Heraeus

Precious Metals

Precious Metal Catalysts

for the Fine Chemical, Pharmaceutical and Agrochemical Industry

Process Optimization with Precious Metal Catalysis

Catalysts are a particularly crucial component in the production processes of the fine chemical, pharmaceutical and agrochemical industries. Complex molecules require complicated, multi-step synthesis routes that often result in low yields and a larger amount of by-products. For companies in these industries, optimizing these synthesis pathways is critical as it directly impacts cost efficiency and sustainability. This challenge requires innovative approaches and advanced technologies to improve production methods and reduce waste.

Heraeus Precious Metals offers a comprehensive range of homogeneous and heterogeneous precious metal catalysts that are characterized by high activity, selectivity and reusability. This makes them the perfect tool for carrying out complex syntheses, e.g. for the production of active ingredients under low pressure and at low temperature, which nevertheless enable the highest yields. The application of recycling strategies enhances the cost-efficient and sustainable use of scarce precious metals.

HOMOGENEOUS CATALYSTS

- Extensive portfolio of salts and compounds for all precious metals
- Focus on palladium phosphines for C-C coupling reactions
- High quality catalysts, e.g. for asymmetric hydrogenation, hydroformylation, hydrosilylation
- Tailor-made solutions for customer processes

HETEROGENEOUS CATALYSTS

- High quality catalysts, e.g. for hydrogenation and oxidation reactions
- Customized and value engineered catalyst solutions to your application needs
- Perfect combination of activity, selectivity and reusability for highest performance
- High expertise in custom and toll manufacturing solutions

A Unique One-Stop-Shop: Precious Metals Services

PRECIOUS METALS TRADING

Through trading centers in Hanau (Germany), New York City, Shanghai and Hong Kong, Heraeus Precious Metals is able to execute precious metal trades under current market conditions. In addition to sales and purchasing transactions, it can provide financing options to it's customers based on precious metal leasing.

PRECIOUS METALS ANALYTICS

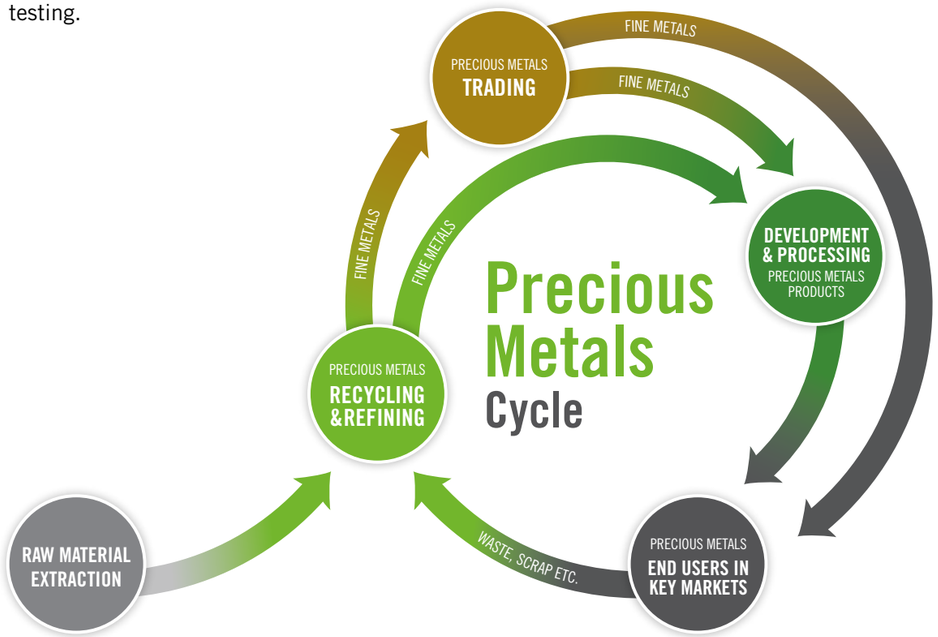
The Global Competence Center Analytics combines state-of-the-art equipment for a wide range of analytical methods with a highly qualified team of precious metal scientists. Services include expert advice to customers to provide them with optimum support in product quality, development projects and the determination of precious metal content and purity in order to meet industry standards for quality and material testing.

