

**■ - BASF**

We create chemistry

**The lowest SO<sub>2</sub> emissions by the inventor of sulfuric acid catalysts**



### Proven in Our Plants, Designed to Enhance Yours

Since 1913 BASF runs the lowest SO<sub>2</sub>-emission sulfuric acid production plants worldwide. Benefit from our experience by choosing our oxidation catalysts. They are optimized for manufacturers that produce:

- Fertilizers
- Chemicals
- Detergents
- Dyes
- Pigments
- Pharmaceuticals
- Refined
- Process
- Steel
- Iron

### BASF Specialty Oxidation Catalysts for Outstanding Performance

We design our catalysts for maximum outcomes. That starts with the unrivaled SO<sub>2</sub>-emissions performance they can deliver because of their large surface area. To our customers, that means effortless regulatory compliance, no additional emission reduction costs, higher conversion, and bigger profits. These results last. Because of their exceptional physical stability, our catalysts give you a longer lifetime, deliver energy savings, and minimize downtime risks.

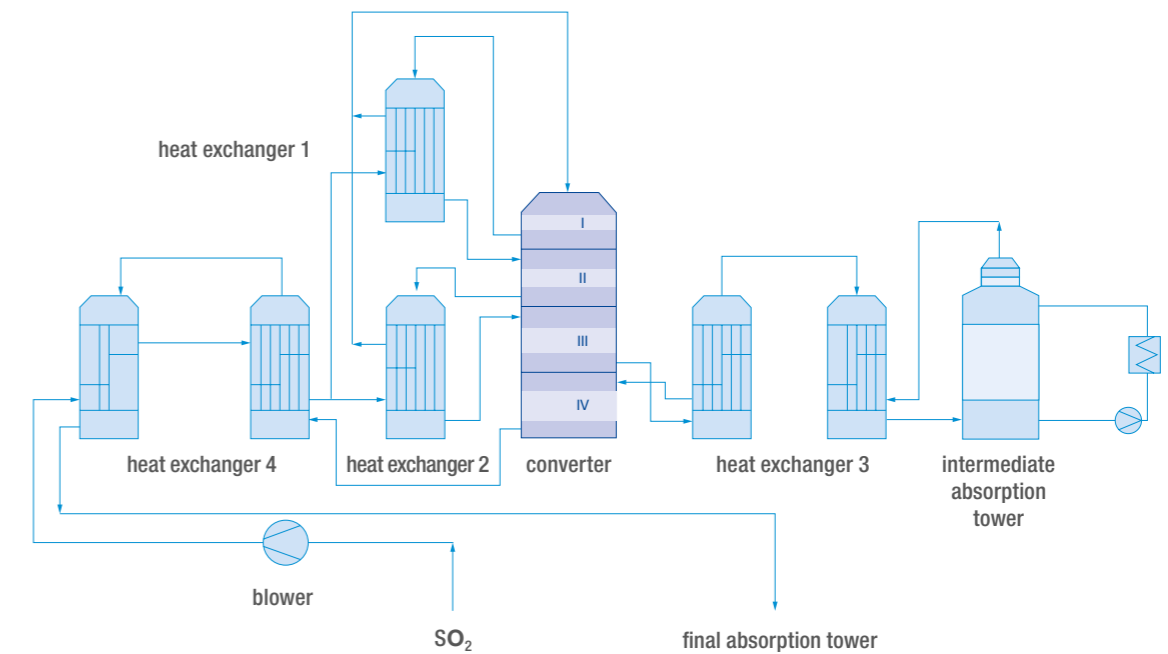
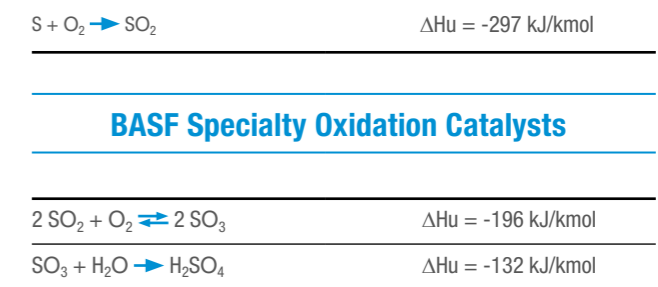
At BASF, all of that comes with total service dedication, reliable customer support backed by the inventor of the sulfuric acid catalyst, and decades of experience in:

