Pushing Innovation with Cascade Reactions in Flow

A novel synthesis platform for scalable processes

Starting points for solving the challenges for fine chemicals industry

Vision and research needs in active ingredients development with the tools of sustainable catalysis

ROADMAP OF GERMAN CATALYSIS RESEARCH

CATALYSIS

An interdisciplinary key technology for a sustainable economic development

Edition November 2023

supported by

DECHEMA · GDCh Gesellschaft Deutscher Chemiker · DBG · DGMK · VDI

Research needs

» The scope of photocatalytic reactions and photocatalytically active materials needs to be broadened, both for homogeneously and heterogeneously catalyzed reactions.

Research needs

» The optimization of the electrochemical reactor must be holistic, i.e. taking into account the electrodes, membranes and process parameters (e.g. p, T).

4.2 Active ingredients

Vision

» In drug discovery, sophisticated methods for late-stage functionalization are applied.

» **Non-toxic metal catalysts**

» **More selective and recyclable**

» Catalysis, in addition to its application in pharmaceutical production, is also used in the field of agrochemicals, as catalyst systems have become cheaper and less toxic.

» **Metallo-enzyme catalysts & cascade reactions for API**

Research needs

» Highly efficient catalysts and robust process steps (TON›1000) need to be developed to minimize precious metal quantities, waste and energy requirements.

» **Catalysts for enantioselective reactions**

» Environmentally friendly LSM systems are to be used extensively.

» The influence of solvent systems in catalysis should be better understood.

» Readily available and non-toxic metals for catalysts are to be used in the production of active ingredients.

» **Recycling of catalysts**

» **Advance biocatalysis**

Exceed your today's profit with sustainable API supply

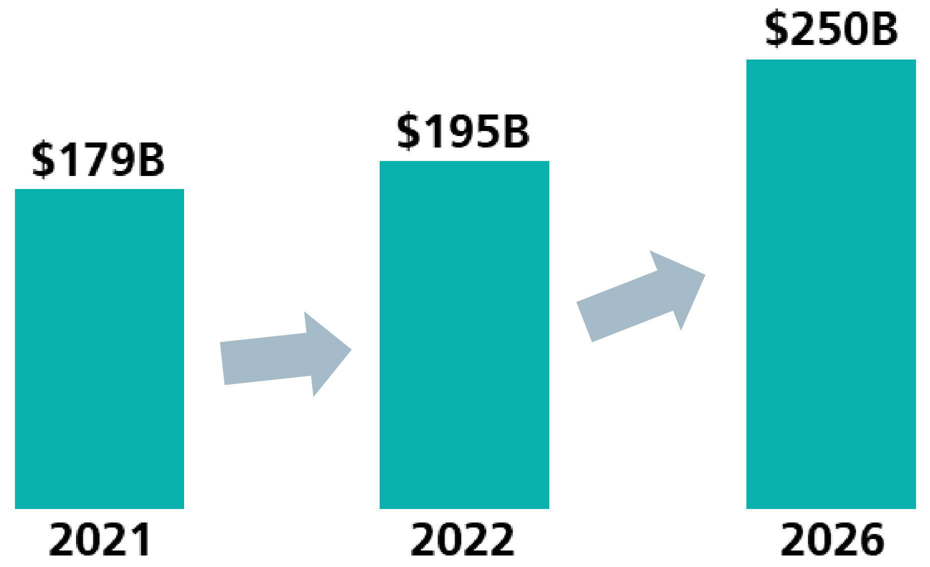
Pharmaceutical API Manufacturing Global Market Report 2023

February 2023 | 250 pages | ID: 6241837 | Format: PDF | The Business Research Company

Major players in the pharmaceutical API manufacturing market are Teva Pharmaceutical Industries Ltd., Sun Pharmaceutical Industries Ltd., Boehringer Ingelheim, PfizerInc., Aurobindo Pharma, Novartis AG, Dr. Reddy's Laboratories, Merck & Co.Inc., BASF SE., Bayer Healthcare, Mylan N.V., Albemarle Corporation, Actavis plc, Hospira Inc., Ranbaxy Laboratories, Virbac, Zoetis, Heska Co., AbbVie Inc., AstraZeneca plc, Eli Lilly and Company, GlaxoSmithKline plc, Sanofi, Bristol-Myers Squibb, CiplaInc., and F. Hoffmann-La Roche Ltd.

