Do you want to combine experience with innovation?

BASF Phthalic Anhydride Catalysts are the market leading solution for your oxidation process.
Phthalic Anhydride Catalyst History

BASF Quality and Reputation are Unmatched

BASF’s Chemical Catalysts combine the strength of BASF – with the experience and expertise of our chemists and engineers. Our phthalic anhydride catalysts are valued components of the oxidation process for worldwide chemical manufacturing companies. BASF’s commitment to the phthalic anhydride process and o-Xylene/naphthalene oxidation to phthalic anhydride catalysts results in products and services that meet and surpass customer expectations and requirements.

Important Facts about Phthalic Anhydride at BASF

- BASF has been producing PA for over 140 years
- BASF has been researching PA catalysts for more than 120 years
- The total PA at BASF’s Ludwigshafen (Germany) site since 1873 is more than 4.0 million tons
- Production experience with post reactors since 1980

World Consumption of Phthalic Anhydride by End Use – 2018

- 12.0% Unsaturated polyester resin
- 49.0% Plasticizers
- 16.0% Others
- 23.0% Alkyd resins

Source: IHS Markit


- 1968 Start-up of two commercial Phthalic Anhydride plants at BASF Ludwigshafen of O4-20
- 1980 First installation of O4-28
- 1993 First installation of O4-28
- 2000 First technical application at BASF Ludwigshafen of O4-26
- 2002 Acquisition of Wacker’s Phthalic Anhydride catalysts and licensing business
- 2003 Introduction of new Phthalic Anhydride catalysts for o-Xylenes oxidation O4-40/42
- 2004 Introduction of new Phthalic Anhydride catalyst for naphthalene/mixed feed oxidation O4-28
- 2005 First installation of O4-28 HiFlex with maximum operational flexibility
- 2009 First installation of O4-68
- 2009 First installation of O4-68 with high PA yield
- 2010 First installation of O4-88 with high PA yield and improved PA quality and first installation of O4-35 with superior PA quality
- 2011 First installation of O4-88
- 2016 First installation of O4-29 HiFlex II with high PA yield and maximum operational flexibility
- 2018 First installation of O4-888, with high PA yield and with improved PA quality and first installation of O4-35 with superior PA quality

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- 49.0% Plasticizers
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Source: IHS Markit
Organization of the Phthalic Anhydride Catalyst Business

**AMERICAS**
- Iselin, New Jersey
  - Catalysts Division Headquarters
  - Regional Sales
  - Regional Customer Service and Supply Chain
- Sao Paulo, Brazil
  - Sales Office

**EMEA**
- Ludwigshafen, Germany
  - Catalyst Production
  - Catalyst Research
  - Regional Sales
  - Technical Service
- De Meern, Netherlands
  - Sales Office
  - Regional Customer Service and Supply Chain

**ASIA**
- Shanghai, China
  - Oxidation and Dehydrogenation
  - Catalysts Global Business Management
  - Regional Sales
  - Technical Service
  - Regional Customer Service and Supply Chain
- Seoul, South Korea
  - Sales Office
- Mumbai, India
  - Sales Office

Phthalic Anhydride Process

**Permanent Improvement of Process and Catalyst**

From o-Xylene to Phthalic Anhydride

From Naphthalene to Phthalic Anhydride
Advantages of BASF as a Phthalic Anhydride Catalyst Supplier

BASF offers over 140 years experience in Phthalic Anhydride (PA) production and 120 years in PA catalysts research. This legacy forms a strong foundation for continuous innovation and product improvement. Products and services are continually reviewed for alignment with our customers’ needs through regular BASF Phthalic Anhydride Customer Forum meetings. Delivery of our product to the customer site is just the beginning of our offering. BASF stands behind its products and, through our technical service representatives in Asia, Europe and America, ensures that our products perform and deliver value. We innovate to make our customers successful.