- Conversion evaluation
- Performance optimization
- Technical assistance
- Customer sample analysis
- On-site plant support
- Spent catalyst disposal assistance
- Process performance evaluation

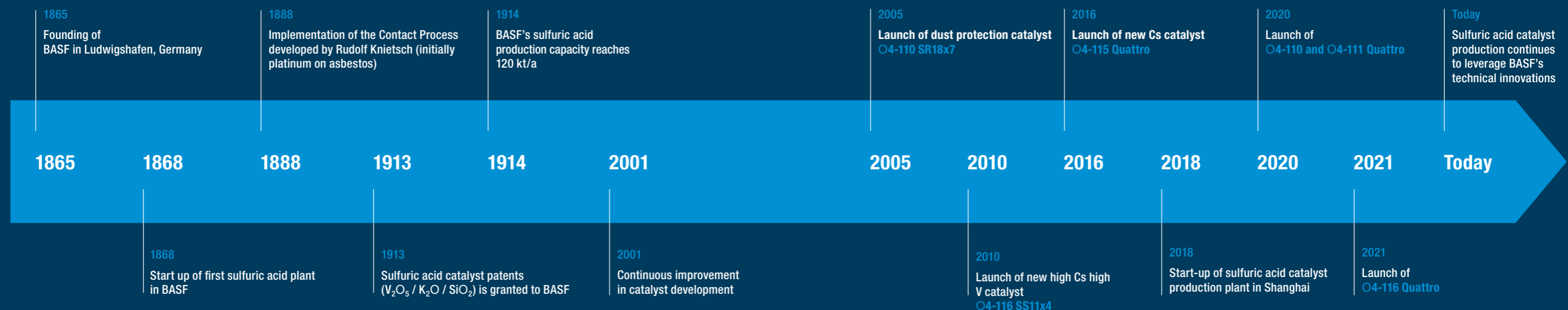
### We Never Stop Inventing

That's how the new O4-115 Quattro was born. The latest addition to our catalyst family features a 30% higher surface area and improved pore accessibility to boost performance, reduce emissions, and further increase your plant capacity.

For years, businesses have trusted us to provide catalysts that promote effective reactions in the sulfuric acid production cycle, as illustrated below:



### History of Sulfuric Acid Production and Sulfuric Acid Catalysts in BASF



# BASF Specialty Oxidation Catalysts Product Portfolio

## Product Overview

	O4-110	O4-111	O4-115	O4-116
Shape and size	SS11x4 Star Ring	SS11x4 Star Ring	SS11x4 Star Ring	SS11x4 Star Ring
	SR18x7 Ring <sup>1)</sup>			
	Quattro <sup>5)</sup>	Quattro <sup>5)</sup>	Quattro	Quattro
Ignition temperature	380°C <sup>2)</sup>	360°C <sup>2)</sup>	340°C <sup>2)</sup>	330°C <sup>2)</sup> <b>NEW</b>
Operating temperatures	420–630°C <sup>3)</sup>	410–600°C <sup>3)</sup>	390–630°C <sup>3)</sup>	380–600°C <sup>3)</sup>
Operating temperatures Quattro	410–630°C	400–600°C	375–630°C	365–600°C
Thermal stability	630°C <sup>4)</sup>	600°C	630°C	600°C
Packaging	200 l drum	200 l drum	200 l drum	200 l drum
	1,000 l big bag	1,000 l big bag	1,000 l big bag	1,000 l big bag
Typical applications	First Bed	Second to Fourth or Fifth Bed	First Bed	After intermediate absorption
	Second Bed possible		Fourth or Fifth Bed	Fourth or Fifth Bed
			Other Beds Possible	