The global pharmaceutical API manufacturing market is expected to grow from $179.05 billion in 2021 to $195.29 billion in 2022 at a compound annual growth rate (CAGR) of 9.1%. The Russia-Ukraine war disrupted the chances of global economic recovery from the COVID-19 pandemic, at least in the short term. The war between these two countries has led to economic sanctions on multiple countries, surge in commodity prices, and supply chain disruptions, causing inflation across goods and services effecting many markets across the globe. The pharmaceutical API manufacturing market is expected to reach $250.66 billion in 2026 at a CAGR of 6.4%.

Global API manufacturing market 2021-2026



straits RESEARCH

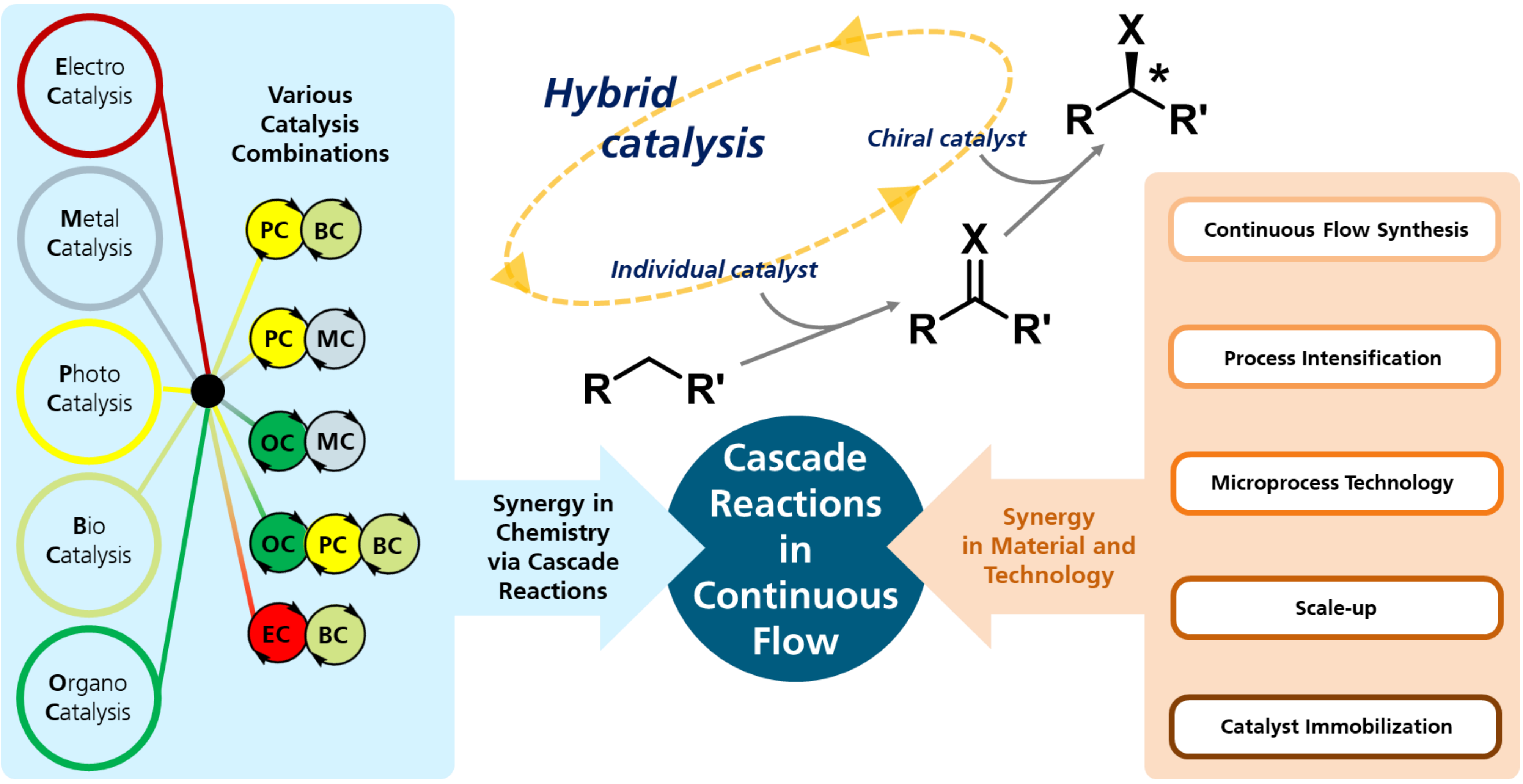
Flow Chemistry Market Size is projected to reach USD 3 Billion by 2030, growing at a CAGR of 10%: Straits Research

The global flow chemistry market size was worth USD 2 billion in 2021. It is estimated to reach an expected value of USD 3 billion by 2030 at a CAGR of 10% over the forecast period (2022-2030). North America dominated the market. It is estimated to reach an expected value of USD 1165 million by 2030 at a CAGR of 10%.

