

China Pentaerythritol Market Research

The Eighteenth Edition
September 2022

Researched & Prepared by:

Kcomber Inc.

Copyright by Kcomber Inc.

Any publication, distribution or copying of the content in this report is prohibited.

Contents

Executive summary	1
Methodology	2
1 Market situation of pentaerythritol	4
1.1 Pentaerythritol development in the world	4
1.2 Pentaerythritol development in China	5
1.3 Product types of pentaerythritol	5
2 Production of pentaerythritol in China	7
2.1 Supply of major raw materials of pentaerythritol	7
2.2 Energy prices in 2021	10
2.3 Price of pentaerythritol	12
2.4 Geographical distribution of producers	13
2.5 Production of pentaerythritol	14
2.6 Summary of Chinese manufacturers and five major producers of pentaerythritol	19
3 Production technology of pentaerythritol in China	22
3.1 Brief introduction and comparison of different production pathways/methods	22
3.2 Technology problems of pentaerythritol	24
3.3 Technology achievements of pentaerythritol research	24
4 Industry analysis in China	26
4.1 SWOT analysis	26
4.2 Competitiveness analysis of Chinese pentaerythritol industry	27
5 Import and export analysis	29
5.1 Anti-dumping duty on pentaerythritol	29
5.2 Import and export of pentaerythritol, 2021	29
6 Consumption of pentaerythritol in China	35
6.1 Consumption pattern	35
6.2 Consumption in major end-use segments	35
6.3 Brief introduction to each major end use segment	36
6.3.1 Alkyd resin	36
6.3.2 Polyurethane	38
6.3.3 Lubricant (high-grade)	39
6.3.4 Rosin pentaerythritol ester	40
6.3.5 Others	41
6.4 Consumption of dipentaerythritol in China and main users	42
6.5 Consumption of tripentaerythritol in China	43
7 Future forecast	44
7.1 Key factors and driving forces for development	44
7.2 Outlook for pentaerythritol industry, 2022–2026	44
8 Conclusions	46
9 Profile of pentaerythritol manufacturers	47
9.1 Active manufacturers	47
9.1.1 Chifeng Ruiyang Chemical Co., Ltd.	47
9.1.2 Hubei Yihua Chemical Industry Co., Ltd.	48
9.1.3 Puyang Pengxin Chemical Co., Ltd.	50
9.1.4 Anhui Jinhe Industrial Co., Ltd.	51
9.1.5 Bazhou Shengfang United Chemical Co., Ltd.	52
9.1.6 Yunnan Yuntianhua Co., Ltd.	53
9.1.7 Shijiazhuang Shuangyan Chemical Co., Ltd.	55
9.1.8 Shandong IFT Science & Technology Co., Ltd.	56
9.1.9 Puyang Yongan Chemical Co., Ltd.	57

9.1.10 Shandong Xinzhiyuan Chemical Co., Ltd.	59
9.1.11 Ningxia Ningshun New Material Technology Co., Ltd.	59
9.2 Idle manufacturers	60
9.2.1 Baoding Guoxiu Chemical Industry Co., Ltd.	60
10 Overview of pentaerythritol market in China, 2019–2023	61

LIST OF TABLES

Table 1.2-1 Pentaerythritol development in China
Table 2.1-1 Unit consumption of major raw materials for pentaerythritol production in China
Table 2.1-2 Production, import, export and apparent consumption of methanol in China, 2017–2021
Table 2.1-3 Production, import, export and apparent consumption of formaldehyde in China, 2017–2021
Table 2.1-4 Production, import, export and apparent consumption of sodium hydroxide in China, 2017–2021
Table 2.1-5 Production, import, export and apparent consumption of sulfuric acid in China, 2017–2021
Table 2.2-1 Energy market prices in China pentaerythritol producers' location, 2021
Table 2.4-1 Capacity and output of pentaerythritol producers in China, 2021
Table 2.5-1 Output of monopentaerythritol, dipentaerythritol and tripentaerythritol in China, 2017–H1 2022, tonne
Table 2.5-2 Basic information of pentaerythritol producers in China
Table 2.5-3 Capacity of monopentaerythritol producers in China, 2019–H1 2022, t/a
Table 2.5-4 Capacity and output of dipentaerythritol producers in China, 2019–H1 2022
Table 2.6-1 Capacity and share of main pentaerythritol manufacturers in China, 2019–2021
Table 2.6-2 Output and share of main pentaerythritol manufacturers in China, 2019–2021
Table 2.6-3 Methanol and acetaldehyde situation of top five manufacturers
Table 2.6-4 Average market price of ethanol at the locations of top two producers, 2021
Table 3.1-1 Monopentaerythritol technology source of Chinese producers, 2021
Table 3.3-1 Patents related to pentaerythritol production applied in China, Jan. 2017–June 2022
Table 4.1-1 SWOT analysis of Hubei Yihua's development in 2021
Table 4.1-2 SWOT analysis of Chifeng Ruiyang's development in 2021
Table 4.1-3 SWOT analysis of Yunnan Yuntianhua's development in 2021
Table 4.1-4 SWOT analysis of Shandong Xinzhiyuan's development in 2021
Table 5.2-1 China's imports and exports of pentaerythritol, 2017–2021
Table 5.2-2 China's import and export volume of monopentaerythritol, dipentaerythritol and tripentaerythritol, 2021, tonne
Table 5.2-3 China's exports of pentaerythritol by destination, 2021
Table 5.2-4 China's imports of pentaerythritol by origin, 2021
Table 5.2-5 China's exports of pentaerythritol by producer, 2021
Table 7.2-1 Forecast on pentaerythritol development in China by output share, 2022–2026
Table 9.1.1-1 Capacity and output of pentaerythritol in Chifeng Ruiyang, 2017–H1 2022
Table 9.1.1-2 Quotation of pentaerythritol in Chifeng Ruiyang, 2017–2022, USD/t
Table 9.1.1-3 Chifeng Ruiyang's export volume of pentaerythritol, 2017–2021
Table 9.1.2-1 Capacity and output of pentaerythritol in Hubei Yihua, 2017–H1 2022

Table 9.1.2-2 Quotation of pentaerythritol in Hubei Yihua, 2017–2022, USD/t
 Table 9.1.2-3 Hubei Yihua's export volume of pentaerythritol, 2017–2021
 Table 9.1.3-1 Capacity and output of pentaerythritol in Puyang Pengxin, 2017–H1 2022
 Table 9.1.3-2 Quotation of pentaerythritol in Puyang Pengxin, 2017–2022, USD/t
 Table 9.1.4-1 Capacity and output of pentaerythritol in Anhui Jinhe, 2017–H1 2022
 Table 9.1.4-2 Quotation of pentaerythritol in Anhui Jinhe, 2017–2022, USD/t
 Table 9.1.5-1 Capacity and output of pentaerythritol in Bazhou Shengfang, 2017–H1 2022
 Table 9.1.5-2 Quotation of pentaerythritol in Bazhou Shengfang, 2017–2022, USD/t
 Table 9.1.6-1 Capacity and output of pentaerythritol in Yunnan Yuntianhua, 2017–H1 2022
 Table 9.1.6-2 Quotation of pentaerythritol in Yunnan Yuntianhua, 2017–2022, USD/t
 Table 9.1.7-1 Capacity and output of pentaerythritol in Shijiazhuang Shuangyan, 2018–H1 2022
 Table 9.1.7-2 Quotation of pentaerythritol in Shijiazhuang Shuangyan, 2018–2022, USD/t
 Table 9.1.8-1 Capacity and output of pentaerythritol in Shandong IFT, 2017–H1 2022
 Table 9.1.8-2 Quotation of pentaerythritol in Shandong IFT, 2017–2022, USD/t
 Table 9.1.9-1 Capacity and output of pentaerythritol in Puyang Yongan, 2017–H1 2022
 Table 9.1.9-2 Quotation of pentaerythritol in Puyang Yongan, 2017–2022, USD/t
 Table 10-1 Overview of pentaerythritol market in China, 2019–2023, tonne
 Table 10-2 Overview of monopentaerythritol market in China, 2019–2023, tonne
 Table 10-3 Overview of dipentaerythritol market in China, 2019–2023, tonne

LIST OF FIGURES

Figure 1.3-1 Product structure of pentaerythritol in China by capacity, 2021
 Figure 2.1-1 Ex-works price of 99.9% purified methanol in China, Jan. 2017–June 2022
 Figure 2.1-2 Ex-works price of 37% formaldehyde in China, Jan. 2017–June 2022
 Figure 2.3-1 Ex-works price of monopentaerythritol in China, 2017–2022
 Figure 2.3-2 Ex-works price of dipentaerythritol in China, 2017–2022
 Figure 2.4-1 Geographical distribution of pentaerythritol producers in China, 2021
 Figure 2.5-1 Capacity and output of pentaerythritol in China, 2017–H1 2022
 Figure 5.2-1 China's imports and exports of pentaerythritol, 2017–2021
 Figure 5.2-2 China's imports and exports of pentaerythritol by month, Jan. 2018–Dec. 2021
 Figure 5.2-3 Top ten export destinations of pentaerythritol from China by volume, 2021
 Figure 5.2-4 Top import origins of pentaerythritol in China by volume, 2021
 Figure 5.2-5 Classification of pentaerythritol exporters in China, 2017–2021
 Figure 6.1-1 Apparent consumption of pentaerythritol in China by end use segment, 2021
 Figure 6.2-1 Apparent consumption of pentaerythritol in China by end-use segment, 2017–2021
 Figure 6.3.1-1 Pentaerythritol consumption volume in alkyd resin in China, 2017–2021
 Figure 6.3.1-2 Output of coating in China, 2017–2021
 Figure 6.3.1-3 Output and sales volume of automobile in China, 2017–2021
 Figure 6.3.1-4 China's import & export of alkyd resin (HS Code: 39075000), 2017–2021
 Figure 6.3.2-1 Pentaerythritol consumption volume in polyurethane in China, 2017–2021
 Figure 6.3.3-1 Pentaerythritol consumption volume in high-grade lubricant in China, 2017–2021
 Figure 6.3.4-1 Pentaerythritol consumption volume in rosin pentaerythritol ester in China, 2017–2021
 Figure 6.3.5-1 Pentaerythritol consumption volume in other fields in China, 2017–2021
 Figure 7.2-1 Forecast on pentaerythritol output in China, 2022–2026

Executive summary

Facing with increasingly stringent environmental standards, high production costs, fierce competition and other factors, China's pentaerythritol industry structure has been continuously optimized and upgraded.

- Production

As the world's largest producer of pentaerythritol, China had 276,500 t/a production capacity as of 2021. In 2021, China's pentaerythritol output was 182,080 tonnes, up 11.2% year on year, and the output of dipentaerythritol increased by 18.5% year on year.

In 2021, there were twelve pentaerythritol producers in China, among which, Hubei Yihua Chemical Industry Co., Ltd. (Hubei Yihua) and Chifeng Ruiyang Chemical Co., Ltd. (Chifeng Ruiyang) were two leading pentaerythritol producers in domestic market. Baoding Guoxiu Chemical Industry Co., Ltd. was still in suspension because its relocation has not been completed yet.

- Consumption

In China, pentaerythritol is mainly consumed in production of alkyd resin, polyurethane (PU), synthetic lubricant, rosin pentaerythritol ester. In 2021, pentaerythritol consumption in the key downstream sector alkyd resin was 68,500 tonnes. It is estimated that the demand from alkyd resin will decrease slowly in the future.

- Import and export

In 2021, China's import volume and export volume of pentaerythritol were 5,543 tonnes and 65,932 tonnes respectively, up by 42.3% and 38.7% year on year respectively. China's export volume of dipentaerythritol was 3,946 tonnes, up by 9.1% year on year.

South Korea, Brazil and The US were the three largest export destinations of China's pentaerythritol by volume, together accounting for 26.4% of the national total export volume in 2021. Sweden was the top import origin of pentaerythritol to China by volume, followed by Taiwan Province and Germany. China's import volume from Sweden accounted for 59.1% of the national total in 2021.

Methodology

- Methodology

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. When necessary, checks were made with Chinese pentaerythritol suppliers regarding market information such as key producers, key end-users, production and export and so on.

2) Telephone interview

CCM has carried out extensive telephone interviews in order to grasp the actual market situation of pentaerythritol in China.

Interviewees cover:

- Producers
- End users
- Traders
- Associations

3) Internet

CCM contacted with players in this industry through B2B websites.

Data processing and presentation

The data collected and compiled were sourced from:

- CCM's own database
- Published articles from periodicals, magazines and journals
- Statistics from governments and international institutes
- Telephone interviews with domestic suppliers, end users, government, industrial experts
- Third-party data providers
- 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 were made in order to analyse the data and have conclusions drawn.

- Unit

- Tonne: equals to metric ton in this report
- /t: per tonne
- t/a: tonne/annual, tonne per year
- USD: US dollar, currency unit in the US
- RMB: currency unit in China, also named yuan

Table null-1 Regions covered

Regions covered (Chinese mainland)	Name
Province (22)	Heilongjiang, Jilin, Anhui, Fujian, Liaoning, Hebei, Shandong, Gansu, Qinghai, Henan, Sichuan, Jiangsu, Hubei, Hunan, Jiangxi, Zhejiang, Guangdong, Shaanxi, Hainan, Shanxi, Guizhou, Yunnan
Autonomous region (5)	Guangxi, Inner Mongolia, Tibet, Xinjiang, Ningxia
Municipality (4)	Beijing, Shanghai, Tianjin, Chongqing

Table null-2 Exchange rate USD/CNY, Jan. 2016–June 2022

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
2016	6.5527	6.5311	6.5064	6.4762	6.5315	6.5874	6.6774	6.6474	6.6715	6.7442	6.8375	6.9182	6.6425
2017	6.8918	6.8713	6.8932	6.8845	6.8827	6.8019	6.7772	6.7148	6.5909	6.6493	6.6300	6.6067	6.7662
2018	6.5079	6.3045	6.3352	6.2764	6.3670	6.4078	6.6157	6.8293	6.8347	6.8957	6.9670	6.9431	6.6070
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	-	-	-	-	-

Source: The People's Bank of China

1 Market situation of pentaerythritol

1.1 Pentaerythritol development in the world

- Supply

Since 2002, the output of pentaerythritol in Europe has been dropping for these reasons: for one thing, consumption of alkyd resin decreased drastically in Europe under stricter environmental requirements; for another, the production cost of pentaerythritol in Europe was quite high.

Along with the fast development of pentaerythritol in China before 2010, pentaerythritol production has shifted to Asia gradually. Due to the high cost in raw materials and environmental protection, some large overseas companies which used to be pentaerythritol producers have turned to purchase pentaerythritol from Asia.

At present, Asia, North America and Europe are the main pentaerythritol production areas in the world. In 2020, pentaerythritol production was not only affected by the aftermath of COVID-19, but also challenged with factors such as shortage of raw materials, and other natural disasters. For example, there were shortages of raw materials in Europe and Asia, and severe hurricanes in North America after November, which caused tight supply of pentaerythritol. In 2021, general COVID-19 situation eased, the supply recovered due to resumed production of pentaerythritol producers. However, producers in the world experienced greater cost pressure with jumping prices of raw materials, as well as rising freight and energy cost, which impacted their production to some degree.

Key players in pentaerythritol business outside mainland China include Perstorp Holding AB, Ercros SA, Celanese Corp., Evonik, LCY Chemical Corp.

Perstorp, the largest pentaerythritol supplier worldwide, strengthened its global supply system of pentaerythritol through production expansion. On the one hand, in 2019, Perstorp planned to build a new 40,000 t/a pentaerythritol production line in India, which is expected to be put into production in Q1 2023. On the other hand, in 2019, Perstorp expanded the effective pentaerythritol production capacity at its Bruchhausen plant in Germany by 12.5%. (Unfortunately, in April 2021, the plant was completely closed for more than a month due to pressure vessel leakage, which eventually led to a significant drop in the company's pentaerythritol output in H1 2021).

- Consumption

Many grades of pentaerythritol are consumed; the most popular one is monopentaerythritol (pure) with a minimum purity of 98%.

As for the downstream, alkyd resin, polyurethane, rosin pentaerythritol ester, tall oil ester and pentaerythritol tetranitrate are the major end-users of pentaerythritol, among which alkyd resin is the largest consumer. Every year, the volume of pentaerythritol consumed in alkyd resin accounts for about 55%–60% of the total consumption globally. The consumption in alkyd resin sector in Europe has seen slower growth in recent years, while that in Asia has been rising. Besides, Asia is the largest pentaerythritol consuming region.

- Price

Till 2008, the global price of pentaerythritol increased year by year and in 2008, the price hit a record high of USD2,300/t. However, the financial crisis erupting in late 2008 brought down the price.

In 2013, Perstorp raised the price of its pentaerythritol for many times.

In 2017, the global price of pentaerythritol continued to increase mainly because of rising raw material costs. During Dec. 2016–March 2018, the price of Perstorp's pentaerythritol in Asian-Pacific region went up USD370/t. In 2019, the price gradually declined.

In 2020–2021, global prices of pentaerythritol witnessed a significant rise, given the increasing raw materials prices. In addition, rising demand from downstream sectors drove up the prices of pentaerythritol. Perstorp, for instance, increased the price of its pentaerythritol in Europe, Middle East and Africa by USD354/t since 1 July, 2021. And pentaerythritol price in North America rose from USD1,850/t in April 2021 to about USD2,100/t in Dec. 2021.

In Q1 2022, global pentaerythritol prices continued to increase.

1.2 Pentaerythritol development in China

Table 1.2-1 Pentaerythritol development in China

Development stage of pentaerythritol	Main event
Beginning stage (1957–1989)	In 1957, Shanghai Reagent Factory initiated the production of pentaerythritol in China, and its output was 20 tonnes at that time. By 1986, the output of pentaerythritol in China reached 14,000 tonnes.
Growth stage (1990–2007)	<p>1990–1998 Driven by the ever-increasing import volume, some domestic production lines were established, but their capacity of pentaerythritol was small, with a maximum volume of less than 5,000 t/a. By the end of 1997, there had been 29 pentaerythritol producers in China, and the total capacity of the active producers was 52,000 t/a, with the operating rate of no more than 58%.</p> <p>1999–2002 By 2002, the number of pentaerythritol producers was reduced to 20, and the total output and apparent consumption of pentaerythritol in China were 51,000 tonnes and 60,000 tonnes, increasing by 299% and 376% respectively over 1990. The annual import volume was around 7,500–10,500 tonnes, while the export volume was less than 300 tonnes.</p> <p>2003–2007 The total capacity of pentaerythritol rose to 167,000 t/a in 2007 from 99,000 t/a in 2003. The operating rate in this period was around 70%–100% and the domestic apparent consumption volume was more than 100,000 tonnes in 2005. In addition, the export volume increased sharply, reaching 46,000 tonnes in 2007, with a CAGR of 55.6% in 2003–2007. Since 2003, China has become a net exporter of pentaerythritol.</p>
Mature stage (2008–2021)	<p>2008–2014 The annual domestic output of pentaerythritol slowed down its growth in this period. And during this time, pentaerythritol in China started to be produced by several major manufacturers, while other manufacturers suspended production or even exited. The export volume of pentaerythritol fluctuated between 52,000 tonnes and 66,000 tonnes in 2008–2013. In 2014, the export slumped to 43,400 tonnes, the lowest since 2008. By contrast, the import volume of pentaerythritol maintained no more than 3,000 tonnes in this period. Asia was the major market of China's pentaerythritol, and its share in total export volume increased from 35% in 2010 to 49% in 2014.</p> <p>2015–2021 The output of pentaerythritol plunged in 2014, and further dropped by 9.0% year on year to 171,500 tonnes in 2015. Although it recovered slightly in 2016 thanks to improved overall situation in chemical industry, the output kept decreasing in 2017–2020. In 2018–2019, two major pentaerythritol producers in China suspended part of their production lines, and in 2020, the industry was affected by the COVID-19, with exports slashed to less than 50,000 tonnes. As the COVID-19 situation eased in 2021, strong demand boosted the output of pentaerythritol significantly, and China recorded the highest imports and exports of pentaerythritol in the past decade. In 2021, the capacity of pentaerythritol in China increased to 276,500 t/a, as there were two new entrants into this industry.</p>

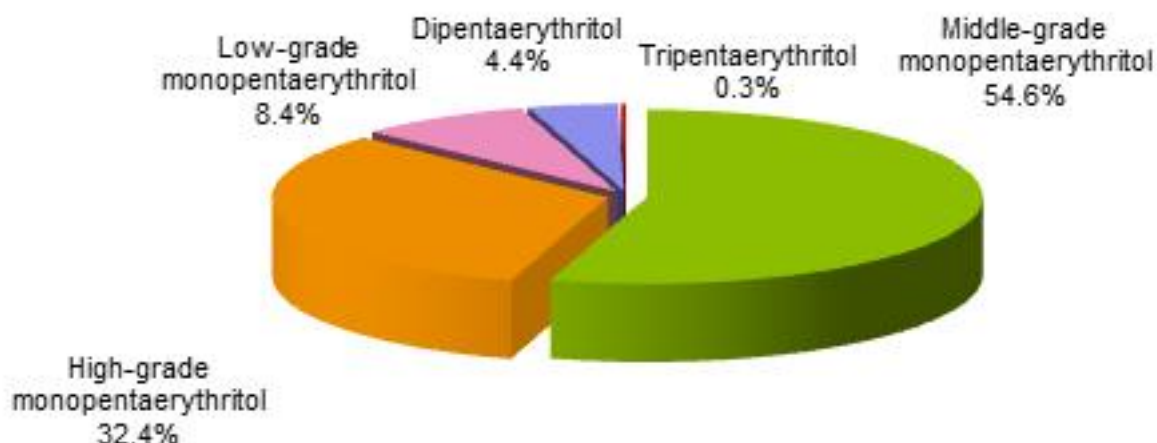
Source:CCM

1.3 Product types of pentaerythritol

Pentaerythritol can be classified as follows:

- Low-grade monopentaerythritol: 93% max.
- Middle-grade monopentaerythritol: 94%–97%
- High-grade monopentaerythritol: 98% min.
- Dipentaerythritol: 85% or 90%
- Tripentaerythritol

Figure 1.3-1 Product structure of pentaerythritol in China by capacity, 2021



Source:CCM

- Monopentaerythritol

Nearly 97% pentaerythritol produced in China is monopentaerythritol, which is mainly consumed in alkyd resins, polyurethane, rosin pentaerythritol ester and lubricant.

