

# Catalysts by Evonik

Accelerating Your Chemistry®





## Accelerating Your Chemistry®

Catalytic processes take place behind the scenes, reducing activation energy and accelerating chemical reactions. Yet catalysts never appear in final products. This ability to reduce activation energy while remaining invisible is expressed by our Purple Box.

It symbolizes performance in five dimensions:

### Tailored solutions

Your goals, needs and wishes are unique – we'll develop the right solution for your process.

### Speed

Time is of the essence for our customers – our teams react swiftly and flexibly to your special wishes. Irrespective of whether the catalyst is based on your recipe or ours, we specialize in scaling-up and on producing sophisticated catalysts on a commercial scale.

### Strength

Evonik catalysts are always heavy-duty performers – you can count on our strength and the power of our catalysts.

### Long life

Efficiency and long-term reliability are decisive for catalytic processes – that's why Evonik catalysts are always designed for a long service life.

### Service

Technical customer service, high throughput screening, metal recovery – Evonik catalysts come with a full service package.



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## Evonik Industries at a Glance ...

Evonik, the creative industrial group from Germany, is one of the world leaders in specialty chemicals. Profitable growth and a sustained increase in the value of the company form the heart of Evonik's corporate strategy. Its activities focus on the key megatrends health, nutrition, resource efficiency and globalization. Evonik benefits specifically from its innovative prowess and integrated technology platforms.

Evonik is active in over 100 countries around the world. In fiscal 2015 more than 33,000 employees generated sales of around € 13.5 billion. As part of the Business Unit Inorganic Materials, the Business Line Catalysts lives up to the principles of resource efficiency. Our products enable and continuously improve production efficiency.

## Together We Bring Catalyst Ideas to Life

Catalysts: the no. 1 value generator in the chemical industry. More than 80 percent of all chemical products are manufactured by means of catalytic processes. Expertise in harnessing the power of catalysts is second nature to us – we can help you significantly reduce energy and resource consumption, or develop new products. As an international leading provider of catalytic technologies, we serve the markets:

- Life Sciences & Fine Chemicals
- Industrial & Petrochemicals
- Polyolefins

Sales:

€ 13.5 billion

Active in over:

100 countries

Employees: more than

33,000

Evonik is a member of

- the European Catalyst Manufacturers Association (ECMA),
- the Catalyst Manufacturers Association of Japan (CMAJ),
- the Synthetic Organic Chemical Manufacturers Association (SOCMA),
- the Drug, Chemical & Associated Technologies Association (DCAT),
- the American Chemistry Council (ACC) and
- the Catalysts Society of Japan (CSJ)

