BASF
We create chemistry

Alumina Catalysts

Table of Content

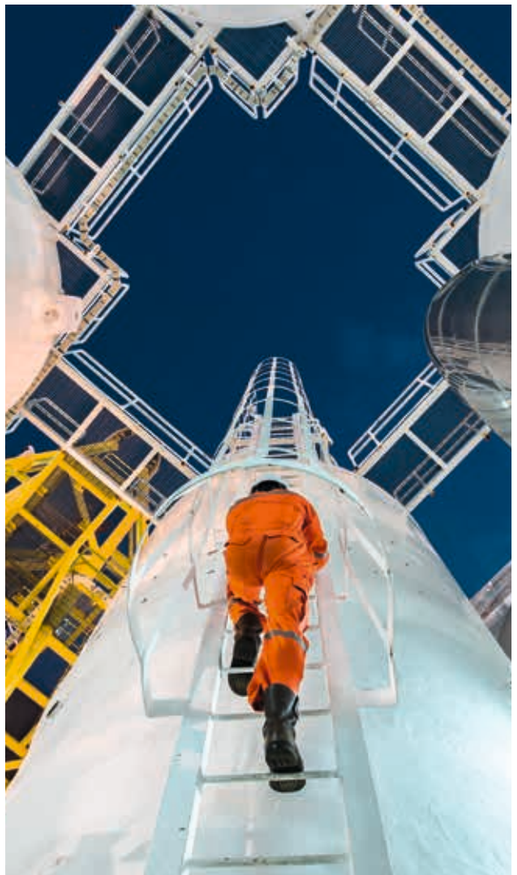
BASF Alumina Catalysts Introduction

Aluminum oxide is present in large quantities in the earth's crust and is derived from bauxite ore. Commonly called "alumina", this oxide is a fascinating material, which has found extensive use as a catalyst and catalyst support in the chemical and petrochemical industries. This is because alumina combines thermal robustness with high chemical stability, and because the physicochemical properties of aluminum oxide can be precisely tuned. Most notably, alumina is capable of providing acidic surface groups, which catalyze a broad range of chemical reactions.

The interplay of the target reaction with optimum catalyst properties and efficient mass and heat transport is essential. Therefore, the BASF portfolio contains a wide selection of alumina catalysts and catalyst supports which are proven in many individual commercial applications.

We offer a variety of different catalyst types and shapes such as alumina extrudates, tablets, spheres and powders which ensures maximum performance to our customers.

BASF's comprehensive alumina catalyst portfolio is rooted in a deep expertise in material science and enabled by state-of-the-art manufacturing capabilities. Since more than 100 years BASF is active in catalyst research and our legacy forms a strong foundation for continuous innovation and product improvement.



Tailor-Made Properties

BASF provides the broadest selection of aluminum oxide catalysts and catalyst support materials in the industry. Each alumina in our portfolio is designed with its own carefully balanced combination of physical and chemical parameters, so that reliable catalyst performance and high productivity can be achieved within each of the diverse range of applications.

The Physical Structure

Heterogeneous catalysis relies on placing active sites in an accessible micro-environment within a catalyst particle. The physical structure of a catalyst involves parameters such as surface area, pore volume, pore size distribution and pore shape which jointly influence internal mass transport. In order to access the catalytic centers, efficient diffusion from the boundary layer through the pore system must be ensured.

Figure 1 illustrates this process along with cylindrical and bottle-neck pore structures in alumina. Depending on the reaction of choice the interplay of internal structure with the catalyst shape has to be balanced.

BASF alumina catalysts cover all pore dimensions from the micro- to the macroporous regime. This selection is combined with the great variety of catalyst shapes in our portfolio.

... At a Glance

Physical Structure

- Typical surface area range from 50 to 350 m^2/g
- Defined pore shapes and pore size distributions

Chemical Composition

- Well-crystallized aluminum hydroxide raw materials
- On-purpose incorporation of dopants and promoters

Crystallinity and Surface Chemistry

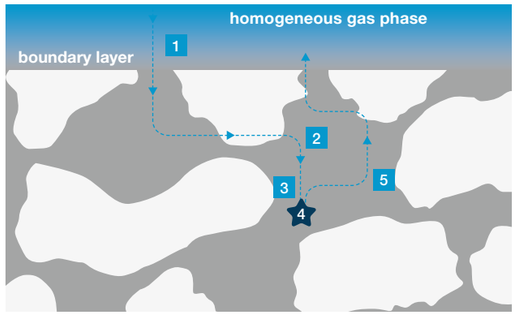
- Various crystallographic modifications such as gamma and eta alumina
- Tunable surface activity via interplay of acid and basic sites

Catalyst Shape

- Extrudates
- Tablets
- Spheres
- Powders

Figure 1 Pore structures found in alumina and fundamental steps of the catalytic process

Bottle-neck pore structure



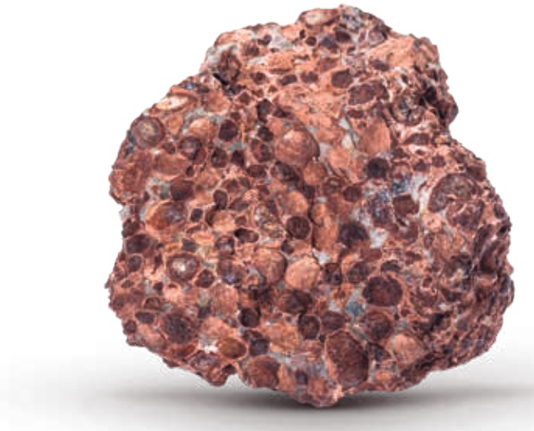
Cylindrical pore structure

During the catalytic process, diffusion from the external boundary layer (1) through the internal pore system (2) is followed by adsorption on the catalyst surface (3). The reaction takes place at the active center (4) with subsequent desorption and diffusion to the surface of the pellet (5)

The Chemical Composition

On the industrial scale, the Bayer process is used to extract iron, silicon and other oxide impurities from bauxite to convert it to various mineral forms of aluminum hydroxide and oxyhydroxide. For example, $Al(OH)_3$ (gibbsite) and AlO(OH) (boehmite) are suitable precursors for the production of alumina catalysts and catalyst supports.

The chemical analysis refers to the amounts of the elements present in a material. Depending on the type of reaction to which the alumina catalyst or catalyst support is applied, the presence of certain elements may be essential or detrimental (table 1).