PRECIOUS METALS INNOVATION

Heraeus Precious Metals operates Global Innovation Centers in Germany, China and the USA. The team of researchers and developers work on developing new products, advising customers and collaborating with them on synthesis solutions.

PRECIOUS METALS RECYCLING

As specialists in the handling of spent precious metal catalysts, Heraeus offers the fastest possible precious metal recovery with the highest yield. The reclaimed precious metal can be used again for the manufacture of new catalysts.



Pd(0) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Pd_2(dba)_3$	51364-51-3	$C_{68}H_{56}O_4Pd_2$	20.0%	1150.03
$Pd(dba)_2$	32005-36-0	$C_{34}H_{28}O_2Pd$	20.0%	575.02
Pd_2dba_3 x $CHCl_3$	52522-40-4	$C_{52}H_{43}Cl_3O_3Pd_2$	20.6%	1035.10
$Pd(PPh_3P)_4$	14221-01-3	$C_{72}H_{60}P_4Pd$	9.2%	1155.59

Pd(II) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$PdCl_2$	7647-10-1	$PdCl_2$	60.0%	177.31
Pd(II) acetate	3375-31-3	$C_4H_{12}O_4Pd$	48.0%	224.51
Pd(II) acetate „N-free“	3375-31-3	$C_{12}H_{36}O_{12}Pd_3$	47.4%	224.51
$Pd(acac)_2$	14024-61-4	$C_{10}H_{14}O_4Pd$	34.9%	304.64
$[Pd(allyl)Cl]_2$	12012-95-2	$C_6H_{10}Cl_2Pd_2$	58.2%	365.89
$Pd(COD)Cl_2$	12107-56-1	$C_8H_{12}Cl_2Pd$	37.3%	285.50
$Pd(MeCN)_2Cl_2$	14592-86-4	$C_4H_6Cl_2N_2Pd$	41.0%	259.43
$Pd(PhCN)_2Cl_2$	14220-64-5	$C_{14}H_{10}Cl_2N_2Pd$	27.7%	383.57
$[Pd(cinnamyl)Cl]_2$	12131-44-1	$C_{18}H_{18}Cl_2Pd_2$	41.0%	518.08

As key players in organic synthesis, palladium catalysts offer a wide array of chemical transformations. Popular options include catalysts like $Pd(PPh_3)_4$ and $Pd(OAc)_2$ for cross-coupling and C-H activation respectively. Other significant catalysts such as $PdCl_2(PPh_3)_2$ and $Pd(dba)_2$ pave the way for Stille and Sonogashira reactions. Further palladium compounds and information are available on request. Our technical experts will be pleased to advise you on your inquiries.

Homogeneous Catalysts > **Palladium**

Pd(II) Phosphine Complexes: Monodentate Ligands

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Pd(PPh_3)_2Cl_2$	13965-03-2	$C_{36}H_{30}Cl_2P_2Pd$	15.0%	701.90
$Pd(P(o\text{-}tol)_3)_2Cl_2$	40691-33-6	$C_{42}H_{42}Cl_2P_2Pd$	13.5%	786.06
$Pd(Amphos)_2Cl_2$	887919-35-9	$C_{32}H_{56}Cl_2N_2P_2Pd$	15.0%	708.08
$Pd(PtBu_2Ph)_2Cl_2$	34409-44-4	$C_{28}H_{46}Cl_2P_2Pd$	17.1%	621.94
$Pd(PCy_3)_2Cl_2$	29934-17-6	$C_{36}H_{66}Cl_2P_2Pd$	14.4%	738.19

