

Progress in Technology for Polyolefins Production III

Study Presentation

January 2021



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This TCGR multi-client study was launched in September 2020 and completed in December 2020. The study's scope, and specific contents (as depicted in the ToFC on pages 7-13 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 "voice of customer" interviews. These are leading industrial developers, suppliers, and end-users of polyolefin catalyst, process and resin technologies.

I. INTRODUCTION

The Catalyst Group Resources' (TCGR's) multi-client study series on advanced polyolefin catalysts, processes and products have been occurring on a regular basis since the mid-1980s, including during the metallocene revolution of the late-1980's into the 1990's (remember the METCON Conference Series?) and have continued up until our most recent offering, ***"Progress in Technology for Polyolefin Production: Quantifying the Valued-Added of Advanced Catalysts, Co-Catalysts/activators and Stereo regulators"*** completed in December 2011. Two, more focused, Select-Client updates were also completed as follows: ***"Polyolefin Catalysts and Processes: Technological and Commercial Impacts on PE and PP"*** was completed in 2017 and ***"Polyolefins Catalysts and Processes: Competitive Implications of Industry Consolidation"*** in 2018, to keep abreast with some important and timely changes.

TCGR has now completed its more in-depth and comprehensive industry reassessment. As client subscribers will remember, in 2011, our well-received study not only documented commercial and R&D advances in deep technical terms but also economically benchmarked how R&D and breakthroughs contributed commercially to the bottom line (via return on investment or ROI) through new products, efficiency and production gains. It demonstrated how producers, catalyst suppliers and developers, process and product technology licensors, and differentiated resin converters shared in different gains across the value chain. It helped benchmark "How much should we be spending on research?" and the "Catch-22" corollary: "What is the value to us that this research will create?"

II. BACKGROUND

In this recently completed 2020 update to the 2011 assessment, TCGR has revisited both the new product markets, as well as the R&D pipelines, documenting and analyzing opportunities of benefit to polyolefins (PO) producers in their business planning and decision making. **New/key** to this updated study is a comprehensive "Voice of Customer Survey" on resin converters and the changing resin requirements to meet the future needs from within industry. This study documents, through patent and literature surveys, detailed assessments of emerging technologies, as well as product and process advances, the following:

- New and improved PO resins to serve the faster growing differentiated or "specialty" market applications, including large volume price-sensitive markets, as well as sophisticated niche applications;
- Gains in production volumes from fixed assets which can be achieved through recent improvements in processes and in catalysts, co-catalysts/activators and/or electron donor (ED) technologies;

- Value-added returns on R&D, which can result from developing, licensing or joint venture cutting-edge polyolefin process, catalyst, co-catalyst/activator and product advances; and
- **New/key:** A Voice-of-Customer survey with convertors to understand the missing new product needs from within the marketplace.

According to Crain Communications (Plastics News) sales of all resins exceeded \$100 BIL/yr in 2019 to convertors. Obtaining feedback on trends and unmet market needs has proven vital information for producers. A sample of convertors interviewed include: Performance Pipe, Pipeline Plastics, LLC, Central Plastics, Inc., Allied Plastics, Inc., Plastics UNLIMITED, C-P Flexible Packaging, Berry Plastics Corporation, Myers Industries, Inc., Transcendia and ESENTTIA. With the expert input from Crain and TCGR interviews, a more comprehensive assessment has emerged.

Within these broad activity areas of catalysts and products, TCGR has documented the industry research efforts covering the full spectrum of traditional Ziegler-Natta and chromium oxide catalysts through to advanced single-site catalysts, as well as traditional free-radical high pressure polymerized LDPE. Nowhere in industry is there such a direct correlation between molecular knitting than in the polyolefin products industry. Metallocene and other single-site catalysts (CGTs, SSCs) will continue to play a pivotal role in product differentiation.

III. THE NEED FOR THIS STUDY

The need for innovation in the polyolefins industry is clear. Without continuous innovation in products, processes and catalysts, a polyolefin producer or supplier of technologies and catalysts is doomed to commercial obsolescence within five to seven years. Moreover, it seems this cycle is becoming narrower, as consolidations within the value chain have been speeding up in recent years.

