Precious Metal Compounds and Catalysts

INCLUDING:

- Compounds and Homogeneous Catalysts
- Supported & Unsupported Heterogeneous Catalysts
- Fuel Cell Grade Products
- FibreCat™ Anchored Homogeneous Catalysts
- Precious Metal Scavenger Systems

Alfa Aesar

Where Science Meets Service

www.alfa.com

Precious Metal Compounds and Catalysts from Alfa Aesar

When you order Johnson Matthey precious metal chemicals or catalyst products from Alfa Aesar, you can be assured of Johnson Matthey quality and service through all stages of your project. Alfa Aesar carries a full range of Johnson Matthey catalysts in stock in smaller catalog pack sizes and semi-bulk quantities for immediate shipment. Our worldwide plants have the stock and manufacturing capability to meet your needs when it is time to scale up. All products are lot-traceable to ensure you get the specific material you need.

As a leading manufacturer and supplier of PGM homogeneous and heterogeneous catalysts, Johnson Matthey offers toll and custom manufacturing, as well as refining and analytical services. Johnson Matthey is developing new catalytic materials for applications such as pharmaceuticals, fuel cells, sensors, automobiles, batteries, photographic materials, specialized plating, and catalyst manufacture.

Alfa Aesar

Table of Contents

About Us

GLOBAL INVENTORY

The majority of our compounds, catalysts and related products are available in research and development quantities from stock. We also supply most products from stock in semi-bulk or bulk quantities. Many are in regular production and are available in bulk for next day shipment. Our experience in manufacturing, sourcing and handling a wide range of products enables us to respond quickly and efficiently to your needs.

CUSTOM SYNTHESIS

We offer flexible custom manufacturing services with the assurance of quality and confidentiality. We can deliver the chemical you need in sizes for research, pilot-scale and full-scale production applications.

CUSTOMER SERVICE

Our dedicated scientific and commercial teams offer full service from production to delivery. Most products are stocked in catalog pack sizes and the majority are available from stock in semi-bulk and bulk quantities as well. All specialty and bulk products are shipped with a batch specific certificate of analysis and material safety data sheet. Because we understand that specific packaging is often important, we offer custom packaging and labeling to meet your requirements.

QUALITY CONTROL

We employ advanced quality control for both in-process and final product testing phases. The high standard of our modern quality control and assurance facilities is matched by the expertise of our experienced staff.

How to Order/ General Information

ORDERING
There is no minimum order. All orders are accepted, regardless of size.

PRICING
Most current pricing may be found at our website: www.alfa.com. In cases where the selling price has changed significantly, we will contact you prior to filling your web, email or faxed order. Our payment terms are net 30 days of invoice.

SHIPPING
Whenever possible, we will ship products by the method specified on your order.

TECHNICAL SERVICE
At your request, we will furnish technical assistance and information with respect to our products. Our Technical Service Representatives are trained in specific product lines to answer your questions regarding applications, specifications, product properties and handling.

MATERIAL SAFETY DATA SHEETS
Each product ordered is automatically accompanied by a Material Safety Data Sheet (MSDS). If one is not immediately available, a copy will be sent via mail as soon as possible. If an MSDS is needed prior to shipment of a product please call us or visit our MSDS website at www.alfa.com/en/go160w.pgm#msds.

CERTIFICATES OF ANALYSIS
Lot specific Certificates of analysis are available online at www.alfa.com. Please contact us by phone, fax or email to request Certificates of Analysis as needed.

RETURN SHIPMENTS
Some materials are not returnable. Returned shipments cannot be accepted unless prior arrangements have been made. Requests for return authorization must be made within 30 days of your receiving the materials. Restocking fees may be charged on authorized returns.

TERMS OF SALE

Full details of Terms and Conditions are listed on our website (www.alfa.com). For health and safety reasons, wes hall not supply chemicals to private individuals or deliver to residential addresses. Orders will bea ccepted from legitimate business customers only.

NEW CUSTOMERS
We welcome new customers and setting up an account with Alfa Aesar is easy. Just contact us and a customer service representative will assist you.

Abbreviations and Codes

The following abbreviations are used throughout our listing of products.

Å	Angstrom
AAS	Atomic absorption spectrometry
ACS	Chemicals meeting the specifications outlined by the American Chemical Society
AES	Atomic emission spectrometry
APS	Average particle size
anhy	Anhydrous
approx.	Approximately
aq.	Aqueous
Atm	Atmospheres
b.p.	Boiling point in °C at 760mm pressure, unless otherwise specified
(c)	Contained weight of active material
°C	Celsius
ca	Circa
cc	Cubic centimeter
cm	Centimeter
cont.	Contained
cP	Centipoise
cS	Centistoke
d.	Density
dec.	Decomposes
dia.	Diameter
ea.	Each
ee	Enatiomeric excess
eV	Electron volt
°F	Fahrenheit
f.p.	Flash point
FSSS	Fisher sub-sieve sizer
F.W.	Formula weight
g	Gram
g/l	Grams per liter (gas density)
GC	Gas chromotography
GLC	Suitable for use in gas liquid chromotography
HPLC	High-performance liquid chromotography
ICP	Inductively Coupled Plasma
ID	Inner diameter
in	Inch
incl	Includes
IR	Infrared
J/mol·K	Joule(s) per mole Kelvin
kg	Kilogram
L or l	Liter
lb	Pound
µ	Micro
µg	Microgram
µm	Micrometer (micron)
m	Meter
M	Molarity of solution
max	Maximum
meq	Milliequivalent
Merck	The Merck Index
mg	Milligram
micron	Micrometer
min.	Minimum
ml	Milliliter
mm	Millimeter
mmol	Millimole
Mn	Number averaged molecular weight
mol	Mole
m.p.	Melting point
M.W.	Molecular weight
Mw	Weighted averaged molecular weight
Mw/Mn	Monodispersity value
(N)	Nematic phase of a liquid crystal