From crude ore bauxite.....
... to ultrapure alumina

Table 1

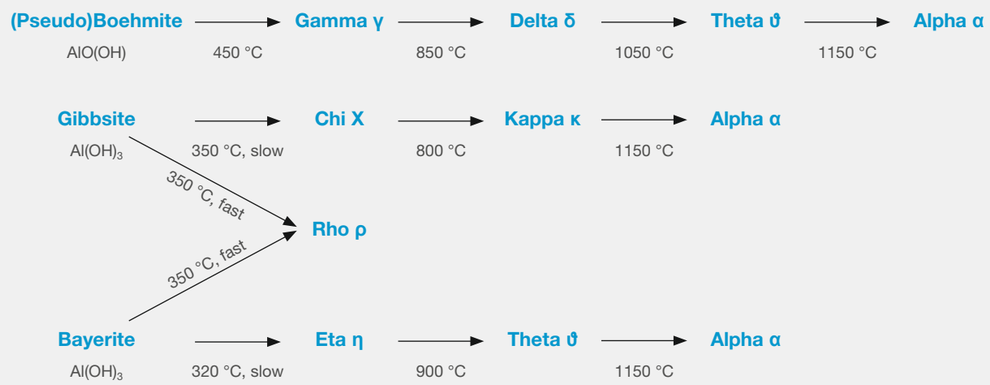
		Bauxite	Gibbsite	Al 3992 E 1/8"	Al 4126 E 1/8"	Al 0104 T 1/8"
Al_2O_3	wt %	50	65	99.9	99.7	99.7
Na	wt %	–	0.5	0.01	0.01	0.2
Fe	wt %	15	0.09	0.01	0.08	0.02
Si	wt %	10	0.05	0.03	0.07	0.06
H_2O	wt %	21	balance	< 1	< 1	< 1
TiO_2	wt %	4	–	–	–	–

Table 1 compares the chemical composition of crude bauxite to that of aluminum hydroxide (gibbsite) produced from it, and to various high purity BASF alumina catalysts and catalyst supports

Crystallinity and Surface Chemistry

Aluminum oxide can occur in several crystallographic modifications and commercial catalyst systems most often consist of mixtures of two or more transition stages, which will jointly determine the overall catalytic function. The exact crystalline nature of the alumina catalyst will be determined by both the hydroxide or oxyhydroxide precursor and the thermal process to which the catalyst is subjected during its manufacture. Possible routes towards transition aluminas are depicted in figure 2.

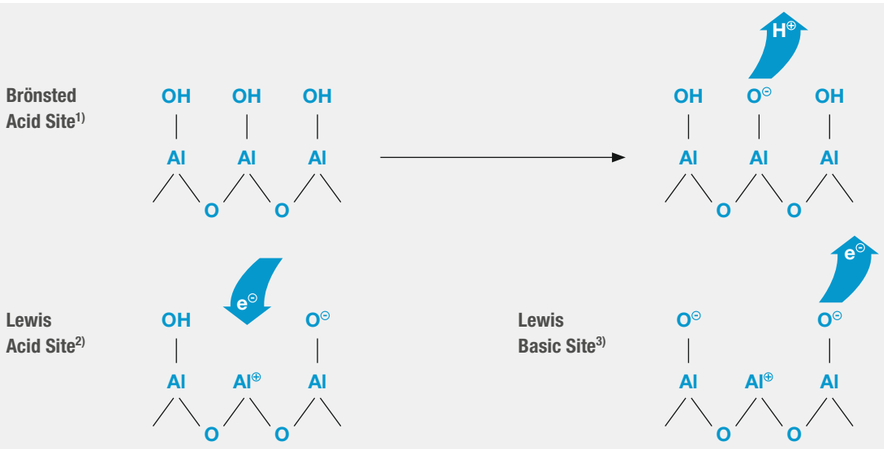
Figure 2 Thermal dehydration of aluminum hydroxides and oxyhydroxides leads to the formation of transition aluminas



Consequently, the surface chemistry of alumina catalysts is highly complex but often involves the presence of three characteristic catalytic sites (*figure 3*). Aluminum oxide can exhibit both Brönsted and Lewis acidity but also basic groups may be introduced into the catalyst.

Choice of selected high quality raw materials in combination with the right thermal conditions during the catalyst manufacture are among the core competencies of BASF and ensure proper adjustment of alumina bulk and surface properties.

Figure 3 Acidic and basic catalytic sites found on the alumina surface



[1] Hydroxyl groups on the oxidic alumina surface act as Brönsted acid sites (can donate a proton)
[2] Exposed aluminum atoms may function as Lewis acid sites (can accept an electron pair)
[3] Lewis basic sites (can donate an electron pair) of various strength have also been detected on the alumina surface

Example: Ethanol to Ethylene

It is well known that aluminum oxide is a powerful catalyst for the conversion of ethanol to ethylene, which proceeds via the intermediate diethyl ether. To demonstrate the interplay of material composition and surface chemistry, three BASF alumina catalysts (A, B, C) obtained from different production routes have been applied in this model reaction under identical test conditions. Table 2 compares the material properties of the aluminas tested and their catalytic performance.

From the experimental results it becomes evident that even trace impurities such as (alkaline) Na_2O and (acidic) SiO_2 will have a strong influence on the catalyst activity and selectivity towards ethylene. The formation of coke is undesirable and depends on the nature of the alumina catalyst and its acidity level which consequently needs to be adjusted to an optimum level.

Table 2

		Alumina A	Alumina B	Alumina C
Relative acidity	mmol NH_3/g	0.046	0.06	0.021
Na_2O	wt %	0.01	0.03	0.25
SiO_2	wt %	0.01	0.13	0.02
Conversion	%	99.8	85.7	66.2
$Selectivity_{Ethylene}$	%	99.2	89.2	25.3
$Selectivity_{Diethyl\ ether}$	%	0.2	0.1	70.1
$Selectivity_{Others}$	%	0.6	10.7	4.6
Carbon	wt %	0.2	0.5	0.1

Table 2 demonstrates impact of surface acidity and chemical composition on the catalyst performance for the dehydration of ethanol to ethylene

The Shape of the Catalyst

The main motivation for converting a powder into a shaped body such as an extrudate, tablet or sphere is to enable continuous catalyst operation under industrial fixed-bed conditions. A special case are fluid, moving and slurry bed configurations to which (micro)spherical and powder catalysts may be applied, in some cases acting as support material (figure 4).

Depending on the shaping technique applied, four types of alumina catalysts are available from BASF: **Extrudates**, **tablets**, **spheres** and **powders** (figure 5).

Extrudates made from alumina represent a well-established solution for many catalytic processes. Their moderate bulk density results in a lower installed catalyst weight per reactor volume as compared to other catalyst types. The high void fraction enabled by extrudates will also result in decreased pressure drop across the catalyst bed and in more balanced temperature profiles. Extrudates can be produced in many different shapes. By proper design of the geometric dimensions, it is possible to support fast reaction kinetics by higher geometric surface area and to achieve better catalyst activity in diffusion-limited reactions.

BASF supplies alumina extrudates with standard diameters ranging from 1/16" (1.5–1.6 mm) to 1/8" (3.1–3.2 mm). Special cross-sections such as stars, trilobes and innovative ring-type geometries represent an essential part of our portfolio. Alternative shapes and sizes are available on demand.