July 06, 2022 13:00 ET | Source: Straits Research

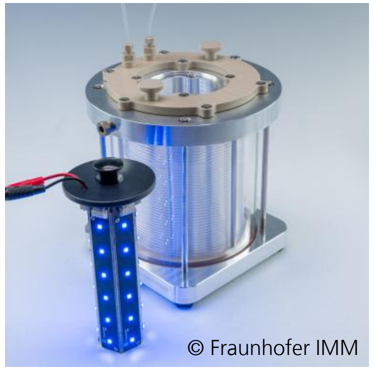
An innovative technology based on the principles of Green Chemistry

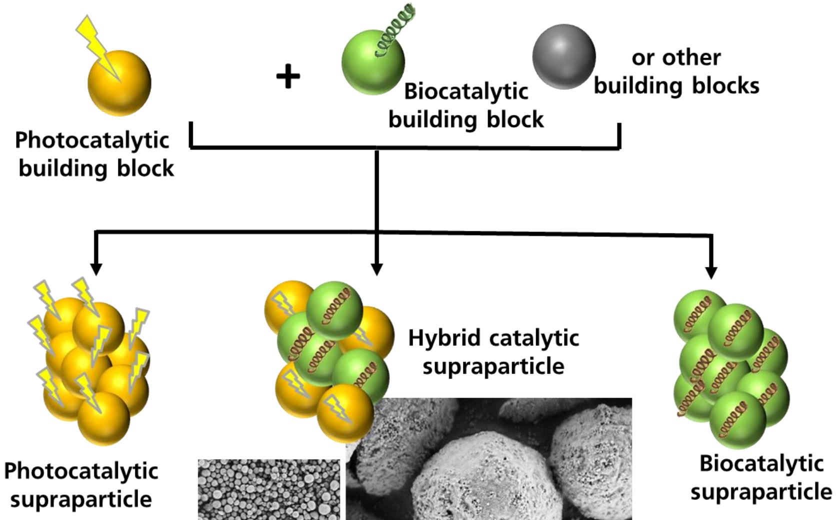
Cascade reactions applying combined catalysis in continuous flow

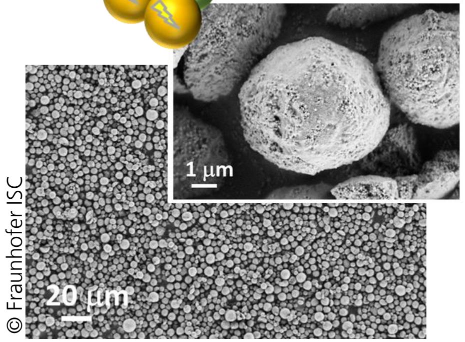


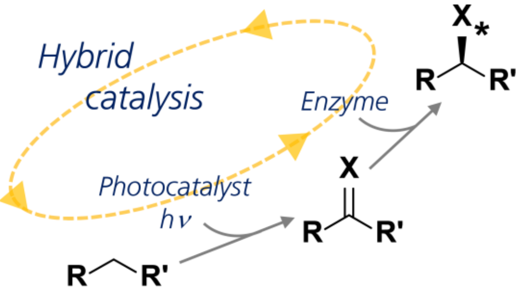
The catalyst technology
Supraparticles & Polymeric foils

