnes to 326,014 tonnes, at a CAGR of 17.33%. The output of paper increased from 107,650,000 tonnes in 2019 to 135,839,000 tonnes in 2021, at a CAGR of 12.33%.

Figure 6.1.3-1 Titanium dioxide consumption in papermaking industry and output of paper in China, 2019–2021



Source: CCM & NBS

One of the most important applications of TiO_2 in papermaking is decorative paper, which is mainly used to make

furniture, floor and wallpaper. Incomplete statistics show that TiO_2 content in decorative paper is 20%–40%, while that in other paper is 1%–5%. With the increase of domestic consumption level and the demand for house decoration and high-grade furniture, demand for decorative paper is expected to keep rising, thus driving up the consumption of TiO_2 in this field.

For different kinds of paper, the required TiO_2 addition and quality are different. In general, quality requirements for TiO_2 used in the papermaking industry are good covering force, good achromic ability, uniform granularity, good dispersity in water and high purity. TiO_2 is mainly used as fillers and colorants in papermaking industry in China.

Traditionally, anatase TiO_2 is extensively used in papermaking, which has better whiteness than the rutile type. But in recent years, the quality of rutile TiO_2 in China has improved greatly, including the whiteness. Thus, more and more paper producers prefer to use the rutile ones to improve their products' anti-aging ability.

Besides, paper for different purposes requires different types of TiO_2. For example, rutile TiO_2 is used in decorative paper, mainly owing to its excellent oxidative stability and weather resistance. The rutile TiO_2 made through chloride process is much preferred for its better whiteness, rutile crystal content and stability. In contrast, banknote paper requires sulfate anatase TiO_2 to better satisfy its requirement of opacity.

During the 14th Five-Year Period, development goals for the papermaking industry by 2025, proposed by China Paper Association, are listed as follows:

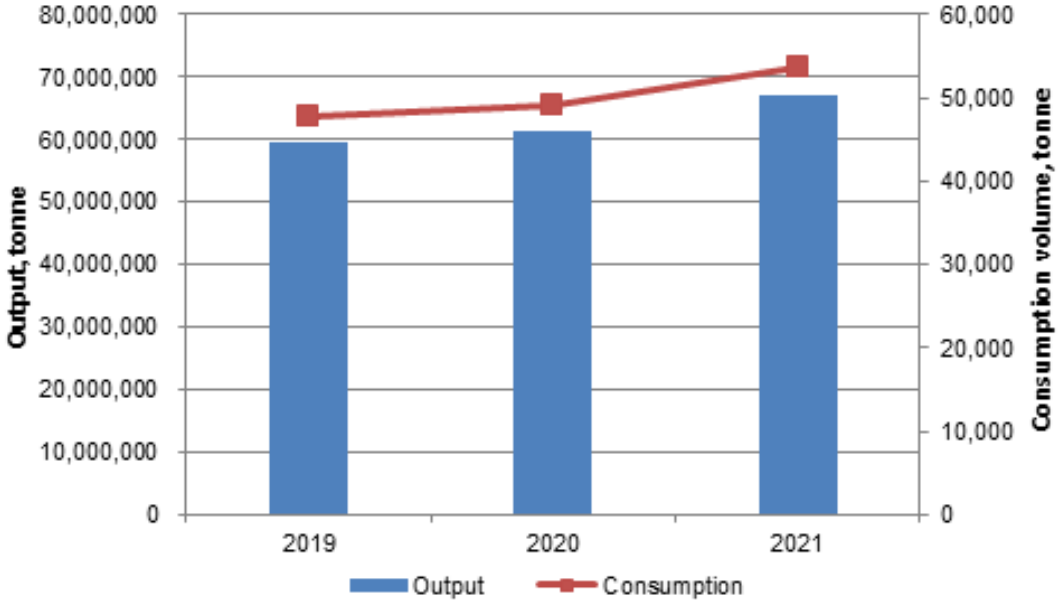
- The output of paper and paperboard will reach 140 million tonnes in China, and the annual per capita consumption will reach 100kg.
- The output of virgin pulp will reach 30 million tonnes.
- The output of paper products will reach 90 million tonnes.
- Product structure will be optimized, and product quality & variety improved.

The papermaking industry may witness rapid growth in the next five years, and the demand for paper products will increase significantly, thereby driving up the demand for TiO_2 in this industry.

6.1.4 Chemical fiber

The chemical fiber industry's TiO_2 consumption accounted for 2.03% of the total in 2021, with 53,668 tonnes. It grew at a CAGR of 6.16% in 2019–2021; the same growth rate is seen in the output of chemical fiber in this period, as it increased from 59,528,000 tonnes in 2019 to 67,085,000 tonnes in 2021.

Figure 6.1.4-1 Titanium dioxide consumption in chemical fiber and output of chemical fiber in China, 2019–2021



Source: CCM & NBS

Major categories using TiO_2 in chemical fiber industry are terylene, polyamide fiber, and viscose fiber. According to statistics from China Chemical Fibers Association, in 2021, the output of terylene, polyamide fiber and viscose fiber was 53,630,000 tonnes, 4,150,000 tonnes and 4,031,000 tonnes respectively, with a yearly increase of 8.94%, 8.00% and 1.93% respectively. Many other chemical fibers have also developed quickly in China in recent years.

