

**SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023:  
International, Commercial and Technical Progress**

**Study Presentation**

**December 2019**



## **SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023: International, Commercial and Technical Progress**

*This TCGR multi-client study was launched in July 2019 and completed in December 2019. The study's scope, and specific contents (as depicted in the ToC on page 9-18 of this presentation), reflect the inputs from a group of "charter" subscribers who indicated their priorities for coverage, areas to be expanded/deepened and focal points for emphasis in opportunity identification. These are leading industrial developers, suppliers, and end-users of specialty zeolites in catalytic applications.*

### **I. BACKGROUND**

The Catalyst Group Resources (TCGR) has been recognized as the definitive source for information on the technical and commercial use of zeolites, molecular sieves and zeolite catalysts, since the company's founding in the 1980s. Much of the expertise for this position has been due to the ex-Union Carbide employees who contributed a large part in the founding of The Catalyst Group. While this legacy catalyst and process licensing business was eventually absorbed into the Honeywell/UOP organization, and the chemicals businesses were later absorbed into Dow Chemical, the strength of knowledge obtained in manufacturing zeolites, zeolite catalysts and process applications became imbedded in our genes.

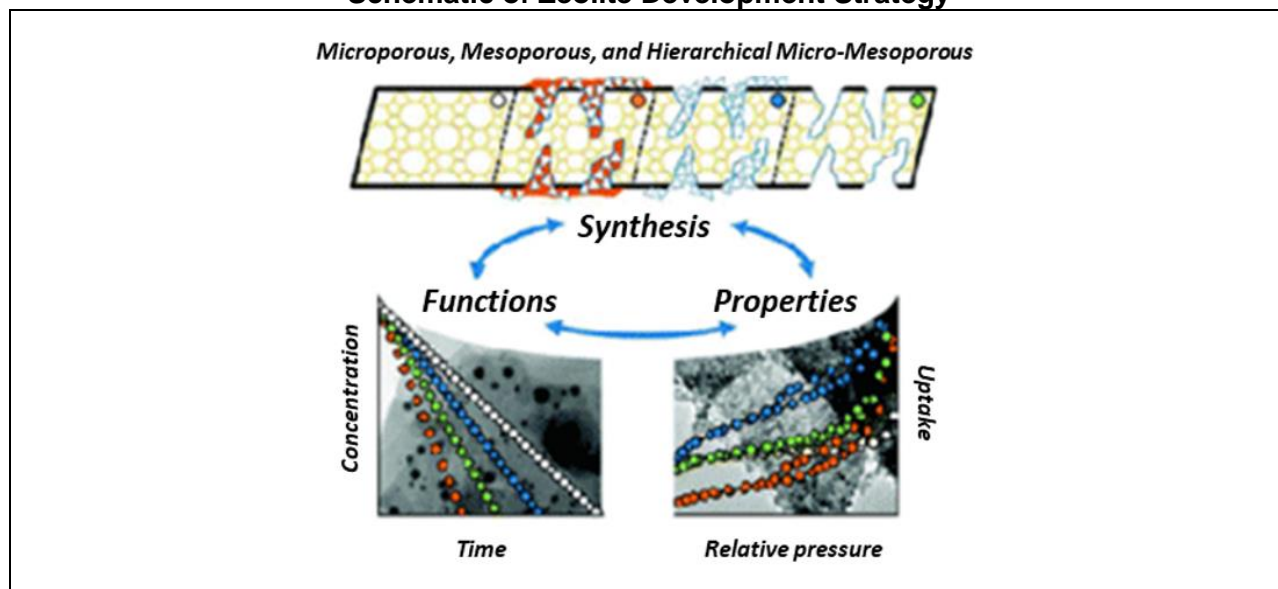
Since its founding, The Catalyst Group Resources (TCGR) has generated three (3) well received industrial focused multi-client zeolite studies entitled "**Specialty Zeolites in Catalysis**" first in 1992, a ten year update in 2002, then again in 2014. Each study provided commercial and technical market size and growth, new applications advances and a summary/status on competition, barriers to entry and business strategies being deployed in the market. In both the 2002 and 2014 reports, we focused on providing detailed capacity by process buildup analysis of specialty zeolite catalyst usage in refining, petrochemicals, chemicals, fine and intermediate chemicals. The reports provided significant detail on the use and supply of these catalysts in each application and by the catalyst producers/licensors supplying them. In our most recent 2014 report, we also added the growing use of zeolites in the diesel automotive environmental market, completing and updating historical data.