Value Added Customer Service

From order placement through invoicing, BASF’s Customer Service functions as the customer’s voice by:
- Assigning a primary customer service representative
- Providing a Customer Service Network with 3 central hubs
- Addressing customer concerns in the language of the customer

Expert Technical Service

Our technical service staff has extensive professional experience in Phthalic Anhydride catalysts, including hands-on operational expertise in the areas of supervision, startup assistance and catalyst performance optimization. BASF has more than 80 years of experience in the loading and startup supervision of Phthalic Anhydride catalysts.

- o-Xylene and naphthalene/mixed feed oxidation in fixed bed process
- o-Xylene loadings up to 100 g/Nm³
- Supply of complete catalyst filling and measurement equipment on loan basis, including 5-tube, 10-tube and 20-tube catalyst filling machines
- Optimization of catalyst operation condition using portable COx analyzers
- Verification of air flow measurements by total combustion

Main By-Products in Reaction Gas (o-Xylene feed)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maleic Acid</td>
<td>2.2–4.0 wt.%</td>
</tr>
<tr>
<td>Benzoic Acid</td>
<td>0.4–0.8 wt.%</td>
</tr>
<tr>
<td>Citraconic Anhydride</td>
<td>0.3–0.5 wt.%</td>
</tr>
<tr>
<td>Phthalide</td>
<td>0.01–0.1 wt.%</td>
</tr>
<tr>
<td>o-Tolualdehyde</td>
<td>0.005–0.02 wt.%</td>
</tr>
</tbody>
</table>

Typical concentrations in reactor outlet gas (ROG) at 100 g/Nm³ for o-Xylene feed.

Main By-Products in Reaction Gas (naphthalene feed)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthoquinone</td>
<td>0.03–1.0 wt.%</td>
</tr>
<tr>
<td>Phthalalimide</td>
<td>0.01–0.3 wt.%</td>
</tr>
<tr>
<td>Maleic Anhydride</td>
<td>1.8–3.5 wt.%</td>
</tr>
<tr>
<td>Benzoic Acid</td>
<td>0.3–0.7 wt.%</td>
</tr>
</tbody>
</table>

Typical concentrations in reactor outlet gas (ROG) at 40 g/Nm³ for naphthalene feed.
**Shanghai BASF Process Catalysis R&D Center**

- Grand opening in 2019, dedicated R&D center for process catalysts and adsorbents research
- Development of catalysts and adsorbent solutions mainly for Asian Market
- Fast and timely support to our local customers, including BASF PA catalysts customer

- Catalyst characterization: ICP-OES, XRF, XRD, SEM/TEM, BET, XPS
- PA composition analysis: PPA, CPA, ROG, light ends, heavy ends analysis, through GC, GC-MS
- Raw material analysis: o-Xylene and naphthalene analysis through GC, GC-MS, AAS, CHNS/O analyzer

**Catalyst Research Ludwigshafen**

- Inorganic Solids
- Zeolites
- Catalysts for Oleochemicals
- Custom Catalysts
- Amination Catalysts
- Syngas Catalysts

**36 Professionals**

**87 Technicians**

**Fuel Cell Catalysts**

**Catalysts for Petrochemicals**

**Hydrogenation Catalysts**

**Oxidation Catalysts**

**Acid/Base Catalysis**

**Catalyst Supports**

**International Cooperations with Universities**

**Investing in innovation:**
BASF expanded its research activities with the new R&D center in Shanghai
Phthalic Anhydride Catalyst Portfolio