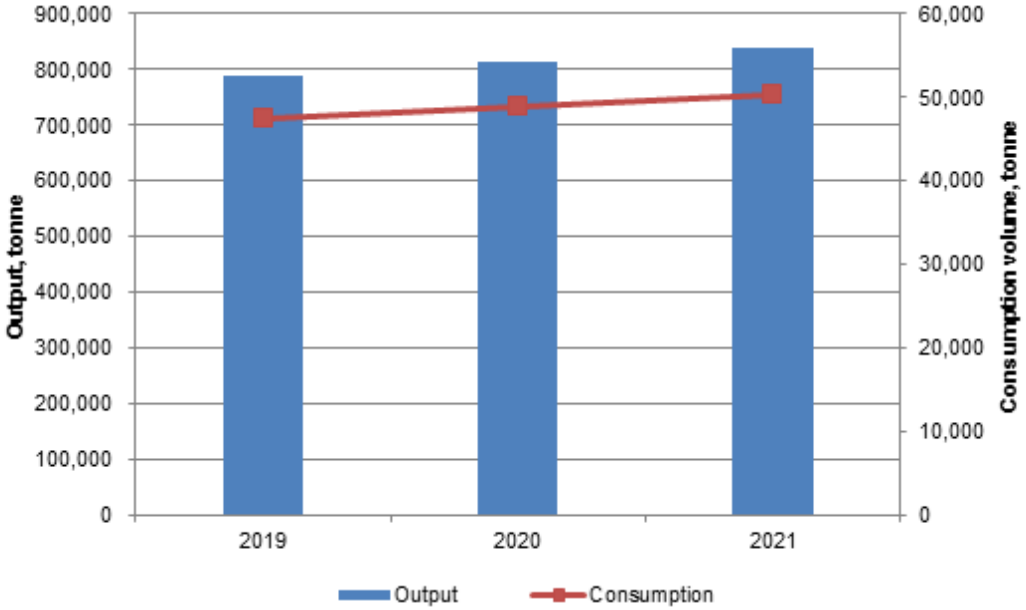
TiO_2 is usually used as a delusterant in the chemical fiber industry, with the effect generally being achieved at an addition of 2 kilograms per tonne. Requirements for TiO_2 used in the chemical fiber industry are: good whiteness, strong tinting strength, stable chemical properties, good dispersion, fine and uniform particles and good water dispersion. The particle size of fiber grade TiO_2 usually falls between 0.15 μm and 0.35 μm, and the process to make this kind of TiO_2 is complicated.

Compared with delustered fiber, semi-dull fiber is more popular in China. It is reported that the average TiO_2 addition is only 0.20%–0.50% in semi-dull fiber, while in delustered fiber, the application is 0.50%–1.50%.

6.1.5 Ink

With the increase of China's ink output, TiO_2 consumption in the ink industry reached 50,340 tonnes in 2021, accounting for 1.90% of the total in China, with a CAGR of 3.05% in 2019–2021.

Figure 6.1.5-1 Titanium dioxide consumption in the ink industry and output of ink in China, 2019–2021



Source: CCM

The amount of TiO_2 added to ink products is relatively large, typically between 20% and 50%. In recent years, the consumption of TiO_2 in ink has increased along with the rise of ink output. As the demand for packaging in China still goes up, the consumption of TiO_2 in ink will continue to grow steadily.

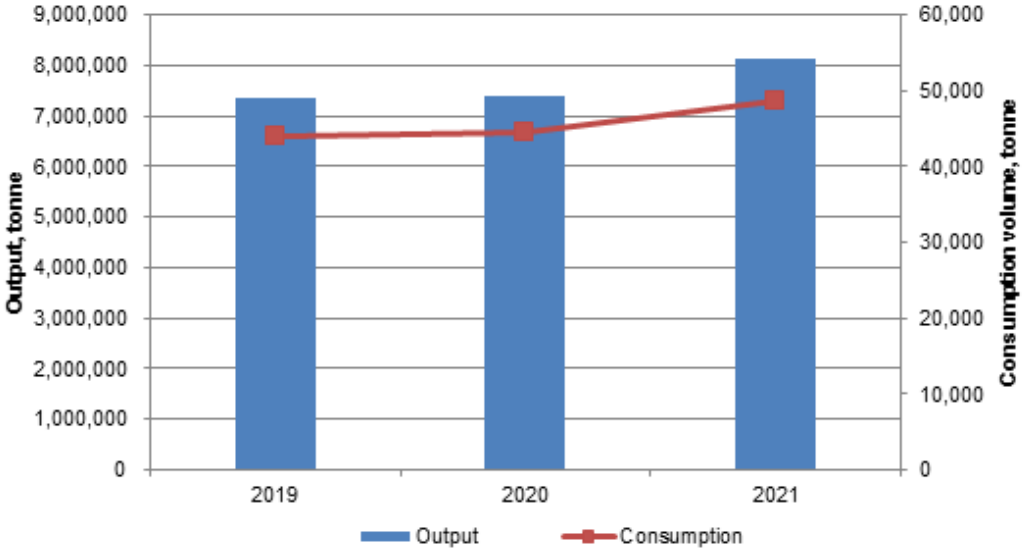
In ink production, different types of ink products have different quality requirements. Generally speaking, TiO_2 used in the ink industry should have high covering ability and tinting strength, good achromic ability, moisture, chroma, dispersity. Rutile type is preferable in this field. And imported TiO_2 usually has better chroma and tinting strength than homemade one.

6.1.6 Rubber

In 2019–2021, the consumption volume of TiO_2 in the rubber industry was 44,028 tonnes, 44,388 tonnes and 48,702 tonnes respectively, with a CAGR of 5.17%. The industry accounted for 1.84% of the total TiO_2 consumption in 2021. During the same period, the output of synthetic rubber grew at a similar rate, reaching

8,117,000 tonnes in 2021.

Figure 6.1.6-1 Titanium dioxide consumption in the rubber industry and output of synthetic rubber in China, 2019–2021



Source: CCM & NBS

TiO_2 is used in tire, rubber duct, rubber overshoes, texrope belt and so on. Thereinto, tire consumes the largest amount of TiO_2. Usually, a certain amount of rutile TiO_2 is added to tire to enhance the resistance to ozone and ultraviolet ray.

TiO_2 products used in rubber industry should have good heat resistance, covering ability, achromic ability and good dispersity. In general, the anatase type is preferred in the rubber industry. However, tire requires good weatherability and high ultraviolet-resistance, and thus uses more rutile type.