As the above has been fairly well defined now, it was not our intent in this 2019 version to heavily revisit existing applications, supplier profiles, SWOTS and the like. Rather, in listening to the marketplace producers, users and catalyst suppliers, we have updated but condensed all of this into a single chapter Section III - Market Size and Growth, Competitive Landscape Changes, excluding China (see Table of Contents, pp 9-18). The emphasis instead is in three (3) new areas: 1) Advances in Zeolite and Catalyst Manufacturing Methods; 2) China and the Growing Dragon - the growing Western Supplier; and 3) Recent R&D, New Process and Product Developments.

For TCGR's reports in the zeolites area, we have always involved the world's most renowned zeolite experts. The 2002 report was authored with contributions from Dr Wolfgang Holderich, University of Aachen, ex BASF and Dr Art Chester, formerly of ExxonMobil, who also obtained oversight from other leaders.

In the earlier 1992 study, other contributors have been Dr. George Kokotailo, formerly of Mobil, Dr. Sigmund Csicsery, formerly of Chevron Research and Dr. Tomoyuki Inui, retired from the University of Tokyo. In our 2014 update, we used Dr. Bill Borghard, formerly of ExxonMobil, Jim D'Auria, ex UOP, and Dr. Vince Durante, ex Sunoco and BASF. As an active participant in the International Zeolite Association (IZA) through our Dialog Group™, TCGR's expertise is well-recognized by all industry participants.

**Figure 1**  
**Schematic of Zeolite Development Strategy**



## II. THE NEED FOR THE STUDY

In our most recent (2014) benchmarking report, the zeolite and catalyst segment overall was growing on average at a rate of 6-8% CAGR! Certain applications such as diesel automotive catalysts, MTO, and selective olefins manufacture were growing even more quickly. Therefore, for both zeolite producers as well as catalyst suppliers, this market deserves high attention! Equally important, specialty zeolites and specialty zeolite catalysts commanded both a premium price and higher margin (compared to mixed oxide heterogeneous catalysts) due their higher cost/performance, advancing both yield and selectivity in the applications that they serve. Therefore, applications R&D and expansion of specialty zeolites usage is expected to continue to be a high investment priority for both end users and catalyst companies.

It is quite a challenge to assemble reliable knowledge and participation within individual applications – a prerequisite to understanding each market and the business acumen in order to define the specific opportunities. While the commodity areas are more open, due to the nature and importance of this subject, details are often shrouded in industrial secrecy! This is why The Catalyst Group Resources (TCGR) is uniquely positioned, with the skill and knowledge required, to assemble this new 2019 benchmarking report.

There are some important industry trends that justified deeper investigation affecting these businesses moving forward:

- The explosive growth in Chinese zeolite production in the last five (5) years, with more being sold to Western catalyst producers yearly, generally at 10-15% below OECD manufacturing costs. What will be the longer-term ramifications? This required some skill inside of China to unravel those insights involving labor, energy and raw materials costs.
- It has long been talked about within the zeolite industry, about how to transition from largely batch manufacturing operations into semi-continuous/continuous operations, as is currently practiced for A, X and Y. TCGR has more closely examined these advances in this update. We are aware of some Chinese commercial advances in this subject.

**Table 1**  
**Specialty Zeolite Manufacturers in China**

Company	Province	Capacity (mt/yr)				
		NaY	ZSM-5	Beta	Specialty	All Zeolites
1st Tier Manufacturers						
Hengyu Molecular Sieves Co. Ltd.		6,000	2,000		600	8,600
Shanghai Xinnian Petrochemical Additives Co., Ltd. (XinNian)	Shanghai	2,000	500	500	1,500	4,500
Chai Tai Energy materials, Ltd. (CT Energy)	Liaoning		2,000			2,000
Shandong Qilu Huaxin HiTec Co., Ltd. (QHX)	Shandong	•	•	•		10,000
Catalyst Co. Of Nanjing Refinery – Sinopec	Jiangsu		•			•
Fushun Catalyst Co. Of PetroChina	Liaoning		•			•
Lanzhou Catalysy Co. Of PetroChina	Gansu	17,000	•			> 17,000
Changling Catalyst Co. Of Sinopec	Hunan	20,000	•			> 20,000
Oilu Catalyst Co. Of Sinopec	Shandong	25,000	•			> 25,000