Pd(II) Phosphine Complexes: Bidentate Ligands

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Pd(dppe)Cl_2$	19978-61-1	$C_{26}H_{24}Cl_2P_2Pd$	18.5%	575.74
$Pd(dppp)Cl_2$	59831-02-6	$C_{27}H_{26}Cl_2P_2Pd$	18.0%	589.77
$Pd(dppb)Cl_2$	29964-62-3	$C_{28}H_{28}Cl_2P_2Pd$	17.6%	603.79
$Pd(dppf)Cl_2$	72287-26-4	$C_{34}H_{28}Cl_2FeP_2Pd$	14.5%	731.70
$Pd(dppf)Cl_2$ x CH_2Cl_2	95464-05-4	$C_{35}H_{30}Cl_4FeP_2Pd$	13.0%	816.64
$Pd(dtbpf)Cl_2$	95408-45-0	$C_{26}H_{44}Cl_2FeP_2Pd$	16.3%	651.74
$Pd(DPEPhos)Cl_2$	205319-06-8	$C_{36}H_{28}Cl_2OP_2Pd$	14.9%	715.88
$Pd(Xantphos)Cl_2$	205319-10-4	$C_{39}H_{32}Cl_2OP_2Pd$	14.1%	755.95

Further phosphine complexes and information are available on request. Our technical experts will be pleased to advise you on your inquiries.

Pt(II) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Pt(acac)_2$	15170-57-7	$C_5H_7O_2Pt$	49.6%	393.29
$Pt(PPh_3)_2Cl_2$	15604-36-1	$C_{36}H_{30}Cl_2P_2Pt$	24.7%	790.57
$[Pt(cyclohexene)Cl_2]_2$	12176-53-3	$C_{12}H_{20}Cl_4Pt_2$	56.0%	696.26
$Pt(COD)Cl_2$	12080-32-9	$C_8H_{12}Cl_2Pt$	52.1%	374.16
$Pt(nbd)Cl_2$	12152-26-0	$C_7H_8Cl_2Pt$	54.5%	358.12
$Pt(MeCN)_2Cl_2$	13869-38-0	$C_4H_6Cl_2N_2Pt$	56.0%	348.09
$Pt(BnCN)_2Cl_2$	15617-19-3	$C_{14}H_{10}Cl_2N_2Pt$	41.3%	472.23

Further platinum compounds and information are available on request. Our technical experts will be pleased to advise you on your inquiries.

Hydrosilylation Catalysts

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
Karstedt's catalyst	68478-92-2	$O[Si(CH_3)_2CH{=}CH_2]_2Pt$	19.7%	–
Ashby's catalyst	68585-32-0	$C_{12}H_{24}O_4SiPt$	17.0%	–
$Pt(dodecene)Cl_2$	129153-28-2	$C_{12}H_{24}Cl_2Pt$	4.2%	–
$(MeCp)PtMe_3$ (UV curing)	94442-22-5	$C_9H_{16}Pt$	61.1%	319.30

Hydrosilylation catalysts are available in many concentrations and dilutions – please inquire.

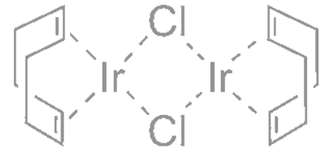
Ir(I) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$[Ir(COD)Cl]_2$	12112-67-3	$C_{16}H_{24}Cl_2Ir_2$	57.2%	671.70
$[Ir(COD)_2]BF_4$	35138-23-9	$C_{16}H_{24}I_2Ir_2$	38.3%	495.39
$[Ir(COD)OMe]_2$	12148-71-9	$C_{16}H_{24}I_2Ir_2$	45.0%	854.60

Ir(III) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
Ir acetate	52705-52-9	$C_{12}H_{24}O_{16}Ir_3$	49.0%	1000.97
$Ir(acac)_3$	15635-87-7	$C_{15}H_{21}O_6Ir$	39.3%	489.53
$[IrCp^*Cl_2]_2$	12354-84-6	$C_{20}H_{30}Cl_4Ir_2$	48.3%	796.71
R,R - Ir(Cp*)(TsDPEN)Cl	1244963-99-2	$C_{31}H_{36}ClIrN_2O_2S$	26.4%	728.38
S,S - Ir(Cp*)(TsDPEN)Cl	1099830-90-6	$C_{31}H_{36}ClIrN_2O_2S$	26.4%	728.38

Further iridium compounds, substitution patterns and information are available on request. Our technical experts will be pleased to advise you on your inquiries.