During the 14th Five-Year Period, total output in rubber industry should follow a stable uptrend with slightly lower average annual growth rate than the current level, and the scale, influence and export share of China's rubber industry should be strengthened, according to the latest rubber industry development plan. It also sets output targets for main rubber products by 2025, including:

- Tire: the output will be 704 million, and radialization rate reach 96%.
- Cycle tire: the cover tire and inner tube of motorcycle will reach 120.70 million and 211.10 million respectively; those of bicycle will be 420 million and 550 million respectively; those of electric bicycle will be 363 million and 77 million respectively.
- Other rubber products: 4.5 billion pieces for seal products, 2.5 billion pieces for rubber damper, 6 million pieces for engineering rubber products and 1.5 billion pieces for rubber products in electronic appliances.

So in the next few years, the output of tires and other rubber products is expected to increase steadily, and the demand for TiO_2 in the rubber industry will also increase.

6.1.7 Other consumption fields

There are also other fields using TiO_2, such as welding rod, enamel, tile, cosmetics, pharmaceutical, electronics, leather, food, alloy and glass. Generally speaking, TiO_2 consumption in these fields is relatively small.

7 Forecast on Chinese titanium dioxide, 2022–2026

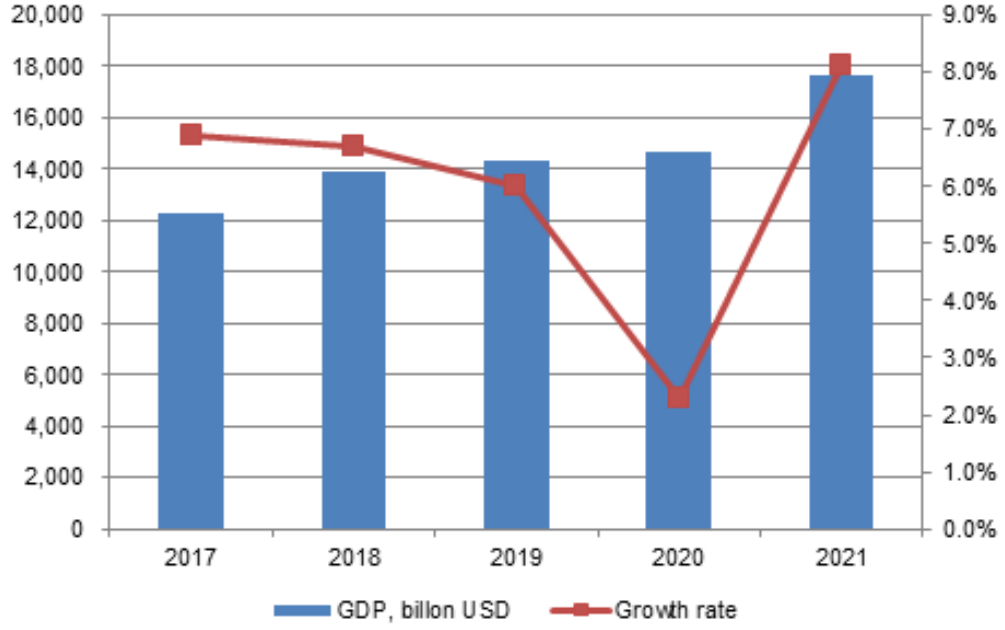
7.1 Drivers

Good performance of Chinese economy

China's economy has kept growing and its resilience continues to be highlighted. The GDP growth rate stayed above 6% in 2017–2019. Although the rate declined in 2020 due to severe damage wrought by COVID-19, the year 2021 saw the GDP grew by 8.1% year on year to USD17,700 billion (RMB114,367 billion).

China still faces uncertain situations and problems that are likely to persist in the medium and long run. China will accelerate fostering a "dual circulation" development pattern in which domestic economic cycle plays the leading role while international economic cycle serves as an extension and a supplement to combat global economic downturn and shrinking international market.

Figure 7.1-1 GDP development and annual growth rate in China, 2017–2021



Source: National Bureau of Statistics

Stringent environmental regulations

In recent years, domestic environmental protection efforts have been gradually strengthened. Supervision teams from the central government have went through 31 provinces and municipalities since 2015, and the "Look Back" activities were launched to review environmental protection work nationwide in Sept. 2018. Enterprises deemed to be environmentally unqualified would be punished by shutdowns and rectifications, which will not only increase enterprises' pollution treatment costs, but also reduce the living space of small- and medium-sized enterprises, thus leading to the collapse of sub-standard TiO_2 enterprises. There were about 60 domestic TiO_2 manufacturers before 2015, but now the number reduces to somewhere slightly over 42. As of 2021, there were 13 domestic TiO_2 manufacturers whose capacity crossed the 100,000 t/a line; they took up 70.85% of the total capacity, indicating a high industrial concentration. In addition, stricter environmental regulations have accelerated the development of the chloride process TiO_2.

Growing domestic demand from downstream industries

The downstream industries of TiO_2 such as coating, plastics and papermaking, will maintain a growth trend in their output during 2022–2026. Coating is the largest consumer of TiO_2, and the demand for coating in the real estate industry and the renovation of old houses is still strong. Therefore, the demand for TiO_2 in coatings will continue to grow in the next few years.

- Real estate industry: Statistics show that in 2021, China saw decreased floor space of buildings newly

started and land acquisition area of real estate development enterprises. In the next two years, China's real estate sector will go into an adjustment period. The adjustment may be reflected in TiO_2 consumption in the coating industry accordingly. Nevertheless, it should be noted that as the number of houses in China continues to grow, demand for redecoration will keep expanding, stimulating the demand for coating. Thus, the real estate market still has the potential to boost the demand for TiO_2.

● Renovation of old houses: With the advancement of the old house renovation project in China, the demand for coating will continue to expand.