N	Normality of solution
n_D^{20}	Refractive index for the sodium D line at 20 °C (or temperature indicated)
nm	Nanometer
NEW!	New product
NMR	Nuclear magnetic resonance
OD	Outer diameter
oz	Ounce
optical gr.	Suitable for optical applications
pc(s)	Piece(s)
pH	Value taken to represent the acidity or alkalinity of an aqueous solution
POR	Price on request
ppb	Parts per billion
ppm	Parts per million
prec.	Precipitated
Primary Standard	Analytical reagent of exceptional purity, for standardizing volumetric solutions and preparing reference standards
P.T.	Passes test
PTFE	Poly(tetrafluoroethylene)
Purified	A grade of higher quality than technical, often used where there are no official standards
P.V.	Pore volume
Reagent	Reagent grade
REM	Rare earth metal
(REO)	Rare earth oxide base - content of specific rare earth element in comparison to total rare earths present
S.A.	Surface area
soln.	Solution
Sp.Gr.	Specific gravity
Sp.Rot.	Specific rotation
stab.	Stabilized
subl.	Sublimes
Tc	Critical temperature
tech.	Technical grade
TLC	Thin-layer chromotography
TSCA	Toxic Substance Control Act
UN	Hazardous material transportation identification number
λ	Wavelength in nanometers
wt	Weight
w/w	Weight/weight
w/v	Weight/volume
XRD	X-ray diffraction
△	Air sensitive
◪	Moisture sensitive
■	Hygroscopic
▲	Light sensitive
≈	Approximately
>	Greater than
≥	Greater than or equal to
<	Less than
≤	Less than or equal to
[ ]	Numbers in brackets after the chemical description indicate the Chemical Abstract Service Registry Number
- mesh #	90% particles pass through screen having a given mesh size
+ mesh #	90% particles are retained by a screen having a given mesh size
†	Denotes substance is listed in Toxic Substance Control Act (TSCA) inventory