## Markets & Brands

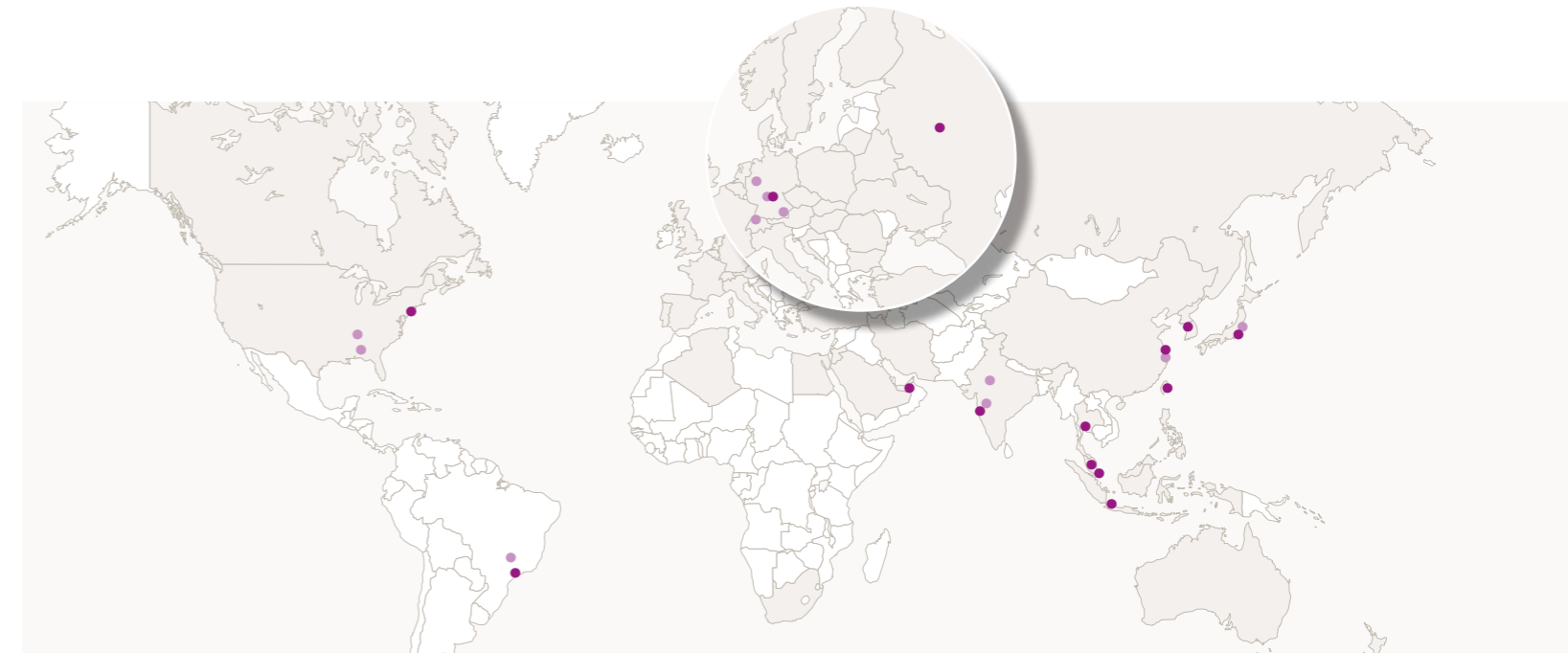
Today, Evonik has eight major catalyst brands for homogeneous and heterogeneous catalytic processes under one roof. This unique variety of catalysts gives us the flexibility to find the most cost-efficient solution for your needs.

With its homogeneous and heterogeneous catalysts for batch, semi-batch and continuous processes, Evonik serves the following markets:

| Life Sciences & Fine Chemicals | Industrial & Petrochemicals | Polyolefins |
|--------------------------------|-----------------------------|-------------|
| Noblyst®                       | Noblyst®                    | Catlyen®    |
| MC                             | Aerolyst®                   |             |
| catMETium®                     | Octolyst®                   |             |
| KALCAT™                        | KALCAT™                     |             |
| MONCAT™                        | MONCAT™                     |             |



## Global Presence



### Our mission

“Together we bring catalyst ideas to life, creating value by our passion and focus.”

### Our vision

“To be globally recognized as the preferred partner for major catalyst users, and to develop and attract talented people for our international team.”

- Sales office
- Production site





## Life Sciences & Fine Chemicals

Life Sciences are helping to improve the quality and standard of living with applications including care specialties, feed and food, pharmaceuticals, edible oils and the agricultural industry. Fine chemicals are used as starting materials for specialty chemicals. The latter are obtained either by direct formulation or after chemical/biochemical transformation of intermediates to active substances.

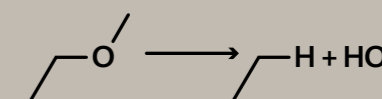
With the ability to fine-tune selectivity, activity and filterability with unparalleled precision, regardless of the reaction type, Evonik is the right partner to deliver catalysts that contribute tangibly to value creation.

Throughout the process, sustainability concerns motivate us to continuously improve our products and practices. By enhancing both the efficiency and yields of your chemical processes, our catalysts help to produce a larger quantity of the desired product in a shorter period of time, making a difference in reducing energy and resource consumption.