Catalyst Portfolio for o-Xylene Oxidation

<table>
<thead>
<tr>
<th>Phthalic Anhydride Catalyst</th>
<th>O4-68</th>
<th>O4-66</th>
<th>O4-88</th>
<th>O4-888</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Gas phase Oxidation of o-Xylene to PA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td>V2O5, TiO2 and Promoters on Ceramic Rings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape (mm)</td>
<td>Rings, 7<em>7</em>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filling Density (kg/l)</td>
<td>approx. 0.93 in 25 mm ID tube</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air max. [Nm³/h/tube]</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Stability [°C]</td>
<td>up to 500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load [g/Nm³]</td>
<td>max. 80 max. 100 max. 100 max. 100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layers</td>
<td>4 4 5 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filling Height [m]</td>
<td>2.2–3.4 3.0–3.7 3.0–3.7 3.0–3.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA-Yield (Reactor Gas) [wt.-%]</td>
<td>114–115 114–115 115–116 115.5–116.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phthalide (Reactor Gas) [wt.-%]</td>
<td>0.02–0.07 0.02–0.1 0.02–0.1 0.02–0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aromatics (in Off Gas) [mg/m³]</td>
<td>20–40 20–40 20–40 20–40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start-up time [day]</td>
<td>To 80 g/Nm³ 18 –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To 100 g/Nm³ 28 55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restart Time [day]</td>
<td>To 80 g/Nm³ 34 62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To 100 g/Nm³ 34 62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* in combination with post reactor

Expected Quality of Pure PA by BASF o-x Feed PA Catalysts

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity (wt-%)</td>
<td>&gt; 99.9</td>
</tr>
<tr>
<td>Solidification Point [°C]</td>
<td>&gt; 131.0</td>
</tr>
<tr>
<td>Color (Hazen) [APHA]</td>
<td>5–10</td>
</tr>
<tr>
<td>Heat Stability [APHA] (90 min, 250°C)</td>
<td>15–30</td>
</tr>
</tbody>
</table>

Our portfolio offers innovative solution for every challenge in oxidation.
For PA producers, BASF’s o-Xylene catalysts offer safe operation at maximum capacity up to 100 g/Nm³ feed with superior PA quality guaranteed by expert technical service and long-term commitment in innovation demonstrated in the world’s longest reference list and in-house operation.

### O4-68 Catalyst Advantages
- Higher proportion of selective layers per tube
- Hot Spot (HS) remains longer in selective layers
- Higher Phthalic Anhydride yield in 2nd operation year
- Top performance for low loading

### O4-66 Catalyst Advantages
- Improved 4-layer catalyst generation
- Improved stability of 1st catalyst layer
- Designed for harsh operation conditions
- Higher Phthalic Anhydride yield in 2nd and 3rd operation year

### O4-88 Catalyst Advantages
- Higher yield vs. O4-66
- 3 selective layers
- Patentied new active mass
- Easy start-up behavior

### O4-888 Catalyst Advantages
- 5 layer catalyst system
- Improved selective layers and active layers
- Excellent product quality

#### Reference List

**China**
- Nan Ya
- Nanjing Libang
- Qili Plasticizers
- Shandong Hongxin
- Shandong Lihuayi
- Shanghai Huayi
- Shijiaotunhang Bairong
- Tongling Organic
- UPC Linyuan
- UPC Malaysia
- UPC Nanchong
- UPC Panjin
- UPC Zhenghan
- UPC Zhuhai
- Zhejiang GST