Alfa Aesar

Periodic Table of Elements

Visit Our Website at
www.alfa.com

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1.00794 1 **H** $1s^1$ bp: -252.87°C d: 0.089 g/l Hydrogen																	4.002602 2 **He** $1s^2$ bp: -268.9°C d: 0.179 g/l Helium
6.941 3 **Li** [He] $2s^1$ mp: 180.5°C d: 0.53 g/cc Lithium	9.012182 4 **Be** [He] $2s^2$ mp: 1287°C d: 1.848 g/cc Beryllium											10.811 5 **B** [He] $2s^2 2p^1$ mp: 2076°C d: 2.46 g/cc Boron	12.0107 6 **C** [He] $2s^2 2p^2$ mp: 3527°C d: 2.26 g/cc Carbon	14.0067 7 **N** [He] $2s^2 2p^3$ bp: -195.8°C d: 1.25 g/l Nitrogen	15.9994 8 **O** [He] $2s^2 2p^4$ bp: -182.9°C d: 1.43 g/l Oxygen	18.9984032 9 **F** [He] $2s^2 2p^5$ bp: -188.1°C d: 1.696 g/l Fluorine	20.1797 10 **Ne** [He] $2s^2 2p^6$ bp: -246.1°C d: 0.8999 g/l Neon
22.989769 11 **Na** [Ne] $3s^1$ mp: 97.72°C d: 0.968 g/cc Sodium	24.3050 12 **Mg** [Ne] $3s^2$ mp: 650°C d: 1.738 g/cc Magnesium											26.981539 13 **Al** [Ne] $3s^2 3p^1$ mp: 660.3°C d: 2.70 g/cc Aluminum	28.0855 14 **Si** [Ne] $3s^2 3p^2$ mp: 1414°C d: 2.33 g/cc Silicon	30.973762 15 **P** [Ne] $3s^2 3p^3$ mp: 44.2°C d: 1.82 g/cc Phosphorus	32.065 16 **S** [Ne] $3s^2 3p^4$ mp: 115.21°C d: 1.96 g/cc Sulfur	35.453 17 **Cl** [Ne] $3s^2 3p^5$ bp: -34.0°C d: 3.21 g/l Chlorine	39.948 18 **Ar** [Ne] $3s^2 3p^6$ bp: -185.8°C d: 1.784 g/l Argon
39.0983 19 **K** [Ar] $4s^1$ mp: 63.4°C d: 0.856 g/cc Potassium	40.078 20 **Ca** [Ar] $4s^2$ mp: 842°C d: 1.55 g/cc Calcium	44.955912 21 **Sc** [Ar] $3d^1 4s^2$ mp: 1541°C d: 2.985 g/cc Scandium	47.867 22 **Ti** [Ar] $3d^2 4s^2$ mp: 1668°C d: 4.507 g/cc Titanium	50.9415 23 **V** [Ar] $3d^3 4s^2$ mp: 1910°C d: 6.11 g/cc Vanadium	51.9961 24 **Cr** [Ar] $3d^5 4s^1$ mp: 1907°C d: 7.14 g/cc Chromium	54.938045 25 **Mn** [Ar] $3d^5 4s^2$ mp: 1246°C d: 7.47 g/cc Manganese	55.845 26 **Fe** [Ar] $3d^6 4s^2$ mp: 1538°C d: 7.87 g/cc Iron	58.933195 27 **Co** [Ar] $3d^7 4s^2$ mp: 1495°C d: 8.90 g/cc Cobalt	58.6934 28 **Ni** [Ar] $3d^8 4s^2$ mp: 1455°C d: 8.908 g/cc Nickel	63.546 29 **Cu** [Ar] $3d^{10} 4s^1$ mp: 1084°C d: 8.92 g/cc Copper	65.38 30 **Zn** [Ar] $3d^{10} 4s^2$ mp: 419.5°C d: 7.14 g/cc Zinc	69.723 31 **Ga** [Ar] $3d^{10} 4s^2 4p^1$ mp: 29.8°C d: 5.90 g/cc Gallium	72.64 32 **Ge** [Ar] $3d^{10} 4s^2 4p^2$ mp: 938.3°C d: 5.32 g/cc Germanium	74.92160 33 **As** [Ar] $3d^{10} 4s^2 4p^3$ 817°C subl. d: 5.73 g/cc Arsenic	78.96 34 **Se** [Ar] $3d^{10} 4s^2 4p^4$ mp: 221°C d: 4.82 g/cc Selenium	79.904 35 **Br** [Ar] $3d^{10} 4s^2 4p^5$ bp: 59.47°C d: 3.12 g/cc Bromine	83.798 36 **Kr** [Ar] $3d^{10} 4s^2 4p^6$ bp: -157.36°C 3.73 g/l Krypton
85.4678 37 **Rb** [Kr] $5s^1$ mp: 39.3°C d: 1.532 g/cc Rubidium	87.62 38 **Sr** [Kr] $5s^2$ mp: 777°C d: 2.64 g/cc Strontium	88.90585 39 **Y** [Kr] $4d^1 5s^2$ mp: 1526°C d: 4.47 g/cc Yttrium	91.224 40 **Zr** [Kr] $4d^2 5s^2$ mp: 1855°C d: 6.51 g/cc Zirconium	92.90638 41 **Nb** [Kr] $4d^4 5s^1$ mp: 2477°C d: 8.57 g/cc Niobium	95.96 42 **Mo** [Kr] $4d^5 5s^1$ mp: 2623°C d: 10.28 g/cc Molybdenum	98 43 **Tc** [Kr] $4d^5 5s^2$ mp: 2157°C d: 11.50 g/cc Technetium	101.07 44 **Ru** [Kr] $4d^7 5s^1$ mp: 2334°C d: 12.37 g/cc Ruthenium	102.90550 45 **Rh** [Kr] $4d^8 5s^1$ mp: 1964°C d: 12.45 g/cc Rhodium	106.42 46 **Pd** [Kr] $4d^{10}$ mp: 1554.9°C d: 12.02 g/cc Palladium	107.8682 47 **Ag** [Kr] $4d^{10} 5s^1$ mp: 961.8°C d: 10.49 g/cc Silver	112.411 48 **Cd** [Kr] $4d^{10} 5s^2$ mp: 321.1°C d: 8.65 g/cc Cadmium	114.818 49 **In** [Kr] $4d^{10} 5s^2 5p^1$ mp: 156.6°C d: 7.31 g/cc Indium	118.710 50 **Sn** [Kr] $4d^{10} 5s^2 5p^2$ mp: 231.9°C d: 7.31 g/cc Tin	121.760 51 **Sb** [Kr] $4d^{10} 5s^2 5p^3$ mp: 630.6°C d: 6.69 g/cc Antimony	127.60 52 **Te** [Kr] $4d^{10} 5s^2 5p^4$ mp: 449.5°C d: 6.24 g/cc Tellurium	126.90447 53 **I** [Kr] $4d^{10} 5s^2 5p^5$ mp: 113.7°C d: 4.94 g/cc Iodine	131.293 54 **Xe** [Kr] $4d^{10} 5s^2 5p^6$ mp: -108°C d: 5.89 g/l Xenon