In addition, downstream industries of TiO_2 have gradually expanded to fields like cosmetics, toys, food and medicine. With the development of economy and researches on broadening the application, the demand for TiO_2 will become larger.

7.2 Barriers

Backward production process

In 2021, LB Group had 1,010,000 t/a TiO_2 production capacity, ranking first in China and third worldwide, following Chemours (1,250,000 t/a) and Tronox (1,080,000 t/a). Although the capacity gap seems not large, the production techniques they use still tell the difference between domestic and overseas TiO_2 industries.

Specifically, in 2021, about 90% of China's TiO_2 was produced with sulfate process, while more than 70% of TiO_2 from the top five foreign producers (Chemours, Tronox, Venator, Kronos and INEOS) was produced through chloride process. Chemours and INEOS even apply chloride process in all their TiO_2 production lines.

The overall quality of China's TiO_2 is still far from high-end application. China's chloride-processed TiO_2 just accounted for about 12% of the total TiO_2 capacity in 2021, which is far lower than that of overseas manufacturers. Domestic TiO_2 are mostly of lower grade that can only be used in the bottom-end products such as latex paint for building, and the export destinations are mainly countries which need low-grade TiO_2 in large amount. Only a small proportion is for developed areas such as the US, Japan and Western Europe.

Reliance on high-quality ilmenite imports

Domestic titanium concentrate output increased from 5,015,000 tonnes in 2019 to 5,825,000 tonnes in 2021. However, during the same period, the dependency on ilmenite imports in China remained above 50%, with the import volume climbing from 2,598,605 tonnes to 3,796,756 tonnes. At present, China TiO_2 industry is ushering in a new round of capacity expansion. Once the new capacity comes into mass production, the next things may be supply shortage of ilmenite and ensuing soaring price. Moreover, it may even break the balance of supply and demand of ilmenite in China and perhaps in the world.

Large gap between TiO_2 manufacturers

Capacity: In 2021, there were over 42 TiO_2 manufacturers in China, and only 13 manufacturers had capacity of or above 100,000 t/a. Among them, the top five held 2,025,000 t/a, occupying 47.11% of the total. This means that most TiO_2 producers are of small production scale.

Technique: As of 2021, there were only four TiO_2 manufacturers whose chloride process TiO_2 projects had been built and put into production—LB Group Co., Ltd. (360,000 t/a), Yibin Tianyuan Haifeng Hetai Co., Ltd. (100,000 t/a), CITIC Titanium Industry Co., Ltd. (60,000 t/a) and Pangang Group Vanadium & Titanium Resources Co., Ltd. (15,000 t/a).

7.3 Qualitative forecast

China's titanium dioxide industry is likely to develop in the following trends.

Further integration of TiO_2 industry

As of 2021, the concentration of China's TiO_2 industry had increased: there were 13 manufacturers with capacity of 100,000 t/a and above, accounting for about 70.85% of the national total; 10 medium-sized enterprises with

capacity in the 50,000 t/a–100,000 t/a range, accounting for 13.96% of the total. LB Group, in particular, had TiO_2 capacity of 1.01 million t/a, ranking third in the world.

Tighter supply of titanium ore

Since the price fall in 2012, major titanium ore suppliers worldwide have slashed their capital expenditure; therefore, there has been hardly any new mine exploited and some existing mines are getting close to exhaustion. China will see new TiO_2 capacity be put into production in the future, but domestic titanium ore resources might fail to satisfy the growing demand from TiO_2 production. The supply of titanium ore will be further tightened.

Development of both production techniques

Currently in the overseas market, especially in developed countries, chloride process is the main production technique, while in China, although there are some producers like LB Group that have built chloride process TiO_2 production lines, sulfate process still dominates. It is believed that the development of advanced chloride process will forge ahead along with the improvement of sulfate process.

Waste sulfuric acid is the main pollutant when applying sulfate process. Now it can be recycled to produce phosphate. For example, all of the waste sulfuric acid of LB Sichuan Titanium Industry Co., Ltd. is used to produce phosphate, which reduces the pollution significantly. Other improvements to sulfate process include: using acid-soluble titanium slag instead of titanium concentrate as raw material, utilizing waste heat from sulfur-based sulfuric acid production, recycling of waste acid and concentrated acid, etc.

It is worth mentioning that the technology of converting ferrous sulfate to ferric phosphate has attracted the attention of TiO_2 manufacturers. Ferrous sulfate is a by-product of TiO_2; it can react with phosphoric acid to produce ferric phosphate, a raw material for lithium iron phosphate. This by-product can be used for high-efficient and value-added purposes through the construction of iron phosphate production lines. Not only can the manufacturing costs of TiO_2 be reduced, but also the industrial chain can be extended, so as to realize a green and circular economy through comprehensive utilization of resources.

In addition, improved sulfate process has its own advantages. It can produce both high-end rutile TiO_2 and low-end anatase TiO_2, while chloride process can only produce rutile TiO_2. Although rutile TiO_2 can be transformed into anatase TiO_2, the extra process will add production costs.