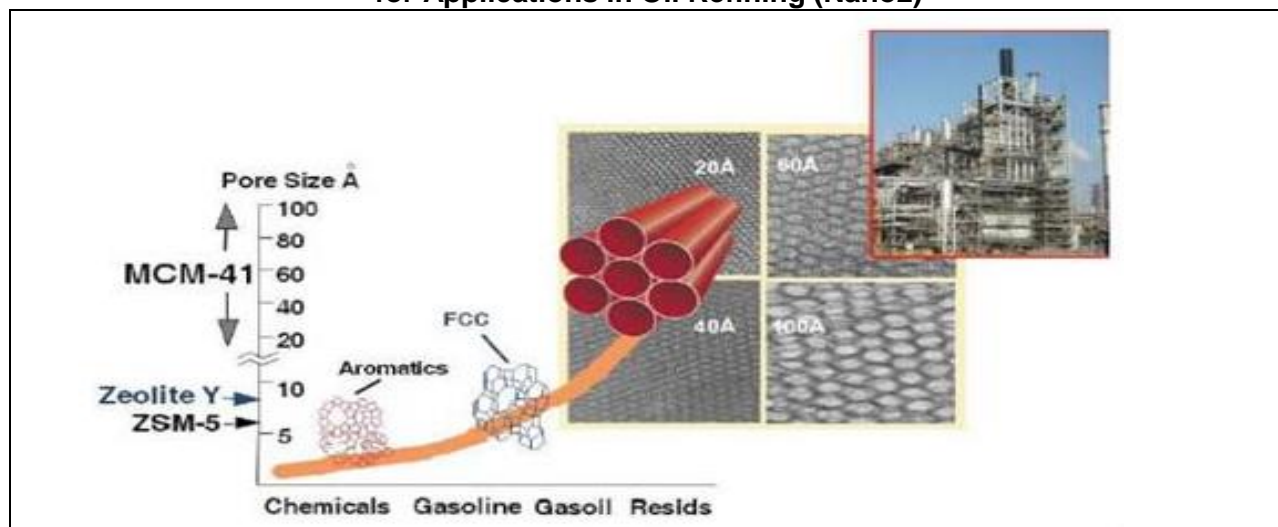
Note: • indicates capacity exists, but volume unverified

Source: Company websites/literature; TCGR multi-client studies (2002 and 2013).

- The typical synthesis in industry relies on batch wise hydrothermal methods, which usually takes tens of hours or even several days to complete. People have long believed that crystallization of zeolites is very slow, particularly to obtain the needed Si/Al ratios and crystal purities. Evidence is now beginning to emerge that crystallizations can be short (Ref 1), that in some cases SDAs are not needed and that smaller capacity but continuous manufacture is feasible (Ref 2).

This newly completed report ***“SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023: International, Commercial and Technical Progress”*** complements an ongoing portfolio of similarly well-received studies TCGR has delivered to clients over recent years. This growing experience demonstrates TCGR’s unique capability, resources and expertise to deliver exceptional insight.

**Figure 2**  
**Examples of Nanotechnology in Commercial Catalysis Products**  
**for Applications in Oil Refining (Nano2)**



Recent multi-client reports and studies from our membership-directed programs include:

- ***The Catalytic Process Industries in China: Markets, Technologies & Strategic Implications-Update 2019*** (proposed April 2019)
- ***The Separations Report 2019 (2nd biennial edition)*** (July 2019)
- ***The Intelligence Report: Business Shifts in the Global Catalytic Process Industries, 2017-2023*** (May 2018)
- ***Recent Progress in Zeolitic Membranes for Gas Separations and Catalysis*** (December 2016)
- ***Benchmarking CO<sub>2</sub> Capture Technology (Vol. 3): Update on Selected Pre-/Oxy-Combustion and Post-Combustion Capture Routes*** (September 2016)
- ***Specialty Zeolites in Catalysis, 2002-2020*** (February 2014)
- ***The Industrial Adsorbents Business: Commercial Strategy, Technical and R&D Assessment in Refining, Chemicals/Syngas, Natural Gas and Industrial Gases*** (July 2013)
- ***Unconventional Catalytic Olefins Production: Commercial Vision and Breakout?*** (January 2013)

Ref 1. "Continuous flow synthesis of ZSM-5 zeolite on the order of seconds," L. Zhendong, et al.; Mark E. Davis edited; <https://www.pnas.org/content/113/50/14267>.