Capacity of most pentaerythritol producers in China has remained unchanged since 2015, but there were changes as the following:

- Hubei Yihua Chemical Industry Co., Ltd. cut its pentaerythritol capacity by 8,000 t/a to 70,000 t/a in 2017.
- Chifeng Ruiyang Chemical Co., Ltd. (Chifeng Ruiyang) cut its pentaerythritol capacity by 60,000 t/a to 60,000 t/a in 2018, by 15,000 t/a to 45,000 t/a in 2019, and by 2,000 t/a to 43,000 t/a in 2020.
- Ningxia Ningshun New Material Technology Co., Ltd.'s 14,000 t/a pentaerythritol project and Shandong Xinzhiyuan Chemical Co., Ltd.'s 30,000 t/a pentaerythritol project were put into trial production in Oct. and Nov. 2021, respectively.

- Dipentaerythritol

Dipentaerythritol is used for the production of high-level paint for high temperature purpose and aviation lubricant.

Although many producers claim that they have the ability to produce dipentaerythritol, the actual production scale is still small. In 2021, there were eleven dipentaerythritol producers in China with total capacity of 12,500 t/a. Chifeng Ruiyang, with 2,500 t/a production capacity, is the largest dipentaerythritol producer in China.

In the long term, dipentaerythritol will be well developed in China. It is forecasted that more and more manufacturers will invest in dipentaerythritol production to earn more profit.

- Tripentaerythritol

Tripentaerythritol is used for antifoaming coating, lubricant for vehicle and motors. Up to June 2022, there were only three tripentaerythritol producers, namely Chifeng Ruiyang (200 t/a), Puyang Yongan Chemical Co., Ltd. (500 t/a) and Baoding Guoxiu Chemical Industry Co., Ltd. (100 t/a).

The optimal feedstock ratio for the preparation of tripentaerythritol is:
Formaldehyde (10%–30%): aldehyde: caustic soda = 4.2:1:1.15–1.25 (mol/mol)

The total yield is 95% min., including 8% min. of tripentaerythritol.

2 Production of pentaerythritol in China

2.1 Supply of major raw materials of pentaerythritol

Major raw materials for pentaerythritol production in China include methanol, formaldehyde, acetaldehyde, sodium hydroxide and sulfuric acid. These raw materials are fairly abundant in China, so the production of pentaerythritol is much more affected by its demand and price than by the supply of its raw materials.

Table 2.1-1 Unit consumption of major raw materials for pentaerythritol production in China

Raw material	Specification	Unit consumption, kg/t
Methanol	98%	1,300–1,350
Formaldehyde	37%	2,880–2,950
Acetaldehyde	98%	350–365
Sodium hydroxide	Technical	255
Sulfuric acid	30%	774

Source:CCM

- Methanol

From 2017 to 2021, both the supply (capacity and output) and demand of methanol in China kept increasing stably year by year.

Table 2.1-2 Production, import, export and apparent consumption of methanol in China, 2017–2021

Year	Capacity, t/a	Output, tonne	Import volume, tonne	Export volume, tonne	Apparent consumption, tonne
2017	61,250,000	53,808,827	8,144,763	126,703	61,826,887
2018	67,110,000	55,756,600	7,427,000	317,000	62,866,600
2019	74,670,000	62,157,400	10,895,900	171,000	72,882,300
2020	90,425,000	63,570,000	13,008,957	89,106	76,489,852
2021	93,445,000	75,301,800	11,197,992	392,841	86,106,951

Note: Apparent consumption=Output+Import-Export

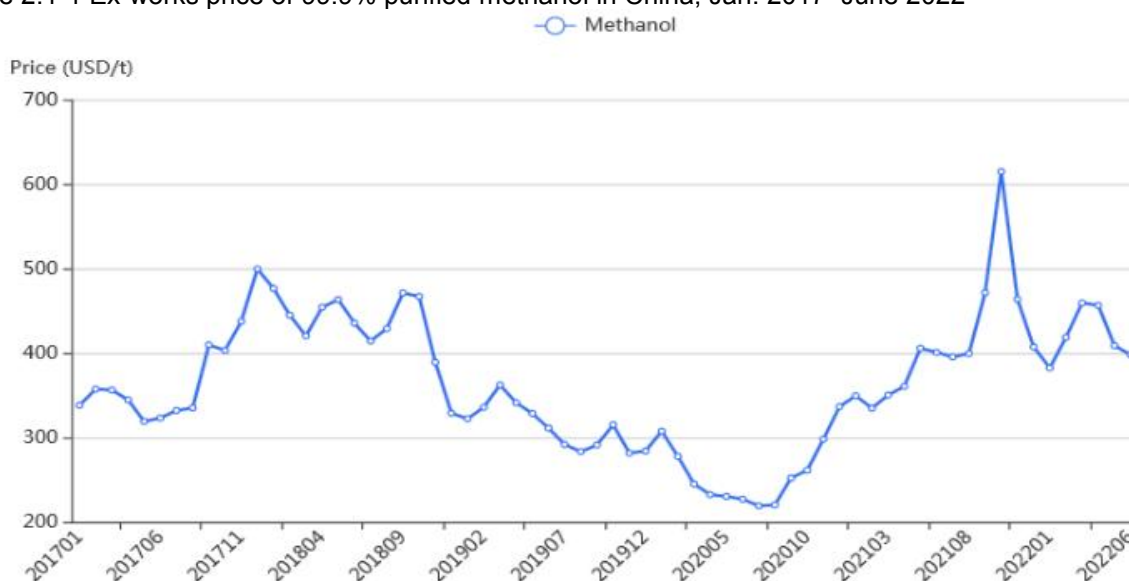
Source:China Customs & CCM

The ex-works price of 99.9% purified methanol started to rebound from the bottom in late 2015 and reached USD499/t in Dec. 2017.

Starting from 2018, the price saw another downward trend, with several fluctuations though; it decreased from USD476/t in Jan. 2018 to USD219/t in July 2020.

Since Aug. 2020, supported by recovery of the global economy and the demand, the price of methanol went upward and kept growing, hitting the highest record in Oct. 2021, to USD615/t, affected by energy shortage. Then the price fell back quickly. In H1 2022, the methanol price rose slightly and then backed to a downtrend, but the price was at a relatively high level on the whole.

Figure 2.1-1 Ex-works price of 99.9% purified methanol in China, Jan. 2017–June 2022



Source:CCM

- Formaldehyde

Generally speaking, formaldehyde is a basic and low value-added chemical. As liquid formaldehyde is inconvenient to transport, formaldehyde is usually consumed in places close to its producing area in order to reduce freight charges. And both the import and export volume of the product in China are quite small.

The output of formaldehyde in China decreased to 12,851,000 tonnes in 2017, triggered by plummeting downstream consumption. This was because major downstream wood flooring factories suspended or reduced production during central and provincial environmental protection inspections. It kept decreasing in 2018, influenced by environmental protection inspections, industrial park relocation, decreasing demand, etc. But it rebounded to 13,100,000 tonnes in 2019.

In 2020, affected by the COVID-19, demand from downstream real estate and other industries reduced, so the output declined by 9.2% year on year.

In 2021, the supply and demand of formaldehyde recovered, and the output of formaldehyde increased significantly year on year.

Table 2.1-3 Production, import, export and apparent consumption of formaldehyde in China, 2017–2021

Year	Capacity, t/a	Output, tonne	Import volume, tonne	Export volume, tonne	Apparent consumption, tonne
2017	36,000,000	12,851,000	1	8,466	12,842,535
2018	36,000,000	12,500,000	1	8,300	12,491,701
2019	36,000,000	13,100,000	3	11,768	13,088,234
2020	36,160,000	11,900,000	5	12,537	11,887,468
2021	37,010,000	14,580,000	2	4,243	14,575,759

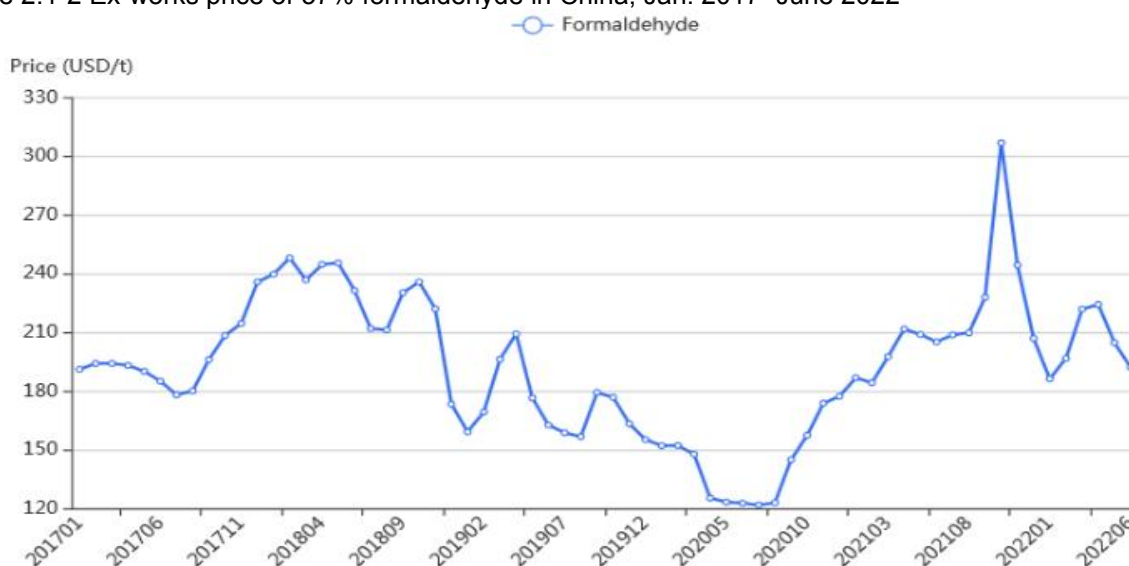
Note: Apparent consumption=Output+Import-Export
Source:China Customs & CCM

The price of formaldehyde is primarily decided by methanol price, because the cost of methanol, the key raw material of formaldehyde, accounts for around 90% of the total production cost of formaldehyde in China.

The price of formaldehyde fluctuated along with that of methanol. In H1 2017, the ex-works price of formaldehyde remained stable, then it followed an upward track till almost H1 2018. Another round of

downtrend with large fluctuations was seen later, decreasing from USD231/t in June 2018 to USD122/t in July 2020. The price quickly bounced back and rocketed to USD307/t in Oct. 2021.

Figure 2.1-2 Ex-works price of 37% formaldehyde in China, Jan. 2017–June 2022



Source:CCM

- Acetaldehyde

Acetaldehyde is an important intermediate of organic chemical products. As its boiling point is only 20.8°C, acetaldehyde is difficult to transport and typically produced in places close to where it is used.

Acetaldehyde is mainly used to produce acetic acid. However, the growth of acetaldehyde consumption in this end-use segment will slow down in the future because any new acetic acid plant will be based on the methanol carbonylation process, and little acetaldehyde will be used for acetic acid production.

The import and export volume of acetaldehyde are very small, and generally its domestic output can satisfy domestic demand.

- Sodium hydroxide and sulfuric acid

China's sodium hydroxide output kept increasing in 2017–2021. In 2021, China produced 38,913,000 tonnes of sodium hydroxide in total, up by 5.9% year on year.

In terms of sulfuric acid, in 2017–2019, domestic output slid down due to increasingly stringent environmental protection control, but it has rebounded since 2020. The output increased to 93,827,000 tonnes in 2021, edging up by 1.6% year on year.

Table 2.1-4 Production, import, export and apparent consumption of sodium hydroxide in China, 2017–2021

Year	Output, tonne	Import volume, tonne	Export volume, tonne	Apparent consumption, tonne
2017	33,652,000	9,273	536,932	33,124,341
2018	34,202,000	8,382	622,196	33,588,186
2019	34,642,000	8,497	586,077	34,064,420
2020	36,739,000	7,755	560,649	36,186,107
2021	38,913,000	10,868	387,806	38,536,061

Note:1. Apparent consumption=Output+Import-Export 2. The data of import and export in 2020 has been revised.
Source:NBS & China Customs & CCM

Table 2.1-5 Production, import, export and apparent consumption of sulfuric acid in China, 2017–2021

Year	Output, tonne	Import volume, tonne	Export volume, tonne	Apparent consumption, tonne
2017	92,129,200	1,212,853	693,264	92,648,789
2018	91,297,600	953,355	1,280,853	90,970,102
2019	89,357,000	530,538	2,174,783	87,712,755
2020	92,382,000	636,224	1,722,952	91,295,271
2021	93,827,000	414,269	2,840,301	91,400,968

Note: Apparent consumption=Output+Import-Export

Source: NBS & China Customs & CCM

2.2 Energy prices in 2021

In 2021, global economy continued recovering, despite disturbances to commodity circulation caused by repeated COVID-19 resurgences. Energy demand recovered quickly as socio-economic activities revitalized. Besides, under initiatives to switch to greener energy, gap between energy supply and demand has widened globally, as investment in traditional energy was insufficient. Consequently, prices of energy sources such as coal and gas skyrocketed, hitting new highs in recent years. The hikes in energy prices were transmitted to downstream industries, resulting in cost pressures on pentaerythritol producers.

In terms of the supply and price of coal and electricity, pentaerythritol producers in the Northwest China boast comparative advantages in cost compared with that in Central China or East China.

Table 2.2-1 Energy market prices in China pentaerythritol producers' location, 2021

No.	Producer	Location	Average market price of electricity, USD/KWh	Method of steam generation	Average market price of coal, USD/t	Average market price of gas, USD/m ³
1	Hubei Yihua Chemical Industry Co., Ltd.	Hubei	0.0678	Coal	118.30	/
2	Chifeng Ruiyang Chemical Co., Ltd.	Inner Mongolia	0.0511	Coal	91.06	/
3	Puyang Pengxin Chemical Co., Ltd.	Henan	0.0603	Coal	81.66	/
4	Anhui Jinhe Industrial Co., Ltd.	Anhui	0.0604	Coal	97.58	/
5	Yunnan Yuntianhua Co., Ltd.	Yunnan	0.0329	Coal	94.59	/
6	Puyang Yongan Chemical Co., Ltd.	Henan	0.0603	Coal	84.84	/
7	Shijiazhuang Shuangyan Chemical Co., Ltd.	Hebei	0.0654	Gas	/	0.22
8	Shandong IFT Science & Technology Co., Ltd.	Shandong	0.0651	Coal	90.00	/
9	Bazhou Shengfang United Chemical Co., Ltd.	Hebei	0.0654	Coal	87.57	/
10	Shandong Xinzhiyuan Chemical Co., Ltd.	Shandong	0.0651	Gas	/	0.24
11	Ningxia Ningshun New Material Technology Co., Ltd.	Ningxia	0.0418	Coal	82.49	/
12	Baoding Guoxiu Chemical Industry Co., Ltd.	Hubei	0.0678	Coal	118.30	/

Note: 1. Steam of Putang Pengxin, Shandong IFT and Ningxia Ningshun is mainly from procurement. 2. Steam coal is calculated as 5,500 kcal.

Source: CCM

2.3 Price of pentaerythritol

- Price of monopentaerythritol

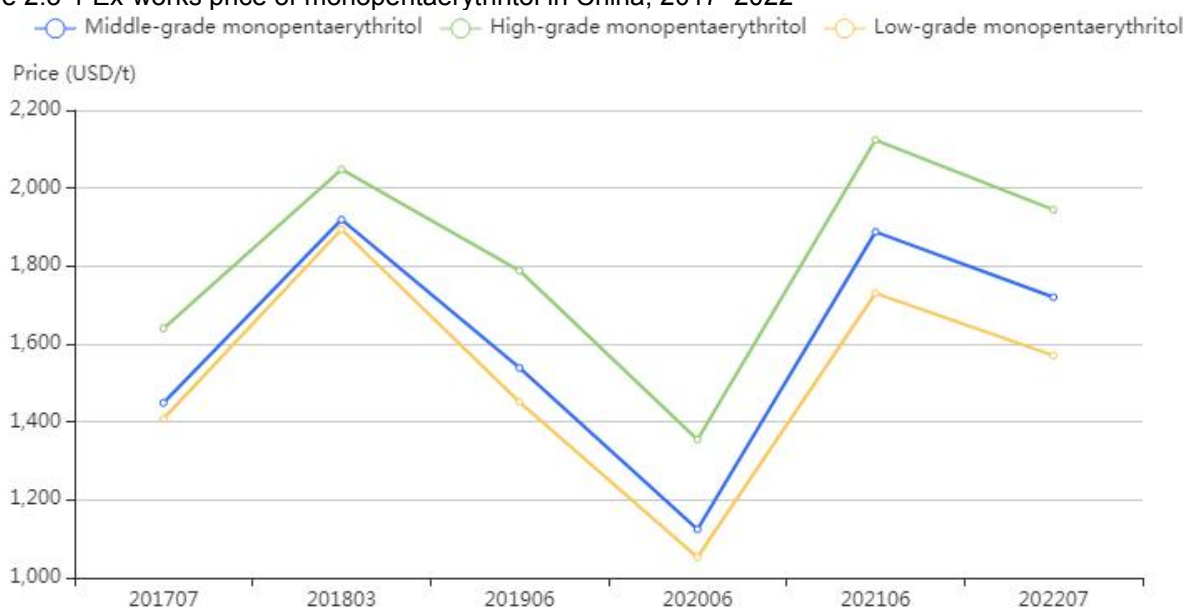
From June 2017 to July 2022, China's ex-works price of monopentaerythritol substantially fluctuated but basically remained under USD2,200/t.

From July 2017, domestic ex-works price of monopentaerythritol have sharply increased along with soaring raw material prices. Up to March 2018, the ex-works prices of methanol and formaldehyde had increased by USD88/t and USD59/t respectively. On top of that, production cuts of some pentaerythritol manufacturers triggered by stringent environmental protection inspections, especially in Hebei and Shandong provinces, also boosted the price.

From 2019 to H1 2020, the ex-works price of monopentaerythritol in China decreased a lot, influenced by decreasing prices of raw materials. Up to June 2021, with recovered economy, the price rebounded rapidly.

Up to July 2022, domestic ex-works price of monopentaerythritol decreased as raw material prices fell. Besides, weak market demand also dragged the price down.

Figure 2.3-1 Ex-works price of monopentaerythritol in China, 2017–2022



Source:CCM

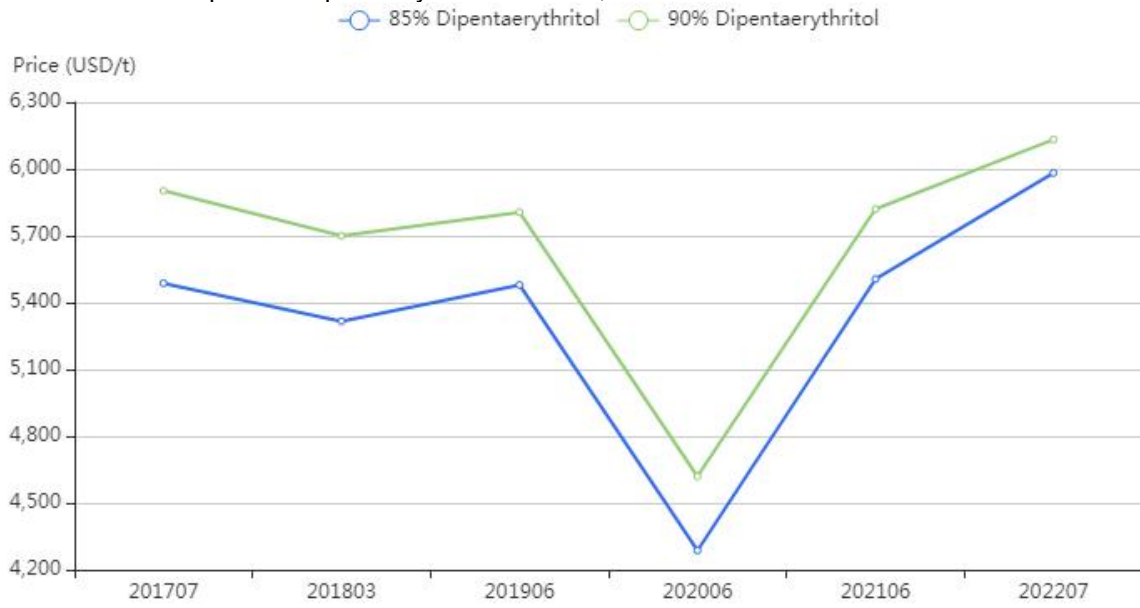
- Price of dipentaerythritol

Domestic dipentaerythritol price was relatively stable in 2017–2019.

However, under the COVID-19 pandemic, the ex-works prices of 85% and 90% dipentaerythritol declined due to shrinking downstream demand; in June 2020, the prices decreased to USD4,287/t and USD4,619/t respectively.

As the global economy has been recovering, the demand for dipentaerythritol increased and the prices recorded in June 2021 returned to the level during 2017–2019. This upward trend continued as of July 2022.