1) The SR18x7 Ring will only be delivered in a 200 l drum  
 2) In continuous operations generally 30–50°C higher

3) Depending upon gas composition  
 4) Continuous operation peaks up to 650°C

### BASF Offers Full Systems Design for:

- Performance reliability from planning through all phases of plant operation
- Simulations of plant operations
- Converter design calculations
- Highest conversion requirements
- Capital investment optimization
- SO<sub>2</sub> emission reduction
- Environmental protection maximization

### Knowledge: Ours Becomes Yours

Profit from the deep expertise and know-how we have acquired from operating our own state-of-the-art sulfuric acid plants since 1913. The production support and asset utilization mastery of our technical services will help you work more efficiently, with less downtime, and higher profits.

#### Ready to save even more?

Meet our spent catalyst disposal service: You won't need dedicated personnel, you'll save time, and drop your warehousing costs. Get in touch with us.

[www.catalysts.basf.com/sulfuric-acid-catalysts](http://www.catalysts.basf.com/sulfuric-acid-catalysts)

# Catalyst O4-110

## The New O4-110 Quattro

- Primarily for use in the first converter bed
- Suitable for sulfur combustion gases, waste gases from metallurgical plants or H<sub>2</sub>S ("wet") combustion
- 380°C ignition temperature<sup>1)</sup>
- 410–630°C operating temperature range<sup>2)</sup>
- 650°C short term peak temperature
- Ideally suited for high SO<sub>2</sub> contents of up to 13%
- Ultra low screening loss due to high mechanical strength.

1) In continuous operations generally 30–50°C higher  
 2) Depending upon gas composition

Compared to star-ring shaped catalysts, it features some significant advantages:

#### Quattro values compared with Star Ring shape

geometric surface area	30 % higher
cutting hardness	50 % higher
attrition	60 % lower

- Higher strength which results in a longer production lifetime
- Strongest catalyst on the market with a central hole
- This catalyst is dedicated to boost your performance, reduce emission and increase the plant capacity



Catalyst O4-110 SR18x7



Catalyst O4-111 SS 11x4



Catalyst O4-110 Quattro\*

### Advantages of Dust Protection

- Increase of catalytically active mass in volume restricted beds
- Superb dust filtering properties
- Extended periods between screening





# Catalyst O4-111

## The New O4-111 Quattro

- Superior activity
- Close approach to thermodynamic equilibrium
- Very high SO<sub>2</sub> conversion rates when combined with low inlet temperatures in the last bed
- 360°C ignition temperature<sup>1)</sup>
- 400–600°C operating temperature range<sup>2)</sup>
- Highly active for beds after first converter bed

<sup>1)</sup> In continuous operations generally 30–50°C higher  
<sup>2)</sup> Depending upon gas composition

### Quattro values compared with Star Ring shape

geometric surface area	30 % higher
cutting hardness	50 % higher
attrition	60 % lower

- Higher strength which results in a longer production lifetime
- Strongest catalyst on the market with a central hole
- This catalyst is dedicated to boost your performance, reduce emission and increase the plant capacity



Catalyst O4-111 SS 11x4



Catalyst O4-111 Quattro\*



### Advantages

- Outstanding mechanical properties
- High activity
- Superior cutting hardness



# Catalyst O4-115

Built to boost performance, reduce emissions, and enhance plant capacity. The new Quattro shape is next-level catalyst technology.