Rh(I) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Rh(PPh_3)_3Cl$	14694-95-2	$C_{54}H_{45}P_3ClRh$	11.1%	925.22
$Rh(PPh_3)_3(CO)(H)$	17185-29-4	$C_{55}H_{45}P_3ORh$	11.2%	918.78
$Rh(acac)(CO)_2$	14874-82-9	$C_7H_7O_4Rh$	39.9%	258.03
Rh(acac)(COD)	12245-39-5	$C_{13}H_{19}O_2Rh$	33.2%	310.19
$Rh(acac)(ethylene)_2$	12082-47-2	$C_9H_{15}O_2Rh$	40.0%	258.12
$Rh(acac)(PPh_3)(CO)$	25470-96-6	$C_{24}H_{23}O_3PRh$	20.9%	493.32
$[Rh(ethylene)_2Cl]_2$	12081-16-2	$C_8H_{16}Cl_2Rh_2$	53.0%	388.93
$[Rh(COD)Cl]_2$	12092-47-6	$C_8H_{16}Cl_2Rh_2$	51.0%	493.08
$[Rh(COD)_2]BF_4$	35138-22-8 / 207124-65-0	$C_{16}H_{24}BF_4Rh$	25.3%	406.07
$[Rh(COD)_2]OTf$	99326-34-8	$C_{17}H_{24}F_3O_3SRh$	22.0%	468.34
$[Rh(COD)(dppb)]BF_4$	79255-71-3	$C_{36}H_{40}BF_4P_2Rh$	14.2%	724.36
$[Rh(COD)((R,R)$-Et-Du-Phos$)]BF_4$	228121-39-9	$C_{30}H_{48}BF_4P_2Rh$	15.6%	660.37
$[Rh(nbd)Cl]_2$	12257-42-0	$C_{14}H_{16}Cl_2Rh_2$	44.6%	460.99
$[Rh(nbd)_2]BF_4$	36620-11-8	$C_{14}H_{16}BF_4Rh$	27.5%	373.99
$[Rh(nbd)_2]OTf$	178397-71-2	$C_{15}H_{16}F_3O_3SRh$	23.6%	436.25
Rh(acac)(nbd)	32354-50-0	$C_{12}H_{15}O_2Rh$	35.0%	294.16
$[Rh(nbd)Cl]_2$	12257-42-0	$C_{14}H_{16}Cl_2Rh$	44.6%	461.00
$[Rh(nbd)_2]BF_4$	36620-11-8	$C_{14}H_{16}BF_4Rh$	27.5%	373.99

Further rhodium compounds, substitution patterns and information are available on request. Our technical experts will be pleased to advise you on your inquiries.

Homogeneous Catalysts > **Rhodium**

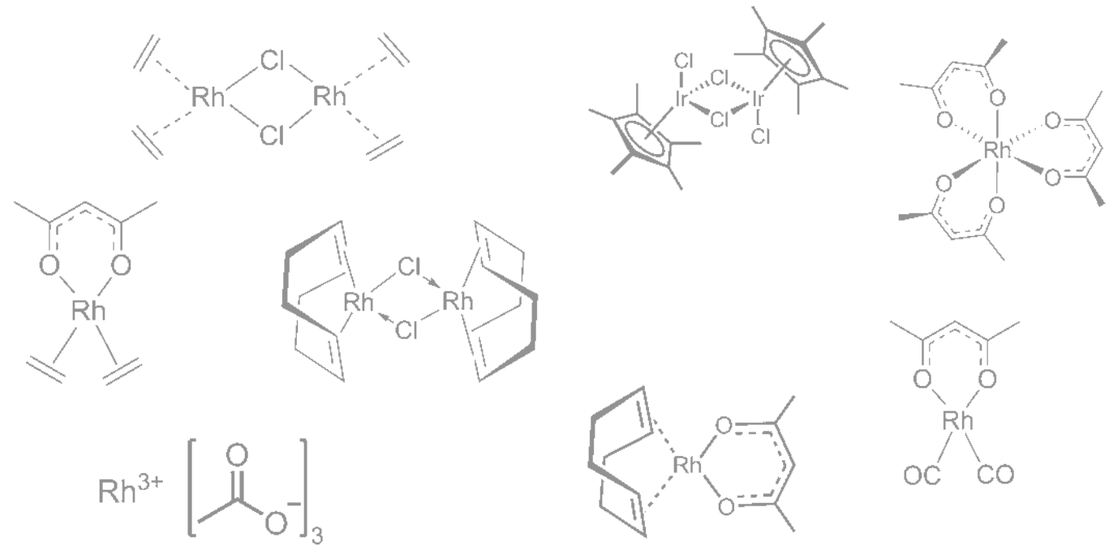
Rh(II) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
Rh(II) acetate	15956-28-2	$C_8H_{12}O_8Rh_2$	46.6%	441.99
Rh(II) octanoate	73482-96-9	$C_{32}H_{60}O_8Rh_2$	26.4%	778.64
Rh(II) 2-ethylhexanoate	20845-92-5	$C_{24}H_{45}O_6Rh$	2.3%	532.52