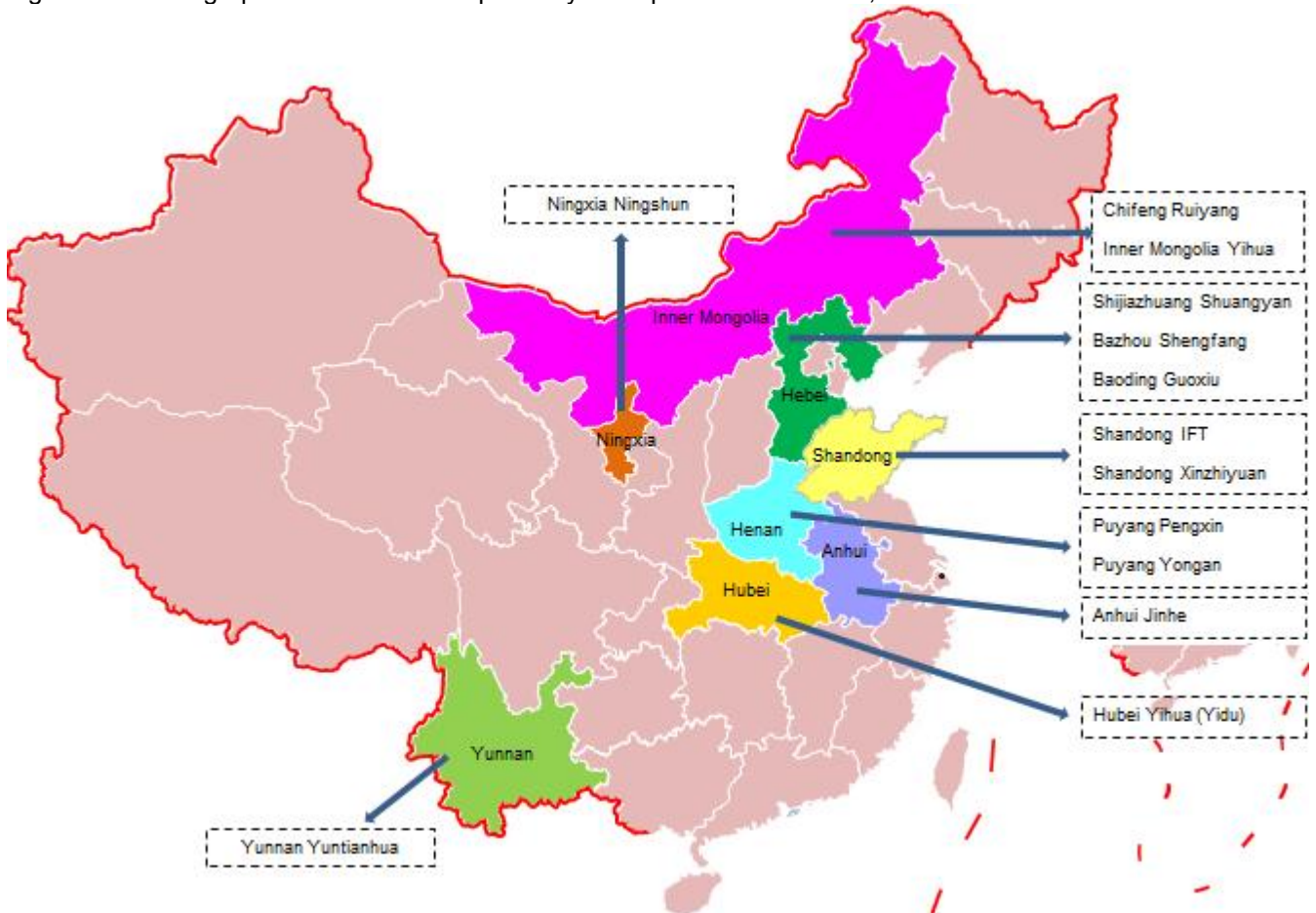
Figure 2.3-2 Ex-works price of dipentaerythritol in China, 2017–2022



Source:CCM

2.4 Geographical distribution of producers

Figure 2.4-1 Geographical distribution of pentaerythritol producers in China, 2021



Note:Hubei Yihua has two production bases producing pentaerythritol, including Hubei Yihua and Inner Mongolia Yihua.

Source:CCM

Table 2.4-1 Capacity and output of pentaerythritol producers in China, 2021

Producer	Capacity, t/a	Output, tonne		
		Mono-	Di-	Tri-
Chifeng Ruiyang	45,500	46,750	2,000	50
Hubei Yihua (Yidu)	40,000	35,700	700	0
Inner Mongolia Yihua	30,000	18,800	0	0
Puyang Pengxin	20,000	18,000	600	0
Anhui Jinhe	20,000	18,700	450	0
Yunnan Yuntianhua	10,000	13,200	0	0
Puyang Yongan	10,000	7,000	450	80
Shijiazhuang Shuangyan	10,000	6,500	300	0
Shandong IFT	12,000	4,200	0	0
Bazhou Shengfang	15,000	2,300	0	0
Shandong Xinzhiyuan	30,000	4,000	200	0
Ningxia Ningshun	14,000	2,000	100	0
Baoding Guoxiu	20,000	0	0	0

Note: The capacity of pentaerythritol in Chifeng Ruiyang is the sum of monopentaerythritol capacity and dipentaerythritol capacity.
Source: CCM

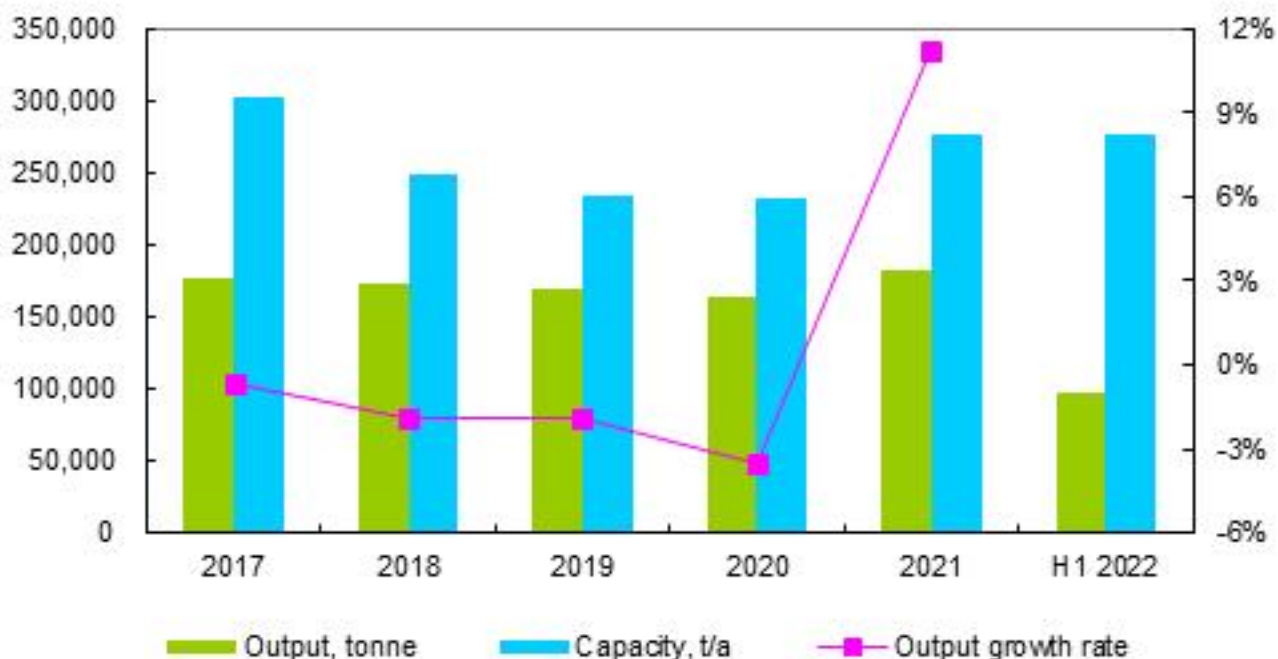
2.5 Production of pentaerythritol

China's pentaerythritol capacity reached 301,500 t/a in 2017, but decreased to 232,500 t/a in 2020, because Guizhou Kailin Xifeng Synthetic Ammonia Co., Ltd. (capacity of 30,000 t/a) and Jiangsu Kailin Ruiyang Chemical Co., Ltd. stopped producing pentaerythritol permanently. During 2017–2020, domestic manufacturers maintained stable production due to stable demand (especially overseas demand for dipentaerythritol), despite high raw material prices and strict environmental protection inspections.

China's pentaerythritol production capacity jumped to 276,500 t/a in 2021, boosted by the 14,000 t/a and 30,000 t/a production lines of Ningxia Ningshun New Material Technology Co., Ltd. and Shandong Xinzhiyuan Chemical Co., Ltd. respectively, which were put into trial production in Q4 2021. The output of pentaerythritol also witnessed a significant increase this year thanks to strong demand.

Dipentaerythritol and tripentaerythritol are by-products from the production of monopentaerythritol. Only Chifeng Ruiyang has a dedicated dipentaerythritol production line, so basically, the capacity of monopentaerythritol can be regarded as that of pentaerythritol. The output of dipentaerythritol is determined by that of monopentaerythritol.

Figure 2.5-1 Capacity and output of pentaerythritol in China, 2017–H1 2022



Source:CCM

Table 2.5-1 Output of monopentaerythritol, dipentaerythritol and tripentaerythritol in China, 2017–H1 2022, tonne

Year	Monopentaerythritol	Dipentaerythritol	Tripentaerythritol
2017	171,800	4,300	150
2018	168,300	4,500	150
2019	165,750	3,800	150
2020	159,500	4,050	130
2021	177,150	4,800	130
H1 2022	94,000	2,880	60

Source:CCM

Table 2.5-2 Basic information of pentaerythritol producers in China

No.	Producer	Abbreviation	Location
1	Hubei Yihua Chemical Industry Co., Ltd.	Hubei Yihua	Yidu City, Hubei Province; Wuhai City, Inner Mongolia Autonomous Region
2	Chifeng Ruiyang Chemical Co., Ltd.	Chifeng Ruiyang	Chifeng City, Inner Mongolia Autonomous Region
3	Puyang Pengxin Chemical Co., Ltd.	Puyang Pengxin	Puyang City, Henan Province
4	Anhui Jinhe Industrial Co., Ltd.	Anhui Jinhe	Chuzhou City, Anhui Province
5	Yunnan Yuntianhua Co., Ltd.	Yunnan Yuntianhua	Shuifu County, Yunnan Province
6	Puyang Yongan Chemical Co., Ltd.	Puyang Yongan	Puyang City, Henan Province

7	Shijiazhuang Shuangyan Chemical Co., Ltd.	Shijiazhuang Shuangyan	Shijiazhuang City, Hebei Province
8	Shandong IFT Science & Technology Co., Ltd.	Shandong IFT	Jinan City, Shandong Province
9	Bazhou Shengfang United Chemical Co., Ltd.	Bazhou Shengfang	Bazhou City, Hebei Province
10	Shandong Xinzhiyuan Chemical Co., Ltd.	Shandong Xinzhiyuan	Heze City, Shandong Province
11	Ningxia Ningshun New Material Technology Co., Ltd.	Ningxia Ningshun	Yinchuan City, Ningxia Hui Autonomous Region
12	Baoding Guoxiu Chemical Industry Co., Ltd.	Baoding Guoxiu	Baoding City, Hebei Province

Source:CCM

In 2021, there were eleven active monopentaerythritol producers in China with total capacity of 254,000 t/a.

Baoding Guoxiu was required to relocate to an industrial park, so it suspended production in 2018. As of H1 2022, its relocation project has not been completed yet.

Hubei Yihua cut its capacity by 8,000 t/a to 70,000 t/a in 2017. It stopped manufacturing pentaerythritol in its Yichang factory because of the upgrading of its synthetic ammonia installation. The company focuses on the manufacturing of 95% and 98% monopentaerythritol to fulfil larger market demand for high-end products. It continues the production of dipentaerythritol with a small amount.

Table 2.5-3 Capacity of monopentaerythritol producers in China, 2019–H1 2022, t/a

No.	Producer	Status, 2021	Low-grade				Middle-grade				High-grade				Total			
			2019	2020	2021	H1 2022	2019	2020	2021	H1 2022	2019	2020	2021	H1 2022	2019	2020	2021	H1 2022
1	Hubei Yihua *1	Active	0	0	0	0	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	70,000	70,000	70,000	70,000
2	Chifeng Ruiyang *2	Active	0	0	0	0	28,000	26,000	26,000	26,000	17,000	17,000	17,000	17,000	45,000	43,000	43,000	43,000
3	Puyang Pengxin	Active	9,000	9,000	9,000	9,000	5,000	5,000	5,000	5,000	6,000	6,000	6,000	6,000	20,000	20,000	20,000	20,000
4	Anhui Jinhe	Active	5,000	5,000	5,000	5,000	10,000	10,000	10,000	10,000	5,000	5,000	5,000	5,000	20,000	20,000	20,000	20,000
5	Yunnan Yuntianhua	Active	2,000	2,000	2,000	2,000	0	0	0	0	8,000	8,000	8,000	8,000	10,000	10,000	10,000	10,000
6	Puyang Yongan	Active	0	0	0	0	10,000	10,000	10,000	10,000	0	0	0	0	10,000	10,000	10,000	10,000
7	Shijiazhuang Shuangyan	Active	0	0	0	0	10,000	10,000	10,000	10,000	0	0	0	0	10,000	10,000	10,000	10,000
8	Shandong IFT	Active	0	0	0	0	2,000	2,000	2,000	2,000	10,000	10,000	10,000	10,000	12,000	12,000	12,000	12,000
9	Bazhou Shengfang	Active	8,000	8,000	8,000	8,000	5,000	5,000	5,000	5,000	2,000	2,000	2,000	2,000	15,000	15,000	15,000	15,000
10	Shandong Xinzhiyuan	Active	/	/	0	0	/	/	30,000	30,000	/	/	0	0	/	/	30,000	30,000
11	Ningxia Ningshun	Active	/	/	0	0	/	/	14,000	14,000	/	/	0	0	/	/	14,000	14,000
12	Baoding Guoxiu	Idle	0	0	0	0	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	20,000	20,000	20,000	20,000
Total			24,000	24,000	24,000	24,000	115,000	113,000	157,000	157,000	93,000	93,000	93,000	93,000	232,000	230,000	274,000	274,000

Note:*1. Hubei Yihua has two production bases producing pentaerythritol, including Hubei Yihua (Yidu) and Inner Mongolia Yihua. Hubei Yihua (Yichang) has stopped pentaerythritol production. *2. Chifeng Ruiyang has just one production base producing pentaerythritol now. Jiangsu Ruiyang and Guizhou Kailin have stopped pentaerythritol production.

Source:CCM

There were eleven dipentaerythritol producers in China, with total capacity of 12,500 t/a in 2021. Dipentaerythritol used to be merely a by-product of monopentaerythritol, but has become a critical part of manufacturers' product portfolio now. Chifeng Ruiyang and Anhui Jinhe have successfully developed synthetic method for dipentaerythritol, and many other companies are sticking to the R&D.

China's dipentaerythritol output increased from 3,800 tonnes in 2019 to 4,800 tonnes in 2021, largely driven up by huge domestic and overseas demand.

Table 2.5-4 Capacity and output of dipentaerythritol producers in China, 2019–H1 2022

No.	Producer	Capacity H1 2022, t/a	Output, tonne			
			2019	2020	2021	H1 2022
1	Chifeng Ruiyang	2,500	1,500	1,800	2,000	1,000
2	Hubei Yihua	2,400	600	600	700	400
3	Puyang Pengxin	1,000	600	600	600	350
4	Anhui Jinhe	1,000	400	450	450	250
5	Puyang Yongan	2,000	400	400	450	200
6	Shijiazhuang Shuangyan	500	300	200	300	200
7	Shandong IFT	600	0	0	0	0
8	Bazhou Shengfang	400	0	0	0	0
9	Shandong Xinzhiyuan	1,000	/	/	200	300
10	Ningxia Ningshun	600	/	/	100	180
11	Baoding Guoxiu	500	0	0	0	0
Total		12,500	3,800	4,050	4,800	2,880

Note: Hubei Yihua has two production bases producing pentaerythritol, including Hubei Yihua (Yidu) and Inner Mongolia Yihua.
Source: CCM

There are also some pentaerythritol projects in China in the future.

- Shandong Xinzhiyuan's 30,000 t/a pentaerythritol project (phase II)
- Ningxia Ningshun's 6,000 t/a pentaerythritol project (phase II)
- Puyang Runfeng Chemical Technology Co., Ltd.'s 20,000 t/a pentaerythritol project

2.6 Summary of Chinese manufacturers and five major producers of pentaerythritol

There were twelve pentaerythritol manufacturers that have capacity over 10,000 t/a in 2021 in China. The combined capacity of the top two was 115,500 t/a.

Capacity in most pentaerythritol producers scarcely changed, except that Chifeng Ruiyang reduced its capacity from 124,500 t/a in 2017 to 45,500 t/a in 2020.

In 2019–2021, the competitive landscape of the pentaerythritol industry in China

had bigger change. The share of pentaerythritol capacity in China's top two producers decreased. Meanwhile, the share of output in top two producers fluctuated, falling in 2021 to roughly the same level of 2019.

Table 2.6-1 Capacity and share of main pentaerythritol manufacturers in China, 2019–2021

Item	Capacity, 2021		Capacity, 2020		Capacity, 2019	
	Volume, t/a	Share	Volume, t/a	Share	Volume, t/a	Share
Top two	115,500	41.8%	115,500	49.7%	117,500	50.1%
Top five	185,500	67.1%	170,500	73.3%	172,500	73.6%
Total	276,500	/	232,500	/	234,500	/

Note: Ranking is determined by capacity.

Source: CCM

Table 2.6-2 Output and share of main pentaerythritol manufacturers in China, 2019–2021

Item	Output, 2021		Output, 2020		Output, 2019	
	Volume, tonne	Share	Volume, tonne	Share	Volume, tonne	Share
Top two	104,000	57.1%	98,350	60.1%	97,300	57.3%
Top five	154,950	85.1%	145,300	88.8%	147,300	86.8%
Total	182,080	/	163,680	/	169,700	/

Note: Ranking is determined by output.

Source: CCM

- Raw material situation of top 5 pentaerythritol manufacturers

Table 2.6-3 Methanol and acetaldehyde situation of top five manufacturers

Raw material	Specification	Producer	Source	Capacity in 2021, t/a	Purchase volume in 2021, tonne	Price in July 2022, USD/t
Methanol	99.0%	Hubei Yihua	Itself	122,000	/	/
		Anhui Jinhe	Itself	80,000	/	/
		Chifeng Ruiyang	Outsourcing	/	70,700	347
		Puyang Pengxin	Outsourcing	/	25,500	381
		Shandong Xinzhiyuan	Outsourcing	/	5,500	390
Acetaldehyde	99.8%	Hubei Yihua	Itself	20,000	/	/
		Chifeng Ruiyang	Itself	24,000	/	/
		Anhui Jinhe	Itself	12,000	/	/
		Puyang Pengxin	Outsourcing	/	6,500	1,196
		Shandong Xinzhiyuan	Outsourcing	/	1,600	1,196

Source: CCM

Table 2.6-4 Average market price of ethanol at the locations of top two producers, 2021

No.	Producer	Location	Average market price, USD/t
1	Hubei Yihua	Hubei	1,199
2	Chifeng Ruiyang	Inner Mongolia	1,165

Note: The raw material of Chifeng Ruiyang's acetaldehyde is ethanol, which is made by purchased corn. Average market price of corn in Inner Mongolia was USD0.38/kg in 2021.

Source:CCM

3 Production technology of pentaerythritol in China

3.1 Brief introduction and comparison of different production pathways/methods

Technology pathway of pentaerythritol

According to the species of condensing agent, the preparation for pentaerythritol can be classified into calcium pathway and sodium pathway.

- Calcium pathway

The condensing agent is calcium hydroxide. The product quality through calcium pathway is good. But the route is long and it tends to form formose, which hinders the yield of pentaerythritol.

At present, no producer uses this pathway to produce pentaerythritol in China. Moreover, relevant patent information during 2017–2021 shows that no new technological breakthrough was made for calcium-based pentaerythritol.

- Sodium pathway

The condensing agent is sodium hydroxide. The route is relatively short. In addition, it is easy to collect and recycle the byproduct sodium formate.

The sodium pathway is widely used around the world. China began to use sodium pathway in 1972. Currently, this pathway is the mainstream production technology in China.

Production method

- High temperature method

The reaction temperature ranges from 40°C to 80°C. The polymerization rate is high in this process and the reaction heat could not be removed in time which results in acceleration of subsidiary reactions and byproducts. This pentaerythritol production method has low yield coefficient and difficulties in the following separation process.

- Low temperature method

The reaction temperature is 25°C–40°C, where the yield of side products is low. This is the most widely used method in the world, and it is also adopted by most producers in China.

Compared with the high temperature method, low temperature sodium pathway has following features:

Advantages:

- High ratio of formaldehyde
- Good product quality
- Surplus formaldehyde can be recycled. The unit consumption of formaldehyde and alkali is low.
- Small consumption of steam
- High reacting concentration
- Large production capacity
- Low pollution to the environment

Disadvantages:

- More equipment
- Long flowchart
- High consumption of formaldehyde requires a large amount of freezing salt solution, which is to say, it requires a large amount of resources.

Both theoretically and practically, this method is favorable for mass production and easy to control the process. It has become the main trend in pentaerythritol production.

Table 3.1-1 Monopentaerythritol technology source of Chinese producers, 2021

No.	Producer	Capacity'21, t/a	Pathway	Technology source
1	Hubei Yihua	70,000	Sodium pathway (Low temperature)	Samyang, South Korea
2	Chifeng Ruiyang	43,000	Sodium pathway (Low temperature)	Domestic technology
3	Puyang Pengxin	20,000	Sodium pathway (Low temperature)	Hubei Yihua
4	Anhui Jinhe	20,000	Sodium pathway (Low temperature)	Domestic technology
5	Yunnan Yuntianhua	10,000	Sodium pathway (Low temperature)	Eurotecnica, Italy
6	Bazhou Shengfang	15,000	Sodium pathway (Low temperature)	Domestic technology
7	Shandong IFT	12,000	Sodium pathway (Low temperature)	Domestic technology
8	Puyang Yongan	10,000	Sodium pathway (Low temperature)	Domestic technology
9	Shijiazhuang Shuangyan	10,000	Sodium pathway (High temperature)	Domestic technology
10	Shandong Xinzhiyuan	30,000	Sodium pathway (High temperature)	Domestic technology
11	Ningxia Ningshun	14,000	Sodium pathway	Domestic technology

Note: Ningxia Ningshun does not disclose its production method.