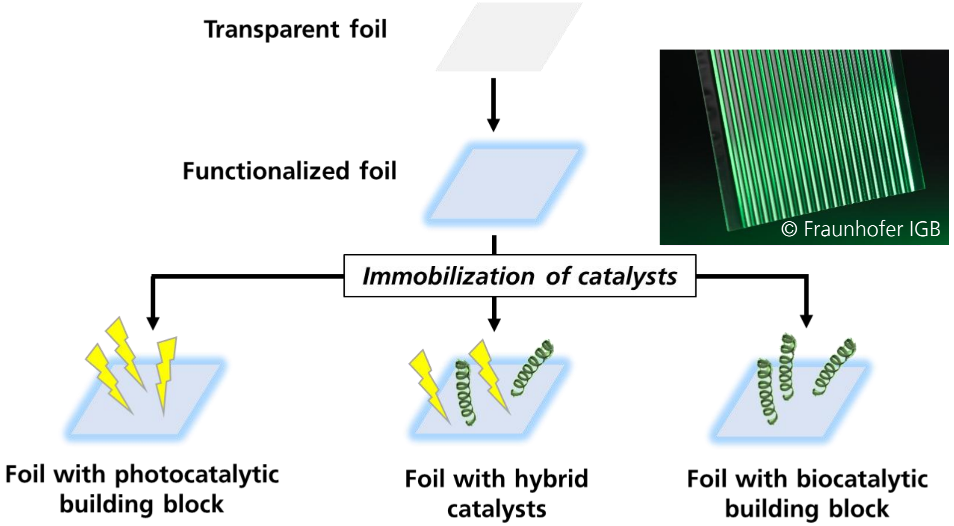
IP secured with DE 10 2023 203 407 B4

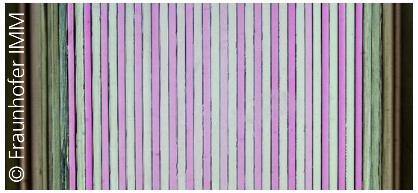


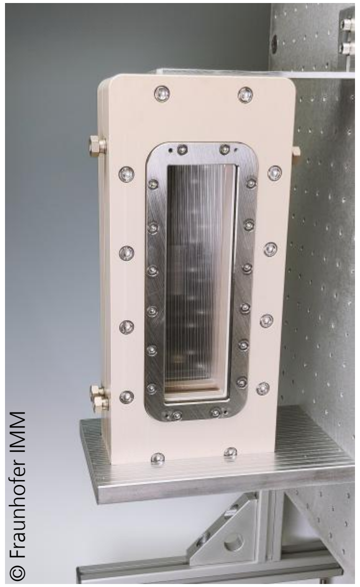












Enantioselective and heterogenized for desired chirality and less waste!

Our reactor technology

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Falling Film Microreactor

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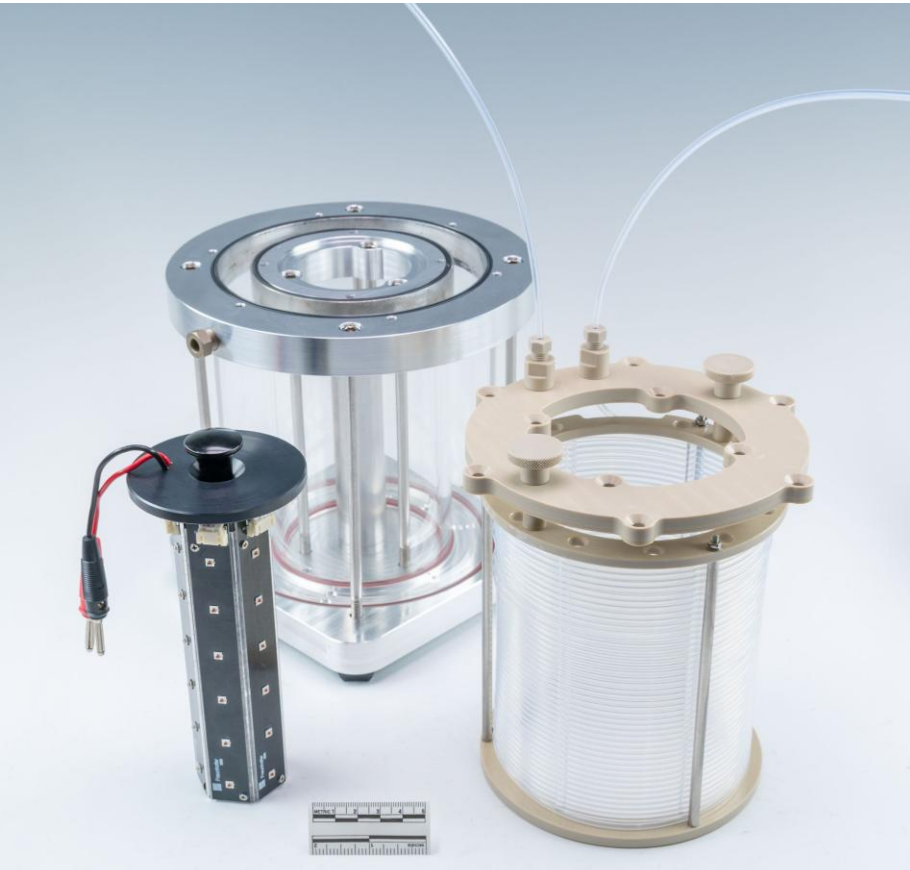

