THE CATALYTIC PROCESS INDUSTRIES IN CHINA:
MARKETS, TECHNOLOGIES & STRATEGIC
IMPLICATIONS - UPDATE 2013

- PRESENTATION -

A Multi-Client Study Series
(completed April-June 2013)
I. BACKGROUND

Launched as a study proposal in 2004, and then produced as four industry segment reports by The Catalyst Group Resources (TCGR) in April/May/June /July 2005, “The Catalytic Process Industries in China: Markets, Technologies & Strategic Implications” was historic, insightful, and useful. The multi-client study was comprised of four (4) “stand alone,” but integrated reports on the Chinese market, each dedicated to a major catalytic process area: refining, petrochemical/chemical, polymerization and environmental (mobile and stationary) and provided analysis of the market size, growth factors, trade issues, pricing factors and R&D efforts of an increasingly important industry. Strategies and recommendations were provided in order for Western and other Asian companies to evaluate opportunities and begin participation.

Based on the 7-8 years that have passed, the catalytic process industries in China needed to be re-analyzed and segment reports updated in light of sector changes in technology, supply, security and political/regional influences. Due to the important changes which have occurred, TCGR, along with the China National Chemical Information Center (CNCIC), completed a four volume update, entitled “The Catalytic Process Industries in China: Markets, Technologies & Strategic Implications - Update 2013.” This “Update 2013” delineates important changes to the landscape, the economics and the industry implications based on societal change and technology advances that have taken place over the past 7-8 years. This study has global strategic, commercial and technological uses and provides a serious guide for industry executives in business decision-making.

II. EXCERPTS FROM THE 2013 STUDY SERIES

Examples of findings in each of the four (4) segments of the 2013 report series include:

In refining catalysts:

• China’s refining industry is maturing and becoming more sophisticated from within and internationally. Key examples are highlighted – increased IOC domestic investment - the formation of the SINOPEC Catalyst Company now selling internationally - increasing numbers of international catalyst companies investing in China, e.g., Sud-Chemie/Clariant, Grace, BASF, Johnson Matthey, Umicore and others.

• The blazing increase in China’s thirst for energy to maintain its domestic growth has led to ever increasing international crude oil consumption and along with it the need to increase the complexity of its refining operations. This has resulted in increased hydrotreating, hydrocracking and octane processes as its international fuel standards propel higher to meet transport emission standards.
The increasing deployment of R&D, at levels higher than in the OECD, with more numerous domestic and international patent awards.

More specifically, China has the ability to conduct independent research, development and production of refining catalysts according to the needs of the global refining industry. Properties of these catalysts have reached the world advanced level and some of them have been sold in overseas markets. In 2011 the capacity of oil refining catalysts in China reached 207.2 kt/a. Major oil refining catalyst varieties in China are catalytic cracking (FCC) catalysts and they account for 79% of the total capacity of oil refining catalysts. Hydrocracking, hydrotreating and catalytic reforming catalysts are also produced, per the Table below.

In 2011, the total output of oil refining catalysts in China was around 204.4 kt, imports were 8.9 kt, exports were around 25.0 kt, and apparent consumption was around 188.3 kt.

### Capacity of the Oil Refining Catalyst Sector in China

<table>
<thead>
<tr>
<th>Type</th>
<th>Capacity</th>
<th>% of Total</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCC</td>
<td>193.0</td>
<td>93.15%</td>
<td>196.3</td>
</tr>
<tr>
<td>Reforming</td>
<td>1.3</td>
<td>0.63%</td>
<td>0.48</td>
</tr>
<tr>
<td>Hydrocracking &amp; Hydrotreating</td>
<td>10.9</td>
<td>5.26%</td>
<td>6.05</td>
</tr>
<tr>
<td>Others</td>
<td>2.0</td>
<td>0.97%</td>
<td>1.6</td>
</tr>
<tr>
<td>Total</td>
<td>207.2</td>
<td>100.00%</td>
<td>204.4</td>
</tr>
</tbody>
</table>

**In petrochemical/chemical catalysts:**

- In 2011, China had over 170 specialized petrochemical catalyst manufacturers, 80 of which were manufacturers of syngas and its derivative catalysts, accounting for over 35% of petrochemical catalyst manufacturers; about 30 of which were oxidation catalyst manufacturers. Driven by the development of the Chinese chemical industry, China's catalyst industry will further develop. According to forecasts, China will consume 212.83 kt petrochemical catalysts in 2016, and will report 11.5% annual growth during 2011-2016. 2016 will not witness too many changes in consumption structure and will report higher percentage of consumption of catalysts for organic synthesis.

- Unlike the refining industry, which has been internationalizing driven by domestic energy demand and feedstock security impetus, China's petrochemical industry supply/demand is still largely domestically focused, albeit international chemical companies have invested in domestic production. It is more fragmented and less State run, bearing in mind the largest petrochemical producers SINOPEC, PetroChina and CNOOC are still integrated government companies.
Technology and chemical catalysts outside of large commodity applications are still underdeveloped—based on scale, as well as lack of consolidation due to industry maturity—and are generally behind OECD standards in terms of cost/performance.

Key trends are shaping the next five years, with the stated petrochemical/chemical theme in China as “innovation and transformation, better industry layout, elimination of obsolete capacity and resource utilization.”

The study analyzes how the low percentage of China aromatics catalysts compared to the global consumption can be explained by the fact that most BTX catalysts and production processes use imported Western licensed technology, particularly for reforming and p-xylene production. Additionally, the doubling of catalyst consumption forecasted in this report between 2011 and 2016, attests to the opportunities contained within the Chinese petrochemical/chemical industry and the catalysts required to supply it.

The idea of transformation, along with innovation, in the petrochemical/chemical industry still has a long road ahead. The large number of Chinese catalyst manufacturers identified in this report will also need to consolidate, along with industry plans to do so within the chemical industry. These trends spell opportunity in growth for Western catalyst suppliers who produce domestically. For those seeking catalyst industry opportunities, this report shows that there are areas of more sophistication and areas where it is less so.

In polymerization catalysts:

Overall highlights:

- China is at an interesting junction in terms of its synthetic resins industry development cycle. In the last decade, it has focused on domestic self-sufficiency in resin production as well as in process technology and catalyst supply for commodity grades. Now it finds, not surprisingly, that during this same time, Western and other foreign product technology and more advanced value added catalyst technologies have not stood still. As a result, there is still a growing product need, particularly in more sophisticated segments like PE, where metallocene grades have expanded rapidly in the international market, spawning plastomers and other variants.

- The development trends in various polymerization catalyst products are critical to success. Traditional Z-N catalysts are now, and will remain, the main type of polymerization catalysts to be developed and produced, as they have a technical space for development. Metallocene catalysts are now being developed and will eventually be industrialized, as will late transition metal catalysts currently being investigated at the R&D level.
Polymer-specific highlights:

- There are currently seven polyolefin (PE and PP) catalyst producers in China. In 2011, China had a total polyolefin catalyst production capacity of 1940 t/a and a total output of 1189 tons, including a total PP catalyst capacity of 800 t/a and a total PP catalyst output of 553 tons. Capacity for PE catalysts reached 1140 t/a and output reached 636 tons. In 2011, China was able to supply more than 90% of its total polyolefin catalyst consumption.

- Among elastomer catalysts in China, the relatively technically mature and industrially produced ones mainly include nickel-based catalysts for butadiene rubber, vanadium-based catalysts for EPR and neodymium-based catalysts for isoprene rubber. The two latter types of catalysts are being produced in China.

- China’s PVC, PS and ABS polymerization initiators are relatively technically mature. Domestic initiator manufacturers’ products can meet the needs of most resin manufacturers, but because the quality and stability of their initiator products are more secure, two major Western producers occupy a large share of China’s initiator market.

- Most PET produced in China is PET chips. The catalysts used for the polymerization of PET chips are basically Sb (antimony)-based catalysts. Sb_2(OCH_2CH_2O)_3 has better performance than Sb_2O_3 and Sb(Ac)_3, and is considered to be the ultimate product of the antimony-based catalysts and will eventually replace Sb_2O_3 and Sb(Ac)_3. In 2011, China’s PET production was 27,100kt, which is calculated to consume about 8130t of antimony-based catalysts.