Source: CCM

Condensation method

Batch condensation

The reaction takes place in one reactor. Usually in this process, electro dialysis method is employed in the crystallization and centrifugation steps in order to obtain sodium formate. The concentration of pentaerythritol solution must be diluted to less than 14% before electro dialysis in order to avoid the jam of the electro dialysis equipment.

For batch reaction, the final yield of pentaerythritol can reach up to 90%.

Disadvantages:

- Energy cost of the batch condensation process is high.
- The remained formaldehyde in solution can cause film poisoning so that the life of the selection film in the electro dialysis chamber is quite short.

Advantages:

- The purity of both pentaerythritol and sodium formate is good.
- Re-crystallization is not necessary.

Continuous condensation

This method is believed as the future trend. The reaction takes place in a number of continuous reactors. Formaldehyde, acetaldehyde and caustic soda continuously enter the reactors from the bottom and proper quantity of acetaldehyde is supplemented to the reactors.

Advantages:

- High purity pentaerythritol can be gained.
- Different purities of pentaerythritol can be offered from 94% to 99% according to the requirements of clients.
- Energy can be effectively used.
- Larger capacity because of continuous reaction

- Lower energy cost because of proper usage of twice steam

Disadvantages:

- It has a smaller yield compared with batch reaction.
- Because the feedstock enters the reactor from the bottom, there are great changes of mole proportion between formaldehyde and acetaldehyde from bottom to top of the reactor.
- High equipment investment

3.2 Technology problems of pentaerythritol

In recent years, China has made great progress in pentaerythritol production technology. But compared with the overseas market, the Chinese pentaerythritol industry still has many disadvantages:

- Inefficient production technology
- Low-purity products
- Less production specifications
- Severe pollution

There are several pentaerythritol manufacturers and research institutes that do lots of R&D on pentaerythritol production, such as Anhui Jinhe and Chifeng Ruiyang. But there are still some technology bottlenecks in pentaerythritol production:

- In the progress of polymerization, Cannizzaro is an exothermic reaction, which gives out a lot of heat. If the heat is not removed immediately, fast reaction would easily form byproducts, which increases the difficulty in product separation, and influences the conversion rate of the reaction. This is the main reason why the purity of home-made pentaerythritol is low.
- In the de-aldehyde step (distillation), it is difficult to separate methanol from pentaerythritol formed after a long time of condensation.
- In the centrifugal step, it is hard to separate pentaerythritol from sodium formate. The ideal rate of pentaerythritol and sodium formate in the mother solution is 1:4.
- The catalyst in the production is corrosive to facilities, which increases production cost and influences the quality of pentaerythritol.
- It produces lots of organic wastewater, which is highly polluting to the environment.

3.3 Technology achievements of pentaerythritol research

In recent years, many researches related to pentaerythritol have been done in China.

Table 3.3-1 Patents related to pentaerythritol production applied in China, Jan. 2017–June 2022

No.	Patent name	Applicant	Date of application
1	A comprehensive utilization method of wastewater (from pentaerythritol production) in formaldehyde and acetaldehyde production	Anhui Jinhe Industrial Co., Ltd.	2019/11/19
2	A multiple-effect evaporation method in pentaerythritol production	Anhui Jinhe Industrial Co., Ltd.	2019/11/19
3	A preparation method of tripentaerythritol	Anhui Jinhe Industrial Co., Ltd.	2018/12/10
4	A production method of 75% tripentaerythritol	Anhui Jinhe Industrial Co., Ltd.	2018/12/10
5	A method for lowering chromaticity of pentaerythritol	Anhui Jinhe Industrial Co., Ltd.	2018/12/10
6	A recovery method of acetaldehyde and equipment during the production of pentaerythritol	Anhui Jinhe Industrial Co., Ltd.	2018/1/13
7	A production method of tripentaerythritol with a purity greater than 90%	Chifeng Ruiyang Chemical Co., Ltd.	2020/9/9
8	A production method of 95% dipentaerythritol	Chifeng Ruiyang Chemical Co., Ltd.	2020/9/4
9	A crystallization device for pentaerythritol production	Chifeng Ruiyang Chemical Co., Ltd.	2020/9/2

10	A method and device for continuous condensation of mono-, di- and tripentaerythritol	Chifeng Ruiyang Chemical Co., Ltd.	2020/3/31
11	A purification method and device for by-product crude sodium formate from pentaerythritol production	Chifeng Ruiyang Chemical Co., Ltd.	2019/12/24
12	A sampling mechanism used for sampling during pentaerythritol production	Chifeng Ruiyang Chemical Co., Ltd.	2019/8/14
13	A gas-liquid separator for treating tail gas produced from pentaerythritol production	Chifeng Ruiyang Chemical Co., Ltd.	2019/8/6
14	A transfer and dust removal mechanism for corn crushing process of pentaerythritol production	Chifeng Ruiyang Chemical Co., Ltd.	2019/8/6
15	A production system and production method of 99% pentaerythritol	Chifeng Ruiyang Chemical Co., Ltd.	2018/12/28
16	A wastewater pretreatment system during the production of pentaerythritol	Chifeng Ruiyang Chemical Co., Ltd.	2018/6/25
17	Wastewater pretreatment tank during the production of pentaerythritol	Chifeng Ruiyang Chemical Co., Ltd.	2018/6/25
18	A preparation method of monopentaerythritol and dipentaerythritol	Jiangsu Hankai Engineering Technology Co., Ltd.	2019/4/30
19	A method for processing pentaerythritol mother liquor	Inner Mongolia Yihua Chemical Co., Ltd.	2021/6/7
20	A production method for further purification of tripentaerythritol	Puyang Yongan Chemical Co., Ltd.	2019/3/27
21	Equipment and preparation method of liquid pentaerythritol from pentaerythritol mother liquor	Puyang Yongan Chemical Co., Ltd.	2018/6/19
22	Equipment and preparation method for removing methylal in crude pentaerythritol	Puyang Yongan Chemical Co., Ltd.	2018/6/19
23	Pentaerythritol recycling equipment and recovery method for spent activated carbon	Puyang Yongan Chemical Co., Ltd.	2018/6/19
24	Equipment of liquid pentaerythritol from pentaerythritol mother liquor	Puyang Yongan Chemical Co., Ltd.	2018/6/19
25	Pentaerythritol recycling equipment for spent activated carbon	Puyang Yongan Chemical Co., Ltd.	2018/6/19
26	A system and method for separating pentaerythritol and calcium formate from pentaerythritol mother liquor	Wuxi Rongfeng Biological Engineering Co., Ltd.	2022/2/18
27	An extraction column of pentaerythritol mother liquor	Wuxi Rongfeng Biological Engineering Co., Ltd.	2021/7/26
28	A process for separating pentaerythritol byproduct sodium formate through membrane	Zhejiang Lanbo New Material Technology Co., Ltd.	2021/7/15

Source:CCM

4 Industry analysis in China

4.1 SWOT analysis

Table 4.1-1 SWOT analysis of Hubei Yihua's development in 2021

	Strength	Weakness
Hubei Yihua	1. Top pentaerythritol producer in China 2. As a listed company, Hubei Yihua enjoys mature financing channels. 3. Advanced equipment and technology from Samyang Chemical Industries Co., Ltd. 4. Self-sufficiency of formaldehyde, acetaldehyde and energy	1. Insufficient supervision on pentaerythritol production work safety. 2. Waste water treatment
Opportunity	SO	WO
Some pentaerythritol manufacturers have stopped production because of environmental issues and low profits.	1. Improve product quality so as to take up more domestic market shares of high-end products. 2. Expand its international presence.	Upgrade current production equipment and improve environmental protection technologies.
Threat	ST	WT
1. As a large-scale manufacturer of minerals and chemicals, Hubei Yihua is troubled by slow industrial transformation and upgrading. 2. Pentaerythritol producers suffer increasingly stringent requirements for waste disposal and work safety.	Shift from low-grade monopentaerythritol to high-grade ones and dipentaerythritol to take up larger shares in domestic market.	Increase investment in environmental protection facilities.

Source:CCM

Table 4.1-2 SWOT analysis of Chifeng Ruiyang's development in 2021

	Strength	Weakness
Chifeng Ruiyang	1. Leading pentaerythritol producer in China 2. Broad product portfolio: monopentaerythritol (95%, 98% and 99%), dipentaerythritol (85% and 95%) and tripentaerythritol	1. Waste water treatment 2. Chifeng Ruiyang still cannot rival its overseas counterparts in product quality.
Opportunity	SO	WO
Demand for dipentaerythritol and tripentaerythritol rises steadily.	1. Expand in domestic dipentaerythritol and tripentaerythritol markets. 2. Improve the quality of dipentaerythritol and tripentaerythritol and expand its presence in overseas markets.	Enlarge the production capacity of high-purity monopentaerythritol, dipentaerythritol and tripentaerythritol in the future.
Threat	ST	WT
1. Intense competition in domestic and overseas pentaerythritol markets. 2. More stringent environmental policies in China	Increase investment into waste disposal facilities due to huge environmental protection pressure.	Increase investment in environmental protection facilities and the R&D of products.

Source:CCM

Table 4.1-3 SWOT analysis of Yunnan Yuntianhua's development in 2021

	Strength	Weakness
Yunnan Yuntianhua	1. Advanced technology and equipment from Eurotecnica in Italy, and high product quality. 2. As a listed company, Yunnan Yuntianhua enjoys diversified financing channels and is well-capitalized	Narrow product mix: 98% and 99% monopentaerythritol only
Opportunity	SO	WO
Domestic demand for high-grade monopentaerythritol, dipentaerythritol and	Expand in the domestic high-end pentaerythritol market based on its low operating costs and high product	Extend to the production of dipentaerythritol and

tripentaerythritol increases quickly.	quality.	tripentaerythritol
Threat	ST	WT
1. Intense competition in the pentaerythritol market. 2. More stringent environmental protection policies in China	Increase investment into waste disposal facilities due to huge environmental protection pressure.	Create brand awareness to enlarge market share.

Source:CCM

Table 4.1-4 SWOT analysis of Shandong Xinzhiyuan's development in 2021

Shandong Xinzhiyuan	Strength	Weakness
	It has the largest single-line production capacity, reaching 30,000 t/a.	As a new entrant, it lacks market recognition.
Opportunity	SO	WO
Domestic demand for high-grade pentaerythritol increases quickly.	1. Increase R&D investment to improve high quality pentaerythritol. 2. Expand in overseas market.	1. Create brand awareness to enlarge market shares. 2. Accelerate independent R&D on downstream products.
Threat	ST	WT
Intense competition in the pentaerythritol market.	Increase capacity for high-purity products to gain more market share.	Increase investment in the R&D of products.

Source:CCM

4.2 Competitiveness analysis of Chinese pentaerythritol industry

- Sufficient raw material supply

China's sufficient feedstock supply is conducive to its pentaerythritol production. China's output of methanol, the most important raw material for pentaerythritol, kept growing in the past five years, reaching 75,301,800 tonnes in 2021; and the product quality has improved. Abundant supply of methanol, as well as formaldehyde, ensures the production of pentaerythritol.

Some domestic large-scale formaldehyde and pentaerythritol manufacturers, such as Hubei Yihua, Yunnan Yuntianhua and Shandong Xinzhiyuan, self-produce methanol, which significantly helps save production cost and therefore increases profits. These producers have already benefited from integrated industrial chains and largely extended their industrial scales.

- High quality

China's pentaerythritol quality has kept improving in recent years and the gap between domestic and overseas products has narrowed. This should be attributed to technology advancement of leading domestic manufacturers. Hubei Yihua introduced proprietary production method of monopentaerythritol and dipentaerythritol from Samyang Chemical Industries Co., Ltd. in 2002 so as to produce pentaerythritol of world leading quality (hydroxyl content: 98%). Yunnan Yuntianhua imported a full set of pentaerythritol production lines from Eurotecnica, and it is able to manufacture pentaerythritol of diversified purities (96%–99%) with stable quality. Technological upgrading of leading enterprises has significantly pushed up product quality of the whole industry.

In this context, mainstream pentaerythritol producers switch to the production of high-purity, high-quality pentaerythritol products to satisfy constantly growing international demands. For instance, Yunnan Yuntianhua has reduced the production of 93% pentaerythritol in recent years and turned to produce more 98% pentaerythritol, 99% pentaerythritol to meet market demand. That is to say, domestic manufacturers' pentaerythritol product portfolios have undergone adjustment.

- Low price

Low price used to be one of the important features of China's chemical industry. China's pentaerythritol products maintain relatively low prices in spite of improved quality because the price of formaldehyde is

much lower than that in developed countries. Moreover, China's labor resources are still sufficient and cheaper, leading to lower operating cost of pentaerythritol manufacturers.

5 Import and export analysis

5.1 Anti-dumping duty on pentaerythritol

- India

On 4 Feb., 2005, the Ministry of Commerce and Industry of India launched an anti-dumping investigation against the imports of pentaerythritol originating in or exported from China and Sweden.

On 2 Feb., 2006, the Ministry of Commerce and Industry of India published the final affirmative determination on concerning imports of pentaerythritol originating in or exported from China and Sweden.

On 20 April, 2006, the Ministry of Finance (MOF) of India announced the imposition of an anti-dumping duty on pentaerythritol from China and Sweden.

On 26 March, 2010, the Ministry of Commerce and Industry of India initiated the first anti-dumping sunset review investigation on concerning imports of pentaerythritol from China and Sweden.

On 25 March, 2011, the Ministry of Commerce and Industry of India decided to continue anti-dumping duty against products from China, while revoke the anti-dumping duty on Swedish ones.

On 14 June, 2011, the MOF of India announced the prolongation of anti-dumping duty against pentaerythritol from China for the first time.

On 7 June, 2016, the Ministry of Commerce and Industry of India initiated the second sunset review of anti-dumping campaign anti-dumping investigations concerning imports of pentaerythritol originating in or exported from China at the request of Kanoria Chemicals and Industries Limited. The period of investigation (POI) for the purpose of the review was April, 2015–March, 2016 (12 months). The examination in the context of injury analysis covered the periods April 2012–March 2013, April 2013–March 2014, April 2014–March 2015 and the POI.

On 12 May, 2017, the Ministry of Commerce and Industry of India delivered the final determination on the second sunset review of anti-dumping campaign against pentaerythritol from China, deciding to collect an anti-dumping duty of USD185.15/t on involved products, which would be implemented since issuance.

- Turkey

In Feb. 2005, Turkey launched an investigation of anti-dumping measure on pentaerythritol from China. On 28 July, 2005, it decided to impose an anti-dumping duty of USD270/t on all imports of pentaerythritol from China.

On 23 July, 2010, Turkey launched the sunset review investigation of anti-dumping measure on pentaerythritol from China. On 3 May, 2011, it decided that the duty of USD270/t on pentaerythritol from China would be imposed for another five years.

On 14 May, 2017, Turkey delivered the final determination on the sunset review of anti-dumping campaign against pentaerythritol from China, deciding to keep collecting an anti-dumping duty of USD270/t on involved products.

- The European Union

On 17 Jan., 2006, the European Commission published a notice of initiation of an anti-dumping proceeding concerning pentaerythritol originated from the US, China, Russia, Turkey and Ukraine. But the anti-dumping investigation into pentaerythritol originated from the five countries was terminated on 5 April, 2007.

5.2 Import and export of pentaerythritol, 2021

China is a net exporter of pentaerythritol. Annual export of pentaerythritol from China fell within the range of 50,000 tonnes–57,000 tonnes in 2017–2019. The export volume dropped by about 8% year on year in 2020, due to sluggish overseas demand influenced by COVID-19. However, it surged to 65,932 tonnes in 2021 with recovered overseas demand.

In 2017–2021, China's annual import volume of pentaerythritol kept over 3,500 tonnes; especially in 2021,

the import increased significantly, reaching 5,543 tonnes, an year-on-year increase of 42.3%.

In 2021, China's pentaerythritol import price and export price averaged at USD1,809/t and USD1,951/t, with a yearly increase of 23.6% and 34.4% respectively.

Figure 5.2-1 China's imports and exports of pentaerythritol, 2017–2021



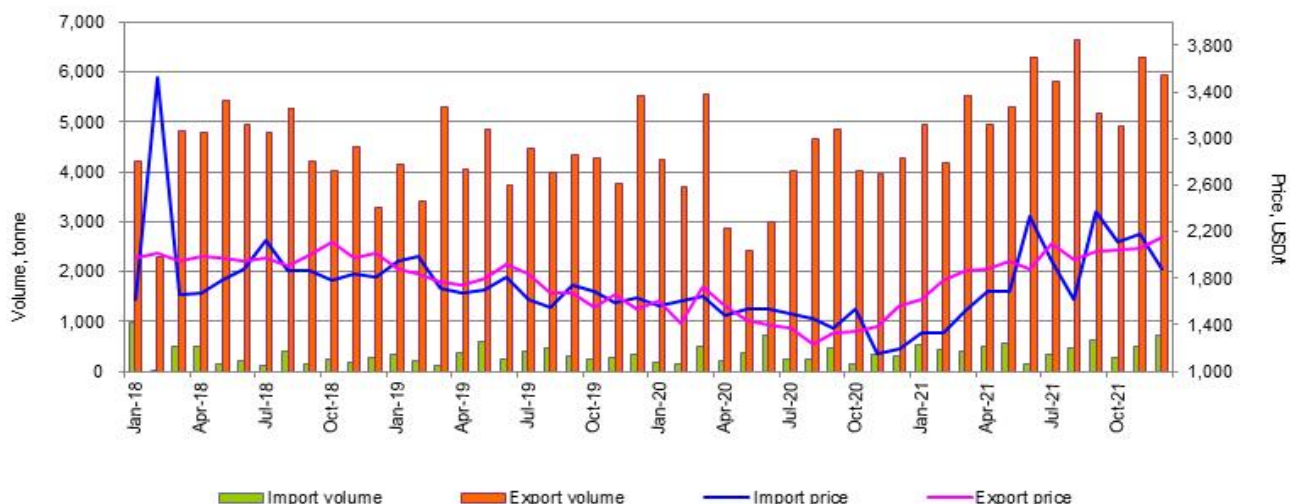
Source: China Customs & CCM

Table 5.2-1 China's imports and exports of pentaerythritol, 2017–2021

Year	Import			Export		
	Volume, tonne	Value, USD	Price, USD/t	Volume, tonne	Value, USD	Price, USD/t
2017	3,563	6,197,207	1,740	56,527	101,509,463	1,796
2018	3,658	6,369,767	1,742	52,613	104,256,870	1,982
2019	3,947	6,728,863	1,705	51,922	89,978,940	1,733
2020	3,896	5,704,339	1,464	47,538	69,037,148	1,452
2021	5,543	10,030,031	1,809	65,932	128,638,120	1,951

Source: China Customs & CCM

Figure 5.2-2 China's imports and exports of pentaerythritol by month, Jan. 2018–Dec. 2021



Source:China Customs & CCM

Table 5.2-2 China's import and export volume of monopentaerythritol, dipentaerythritol and tripentaerythritol, 2021, tonne

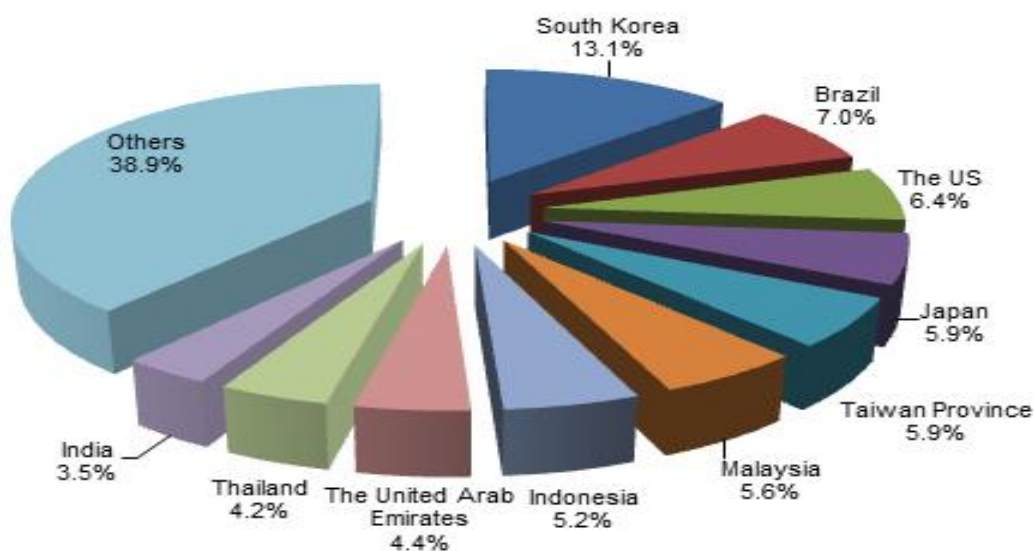
Item	Monopentaerythritol	Dipentaerythritol	Tripentaerythritol
Export volume	61,923	3,946	63
Import volume	5,503	24	16

Source:China Customs & CCM

China mainly exports pentaerythritol to Asia and America; export to European countries is small due to production and delivery costs and higher self-sufficiency in this region.

In 2021, South Korea was the largest export destination of China's pentaerythritol by volume, accounting for 13.1% of total export volume, followed by Brazil, The US, Japan and Taiwan Province, while Sweden, Taiwan Province and Germany were the three largest import origins of pentaerythritol to China by volume, together accounting for 97.7% of total import volume.

Figure 5.2-3 Top ten export destinations of pentaerythritol from China by volume, 2021



Note:Due to rounding, the total may not equal 100.0%.