On the other hand, alumina tablets, because of the compacting process used in their manufacture, exhibit enhanced mechanical strength and benefit from very regular shapes. Along with spherical alumina products, tablets are frequently applied as robust catalyst support materials.

Our standard sizes for alumina tablets cover the full range of diameters between 1/8" (3.1–3.2 mm) and 1/4" (6.3–6.4 mm). A special offering from BASF are hollow-core tablets combining superior mechanical properties with low pressure drop.

Figure 4 A wide range of catalyst types are available from BASF to match the needs of different reactor systems

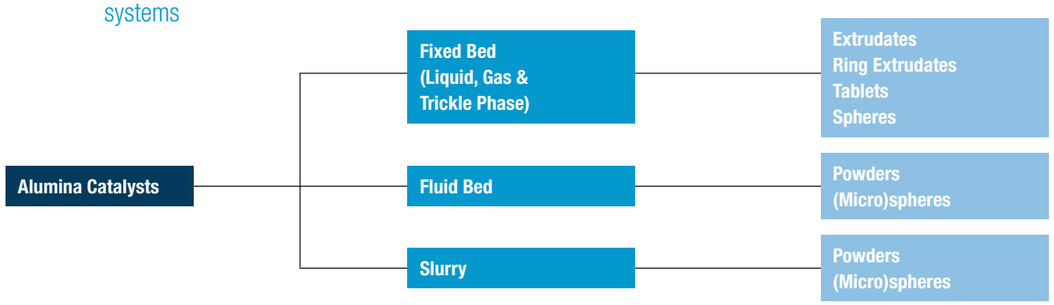
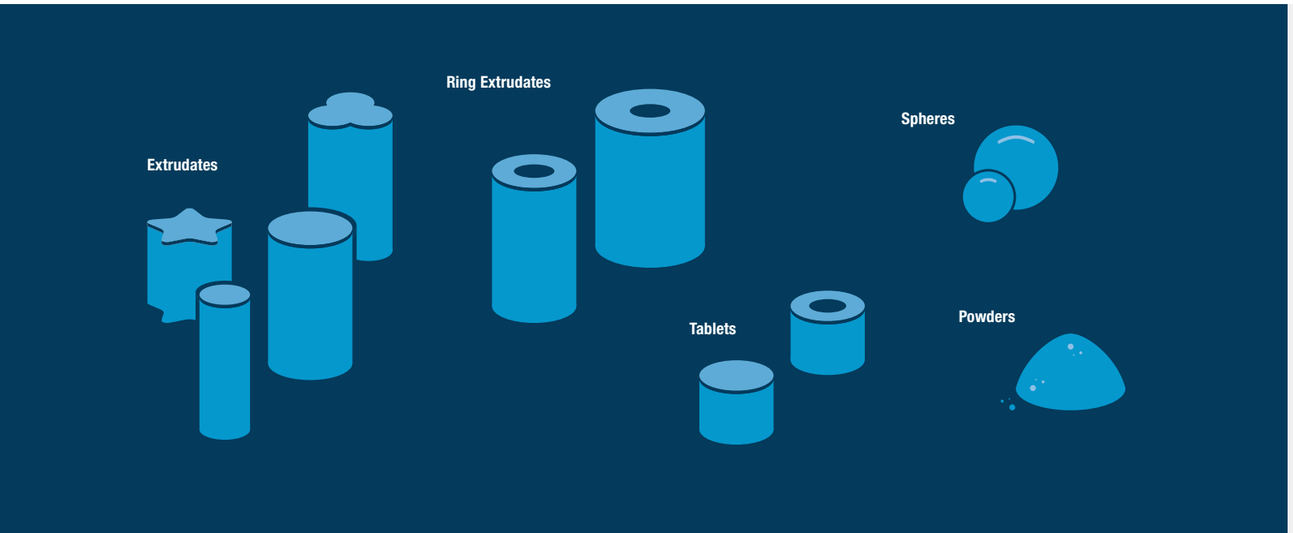


Figure 5 Representative types and shapes of alumina catalysts offered by BASF



Several options are often possible for a specific catalyst application and our team is available to help in selecting the optimum solution. The decision of what catalyst type, shape and size to use in a particular industrial process can be facilitated by analysis of the following fundamental operational parameters:

Are the **reaction kinetics** known?

Is the **chemical reaction** of interest limited **by diffusion**?

What is the **maximum** acceptable **pressure drop**?

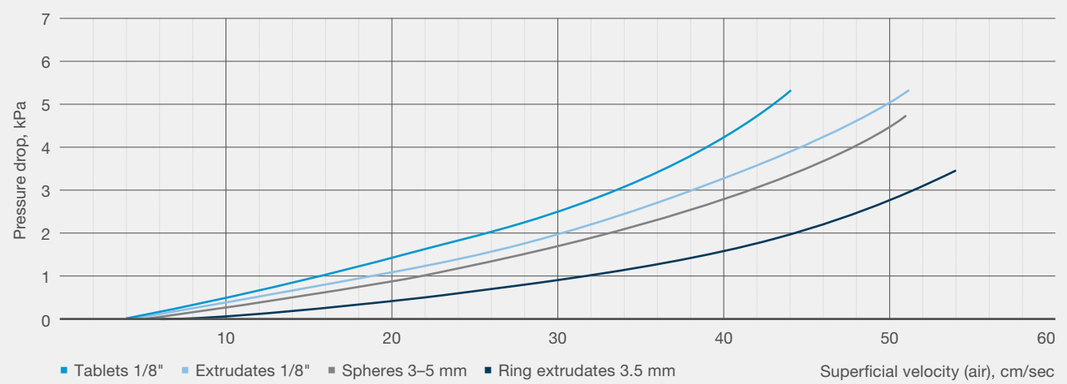
To which **level of mechanical forces** is the catalyst subjected?

If the target reaction suffers from diffusion limitation, the catalyst particle size should be as small as possible. This will result in a large geometric surface area as typically found in extrudates, but the maximum tolerable pressure drop may become the size-limiting factor.

In order to support our customers with their choice of the right catalyst shape, BASF has developed a unique **simulation tool** which allows the prediction of pressure drop behavior of a catalyst type of interest. Real-world flow parameters and gas properties as defined by the commercial process may be included in the tool in order to compare the expected behavior of suitable catalyst candidates. Figure 6 highlights the pronounced differences between standard extrudates, tablets, spheres and advanced ring-type extrudates.

Besides pressure drop and mass transport aspects the mechanical strength of the catalyst or catalyst support has to be considered, especially in processes with possible pressure swings or irregular feedstock flow. In this case tableted or spherical alumina catalysts are recommended.