**Korea**
- Aekyung

**Russia**
- Gazprom

**Sweden**
- Perstorp

**USA**
- Stepan

---

**Portfolio** Phthalic Anhydride Catalysts
Catalyst Portfolio for Naphthalene/Mixed Feed Oxidation

<table>
<thead>
<tr>
<th>Phthalic Anhydride Catalyst</th>
<th>O4-29 HiFlex II</th>
<th>O4-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Gas phase Oxidation of Naphthalene/Mixed feed to PA</td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td>V₂O₅, TiO₂ and Promoters on Ceramic Rings</td>
<td></td>
</tr>
<tr>
<td>Air max. [Nm³/h/tube]</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Thermal Stability [°C]</td>
<td>up to 500</td>
<td></td>
</tr>
<tr>
<td>Feed (Ratio)</td>
<td>Naphthalene: 100–35% o-Xylene: 0–65%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naphthalene: 80 Mixed Feed: 85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naphthalene: 100–50% o-Xylene: 0–50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Naphthalene: 85 Mixed Feed: 90</td>
<td></td>
</tr>
<tr>
<td>Load [g/Nm³]</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Layers</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Shape [mm]</td>
<td>Rings, 8&quot;x6.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL1/CL2/CL3: Rings, 8&quot;x5.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL4/CL5: Rings, 7.7&quot;x4</td>
<td></td>
</tr>
<tr>
<td>Filling Density [kg/l]</td>
<td>approx. 0.88 in 25 mm ID tube</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL1/CL2/CL3: approx. 0.88 in 25 mm ID tube</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CL4/CL5: approx. 0.93 in 25 mm ID tube</td>
<td></td>
</tr>
<tr>
<td>Initial Salt Bath Temperature [°C]</td>
<td>355–365</td>
<td></td>
</tr>
<tr>
<td></td>
<td>350–365</td>
<td></td>
</tr>
<tr>
<td>Phthalic Anhydride Yield (Reactor Gas) [wt.-%]</td>
<td>Naphthalene: 104.5–105.5 o-X/Naphthalene (50:50): 109.5–110.5</td>
<td></td>
</tr>
<tr>
<td>By-products in Reactor Gas</td>
<td>Naphthalic Anhydride: 0.05–1.0</td>
<td></td>
</tr>
<tr>
<td>Naphthalonone [wt.-%]</td>
<td>0–0.05</td>
<td></td>
</tr>
<tr>
<td>Phthalide [wt.-%]</td>
<td>0–0.03</td>
<td></td>
</tr>
<tr>
<td>(100% Naphthalene Feed)</td>
<td>(50/50 Feed)</td>
<td></td>
</tr>
</tbody>
</table>

For PA producers, BASF’s Naphthalene and mixed feed catalysts offer superior PA yield and leading PA quality guaranteed by expert technical service and long-term commitment in innovation demonstrated in the world’s longest reference list.

### Expected Quality of Pure PA by BASF Naphthalene/Mixed Feed PA Catalysts

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</tr>
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### O4-29HFII Catalyst Advantages
- Improved 4 layer catalyst generation
- Higher yield vs. O4-29HF
- Up to 65% o-Xylene in feed

### O4-35 Catalyst Advantages
- Latest generation 5-layer catalyst system
- Catalyst geometry adjusted for maximum performance
- Superior PA quality
Customers who utilize our catalysts are offered individualized service agreements for a wide range of technical services. BASF’s dedicated technical service team has extensive experience in oxidation and dehydrogenation catalytic behavior under a variety of operating conditions. This technical team is equipped with a full range of resources to analyze the most complex problems, and has full access to our R&D facility and dedicated R&D personnel. This comprehensive service approach provides the best possible assistance to our customers anytime and anywhere in the world.

Each region in the world is assigned a dedicated BASF technical team.

Asia Pacific
through our PA catalyst global business management in Shanghai

Europe, the Middle East, and Africa (EMEA)
through our technical service team in Ludwigshafen

Americas
through our technical service team in Ludwigshafen

Features
- Catalyst selection and performance forecasting
- Loading and start-up support
- Performance evaluation and optimization of current run by using portable COx analyzer
- Analysis of aged catalyst
- Troubleshooting
- Lifetime calculations
- Training of production staff
- Verification of air flow measurements by total combustion
- ROG PA yield calculation

Customer Support:
BASF Phthalic Anhydride Catalyst Package

BASF provides not only the fitting Phthalic Anhydride catalyst. In addition, we provide top class technological expertise by our experts as well as guidelines for the catalyst’s use. We support our customers even by conducting dedicated experiments in our R&D department, in case that is necessary. Last but not least, we offer in-depth catalyst training covering the whole theoretical background of this technology.

Reference List

China
- Cixian Sinbo
- Henan Qing’an
- Jining Carbon
- Jiaozuo Sirul
- Kaifeng Jiuhe
- Shandong Hengxin
- Shifangsheng Baolong
- Taixing Union Zond
- Tangshan Risun
- Xingtai Risun
- Zaozhuang JFE

Korea
- OCI
- Eteknetz
- USA
- Koppers
- Czech Republic
- Deza

China
- Huanghua Xinxuotiding
- Belgium
- Rain Carbon

O4-29 HiFlex II

O4-35
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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