In environmental (mobile/stationary) catalysts:

Overall:

- In the face of increasing constraints from resources and the environment, China is being required to accelerate the upgrading of its technology, equipment and service level in energy conservation and environmental protection as defined in the Outline of the 12th Five-year Plan. It is estimated that the potential energy conservation via technological and economic changes will be more than 400 million tons of standard coal in 2015 and can bring about an investment of nearly RMB1000 billion. The total output value of energy conservation services may reach more than RMB300 billion and those for environmental services may reach RMB500 billion.

- Despite the rapid development in China’s energy conservation and environmental protection sectors, their overall development level is still quite low. The major problems that participants in the emissions catalysts industries face are as follows: (1) the innovation ability is not strong; (2) the structure is not rational; (3) the market is not standardized; (4) the policy mechanism is not optimized; and (5) the service/support system is not complete.
Mobile Emission Catalysts:

- By the end of 2011, there were 27 enterprises in China producing ceramic-support tail gas catalysts for motor vehicles (automobiles and motorcycles), including 17 enterprises producing catalysts for motorcycles. In addition, there were four (4) enterprises specialized in the production of metal-support catalysts for motorcycles. It is expected that the output of motor vehicle three-way catalysts will reach 74.0ML in 2016 and the average annual growth will be 10.4% during 2011-2016. The demand for motor vehicle three-way catalysts will reach 78.0ML in 2016 and the average annual growth will be 11.6% during 2011-2016.

Stationary Catalysts:

- The total demand of SCR catalysts in thermal power plants of China will reach 83.2km³ in 2016. Of the total, the first-charge amount of catalysts in new generating units will be 42km³ (based on 50×106W new thermal power generating units), the additional amount of catalysts will be 31.3km³ and the renewal amount of catalysts will be 9.9km³.

- It is expected that with the constant increase of the sulfur capacity the output of Claus catalysts in China will reach 14.0kt in 2016 and the average annual growth will be 14.8% during 2011-2016. The demand of Claus catalysts in China will reach 10.0kt in 2016 (without considering the new sulfur capacity in 2016).

III. THE NEED FOR THIS STUDY “UPDATE”

Industrially, China continues its rapid transformation from a government regulated and managed system into a market-driven economy. These changes are occurring at the same time it is experiencing substantial fluctuation GDP growth! Such volatility adds enormous complexity into their indigenous catalytic process industries in refining, petrochemical/chemical, polymerization and environmental catalysis, all of which need to keep pace in technological evaluation and production capacity. Over the next decade, this spells “opportunity” for global as well as indigenous suppliers if they can understand and take advantage of the industrial dynamics in their respective industries.

Already, foreign investment capital in the range of $100 billion is being deployed by the majors, including Shell, ExxonMobil, BP, BASF, Clariant/Süd-Chemie, Albemarle, W.R. Grace, etc. Concurrently, the demand and sophistication levels of the Chinese majors are also rapidly growing the industrial consumption of catalysts. While initial demand for new supply has traditionally been served via Western catalyst imports, increasingly they are being replaced by domestically produced product.

In no area of the globe is there greater potential for growth and opportunity than China. The PRC represents an enormous marketplace, yet it is characterized by complex industry structures and influential governmental participation. Understanding how the markets, the players and the local and national government bodies interact is crucial for successful
involvement. In addition, knowing the specific market sizes, potential for growth and opportunities for participation will undoubtedly increase the likelihood of success. The catalytic process industries, and the markets for catalysts themselves, represent large potentials, but also significant uncertainties. As a result, it is clear that both global and indigenous industry participants could benefit from an updated understanding, and assessment, of this situation.

IV. SCOPE & METHODOLOGY

As in its original study in 2004-05, the “Update 2013” was produced by the combined efforts of two well-known and well-respected sources: The Catalyst Group Resources (TCGR) and the China National Chemical Information Center (CNCIC), a Chinese government affiliated statistical bureau. These two organizations formalized their relationship via a Memorandum of Understanding (MOU) in September 2011 and this study demonstrates the strength and value of their combined efforts.

The TCGR/CNCIC “team” worked inside China and gathered locally (on the ground) information on the supply/demand, producers, the structure and changes (trends) expected over the next 5-10 years. Secondly, TCGR/CNCIC documents the supply chain by process. In addition to the statistical information, TCGR/CNCIC provides local and outside interpretation of the business in catalysts (as an industry) and how the end-users are driving change.

In this series of four (4) catalyst industry reports, the Chinese catalyst and catalytic process industries are broken into four major “segments” and documented with regard to the following topics:

- **Refining**: Fluid Catalytic Cracking; Reforming; Hydrocracking; Hydroprocessing; Other (including Isomerization, Lubes, etc.)

- **Petrochemical/Chemical**: Aromatic; Organic Synthesis; Oxidation; Syngas & Derivatives; Hydrogenation & Dehydrogenation

- **Polymerization**: Polyethylene; Polypropylene; Elastomers; PVC; PS; ABS; PET

- **Environmental**: Mobile; Stationary

Each of the four segment reports is a “stand alone” but integrated strategic assessment of the current situation in China. It offers executive level guidance on opportunities and threats, with supporting data to enable further analyses in-house. Reports document markets sizes, suppliers and buyers, industry structure, price trends and trade flows as well as technological developments and the competitive landscape. Analyses are provided so that resultant opportunities are identified and characterized, including notable hurdles.
Conclusions and recommendations are made with specific action steps to be considered for short-term implementation.

In this approach, TCGR combines its understanding of the global catalyst industries, including the markets, technologies, participants and strategic issues, along with the detailed and local knowledge of the China National Chemical Information Center (CNCIC), in order to provide insightful analyses and assessments of the major segments. TCGR incorporates data assembled by CNCIC, collected via internal PRC sources as well as primary market research surveys, and assesses the findings as to their importance to, and impacts on, global companies seeking to participate in PRC’s strong prospects for the future. The insights provide guidance and recommendations to help steer involvement and evaluate options.

The locally-collected market data by CNCIC, along with the technological assessments and competitive/strategic implications by TCGR, allows subscribers to derive strategies and begin or enhance their participation.

Included in the areas being assessed, by catalytic process, are:

- Industry Overview
- Current Status
- Segment Analysis (by Sub-segment)
  - Introduction
  - Manufacturers and Output
  - Consumers and Consumption
  - Trade (Imports and Exports)
  - Prices and Affecting Factors
  - Market Drivers
  - Technology Development
  - Forecast of Market Trends
- Issues/Concerns
- Opportunities/Challenges
- Conclusions

Particular attention is given to how the industry segment operates within China as well as how, and to what degree, it interacts with global companies (customers, suppliers, etc.). There are also highlighted differences between methods and operations of Chinese companies relative to Western and/or other Asian participants.

In developing its assessment, TCGR/CNCIC also notes indigenous R&D and process technology directions that differ from their Western counterparts. These analyses are insightful for those contemplating future investment in PRC.

The actual Table of Contents for each of the four (4) segment reports is presented at the end of this presentation (see pp. 11-34).
In order to heighten the value-added from study participation, TCGR/CNIC worked with “charter” subscribers (i.e., those who signed up for the study by November 14th, 2012) to define the scope of the report by delineating areas of particular interest for inclusion in each assessment.

V. QUALIFICATIONS

The Catalyst Group Resources (TCGR) and the China National Chemical Information Center (CNCIC) are uniquely qualified to provide this catalyst industry report series. TCGR is the leading global catalyst industry consulting organization with nearly 30 years of experience serving a global client base. Among its most prominent reports, produced bi-annually since 1986, is The Intelligence Report: Business Shifts in the Global Catalytic Process Industries, which addresses the global catalyst and process technology industries. An "industry standard" for almost 30 years, each edition provides a comprehensive, global assessment of the refining, petrochemical, polymer, fine/pharma, and environmental catalyst industries.