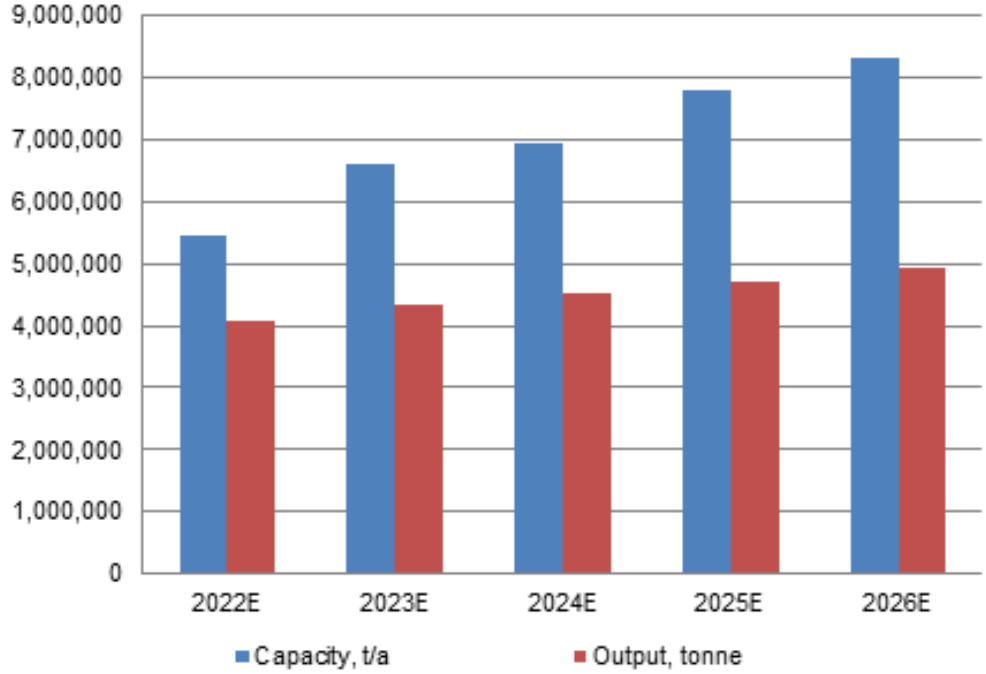
7.4 Quantitative forecast

With the phase-out of backward capacity and restriction on sulfate process TiO_2 capacity expansion, domestic sulfate process TiO_2 capacity will be further concentrated in the future. If sulfate process capacity of less than 20,000 t/a should be eliminated, the total TiO_2 capacity will be cut by about 25,000 t/a, and if the elimination threshold is raised to 50,000 t/a, about 500,000 t/a production capacity will be evaporated.

As China's chloride process TiO_2 has not fully mastered the core technology so far, chloride process TiO_2 production is still in its early stage. The TiO_2 capacity of the chloride process only accounted for some 12% of the total domestic capacity in 2021, which is still miles away from foreign giants. According to the *Guidance Catalogue for Industrial Structure Adjustment (2019 Edition)*, construction of chloride process TiO_2 production lines with capacity of 30,000 t/a and above is encouraged. It is expected that in the next five years, chloride process TiO_2 capacity will be further increased.

In 2019–2021, there were many TiO_2 construction projects in China. With the new capacity released, domestic TiO_2 capacity and output will keep growing. It is estimated that by 2026, the total TiO_2 capacity will exceed 8 million t/a and the output will jump to about 5 million tonnes in China.

Figure 7.4-1 Forecast on capacity and output of titanium dioxide in China, 2022–2026



Source: CCM

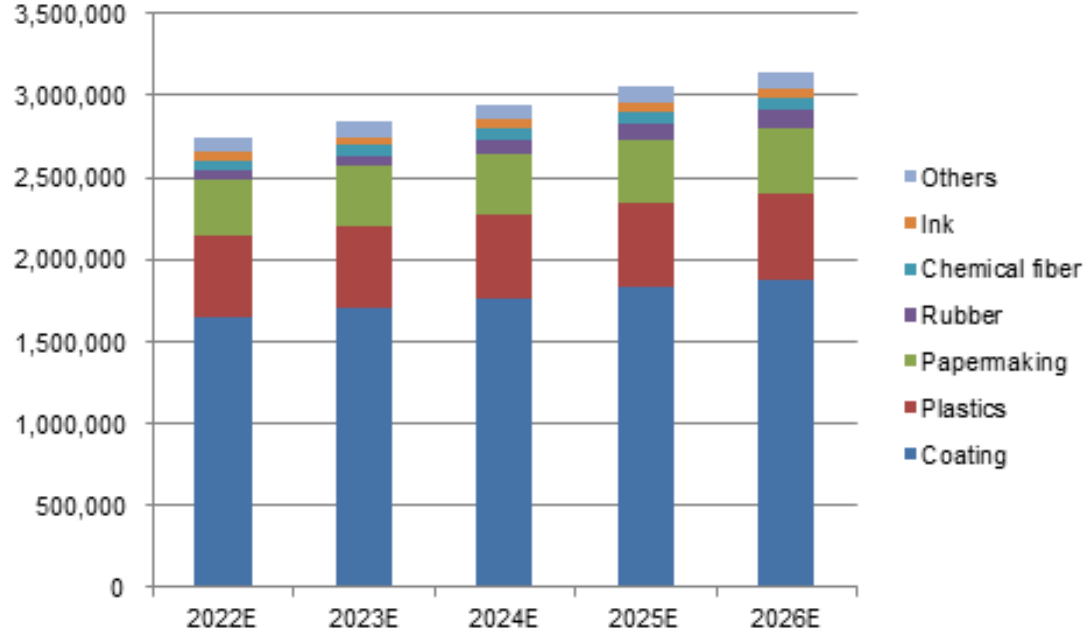
In the next five years, coating, plastics and papermaking industries will still be the three largest downstream sectors, together consuming 90% or so TiO_2 products in China.

The coating market absorbs the biggest portion of TiO_2. It is expected that the demand from coating industry will grow at a CAGR of about 3% during 2022–2026. As the economy grows, the coating market will be promising with the support of major customers like real estate, renovation and automobile enterprises. Besides, coating industry will follow an environment-friendly & water-based path as the 14th Five-Year Plan promoted and the general trend in the industry demonstrated.

At present, TiO_2 demand from plastics industry accounts for about 18% of the total in China. As environmental protection requirements push the industry to upgrade and the government encourages high-tech and light-weight products, China's plastics industry is expected to see a jump in demand and thus consume more TiO_2, growing at a CAGR of about 1% in consumption volume during 2022–2026.

Being the third largest application field of TiO_2, papermaking makes up about 12% of the total consumption. TiO_2 demand growth from this industry will slow down due to the elimination of outdated capacity as well as paperless trend in the digital age, which may be offset somewhat by surging demand for decorative paper though. It is expected that the demand for TiO_2 in papermaking industry will grow at a CAGR of about 5% in 2022–2026.