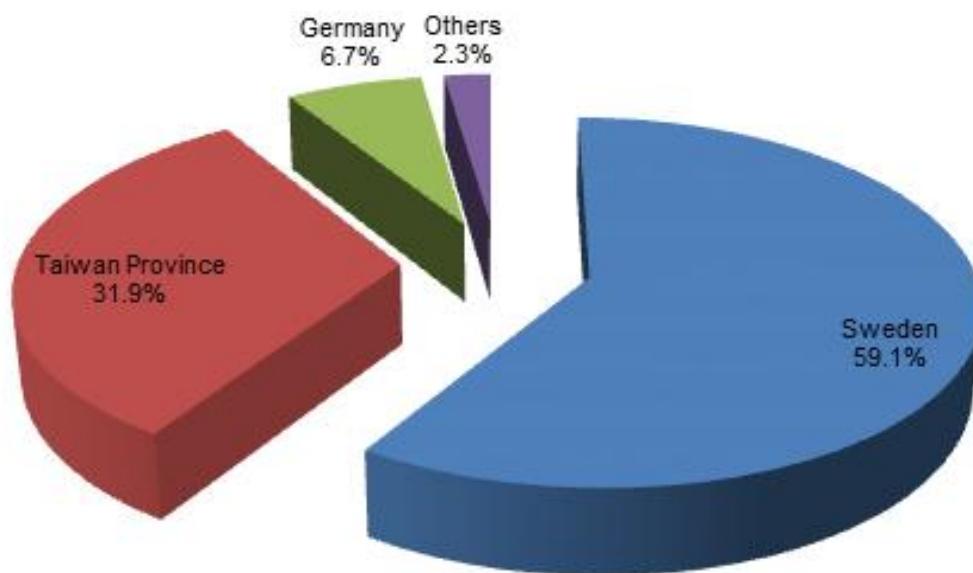
Source:China Customs & CCM

Table 5.2-3 China's exports of pentaerythritol by destination, 2021

No.	Destination	Export volume, tonne	Export value, USD	Export price, USD/t
1	South Korea	8,644	17,253,577	1,996
2	Brazil	4,594	8,212,811	1,788
3	The US	4,200	9,064,636	2,158
4	Japan	3,907	10,307,563	2,638
5	Taiwan Province	3,860	11,373,093	2,947
6	Malaysia	3,704	6,772,171	1,828
7	Indonesia	3,435	5,779,079	1,682
8	The United Arab Emirates	2,909	4,833,078	1,662
9	Thailand	2,778	4,871,367	1,753
10	India	2,276	3,831,963	1,684
	Others	25,625	46,338,782	1,808
	Total	65,932	128,638,120	1,951

Source: China Customs & CCM

Figure 5.2-4 Top import origins of pentaerythritol in China by volume, 2021



Source: China Customs & CCM

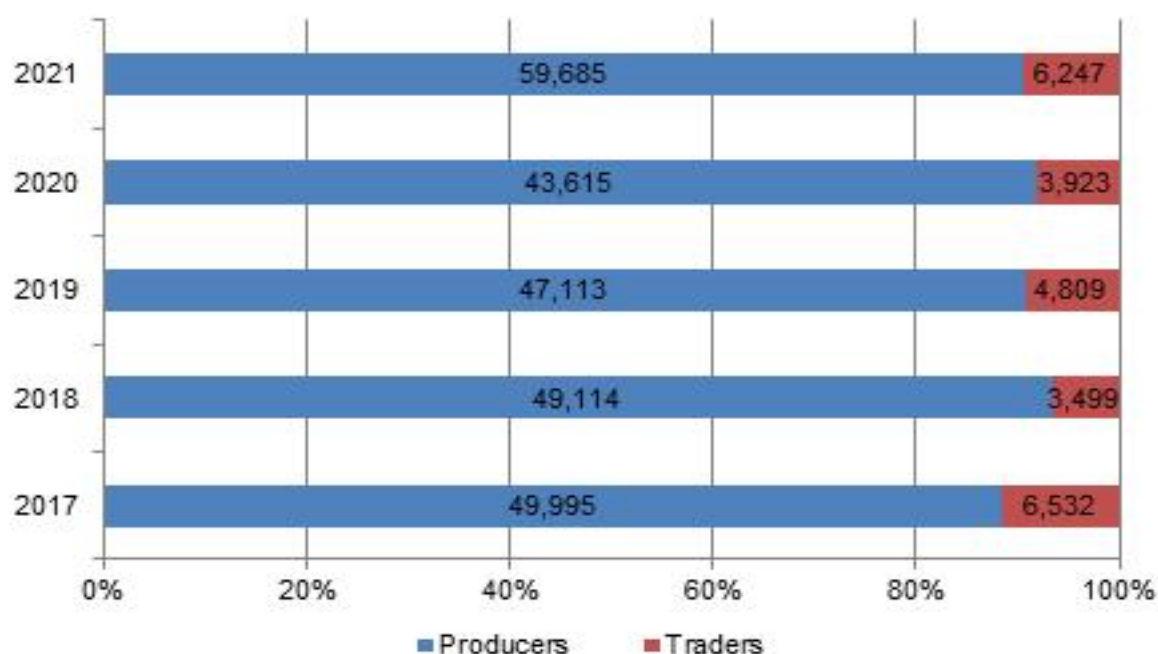
Table 5.2-4 China's imports of pentaerythritol by origin, 2021

No.	Origin	Import volume, tonne	Import value, USD	Import price, USD/t
1	Sweden	3,276	5,262,546	1,607
2	Taiwan Province	1,770	3,283,756	1,855
3	Germany	371	1,036,899	2,794
	Others	127	446,830	3,532
	Total	5,543	10,030,031	1,809

Source: China Customs & CCM

The volume of pentaerythritol directly exported by producers has remained over 43,000 tonnes in 2017–2021, and over 63.5% of exported pentaerythritol in 2021 was produced by Hubei Yihua and Chifeng Ruiyang, the top two producers in China.

Figure 5.2-5 Classification of pentaerythritol exporters in China, 2017–2021



Source: China Customs & CCM

Table 5.2-5 China's exports of pentaerythritol by producer, 2021

No.	Producer	Export volume, tonne	Export value, USD	Export price, USD/t
1	Hubei Yihua Chemical Industry Co., Ltd.	25,771	47,444,085	1,841
2	Chifeng Ruiyang Chemical Co., Ltd.	16,082	33,396,414	2,077
3	Puyang Pengxin Chemical Co., Ltd.	14,609	27,473,642	1,881
4	Anhui Jinhe Industrial Co., Ltd.	3,202	5,561,134	1,737
	Others	6,267	14,762,845	2,356
	Total	65,932	128,638,120	1,951

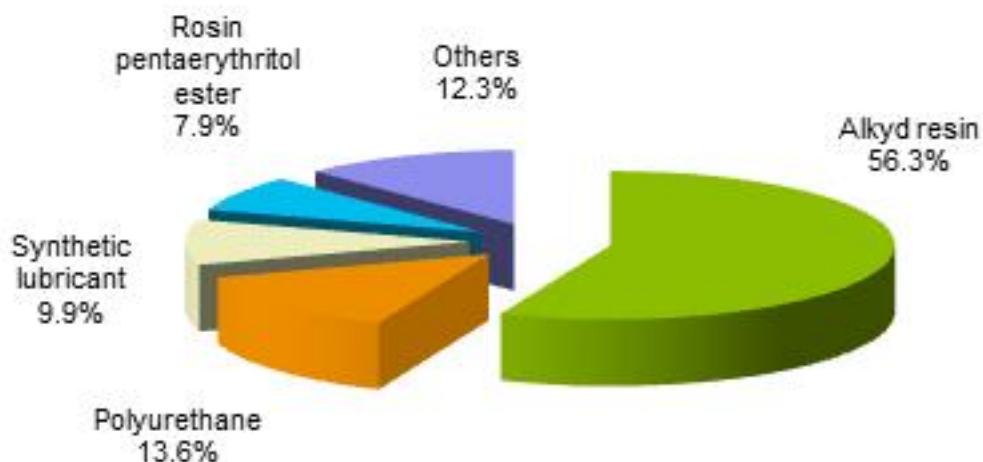
Source: China Customs & CCM

6 Consumption of pentaerythritol in China

6.1 Consumption pattern

As an important raw material and intermediate for fine chemicals, pentaerythritol is mainly consumed in the production of alkyd resin, polyurethane (PU), synthetic lubricant, rosin pentaerythritol ester, etc. in China.

Figure 6.1-1 Apparent consumption of pentaerythritol in China by end use segment, 2021



Source:CCM

Dipentaerythritol is mainly consumed in the production of dipentaerythritol hexaacrylate (DPHA) and dipentaerythritol ester in China.

DPHA is mainly used in ultraviolet curing coating, which can increase the hardness and reaction degree of crosslinking. Dipentaerythritol ester is widely used in synthetic polymeric compound, lubricant oil, paint, printing ink, surfactant, etc.

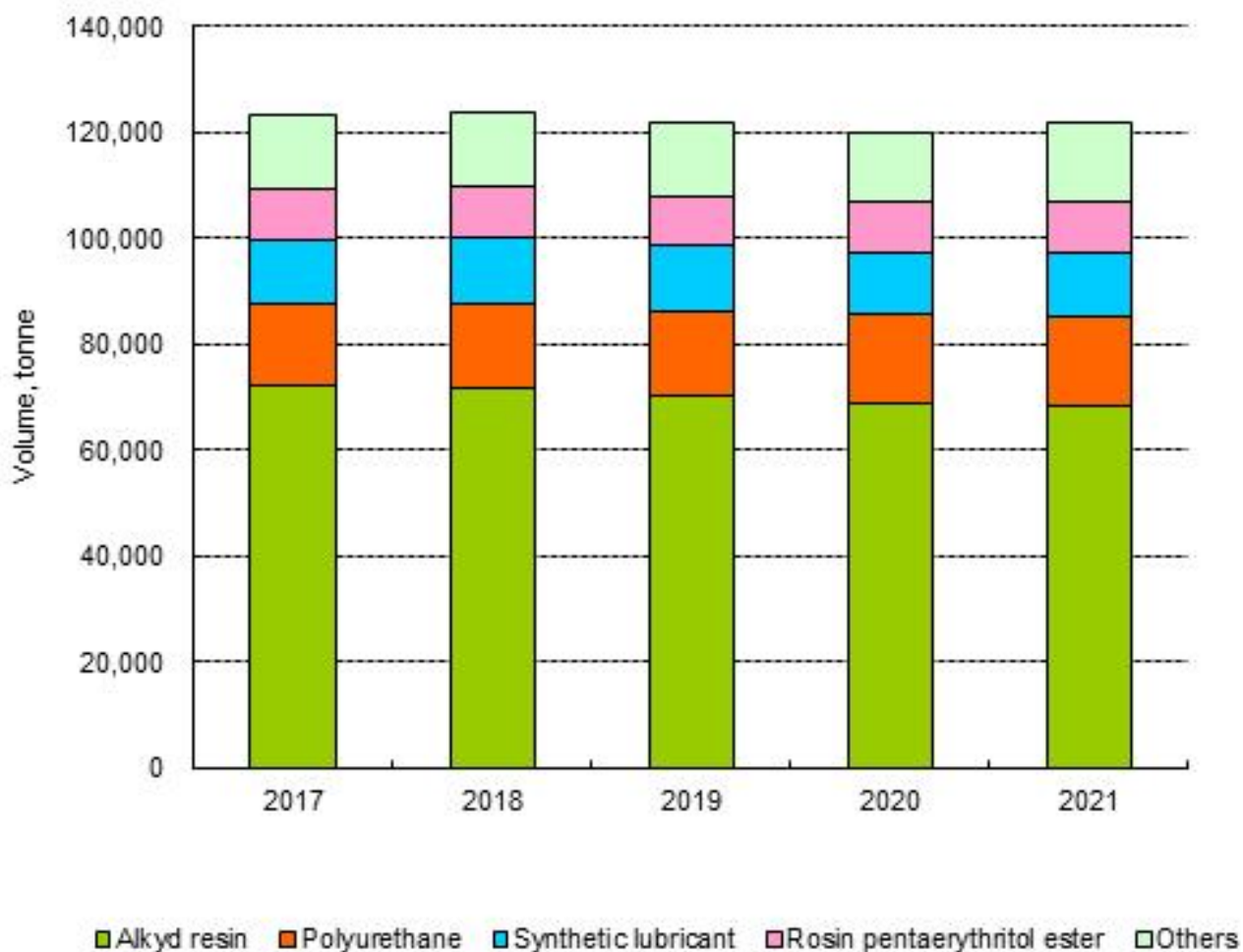
Triptaerythritol is used to produce triptaerythritol octaacrylate, triptaerythritol phosphate flame retardant, ect.

6.2 Consumption in major end-use segments

Thanks to improved economy in China, the consumption of pentaerythritol maintained stable in 2016–2018. It fluctuated in 2019–2021; a slight fall was witnessed in 2020 as the market was stricken by the COVID-19 outbreak.

To be specific, consumption of pentaerythritol saw continuous decreases in alkyd resin sector but increases in PU sector in 2017–2021, while the volumes in synthetic lubricant, rosin pentaerythritol ester and other fields fluctuated overall. As synthetic lubricant, rosin pentaerythritol ester and PU have higher quality requirements for pentaerythritol, domestic pentaerythritol has been gradually developing towards higher-end of the spectrum.

Figure 6.2-1 Apparent consumption of pentaerythritol in China by end-use segment, 2017–2021



Source:CCM

6.3 Brief introduction to each major end use segment

6.3.1 Alkyd resin

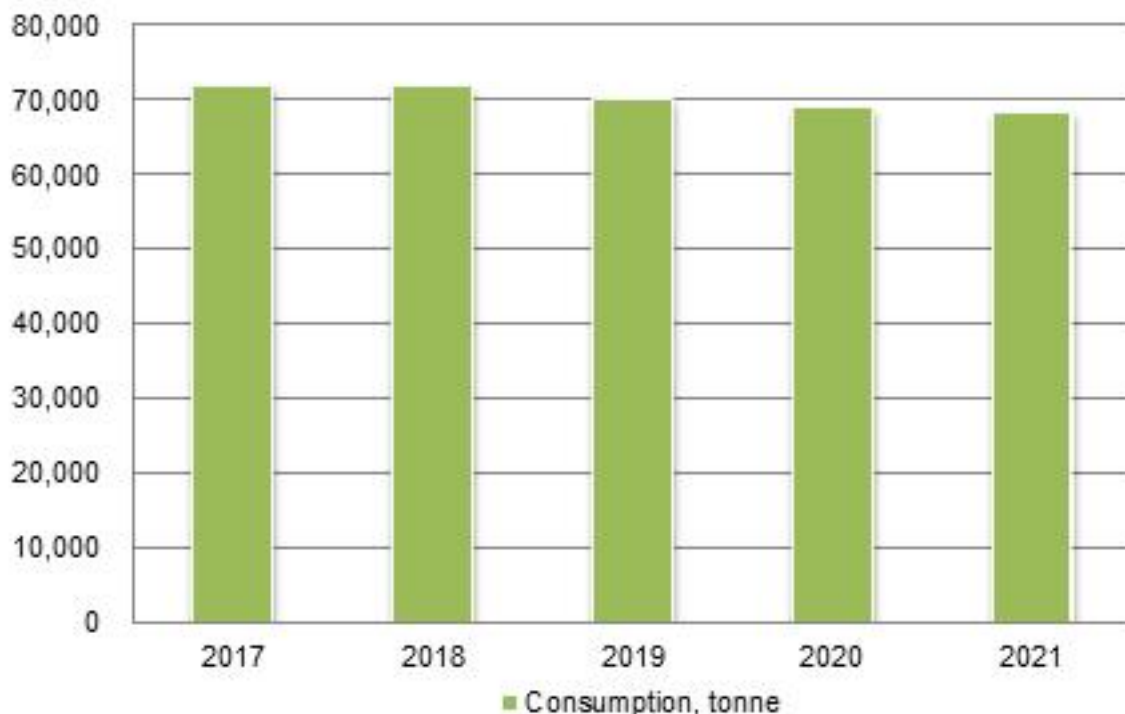
In China, a large number of pentaerythritol is used in the production of alkyd resin coatings and the applications in bridges, vehicles, ships and aircraft coating continuously support the demand for pentaerythritol.

Alkyd resin is prepared by polycondensation reaction with polyhydric alcohol, organic acid and fatty acid as main raw materials. The polyhydric alcohols commonly used in the production of alkyd resin include glycerol, pentaerythritol, propylene glycol, etc. Thereinto, pentaerythritol has the advantages of good quick drying, high hardness, and high gloss, and has been widely used in industrial production.

China's pentaerythritol consumption in alkyd resin kept decreasing, at a CAGR of -1.2% in 2017–2021, because of the decreasing domestic demand for alkyd resin, which has faced strong competition from acrylic resin.

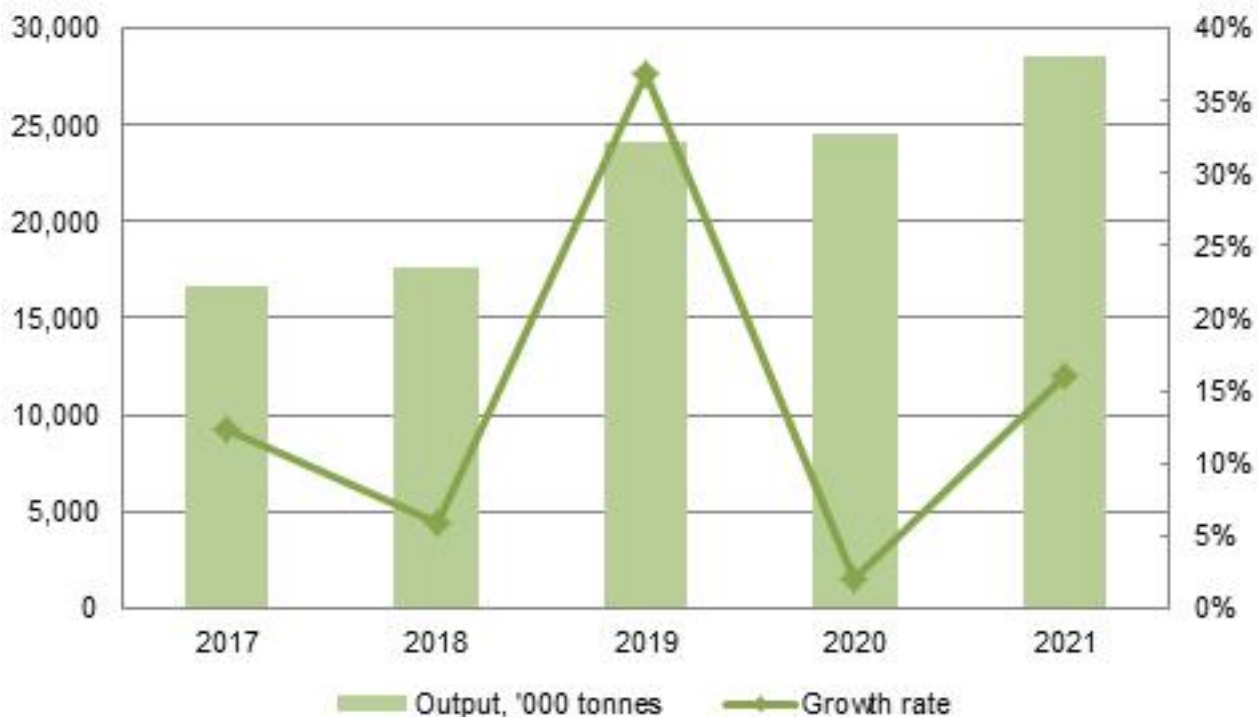
In 2021, the consumption volume of pentaerythritol in alkyd resin came down to 68,500 tonnes, mainly influenced by the impact of alternatives. Steady improvement of domestic building industry and quite stable development of automobile industry were seen in 2021, yet the downstream market share of alkyd resin kept declining. As for the building industry in 2021, the total gross output value was USD4,535.8 billion, up by 11.0% year on year. Moreover, the national housing construction area was about 15.8 billion m², up by 5.4% year on year.

Figure 6.3.1-1 Pentaerythritol consumption volume in alkyd resin in China, 2017–2021



Source:CCM

Figure 6.3.1-2 Output of coating in China, 2017–2021



Source:National Bureau of Statistics & China Coating Industry Association

Production of coating has increased rapidly in China. The output of coating in China kept increasing in 2017–2021, with a CAGR of 14.5%. However, in recent years, with emergence of alternatives, the proportion of alkyd resin coatings to the total has been on the decline.

In China, coating is widely used in ships, bridges, automobiles, etc. Take automobile as an example, the domestic automobile industry saw a rapid development, with the output increasing from 23.7 million sets in 2014 to over 29.0 million sets in 2017. Yet mainly because of cancellation of tax incentives for purchasing passenger cars, automobile output dropped continuously, and the figure in 2020 was 25.2 million sets. In 2021, automobile output showed a modest recovery to 26.1 million sets. Unfortunately, the increase in

automobile output had little effect on bringing up pentaerythritol consumption in alkyd resin.