Capillary Photoreactor

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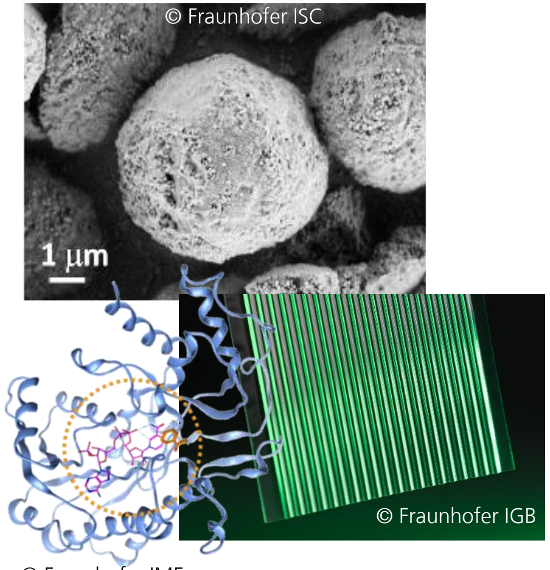
Flexible and scalable flow technology !

A modular platform technology for cascade reactions

Modules for the synthesis of fine chemicals or APIs

Catalysts 1
- Selection and develop-ment of catalysts
- Hybrid catalysts
- Immobilization on surfaces
- Scale-up



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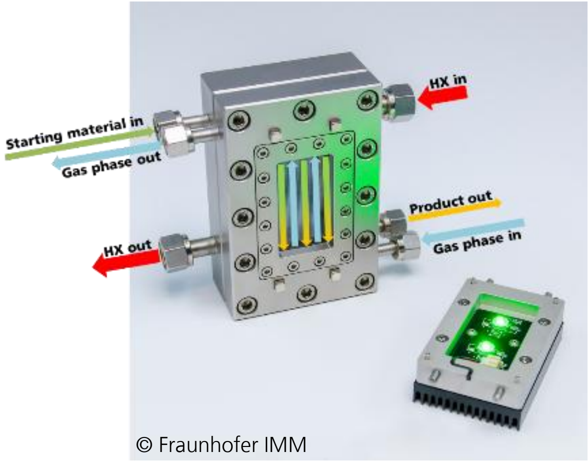
Flow reactors 2
- Development of customer & process specific reactor systems
- Reactor scale-up



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Synthesis plants 3
- Development of customer & process specific plants
- Integration of analytics and control elements

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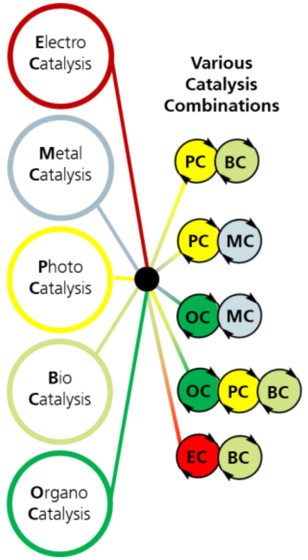
Process development 4
- Process evaluation
- Transfer from batch to flow mode
- Cascade reactions



Advantages of our flow technology & development services

These advantages	translated into	Your benefit
Mild reaction conditions with photo- and biocatalysis	maximize	your product **quality** by less degradation
Orthogonal reactivity in metal-, photo- and biocatalysis	allows	**novel synthesis routes** and **products** for your portfolio
Process-oriented **combination** and **immobilization** of catalysts	allows	**high flexibility** in process design on a **small footprint**
Clever and **adaptable** reactor design	achieves	**better** process **control**
Process **intensification** with electro-organic synthesis and heterogeneous catalysis	avoids	**needless waste** and high efforts for the **downstream**
Intrinsic scale-up of flow reactors	results in	**cost reduction** for your processes

Pushing our knowledge and expertise to your needs and challenges!

Long-term
Partnership for Sustainable Chemical Production

Feasibility studies + Process development + Technology development

MATERIALS ✓ TECHNOLOGY ✓
RE-THINKING ✓ CATALYSTS ✓

- Building blocks of interest
- Reactions & processes of interest
- Technology of interest

Fraunhofer

Industrial Partner

Range of services

We conduct research on your behalf

Process, technology and product development

Analysis and testing services

Consultancy and studies

Cooperation models – ways of working together

- **One-off contracts** industrial contract research
- **Joint research** projects with multiple partners
- **Strategic partnerships** national and international
- **Licensing** of technologies and processes
- **Technology transfer through to spin-offs**
- **Training**

»Enantioselective, Sustainable and Scalable API syntheses via Cascade Reactions in Flow.«

A strong partnership between you and Fraunhofer to drive innovation to the next level

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