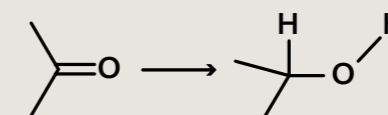
### Growing with Evonik:

- heterogeneous and homogeneous catalysts portfolio for many reaction types
- global presence for close customer proximity
- early involvement by Evonik's catalyst experts in customers research projects ensures successful identification of high-performance catalysts

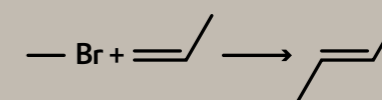
## Reaction Types



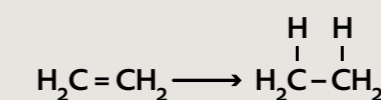
Hydrogenolysis



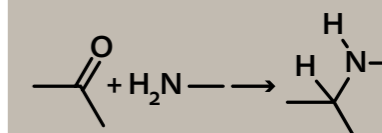
C=O Bonds



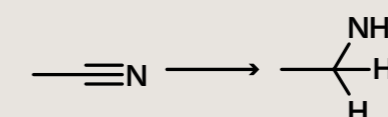
CC Coupling



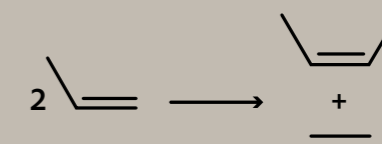
CC Bonds



Reductive Alkylation / Amination



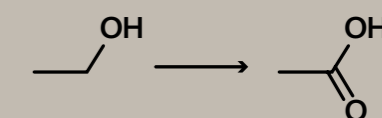
CN Bonds



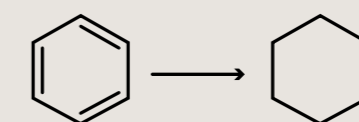
Metathesis



Nitro Groups



Dehydrogenations / Oxidations



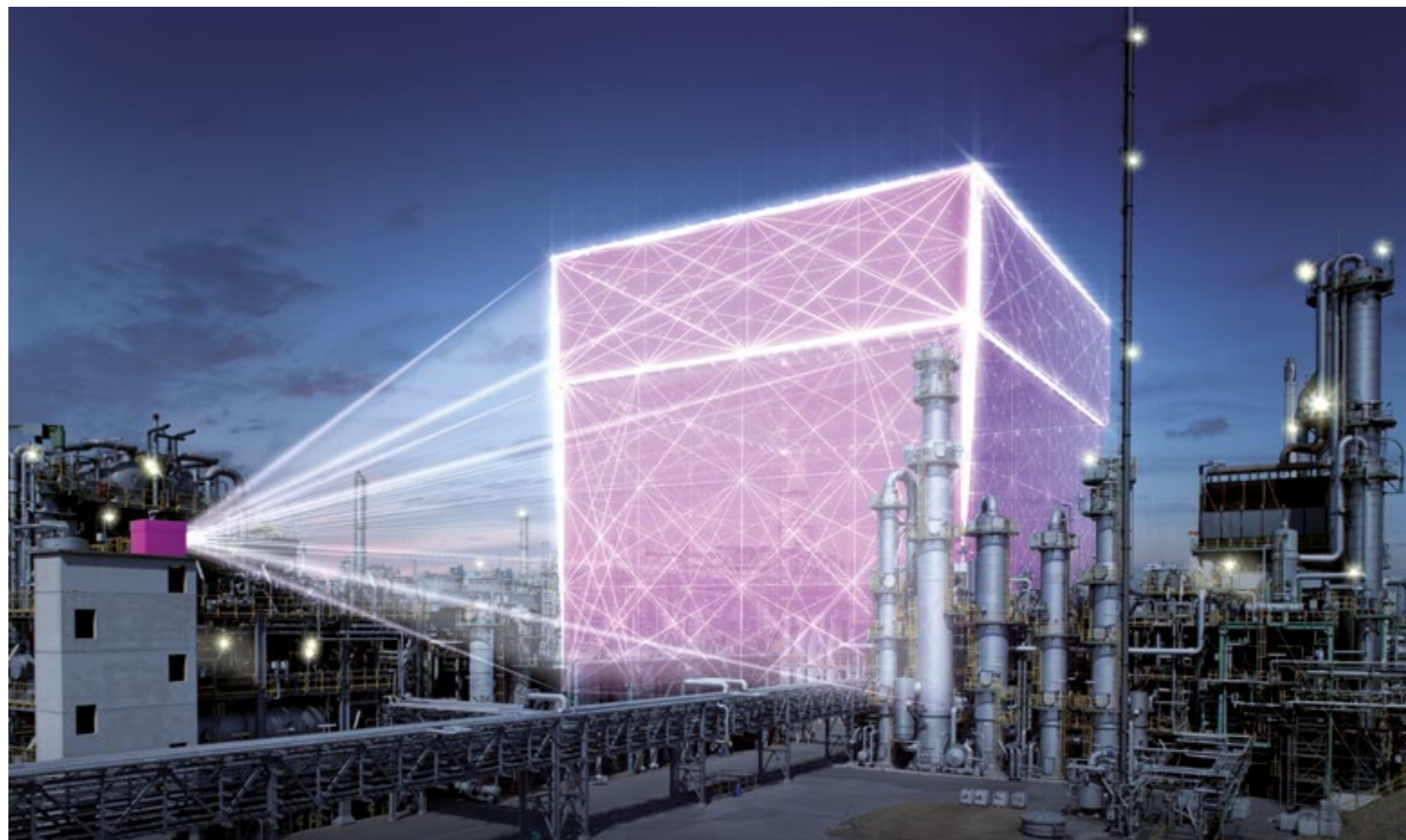
Aromatics

## Industrial & Petrochemicals

Market changes, new technologies, and the availability of new raw materials are constantly posing new challenges and offering fresh opportunities to the chemical industry. With Evonik's catalyst experts you have proficient and experienced support at your side. The range of catalysis solutions for the Industrial & Petrochemicals market segment is as extensive and varied as the market itself. Evonik is in a position to actively support the development of catalysts right from the initial concept.

In addition, thanks to many years of experience in scaling up catalysts, Evonik can efficiently take catalyst recipes developed by customers to full commercial production. With innovative custom-designed catalysts, customers receive specially tailored – and thus the best possible – solutions.

For many existing processes Evonik can offer drop-in solutions based on proprietary catalysts with global references.



## Petrochemicals

Evonik's Petrochemicals customers can avail of specially developed proprietary catalysis solutions for applications such as selective and complete hydrogenations of acetylenes or dienes in aliphatic, aromatic or aliphatic-aromatic compounds. In the area of oxidation reactions Evonik has developed highly selective catalysts, which can be tailored to required activity, thus fitting to specific plant design. Technology platforms offering lab test facilities, constant product development and in depth technical support complete our value solution approach.

### Selected applications:

|   |