The China National Chemical Information Center (CNCIC) is China’s leading data and information provider, with proven capabilities in data gathering and industry evaluation. CNCIC is conducting the local data collection in China, through sources in the PRC as well as through primary market research interviews. It is also providing insightful analyses and commentary on issues and opportunities affecting market participation, from both indigenous Chinese and external (Western, other Asian) perspectives. CNCIC has unique capabilities and contacts within the local market to permit detailed data collection as well as to provide industry insights.

Together, the “team” of these two organizations provides complimentary capabilities in a unique industry service available through this multi-subscriber report series from TCGR/CNIC.

VI. DELIVERABLES & PRICING

This report series is timely and strategically important to catalyst producers and others involved in the global catalytic process industries. Based on CNCIC’s locally-conducted (in PRC) interviews and data sources, as well as TCGR’s proven industry experience and perspective, each segment report in the series provides subscribers unparalleled insights into an increasingly important area.

Each segment report is a “stand alone” document of 75-100 pages with all pertinent insights into the industry, the opportunities and the risks, including segment-specific recommendations. Reports follow a prototypical outline and can be purchased individually or as a group (of 2, 3 or all 4 reports).
Report Segment  

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<td>April 2013</td>
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<td>II. Petrochemical/Chemical Catalysts in PRC – Update 2013</td>
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<td>III. Polymerization Catalysts in PRC – Update 2013</td>
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Participation  

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<tr>
<td>All four (4) Catalyst Segment Reports</td>
<td>US$29,500</td>
</tr>
<tr>
<td>Each report segment in PDF format (in addition to subscription price)</td>
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The segment reports became available on a rolling basis in the second quarter of 2013. The Refining Catalysts report was ready in April 2013, the Petrochemicals/Chemicals report in May 2013, the Polymerization report in May 2013, and the Environmental report in June 2013.

- Notice to Subscribers of the 2005 Multi-Client Study Series -

Due to the complementary nature of this study series to the one completed back in 2005, we are offering a discounted price to subscribers of that series. Subscribers are requested to contact TCGR’s John J. Murphy at +1.215.628.4447, or John.J.Murphy@catalystgrp.com for further details. When completing the order form, please make sure to indicate your company’s subscription to the 2005 multi-client series.

The study series, “The Catalytic Process Industries in China: Markets, Technologies & Strategic Implications – Update 2013,” is available on a subscription basis from The Catalyst Group Resources (TCGR) and the China National Chemical Information Center (CNCIC).

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<td>Petrochemical/Chemical Catalysts in PRC</td>
<td>_______</td>
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<td>May 2013</td>
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<tr>
<td>Environmental Catalysts in PRC</td>
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<td>June 2013</td>
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REFINING CATALYSTS
TABLE OF CONTENTS

SECTION I. INTRODUCTION ................................................................................. 1

SECTION II. EXECUTIVE SUMMARY ................................................................. 3
A. The Energy Environment in China ................................................................. 5
  1. Primary Energy Resources ........................................................................ 5
  2. Oil Supply/Demand ..................................................................................... 6
B. Alternative Fuels and Routes to Chemicals ..................................................... 7
  1. Coal-to-Dimethyl Ether (DME) ................................................................... 7
  2. Coal-to-liquids (CTL) ................................................................................ 8
C. The International Refining Catalyst Market and PRC's Role Within It .......... 10
D. Oil Refining Catalysts in China .................................................................... 13

SECTION III. THE OIL REFINING CATALYST INDUSTRY IN CHINA ....... 17
A. Summary ..................................................................................................... 17
  1. Introduction to the Oil Refining Industry in China ...................................... 17
  2. Brief Introduction of Oil Refining Catalysts in China ............................... 24
B. Industrial Structure ..................................................................................... 25
  1. Producers .................................................................................................. 26
    a. SINOPEC Corp. Changli Company ....................................................... 27
    b. SINOPEC Corp. Qilu Company ........................................................... 28
    c. SINOPEC Corp. Fushun Company ...................................................... 28
    d. SINOPEC Catalyst Company Nanjing Division ..................................... 28
    e. Hunan Jianchang Petrochemical Co., Ltd ............................................. 29
    f. PetroChina Lanzhou Company - catalysts plant ................................... 29
    g. PetroChina Fushan (North) Company - catalysts plant ....................... 29
    h. XinNian Petrochemical Additives Company ....................................... 30
    i. Shenyang Sanju Kaite Catalyst Co., Ltd ............................................... 30
    j. Shanxi Tengming Technology Co., Ltd ............................................... 30
    k. LeShan ReZel Catalysts Co., Ltd ......................................................... 31
    l. Yingdao Huicheng Petroleum Chemical Technology Co., Ltd .............. 31
    m. Noblestar Catalysts Co., Ltd ............................................................... 31
  2. Research Institutes ................................................................................... 33
C. ANALYSIS OF THE MARKET SUPPLY/DEMAND BALANCE .............. 34
1. Production of Oil Refining Catalysts in China................................. 34
   a. FCC ............................................................................................................. 34
   b. Catalytic reforming .................................................................................. 34
   c. Hydrocracking and hydrofining .............................................................. 34
   d. Other catalysts ......................................................................................... 34
2. Consumption of Oil Refining Catalysts in China............................. 37
   a. Catalytic cracking catalysts ................................................................. 37
   b. Reforming catalysts ............................................................................. 37
   c. Hydrogenation catalysts ...................................................................... 38
3. Imports and Exports ............................................................................ 39
   a. The profile of import of petroleum refining catalysts ......................... 39
   b. The profile of export of petroleum refining catalysts ......................... 40
4. Analysis of the Market Supply/Demand Balance of Oil Refining Catalysts ................................................................. 42
D. PRICE CHANGES AND AFFECTING FACTORS ............................... 44
1. Price Changes of Refining Catalysts .................................................... 44
2. Factors Affecting Price Changes .......................................................... 45
E. MARKET GROWTH AND AFFECTING FACTORS .............................. 46
1. Market Growth ........................................................................................ 46
2. Affecting Factors ..................................................................................... 47
   a. Economic growth drives petroleum demand strongly ...................... 47
   b. Clean fuel promotes the rising demand of catalyst ......................... 48
F. TECHNOLOGIES OF OIL REFINING CATALYSTS ....................... 50
1. Relatively Mature Technologies............................................................. 50
   a. Catalytic cracking (FCC) catalysts ....................................................... 50
   b. Hydrogenation catalysts ..................................................................... 51
      i. RN series of hydrofining catalyst .................................................... 51
      ii. Hydrofining RS series of catalyst .................................................... 51
      iii. Medium-pressure hydro-modification catalyst RT-5 ..................... 52
      iv. 3974 catalyst .................................................................................. 52
      v. Catalysts of residual oil hydrogenation RHT .................................. 53
vi. Hydrocracking catalysts FC-14 which can produce a large amount of diesel ................................................................. 53
vii. Hydrocracking pretreatment catalyst ............................................... 54
viii. Paraffins hydrofining catalysts .......................................................... 54
ix. RMC-II medium pressure hydrocracking catalysts......................... 55
c. Catalytic reforming catalysts ............................................................... 56
   i. Pt - Re/Al₂O₃ half regeneration reforming catalyst ......................... 56
   ii. Pt-Sn/Al₂O₃ continuous reforming catalyst .................................... 56
2. Relatively New Technologies .............................................................. 57
   a. Heavy oil catalytic cracking processes and catalysts ..................... 58
   b. FCC gasoline, diesel hydrotreating .............................................. 58
      i. Petroleum selective hydrogenation ........................................... 58
      ii. Catalysts and additives for gasoline with reduced olefin content .... 59
      iii. Gasoline hydrodesulfurization catalyst ................................ 59
      iv. Gasoline binary hydrogenation catalyst LY-9802 ..................... 59
   c. Hydrocracking PHC-03 catalyst ..................................................... 60
G. Spent Catalyst Recycling ................................................................. 60

SECTION IV. ISSUES AND CONCERNS IN THE CHINESE ENERGY AND REFINING CATALYST INDUSTRY .......................................................... 61