Rh(III) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
Rh(III) acetate	42204-14-8	$C_6H_9O_6Rh$	37.5%	280.04
$Rh(acac)_3$	14284-92-5	$C_{15}H_{21}O_6Rh$	25.7%	403.26
$[RhCp^*Cl_2]_2$	12354-85-7	$C_{20}H_{30}Cl_4Rh_2$	16.7%	618.07
$Rh(Cp^*)$(S,S -TsDPEN)Cl	1244964-49-5	$C_{31}H_{36}ClN_2O_2RhS$	16.1%	639.06
$Rh(Cp^*)$(R,R -TsDPEN)Cl	1244959-33-8	$C_{31}H_{36}ClN_2O_2RhS$	16.1%	639.06
$Rh(Cp^*)$(S,S -MsDPEN)Cl	1097730-64-7	$C_{25}H_{32}ClN_2O_2RhS$	18.3%	562.96
$Rh(Cp^*)$(R,R -MsDPEN)Cl	1097730-62-5	$C_{25}H_{32}ClN_2O_2RhS$	18.3%	562.96

Further rhodium compounds, substitution patterns and information are available on request. Our technical experts will be pleased to advise you on your inquiries.



Ru(0) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Ru_3(CO)_{12}$	15243-33-1	$C_{12}O_{12}Ru_3$	47.5%	639.33

Ru(I) Compounds

Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$[CpRu(CO)_2]_2$	12132-87-5	$C_{14}H_{10}O_4Ru_2$	45.5%	444.37

Ru(II) Compounds

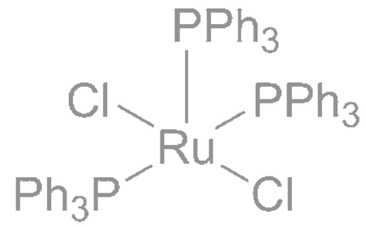
Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
$Ru(PPh_3)_3Cl_2$	15529-49-4	$C_{54}H_{45}Cl_2P_3Ru$	10.5%	958.83
$[Ru(CO)_3Cl_2]_2$	22594-69-0	$C_6O_6Cl_4Ru_2$	39.5%	512.01
$Ru(DMSO)_4Cl_2$	11070-19-2	$C_8H_{24}Cl_2O_4RuS_4$	20.8%	484.48
$[Ru(COD)Cl_2]n$	50982-12-2	$C_8H_{12}Cl_2Ru$	33.5%	280.16
$[Ru(benzene)Cl_2]_2$	37366-09-9	$C_{12}H_{12}Cl_4Ru_2$	40.4%	500.18
$[Ru(toluene)Cl_2]_2$	52462-27-8	$C_{14}H_{16}Cl_4Ru_2$	38.3%	528.23
$[Ru(p\text{-}cymene)Cl_2]_2$	52462-29-0	$C_{20}H_{28}Cl_4Ru_2$	33.0%	612.39
Ru(p-cymene)(TsEN)Cl	208988-63-0	$C_{19}H_{27}ClN_2O_2RuS$	20.9%	484.03
$[Ru(mesitylene)Cl_2]_2$	52462-31-4	$C_{18}H_{24}Cl_4Ru_2$	34.6%	584.34
Ru(p-cymene)(S,S -TsDPEN)Cl	192139-90-5	$C_{31}H_{35}ClN_2O_2RuS$	15.9%	636.21
Ru(p-cymene)(R,R -TsDPEN)Cl	192139-92-7	$C_{31}H_{35}ClN_2O_2RuS$	15.9%	636.21
Ru(p-cymene)(S,S -MsDPEN)Cl	329371-25-7	$C_{25}H_{31}ClN_2O_2RuS$	18.0%	560.11
Ru(p-cymene)(R,R -MsDPEN)Cl	1097730-63-6	$C_{25}H_{31}ClN_2O_2RuS$	18.0%	560.11