|---|
| Vinyl acetate monomer (VAM)               |
| Alpha-methylstyrene (AMS)                 |
| C3/C4 Olefins (Propylene, 1-Butene, MTBE) |
| Vinyl chloride monomer (VCM)              |

## Industrial Chemicals

As in petrochemical applications, exclusively developed catalysts are used here to meet the most varied requirements of our customers in industrial chemicals. Catalysts offered contain a broad spectrum of materials, such as precious and nonprecious metals as active components, often supported on substrates with customized acidity or basicity. Increasing the efficiency of the process by means of an optimal combination of activity, selectivity and catalyst service life is a prerequisite for value creation.

### Selected applications:

|                             |
|-----------------------------|
| Caprolactam                 |
| 1,4-Butanediol (BDO)        |
| Propylene oxide             |
| Toluenediamine (TDA)        |
| Hexamethylenediamine (HMDA) |
| Aniline                     |
| Fatty acid hydrogenation    |
| Stearic acid                |





## Polyolefins

Polyethylene (PE) and polypropylene (PP) have come to be the most important polymers in the world: in 2010, the quantities produced for both plastic materials together amounted to more than 120 million tons; the estimated worldwide capacity for both polymer classes amounted to more than 160 million tons. Ziegler-Natta (ZN) catalysis, for which Karl Ziegler and Giulio Natta were awarded the Nobel Prize for chemistry in 1963, is still widely used today. In PE production, it is used in 50 percent of all cases and in the production of PP, more than 95 percent of the time.

Our Catylen® family of products are key components of the Ziegler and ZN catalysts; although they are used in very small amounts, they have a profound influence on the ultimate properties of the polymers.

The Evonik Catylen® D series offers the broadest selection of silane donors in the industry. In addition, the availability of various packaging options as well as mineral oil dilutions means that Evonik's product offering can accommodate virtually all commercial polypropylene processes in use today.

For catalyst precursors, Evonik's ability to tailor the particle size parameters of the Catylen® S family of products helps to ensure that the catalyst producer can obtain the proper raw material for the desired polyolefin application.