A. The Energy Industry ........................................................................ 61
   1. Less Petroleum Reserves, Higher Dependence on Imported Petroleum .... 61
   2. High Consumption of Coal, Serious Environmental Pollution ............ 61
   3. New Energy Resources Abundant, but Underutilized.......................... 61
B. Rapidly Evolving Laws and Regulations ........................................... 63
   1. The 12th of 5 Years Plan of Petrifaction Chemical Industry ............... 63
   2. The Policy of Coal Chemicals .......................................................... 63
C. The Catalyst Industry ....................................................................... 65
   1. More Varieties but Less Serialization .......................................... 66
   2. Long Period from the Development to Industrialization of New Products ... 67
   3. No Breakthrough for the New Generation of Molecular Sieve Cracking Active Components .................................................. 67
   4. Fierce Competition Between the Catalysts Companies, and the Technologies are Secret from Each Other................................. 67
SECTION V. OPPORTUNITIES AND THREATS TO THE CURRENT SITUATION IN THE CHINESE REFINING CATALYST INDUSTRY ............ 69
A. Limited Restriction to Foreign Participation ............................................................... 69
B. Changing Energy and Fuel Requirements ................................................................. 69
C. Future R&D Needs ..................................................................................................... 72
   1. Heavy Oil Cracking Catalyst ................................................................................. 72
   2. Gasoline, Diesel Quality, Reduced Environmental Pollution Catalyst ............ 72
      a. FCC gasoline with reduced olefin content ....................................................... 72
      b. Etherification technology of catalytic cracking light gasoline ....................... 72
      c. FCC gasoline desulfurization ......................................................................... 72
   3. Reforming Catalysts ............................................................................................... 73
D. Alternative Fuels and Related Catalyst Needs .......................................................... 73
   1. The Catalysts of Coal Conversion Into Petroleum .............................................. 73
      a. Coal direct liquefaction .................................................................................. 73
      b. Indirect coal liquefaction ................................................................................. 73
   2. The Catalyst of Methyl Alcohol Synthesized from Syngas ................................. 74
   3. The Catalyst of Methyl Alcohol Conversion to Dimethyl Ether (DME) .......... 75

SECTION VI. CONCLUSIONS AND RECOMMENDATIONS ..................................... 77
A. Conclusions from an International Perspective ...................................................... 78
B. Recommendations from an International Perspective ............................................. 79

FIGURES

Figure II-1  Composition of the Capacity of Oil Refining Catalysts in 2011 .......... 13
Figure II-2  Composition of the Output of Oil Refining Catalysts in 2011 .......... 14
Figure II-3  Market Shares Held by Major Oil Refining Catalyst Producers in China ................................................................. 15
Figure II-4  Consumption Composition of Oil Refining Catalysts in China in 2011 ................................................................. 15
Figure III-1  Administrative Affiliation of Oil Refining Catalyst Producers and Research Institutes in China ................................................................. 26
Figure III-2  Oil Refining Catalyst Capacity in 2011 ................................................ 35
Figure III-3  Oil Refining Catalyst Output in 2011 .................................................... 36
Figure III-4  Market Share of China's Major Oil Refining Catalyst Producers...... 37  
Figure III-5  Oil Refining Catalysts Consumption, by Segment, in China in  
2011 ................................................................. 38  
Figure III-6  Demand Changes for Crude Oil in China................................. 47  

TABLES  
Table II-1  China's Major Proven Reserves of Primary Energy .......................... 5  
Table II-2  Oil Supply and Demand in China, 2006-2011................................. 6  
Table II-3  Production Situation of Dimethyl Ether (DME) in China in 2002- 
2011 and the Prediction in 2016 ........................................................... 8  
Table II-4  Main Production Enterprises of Coal to Liquid in China in 2011 ....... 9  
Table II-5  Production Situation of Coal to Liquid in China in 2006-2011  
and the Prediction in 2016 ................................................................. 9  
Table II-6  Changes in Worldwide Refining Capacity 2011 vs. 2010 (World)..... 10  
Table II-7  Regional Look at Worldwide Refining Operations 2011 ............... 11  
Table II-8  Global Refinery Catalyst Market: 2009-2017 .................................. 12  
Table II-9  Production of Oil Refining Catalysts in China .............................. 13  
Table II-10  Production of Major Oil Refining Catalyst Producers in China...... 14  
Table III-1  Number of Refineries in China and Their Capacity Distribution..... 18  
Table III-2  Capacity of Major Crude Oil Processing Enterprises in China ...... 18  
Table III-3  Composition of The Major Process Units in Oil Refining  
Enterprises in China 2011 ................................................................. 21  
Table III-4  Capacity of the Oil Refining Catalyst Sector in China.................. 24  
Table III-5  Major Oil Refining Catalyst Varieties in China ............................ 24  
Table III-6  Major Oil Refining Catalyst Producers in China .......................... 27  
Table III-7  Major Oil Refining Catalyst Producers in China and their Contact  
Details .............................................................................................. 32  
Table III-8  Research Institutes Engaged in Oil Refining Catalyst Research in  
China ............................................................................................... 33  
Table III-9  Production of Oil Refining Catalysts in China .............................. 35  
Table III-10  Production of Major Oil Refining Catalyst Producers in China.... 36  
Table III-11  Consumption Composition of Oil Refining Catalysts in China in  
2011 ............................................................................................... 39  
Table III-12  Imports and Exports of Oil Refining Catalysts in China in 2011 ....... 39
Table III-13  Analysis of the Market Supply/Demand Balance of Oil Refining Catalysts in China ................................................................. 43
Table III-14  Catalyst Efficiency in Refining Industry in China ................................. 44
Table III-15  Price Changes of Oil Refining Catalysts in China ................................. 44
Table III-16  Demand Projection for Oil Refining Catalysts in China ......................... 47
Table III-17  Comparison of Gasoline Specifications between China and Europe .... 48
Table III-18  Comparison of Diesel Specifications between China and Europe ..... 48
Table III-19  Timetable for Diesel and Gasoline Quality Upgrading in China ........ 49
Table III-20  Physical and Chemical Properties of RN-10 Catalyst ......................... 51
Table III-21  Physical and Chemical Properties of RS Pre-hydrogenation Catalyst ................................................................. 52
Table III-22  Composition of Semi-Regeneration Reforming Catalysts ................. 56
Table III-23  Physical and Chemical Properties of Continuous Reforming Catalysts .............................................................................. 57
Table V-1  Capacity Expansion of Oil Refining Catalysts in China ....................... 71
# PETROCHEMICAL/CHEMICAL CATALYSTS

## TABLE OF CONTENTS

### SECTION I. INTRODUCTION.......................................................................................... 1

### SECTION II. EXECUTIVE SUMMARY ........................................................................... 3

### SECTION III. THE PETROCHEMICAL/CHEMICAL CATALYST INDUSTRY IN CHINA .................................................................................................................. 11

#### A. Petrochemical industry overview .................................................................................. 11

#### B. Overview of petrochemical catalyst industry in China .................................................. 12

1. Brief introduction to petrochemical catalyst industry in China ........................................ 12

2. Petrochemical catalyst manufacturers in China .............................................................. 15

3. Petrochemical catalyst science and research organizations in China ........................... 18

#### C. Analysis of production and consumption balance of petrochemical catalysts in China .................................................................................................................. 21

1. Overview ........................................................................................................ 21

2. Analysis of petrochemical catalyst production in China ................................................. 21

   a. Petrochemical catalyst manufacturers in China .................................................. 21

      i. Aromatic compound catalyst ................................................................... 21

      ii. Organic synthesis catalyst ........................................................................ 22

      iii. Oxidation catalyst .................................................................................... 23

      iv. Syngas and its derivative catalyst ............................................................... 24

   b. Petrochemical catalyst output in China .............................................................. 31

