We create chemistry that makes high performance love low carbon footprints.
**BASF FUEL PROCESSOR CATALYSTS**

**BASF – The Chemical Company**

Just as catalysts make the right reactions happen, so do we. Our process catalysts and technologies combine the strength of BASF – The Chemical Company, with the experience of our chemists and engineers and expertise in process technology.

Our dedication to catalyst chemistry results in products and services that meet and exceed customer expectations and requirements. We are committed to work diligently with you to understand your needs and translate them into the right product for your process.

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**WE CATALYZE YOUR PROCESS**

You Benefit from a Broad Range of Competencies

We offer a broad variety of technologies and products to the fuel cell industry. With our long term experience in the fuel processor area, we deliver a wide variety of adsorbents and catalysts needed to generate hydrogen for fuel cell applications.

The catalysts are used for but not limited to the following applications:

- Desulfurization
- Reforming
- High and low temperature CO-Shift
- CO fine polishing
- Anode tail gas oxidation

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**Product Line**

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Sulfur Removal</td>
<td>Steam Reforming (SRM)</td>
<td>High Temperature CO-Shift</td>
<td>CO Removal</td>
</tr>
<tr>
<td></td>
<td>Autothermal Reforming (ATR)</td>
<td>Low Temperature CO-Shift</td>
<td></td>
</tr>
</tbody>
</table>

FUEL

<table>
<thead>
<tr>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>25–50°C</td>
</tr>
<tr>
<td>500–900°C</td>
</tr>
<tr>
<td>730–820°C</td>
</tr>
<tr>
<td>180–300°C</td>
</tr>
<tr>
<td>80–240°C</td>
</tr>
</tbody>
</table>

H₂
D SERIES CATALYSTS + ADSORBENTS
SYSTEMS FOR SULFUR REMOVAL

Sulfur – A Challenge for Fuel Cell Systems

Natural gas and liquefied petrol gas contain a range of sulfur compounds which petroleum can severely deactivate fuel processor or fuel cell catalysts.

BASF D Series adsorbents and catalysts are used to remove sulfur before the fuel is fed into the reformer. D Series products have been qualified for numerous fuel cell units. Our D Series adsorbents are key to providing uninterruptible power for data centers and hospitals – in a highly efficient and reliable way.

D Series Catalysts Benefits:
- High desulfurization capacity
- Suitable for a wide range of sulfur components
- Simple and robust desulfurization solution

D Series – Improved Solutions for Sulfur Removal

BASF offers a wide range of desulfurization materials for a variety of operation and system conditions. Together with our customers, we can then identify the most appropriate product to efficiently and effectively remove sulfur from the natural gas and LPG feeds.

Usually, a two-stage adsorption process is most efficient. For special cases, a hydrodesulfurization or oxidation sulfur removal can be offered.

Product | Removal Type | Selectivity | Metal Type | Typical Operating Temperature | Shape
---|---|---|---|---|---
Two-Stage Sulfur Removal Adsorbents
DP-45 | Stage I, Removal of inorganic components | H₂S, COS, Mercaptanes and THT | Base Metal | <250°C | Pellets
DP-100/DP-200/DP-300/DP-330 | Stage II, Removal of organic components | THT, DMS, Disulfides | Zeolite | <50°C | Extrudates
Selective Catalytic Sulfur Oxidation (SCSO)
DM-80 | Conversion of organic and inorganic compounds to SO₂/SO₃ | Conversion of sulfur compounds to SO₂/ SO₃ (Oxidation) | Precious Metal | 250–275°C | Monoliths
DP-20 | SO₂ removal | Trap for SO₂ | Base Metal | 250–400°C | Extrudates
DP-25 | SO₂/SO₃ removal | Trap for SO₂/SO₃ | Base Metal | 250–400°C | Extrudates

Keep the sulfur in a cool place with our desulfurization materials.

25–50°C Celsius
R SERIES CATALYSTS
CATALYSTS FOR REFORMING

Materials for Steam and Autothermal Reforming of Different Fuels

Hydrogen production is one of the key factors involved in the development of fuel cells. As hydrogen is not widely and economically available, hydrogen for fuel cells must be produced from hydrocarbon feedstocks such as natural gas, LPG, gasoline, diesel and alcohols.

Hydrogen production must therefore be accomplished on a much smaller scale than conventional industrial production of hydrogen. Hence, new technologies for reforming are required, and this necessitates new developments in catalysts. Consequently, our R Series Catalysts keep residential homes powered at any time.

R Series Catalysts Benefits:
- Resistant to frequent load changes and start/stop cycles
- Operation at high space velocity
- Enable compact reformer design
- Tolerant to liquid water
- Tolerant to air

R Series –
Improved Solutions for Reforming

R Series Product Portfolio

BASF offers a wide range of reforming catalysts, both base metal and precious metal materials, for different fuels and reforming technologies.

<table>
<thead>
<tr>
<th>Monoliths</th>
<th>Fuel Feed</th>
<th>Metal Type</th>
<th>Typical Operating Temperature</th>
<th>Typical Operating Space Velocity (hr⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM-47</td>
<td>LPG, NG*</td>
<td>Precious Metal</td>
<td>550–850°C</td>
<td>&lt;30,000</td>
</tr>
<tr>
<td>RM-75</td>
<td>NG</td>
<td>Precious Metal</td>
<td>550–850°C</td>
<td>&lt;30,000</td>
</tr>
<tr>
<td>RM-05</td>
<td>Methanol</td>
<td>Precious Metal</td>
<td>250–400°C</td>
<td>&lt;30,000</td>
</tr>
<tr>
<td>Pellets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP-61</td>
<td>NG, pretreatment of C₂ + hydrocarbons</td>
<td>Base Metal</td>
<td>380–550°C</td>
<td>&lt;8,000</td>
</tr>
<tr>
<td>RP-75</td>
<td>NG</td>
<td>Base Metal</td>
<td>400–750°C</td>
<td>&lt;10,000</td>
</tr>
<tr>
<td>RP-60</td>
<td>Methanol</td>
<td>Base Metal</td>
<td>200–290°C</td>
<td>&lt;10,000</td>
</tr>
</tbody>
</table>

* Has potential to work on gasoline, diesel fuels

Our catalysts will take the hot seat – to give you hydrogen.