## The O4-115 Quattro

Already in use in several plants worldwide, the O4-115 Quattro is primarily used in the fourth and fifth beds of sulfuric acid plants. Compared to star-ring shaped catalysts, it features some significant advantages:

Quattro values compared with Star Ring shape	
geometric surface area	30 % higher
cutting hardness	50 % higher
attrition	60 % lower

- Higher strength which results in a longer production lifetime
- Strongest catalyst on the market with a central hole
- This catalyst is dedicated to boost your performance, reduce emission and increase the plant capacity



## General

- Caesium catalyst promoter that enhances vanadium action
- Activates at lower temperatures than standard catalysts
- 340°C ignition temperature<sup>1)</sup>
- 375–630°C operating temperature range<sup>2)</sup>

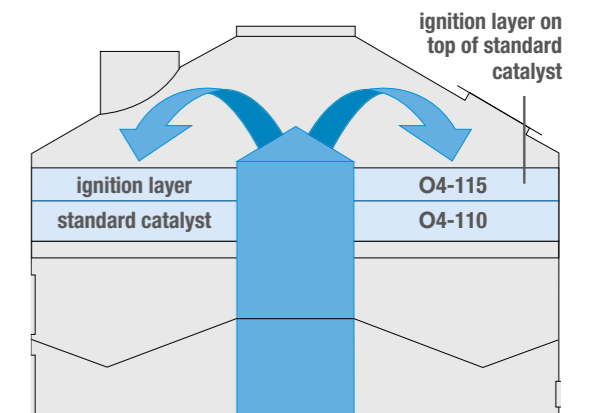
## After Intermediate Absorption or Final Bed

- When used in the final bed at low inlet temperatures, SO<sub>2</sub> conversion is maximized, emissions are reduced, and production is increased

## First Bed

- 650°C short term peak temperature
- When used in the first bed, bed inlet temperature reduced to save energy and start-up time

<sup>1)</sup> In continuous operations generally 30–50°C higher  
<sup>2)</sup> Depending upon gas composition



## Advantages of Ignition Layer

- Ignition of O4-115 in the top layer already at very low temperatures
- Temperature increase in the Ignition layer due to highly exothermic reaction in the first 15–20 cm\* supports the operation of standard catalyst
- Ignition layer after Intermediate Absorption possible\*