132.905452 55 **Cs** [Xe] $6s^1$ mp: 28.4°C d: 1.88 g/cc Cesium	137.327 56 **Ba** [Xe] $6s^2$ mp: 727°C d: 3.51 g/cc Barium	57-71 **La-Lu**	178.49 72 **Hf** [Xe] $4f^{14} 5d^2 6s^2$ mp: 2233°C d: 13.31 g/cc Hafnium	180.94788 73 **Ta** [Xe] $4f^{14} 5d^3 6s^2$ mp: 3017°C d: 16.65 g/cc Tantalum	183.84 74 **W** [Xe] $4f^{14} 5d^4 6s^2$ mp: 3422°C d: 19.25 g/cc Tungsten	186.207 75 **Re** [Xe] $4f^{14} 5d^5 6s^2$ mp: 3186°C d: 21.02 g/cc Rhenium	190.23 76 **Os** [Xe] $4f^{14} 5d^6 6s^2$ mp: 3033°C d: 22.61 g/cc Osmium	192.217 77 **Ir** [Xe] $4f^{14} 5d^7 6s^2$ mp: 2446°C d: 22.56 g/cc Iridium	195.084 78 **Pt** [Xe] $4f^{14} 5d^9 6s$ mp: 1768.4°C d: 21.09 g/cc Platinum	196.966569 79 **Au** [Xe] $4f^{14} 5d^{10} 6s^1$ mp: 1064.2°C d: 19.30 g/cc Gold	200.59 80 **Hg** [Xe] $4f^{14} 5d^{10} 6s^2$ bp: 356.73°C d: 13.534 g/cc Mercury	204.3833 81 **Tl** [Xe] $4f^{14} 5d^{10} 6s^2 6p^1$ mp: 304°C d: 11.85 g/cc Thallium	207.2 82 **Pb** [Xe] $4f^{14} 5d^{10} 6s^2 6p^2$ mp: 327.5°C d: 11.34 g/cc Lead	208.98040 83 **Bi** [Xe] $4f^{14} 5d^{10} 6s^2 6p^3$ mp: 271.3°C d: 9.78 g/cc Bismuth	[209] 84 **Po** [Xe] $4f^{14} 5d^{10} 6s^2 6p^4$ mp: 254°C d: 9.20 g/cc Polonium	[210] 85 **At** [Xe] $4f^{14} 5d^{10} 6s^2 6p^5$ mp: 302°C d: none Astatine	[222] 86 **Rn** [Xe] $4f^{14} 5d^{10} 6s^2 6p^6$ bp: -61.7°C d: 9.73 g/cc Radon
[223] 87 **Fr** [Rn] $7s^1$ mp: 27°C d: 2.29 g/cc Francium	[226] 88 **Ra** [Rn] $7s^2$ mp: 700°C d: 5.00 g/cc Radium	89-103 **Ac-Lr**	[261] 104 **Rf** [Rn] $5f^{14} 6d^2 7s^2$ mp: none d: none Rutherfordium	[262] 105 **Db** [Rn] $5f^{14} 6d^3 7s^2$ mp: none d: none Dubnium	[266] 106 **Sg** [Rn] $5f^{14} 6d^4 7s^2$ mp: none d: none Seaborgium	[264] 107 **Bh** [Rn] $5f^{14} 6d^5 7s^2$ mp: none d: none Bohrium	[277] 108 **Hs** [Rn] $5f^{14} 6d^6 7s^2$ mp: none d: none Hassium	[268] 109 **Mt** [Rn] $5f^{14} 6d^7 7s^2$ mp: none d: none Meitnerium	[271] 110 **Ds** [Rn] $5f^{14} 6d^9 7s^1$ mp: none d: none Darmstadtium	[272] 111 **Rg** [Rn] $5f^{14} 6d^{10} 7s^1$ mp: none d: none Roentgenium	[285] 112 **Cn** [Rn] $5f^{14} 6d^{10} 7s^2$ mp: none d: none Copernicium	[284] 113 **Uut** [Rn] $5f^{14} 6d^{10} 7s^2 7p^1$ mp: none d: none Ununtrium	[289] 114 **Uuq** [Rn] $5f^{14} 6d^{10} 7s^2 7p^2$ mp: none d: none Ununquadium	[288] 115 **Uup** [Rn] $5f^{14} 6d^{10} 7s^2 7p^3$ mp: none d: none Ununpentium	[293] 116 **Uuh** [Rn] $5f^{14} 6d^{10} 7s^2 7p^4$ mp: none d: none Ununhexium	ISO 9001:2008 ISO 14001:2004 BS OHSAS 18001:2007 Certified	
		138.90547 57 **La** [Xe] $5d^1 6s^2$ mp: 920°C d: 6.15 g/cc Lanthanum	140.116 58 **Ce** [Xe] $4f^1 5d^1 6s^2$ mp: 795°C d: 6.69 g/cc Cerium	140.90765 59 **Pr** [Xe] $4f^3 6s^2$ mp: 935°C d: 6.64 g/cc Praseodymium	144.242 60 **Nd** [Xe] $4f^4 6s^2$ mp: 1024°C d: 6.8 g/cc Neodymium	[145] 61 **Pm** [Xe] $4f^5 6s^2$ mp: 1100°C d: 7.26 g/cc Promethium	150.36 62 **Sm** [Xe] $4f^6 6s^2$ mp: 1072°C d: 7.35 g/cc Samarium	151.964 63 **Eu** [Xe] $4f^7 6s^2$ mp: 826°C d: 5.24 g/cc Europium	157.25 64 **Gd** [Xe] $4f^7 5d^1 6s^2$ mp: 1312°C d: 7.90 g/cc Gadolinium	158.92535 65 **Tb** [Xe] $4f^9 6s^2$ mp: 1356°C d: 8.22 g/cc Terbium	162.500 66 **Dy** [Xe] $4f^{10} 6s^2$ mp: 1407°C d: 8.55 g/cc Dysprosium	164.93032 67 **Ho** [Xe] $4f^{11} 6s^2$ mp: 1461°C d: 8.79 g/cc Holmium	167.259 68 **Er** [Xe] $4f^{12} 6s^2$ mp: 1529°C d: 9.07 g/cc Erbium	168.93421 69 **Tm** [Xe] $4f^{13} 6s^2$ mp: 1545°C d: 9.32 g/cc Thulium	173.054 70 **Yb** [Xe] $4f^{14} 6s^2$ mp: 824°C d: 6.57 g/cc Ytterbium	174.9668 71 **Lu** [Xe] $4f^{14} 5d\ 6s^2$ mp: 1652°C 9.84 g/cc Lutetium	
		[227] 89 **Ac** [Rn] $6d^1 7s^2$ mp: 1050°C d: 10.07 g/cc Actinium	232.03806 90 **Th** [Rn] $6d^2 7s^2$ mp: 1842°C d: 11.72 g/cc Thorium	231.03588 91 **Pa** [Rn] $5f^2 6d^1 7s^2$ mp: 1568°C d: 15.37 g/cc Protactinium	238.02891 92 **U** [Rn] $5f^3 6d^1 7s^2$ mp: 1132.3°C d: 19.05 g/cc Uranium	[237] 93 **Np** [Rn] $5f^4 6d^1 7s^2$ mp: 637°C d: 20.45 g/cc Neptunium	[244] 94 **Pu** [Rn] $5f^6 7s^2$ mp: 639.4°C d: 19.81 g/cc Plutonium	[243] 95 **Am** [Rn] $5f^7 7s^2$ mp: 1176°C d: 13.67 g/cc Americium	[247] 96 **Cm** [Rn] $5f^7 6d^1 7s^2$ mp: 1340°C d: 13.51 g/cc Curium	[247] 97 **Bk** [Rn] $5f^9 7s^2$ mp: 986°C d: 14.78 g/cc Berkelium	[251] 98 **Cf** [Rn] $5f^{10} 7s^2$ mp: 900°C d: 15.10 g/cc Californium	[252] 99 **Es** [Rn] $5f^{11} 7s^2$ mp: 860°C d: 8.84 g/cc Einsteinium	[257] 100 **Fm** [Rn] $5f^{12} 7s^2$ mp: 1527°C d: none Fermium	[258] 101 **Md** [Rn] $5f^{13} 7s^2$ mp: 827°C d: none Mendelevium	[259] 102 **No** [Rn] $5f^{14} 7s^2$ mp: 827°C d: none Nobelium	[262] 103 **Lr** [Rn] $5f^{14} 6d\ 7s^2$ mp: 1627°C d: none Lawrencium	