## Polypropylene

Polypropylene (PP) is a thermoplastic polymer made by polymerization of propylene. It is used in a wide variety of applications including food packaging, ropes, textiles, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components and polymer banknotes.

## Polyethylene

Polyethylene (PE) is a thermoplastic polymer made by polymerization of ethylene. It is used in a wide variety of applications where blow molding, injection molding or extrusion coating can be applied.

Polyethylene is the most common polymer and is produced on a multi-million ton scale annually.

### Stereomodifiers

| Product         | Description  | Chemical Name                    |
|-----------------|--------------|----------------------------------|
| Catylen® D 300  | C donor      | Cyclohexylmethyldimethoxysilane  |
| Catylen® D 400  | D donor      | Dicyclopentyl dimethoxysilane    |
| Catylen® D 500  | DIB          | Diisobutyldimethoxysilane        |
| Catylen® D 600  | DIP, P donor | Diisopropyldimethoxysilane       |
| Catylen® D 700  | IBIP         | Isobutylisopropyldimethoxysilane |
| Catylen® D 800  | NPTMS        | n-Propyltrimethoxysilane         |
| Catylen® D 900  | IBMDMS       | Isobutylmethyldimethoxysilane    |
| Catylen® D 1000 | TEOS         | Tetraethoxysilane                |
| Catylen® D 1100 | TMOS         | Tetramethoxysilane               |
| Catylen® D 1200 | IBTEO        | Isobutyltriethoxysilane          |
| Catylen® D 1300 | PTEO         | n-Propyltriethoxysilane          |
| Catylen® D 1400 | IBTMO        | Isobutyltrimethoxysilane         |
| Catylen® D 1500 | CHEDMS       | Cyclohexylethyldimethoxysilane   |

### Ziegler and Ziegler-Natta catalyst precursors

| Product        | Process         | Application     |
|----------------|-----------------|-----------------|
| Catylen® S 101 | Gas phase       | PP              |
| Catylen® S 102 | Slurry          | PE (HDPE, UHMW) |
| Catylen® S 103 | General purpose | PE, PP          |
| Catylen® S 200 | Slurry          | PE              |

Customized Catylen® S grades with tailor-made particle size distribution available upon request

## Finding the Right Catalyst Custom Catalysts

With our long history in the development and production of catalysts, we have accumulated considerable expertise and built up a large portfolio of proprietary catalysts. Most of our products have been tailored for many challenging catalytic reactions. Therefore, our portfolio may already contain a suitable catalyst for your process. To identify this catalyst we can use either classical sampling and testing or our parallel rapid screening equipment. When the need for a custom catalyst arises, we leverage our core competencies in the context of a project.

Over the last two decades the demand for custom specific catalysts has increased dramatically. We are creative in finding new solutions and are open to ideas that are not obvious at first glance. Evonik specializes in scaling up and producing sophisticated catalysts on a commercial scale. A robust and stable production process is crucial to all catalysts, and we know how to design this. The best catalyst in the laboratory is of no use if it cannot be produced in commercial quantities. Reliable, delivering on our promises, our professional project management with cross-functional teams makes the project flow smoothly. We are never complacent about our achievements and continually strive for constant self-renewal in our business processes for your benefit.

## Project Categories

| Joint Development  | Custom Design  | Custom Manufacturing   | Toll Manufacturing                                 |
|--|--|--|--|
| Catalyst and process needs to be developed; close interaction between you and Evonik | Catalyst needs to be developed for existing commercial application | Catalyst lab recipe exists, but has not yet been produced commercially | Catalyst and manufacturing process is well defined |

## Catalyst Guide

Our website carries an interactive search engine, the Catalyst Guide. This web-based tool not only gives you a preliminary idea of the Evonik catalysts suitable for a particular reaction but offers you much more, providing information on reaction conditions, reaction mechanisms, patents and the scientific literature. Evonik's Catalyst Guide is indispensable for anyone working in catalysis.