\* Depending on SO<sub>2</sub> gas concentration and gas velocity

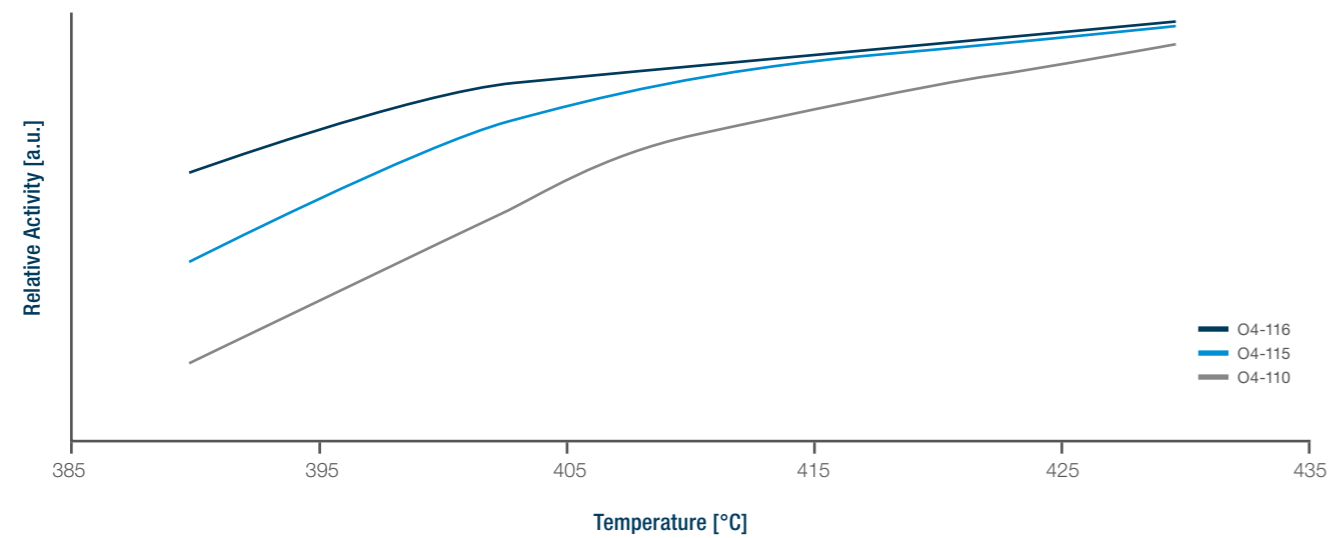
# Catalyst O4-116

## Development

- Dedicated mixture of different support materials ensure optimum pore size distribution for the low temperature application
- Best solution to achieve ultra low emission
- Improved new active phase
- No changes in handling and disposal despite new active phase



**O4-116 is Designed Especially for Passes After the Intermediate Absorption to Minimize SO<sub>2</sub>-Emission**



## Advantages

- Highest activity at temperatures below 400°C
- Excellent mechanical stability
- Star Ring shape to minimize the pressure loss



# Globally Active

## AMERICAS

- Iselin, New Jersey**
  - Technical Service
- Houston, USA**
  - Warehousing

## EMEA (EUROPE, MIDDLE EAST AND AFRICA)

- Ludwigshafen, Germany**
  - Technical Service
  - Manufacturing
  - Research & Development
- Ndola, Zambia**
  - Warehousing

## ASIA

- Shanghai, China**
  - Technical Service
  - Manufacturing
  - Research & Development





# The BOSS 100

## BASF Optimal SO<sub>2</sub> Measurement System 100

### On-site SO<sub>2</sub> Measurement Technology

BASF has developed a new, portable measurement tool to determine catalyst and plant performance: The BOSS 100 provides reliable, accurate data on SO<sub>2</sub> concentration throughout a facility in order to detect leakages and performance issues. BASF supports the customer in taking the appropriate measures to reach manufacturing excellence through our experience, technical expertise and innovative strength.

### Why use the BOSS 100?

Production performance deviations can appear for a number of reasons. As the world's leader in catalysis, BASF has identified key issues:

- Hardware related issues, e.g. leaking/limited heat removal capacity leading to fouling, corrosion, etc.
- Operational related issues e.g. bed inlet temperatures not accurate
- Catalyst related issues e.g. insufficient activity, poisoning and channelling

The BOSS 100 offers a fast and reliable way of detecting and solving these issues.

### Unparalleled Technical Expertise

The Optimal SO<sub>2</sub> measurement System BOSS 100 is a technology package based on Micro GC technology enhanced by our specialists to meet the exact needs of our customers. The advantages of this tailored measurement system are:

- Ability to take SO<sub>2</sub> measurements in the presence of SO<sub>3</sub> in a wide concentration range
- Ability to analyze samples in under two minutes
- Use of a special drying agent that does not interfere with the measurement

The sophisticated system of the BOSS 100 is a combination of gas preparation, collection and analysis. In addition, it includes data processing modules and it is fully supported by the BASF Analyzing Center.

This easy-to-handle system allows BASF's customers to determine the right way to eliminate plant underperformance by providing solutions based on their specific situation.



### Full-loop Technical Support

The BOSS 100 is fully supported by the BASF Analyzing Center and managed by experienced catalysts experts. As a result, customers can expect full-loop service:

- On-site measurement and technical support
- Customer sample analysis
- Conversion evaluation
- Process performance evaluation
- Plant performance optimization

### Measurement & Reporting

The BOSS 100 enables measurement of SO<sub>2</sub> in a wide range of concentrations: 50 ppmv–15 vol. %. Two types of measurement reports are available:

- The Thermodynamic Simulation Report
- The Analytical Measurement Report

### Evaluation

You can expect results and recommendations shortly after all measurements have been executed.

**The Thermodynamic Simulation Report** compares a simulation for fresh catalysts to the actual performance thus helping with identifying and optimizing performance problems in particular.

**The Analytical Measurement Report** summarizes all analyzed parameters providing comments and recommendations with respect to data consistency.