As we have already demonstrated in the past, innovation requires R&D, but TCGR has shown in the past (2011) there is ongoing value-added in this endeavor, whether it is (1) improved productivity from existing assets; (2) improving processes and obtaining value added from licensing or joint venturing cutting edge polyolefin catalyst or process advances; or (3) developing superior resins which can be sold for higher pricing. Indeed, the polyolefin industry has a rich history of innovation, such as Dow's new plastomers (AFFINITY™), polyolefin elastomers (ENGAGE™) and performance EPDM (NORDEL™) based on their INSITE™ technology. ExxonMobil has also led the way with numerous mLLDPEs (EXCEED™), plastomer (EXACT™) and elastomer breakthroughs, multiblock copolymers, diblock polymers and even the unprecedented copolymerization of ethylene with butadiene using neodymium metallocene catalysts, to mention a few.

The above are only a small number of advances being made by producers. On the specialty side CPChem, LyondellBasell, Mitsui, Mitsubishi, Borealis, NOVA Chemicals, W.R. Grace and others have been examined. Critical aspects like import/export outlooks have been reviewed 2020-2025 because of the obvious concerns about oversupply in the markets.

Subscribers benefit from receiving TCGR’s independent, third-party view of R&D trends and directions, new market developments, improvements to manufacturing and technology licensing. By participating in this multi-client study approach, they also share cost across the industry, so that they receive the benefit at a fraction of the normal costs of undertaking their own independent company evaluations. TCGR’s polyolefin experts are industry seasoned executives. Combined with the confidential input from “charter subscribers” who have helped to shape the final study contents, TCGR reports are known to be “by the industry, for the industry”.

IV. SCOPE AND METHODOLOGY

For details on this report’s scope, we direct your attention to the study’s actual Table of Contents (see pp. 7-13). This has been modified based on the collective input from “charter” subscribers (i.e., those that signed-up prior to study launch). The objective on a global basis is identifying and documenting new product, catalyst and ID/ED, cocatalyst other advances that have occurred over the last 9-10 years covering regions: Asia/Pacific, China, India, Japan, Europe, Middle East and the Americas.