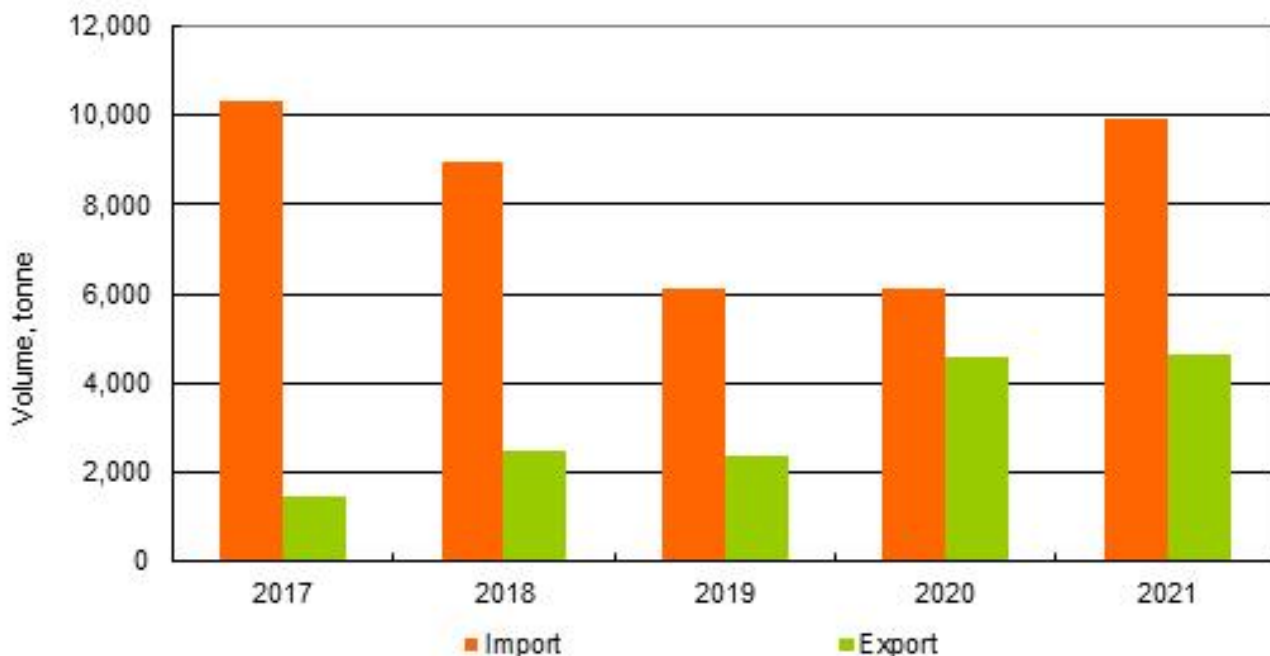
Figure 6.3.1-3 Output and sales volume of automobile in China, 2017–2021



Source: China Association of Automobile Manufacturers

In China, the import volume of alkyd resin decreased from 10,294 tonnes in 2017 to 6,143 tonnes in 2020, and the export volume increased from 1,439 tonnes in 2017 to 4,596 tonnes in 2020. In 2021, both import and export of alkyd resin increased, reaching 9,922 tonnes and 4,652 tonnes, respectively.

Figure 6.3.1-4 China's import & export of alkyd resin (HS Code: 39075000), 2017–2021



Source: China Customs

Alkyd resin is the largest end use segment of pentaerythritol in China, yet the alkyd resin made from pentaerythritol accounts for a small proportion of the total. And with heavy competition from acrylic resin, demand for pentaerythritol from this sector will decrease slowly.

6.3.2 Polyurethane

In polyurethane (PU) production, pentaerythritol is used to make polyester polyols and polyether polyols, the

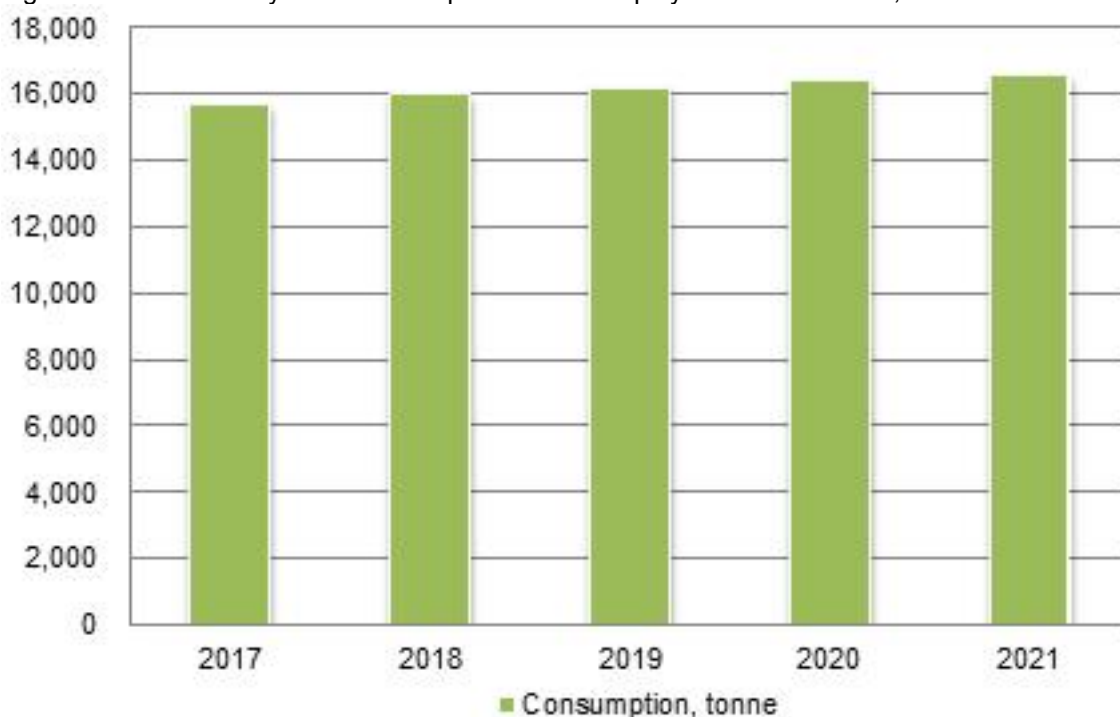
latter of which are one of the main raw materials for polyurethane foam materials.

As a substitute for glycerol, pentaerythritol is used to produce PU materials. In recent years, the Chinese PU industry developed rapidly. At the same time, glycerol market has been in short supply in recent years, even though glycerol output rose in general. As a result, many PU manufacturers have adopted pentaerythritol to replace glycerol.

In the past, glycerol was widely used in the preparation of rigid PU or semi-rigid PU, as it has three functional groups of hydroxyl, which are easy to form three-dimensional network embodying the hardness property to the PU products. As pentaerythritol has four hydroxyl groups, it is more suitable for the preparation of rigid PU or semi-rigid PU, compared with polyether triols like glycerol. So pentaerythritol has been widely used to replace glycerol to produce polyester polyols and polyether polyols.

In 2015, the output of pentaerythritol in China decreased, and the consumption volume of pentaerythritol in PU industry also dropped by 8.7% year on year. Since 2016, the consumption volume of pentaerythritol in PU production has kept increasing, up from 15,400 tonnes in 2016 to 16,600 tonnes in 2021.

Figure 6.3.2-1 Pentaerythritol consumption volume in polyurethane in China, 2017–2021



Source:CCM

PU can be used in energy-saving materials. The consumption volume of pentaerythritol in the PU industry will keep a stable growth in the next few years.

On one hand, PU will maintain a stable growth in the traditional industries, such as automobile, household appliances and textile. Take automobiles as an example, with further implementation of the national energy-saving and emission reduction policies, increasing demand for energy-saving materials in automobiles will ensure the continuous growth of the demand for PU foam.

On the other hand, building energy conservation, new energy, high-speed rails, pipeline transportation, medical treatment and other fields will be new development trends for PU industry. Taking the construction industry as an example, with implementation of relevant laws and regulations on building energy conservation in China, the application of rigid PU foam will be widened, which also gives a development opportunity to the popularization of PU.

6.3.3 Lubricant (high-grade)

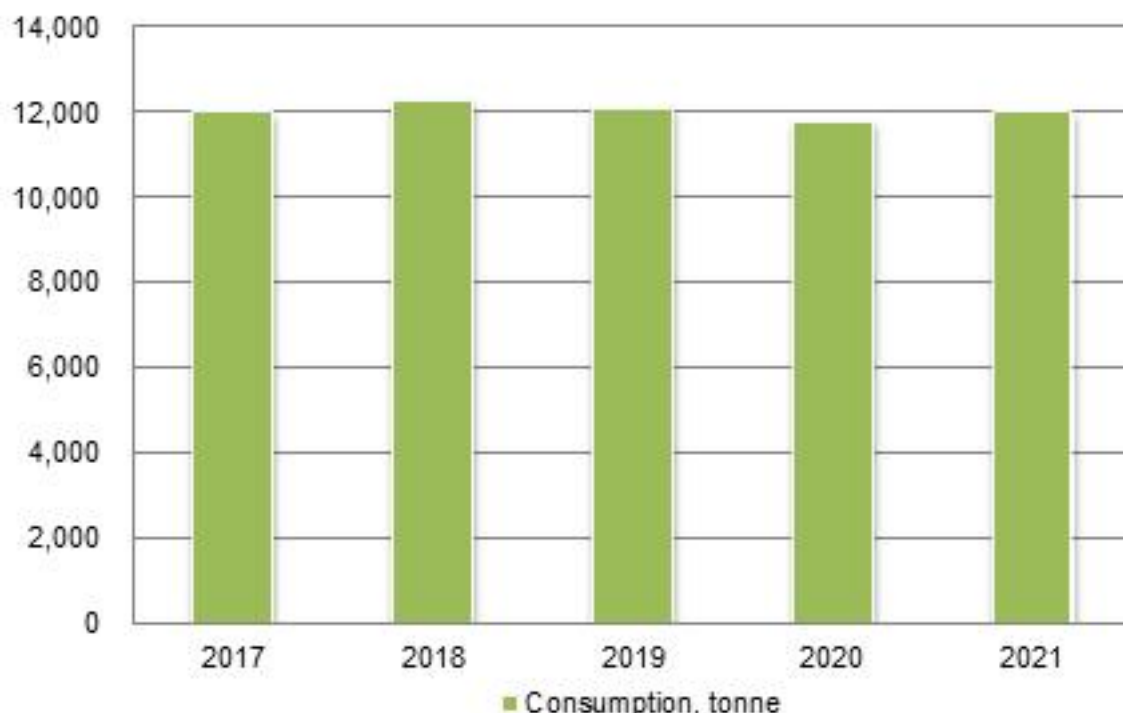
Usually in lubricant field, high purity monopentaerythritol (98% at minimum) or dipentaerythritol is required to react with C5–10 aliphatic acids to generate aliphatic esters. Aliphatic esters can be used as the base oil in high-grade lubricants for excellent high- and low-temperature properties, high flash point and low pour point.

High-grade lubricant is widely used in the aviation field, mainly applied in aeroengines and chains under high temperature working conditions. It is also used in other fields such as automobile engines.

Domestic consumption volume of pentaerythritol in high-grade lubricant reduced in 2015, owing to sluggish economy, but as the economy improved in 2016, the consumption increased by 72.1% year on year. In 2017, the National Standards for Pollutants Discharge by Motor Vehicles (Phase V) was implemented. Therefore, quality of lubricant needed to be improved and the demand for high-grade lubricant for vehicles increased. The consumption of pentaerythritol was above 12,000 tonnes from 2017 to 2019.

In 2020, demand for high-grade lubricant weakened slightly because of the ravaging COVID-19, and the consumption of pentaerythritol in high-grade lubricant reduced to 11,800 tonnes. Boosted by the steady economic recovery and rising demand from domestic high-grade lubricant market, China saw a slight increase in pentaerythritol consumption in this sector in 2021.

Figure 6.3.3-1 Pentaerythritol consumption volume in high-grade lubricant in China, 2017–2021



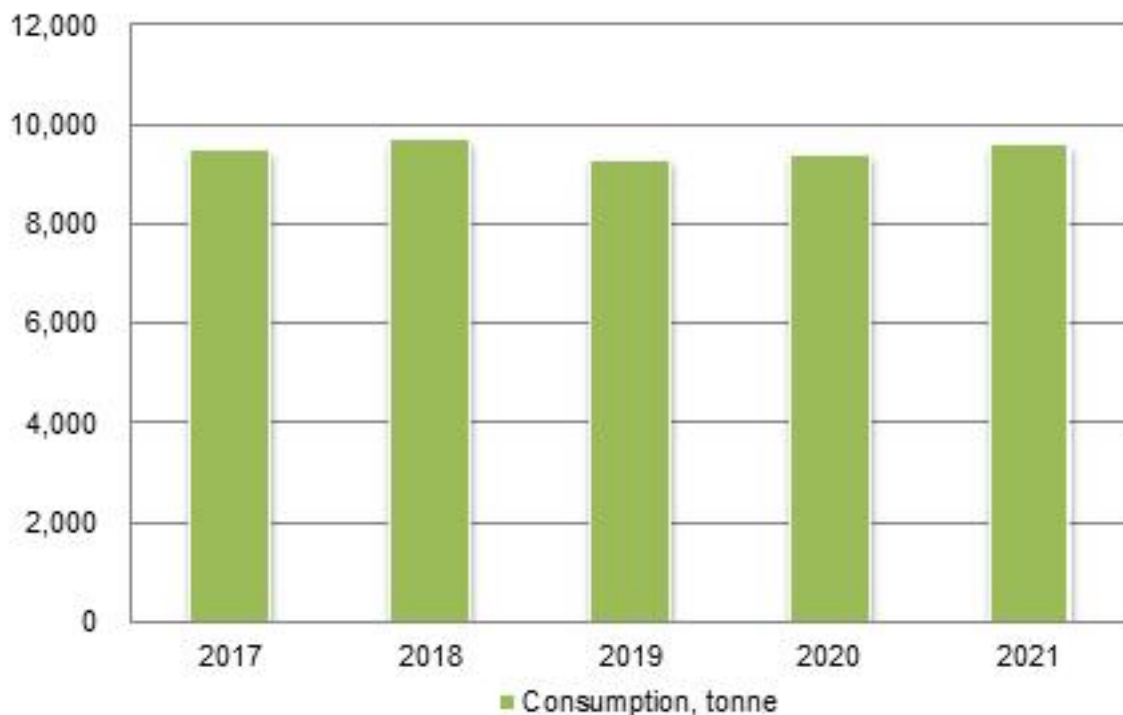
Source:CCM

6.3.4 Rosin pentaerythritol ester

In China, rosin pentaerythritol ester is reported as a high-grade product to be widely used in coatings, papermaking, adhesives, rubber assistants and ink (tall oil). These sectors are developing, which require much higher-grade products (like rosin pentaerythritol ester) to replace the current low-grade products.

With recovered chemical market in China, consumption volume of pentaerythritol in rosin pentaerythritol ester grew back to 9,200 tonnes in 2016, and expanded steadily till 2018. Though the volume dropped slightly to 9,300 tonnes in 2019, it climbed back to 9,600 tonnes in 2021.

Figure 6.3.4-1 Pentaerythritol consumption volume in rosin pentaerythritol ester in China, 2017–2021



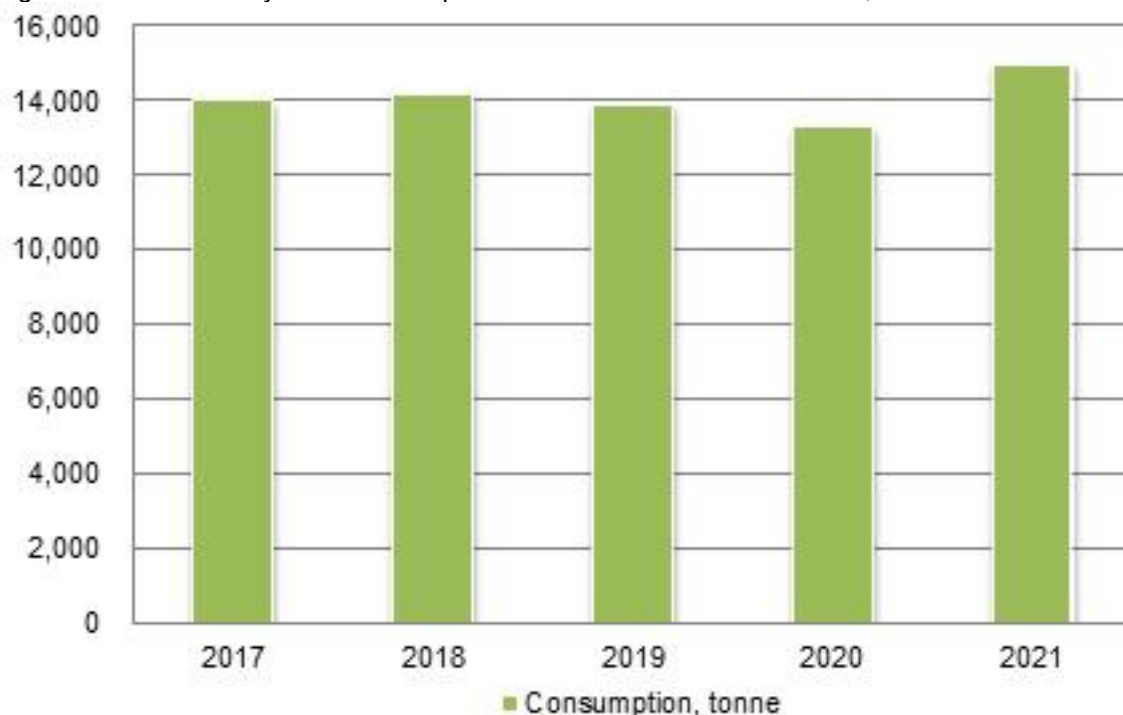
Source:CCM

6.3.5 Others

Pentaerythritol can be made into the following derivatives:

- Pentaerythritol tetranitrate: It is a strong explosive.
- Fatty acid ester is used as plasticizer and stabilizer to make high temperature/insulation PVC. It is a fast growing area, especially under the influence of the impact of ROHS Directive and WEEE Directive.
- Antioxidant 1010 (tetra (β -(3,5-ditertbutyl-4-hydroxy phenyl) propionate)): It is used in rubber, plastic anti-aging agents, antioxidants and so on.
- Antioxidant 618 (distearic pentaerythritol diphosphite) for ABS resin, PS, PC, etc.
- Antioxidant 626 (bis-(2,4-di-tert-butyl-pheny)-phosphiterythritol diphosphite): It is used in the production of plastics.
- Polyisobutylene pentaerythritolate: It is an antioxidant.
- Pentaerythritol triacrylate: It is used in coatings, inks, adhesives, light polymers and other fields.
- Pentaerythritol and neopentleglycol-pentaerythritol binary system for heat storage materials.
- Cyclohexanone pentaerythritol ketal for deforming agents.
- Polyoxyethylene polyoxypropylene pentaerythritol ether: It can be used as emollient and anti-caking agent in personal care products, and as a food processing aid, etc.

Figure 6.3.5-1 Pentaerythritol consumption volume in other fields in China, 2017–2021



Source:CCM

With transformation and upgrading of China's economy and strengthening of environmental protection, standards of chemical industry need to be improved continuously, which is bound to affect the supply of pentaerythritol. On the whole, the consumption volume of pentaerythritol in other industries has declined since 2013.

During 2016–2018, the consumption volume of pentaerythritol in other industries increased at a CAGR of 1.8%, but it decreased slightly in 2019–2020. In 2021, boosted by improvements in the construction sector and other industrial sectors, demand for pentaerythritol in other industries also increased.

6.4 Consumption of dipentaerythritol in China and main users

Dipentaerythritol is usually used as a raw material in the production of dipentaerythritol hexaacrylate (DPHA) and dipentaerythritol ester, etc. It is widely used in coating, aerospace, polymer industries and other fields. The end products have excellent comprehensive performance and score higher in environmental protection.

From 2017 to 2021, the consumption of dipentaerythritol in China witnessed a stable growth, with increases in both volume and market value. The consumption rose from 382 tonnes in 2017 to 877 tonnes in 2021.

Dipentaerythritol hexaacrylate (DPHA)

In China, the largest end use segment of dipentaerythritol is DPHA. The rapid development of DPHA's downstream products kept the DPHA industry growing in recent years. Ultraviolet curing coating (UVCC), the largest consumer of DPHA in China, has the advantages of environmental friendliness, fast curing, high hardness and abrasion resistance. With the improvement of environmental consciousness, UVCC is becoming more and more popular in China.

Dipentaerythritol ester

Dipentaerythritol ester is another major downstream product of dipentaerythritol. It is used to make lubricants with strong inoxidizability and high thermal stability, which are used in the machines working in high temperatures, such as turbojet engine. The demand from dipentaerythritol ester for dipentaerythritol increases slower than that from DPHA, mainly due to the high price and low usage amount of dipentaerythritol ester.

6.5 Consumption of tripentaerythritol in China

The production technology of tripentaerythritol in China has not yet made a breakthrough, the production of tripentaerythritol still has problems of low yield, difficulty in separation and low purity. At present, only a few manufacturers can produce tripentaerythritol, which greatly limits the application of tripentaerythritol.

In 2021, the consumption of tripentaerythritol in China was about 80 tonnes.

7 Future forecast

7.1 Key factors and driving forces for development

- Environmental pressure

The Chinese government has focused on environmental protection and improved environmental standards, which has incurred higher environmental costs for manufacturers. On one hand, these initiatives may lead producers to improve their technical routes to meet environmental standards. On the other hand, environmental pressure can lead to the elimination of some small manufacturers, which will further improve the future concentration of pentaerythritol industry in China. With the government's increasingly stringent environmental regulations and policies, companies with better environmental protection facilities have obvious advantages.

At present, the Chinese government attaches more importance to pollution control and energy conservation. Since there is still some pollution in the production of pentaerythritol, environmental supervision and examination will directly affect operation of pentaerythritol producers and the price of pentaerythritol. In 2016–2017, Hubei Yihua stopped the pentaerythritol production line in the Yichang factory; this period also saw a decline in pentaerythritol output in Baoding Guoxiu which is located in the Beijing-Tianjin-Hebei region, where the pentaerythritol production is seriously influenced by environmental pressure. Notably, Baoding Guoxiu, listed among 35 manufacturers of hazardous chemicals by authorities in Hebei Province, was required to relocate, and it suspended production in 2018–2021.

- Competition

China's pentaerythritol industry has witnessed overcapacity for many years. In the future, such competition will prove to be a negative factor to the price of pentaerythritol. Overcapacity, coupled with the competition from alternatives to pentaerythritol, will also weaken the bargaining power of pentaerythritol manufacturers and squeeze their future profit margins.

- Challenge from the COVID-19

Under the COVID-19 pandemic, the global economy encountered recession. Although the economy has been gradually recovering, production and sales of pentaerythritol, as well as the upstream and downstream sectors will be more or less influenced.