   3. Analysis and forecast of petrochemical catalyst consumption in China ................... 33

      a. Aromatic compound catalyst ...................................................................... 33

         i. BTX ......................................................................................................... 33

         ii. Alkylation of ethylene and benzene into ethylbenzene .......................... 33

         iii. Alkylation of propylene and benzene into cumene ............................... 34

      b. Organic synthesis catalyst ........................................................................... 34

         i. Catalysts for the oxo-synthesis of butanol and octanol .......................... 34

         ii. Preparation of acetic acid by oxo synthesis ............................................. 35

         iii. Synthesis of vinyl chloride from calcium carbide and acetylene ........... 35
c. Oxidation catalyst........................................................................................ 36
   i. Organic chemical .................................................................................... 36
   ii. Inorganic chemicals ............................................................................. 42
d. Syngas and derivative catalyst ................................................................. 43
   i. Syngas in synthetic ammonia production—CO+H₂ .............................. 43
   ii. Carbon monoxide shift catalysts ......................................................... 43
   iii. Methanation ........................................................................................ 44
   iv. Ammonia synthesis ............................................................................ 44
   v. Hydrogen production .......................................................................... 45
   vi. Preparation of chemicals from syngas ................................................. 45
   vii. Methanol ........................................................................................... 46
   viii. Methanol to olefin ............................................................................ 46
   ix. Coal to ethylene glycol ..................................................................... 48
e. Hydrogenation catalyst............................................................................ 48
   i. Purification of feed gas for synthetic ammonia .................................... 48
   ii. Olefin (ethylene, propylene) purification ............................................. 49
   iii. Refining terephthalic acid ................................................................. 49
   iv. Butyraldehyde and octenal hydrogenation to 2-ethyl hexanol .......... 50
   v. Hydrogenation of benzene to cyclohexane and the hydrogenation of benzene to caprolactam ......................................................... 50
   vi. Hydrogenation of nitrobenzene to aniline ......................................... 51
   vii. Grease hydrogenation ..................................................................... 51
   viii. Others .............................................................................................. 52
f. Dehydrogenation catalyst....................................................................... 52
   i. Dehydrogenation of ethylbenzene to styrene .................................... 52
   ii. The dehydrogenation of isopropanol to acetone ............................... 53
   iii. Dehydrogenation of cyclohexanol to cyclohexanone (caprolactam).... 53
   iv. Preparation of butadiene from butene ............................................... 53
   v. Preparation of isobutene from isobutane .......................................... 54
g. Others ................................................................................................... 55
h. Summary .................................................................................................. 55
4. Import and export .................................................................................... 59
5. Analysis of supply and demand balance of petrochemical catalysts........ 59
6. Price movements and influencing factors ................................................................. 62
D. Current technologies and R&D progress of major petrochemical catalysts ...... 62
1. Aromatic compound catalyst ................................................................................. 62
   a. BTX isomerization catalyst .............................................................................. 62
   b. Toluene disproportionation and transalkylation catalyst .................................. 63
   c. Synthesis of ethylene and benzene to ethylbenzene ...................................... 65
   d. Alkylation of propylene and benzene into cumene ...................................... 67
2. Organic synthesis catalyst .................................................................................... 68
   a. Oxo-synthesis of propylene to butanol and 2-ethyl hexanol ......................... 68
   b. Oxo synthesis of methanol to acetic acid ...................................................... 69
3. Oxidation catalyst .................................................................................................. 69
   a. Partial oxidation of ethylene to ethylene oxide .............................................. 69
   b. Epoxyp propane (hydrogen peroxidation process) .......................................... 70
   c. Production of VAM through ethylene and acetylene .................................. 70
   d. Oxidation of propylene to acrylate .............................................................. 71
   e. Ammoxidation of propylene to acrylonitrile ............................................... 72
   f. Oxidation of n-butane or benzene to maleic anhydride ................................ 73
   g. Isobutene (tertiary butanol) oxidation to MMA .......................................... 74
   h. O-xylene oxidation to phthalic anhydride ..................................................... 75
   i. PX oxidation to terephthalic acid ................................................................. 75
   j. Methanol oxidation to formaldehyde ............................................................ 76
4. Syngas and derivative catalyst ............................................................................. 76
   a. Synthesis of methanol from carbon monoxide and hydrogen ...................... 76
   b. Direct synthesis of syngas to dimethyl ether ............................................... 77
   c. Production of light olefins directly from synthesis gas (syngas-to-olefins)....... 78
   d. Production of aromatics from syngas (syngas-to-aromatics) ....................... 78
   e. Production of ethanol from syngas (syngas-to-ethanol) .............................. 78
   f. Production of olefin from methanol ............................................................ 79
   g. Conversion of methanol into aromatics (methanol-to-aromatics) ............... 81
   h. Alkylation of toluene and methanol into p-xylene ..................................... 82
   i. Coal to ethylene glycol ............................................................................... 82
5. Hydrogenation catalyst
   a. Olefin purification
      i. C₂ selective hydrogenation
      ii. Purification in propylene hydrogenation
   b. The hydrogenation of benzene to cyclohexane
   c. PTA

6. Dehydrogenation catalyst
   a. Dehydrogenation of ethylbenzene to styrene
   b. Dehydrogenation of isopropanol to acetone
   c. Isobutene
      i. Dehydrogenation of iso-butane to isobutene
      ii. MTBE cracking process
   d. Isobutene

7. Others

SECTION IV. ISSUES AND CONCERNS IN THE CHINESE PETROCHEMICAL/CHEMICAL CATALYST INDUSTRY

A. Issues
   1. Chinese catalytic process industries are comprehensive
   2. R&D remains insufficient, inefficient
   3. Strength of leaders hindering progress

B. Concerns
   1. Catalyst processes which are “green” are needed
      a. MMA production
      b. Epoxymethane production
   2. New raw material substitution routes should be pursued
      a. Alkane conversion process
      b. New coal-based chemicals production process
   3. Development and applications of new catalytic materials are justified
      a. Cellular compound material
      b. Amorphous alloys
      c. Nano materials
      d. Ionic liquids
SECTION V. OPPORTUNITIES AND THREATS TO THE CURRENT SITUATION IN THE CHINESE PETROCHEMICAL/CHEMICAL CATALYST INDUSTRY

SECTION VI. CONCLUSIONS AND RECOMMENDATIONS

SECTION VII. APPENDIX

FIGURES

Figure II-1 Consumption of Petrochemical/Chemical Catalysts in China in 2011

Figure III-1 Consumption of Petrochemical/Chemical Catalysts in China in 2011 (% of total)

TABLES

Table II-1 Output of Petrochemical and Chemical Catalysts in China in 2011

Table II-2 Global Petrochemical/Catalyst Market by Application

Table III-1 Supply and Demand of Major Petrochemical Products in China in 2011

Table III-2 Global Petrochemical/Catalyst Market by Application

Table III-3 A Selection of the Major Petrochemical Catalyst Producers in China

Table III-4 Major Petrochemical and Chemical Catalyst Research Institutes in China

Table III-5 Contact Details for the Major Petrochemical and Chemical Catalyst Research Institutes in China

Table III-6 Production of Aromatic Compound Catalysts in China

Table III-7 Production of Major Organic Synthesis Catalysts in China

Table III-8 Production of Major Oxidation Catalysts in China

Table III-9 Production of Major Syngas and its Derivative Catalysts in China

Table III-10 Production of Major Hydrogenation and Dehydrogenation Catalysts in China

Table III-11 Output of Petrochemical and Chemical Catalysts in China in 2011

Table III-12 Consumption of Petrochemical and Chemical Catalysts in China in 2011 and Forecast

