TCGR
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Select Client Study

Polyolefin Catalysts and Processes: Technological and Commercial Impacts on PE and PP 2015-2025

Study Presentation

(completed May 2017)

Comprehensive Assessment

Deep Knowledge

Global Impact

P.O. Box 680 • Spring House, PA 19477 USA • Tel: +1 (215) 628-4447 • Fax: +1 (215) 628-2267 • www.catalystgrp.com

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Some Background Provides Justification for Study Subscription

- **Background**
  - This TCGR Select-Client Study is designed to provide a quick "snapshot" of key business, market, and technological shifts within the polyolefins industry
- **Objective**
  - Looking through 2025, TCGR has considered commercial and technological developments that will provide study participants with expert information for future business planning. By focusing on emerging technologies, TCGR has detailed how changes occurring now & scheduled to occur will impact the industry of tomorrow.
  - Provide actionable guidance to study participants interested in maximizing their opportunities within the industry
- **Scope**
  - PP & PE – Globally focused study examining the recent catalyst, process technology, and application changes and their impact on production and application developments.
  - Top polyolefin resin producers, catalyst manufacturers and process technology licensors
- **Methodology**
  - TCGR has augmented its in-house expertise with polyolefin experts that have >30 years' industry experience (a mixture of commercial & technical) in completing this study.
  - TCGR also utilized publicly available and in-house information and expertise collected over 35+ years in the polyolefin catalyst industry
  - Patent searches, technical literature reviews, and in-field interviews were conducted with catalyst manufacturers, process licensors, resin producers, and end users/convertors

The study's scope/TofC, on the following two pages, reflects inputs from "charter" subscribers, industry leaders in polyolefin resin production, process licensing and catalyst supply…

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Industry statistics on resins, processes and catalysts with analysis/insights…

Detailed evaluations of recent patenting/ IP in PE developments with critical assessments of focal areas, opportunities and strategies…

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Table of Contents *(cont'd)*

Detailed evaluations of recent patenting/IP in PP developments with critical assessments of focal areas, opportunities and strategies…

Subscriber-defined growth applications where linkage between technology/IP and resin provide a solution…

Key take-aways from the analysis in catalysts, processes and resins…

Study Highlights Include…

- The imbalance between regional resin consumption vs. production growth emphasizes feedstock advantages (e.g., for North American-based producers) but also points out remaining deficiencies in technology capabilities for value-added/specialty grades, notably in China.

- Process advances targeted towards improved production efficiencies (e.g., reactor onstream time, energy and/or feedstock utilization, etc.) as well multi-modal and/or broad molecular weight distribution (MWD) resins with specific co-monomer incorporation are critical to success; the efforts by LyondellBasell on Hyperzone technology are linking the advanced process with application-specific grades.

- Catalyst and co-catalyst systems remain at the heart of competitive resin product offerings and recent progress reflects activities in Ziegler-Natta and metallocene/single-site (SSCs), including replacement of Cr-based systems; progress towards non-phthalate donors in Z-N systems, addressing REACH concerns, continues apace.

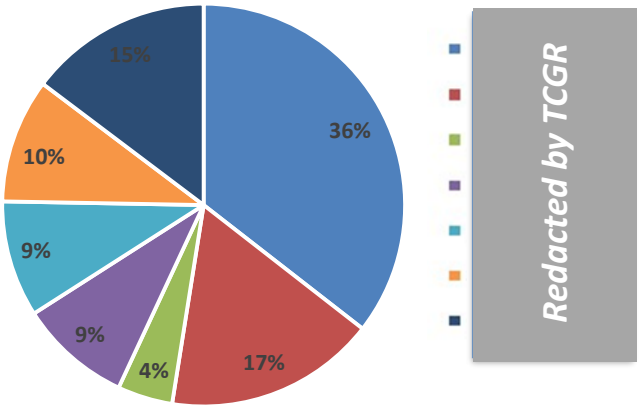
- From a strategic perspective, the linkage between catalyst development and resin performance requirements remains critical; any disconnect between them (which can arise in 3rd party supply arrangements) can adversely affect access to novel high-growth applications and, therefore, product price premiums.

Resin-, process- and catalyst-specific analyses of the major PE and PP participants are provided and critiqued…

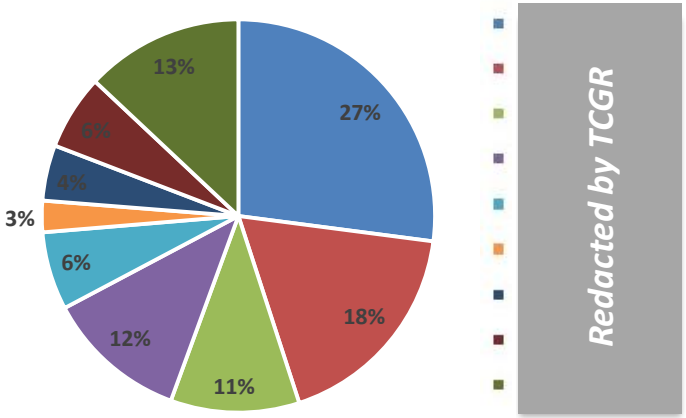
An Indication of the Study's Value Can Be Seen in Excerpted Pages from the Assessment (1 of 3)