### Finding the Right Solution

On-site measurements allow for the development of customized solutions: The portable system locates leakages and other issues where they arise. Based on these results it is possible to systematically identify weak spots and to develop specific procedures to correct performance issues and improve the plant's overall efficiency.

Like this, the BOSS 100 – as the latest generation of SO<sub>2</sub> conversion measurement systems – offers the key to tailored solutions for manufacturing excellence.



# Innovation loves Experience

## Research

Effective and efficient research and development is a prerequisite for innovation as well as an important growth engine for BASF. We develop innovative processes, technologies and products for a sustainable future and drive forward digitalization in research worldwide. This is how we ensure our long-term business success with chemistry-based solutions for our customers in almost all industry sectors.

Our innovative strength is based on a global team of more than 11,000 highly qualified employees involved in research and development in 2018. Together with the development units in our operating divisions, our three research divisions form the core of our global Know-How Verbund. It is complemented by our global network of outstanding universities, research institutes and companies. In 2018, our research pipeline comprised around 3,000 projects. Expenses for research and development amounted to 2,028 million.

BASF's key competencies in research include the preparation, testing and scale-up of new and improved heterogeneous catalysts like sulfuric acid catalysts for internal and external customers. Our R&D experts for sulfuric acid catalysts in Ludwigshafen, Germany and Shanghai, China ensure that the excellent quality of our catalysts meets our own expectations and those of our customers.

## Manufacturing

For more than a century, BASF has produced its sulfuric acid catalysts in manufacturing facilities at its Ludwigshafen, Germany, Verbund site. The site is distinguished by extensive expertise, with its current employees collectively sharing more than 150 years of experience in manufacturing sulfuric acid catalysts.

The original site at Ludwigshafen became operational in 1865 and is today BASF's most important production site. At Ludwigshafen, we use petrochemical and inorganic substances and process them into high value-added chemical products for the global market. The tightly knit network of more than 160 production facilities provides exceptionally favorable conditions for the manufacture of complex and highly refined chemicals. As the BASF Group's technology platform and center of excellence, the Ludwigshafen site is a major source of innovation in products, methods and processes.

The central location of the site in southwest Germany, as well as its state-of-the-art logistics infrastructure with excellent rail, road and water transport links, offer ideal prerequisites for BASF to reliably supply customers all over the world. Two combined-cycle gas turbine power stations, a highly efficient wastewater treatment plant, and state-of-the-art infrastructure across the site ensure sustainable manufacturing operations.

In 2018, BASF inaugurated a new sulfuric acid production plant in Shanghai to provide even better support our customers in all regions.



## Why BASF?

Our goal is to drive our customers' success. We accomplish this through our commitment to excellence and our passion for innovation, which helps deliver enhanced production economics and increased productivity. We are the partner of choice in our industry, with extensive expertise in both catalysts and applications.

## About Us

The BASF Group, consisting of BASF SE plus more than 100 subsidiaries, produces over 8,000 products and has operations in more than 39 countries.

BASF's Catalysts division is comprised of main research centers in the United States and Europe, production facilities all over the world, and a worldwide marketing and technical service team with regional Catalysts marketing

and technology centers in Asia Pacific, Europe, and the Americas regions.

The Catalysts division produces more than 150 different catalysts. The majority of our portfolio is readily available on the open market. Some of these catalysts are specially developed in cooperation with our customers to meet their specific requirements.







We create chemistry

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## About Us

BASF's Catalysts division is the world's leading supplier of environmental and process catalysts. The group offers exceptional expertise in the development of technologies that protect the air we breathe, produce the fuels that power our world and ensure efficient production of a wide variety of chemicals, plastics and other products, including advanced battery materials. By leveraging our industry-leading R&D platforms, passion for innovation and deep knowledge of precious and base metals, BASF's Catalysts division develops unique, proprietary solutions that drive customer success.

## BASF – We create chemistry

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