Figure 6 Comparison of the pressure drop behavior for different catalyst types



Unique Offer from BASF: Ring-Shaped Alumina Extrudates

Maximum process performance is enabled by catalyst innovation. Our ring-shaped catalysts are an established solution to match design limitations of the process equipment in use. These catalysts combine several distinct advantages in one single product:

1. Reduced Pressure Drop
2. Lower Cost of Reactor Fill
3. Enhanced Mass Transport
4. Efficient Catalyst Regeneration

Among all shapes, ring extrudates offer the lowest pressure drop across a catalyst bed (figure 6). Their hollow geometry results in a void fraction which is significantly higher than that of densely packed standard catalysts (table 3). For our customers this advantage translates into the option of higher feed throughput and higher production rates at constant reactor pressure.

Table 3

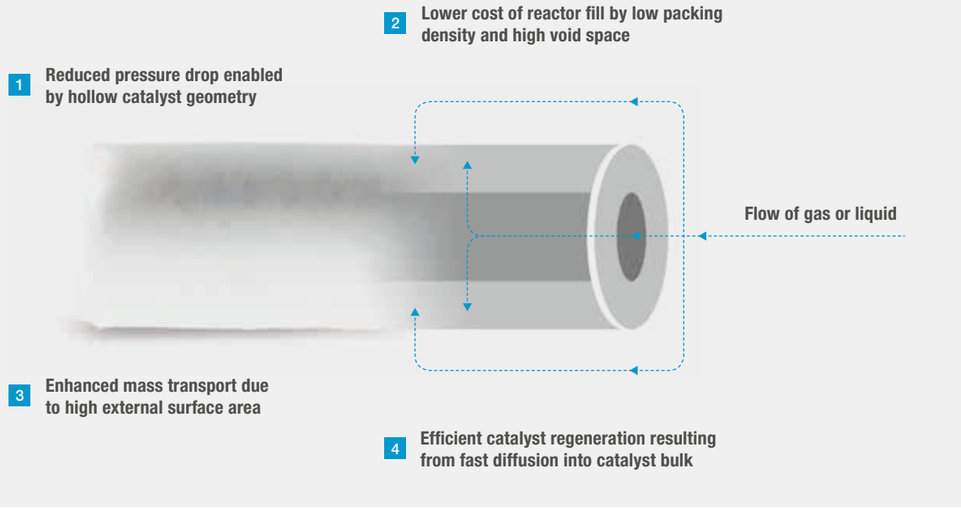
	Void fraction catalyst bed	Relative pressure drop	Relative geometric surface area
Tablets 1/8"	0.35	100	100
Extrudates 1/16"	0.41	130	140
Extrudates 1/8"	0.41	45	75
Trilobes 1/8"	0.44	50	115
Stars 3.5 mm	0.48	50	155
Rings 3.5 mm	0.52	35	85

Table 3 compares void fraction, pressure drop characteristics and geometric surface area of various types and shapes of catalyst (values are reported relative to 1/8" tablets)

Due to the low packing density of ring-shaped extrudates, less catalyst weight needs to be installed to fill the reactor volume than for other catalyst types. In other words: The special cylindrical geometry results in a higher availability of utilizable alumina per unit weight of catalyst. BASF ring-shaped alumina extrudates therefore offer an attractive economic benefit when comparing cost of reactor fill per kilogram.

At the same time, on an individual catalyst pellet level, the external surface area of a ring extrudate exceeds that of full extrudates or tablets of similar dimension. Processes in which mass transfer limitations occur can especially take advantage of the cylindrical geometry. The four linear surfaces available on the catalyst particle improve external mass transfer and also enable rapid access of the reactants to the catalyst bulk. Frequently, the application of BASF ring-shaped alumina catalysts leads to a boost in catalytic activity of 15–25 %.

Figure 7 BASF ring-shaped extrudates exhibit geometric features which maximize catalyst productivity and are available with outer diameters of 3.5 and 4.5 mm



Example: Oxidative Catalyst Regeneration

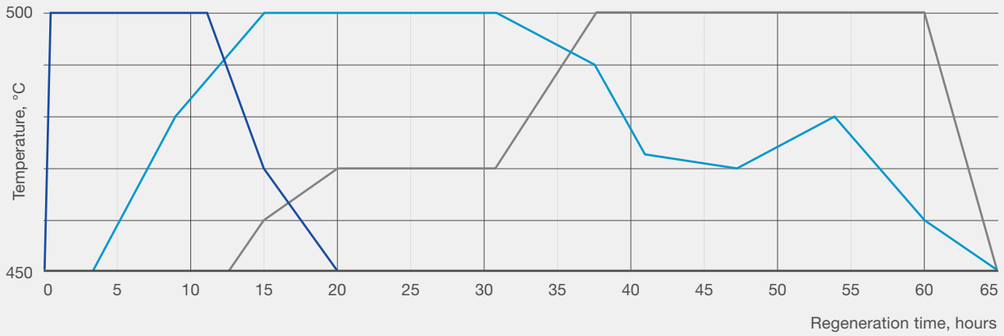
Oxidative regeneration of catalysts is a well-known but highly diffusion limited process that is required on a periodic basis. A fast and reliable protocol can limit downtime of production plants and will support overall economic process operation.

The regeneration of a competitive alumina sphere was compared to the performance of ring-shaped BASF Al 3996 E (figure 8). Both catalysts were applied under identical conditions during the same period of time for the dehydration of tert-butyl alcohol (TBA) to isobutylene.

At constant bed volume, the two catalysts accumulated 12.8 wt % and 29.4 wt % of coke respectively (table 4). To monitor the regeneration behavior, three thermocouples were installed at different positions in the catalyst bed.

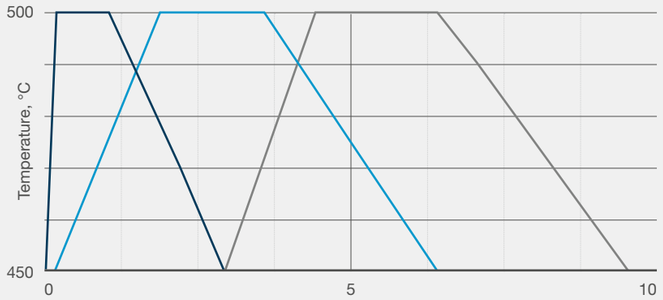
Figure 8a shows that the duration of the regeneration is 65 hours for the competitive spherical catalyst with the heat wave proceeding rather slowly through the catalyst bed. It should be noted that the coke combustion occurs non-uniformly since several steps are observed in the temperature profiles.

Figure 8a Regeneration characteristics of a competitive alumina sphere



On the other hand, the regeneration process is completed in less than 10 hours for BASF Al 3996 E as depicted in figure 8b. The thermocouples indicate a linear increase followed by a linear decrease of temperature in all three reactor zones so that the regeneration sequence can be completed in a controlled and predictable manner.