Key

1.00794 1
H
$1s^1$
bp: -259.3°C
d: 0.088 g/l
Hydrogen

- Element
- Density
- Boiling or Melting Point in °C
- Electron Configuration
- Symbol
- Atomic Weight
- Atomic Number

Catalysis and Catalysts

By Martyn V. Twigg, Chief Scientist, Johnson Matthey

1. Introduction

Catalysis impinges on every aspect of modern life: the availability of a plentiful supply of food free from the ravages of pests, drugs that cure illnesses, fuels for transport, maintaining a clean, safe environment, even the very fibers of our clothes and their colors all critically depend on catalysis in their manufacture. Johnson Matthey supplies the entire range of catalysts for all these industrial processes as well as those mainly intended for laboratory work listed in this catalog.

Catalysts enable chemical reactions to take place that otherwise would only take place slowly, and in some instances so slowly they would effectively not take place at all in the absence of a catalyst. Platinum was the first heterogeneous catalyst to be discovered, and all of the platinum group metals (PGMs) show very high catalytic activity. Their study has been key to understanding and the overall development of the subject of catalysis. This article outlines the discovery of heterogeneous catalysis and its early development, and goes on to discuss unsupported metal catalysts, supported metal catalysts, and soluble homogeneous catalysts that can offer extraordinary activity and selectivity. Where possible some indication is given about the practical applications of the catalysts discussed, and references are made to some sources of further information.

2. Historical Aspects

Sir Humphrey Davy discovered [1] the amazing catalytic properties of platinum in 1817, the same year as the company that was to become Johnson Matthey was established [2]. He found a coil of heated platinum wire became white hot when placed in a mixture of domestic “town gas” and air. Flameless catalytic combustion was seen for the first time, and in so doing Sir Humphry Davy became the founding father of heterogeneous catalysis [3]. He also showed ethanol vapor is selectively oxidized over platinum to acetaldehyde and water. Today Johnson Matthey manufactures platinum alloy wires that are used industrially for the selective oxidation of ammonia to nitric oxide for nitric acid production [4], and to produce hydrogen cyanide from ammonia and methane [5].

Later, in 1820, Sir Humphry’s cousin, Edmund Davy, reported the preparation of finely divided platinum “black” that he made by reducing a hot platinum sulfate solution with ethanol. He showed ethanol vapor in air is readily oxidized to acetaldehyde over platinum black, and this in turn is oxidized to acetic acid [6]. Platinum black, the first heterogeneous powder catalyst, was more active than platinum wire because it had a much higher surface area. Later platinum black was prepared by reducing a platinum salt solution with formaldehyde [7]. Catalytically this was very active, and it was used in numerous hydrogenation reactions, but its preparation was not always reproducible and its colloidal nature made it difficult to separate from reaction mixtures. A little more than a century after Edmund Davy’s original report on the preparation of platinum black, Voorhees and Adams overcame some of its practical difficulties with the introduction of what became known as Adams’ Catalyst [8]. More recently, a range of soluble homogeneous metal complexes was introduced as catalysts [9]. Amongst the first were rhodium-based hydrogenation and alkene hydroformylation catalysts. Others later catalyzed a range of carbon-carbon bond forming reactions that began a revolution in organic syntheses.