- Domestic downstream market

The major downstream market of pentaerythritol is alkyd resin, accounting for more than half of pentaerythritol consumption in China in 2017–2021. It is estimated that the pentaerythritol consumption volume in alkyd resin will decrease slowly. On one hand, the volume of alkyd resin produced from pentaerythritol accounts for about 3% of the total alkyd resin. On the other hand, alkyd resin made from pentaerythritol is facing strong competition from acrylic resin, which will affect demand for pentaerythritol from the coating & painting industry.

- Overseas market

In 2017–2021, the export volume of pentaerythritol accounted for some 30% of the total pentaerythritol output. It's estimated that the demand from overseas markets will increase slightly in the near future. But in the long run, the demand is relatively stable.

7.2 Outlook for pentaerythritol industry, 2022–2026

- Production

The pentaerythritol industry still faces problems such as growing production cost, shrinking profit, weak downstream market and increasing environmental pressure in particular, which will directly affect the output of pentaerythritol. Besides, demand from the largest downstream sector alkyd resin will decrease further.

It is estimated that the output of pentaerythritol will increase at a CAGR of 1.1% from 2022 to 2026.

- Industry concentration

Chifeng Ruiyang and Hubei Yihua occupied about 60% of the Chinese pentaerythritol market in 2017–2021.

However, with two new entrants joining the industry, greater change to the concentration rate has been witnessed. In the future, the industry will experience fiercer competition and small producers will find it difficult to operate under current cost pressures from both raw materials and environmental protection and will cut or suspend their production. This will provide opportunities for leading pentaerythritol producers to expand their market share. Besides, entry barriers to the industry will increase.

- Price level

In the next few years, the price of pentaerythritol is estimated to increase mainly because of the increases in the price of methanol and formaldehyde, the raw materials of pentaerythritol, and the increasing environmental pressure. Additionally, fluctuating energy prices will result in greater cost pressures on pentaerythritol manufacturers. While CPI is expected to rise, housing price may stabilize, and salary expectations of workers will see limited change. Therefore, manufacturers may have small pressure of labor cost in the next two years.

- Product structure

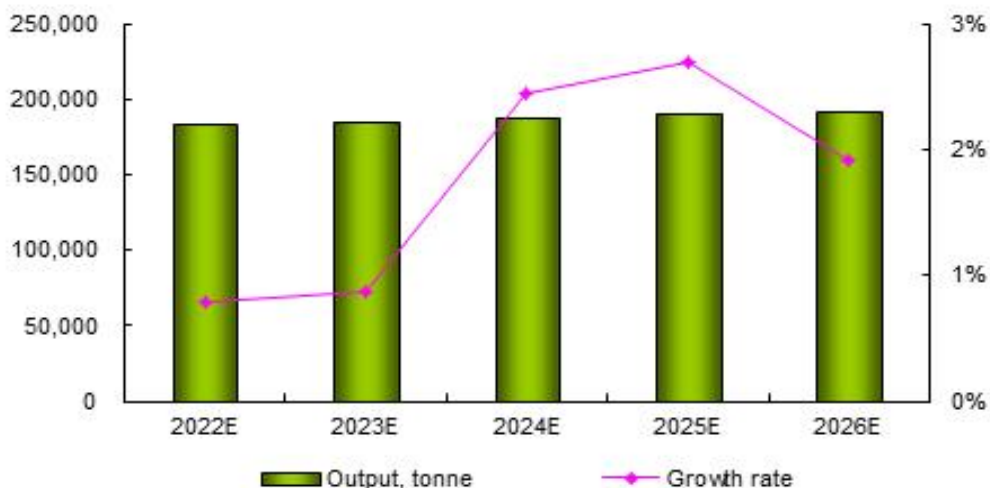
At present, the competition in the Chinese pentaerythritol industry becomes more intense. And the demand for high-quality pentaerythritol is increasing in both overseas and domestic markets. Producers have to change their competitive strategies if they want to get more market shares and profits. Therefore, the capacity of low-grade pentaerythritol will continue to decrease, while the capacity of high-grade pentaerythritol, dipentaerythritol and tripentaerythritol will expand in the future. CCM also believes that increasing product differentiation to promote competition is conducive to further optimize the structure of pentaerythritol industry.

Table 7.2-1 Forecast on pentaerythritol development in China by output share, 2022–2026

Year	Monopentaerythritol			Dipentaerythritol	Tripentaerythritol	Total
	Low-grade	Middle-grade	Dipentaerythritol			
2022	11.1%	45.7%	40.4%	2.7%	0.1%	100.0%
2023	10.4%	43.5%	43.2%	2.8%	0.1%	100.0%
2024	9.8%	43.0%	44.2%	2.9%	0.1%	100.0%
2025	9.2%	42.8%	44.8%	3.1%	0.1%	100.0%
2026	9.2%	42.5%	45.1%	3.1%	0.1%	100.0%

Source:CCM

Figure 7.2-1 Forecast on pentaerythritol output in China, 2022–2026



Source:CCM

8 Conclusions

In China, there were twelve pentaerythritol manufacturers in 2021, one of which suspended production for environmental protection. Both capacity and output of pentaerythritol in China kept decreasing from 2017 to 2020. However, in 2021, the capacity picked up as two new players entered the industry, and the output was higher than annual output recorded in five years before. It is estimated that the output of pentaerythritol in China will keep increasing slowly in 2022–2026.

Domestic pentaerythritol prices increased in H2 2017–March 2018, mainly triggered by stringent environmental protection inspections and requirements. The prices declined in 2019–H1 2020 because of decreasing prices of raw materials. From then on to H1 2021, the prices gradually recovered as prices of raw materials and demand increased. Pentaerythritol prices retreated in Q2 2022.

In 2018, China's pentaerythritol export volume decreased a lot year on year, mainly because of rising pentaerythritol prices. The export kept decreasing in 2019, though the average price was much lower. In 2020, it fell further due to the damage COVID-19 brought on to the global economy. But such a trend reversed in 2021, with overseas demand boosting China's pentaerythritol exports.

As to pentaerythritol import, the volume in 2017 surpassed 3,000 tonnes for the first time since 2003. The volume remained below 4,000 tonnes in 2017–2020, but exceeded 5,500 tonnes in 2021.

The pentaerythritol industry in China has faced fierce competition, low profit and great environmental pressure, which in fact have affected some manufacturers. For example, Baoding Guoxiu suspended production since 2018 and Shandong IFT halted pentaerythritol production in H1 2022.

9 Profile of pentaerythritol manufacturers

9.1 Active manufacturers

9.1.1 Chifeng Ruiyang Chemical Co., Ltd.

Address: Yuanbaoshan District, Chifeng City, Inner Mongolia Autonomous Region 024000, P. R. China
Tel.: +86-476-5999183, 5999156, 5999166
Fax: +86-476-5999163
E-mail: ruiyanghuagong@sina.com
Person to contact: Mr. Ma, Mr. Yan
Website: www.nmruiyangchemical.com

- Company background

Chifeng Ruiyang Chemical Co., Ltd. (Chifeng Ruiyang), was established in 2005 and specializes in the production of pentaerythritol, alcohol, trimethylolpropane and other products. The company's registered capital was RMB400 million as of July 2022 and it has obtained certifications of ISO 9001 Quality Management System and ISO 14001 Environmental Management System.

In October 2019, Shanghai Zhongyida Co., Ltd. (stock code: 600610) purchased 100% equity of Chifeng Ruiyang. Before that, Chifeng Ruiyang was a sub-subsidiary of Guizhou Kailin Group Co., Ltd. Jiangsu Ruiyang had three pentaerythritol production bases before 2018, namely Jiangsu Kailin Ruiyang Chemical Co., Ltd. (Jiangsu Ruiyang), Chifeng Ruiyang and Guizhou Kailin Xifeng Synthetic Ammonia Co., Ltd. (Guizhou Kailin, still a subsidiary of Guizhou Kailin Group Co., Ltd.).

- Main products

- Pentaerythritol
- Trimethylolpropane
- Alcohol
- Formaldehyde
- Acetaldehyde

- Pentaerythritol

Capacity of the three pentaerythritol production bases (Jiangsu Ruiyang, Chifeng Ruiyang and Guizhou Kailin) before 2018 was 25,000 t/a, 40,000 t/a and 60,000 t/a, respectively. Chifeng Ruiyang's overall pentaerythritol capacity was 45,500 t/a in 2021.

- Chifeng Ruiyang Chemical Co., Ltd.

Chifeng Ruiyang's 5,000 t/a new high-quality pentaerythritol project was built up in 2018. It can produce all three kinds of pentaerythritol with the capacity of 43,000 t/a monopentaerythritol (95%, 98% and 99%), 2,500 t/a dipentaerythritol (85% and 90%) and 200 t/a tripentaerythritol (80%).

- Jiangsu Kailin Ruiyang Chemical Co., Ltd.

Jiangsu Ruiyang permanently stopped pentaerythritol production in 2018.

- Guizhou Kailin Xifeng Synthetic Ammonia Co., Ltd.

There were two production lines in Guizhou Kailin Xifeng Synthetic Ammonia Co., Ltd. (each with 30,000 t/a capacity), one of which was reformed to produce ferric phosphate in 2018. The other is used for the transitional production of pentaerythritol. Whether this production line will be used to produce pentaerythritol depends on market demand. In 2018, Chifeng Ruiyang leased production equipment with capacity of 15,000 t/a from Guizhou Kailin to produce pentaerythritol.

Table 9.1.1-1 Capacity and output of pentaerythritol in Chifeng Ruiyang, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	124,500	62,500	47,500	45,500	45,500	45,500
Output, tonne	58,050	49,550	43,400	45,550	48,800	24,020

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.

However, as Chifeng Ruiyang has a separate dipentaerythritol production line, the capacity of pentaerythritol in Chifeng Ruiyang is the sum of monopentaerythritol capacity and dipentaerythritol capacity.
Source:CCM

• Technology

Chifeng Ruiyang's process route is sodium method, and calcium method production facilities have not been built due to market changes and technical factors.

• Sales

Chifeng Ruiyang's pentaerythritol products have been exported to over 35 countries.

Its key customers are producers in the coating, lubricant and fine chemical business as well as chemical traders.

• Price

Table 9.1.1-2 Quotation of pentaerythritol in Chifeng Ruiyang, 2017–2022, USD/t

Specification	Monopentaerythritol		Dipentaerythritol		Tripentaerythritol
	95%	98%	85%	90%	
July 2017	N/A	1,450	5,600	N/A	N/A
March 2018	1,894	1,650	N/A	N/A	N/A
June 2019	1,524	1,713	6,822	N/A	11,612
June 2020	N/A	1,318	4,207	N/A	11,218
June 2021	1,966	2,124	N/A	N/A	N/A
July 2022	1,795	1,944	N/A	N/A	N/A

Source:CCM

• Export

Table 9.1.1-3 Chifeng Ruiyang's export volume of pentaerythritol, 2017–2021

Year	Export of monopentaerythritol		Export of dipentaerythritol	
	Volume, tonne	Growth rate	Volume, tonne	Growth rate
2017	17,344	-8.8%	1,767	70.6%
2018	14,881	-14.2%	2,102	19.0%
2019	12,392	-16.7%	1,212	-42.3%
2020	11,361	-8.3%	N/A	/
2021	15,232	34.1%	850	/

Source:CCM

9.1.2 Hubei Yihua Chemical Industry Co., Ltd.

Address: No. 52 Yanjiang Avenue, Yichang City, Hubei Province 443000, P. R. China
Tel.: +86-717-8868235; 13886744644; 15901032658

Fax: +86-717-6466258
 Person to contact: Mr. Huang; Mr. Liu
 Website: www.hbyh.cn

- Company background

Hubei Yihua Chemical Industry Co., Ltd. (Hubei Yihua, former Hubei Yichang Chemical Plant) was founded in 1977. It publically issued 16.35 million RMB-denominated common shares in July 1996 and was listed on the Shenzhen Stock Exchange (SZSE) in Aug. 1996. Hubei Yihua (stock code: 000422) is the first listed nitrogenous fertilizer manufacturer in China.

In 2021, Hubei Yihua achieved a revenue of USD2,870.0 million (RMB18,544.1 million), a 34.3% increase year on year; the net profit attributable to shareholders of the listed company was USD242.8 million (RMB1,569.0 million), surging more than tenfold over the figure in the previous year.

- Main products

Hubei Yihua mainly engages in the production and sales of fertilizers and chemicals. It had capacity of 1,560,000 t/a urea, 1,260,000 t/a diammonium phosphate, 840,000 t/a polyvinyl chloride (PVC), 900,000 t/a caustic soda, and 70,000 t/a pentaerythritol as of the end of 2021.

1) Major fertilizers

- Urea
- Diammonium phosphate

2) Major chemicals

- Caustic soda
- PVC
- Pentaerythritol
- Sodium hydrosulfite

Other products of the company include formaldehyde, formic acid, liquid chloride, and PVC resin.

- Pentaerythritol

Hubei Yihua focuses on the manufacturing of 95% and 98% monopentaerythritol to fulfil larger market demand for high-end products. It produces dipentaerythritol with a small amount.

Hubei Yihua once had three pentaerythritol factories, which are located in Yidu City, Hubei Province; Wuhai City, Inner Mongolia Autonomous Region; Yichang City, Hubei Province. But it stopped pentaerythritol production in its Yichang factory for the upgrading of its synthetic ammonia installation in 2017, and thus cut its pentaerythritol capacity by 8,000 t/a to 70,000 t/a. In 2017–2021, the capacity of pentaerythritol of Hubei Yihua in Yidu base and Inner Mongolia base was 40,000 t/a and 30,000 t/a respectively.

Table 9.1.2-1 Capacity and output of pentaerythritol in Hubei Yihua, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	70,000	70,000	70,000	70,000	70,000	70,000
Output, tonne	47,300	55,600	53,900	52,800	55,200	23,000

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
 Source: CCM

• Price

Table 9.1.2-2 Quotation of pentaerythritol in Hubei Yihua, 2017–2022, USD/t

Specification	Monopentaerythritol		Dipentaerythritol	
	95%	98%	85%	90%

July 2017	1,315	1,357	N/A	N/A
March 2018	1,973	2,052	N/A	N/A
June 2019	1,597	1,742	N/A	N/A
June 2020	1,150	1,346	5,048	N/A
June 2021	1,888	N/A	N/A	N/A
July 2022	1,795	N/A	N/A	N/A

Source:CCM

● Export

Table 9.1.2-3 Hubei Yihua's export volume of pentaerythritol, 2017–2021

Year	Export volume, tonne	Growth rate
2017	19,820	N/A
2018	22,141	11.7%
2019	22,906	3.5%
2020	21,916	-4.3%
2021	25,771	17.6%

Source:CCM

9.1.3 Puyang Pengxin Chemical Co., Ltd.

Address: West of Shengli Road, Puyang City, Henan Province 457000, P. R. China

Tel.: +86-393-8950030; +86-393-8961860; +86-393-8961018

Fax: +86-393-8961860

E-mail: pengxinchemical@outlook.com

Person to contact: Mr. Zhou

Website: www.pyspx.com

- Company background

Puyang Pengxin Chemical Co., Ltd. (Puyang Pengxin), established in 2002, has total assets of RMB150 million and over 200 employees, covering an area of 77,700 m².

Puyang Pengxin's main capacity include 20,000 t/a pentaerythritol, 1,000 t/a dipentaerythritol, 100,000 t/a formaldehyde, and 13,000 t/a sodium formate. It is also among the first batch of revisors of national standards of pentaerythritol and formaldehyde, as well as industrial standards of dipentaerythritol.

In Aug. 2016, Puyang Pengxin became a co-founder of the Professional Committee of Polyol under the framework of the Formaldehyde Industry Association to enlarge the production scale, advance technology and improve the comprehensive strength of the whole industry.

Puyang Pengxin has been certificated to ISO 9001 Quality Management System and ISO 14001 Environmental Management System.

- Pentaerythritol

Puyang Pengxin mainly produces 92%, 95% and 98% monopentaerythritol and 85% and 90% dipentaerythritol. In H1 2022, it mainly produced 95% monopentaerythritol and 85% dipentaerythritol.

Table 9.1.3-1 Capacity and output of pentaerythritol in Puyang Pengxin, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	20,000	20,000	20,000	20,000	20,000	20,000
Output, tonne	17,200	17,700	17,800	16,600	18,600	9,350

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
Source:CCM

• Sales

In the domestic market, Puyang Pengxin's monopentaerythritol is mainly for alkyd resin and paint.

• Price

Table 9.1.3-2 Quotation of pentaerythritol in Puyang Pengxin, 2017–2022, USD/t

Specification	Monopentaerythritol			Dipentaerythritol	
	92%	95%	98%	85%	90%
July 2017	1,505	1,505	1,667	6,197	6,640
March 2018	N/A	1,600	1,620	5,500	5,700
June 2019	N/A	1,568	1,742	5,080	5,225
June 2020	N/A	1,122	1,136	4,768	N/A
June 2021	N/A	1,888	N/A	N/A	N/A
July 2022	N/A	1,795	N/A	5,982	N/A

Source:CCM

9.1.4 Anhui Jinhe Industrial Co., Ltd.

Address: No. 127 East Street, Lai'an County, Chuzhou City, Anhui Province 239200, P. R. China

Tel.: +86-550-5624224, 5619090, 18805503066, 13956316220

Fax: +86-550-5628694

E-mail: sales-overseas@ajhchem.com

Person to contact: Mr. Zhu, Mr. Chen

Website: www.jinheshiye.com

- Company background

Anhui Jinhe Industrial Co., Ltd. (Anhui Jinhe), set up in Dec. 2006, was listed on the SZSE in July 2011 (stock code: 002597). It achieved a revenue of USD904.6 million (RMB5,845.3 million) and a net profit of USD182.2 million (RMB1,177.1 million) in 2021. As of July 2022, it had over ten subsidiaries including Jinzhisui International Trading (HK) Limited, Jinhe USA LLC and Jinzhisui International Trade (Nanjing) Co., Ltd.

- Main products

- 1) Food additives
 - Acesulfame-K
 - Methyl maltol
 - Ethyl maltol

2) Chemicals

- Formaldehyde
- Liquid ammonia
- Ammonium bicarbonate
- Nitric acid
- Melamine
- Pentaerythritol
- Neopentyl glycol
- Sulphuric acid and others

- Pentaerythritol

Anhui Jinhe started the commercial production of pentaerythritol in Aug. 2008. It has 20,000 t/a pentaerythritol production capacity and mainly produces 95% monopentaerythritol.

Table 9.1.4-1 Capacity and output of pentaerythritol in Anhui Jinhe, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	20,000	20,000	20,000	20,000	20,000	20,000
Output, tonne	15,400	15,400	19,200	18,050	19,150	9,250

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.

Source: CCM

● Technology

Anhui Jinhe uses low-temperature sodium method to produce pentaerythritol. In 2018, the company applied two patents for its tripentaerythritol synthesis method.

● Sales

Most of pentaerythritol produced by the company is sold in the domestic market.

● Price

Table 9.1.4-2 Quotation of pentaerythritol in Anhui Jinhe, 2017–2022, USD/t

Specification	Monopentaerythritol		Dipentaerythritol	
	93%	95%	85%	90%
July 2017	1,350	1,401	5,164	N/A
March 2018	N/A	1,863	5,051	N/A
June 2019	N/A	1,495	4,790	N/A
June 2020	N/A	1,066	3,365	N/A
June 2021	N/A	1,966	N/A	N/A
July 2022	N/A	1,795	N/A	N/A

Source: CCM

9.1.5 Bazhou Shengfang United Chemical Co., Ltd.

Address: Xinzhang Industrial Zone, Shengfang Town, Bazhou City, Hebei Province 065701, P. R. China
Tel.: +86-316-7531828, 13603267665
Fax: +86-316-7531828

Person to contact: Mr. Li

- Company background

Bazhou Shengfang United Chemical Co., Ltd. (Bazhou Shengfang)'s predecessor is Shengfang United Formaldehyde Factory, which was founded in 1996 and renamed as United Chemical Co., Ltd. in 2002. As of July 2022, Bazhou Shengfang mainly produces pentaerythritol, sodium formate and formaldehyde with capacities of 15,000 t/a, 7,000 t/a and 170,000 t/a respectively.

- Pentaerythritol

Bazhou Shengfang's pentaerythritol production line was put into production in April 2008.

The company can produce 80%–90% dipentaerythritol, 93%, 95% and 98% monopentaerythritol. However, at present, the company produces 95% monopentaerythritol only.

Table 9.1.5-1 Capacity and output of pentaerythritol in Bazhou Shengfang, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	15,000	15,000	15,000	15,000	15,000	15,000
Output, tonne	3,500	3,000	2,800	2,000	2,300	1,000

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.

Source:CCM

• Technology

Bazhou Shengfang produces pentaerythritol using a low-temperature sodium method, and it uses self-produced formaldehyde as a raw material.

• Sales

The company claims that its pentaerythritol is mainly used in coating & painting.

At present, it mainly sells 95% monopentaerythritol. Most of pentaerythritol produced by the company is sold in domestic market.

Table 9.1.5-2 Quotation of pentaerythritol in Bazhou Shengfang, 2017–2022, USD/t

Specification	Monopentaerythritol			Dipentaerythritol
	93%	95%	98%	85%
July 2017	1,328	N/A	N/A	N/A
March 2018	1,894	N/A	N/A	N/A
June 2019	1,524	N/A	N/A	N/A
June 2020	1,094	N/A	N/A	N/A
June 2021	N/A	1,888	N/A	N/A
July 2022	N/A	1,645	N/A	N/A

Source:CCM

9.1.6 Yunnan Yuntianhua Co., Ltd.

Address: No. 1417 Dianchi Road, Xishan District, Kunming City, Yunnan Province 650228, P. R. China

Tel.: +86-871-64327067, 18987570122
 Fax: +86-871-64327155
 Person to contact: Mr. Xu
 Website: www.yyth.com.cn

- Company background

Yunnan Yuntianhua Co., Ltd. (Yunnan Yuntianhua) was established in 1997 on the basis of the former Yunnan Natural Gas Plant, which was built in 1974 and started production in 1977.