Figure 7.4-2 Forecast on consumption volume of titanium dioxide in main application industries in China, 2022–2026



Source: CCM

8 Opportunity

8.1 Raw material

Huge opportunities in China's TiO_2 market await domestic and foreign titanium mining and processing producers. Titanium ore accounts for about 60% of TiO_2 production cost. Therefore, the supply of titanium ore is decisive for the development of TiO_2 industry.

According to the USGS, China's ilmenite reserves were 230 million tonnes in 2021, accounting for 30.70% of the global total, ranking first in the world. Despite the large reserves, supply of titanium ore is still tight as the grade of titanium ore resources is low and the mining is difficult in China, so a large amount of imports is still required.

On one hand, producers have paid much attention to the integration of domestic titanium ore resources. For instance, in March 2020, the controlling shareholder of Yibin Tianyuan Haifeng Hetai Co., Ltd. signed a Strategic Cooperation Framework Agreement with Panzhihua State-owned Investment (Group) Co., Ltd., and the two sides will carry out in-depth cooperation in merger and reorganization, industrial resources integration and other fields revolving around titanium industry. And leading titanium dioxide producer CNNC Hua Yuan would set integration of industrial chain as its strategic goal. Experiences show that ilmenite self-sufficiency has played an important role in improving TiO_2 quality, reducing operating cost and boosting financial results. Given that, the company will focus on expanding ilmenite capacity via M&A to build a stable ilmenite supply chain.

On the other hand, domestic chloride process TiO_2 producers have to use imported high-grade titanium ore because the technique requires higher quality and purity of titanium ore. That is why domestic chloride process TiO_2 producers and titanium ore distributors have been looking for high-quality titanium ore sources overseas. As most of the world's large-scale high-quality titanium ore resources have been controlled by large international companies, it is very necessary for Chinese chloride process TiO_2 producers to negotiate a stable supply with high-quality titanium ore suppliers.

In 2019–2021, the dependency on ilmenite import remained above 50%, but domestic demand for high-quality ilmenite still cannot be well satisfied. In this context, domestic TiO_2 manufacturers need to continuously expand its overseas reach in search of high-quality titanium ore resources. Besides, they need to introduce new technology, increase research and development and other means to improve the optimal utilization of titanium ore resources.

8.2 Technical supporting/cooperation

In recent years, domestic TiO_2 industry leaders have begun to build facilities for chloride process TiO_2 production. Communication and cooperation between domestic and overseas technology suppliers in this sector have been increasing. It is expected that more domestic players will embrace chloride process and technological exchanges will increase further.

The cooperation between domestic TiO_2 producers and overseas technology suppliers are as follows:

On 25 Jan., 2019, LB Group announced it had signed a Strategic Cooperation Agreement with Outotec Oyj to optimize and couple the techniques and technologies of pre-reduction of ilmenite, comprehensive utilization of vanadium-titanium magnetite resources and producing chloride process titanium slag from titanium concentrate. Achievements of such cooperation would include: first, chloride process titanium slag thus produced can be used to produce chloride process TiO_2; second, recycle valuable elements such as vanadium and niobium in an efficient way.

On 1 March, 2019, LB Group announced it had reached an accommodation through friendly negotiation with Ti-Cons Jendro, Weiland und Partner Management Consultants on the legal dispute over the Contract of Technology Transfer and Technical Service for the Design, Construction and Operation of Chloride Process TiO_2 Production Line signed before. The day before, the two sides, considering the technology and management advantages from each side, signed a Letter of Intent on Cooperation in Technology Transfer and Production Optimization for the development of chloride process TiO_2.

On 31 May, 2020, LB Group announced it had signed a technical cooperation contract with Ti-Cons Technology Consulting GmbH. The two parties would cooperate in the fields of intelligent automatic control system,

production optimization, improvement of production organization, new products and product quality, environmental protection issues, reduction of production costs, etc.

However, we should notice that leaders in chloride process TiO_2 production as Chemours, Tronox Limited and Venator who have the most advanced techniques and technologies have so far never transferred the core technologies to any other company. The existing chloride process production equipment in China has been self-developed or with the help of foreign technical consultation. Since the technology adopted here in China is not complete and mature, enormous challenges and difficulties are inescapable.

Table 8.2-1 Progress of China's chloride process titanium dioxide project, 2022–2026

No.	Company	Expansion, t/a	Expected finish time
1	Shandong Lubei Chemical Co., Ltd.	60,000	2022
2	CITIC Titanium Industry Co., Ltd.	60,000	2022
3	LB Group Co., Ltd.	500,000	2022–2025
4	Hebei Jicheng New Material Co., Ltd.	480,000	2023–2025
5	Pangang Group Vanadium & Titanium Resources Co., Ltd.	60,000	2024
6	Guangdong Dinglong Industrial Group Co., Ltd.	500,000	2026

Source: CCM

8.3 Development of titanium dioxide for special purpose

Due to the stricter environmental protection policies in China recent years, the demand for TiO_2-based SCR (selective catalytic reduction) catalyst has grown strong. SCR catalyst is of importance to nitric oxide pollution reduction and is mainly composed of nanoscale TiO_2. It not only saves energy and protects the environment, but also shows good photostability and high reactivity in the reaction. With features of non-toxicity, low cost and no secondary pollution, it is a nano-functional material with wide application prospect. Currently, nanoscale TiO_2 is mainly used in wastewater treatment, air purification, sterilization, medical technology and environmental protection material production. It is worth noting that new applications also boost the demand for nanoscale TiO_2. Such as nanoscale TiO_2 for lithium batteries, which is an excellent lithium battery material because of its good lithium intercalation capacity, low toxicity, low energy consumption, good stability, and eco-friendliness. Besides, it can also be used for some capacitor materials, solar energy materials, temperature-reducing and energy-saving materials, etc.