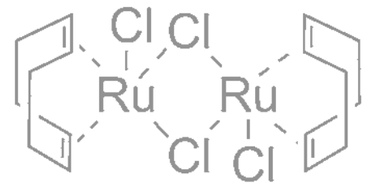
Ru(III) Compounds

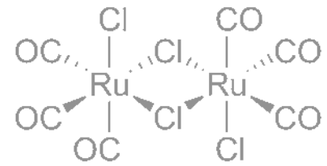
Product Name	CAS No.	Formula	Avg. PM Content	Mol. Weight
Ru acetate	55466-76-7	$C_{12}H_{18}O_{13}Ru_3.C_2H_3O_2$	34.7%	–
$Ru(acac)_3$	14284-93-6	$C_{15}H_{21}O_6Ru$	25.4%	398.39

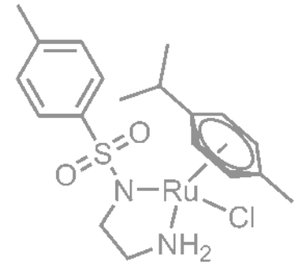
Further ruthenium compounds and information are available on request. Our technical experts will be pleased to advise you on your inquiries.

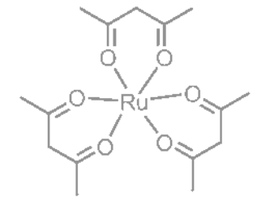
Homogeneous Catalysts > **Ruthenium**

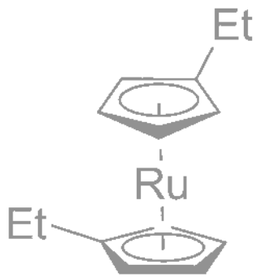


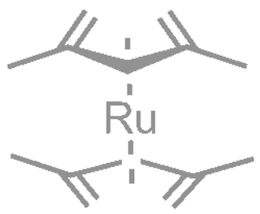


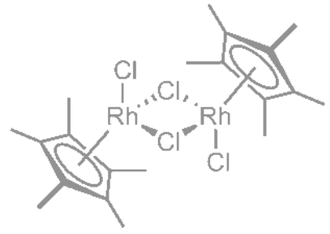






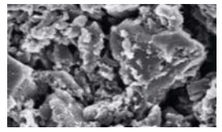




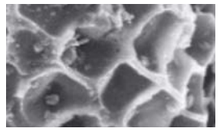


Activated carbon as Catalyst Support

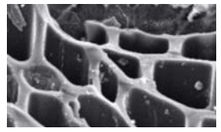
RAW MATERIAL



Coconut shell



Peat



Wood

CARBON SHAPE

Powder

Strands

Granules

Pellets

CHARACTERISTICS

- High specific surface area (BET): 700 – 1500 m^2/g
- Bulk density: 250 – 500 g/L
- Diverse pore structures
- Huge adsorption capacity
- Chemically stable under acidic conditions
- Good filterability

PRE-TREATMENT

- Chemical: Phosphoric acid activated
- Physical: Steam activated

POST-TREATMENT

- Acid washed
- Non-acid washed

SAMPLE KIT – FINDING THE RIGHT CATALYST

Heraeus has developed an extensive portfolio of proprietary catalysts, designed for a variety of challenging catalytic reactions. To help identify the best catalyst for your specific process, Heraeus offers catalyst sample kits.
There may already be a catalyst that suits your process, or it could serve as the foundation for an improved, tailor-made catalyst adapted to your requirements.