In July 1997, Yunnan Yuntianhua was listed on the stock market. By the end of 2021, Yunnan Yuntianhua had total assets of more than USD8.2 billion (RMB53.1 billion) and 11,360 employees. The company mainly engages in the production and sales of fertilizers, fine chemicals, phosphorus chemicals, and fiberglass new materials.

Yunnan Yuntianhua has over 40 subsidiaries.

- Main products

- Fertilizer (monoammonium phosphate, diammonium phosphate, coarse whiting)
- Urea
- Polyformaldehyde
- Pentaerythritol
- Methanol

- Pentaerythritol

Yunnan Yuntianhua has maintained pentaerythritol capacity at 10,000 t/a since 2009 and its annual output of pentaerythritol has exceeded 10,000 tonnes since 2014. Even in 2017 when environmental protection inspections became more stringent, it maintained relatively consecutive production thanks to its advanced environmental protection mechanism. What's more, Yunnan Yuntianhua has reduced the production of low-grade pentaerythritol in recent years and turned to produce more 98% pentaerythritol and 99% pentaerythritol to meet market demand.

Table 9.1.6-1 Capacity and output of pentaerythritol in Yunnan Yuntianhua, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	10,000	10,000	10,000	10,000	10,000	10,000
Output, tonne	13,300	13,300	13,000	12,300	13,200	6,500

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
 Source: CCM

● Technology

Introduced from Eurotecnica Contractors and Engineers S.P.A., the pentaerythritol production process in Yunnan Yuntianhua includes reaction, condensation, crystallization and filtration, re-crystallization and filtration, drying and package, recycling methanol, formaldehyde, and recycling of sodium formate. The total investment for this project was USD27 million. This large-scale production line was based on the low-temperature sodium process, which is highly automated and productive. It can yield high-quality products, with low cost in feedstock and energy.

Besides, Yunnan Yuntianhua built special units to treat wastewater and organic waste. These units applied the DCS3000 system from Honeywell Corporation of the US.

● Sales

The company's pentaerythritol products, mainly of top-grade quality, are mostly supplied to domestic customers. Coating and lubricant manufacturers are two of its major downstream clients, with several

affiliated coating factories of some international leading enterprises purchasing 98% pentaerythritol from Yunnan Yuntianhua.

Table 9.1.6-2 Quotation of pentaerythritol in Yunnan Yuntianhua, 2017–2022, USD/t

Specification	Monopentaerythritol		
	93%	98%	99%
July 2017	1,450	1,700	1,750
March 2018	N/A	1,926	N/A
June 2019	N/A	1,858	N/A
June 2020	N/A	1,613	N/A
June 2021	N/A	1,966	N/A
July 2022	N/A	N/A	N/A

Note: Failed to get its quotation in 2022.
Source: CCM

• Export

According to the contract with Eurotecnica Contractors and Engineers S.P.A, Yunnan Yuntianhua cannot export its pentaerythritol to Europe and the US. Yunnan Yuntianhua believes that it is a mistake to sign such an agreement because of the large international market demand in recent years. It claims that about 20%–30% of its products are exported to India or Southeast Asia.

The company also exports pentaerythritol through one of its joint ventures in Chongqing City, named Chongqing Polycomp International Corp.

9.1.7 Shijiazhuang Shuangyan Chemical Co., Ltd.

Address: Jinzhou Economic Development Zone, Shijiazhuang City, Hebei Province 052260, P. R. China
Tel.: +86-311-83160328, 15933601073
Fax: +86-311-84455221
Person to contact: Mr. Chen

- Company background

Shijiazhuang Shuangyan Chemical Co., Ltd. (Shijiazhuang Shuangyan), established in 2013, is an enterprise that produces chemical raw materials.

As of July 2022, Shijiazhuang Shuangyan mainly produces pentaerythritol, dipentaerythritol, sodium formate, formaldehyde, etc., which are widely used in chemical industries such as coating and painting.

- Pentaerythritol

Shijiazhuang Shuangyan has 10,000 t/a pentaerythritol capacity and mainly produces 95% monopentaerythritol and 85% & 90% dipentaerythritol.

Table 9.1.7-1 Capacity and output of pentaerythritol in Shijiazhuang Shuangyan, 2018–H1 2022

Year	2018	2019	2020	2021	H1 2022
Capacity, t/a	10,000	10,000	10,000	10,000	10,000
Output, tonne	6,800	7,400	5,500	6,800	3,200

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of

monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
Source:CCM

• Technology

Shijiazhuang Shuangyan produces pentaerythritol using a high temperature sodium method, and it also uses formaldehyde produced by itself as pentaerythritol's raw material.

• Sales

The company claims that its pentaerythritol is mainly used in coating & painting. Most of the pentaerythritol produced by the company is sold in domestic market.

Table 9.1.7-2 Quotation of pentaerythritol in Shijiazhuang Shuangyan, 2018–2022, USD/t

Specification	Monopentaerythritol	Dipentaerythritol	
	95%	85%	90%
March 2018	1,926	5,130	N/A
June 2019	1,539	5,225	N/A
June 2020	1,122	4,207	N/A
June 2021	N/A	N/A	N/A
July 2022	N/A	N/A	N/A

Note:Failed to get its quotation in 2021–2022.

9.1.8 Shandong IFT Science & Technology Co., Ltd.

Address: Zoucheng Industrial Park, Taiping County, Zoucheng City, Shandong Province 273517, P. R. China
Tel.: 15665836993
Fax: +86-531-86266311
E-mail: sdiftkj@126.com
Person to contact: Mr. Liu
Website: www.iftchem.com

- Company background

Shandong IFT Science & Technology Co., Ltd. (Shandong IFT), established in 2009 and covering an area of 100,000 m², is a high-tech enterprise established by Shandong Xinshengbao Venture Investment Management Co., Ltd., its controlling shareholder.

Its products cover pharmaceutical intermediates, coating intermediates, rubber chemicals, oilfield chemicals and many others.

- Main products

1) Medicines

- 1-Methyl-5-mercapto-1,2,3,4-tetrazole
- 2-Mercapto-1,3,4 thiadiazole
- 2,5-Dimercapto-1,3,4-thiadiazol
- Methyl isothiocyanate
- 2-Mercapto-5-methyl -1,3,4 thiadiazole and n-methylthiourea

2) Chemicals

- 2,2-Dimethylol propionic acid
- Neopentyl glycol
- 2,2-Dimethyl-1,3-propanediol

- Sodium formates and adipic acid
- Pentaerythritol

- Pentaerythritol

Shandong IFT started commercial production of pentaerythritol in 2009, with capacity of 20,000 t/a, which was reduced to 12,000 t/a in 2012 as it shut down one of its production lines. Due to environmental factors, the company has stopped the production of 92% monopentaerythritol since 2015. In 2020–2021, it produced 95% and 98% monopentaerythritol. However, Shandong IFT suspended pentaerythritol production in H1 2022 because of insufficient orders.

Table 9.1.8-1 Capacity and output of pentaerythritol in Shandong IFT, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	12,000	12,000	12,000	12,000	12,000	12,000
Output, tonne	5,500	4,000	4,500	4,000	4,200	0

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
Source: CCM

• Sales

Shandong IFT engages in the development of polyol products and its main customers are manufacturers of environmental-friendly coatings and related products.

If customers want to purchase monopentaerythritol, they should order it in advance due to low inventory.

• Price

Table 9.1.8-2 Quotation of pentaerythritol in Shandong IFT, 2017–2022, USD/t

Specification	Monopentaerythritol		Dipentaerythritol
	95%	98%	85%
July 2017	1,564	N/A	7,230
March 2018	1,973	2,084	N/A
June 2019	N/A	1,887	N/A
June 2020	1,192	1,360	4,627
June 2021	N/A	N/A	N/A
July 2022	/	/	/

Source: CCM

• Export

Shandong IFT claims that its pentaerythritol is mainly sold to domestic customers or traders, and exported by traders.

9.1.9 Puyang Yongan Chemical Co., Ltd.

Address: West Huanghe Road, High-Tech Development Zone, Puyang City, Henan Province 457000, P. R. China

Tel.: +86-393-4624398, +86-393-4624489, 13080107125

Fax: +86-393-4624496, +86-393-4624296

E-mail: pyyongan@pyinfo.net; yongan@pyyongan.com
 Person to contact: Mr. Lei
 Website: www.pyyongan.com

- Company background

Puyang Yongan Chemical Co., Ltd. (Puyang Yongan), built on the basis of the former Puyang Biochemical Company, engages in the production and sale of pentaerythritol and formates.

Puyang Yongan self-developed the calcium method to produce pentaerythritol and calcium formate. It started commercial production of pentaerythritol in Nov. 2004. Its production capacity includes 10,000 t/a monopentaerythritol, 2,000 t/a dipentaerythritol, 500 t/a tripentaerythritol, 5,000 t/a calcium formate, and 5,000 t/a sodium formate.

- Pentaerythritol

As monopentaerythritol (85%–92%) in domestic market was oversupplied and profits of these products were very low, Puyang Yongan has stopped production of 85%–92% monopentaerythritol since 2007.

The company once suspended the production of pentaerythritol in 2014 and 2015 for not being able to meet the environmental protection standards. It restarted its 10,000 t/a pentaerythritol production line in 2016 when the completion of its technological transformation finally allowed the company to fit into the standards.

During 2017–2021, Puyang Yongan produced 95% monopentaerythritol, 85% dipentaerythritol and 80% tripentaerythritol.

Table 9.1.9-1 Capacity and output of pentaerythritol in Puyang Yongan, 2017–H1 2022

Year	2017	2018	2019	2020	2021	H1 2022
Capacity, t/a	10,000	10,000	10,000	10,000	10,000	10,000
Output, tonne	7,300	7,600	7,700	6,880	7,530	3,440

Note: Dipentaerythritol and tripentaerythritol are byproducts during the production of monopentaerythritol. The capacity of monopentaerythritol equals that of pentaerythritol, and the output of dipentaerythritol is determined by that of monopentaerythritol.
 Source: CCM

• Technology

Puyang Yongan adopted the calcium pathway for the production of pentaerythritol before 2018, but due to a lack of raw materials, the company adjusted its pentaerythritol production lines with the sodium pathway.

• Sales

The company sells its products to producers of alkyd resin and rosin resin, which are mainly located in Guangdong and Fujian provinces.

Most of its 95% monopentaerythritol is sold in domestic market.

• Price

Table 9.1.9-2 Quotation of pentaerythritol in Puyang Yongan, 2017–2022, USD/t

Specification	Monopentaerythritol		Dipentaerythritol	Tripentaerythritol
	95%	98%	85%	80%
July 2017	1,402	N/A	5,164	11,067
March 2018	1,894	N/A	5,209	10,000

June 2019	1,524	N/A	5,225	10,160
June 2020	1,094	N/A	3,786	9,912
June 2021	N/A	2,124	N/A	N/A
July 2022	1,645	N/A	5,982	N/A

Source:CCM

9.1.10 Shandong Xinzhiyuan Chemical Co., Ltd.

Address: Caoxian Chemical Industry Park, Pulianji Town, Caoxian County, Heze City, Shandong Province 274400, P. R. China
Tel.: +86-19805301988
Person to contact: Mr. Zhang

- Company background

Shandong Xinzhiyuan Chemical Co., Ltd. (Shangdong Xinzhiyuan) is a private enterprise founded in Feb. 2019. It covers an area of 113,680 m² with a total construction area of 39,730 m². The company engages in production and sale of chemical products, decorative paper and environment-friendly resin glue.

- Pentaerythritol

Shangdong Xinzhiyuan started commercial production of pentaerythritol in Nov. 2021. Its capacity includes 30,000 t/a 95% monopentaerythritol and 1,000 t/a 85% dipentaerythritol.

The company produced 4,200 tonnes of pentaerythritol in 2021 and 11,300 tonnes in H1 2022.

• Technology

Shangdong Xinzhiyuan produces pentaerythritol using a high temperature sodium method. Its formaldehyde is self-produced.

9.1.11 Ningxia Ningshun New Material Technology Co., Ltd.

Address: Ningdong Chemical New Material Park, Yinchuan City, Ningxia Hui Autonomous Region 750000, P. R. China
Tel.: +86-15129501279
Person to contact: Mr. Wu

- Company background

Established in Dec. 2018, Ningxia Ningshun New Material Technology Co., Ltd. (Ningxia Ningshun) is a private enterprise. Its main businesses cover the production of formaldehyde, polyols and their downstream products.

- Pentaerythritol

Ningxia Ningshun has 14,000 t/a monopentaerythritol and 1,000 t/a dipentaerythritol. Its commercial production began in Oct. 2021, and some 2,100 tonnes of pentaerythritol were produced till the end of 2021. In H1 2022, it produced 5,880 tonnes of pentaerythritol.

According to its construction plan, Ningxia Ningshun will build high-purity pentaerythritol and alkyd resin production line in the future. It is estimated that the company's pentaerythritol will be mainly used as raw material for its alkyd resin.

• Price

In July 2022, its quotation for 95% monopentaerythritol was USD1,600/t.

9.2 Idle manufacturers

9.2.1 Baoding Guoxiu Chemical Industry Co., Ltd.

Address: No. 888 North Second-ring Road, Baoding City, Hebei Province 071051, P. R. China

Tel.: +86-312-3174301, 3185591, 13780321888

Fax: +86-312-3173380

Person to contact: Mr. Li

- Company background

Baoding Guoxiu Chemical Industry Co., Ltd. (Baoding Guoxiu) is a private enterprise built in Jan. 1991 with registered capital of USD10.6 million. Baoding Guoxiu passed the certification of ISO 9000 Quality Management System in 2003.

Baoding Guoxiu specializes in chemical raw material fields. Most customers of Baoding Guoxiu are factories which mainly produce paint and resins. Its main products include pentaerythritol, sodium formate and formaldehyde.

- Pentaerythritol

Pentaerythritol is Baoding Guoxiu's key product, with 20,000 t/a production capacity. Under the severe environmental pressure and located in a densely inhabited region, Baoding Guoxiu was required to remove to an industrial park, and it suspended pentaerythritol production since 2018.

10 Overview of pentaerythritol market in China, 2019–2023

Table 10-1 Overview of pentaerythritol market in China, 2019–2023, tonne

Item	Number of producers as of 2021	Pentaerythritol														
		2019			2020			2021			2022E			2023E		
		Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth
Manufacturers	12	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Capacity, t/a	/	234,500	/	-6.0%	232,500	/	-0.9%	276,500	/	18.9%	276,500	/	0.0%	306,500	/	10.8%
Output	/	169,700	139.4%	-1.9%	163,680	136.4%	-3.5%	182,080	149.6%	11.2%	183,500	151.0%	0.8%	185,100	151.8%	0.9%
Demand																
Alkyd resin	>20	70,200	57.7%	-2.2%	69,100	57.6%	-1.6%	68,500	56.3%	-0.9%	67,600	55.6%	-1.3%	66,500	54.6%	-1.6%
Polyurethane	>30	16,200	13.3%	1.3%	16,400	13.7%	1.2%	16,600	13.6%	1.2%	16,900	13.9%	1.8%	17,300	14.2%	2.4%
Synthetic lubricant	>50	12,100	9.9%	-1.6%	11,800	9.8%	-2.5%	12,000	9.9%	1.7%	12,200	10.0%	1.7%	13,100	10.7%	7.4%
Rosin pentaerythritol ester	>20	9,300	7.6%	-4.1%	9,400	7.8%	1.1%	9,600	7.9%	2.1%	9,800	8.1%	2.1%	10,000	8.2%	2.0%
Others	>100	13,900	11.4%	-2.1%	13,300	11.1%	-4.3%	14,991	12.3%	12.7%	15,000	12.3%	0.1%	15,000	12.3%	0.0%
Total	/	121,700	100.0%	-1.9%	120,000	100.0%	-1.4%	121,691	100.0%	1.4%	121,500	100.0%	-0.2%	121,900	100.0%	0.3%
Apparent Consumption		121,700	100.0%	-1.9%	120,000	100.0%	-1.4%	121,691	100.0%	1.4%	121,500	100.0%	-0.2%	121,900	100.0%	0.3%

Note: Output share=Output/Apparent consumption

Source:CCM

Table 10-2 Overview of monopentaerythritol market in China, 2019–2023, tonne

Item	Monopentaerythritol														
	2019			2020			2021			2022E			2023E		
	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth
Manufacturers (12)	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Capacity, t/a	232,000	/	-6.1%	230,000	/	-0.9%	274,000	/	19.1%	274,000	/	0.0%	304,000	/	10.9%
Output	165,750	136.8%	-1.5%	159,500	133.5%	-3.8%	177,150	146.7%	11.1%	178,350	148.2%	0.7%	179,700	148.9%	0.8%
Import volume	3,922	3.2%	8.2%	3,875	3.2%	-1.2%	5,503	4.6%	42.0%	5,950	4.9%	8.1%	5,735	4.8%	-3.6%
Sweden	3,185	81.2%	10.6%	2,867	74.0%	-10.0%	3,276	59.5%	14.2%	3,600	60.5%	9.9%	3,300	57.5%	-8.3%
Japan	10	0.2%	1.6%	0	/	/	0	/	/	0	/	/	0	/	/
Taiwan Province	465	11.9%	-6.6%	771	19.9%	65.8%	1,770	32.2%	129.6%	1,800	30.3%	1.7%	2,000	34.9%	11.1%
Germany	232	5.9%	-1.6%	184	4.8%	-20.6%	348	6.3%	88.6%	350	5.9%	0.7%	300	5.2%	-14.3%
Others	30	0.8%	/	52	1.3%	75.0%	110	2.0%	111.9%	200	3.4%	81.5%	135	2.4%	-32.5%
Total	3,922	100.0%	8.2%	3,875	100.0%	-1.2%	5,503	100.0%	42.0%	5,950	100.0%	8.1%	5,735	100.0%	-3.6%
Export volume	48,553	40.1%	0.2%	43,921	36.8%	-9.5%	61,923	51.3%	41.0%	63,930	53.1%	3.2%	64,725	53.6%	1.2%
Apparent Consumption	121,119	100.0%	-1.9%	119,454	100.0%	-1.4%	120,731	100.0%	1.1%	120,370	100.0%	-0.3%	120,710	100.0%	0.3%

Source:CCM

Table 10-3 Overview of dipentaerythritol market in China, 2019–2023, tonne

Item	Dipentaerythritol														
	2019			2020			2021			2022E			2023E		
	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth	Quantity	Share	Growth
Manufacturers (11)	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Capacity, t/a	10,900	/	0.0%	10,900	/	0.0%	12,500	/	14.7%	12,500	/	0.0%	13,500	/	8.0%
Output	3,800	851.5%	-15.6%	4,050	892.1%	6.6%	4,800	547.1%	18.5%	5,000	485.4%	4.2%	5,200	500.0%	4.0%
Import volume	14	3.2%	-58.3%	21	4.6%	47.4%	24	2.7%	13.3%	30	2.9%	26.0%	40	3.8%	33.3%
Germany	7	48.3%	-71.8%	11	51.7%	65.7%	24	98.3%	114.5%	28	93.3%	18.6%	34	85.0%	21.4%
Sweden	<1	<0.1%	-99.7%	<1	<0.1%	9.1%	0	/	/	0	/	/	0	/	/
South Korea	<1	2.8%	-78.9%	1	6.8%	277.9%	0	/	/	0	/	/	0	/	/
Japan	1	5.3%	-87.0%	8	37.0%	981.3%	<1	0.9%	-97.2%	1	3.3%	354.5%	1	2.5%	0.0%
Others	6	43.6%	200.0%	1	4.5%	-84.0%	<1	0.8%	-81.3%	1	3.3%	455.6%	5	12.5%	400.0%
Total	14	100.0%	-59.5%	21	100.0%	54.8%	24	100.0%	11.8%	30	100.0%	26.0%	40	100.0%	33.3%
Export volume	3,368	754.7%	-19.1%	3,617	796.7%	7.4%	3,946	449.8%	9.1%	4,000	388.3%	1.4%	4,200	403.8%	5.0%
Apparent Consumption	446	100.0%	19.7%	454	100.0%	1.7%	877	100.0%	93.3%	1,030	100.0%	17.4%	1,040	100.0%	1.0%

Source:CCM

Kcomber's legal disclaimers

1. Kcomber guarantees that the information in the report is accurate and reliable to the best of its knowledge and experience. Kcomber defines the report as a consulting product providing information and does not guarantee its information is completely in accordance with the fact. Kcomber shall not have any obligations to assume any possible damage or consequences caused by subscribers' any corporate decisions based upon subscribers' own understanding and utilization of the report.

2. The complete copyright of the report is and will be held by Kcomber. Subscribers shall not acquire, or be deemed to acquire the copyright of the report.

3. The report provided by Kcomber shall be only used as source of subscriber's internal business decisions and shall not be used for any other purposes without Kcomber's prior written consent, unless stated and approved in license contract signed by both parties. Subscribers shall not distribute, resell and disclose the whole report or any part of the report to third parties and shall not publish any article or report by largely or directly copying or citing the information or data based on Kcomber's report without the prior written consent of Kcomber.

4. "Single User License" means that there shall be only ONE person to receive access and utilize the report. Subscriber can present the content of the report that marked the source from Kcomber to their internal colleagues for their internal communication and utilization, but cannot share the whole report to other individuals. Any citation, distribution, reselling and disclosure of the report as well as its partial content to any third party are prohibited, including but not limited to their parent companies or subsidiaries.

5. "Corporate License" means that subscriber shall not cite, distribute, resell the report or disclose information of the report to any third party without Kcomber's prior written consent, except subscribers' affiliates controlled with ownership of more than 50% of shares.

17th Floor, Huihua Commercial & Trade Building, No. 80 Xianlie Zhong Road Guangzhou,
510070, P.R.China

Website: <http://www.cnchemicals.com>

Tel: +86-20-37616606

Fax: +86-20-37616968

Email: econtact@cnchemicals.com