500–900° Celsius
S SERIES CATALYSTS
CATALYSTS FOR CO-SHIFT REACTIONS

High Temperature CO-Shift

Fuel processors must be able to withstand frequent start-ups and shutdowns as well as condensing and vaporization cycles. In addition, oxygen breakthrough from the upstream reformer during the start-up is always possible. Conventional CO-Shift catalysts react rapidly with oxygen, resulting in temperature excursions and damaging the material. Therefore, a new generation of high temperature CO-Shift catalysts using precious metal instead of base metal was developed with outstanding performance and stability.

Low Temperature CO-Shift

BASF offers a new generation of Cu-catalysts for low temperature CO-Shift that tolerates changes in atmospheres without any loss in activity. These catalysts can be used in the temperature range from 180–280°C and can tolerate peak temperatures of 320°C. Used as small pellets, high specific activity of this material is ensured. Another benefit is the strong adsorption of trace sulfur compounds from the reformate stream, protecting the fuel cell against impurities.

S Series Catalysts Benefits:
■ Precious and base metal catalysts
■ Outstanding performance and stability
■ High specific activity

Back-up and off-grid systems can count on maximum performance of our S Series Catalysts – whenever they need it.

S Series Product Portfolio

CO-Shift catalysts for low and high temperature applications. BASF offers both base metal and precious metal catalysts.

<table>
<thead>
<tr>
<th>Product</th>
<th>Temperature Shift</th>
<th>Metal Type</th>
<th>Typical Operating Temperature</th>
<th>Typical Operating Space Velocity (hr⁻¹)</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP-01</td>
<td>High Temperature</td>
<td>Precious Metal</td>
<td>250–450°C</td>
<td>&lt;15,000</td>
<td>Pellets</td>
</tr>
<tr>
<td>SM-06</td>
<td>High Temperature</td>
<td>Precious Metal</td>
<td>250–400°C</td>
<td>&lt;15,000</td>
<td>Monoliths</td>
</tr>
<tr>
<td>SP-60</td>
<td>Low Temperature</td>
<td>Base Metal</td>
<td>190–280°C</td>
<td>&lt;8,000</td>
<td>Pellets</td>
</tr>
</tbody>
</table>

S Series – Improved Solutions for CO-Shift Reactions

Fuel

H₂

25–50°C  500–900°C  180–300°C  80–240°C

=FUEL=

Sulfur Removal
Steam Reforming (SRM)
Autothermal Reforming (ATR)
High Temperature CO-Shift
Low Temperature CO-Shift
CO Removal
CO SERIES CATALYSTS
Catalysts for CO Removal

Highly Selective Catalysts
for CO Removal

Low temperature fuel cell systems tolerate only small amounts of carbon monoxide (CO). Depending on the operating temperature of the CO-Shift catalyst, some thousand ppm of CO have to be converted to carbon dioxide (CO2). BASF offers different catalytic approaches:

- Catalysts for CO-selective methanation
- Catalysts for CO-selective oxidation
- Catalysts for Tail Gas Oxidation. BASF offers catalysts to remove CO and VOC from tail gas streams to meet emission regulations and/or to generate heat.

CO Series Catalysts will keep your portable fuel cell systems healthy – no matter what.

CO Series Catalysts Benefits:

- Robust material
- Long lifetime
- Outstanding performance
- Tailored solutions

CO Series –
Improved Solutions for CO Removal

CO Series Product Portfolio
BASF offers a wide range of CO removal materials for a variety of operating and system conditions.

<table>
<thead>
<tr>
<th>Product</th>
<th>Combustion Type</th>
<th>Metal Type</th>
<th>Typical Operating Temperature</th>
<th>Typical Operating Space Velocity (hr⁻¹)</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selective CO Removal</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>COM-01</td>
<td>Preferential Oxidation</td>
<td>Precious Metal</td>
<td>90–200°C</td>
<td>&lt;40,000</td>
<td>Monoliths</td>
</tr>
<tr>
<td>COP-01</td>
<td>Selective Oxidation</td>
<td>Precious Metal</td>
<td>80–160°C</td>
<td>&lt;12,000</td>
<td>Pellets</td>
</tr>
<tr>
<td>COP-03</td>
<td>Selective CO Methanation</td>
<td>Precious Metal</td>
<td>180–260°C</td>
<td>5,000</td>
<td>Pellets</td>
</tr>
<tr>
<td>Tail Gas Oxidation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COM-03</td>
<td>Methanol Combustion</td>
<td>Precious Metal</td>
<td>200–700°C</td>
<td>20,000–78,000</td>
<td>Monoliths</td>
</tr>
<tr>
<td>COM-10</td>
<td>H₂ &amp; CO Combustion</td>
<td>Precious Metal</td>
<td>&lt;1,000°C</td>
<td>&gt;200,000</td>
<td>Monoliths</td>
</tr>
<tr>
<td>COM-100</td>
<td>H₂, CH₄ &amp; CO Combustion</td>
<td>Precious Metal</td>
<td>400–750°C</td>
<td>&lt;50,000</td>
<td>Monoliths</td>
</tr>
</tbody>
</table>
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.