In addition, real estate and automobile industries are in need of ever more high-end TiO_2 products. Seeing this, domestic TiO_2 producers have been hurrying up to develop higher-quality special purpose TiO_2 to fill the market gap. For example:

- In Dec. 2019, LB Group applied for a patent of a preparation method of super-weather-resistant titanium dioxide, which enables the surface of TiO_2 to form a more uniform and dense film layer by adopting a special surface treatment process. Products thus obtained also have excellent dispersity and storage stability, and has quite good applicability in formulas in downstream customers due to small coating amount.
- In June 2020, TiO_2 type DR-2589 developed by Kunming Donghao Titanium Co., Ltd. and Inter-China Chemical Co., Ltd. debuted. It is reported that DR-2589 is used in high weather-resistant plastics, with properties of good lightness in coloring, hiding power and dispersion, excellent processability, thermal resistance and chalking resistance.

8.4 Trading

In Nov. 2020, the Ministry of Commerce and the General Administration of Customs of the People's Republic of China issued the NO. 54 Notice on the Adjustment of the Catalogue of Commodities Prohibited from Processing Trade (the Catalogue). TiO_2 was removed from the Catalogue since 1 Dec. 2020, which is propitious to TiO_2 export.

With improvement in quality and broadening application, the competitiveness of China's TiO_2 has been greatly

improved in recent years. China's TiO_2 export volume has maintained a rapid growth, and more and more foreign end users have turned their eyes to China. Domestic producers are actively exploring overseas markets. In addition, due to the COVID and high energy costs, the operating rate of TiO_2 industry in some foreign countries has reduced, which is conducive to China's TiO_2 exports.

CCM believes that it would be wise for foreign companies to work with domestic producers to establish distribution networks worldwide.

9 Contact information of major producers in China

Table 9-1 Contact information of major producers in China

No.	Producer	Website	Telephone	Fax	Address
1	LB Group Co., Ltd.	www.lomonbillions.com	86-391-3126553/3126699	86-391-3126111	No. 1669 Jiaoke Road, Jiaozuo City, Henan Province, P. R. China
2	CNNC Hua Yuan Titanium Dioxide Co., Ltd.	www.zhtb.com	86-555-3501312	86-555-3501312	No. 8 Xingfu Road, Zhangjing Industrial Park, Xibei Town, Xishan District, Wuxi City, Jiangsu Province, P. R. China
3	Pangang Group Vanadium & Titanium Resources Co., Ltd.	www.pgvt.cn	86-812-3385366	86-812-3385285	Pangang Culture Square, 21 Pangang Avenue, East District, Panzhihua City, Sichuan Province, P. R. China
4	GPRO Investment Holding Group Co., Ltd.	www.nthcl.com	86-025-58366818	86-025-58366800	No. 229 East Dawei Road, Nanjing Chemical Industry Park, Jiangsu Province, P. R. China
5	Shandong Doguide Group Co., Ltd.	www.doguide.net	86-533-4161746	86-533-4167746	No. 55 Hengli River, Qiugu, Boshan District, Zibo City, Shandong Province, P. R. China
6	China National Chemical Co., Ltd.	www.chemchina.com/portal/index.htm	86-776-2994352/86-531-67612778	86-776-2993908/86-531-67612796	No. 62 North Sihuan West Road, Haidian District, Beijing Municipality, P. R. China
7	Shandong Lubei Chemical Co., Ltd.	www.lubeichem.com	86-543-6455877/86-543-6452777	86-543-6451577	Lubei High-tech Development Zone, Wudi County, Binzhou City, Shandong Province, P. R. China
8	Shandong Dawn Titanium Industry Co., Ltd.	www.dawntio2.com	86-535-8825068	/	New Materials, New Energy Industrial Park, Longkou Economic Development Zone, Longkou City, Shandong Province, P. R. China
9	Guangxi Jinmao Titanium Co., Ltd.	www.jinmaotaiye.cn	86-774-7301933	86-774-7290558	Chemical Industrial Park, Teng County, Wuzhou City, Guangxi Zhuang Autonomous Region, P. R. China
10	Yunnan Dahutong Industrial & Trade Co., Ltd.	www.yndht.com	86-871-68327488/86-812-6211371	86-871-68316444/86-812-6210817	20th Floor, Building A, Hecheng International, No. 1088 Haiyuan Middle Road, High-tech Zone, Kunming City, Yunnan Province, P. R. China
11	Ningbo Xinfu Titanium Dioxide Co., Ltd.	www.xinfu-tio2.com	86-574-86669696	86-574-86669818	No. 1 Yuejintang Road, Zhenhai District, Ningbo City, Zhejiang Province, P. R. China
12	Panzhihua Taihai Technology Co., Ltd.	www.tisea.cn	86-812-6210820	86-812-6210820	Vanadium Titanium Industrial Park, Panzhihua City, Sichuan Province, P. R. China
13	Anhui Annada Titanium Industry Co., Ltd.	www.andty.com	86-562-3867940	86-562-3864285	No. 1288 South Section of Tongguan Avenue, Tongling City, Anhui Province, P. R. China
14	Guangdong Huiyun Titanium Industry Co., Ltd.	www.gdtitanium.com	86-766-8611868	86-766-8613336	Fuxing Road, Liudu Town, Yunan District, Yunfu City, Guangdong Province, P. R. China
15	CITIC Titanium Industry Co., Ltd.	www.jzty.com.cn	86-416-7183439/7182822	86-416-7182388	No. 1 Jintai Road, Taihe District, Jinzhou City, Liaoning Province, P. R. China
16	Panzhihua Haifengxin Chemical Industry Co., Ltd.	www.tioxite.com	86-812-6210138	86-812-6210199	No. 70 Taiyuan Road, Vanadium Titanium Industrial Park, Panzhihua City,