Table III-13 Import and Export of Petrochemical and Chemical Catalysts in China

Table III-14 Supply/Demand Balance of Petrochemical and Chemical Catalysts in China
Table III-15  Operating Results of SKI Series Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology ........................................ 62
Table III-16  Operating Conditions and Technological Indicators of HAT Series Toluene Disproportionation Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology .................. 64
Table III-17  Major Physical and Chemical Properties of AB Series Ethylbenzene Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology ................................................. 65
Table III-18  Reaction Performance of AB Series Ethylbenzene Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology ................................................................. 66
Table III-19  Major Technology Indicators and Attributes of MEB-01 Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology ........................................................................... 66
Table III-20  Major Technological Indicators and Attributes of MP-01 Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology ........................................................................... 68
Table III-21  Comparison results of CTV-III, CTV-IV and CTV-V Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology ................................................................................ 71
Table III-22  Operating Conditions Suitable for Acrylonitrile Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology 72
Table III-23  Overview of Some Benzene to Maleic Anhydride Catalysts in China ............................................................................................................. 74
Table III-24  Operating Conditions Suitable for C312 Series Catalysts of Southwest Research and Design Institute of Chemical Industry ........ 77
Table III-25  Major Indicators of CTP-II and CTP-III Catalysts of SINOPEC Shanghai Research Institute of Petrochemical Technology .................. 85
Table III-26  Physical Property Indicators of GS Series Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology .................. 87
Table III-27  Reaction Performance of GS Series Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology .................. 87
Table III-28  Attributes of GS Series Catalyst of SINOPEC Shanghai Research Institute of Petrochemical Technology ................................................. 88
Table III-29  Conditions for Hydration -Dehydrogenation of Propylene to Acetone Process ......................................................................................... 88
Table VII-1  Major Petrochemical Catalyst Producers in China ...................... 103
Table VII-2  Contact Details for the Major Petrochemical and Chemical Catalyst Producers in China ........................................................................... 109
# POLYMERIZATION CATALYSTS

## TABLE OF CONTENTS

### SECTION I. INTRODUCTION

### SECTION II. EXECUTIVE SUMMARY

A. Polymer Market Overview and Polymerization Catalyst Market Status Quo..
B. Polymerization Catalyst Market Overview
C. Polymerization Catalyst Technology
D. Issues/Concerns, Opportunities/Threats and Recommendations

### SECTION III. CHINA’S POLYMERIZATION CATALYST INDUSTRY

A. General

1. General Status of Polyolefin Products in China
   a. Profile of China’s polyolefin industry
      i. PE industry
      ii. PP industry
   b. Profile of polyolefin catalysts
      i. PE catalysts
      ii. PP catalysts

2. Status of Elastomers in China
   a. Profile of China’s elastomer industry
   b. Profile of elastomer catalysts

3. Status of PVC in China
   a. Profile of China’s PVC industry
   b. Overview of PVC initiators

4. Status of Polystyrene (PS) in China
   a. Profile of China’s PS industry
   b. Overview of PS initiators

5. Status of ABS Resin in China
   a. Profile of China’s ABS resin industry
   b. Overview of ABS resin initiators

6. Status of Polyester (PET) in China

B. Structure of the Polymerization Catalyst Sector
1. Profile of polyolefin catalyst producers and research institutions .................. 42
   a. SCC Beijing AODA Division ................................................................. 45
   b. Renqiu Lihe Technology Co., Ltd. ......................................................... 45
   c. Yingkou Xiangyang Catalysts LLC ......................................................... 46
   d. Shanghai Leader Catalyst Co., Ltd. ......................................................... 46
   e. Zibo Xinsu Chemical Co., Ltd. .............................................................. 47
   f. Liaoning Dingjide Petrochemical Co., Ltd. .............................................. 47
   g. Shanghai Süd-Chemie Catalysts Co., Ltd. .............................................. 47

2. Profile of elastomer catalyst producers and research institutions ............... 47
3. Profile of PVC initiator producers and research institutions ..................... 52
4. Profile of PS initiator producers and research institutions ....................... 53
5. Profile of ABS initiator producers and research institutions ..................... 54
6. Profile of PET catalyst producers and research institutions ..................... 55

C. Analysis of Market Supply/Demand Balance ........................................... 55
   a. China’s polyolefin catalyst production situation ..................................... 55
   b. China's polyolefin catalyst consumption situation .................................. 57
   c. China’s polyolefin catalyst market supply and demand balance analysis .... 58
   a. China’s elastomer catalyst production situation ..................................... 58
   b. China’s elastomer catalyst consumption situation .................................. 60
   c. China’s elastomer catalyst supply and demand balance analysis .............. 60
3. Analysis of the Market Supply/Demand Balance of PVC Initiators ............ 60
4. Analysis of the Market Supply/Demand Balance of PS Initiators ............... 63
5. Analysis of the Market Supply/Demand Balance of ABS Initiators ............ 67
6. Analysis of the Market Supply/Demand Balance of PET Catalysts ............. 68

D. Price Change and Affecting Factors ....................................................... 70
1. Price Change of Polyolefin Catalysts in China and Affecting Factors ........ 70
   a. Movement of polyolefin catalyst prices in China .................................... 70
   b. Factors that affect the polyolefin catalyst price changes ....................... 71
2. Price Change of Elastomer Catalysts in China and Affecting Factors ........ 71
E. Market Growth and Affecting Factors............................................................... 72

1. Growth of polyolefin catalyst market in China and affecting factors .......... 72
   a. Growth of polyolefin catalyst market ......................................................... 72
   b. Affecting factors ......................................................................................... 72
      i. Status quo and forecast of the demand for polyolefins......................... 72
      ii. New and proposed polyolefin projects in China................................. 73

2. Market growth of elastomer catalysts in China and affecting factors .......... 76
   a. Butadiene rubber catalyst market growth and its influencing factors ....... 76
   b. EPR catalyst market growth and its influencing factors ........................... 78
   c. Isoprene rubber catalyst market growth and its influencing factors ........ 80

3. China’s PVC initiator market growth and affecting factors ....................... 81
   a. PVC initiator market growth ................................................................. 81
   b. Affecting factors ......................................................................................... 82

4. China’s PS initiator market growth and affecting factors ........................... 84
   a. PS initiator market growth ................................................................. 84
   b. Affecting factors ......................................................................................... 85

5. China’s ABS initiator market growth and affecting factors ........................ 87
   a. ABS initiator market growth ................................................................. 87
   b. Affecting factors ......................................................................................... 87

6. China’s PET catalyst market growth and affecting factors ........................ 88
   a. PET catalyst market growth ................................................................. 88
   b. Affecting factors ......................................................................................... 89

F. Imports and Exports........................................................................................... 90

1. Imports and exports of polyolefin catalysts ............................................... 90
   a. Imports of polyolefin catalysts ................................................................. 90
   b. Exports of polyolefin catalysts ................................................................. 91

2. Imports and exports of elastomer catalysts ................................................. 91
   a. Imports of elastomer catalysts ................................................................. 91
   b. Exports of elastomer catalysts ................................................................. 91

G. Polymerization Catalyst Technologies............................................................ 91

1. Polyolefin catalyst technology ................................................................. 91
   a. Mature technology .................................................................................. 91
      i. BCH catalyst ....................................................................................... 91
ii. BCE catalyst ................................................................. 92
iii. SCG-1 series catalysts .............................................. 92
iv. SCG-3/4/5 series catalysts ....................................... 93
v. SLC-type catalysts .................................................. 94
vi. N series catalysts .................................................... 94
vii. DQ catalyst ............................................................ 96
viii. CS series catalysts ................................................ 97
b. New technologies ......................................................... 100
   i. JM-1 catalyst .......................................................... 100
   ii. BCE catalyst ......................................................... 100
   iii. SLC-B catalyst .................................................... 101
   iv. SST non-metallocene PE catalyst ....................... 101
   v. SAL catalyst ........................................................ 102
   vi. PSP-01 spherical catalyst ...................................... 102
   vii. PC-MAX-120 ....................................................... 102
   viii. DQC series catalyst ........................................... 103
   ix. NDQ catalyst ....................................................... 103
   x. Spherical PP catalyst ............................................. 103
   xi. Metallocene catalyst ............................................. 104
2. Elastomer catalyst technology ....................................... 104
   a. Butadiene rubber catalyst technology .................. 104
   b. Rare earth-based isoprene rubber catalyst technology .................................................. 106
c. EPR catalyst technology ............................................. 108

SECTION IV. ISSUES AND CONCERNS FACED BY CHINA’S POLYMERIZATION CATALYST INDUSTRY .............................................. 111
A. Issues .............................................................................. 111
B. Concerns ........................................................................ 112

SECTION V. OPPORTUNITIES AND THREATS FACED BY CHINA’S POLYMERIZATION CATALYST INDUSTRY ........................................... 115
A. Opportunities .................................................................. 115
B. Threats .......................................................................... 116