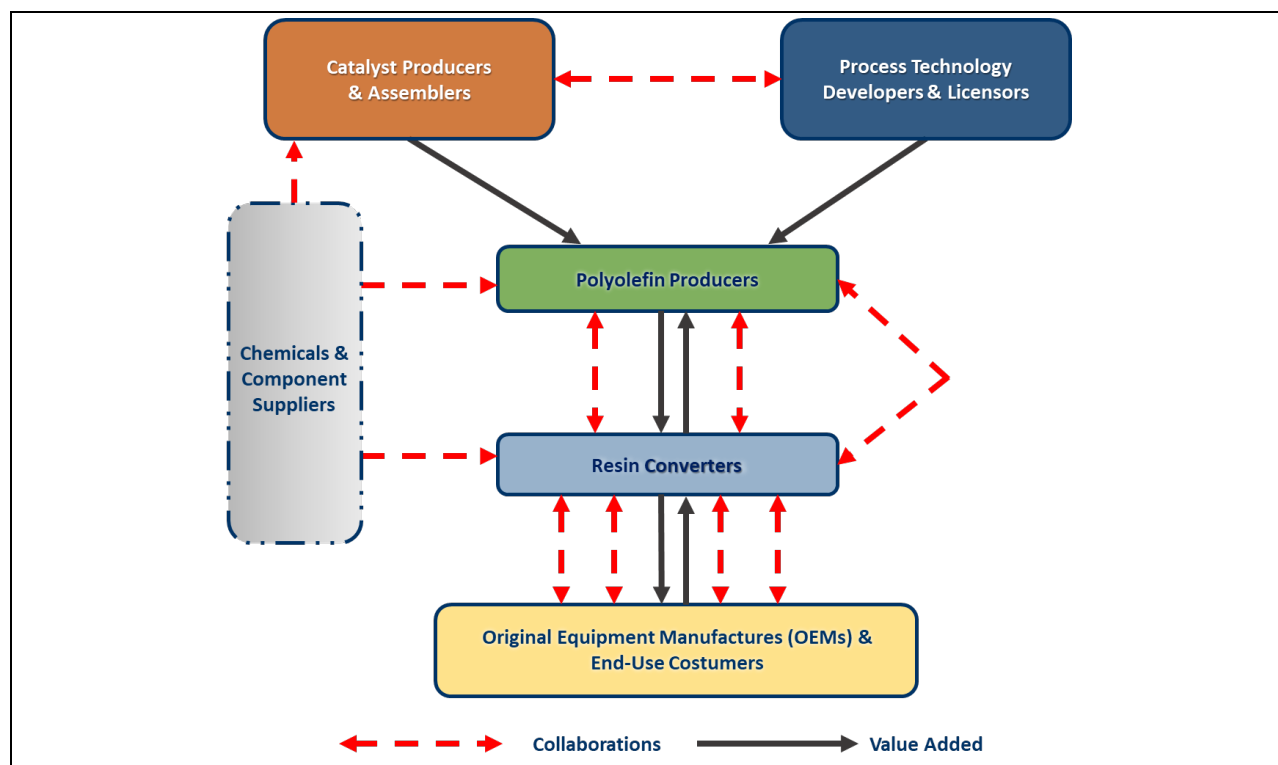


Figure 1 The Polyolefin Value Chain

TCGR, with its polyolefin experts, has completed five (5) year patent and technical literature searches to benchmark R&D and industry activities. The focus and methodology included:

- Documenting improved exploitation of existing assets, and/or improvements available from licensed processes or JVs.
- Highlighting the value-added of new innovative products.
- Identifying promising new developments flowing from advancement in catalysis.
- Focusing on the cost benefits and value-added to producers of PE and PP.

V. 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***

VI. DELIVERABLES AND PRICING

This report is timely and strategically important to those industry participants and observers both monitoring and investing in the development and implementation of technologies for polyolefin production, from catalyst/co-catalyst/activator producers to process licensors and resin producers and users, including convertors. TCGR's report, based on technology evaluations, commercial/ 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.

The study, "**Progress in Technology for Polyolefins Production III**" was completed in December 2020.

Post-production subscribers US\$22,500

Progress in Technology for Polyolefins Production III

Report in PDF format, in addition to subscription price US\$1,000

Notice to Subscribers of TCGR's Earlier (2011, 2017 and 2018) Polyolefins Studies:

*Due to the complementary nature of this study to TCGR's previous reports in this area (namely "**Progress in Technology for Polyolefin Production: Quantifying the Value-Added of Advanced Catalysts, Co-Catalysts/activators and Stereo regulators**" from 2011; "**Polyolefin Catalysts and Processes: Technological and Commercial Impacts on PE and PP**" from 2017 and "**Polyolefins Catalysts and Processes: Competitive Implications of Industry Consolidation**" from 2018), TCGR is offering a discount of \$1,000 off "**Progress in Technology for Polyolefins Production III**" to subscribers of any of the earlier studies. Subscribers are requested to contact John J. Murphy at +1.215.628.4447 or 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 any of the earlier reports.*

** Charter subscribers (those who signed up for the study prior to launch) had the opportunity to work with TCGR to further refine the scope of the report by delineating areas of particular interest for inclusion in the assessment, including "voice of customer" targets/applications (Section V) and catalyst/product advances (Sections III and IV).*

* * * * *

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The Catalyst Group Resources, Inc.
Gwynedd Office Park
P.O. Box 680
Spring House, PA 19477 - USA -

Tel: +1.215.628.4447
Fax: +1.215.628.2267
e-mail: tcgr@catalystgrp.com
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_____ “**Polyolefin Catalysts and Processes: Technological and Commercial Impacts on PE and PP**” (2017)

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Progress in Technology for Polyolefins Production III

(December 2020)

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