No.	Producer	Website	Telephone	Fax	Address
					Sichuan Province, P. R. China
17	Guangxi Shunfeng Titanium Industry Co., Ltd.	www.shunfeng.cc	86-774-2678099	86-774-2678080	No. 15 Longcheng East Road, Longxu Town, Longxu District, Wuzhou City, Guangxi Zhuang Autonomous Region, P. R. China
18	Panzhihua Xingzhong Titanium Industry Co., Ltd.	www.xztypt.com	86-812-621369	/	Vanadium Titanium High-tech Industrial Park, Panzhihua City, Sichuan Province, P. R. China
19	Jiangxi Tikon Titanium Co., Ltd.	/	86-794-8355555	86-794-8352555	No. 4 Antang Road, Fubei Town, Linchuan District, Fuzhou City, Jiangxi Province, P. R. China
20	Kunming Donghao Titanium Co., Ltd.	www.kmdhty.cn	86-871-68854222	/	Kunming Titanium Salt Industrial Base, Fumin County, Kunming City, Yunnan Province
21	Panzhihua Hengtong Titanium Co., Ltd.	www.hengtongty.com	86-812-3509212	86-812-3509218	No. 31 Titanium Avenue, Vanadium Titanium High-tech Industrial Development Zone, Panzhihua City, Sichuan Province, P. R. China
22	Guizhou Sunward Fuquan Chemicals Co., Ltd.	www.sunwardchemical.com	86-871-63102972	/	Shuanglong Industrial Park, Niuchang Town, Fuquan City, Qiannan Prefecture, Guizhou Province, P. R. China
23	Suzhou Hongfeng Titanium Industry Co., Ltd.	www.szhongfeng.com.cn	86-512-65396890	86-512-66729852	No. 151 Bao'an Road, High-tech Zone, Suzhou City, Jiangsu Province, P. R. China
24	Fumin Longteng Titanium Industry Co., Ltd.	/	86-871-68854066	86-871-68854068	Beiying Titanium Industrial Park, Yongding Town, Fumin County, Kunming City, Yunnan Province, P. R. China
25	Wuhan Fangyuan Titanium Dioxide Co., Ltd.	www.fytb.com	86-027-83412402	86-027-83412907	HSBC Corporate Headquarters, Qiaokou District, Wuhan City, Hubei Province, P. R. China
26	Alfa Full (Guangxi Tengxian) Titanium Dioxide Co., Ltd.	www.alfafull.com	86-774-7502178	86-774-7502121	Mengjiang Town, Teng County, Nanning City, Guangxi Zhuang Autonomous Region, P. R. China
27	Panzhihua Tianlun Chemical Co., Ltd.	www.pzhtl.com	86-812-3161186	86-812-3161196	An'ning Industrial Zone, Yanbian County, Panzhihua City, Sichuan Province, P. R. China
28	Yibin Tianyuan Haifeng hetai Co., Ltd.	www.ybty.com	86-831-5980821	86-831-5980823	No. 61 Port Park Road, Lingang Economic and Technological Development Zone, Yibin City, Sichuan Province, P. R. China
29	Panzhihua Taidu Chemicals Co., Ltd.	/	86-510-83220520	86-510-83220520	Vanadium Titanium Industrial Park, Panzhihua City, Sichuan Province, P. R. China
30	Nexttech Materials Co., Ltd.	www.nexttechmat.com	86-562-5327558	/	Jincheng Industrial Park, Tongling City, Anhui Province, P. R. China
31	CNMC (Guangxi) Pgma Co., Ltd.	/	86-774-8835566	86-774-8836098	No.1 Power Plant South Road, Pinggui District, Hezhou City, Guangxi Zhuang Autonomous Region, P. R. China
32	Denox Advanced Materials	denox.net.cn	86-562-2611727	86-562-2611099	No. 399 Changshan Avenue, Economic

No.	Producer	Website	Telephone	Fax	Address
	Co., Ltd.				and Technological Development Zone, Tongling City, Anhui Province, P. R. China
33	Shanghai Pengbo Titanium Dioxide Co., Ltd.	www.pengbotio2.com	86-021-57266998	86-021-57266998	No. 55 Lane 66, Xiasheng Road, No. 2 Industrial Zone, Jinshanwei Town, Jinshan District, Shanghai Municipality, P. R. China
34	Guangxi Detian Chemical Cycle Co., Ltd.	www.gxdtchem.com	86-771-3723388	86-771-3723388	Leiping Town, Daxin County, Guangxi Zhuang Autonomous Region, P. R. China
35	Huai'an Feiyang Titanium Dioxide Manufacturing Co., Ltd.	/	86-517-85730098	86-517-85733099	Erbao Village, Shitang Town, Huaian District, Huaian City, Jiangsu Province, P. R. China
36	Guangxi Xilong Chemical Co., Ltd.	www.bb-hy.com	86-775-8736388	/	Wangmao Industrial Park, Bobai County, Yulin City, Guangxi Zhuang Autonomous Region, P. R. China
37	Hunan Chuangda Yutu Chemcial Co., Ltd.	www.hncdyt.cn	86-734-8300502	86-734-8300502	Jinjialing Village, Chashan'ao Town, Zhuhui District, Hengyang City, Hunan Province, P. R. China
38	Guangxi Baihe Chemical Co., Ltd.	/	86-771-5508881	86-771-5511380	Baihe Base of Pingguo County, Guangxi Zhuang Autonomous Region, P. R. China
39	Panzhihua Zhengyuan Technology Co., Ltd.	/	86-812-8102209	/	Baima Vanadium and Titanium Industrial Park, Miyi County, Panzhihua City, Sichuan Province, P. R. China
40	Yumen Jingyang Titanium Pigment Manufacturing Co., Ltd.	/	86-937-3272185	86-937-3272186	Jianhua Industrial Park, Yumen East Town, Yumen City, Gansu Province, P. R. China

Source: CCM

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