SECTION VI. STRATEGIES AND RECOMMENDATIONS ......................... 119
A. Industry Landscape and Forecast ............................... 119
B. Strategies and Recommendations ................................ 120
**TABLES**

| Table II-1 | Output, Import, Export and Consumption of the Six Major Types of Synthetic Resins in China in 2011 | 4 |
| Table II–2 | Polymerization Catalyst Supply and Demand Balance in China in 2011 | 6 |
| Table II-3 | Worldwide Catalyst Market - Polymerization (US $ MIL) | 6 |
| Table III-1 | China’s Major PE Producers in 2011 | 12 |
| Table III-2 | China’s Major PP Producers in 2011 | 15 |
| Table III-3 | Types of Polyolefin Catalysts in China | 21 |
| Table III-4 | China’s Major Elastomer Producers in 2011 | 24 |
| Table III-5 | Types of Elastomer Catalysts in China | 28 |
| Table III-6 | China’s Major PVC Producers in 2011 | 30 |
| Table III-7 | Major GPPS and HIPS Producers in China in 2011 | 35 |
| Table III-8 | Major EPS Manufacturers in China in 2011 | 36 |
| Table III-9 | Major ABS Resin Producers in China in 2011 | 39 |
| Table III-10 | Major PET Manufacturers in China in 2011 | 42 |
| Table III-11 | Major Polyolefin Catalyst Producers and Research Institutions in China | 43 |
| Table III-12 | Contact Details for Major Polyolefin Catalyst Producers and Research Institutions in China | 44 |
| Table III–13 | Major Elastomer Catalyst Producers and Research Institutions in China | 48 |
| Table III-14 | Contact Details for Major Elastomer Catalyst Producers and Research Institutions in China | 49 |
| Table III-15 | Major PVC Initiator Producers and Research Institutions in China | 52 |
| Table III-16 | Major PS Initiator Producers and Research Institutions in China | 53 |
| Table III-17 | Major ABS Initiator Producers and Research Institutions in China | 54 |
| Table III-18 | Major PET Catalyst Producers in China | 55 |
| Table III-19 | China’s PE Catalyst Production Situation in 2011 | 56 |
| Table III-20 | China's PP Catalyst Production Situation in 2011 | 56 |
| Table III-21 | China’s Polyolefin Catalyst Consumption Situation in 2011 | 57 |
| Table III-22 | China’s Polyolefin Catalyst Supply and Demand Balance Analysis | 58 |
| Table III-23 | China’s Elastomer Catalyst Production Situation in 2011 | 59 |
| Table III-24 | China’s BR/EPR/IR Catalyst Consumption in 2011 | 60 |
Table III-25  China’s Elastomer Catalyst Supply and Demand Balance Analysis in 2011 .................................................................................................................................................. 60
Table III-26  Production Situation of China’s Major PVC Initiator Producers ...... 61
Table III-27  Production Situation of China’s Major PS Initiator Producers .......... 64
Table III-28  Production Situation of China’s Major ABS Initiator Producers ...... 68
Table III-29  China's Polyester Catalyst Production Situation in 2011 ................. 70
Table III-30  Polyolefin Catalyst Prices in China in Recent Years ....................... 71
Table III-31  Projections of Chinese Demand for Polyolefin Catalysts, 2011-2016 ........................................................................................................................................ 72
Table III-32  China’s Polyolefin Resin Consumption Growth Situation in Recent Years, 2011-2016 .................................................................................................................. 73
Table III-33  New and Proposed Polyolefin Projects in China in Recent Years ..... 74
Table III-34  New and Proposed Butadiene Rubber Projects in China ............... 77
Table III-35  New and proposed EPR Projects in China .................................... 79
Table III-36  New and Proposed Isoprene Rubber Projects in China ................. 81
Table III-37  China’s New and Proposed PVC Projects ................................... 83
Table III-38  China’s New and Proposed PS Projects ....................................... 85
Table III-39  China’s New and Proposed ABS Resin Projects ........................... 88
Table III-40  China’s PET Catalyst Demand Forecast, 2011-2016 .................... 88
Table III-41  China's New and Proposed PET Projects .................................... 89
Table III-42  China’s Polyolefin Catalyst Imports in 2011 .................................. 90
Table III-43  China’s Polyolefin Catalyst Exports in 2011 .................................. 91
Table III-44  Performance Indicators of N catalysts ....................................... 96
Table III-45  Performance Indicators of DQ catalyst ...................................... 97
Table III-46  Characteristics and Performance Indices of CS-1 catalyst .......... 98
Table III-47  Characteristics and Performance Indices of CS-2 catalyst .......... 99
Table III-48  Catalytic Activity of Elastomer Catalysts .................................... 109
# ENVIRONMENTAL CATALYSTS

## TABLE OF CONTENTS

**SECTION I. INTRODUCTION**

**SECTION II. EXECUTIVE SUMMARY**

A. Issues Affecting Environmental Catalysts in China

B. Emission Pollution in China – Current Status
   1. Mobile Pollutant (Motor Vehicle) Catalysts
   2. Stationary Pollutant Catalysts
      a. SCR catalysts
      b. Claus desulfurization catalysts

C. Other Areas/Technologies in Emission Control
   1. Catalysts for Waste Water Treatment
   2. Photo-catalysts
   3. Fuel Cells

D. Remaining Challenges in Emission Control

**SECTION III. ENVIRONMENTAL CATALYST INDUSTRY IN CHINA**

A. General
   1. Present Status of Emission Pollution in China
   2. Introduction of Environmental Catalysts
      a. Mobile pollutant catalysts
         i. Automobiles
         ii. Motorcycles
      b. Stationary pollutant catalysts
         i. Denitration catalysts
         ii. Desulfurization catalysts
   3. Laws, Regulations and Policies in China
      a. Mobile pollutant catalysts
         i. Announcement of the State Environmental Protection Administration
         ii. National III and IV emission standards for light vehicles and dates for implementation
         iii. National pollutant emission standards for motorcycles
b. Stationary pollutant catalysts ................................................................. 24
   i. Total emission amount control plan of the State Council for major pollutants during the 12th Five-year Plan period ......................... 24
   ii. Standard for Atmospheric Pollutant Emission in Thermal Power Plants .................................................................................. 27
   v. Guideline for Major High-Tech Commercialization Sectors with Development Priority (2011) ................................................................. 28
   vi. Technical Standard for “Coal Combustion Flue Gas Denitration Technologies and Equipment” ................................................................. 28
   vii. Methods for the Calculation of the N2O Emission Amount in Nitric Acid Producers” .............................................................. 28
   viii. Standard for Atmospheric Pollutant Emission in the Cement Sector ................................................................. 29
B. Structure of the Sector ............................................................................. 33
   1. Mobile Pollutant Catalysts ................................................................. 33
   2. Stationary Pollutant Catalysts ............................................................. 35
      a. SCR catalysts ................................................................................ 35
      b. Desulfurization catalysts .............................................................. 35
C. Analysis of the Market Supply/Demand Balance ......................................... 36
   1. Production of Environmental Catalysts ............................................... 36
      a. Mobile pollutant catalysts ......................................................... 36
      b. Stationary pollutant catalysts .................................................. 43
         i. Total output of SCR catalysts .................................................. 43
         ii. Producers of SCR catalysts .................................................. 43
         iii. Contact details for producers of SCR catalysts .................... 48
         iv. Production of Claus desulfurization catalysts ......................... 50
         v. Contact details for major producers of Claus desulfurization catalysts ................................................................. 52
   2. Consumption and Consumers of Environmental Catalysts .................. 53
      a. Mobile pollutant catalysts ......................................................... 53
         i. Output of motor vehicles ....................................................... 53
         ii. Consumption of catalysts ..................................................... 53
b. Stationary pollutant catalysts ................................................................. 56
i. Consumption of SCR catalysts ............................................................... 56
ii. Downstream users of SCR catalysts ....................................................... 57
iii. Consumption of desulfurization catalysts ........................................... 60
3. Analysis of Supply/Demand Balance ..................................................... 62
   a. Mobile pollutant catalysts ................................................................. 62
   b. SCR denitration catalysts ................................................................. 62
c. Desulfurization catalysts ................................................................. 62
D. Imports and Exports .............................................................................. 63
1. Mobile Pollutant Catalysts ................................................................. 63
2. Stationary Pollutant Catalysts ................................................................. 64
E. Price Changes and Factors Affecting Price ........................................... 65
F. Market Growth and Affecting Factors ................................................... 66
1. Mobile Pollutant Catalysts ................................................................. 66
   a. Supply projection ............................................................................ 66
   b. Demand projection ........................................................................ 66
2. Stationary Pollutant Catalysts ................................................................. 67
   a. SCR catalysts ................................................................................. 67
   b. Claus desulfurization catalysts ......................................................... 70
G. Environmental Catalyst Technologies .................................................... 71
1. Mobile Pollutant Catalyst Technologies ................................................ 71
2. SCR Catalyst Technologies ................................................................. 71
3. Claus Catalyst Technologies ................................................................. 72