Figure 8b Regeneration characteristics of BASF Al 3996 E ring extrudate



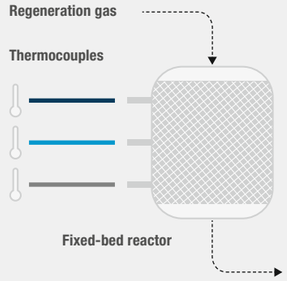
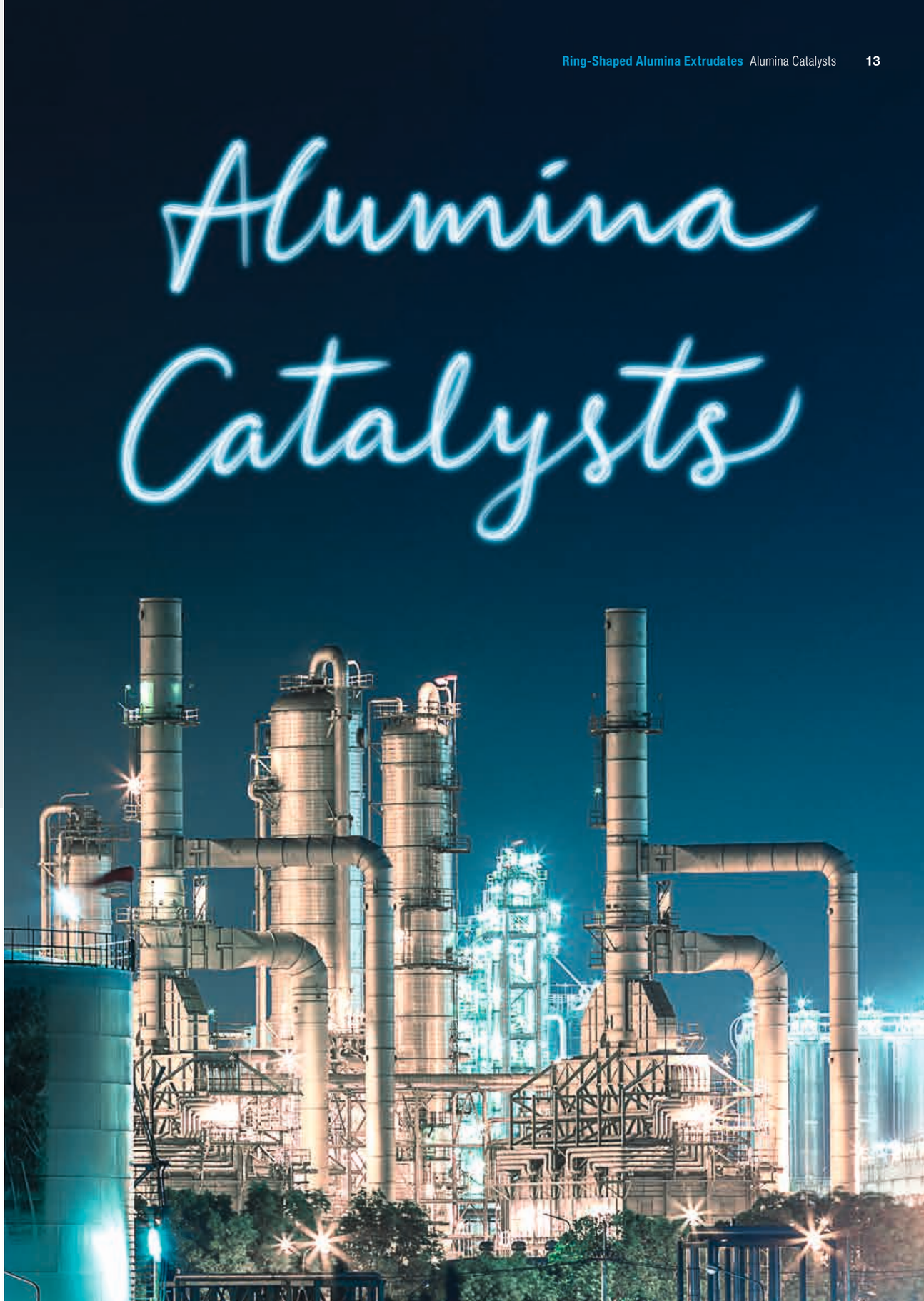


Table 4

		BASF Al 3996 E ring extrudate			Competitor catalyst		
		fresh	spent	regenerated	fresh	spent	regenerated
Surface area	m^2/g	198	127	179	310	40	132
Pore volume	cm^3/g	0.57	0.53	0.59	0.41	0.16	0.49
Packing density	g/cm^3	0.57	0.66	0.58	0.81	1.02	0.73

Table 4 summarizes properties of fresh, spent and regenerated BASF Al 3996 E ring extrudate compared to a competitive alumina sphere

Taking into account the absolute amount of coke deposited on the two catalysts, a 2.3 times higher cycle time would have been expected for regeneration of the competitive alumina compared to BASF Al 3996 E. However, the outcome of the experiment reveals a 6.5 times slower regeneration which can be attributed to strong mass transfer limitations in the case of the spherical catalyst. Furthermore, the completeness of the regeneration process is illustrated by nearly 100 % recovery of surface area and conservation of the packing density for BASF Al 3996 (table 4). Clearly, the highly efficient usage of the regeneration gas is enabled by the innovative ring geometry which is a key factor to ensure high rates for complete catalyst regeneration.



Selected Applications
for BASF Alumina Catalysts

BASF's Chemical Catalysts combine the strength of BASF with the experience and expertise of our chemists and engineers. Catalytic applications for alumina are plentiful and include different dehydration processes which are characterized by the formation of water as the reaction by-product. In the case of alcohol dehydration, olefins are often the desired target compounds. Various other important classes of chemicals such as aliphatic and aromatic amines, nitriles and halocarbons rely on alumina-based catalysis as outlined in the examples below.

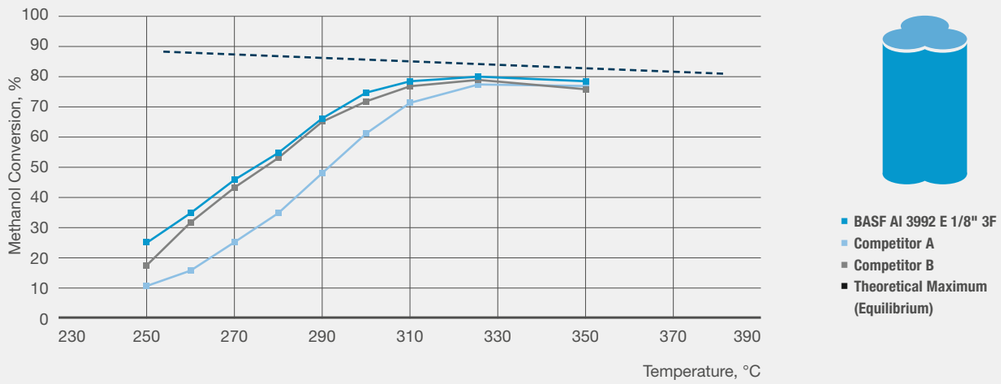
Dehydration of Alcohols:

The dehydration of alcohols represents an important reaction found at the heart of many chemical value chains. Alumina catalysts are also known as "solid acids" and thus make an ideal choice for the acid-catalyzed dehy-dration of alcohols. For years, customers have trusted BASF to provide advanced alumina catalysts that promote effective reactions for the dehydration of **C1 – C4 aliphatic alcohols** as well as for the **cyclization of diols**.