Ref 2. "High Thru-Put Zeolite Manufacture," Chevron Technology Marketing website. <https://www.chevrontechnologymarketing.com/>

### **III. SCOPE AND METHODOLOGY**

As depicted in this report's actual Table of Contents on pages 9-18, there are four (4) major Sections. A summarized approach explains the contents of each in more detail below:

**Section III** – summarizes and condenses past market size and growth information and updates this to a current view.

**Section IV** – provides a more in-depth look at the rising international Chinese suppliers and products being shipped to catalyst producers in the West, as well as final zeolite catalyst products. Included is a more comprehensive understanding of drivers, economics, regulations and commercial landscapes.

**Section V** – updates a customary subject of R&D changes and new product developments. It does not contain a detailed five (5) year patent search, but highlights trends.

**Section VI** – covers new zeolites synthesized, but the focus is on improved cost/performance manufacturing techniques for zeolites or continuous methods with templated, excluding seeding.

**TCGR's unique background and historical development roots in zeolites (ex Union Carbide) provides an unparalleled capability and skill level in this study area. Deep expertise in materials science and process engineering means the ability to provide insights beyond other sources that do not have the industrial experience TCGR and our Dialog Group™ can provide.**

For those that understand and appreciate this study undertaking, you will know how important and critically timely this evaluation is! We are standing at a critical crossroad as it pertains to the path towards 2023. The next (5) years are certain to be telling. Thus, TCGR's study is warranted.

## IV. QUALIFICATIONS

The Catalyst Group Resources, a member of The Catalyst Group, works with clients to develop sustainable competitive advantage in technology-driven industries such as chemicals, refining, petrochemicals, polymers, specialty/fine chemicals, biotechnology, pharmaceuticals, and environmental protection. We provide concrete proven solutions based on our understanding of how technology impacts business.

Using our in-depth knowledge of molecular structures, process systems, and commercial applications, we offer a unique combination of business solutions and technology skills through a range of client-focused services. Often working as a member of our clients' planning teams, we combine our knowledge of cutting-edge technology with commercial expertise to:

- Define the business and commercial impacts of leading-edge technologies
- Develop technology strategies that support business objectives.
- Assess technology options through strategy development, including:
  - Independent appraisals and valuations of technology/potential
  - Acquisition consulting, planning and due diligence
- Provide leading-edge financial methodology for shareholder value creation
- Lead and/or manage client-sponsored R&D programs targeted through our opportunity identification process.
- Provide leading information and knowledge through:
  - World-class seminars, conferences and courses
  - Timely technical publications

The client-confidential assignments conducted by The Catalyst Group include projects in:

- Reinventing R&D pipelines
- Technology alliances
- Technology acquisition
- Market strategy

We have built our consulting practice on long-term client relationships, dedication, and integrity. Our philosophy is clear and focused:

***We Provide the "Catalysts" for Business Growth by Linking Technology and Leading-Edge Business Practices to Market Opportunities***



## **V. DELIVERABLES AND PRICING**

This report is timely and strategically important to those industry participants and observers considering investment, as well as to process technology companies evaluating the specialty zeolite markets. TCGR's report, based on technology evaluations, market assessments and interviews with key players goes beyond public domain information. As a result, subscribers are requested to complete and sign the "Order Form and Secrecy Agreement" on the following page.

***"SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023: International, Commercial and Technical Progress – A New Era!"*** was completed in December 2019.

<u>Post-production subscribers</u>	<u>after December 2019</u>	\$24,500
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### ***SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023: International, Commercial and Technical Progress***

Report in PDF format, in addition to subscription price	\$1,000
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*\*Charter subscribers (those who signed up for the study before launch on July 2, 2019) had the opportunity to work with TCGR in defining the scope of the report by delineating areas of particular interest for inclusion in the assessment.*

*Subscribers also have immediate access to the 2014 edition of the report, entitled **Specialty Zeolites in Catalysis: 2002-2020**, for the discounted fee of \$11,500.*

#### **Notice to Subscribers of TCGR's 2014 edition of "Specialty Zeolites in Catalysis 2002-2020":**

*Due to the complementary nature of this study to TCGR's previous report in this area, namely **Specialty Zeolites in Catalysis 2002-2020** completed in February 2014, TCGR is offering a discount of \$1,000 off **SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023: International, Commercial and Technical Progress** to subscribers of that study. Subscribers are requested to contact John J. Murphy at +1.215.628.4447 or [John.J.Murphy@catalystgrp.com](mailto:John.J.Murphy@catalystgrp.com) if further details are required or to determine if your organization is entitled. When completing the order form, please make sure to indicate your company's subscription to the earlier report.*



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**SPECIALTY ZEOLITES IN CATALYSIS, 2019-2023:  
International, Commercial and Technical Progress**

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