Contact us to request your sample kit.

Applications of PM/C Catalysts

Each chemical reaction has its own unique chemical and physical constraints. The experts at Heraeus are dedicated to helping you identify, optimize, and develop catalysts tailored to your specific conditions.

PM/C materials can catalyze a wide range of hydrogenation reactions. The most important reactions, along with the appropriate catalysts, are shown in the following table:

	Pt/C	Pd/C	Ru/C
NITRO AND NITROSO COMPOUNDS			
Aromatic nitro compounds to anilines	✔	✔	
Halonitroaromatics to halogenated anilines	✔		
Nitroso compounds to anilines	✔	✔	
Nitro compounds to hydroxylamines	✔		
CARBONYL COMPOUNDS			
Ketones/aldehydes to alkanes	✔	✔	
Ketones/aldehydes to alcohols	✔		✔
AROMATICS			
Ring hydrogenation	✔	✔	✔
Aromatic ketones to alicyclic alcohols		✔	✔
Anilines to cyclohexanones		✔	
Dehydrogenation		✔	
C–C MULTIPLE BONDS			
Alkenes to alkanes	✔	✔	
Alkines to alkanes		✔	
α,β-unsaturated carbonyl compounds		✔	
NITRILES			
Nitriles to prim./sec./tert. amines	✔	✔	
Aromatic nitriles to aldehydes	✔	✔	
IMINES AND OXIMES			
Imines to amines	✔	✔	
Oximes to amines	✔	✔	
OXIDATION AND DEHALOGENATION			
Alcohols to aldehydes and ketones	✔	✔	
Dehalogenation X = Cl, Br, I		✔	

Additionally, Heraeus offers the customization and fine-tuning of a catalyst to find the most suitable fit for your application.

Catalysts on other support materials (alumina, titania, silica, etc.) and shapes (pellets, granules, etc.) are available. Contact us and we guide you to the most efficient option for your process including type, precious metal loading and recommended operating conditions.

Contact us – we guide you

Around the Globe … and Around the Clock

About Heraeus Precious Metals

Heraeus Precious Metals is globally leading in the precious metals industry. The company is part of the Heraeus Group and covers the value chain from trading to precious metals products to refining and recycling. It has extensive expertise in all platinum group metals as well as gold and silver.

With more than 3,000 employees at 16 sites worldwide, Heraeus Precious Metals offers a broad portfolio of products that are essential for many industries such as the automotive, chemicals, semiconductor, pharmaceutical, hydrogen and jewelry industry.

Precious Metal Catalysts – Footprint

Trading Locations

Production & Recycling Locations

R&D Innovation Centers

[1]Joint Venture

Circlear – Products Made with 100% Recycled Precious Metals

Using Circlear allows you to reduce your Scope 3 carbon footprint: Recycled precious metals enable circularity for these scarce resources and reduce the need for extraction of primary metals. Precious metals that are recovered using recycling processes have the same high quality and purity. Their major benefit is the significantly reduced carbon footprint – up to 99%* lower than that of primary metals. They therefore have a lower adverse impact on the environment and biodiversity.

All Circlear precious metals are 100% recycled, originating from secondary sources such as spent chemical or automotive catalysts. This is verified and audited by TÜV Süd in accordance with ISO 14021.

* based on data from “The Life Cycle Assessment of Platinum Group Metals” by the International Platinum Group Metals Association (IPA), Reference Year 2022

We conserve resources and promote a circular economy.

RESOURCES are **precious** to us

Our pledge to RESPONSIBILITY

PEOPLE are **precious** to us

CLIMATE is **precious** to us

We prioritize people's well-being and interests.

We decarbonize our business.

Heraeus Precious Metals

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