3. General Catalyst Requirements

All successful industrial catalysts need to have the following properties optimized as much as possible [10]. The longevity of a catalyst used industrially is important [11], although for small-scale laboratory preparations is less vital. High activity and high selectivity is always important.

(a) High activity - enables a minimum volume of catalyst to be used in order to minimize process costs. It is interesting to note that most industrial catalyst fixed-bed reactors operate under conditions where diffusion effects are just beginning to control the overall reaction rate. High activity gives fast chemical reaction rates and short reaction times that maximize production throughput.

(b) High selectivity - provides maximum yield of the desired product and eliminates unwanted by-products. This reduces isolation and purification costs, and improves overall efficiency.

(c) Long life - a catalyst with high activity and high selectivity can only be successful commercially if it also has a sufficiently long operational life. This is a key aspect of the design and manufacture of successful industrial catalysts. Often long life is obtained through proprietary manufacturing processes. The main factors involved are resistance to sintering that reduces surface area of the active phase, and tolerance to catalyst poisons. The poison tolerance can be obtained, for example, by incorporating species that keep them away from the active centers.

(d) High catalyst recycle capability - It is important to easily separate the catalyst from the final product, and reuse it if this is appropriate. Effectively this is what happens continually in fixed bed reactors, but this is not the case with batch reactors. Catalyst utilization is maximized and effective costs are minimized if the catalysts is easily and rapidly reused. Recovery and recycling of spent catalyst is important with PGM catalysts.

(e) Economic considerations - A catalyst with the key technical requirements also needs to be cost effective. Johnson Matthey manufactures both base metal and PGM catalysts. PGM catalysts are widely used in chemical processes ranging from gas phase oxidations through selective hydrogenation of chemical and petrochemical feedstocks, and pharmaceutical intermediates through to fuel cells for electrical power generation. All of the PGMs have catalytic properties, and platinum, palladium, rhodium and ruthenium are the most widely used. PGMs are more expensive than base metals, yet PGM catalysts are often more cost effective. This is because they are more active and selective so less metal is needed in a PGM catalyst than in a base-metal catalyst. Frequently less severe reaction conditions are required, leading to higher selectivity and additional cost savings. Moreover, often PGM catalysts can be reused many times, and the spent catalyst can be reprocessed into fresh catalyst. With our considerable experience and expertise in the manufacture of catalysts and in catalyst technology in general, Johnson matthey always welcomes the opportunity to develop new catalyst systems to meet your unique requirements, be they PGM or base-metal catalysts.

4. Unsupported Metal Catalysts

Compared to supported catalysts based on, for example, alumina or silica supports, that are discussed below, unsupported metal powders generally have only modest surface areas per gram. However, because of their much higher densities and oxide supports, metal powders can provide high surface areas per unit volume, and this is especially true for PGM metal powders [12]. Some features of unsupported metal catalysts include:

(a) Practical advantages - On a volume basis, unsupported metal catalysts provide a high surface area without the presence of any other material. Thus it can be beneficial to use a PGM in an unsupported form where a support could cause side reactions or product retention by absorption, or a reaction may only proceed in the absence of a support, perhaps owing to the larger crystallite size of the finely divided metal in the unsupported form. An unusual example of the use of platinum black is to catalytically decompose excess hydrogen peroxide after oxidation of an organic compound [13].

(b) Thermal stability - Usually unsupported metals readily sinter, and copper is a good example of this. Even when optimally supported, copper catalysts usually only have long lives when they are operated at temperatures well below 350°C. The reasons for this are related to the low melting point of copper that permits ready sintering of small metal crystallites into larger ones with less overall surface area. The high melting points of PGMs make their fine powders more resistant to sintering. This coupled with high intrinsic activity gives them greater utility than their base-metal counterparts as unsupported catalysts.

(c) Safety considerations - Care must be taken when using any PGM catalyst because they are so active they can cause organic vapor/air mixtures to explode so solids containing them should not be allowed to dry on a filter. Filter papers with PGM on them can start burning when dry. It is therefore prudent to keep catalyst residues washed free of organics and stored underwater, until sufficient accumulated residues are available to be sent for PGM recovery.

Adams' Catalyst is a good example of an unsupported catalyst. As previously noted, Voorhees and Adams' overcame some of the practical difficulties of colloidal platinum black as a catalyst with the introduction of what became known as Adams' Catalyst. This is actually a hydrated platinum dioxide that is easily reduced by hydrogen to give a very active form of platinum [8]. This is not only very active, but is easily separated from reaction products by filtration. Adams' catalyst is still widely used in liquid phase organic hydrogenations that are often conveniently carried out at atmospheric pressure. A variety of hydrogenation and oxidation reactions are catalyzed by Adams' catalyst, including clean deuterium/hydrogen exchange, in many types of organic compounds. The range of unsupported metal catalysts offered in the Alfa Aesar catalog includes a range of platinum oxides (including Adams' Catalyst), the oxides of the other platinum group metals, and a number of metal "blacks".