SECTION IV. ISSUES AND CONCERNS IN THE CHINESE ENVIRONMENTAL CATALYST INDUSTRY .................................................. 75
A. The Chinese Approach .......................................................................... 75
B. Problems and Points of Attention in Mobile Emission Catalysts .......... 76
1. Mobile Emission Catalysts ................................................................. 76
   a. Catalytic conversion rate ................................................................. 76
   b. Catalyst deactivation ........................................................................ 76
c. Cold start ......................................................................................... 76
d. Cost .................................................................................................... 76
e. Readjustment orientation of industrial policies .................................... 76
2. Stationary Pollutant Catalysts ................................................................. 77
   a. Development orientation of environmental protection policies ............ 77
   b. Enforcement of environmental protection policies ............................ 77
   c. Safety problem in operation ............................................................... 77

SECTION V. OPPORTUNITIES AND THREATS TO THE CURRENT
SITUATION IN THE CHINESE ENVIRONMENTAL CATALYST INDUSTRY................................................................................................................. 79

A. Opportunities ............................................................................................ 79
1. Mobile Pollutant Catalysts ......................................................................... 79
   a. Implementation of standards for new vehicles ..................................... 79
   b. Implementation of standards for vehicles in service ............................ 79
   c. Brisk demand growth of automobiles promoted by economic growth .... 80
   d. Stricter environmental protection policies and higher motor vehicle
tail gas emission standards ....................................................................... 80
   e. Enhanced awareness of enterprises and society in environmental
   protection ............................................................................................... 81
   f. Standards for oil product quality lagging behind standards for automobile
emission, a negative factor for the implementation of high standards for
   motor vehicle tail gas emission ............................................................ 81
2. Stationary Pollutant Catalysts ................................................................... 81
   a. Policy promoting factors ..................................................................... 81
   b. Market promoting factors .................................................................... 84

B. Threats ....................................................................................................... 85
1. Expansion of Capacity and Upgrading of Domestic Technology ............. 85
2. Entry of New Foreign Companies ............................................................. 86
3. Lack of Denitration Catalyst Production Technologies with Intellectual
   Property Rights and Redundant Introduction of Foreign Technologies .... 86
4. Need of Standardized Management to Chaotic Competition in the
   Denitration Catalyst Market .................................................................. 87

SECTION VI. STRATEGIES AND RECOMMENDATIONS .......................... 89

FIGURES

Figure III-1  Shapes of Automobile Three-way Ceramic-Support Catalysts  .... 20
Figure III-2  Shapes of Motorcycle Metal-Support Catalysts ......................... 21
Figure III-3  Shapes of SCR Catalysts .............................................................. 22
TABLES

Table II-1  Worldwide Market for Pollution Control Catalysts by Application, 2009-2017 (US$MIL) ................................................................. 4
Table II-2  Major Producers and Capacities of Motor Vehicle Catalysts ........ 6
Table II-3  Supply/Demand Balance of Motor Vehicle Ceramic-Support Catalysts ................................................................. 6
Table II-4  Demand Projection of Motor Vehicle Catalysts ....................... 7
Table II-5  Major Producers and Capacities of SCR Catalysts in China .......... 8
Table II-6  Consumption Trend of SCR Catalysts in China, 2000-2011 ........ 9
Table II-7  Market Prospect of SCR Catalysts in Thermal Power Plants of China, 2011-2016 ................................................................. 10
Table II-8  Major Producers and Capacities of Claus Desulfurization Catalysts in China................................................................. 11
Table II-9  Supply/Demand Balance of Claus Catalysts in China and Projection .................................................................................. 12
Table III-1  Total Amount and Output of Civil Automobiles and Motorcycles in China ............................................................................. 16
Table III-2  Output of Thermal Power in China ........................................ 17
Table III-3  Emission Amount of Major Pollutants in China ...................... 19
Table III-4  Emission Limits of Pollutants in China .................................. 24
Table III-5  Dates for Implementation of Standards in China .................... 24
Table III-6  Total Emission Amount Control Plan for NOx and SO2 in Various Provinces of China During the 12th Five-year Plan Period .... 25
Table III-7  Laws, Regulations and Policies Related to NOx and SO2 Emission Standards in China ...................................................... 29
Table III-8  Ownership of Major Producers of Motor Vehicle Catalysts ....... 33
Table III-9  Ownership of Major Producers of SCR Catalysts ................. 35
Table III-10 Ownership of Major Producers of Desulfurization Catalysts ...... 36
Table III-11 Major Producers and Capacities of Motor Vehicle Catalysts ....... 36
Table III-12 Contact Details for the Major Producers of Motor Vehicle Environmental Catalysts in China .................................................. 40
Table III-13 Production of SCR Catalysts in China, 2006-2012 ................. 43
Table III-14 Major Producers and Capacities of SCR Catalysts in China ...... 44
Table III-15 Contact Details for Major Producers of SCR Catalysts in China ... 48
Table III-16 Major Producers and Capacities of Claus Desulfurization Catalysts in China ................................................................. 51
Table III-17  Contact Details for Major Producers of Claus Desulfurization Catalysts in China ............................................................................. 52
Table III-18  Total Output of Automobiles and Motorcycles in China .............. 53
Table III-19  Consumption of Motor Vehicle Ceramic-Support Catalysts .......... 55
Table III-20  Producers and Capacities of Motor Vehicle Tail Gas Catalytic Converters in China ................................................................. 55
Table III-21  Consumption Trend of SCR Catalysts in China During 2000-2011 ....................................................................................... 57
Table III-22  Volume of Denitrification Projects Completed by Major Environmental Protection Companies in China in 2011 ..................... 58
Table III-23  Major End Users of SCR Catalyst Producers in China in 2012 ...... 59
Table III-24  Consumption Trend of Claus Desulfurization Catalysts in China During 2000-2011 ............................................................... 61
Table III-25  Major Users of Desulfurization Catalysts in China in 2011 .......... 61
Table III-26  Supply/Demand Balance of Motor Vehicle Ceramic-support Catalysts, 2006-2016 ....................................................................... 62
Table III-27  Supply/Demand Balance of Claus Desulfurization Catalysts in China During 2006-2016 ........................................................... 63
Table III-28  Imports and Exports of Motor Vehicle Catalysts in China, 2006-2011 ....................................................................................... 63
Table III-29  Imports and Exports of SCR Catalysts in China, 2008-2012 ......... 64
Table III-30  Imports and Exports of Desulfurization Catalysts in China, 2006-2011 ....................................................................................... 65
Table III-31  Demand Projection of Motor Vehicle Catalysts, 2006-2016 ........ 67
Table III-32  SCR Catalyst Projects Being Constructed or Planned for Construction in China ........................................................................... 68
Table III-33  Market Prospect of Thermal Power Station SCR Catalysts in China, 2011-2016 ........................................................................ 69
Table III-34  Consumption of Claus Desulfurization Catalysts in China, 2006- 2016 ....................................................................................... 70
Table III-35  R&D Trends in SCR Catalysts with Intellectual Property Rights in China ...................................................................................... 72
Table V-1  Average Annual Growth of GDP in China and the Total Amount and Output of Civil Automobiles, 2006-2011 ................................. 80