Methanol Dehydration

The dehydration of the simplest alcohol methanol to dimethyl-ether (DME) is an integral part of several important syngas based routes towards olefins and engine fuels. As illustrated by the comparative experiment in figure 9, BASF **Al 3992 E 1/8" 3F** with its advanced trilobular shape combines methanol conversion levels close to equilibrium with a selectivity towards DME well above 99 %. When compared to competi-tive alumina extrudate A under identical test conditions, a 20 °C activity advantage can be realized over most of the investigated temperature regime. For industrial operation this translates into a much broader operating window and greater flexibility in adjusting process parameters. On the other hand, when benchmarked against com-petitive alumina tablet B, the low bulk density of only 0.6 g/cm3 of BASF Al 3992 E 1/8" 3F greatly reduces the cost of fill while maintaining superior cata-lyst activity. Typically, the void fraction of 1/8" trilobe extru-dates will be 25 % higher when compared to tablet geome-tries. Increased product yields, higher feed throughput and energy savings from lower inlet temperature are additional economic advantages offered to our customers.

Figure 9 Performance of the BASF Al 3992 E 1/8" 3F trilobe extrudate for the dehydration of methanol in comparison to competitor catalysts



Ethanol Dehydration

The ethanol to ethylene process represents an attractive option to enter the diverse ethylene value chains based on alternative feedstocks (figure 10). BASF has developed in-depth experience on this application and is able to offer a **state-of-the-art alumina catalyst portfolio** for the steam-assisted dehydration of different ethanol grades. Our customers benefit from the best possible raw material utiliza-tion with both conversion level and selectivity towards ethylene above 99 % regularly achieved on industrial scale. The BASF selection of alumina catalysts is characterized by high catalyst purity in combination with enhanced porosity. Our industry benchmark offerings each combine various strongly acidic catalysts with an individual material profile. Straight, ring-shaped and trilobe extrudates are recom-mended for this application. Figure 11 compares the activity of BASF alumina catalysts as a function of reaction temperature. In addition, BASF operates dedicated pilot plants to replicate real-world operating parameters and deliver recommenda-tions for efficient catalyst operation to our customers.

Figure 10 General process flow of the ethanol to ethylene process

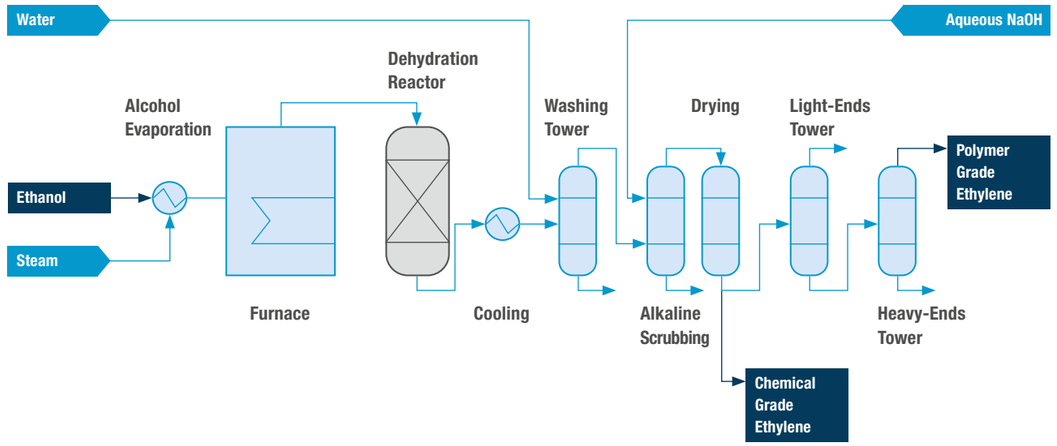
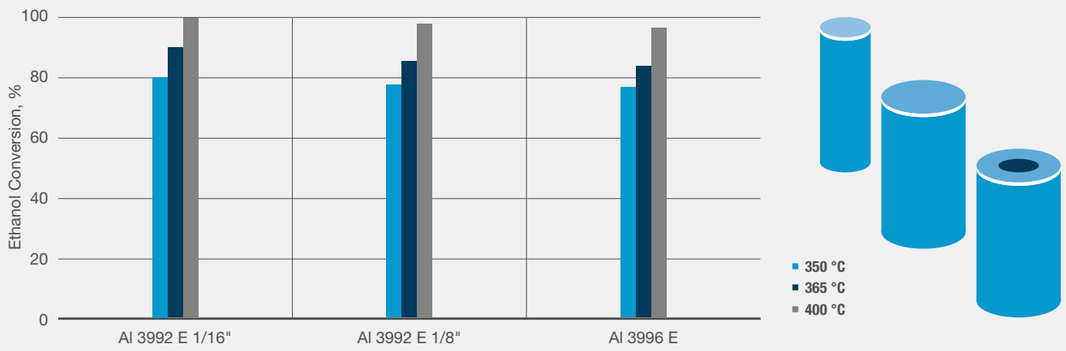


Figure 11 Activity of different BASF alumina catalysts for the conversion of ethanol to ethylene as a function of reaction temperature



Butanol Dehydration

For the dehydration of C4 alcohols, BASF supplies alumina catalysts which have proven their performance for many years on industrial scale. The dehydration of tert-butyl alcohol (TBA) to isobutylene is the most broadly applied commercial process, but the effectiveness of BASF aluminas has also been demonstrated for the conversion of n-butyl alcohol and isobutyl alcohol to the corresponding butenes.

BASF **Al 3996 E** and **Al 3997 E** ring extrudates are the recommended catalysts for the dehydration of tert-butyl alcohol as they combine high catalytic performance with good tolerance towards water levels contained in the alcohol feedstock. Ring extrudates are highly active catalysts and exhibit various advantages such as low pressure drop, reduced cost of fill and improved regeneration characteristics all contributing to economic process operation (figure 8).

Methylamines

The high pressure reaction of methanol and excess ammonia at temperature levels of 400 °C leads to the formation of a product mix of monomethylamine (MMA), dimethylamine (DMA) and trimethylamine (TMA). These amines find numerous applications as intermediates in the synthesis of industrial solvents, detergents, crop protection products and feed additives.