5. Supported Catalysts

Supported catalysts have several advantages over unsupported catalysts including:

(a) Good activity and longer life - resulting from stabilization of highly dispersed small, metal crystallites. Crystallites in the pore structures of support materials are physically separated from each other and this markedly inhibits sintering and loss of active metal surface area.

(b) Higher temperature option - The enhanced resistance to thermal sintering permits the possibility of higher temperature operation, and this can mean less metal is required than otherwise would be the case. As a result supported catalysts are often more active than unsupported catalysts containing more metal.

(c) Fixed-bed operation - Separation of catalytic and physical properties enables active catalysts to have high strength and low pressure-drop characteristics. Some examples include catalysts used in tubular reactors such as multi-hole natural gas steam reforming and ethene to ethylene oxide oxidation catalysts.

(d) Product separation - Powder supported catalysts are easily separated from reaction mixtures, and formed supported catalysts can be used in fixed beds that enable continuous operation.

(e) Cost effective - Supported catalysts can be much more cost effective than unsupported catalysts. For example, one cost reduction technique is to have very small PGM crystallites located only in the outer regions of powder grains, pellets or sphere supports.

The major factors affecting the properties of a supported heterogeneous catalyst are the nature of the support material used, and the location of the metal on and/or within its pore structure. An important function of the support is to keep very small metal crystallites well separated on its extended surface area to provide stable high activity. Supports can also be preformed into special shapes most appropriate for particular fixed-bed reactors.

5.1 Support Selection - The selection of the best type of support for a particular metal in a specific reaction can be critical because the support can substantially alter the rate and course of the reaction. An example is the range of products obtained from mixtures of carbon monoxide and hydrogen over supported rhodium - the nature of the support directs the course of the reaction to give hydrocarbons or oxygenates [14]. The type and physical form of support used is largely determined by the actual reaction and the operating conditions. The pore structure of the support may modify the role of the metal since the course of a reaction is often greatly influenced by the rates of diffusion of reactants and products into and out of the catalyst pores. If the surface area of a support is not sufficiently high, it can limit the metal loading that can be usefully employed. Many of the commonly used catalyst supports, particularly carbons, silicas and aluminas, are available in a large range of particle sizes, each with a range of surface areas and pore size distributions. However, reaction conditions may sometimes limit the choice of support. The support should be stable at the temperature at which the catalysts is used, and it should not interact with the solvent, reactants or reaction products.

5.2 Precipitated and Impregnated Catalysts - With base metal catalysts high metal loadings are usually required because of their low specific activities, and such loadings cannot be easily achieved by the impregnation techniques often used to manufacture low loaded PGM catalysts. As a result many base-metal catalysts are made by methods in which metal and support precursors are precipitated together. After thermal processing and forming into suitable pellets or extrudates they are reduced in the reactor in which the catalyst is to be used. In contrast many supported base metal power catalysts are reduced as a part of their manufacturing process, and stabilized by a protective oxide film on the metal crystallites that is easily reduced in the reactor prior to use.

5.3 Reactor and Catalyst Types - Different reactors require different types of catalysts. The supports for them range from low surface area types with only a few m^2/g such as alpha-alumina rings to very high surface area materials such as activated carbons. Powder catalysts are usually used in stirred liquid phase reactions, while for fixed-bed reactors in gas phase or continuous liquid phase (trickle column) reactors, the choice is usually pelleted, spherical, extruded or granular supports. Pelleted and extruded supports are available in a wide variety of materials and shapes. Refractory ring or multiple hole supports are used in tubular reactors for high loaded nickel catalysts in high temperature steam reforming of hydrocarbons to produce hydrogen. Silver is used on related supports for the selective oxidation of ethene to ethylene oxide, also in tubular reactors. In the former reactors high heat transfer surface area is needed to supply heat to a highly endothermic reaction. In the latter it is necessary to remove heat from a highly exothermic reaction. In both situations ring catalysts are employed for improved geometric surface area and for pressure-drop considerations.

5.4 Powder Support Types - High surface area materials such as activated carbons are used for low loaded PGM catalysts in which the catalytic metal is present in the form of small discrete crystallites perhaps only a few atoms thick. These catalysts are operated at relatively low temperatures, and have a high level of available active metal surface area per unit weight of metal. They are therefore more cost effective than their unsupported counterparts. In most batch processes in the liquid phase where platinum group metal catalysts are used, a powdered support is the preferred choice [15]. The following types of support are the most commonly employed:

(a) Activated carbons - Activated carbon powder is the principal support for catalysts in liquid phase reactions. As the carbons are derived from naturally occurring materials there are many variations, each type having its own particular physical properties and chemical composition. The surface areas of carbons can range from 550m^2/g to over 1500m^2/g. Trace impurities that may be present in certain reactions can occasionally poison catalysts. The high absorptive power of carbons used as the catalyst support can enable such impurities to be removed, leading to longer catalyst life and higher purity products. Carbon-supported catalysts are produced in two physical forms, dry powder and wet powder. The latter form usually contains approximately 50% by weight of water, which is held within the pores of the carbon. There is no supernatant liquid and the water-wet catalyst has the consistency of a dry friable powder.