[www.evonik.com/catalysts](http://www.evonik.com/catalysts)

## MSDS

### Material Safety Data Sheets

Material Safety Data Sheets (MSDS) can be obtained from your local sales representative or from:

Evonik Resource Efficiency GmbH  
Postcode 713/303  
Product Safety Department  
Rodenbacher Chaussee 4  
63457 Hanau-Wolfgang  
Germany  
FAX +49 6181 59-4205  
sds-im@evonik.com

## ESHQ

### Environment, Safety, Health and Quality

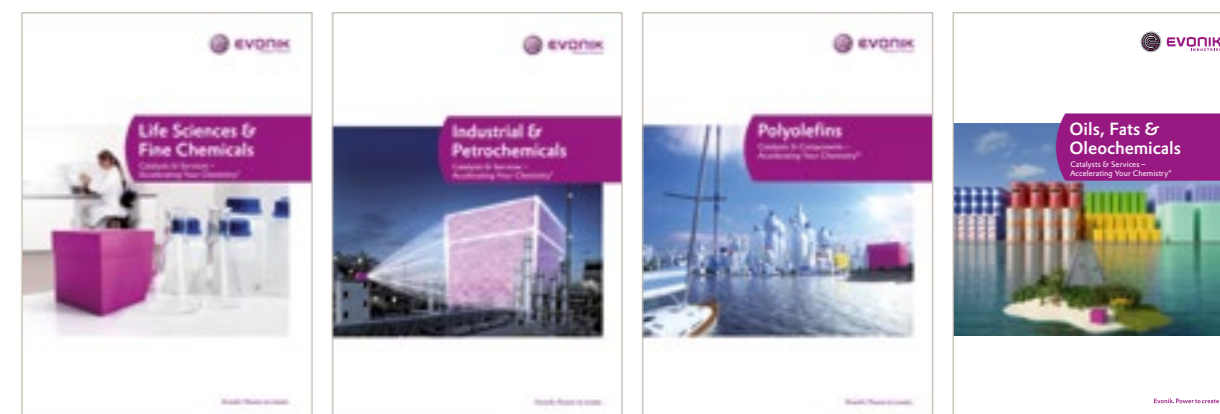
As a subscriber to the Responsible Care® program, Evonik is committed not only to delivering quality products and services but also to maintaining high health, environmental, safety and security standards in the operation of its plants and distribution of its products. Our sites have ISO 9001 and ISO 14001 certification, and all our

US sites are certified in accordance with the RC 14001 standard. Certain products are also Halal and Kosher certified. We take pride in promoting the principles and practices of Responsible Care® by sharing experiences and offering assistance to others who produce, handle transport or dispose of our products.

## Other Brochures

### Additional Services

For access to more of our publications please contact your local sales manager or visit our website at [www.evonik.com/catalysts](http://www.evonik.com/catalysts)





## Europe

Evonik Resource Efficiency GmbH  
Business Line Catalysts  
Rodenbacher Chaussee 4  
63457 Hanau-Wolfgang  
Germany

PHONE +49 6181 59-13399

FAX +49 6181 59-2699

## North America

Evonik Corporation  
Business Line Catalysts  
299 Jefferson Road  
Parsippany, NJ-07054  
USA

PHONE +1 800 422-8773

FAX +1 973 929-8504

## South America

Evonik Brazil Ltda.  
Business Line Catalysts  
Alameda Campinas, 579  
9<sup>th</sup> floor  
01404-000 São Paulo-SP  
Brazil

PHONE +55 11 3146-4063

FAX +55 11 3146-4086

## Japan

Evonik Japan Co., Ltd.  
Business Line Catalysts  
Shinjuku Monolith 12<sup>th</sup> Floor,  
2-3-1, Nishi-Shinjuku,  
Shinjuku-ku

163-0938 Tokyo

Japan

PHONE +81 3 5323-7363

FAX +81 3 5323-8789

## China

Evonik Specialty  
Chemicals (Shanghai) Co., Ltd.  
Business Line Catalysts  
55 Chungdong Road,  
Xinzhuang Industry Park  
201108 Shanghai  
China

PHONE +86 21 6119-1461

FAX +86 21 6119-1142

## India

Evonik Catalysts India Pvt Ltd.  
F - 1/2, MIDC Phase 1  
Dombivli (East) – 421 213  
District Thane  
India

PHONE +91 25 124 71716

FAX +91 25 124 70269

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## Evonik Resource Efficiency GmbH

Business Line Catalysts

[catalysts@evonik.com](mailto:catalysts@evonik.com)

[www.evonik.com/catalysts](http://www.evonik.com/catalysts)

[www.evonik.com](http://www.evonik.com)