BASF has developed the **N 7066 methylamine catalyst** which is based on a silica-doped aluminum oxide phase. Prominent features of this catalyst include a star-shaped geometry, a specific surface area exceeding 200 m2/g and a favorable low packing density of only 0.5 g/cm3. On commercial scale, excellent catalyst lifetime, low pressure drop and reduced coke build-up have been confirmed for BASF N 7066.

Figure 12 compares the deactivation behavior of BASF N 7066 to the performance of two competitive methylamine catalysts in a four week accelerated aging test. On average, the highest methanol conversion is observed and maintained for BASF N 7066, routinely exceeding the level of 99 % under plant conditions. As there is frequently a preference towards the synthesis of a certain methylamine the undesired amine species will be recycled back to the reactor resulting in a complex chemical equilibrium situation. Along with the N 7066 catalyst, the BASF offer includes competent technical support to help our customers in selecting optimum process conditions such as temperature, pressure, flow parameters and nitrogen/carbon ratio. This enables the output of the targeted methylamine to be maximized.

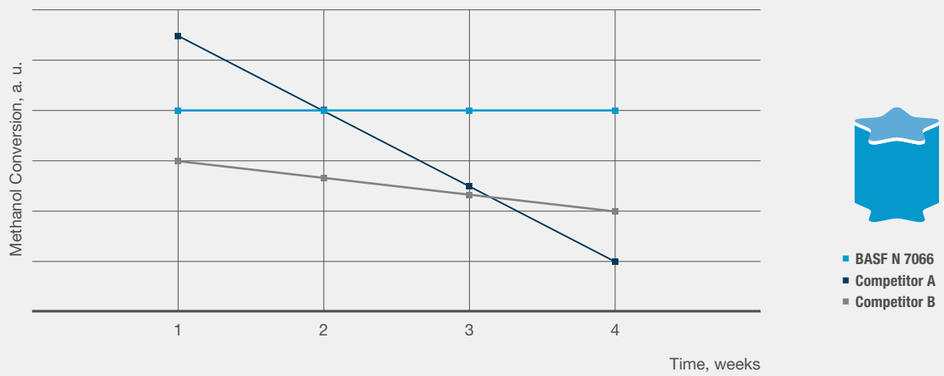


Figure 12 Accelerated aging test comparing the deactivation behavior of the BASF N 7066 methylamine catalyst to the performance of competitor catalysts

Chloromethane

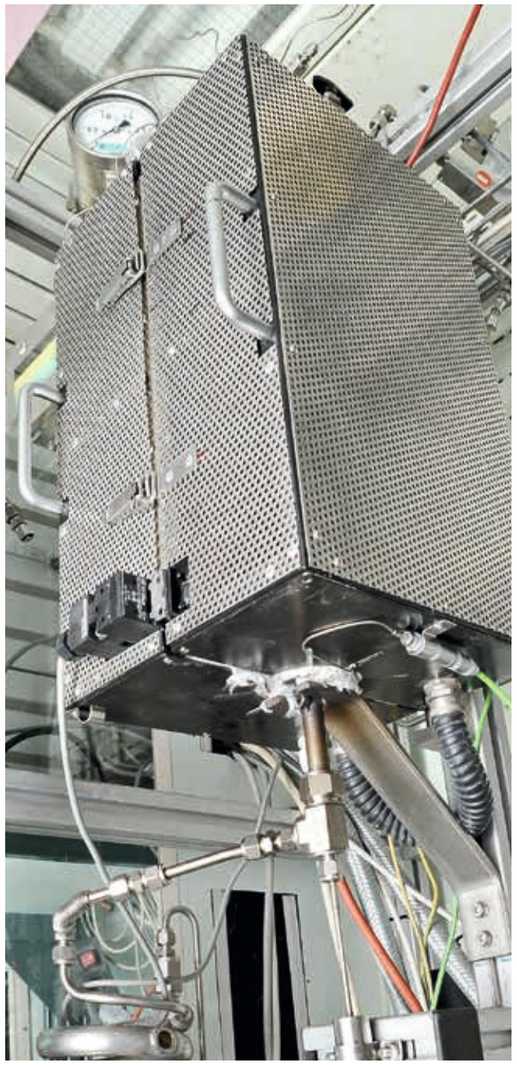
Chloromethane is used for the synthesis of higher chloromethanes such as methylene chloride and chloroform and represents a key intermediate in the chlorosilane and fluorocarbon value chains. Chlorocarbons find application as solvents, not only because of their good dissolution properties, but also due to the fact that they are mostly non-flammable.

On industrial scale methanol and hydrogen chloride are combined in the gas phase and passed over an alumina catalyst bed at temperatures between 200 and 300 °C and 3–6 bar pressure. The factors often limiting the lifetime of the hydrochlorination catalyst are a constant increase in pressure drop induced by coking and the overall loss of catalytic activity caused by the harsh, corrosive reaction environment.

BASF **Al 3992 E 1/8"** and BASF ring extrudates **Al 3996 E** and **Al 3997 E** exhibit very high selectivities towards methyl chloride – values in excess of 99 % are not unusual – and will display lifetimes significantly exceeding competitor catalysts. Additionally, the unwanted dimethyl ether by-product from the self-condensation of methanol is greatly suppressed. The high productivity of BASF alumina catalysts is further illustrated by the amount of methyl chloride produced over 1000 kg catalyst which will easily exceed 20000 metric tons.

Adiabatic testing

Figure 13 BASF's latest-generation testing facilities guarantee catalyst evaluation under real-world conditions



Isothermal testing

Alumina
as a Catalyst Support

BASF offers a wide range of alumina catalyst supports to comprehensively meet the needs of heterogeneous catalyst manufacturers. Substrate selection is critical, and requires well-defined physical and chemical properties of the chosen carrier.

The principal function of a catalyst support is to provide a high surface area scaffold onto which the principal catalytic agent can be deposited. In some cases, the alumina may not only act as a simple support but as a co-catalytic agent, complementing and enhancing the performance of the active metal. The BASF portfolio of catalyst supports includes both alumina tablets and alumina spheres which are available in various shapes and sizes.

Alumina Tablets

Tablets made from aluminum oxide have been widely used for decades as catalyst support materials in chemical and petrochemical processes. BASF has developed a range of mechanically strong alumina tablets with optimized porosity ensuring both accessi-bility of reactants and ease of impregnation of catalytic agents onto the carrier. The surface properties of the tablets may be tailored in such a way that the support will have an inert, interacting or synergistic role. Various tablet sizes are available including hollow-core geometries for demanding applications.