Highlights: PE & PP Licensor Market Share

2016 PP Licensor Landscape



2016 LLDPE/HDPE Licensor Landscape



- 2016 Announcement by Ineos that they will no longer be licensing Innovene S double loop slurry techno gy
  - Text redacted by TCGR
- Sinopec licensing major wins in China and Asia Pacific
  - Text redacted by TCGR
- Industry trend toward JV relationships between feedstock provider, technology licensor, and resin producer
  - Text redacted by TCGR
- Univation acquisition by Dow
  - Text redacted by TCGR
  -

Univation – PE

BACKGROUND

Univation is the leader in low pressure PE licensing with its single PE gas phase reactor. Univation is also a leading supplier of PE catalysts. Univation is constantly looking to improve *Text redacted by TCGR* *Text redacted by TCGR* Univation process offers the broadest product mix from HDPE Chromium to LLDPE metallocene. Univation continues development with its Prodigy catalyst allowing the production of bimodal PE (needed in some application like PE 100 pipe) in one single reactor.

ABSTRACT

During the last 18 months, the focus of Univation has been in the following areas

Text redacted by TCGR

DETAILS

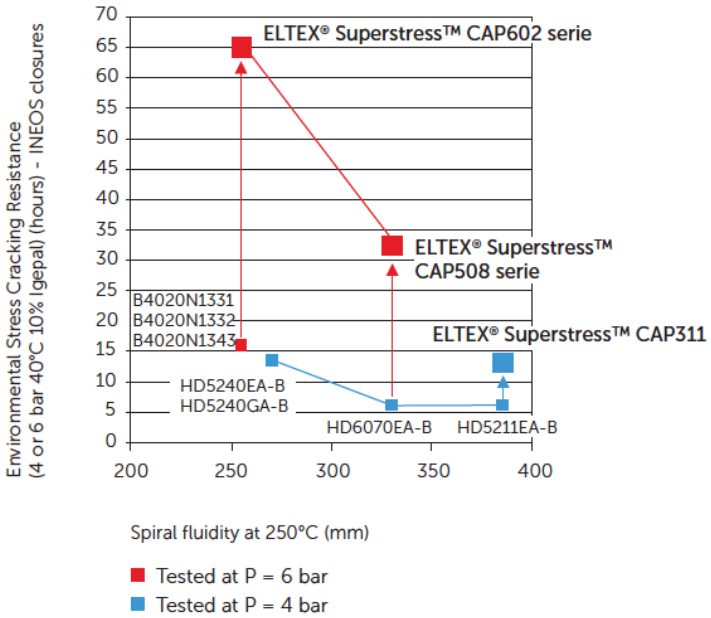
1. Incremental process development to increase operation of its gas phase
   - Production of an antifouling composition that can be fed consistently in the reactor. *Text redacted by TCGR* *Text redacted by TCGR*
   - Method of transition from one catalyst to another without killing the catalyst
   - Method of transition between *Text redacted by TCGR* without shutting down. *Text redacted by TCGR* *Text redacted by TCGR* are introduced sequentially and then the bed is purged extensively before introducing a second metallocene catalyst.
   - Method to inject the catalyst to improve morphology.

PE Injection Molding – Recent Developments by Ineos

- ELTEX SuperstressTM family of HDPE grades developed specifically for demanding caps and closures
  - Enhanced stress crack resistance and organoleptics without compromise on processability
- PE composition having [redacted] 950-960 kg/m3,

  [redacted]

  Text redacted by TCGR
- Using a CGC single site catalyst in [redacted] *Text redacted by TCGR* [redacted] *Text redacted by TCGR* reactors



Comparison of ELTEX Superstress Grades from Ineos Website

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Order Form & Secrecy Agreement

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

Tel: +1.215.628.4447 • Fax:+1.215.628.2267
e-mail: tcgr@catalystgrp.com • website: *www.catalystgrp.com*

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_____ **Polyolefin Catalysts and Processes: Technological and Commercial Impacts on PE and PP, 2015-2025,** to be delivered as a PDF file containing Powerpoint slides, for $15,500; this includes use across locations (i.e. site license).

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Dedicated to monitoring and analyzing technical and commercial developments in catalysis as they apply to the global refining, petrochemical, fine/specialty chemical, pharmaceutical, polymer/elastomer and environmental industries.

Gwynedd Office Park
P.O. Box 680
Spring House, PA 19477 – USA –

+1.215.628.4447
tcgr@catalystgrp.com
www.catalystgrp.com

Mr. John Murphy, President
John.J.Murphy@catalystgrp.com

Mr. Taylor Vozniak, Sales & Project Manager
tvozniak@catalystgrp.com