Alumina Spheres

BASF supplies aluminum oxide catalyst support spheres from unique and controlled manufacturing processes to provide suitable carriers for numerous applications. BASF's high product integrity ensures maximum resistance to attrition, thus minimizing catalyst loss and improving economics of operation. Spheres are available in a range of properties and can exhibit nearly inert to highly active surface chemistry. Vast experience allows BASF to fine-tune density, pore structure, thermal stability and catalytic activity by in-process adjustments or dedi-cated post-treatments.

Research & Development

Innovations based on effective and efficient research and development are an important growth engine for BASF. Our employees work in interdisciplinary teams on advanced processes and products for a sustainable future. This is how we ensure our long-term business success with chemistry-based solutions for almost all sectors of industry.

BASF's global Know-how Verbund covers three central technology platforms and includes R&D units in our operating divisions and at group companies. In addition, BASF is involved in collaborative partnerships with leading universities, research institutes, startup companies, and industrial partners, which add momentum to our research activities around the world.

At present, around 10000 BASF employees work in R&D worldwide, there-of over 1000 experts are involved in catalyst and process research.

The aim of developing an industrial high-performance catalyst is to maximize activity and selectivity of the catalyst. Since these properties generally influence one another, researchers frequently have to find a compromise between these requirements. Interdisciplinary cooperation of many different fields of scientific research is necessary for the optimization of catalyst properties and at the heart of BASF's catalyst and development (figure 14).

10,000
Employees in Research and Development Worldwide

Ca. € 2 bln
in Research and Development Expenditures

1,000
Patents Filed

3,000
R&D Projects

No. 1
in the Patent Asset Index

70
R&D locations Worldwide

Figure 14 Interdisciplinary collaboration is crucial for efficient and fast catalyst development

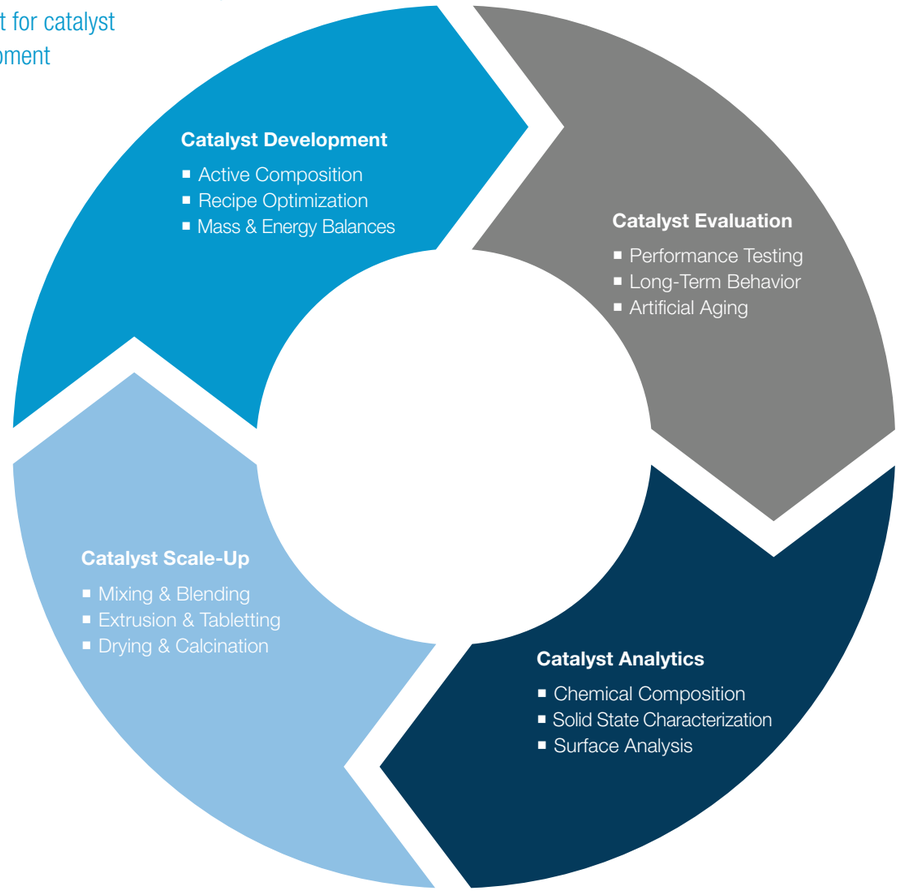
Collaborating with BASF Catalyst R&D

Chemical reactions require chemical catalysts. As the global leader in chemical process catalysts, we act through continuous collaborative partnerships with our clients.

Customers benefit from BASF's integrated approach which is based on a feedback loop concept to address all essential aspects during development or improvement of a catalyst (figure 15).

BASF's laboratories and pilot units are set up to cover all aspects of catalyst recipe formulation, optimization and scale-up and by this enable meaningful test work. Latest-generation reactor technology and analytical tools are both applied to monitor reaction performance as well as to analyze fresh and spent catalyst samples. Our catalyst evaluation facilities are equipped to use reactants from customer plants to create realistic scenarios for catalyst screening and long-term testing. In this way, we ensure fast turnaround and quick identification of promising catalyst compositions. Thanks to the close interaction with BASF catalyst manufacturing new laboratory findings can be rapidly transferred to production scale.

Figure 15 BASF feedback loop concept for catalyst development



Features

- Catalyst selection
- Performance forecasting
- Definition of operating conditions
- On-site loading and start-up support
- Performance monitoring and optimization
- Lifetime calculations
- Analysis of spent catalyst samples
- Training of production staff

Technical Service
and Catalyst Startup Support

We support customers operating BASF alumina catalysts with a competent technical service. BASF's technical service team has long-term experience in optimizing catalyst performance under a variety of operating conditions.

Our experts are equipped with the full range of resources to analyze complex problems, and have full access to our R&D facilities and catalyst experts. BASF's comprehensive service approach provides the best possible assistance to our customers anytime and anywhere in the world.

Regional support for our customers is covered by a dedicated BASF technical team:

Americas:
through our Regional Center in Iselin, USA.

Asia Pacific:
through our Regional Hub in Shanghai, P.R. China.

Europe, Middle East, Africa:
through our Headquarters in Ludwigshafen, Germany.

BASF

We create chemistry

Americas
BASF Corporation
25 Middlesex/Essex Turnpike
Iselin, New Jersey, 08830, USA
Tel: +1-732-205-5000
Fax: +1-732-205-7725
Email: catalysts-americas@basf.com

Asia Pacific
BASF (China) Company Limited
300 Jiang Xin Sha Road
Pudong, Shanghai 200137
P.R. China
Tel: +86-21-2039 2549
Fax: +86-21-2039 4800-2549
Email: catalysts-asia@basf.com

Europe, Middle East, Africa
BASF Services Europe GmbH
Rotherstraße 11
10245 Berlin, Germany
Tel: +49-30-20055000
Email: catalysts-europe@basf.com

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

www.chemicals.basf.com/alumina-catalysts