(b) Aluminas - Activated alumina powders have a lower surface area than most carbons, usually in the range of 75 m^2/g to 350 m^2/g. Alumina is a more easily characterized and a less absorptive materials than carbon, and alumina is also non-combustible. Alumina can be used instead of carbon when excessive absorption of reactants or products needs to be prevented and when its other intrinsic physical and chemical properties benefit the catalytic process.

(c) Kieselguhr - Also known as diatomaceous earth, it is a naturally occurring soft, high silica content sedimentary rock that typically contains about 86% SiO_2. Kieselguhr consists of the fossilized siliceous remains of diatoms, microscopic unicellular aquatic organisms. It has been frequently used as a catalyst support in the past, especially for nickel hydrogenation catalysts, and rather less for PGMs.

(d) Calcium carbonate - This mildly basic support is particularly suitable for palladium, especially when a selective catalyst is required. Since the surface area of calcium carbonate is low, its use is suitable when low absorption of a basic support is required. An example is the prevention of hydrogenolysis of carbon-oxygen bonds. In the lead-treated version of Lindlar's catalyst it is used to selectively hydrogenate alkynes to alkenes [16].

(e) Barium sulfate - Barium sulfate is another low surface area catalyst support. This is a dense material so catalyst made from it requires powerful agitation of the reaction mixture to ensure uniform dispersion of the catalyst. A palladium on barium sulfate catalyst was traditionally used for the conversion of acid chlorides to aldehydes (Rosenmund Reaction) together with an in-site poison to improve the selectivity. In this application, however, it is being replaced increasingly by palladium on carbon catalysts that give better, more reproducible results.

(f) Other powder supports - A variety of other supports are used to prepare powder catalysts for specific applications. These include barium carbonate, strontium carbonate, and various carbon blacks. Silicas and Kieselguhrs are used when supports of relatively low (compared to carbons) absorptive capacity are required, and silica-aluminas can be used when an acidic support is needed. Increasingly metal exchanged zeolites are used as selective catalysts, and the combination of platinum and a zeolite is used industrially in petrochemical processing.

5.5 Preformed Supports

The use of preformed supports to prepare catalysts by impregnation techniques is well suited for PGM catalysts, and it enables an easy separation of catalytic and physical properties. Commonly used shapes include extrudates, granules, pellets, spheres, rings, and multiple-hole shapes. They are prepared in a variety of ways that include pressing powders in a die, paste extrusion, and granulation techniques. The use of strong preformed supports in fixed bed reactors, as noted in

Section 5.3, enables catalytic reactions to be carried out continuously. Many vapor phase reactions have operated in this way on a huge industrial scale for many years, and some of these have been mentioned previously. The largest are those in refineries, hydrogen, ammonia, and methanol production. The advantages of fixed beds of catalyst have been successfully extended to liquid phase reactions by the use of trickle bed reactors. Since the formation of fine catalyst particles by attrition in all of these applications must be kept to a minimum, high physical integrity and mechanical strength are basic requirements of these catalysts, and the use of preformed supports provides this requirement very well.

When making catalyst from preformed supports the catalytically active metal may be deposited on the surface, into the surface or it may be homogeneously impregnated throughout the support depending on the requirements of the specific application. For most purposes with PGM catalysts, the diffusion of reactants into the catalyst pores is relatively slow compared to the catalytic reaction rate so surface impregnation is generally preferred for these catalysts. The quantity of PGM in such a catalyst depends on the nature of the support, and usually does not exceed 2% by weight. In contrast base metal impregnated catalysts can contain more than 20% by weight of the metal oxide before its reduction to the metal. This is because the intrinsic activity of base metals is usually lower than that of PGMs.

In some continuous gas/vapor-phase processes involving hydrocarbons, the catalyst may eventually become deactivated due to masking of the catalytic sites by the deposition of carbonaceous matter (coking). Often catalysts based on suitably robust supports are regenerated in-situ by the controlled oxidation of this coke, taking care to avoid large exotherms in the catalyst bed that could cause sintering of the active metal phase.

Some of the materials used commercially to prepare preformed supports are listed below:

(a) Aluminas - The most commonly used particulate preformed support. It is available in several phases with differing surface areas, and the most frequently used are gamma-alumina (typical surface area more than $100 m^2/g$), and high-fired alpha-alumina (with typical surface areas in the range $1\text{-}10\ m^2/g$). The type and form of the alumina support employed may play a vital role in determining the overall course of the catalyzed reaction. When a support of higher mechanical strength is required, or when a more inert support is necessary, alpha-alumina with a low surface area is used.

(b) Calcium aluminates and magnesium spinel - These low surface area supports are sometimes used in situations where alpha-alumina is favored but a more basic support is desired. They have been used for many years in hydrocarbon steam reforming applications.

(c) Carbons - Although not usually strong enough mechanically to withstand the arduous conditions encountered in industrial gas-phase reactions, granular and extruded carbon are particularly suitable for use in trickle bed reactors, and they are widely used in this area. In contrast to alumina-based catalysts that are often regenerated by an oxidation process, this must not be done with carbon-based catalysts because the carbon support itself would be oxidized.

6. Homogeneous Catalysts

Heterogeneous catalysis is well established and heterogeneous catalysts are widely used industrially. On the other hand homogeneous catalysis involving soluble transition metal complexes is much younger and such processes are not so widely employed. However, homogeneous catalysis has many appealing features especially those associated with selectivity. There are relatively few large-scale applications (Table 1 shows those involving PGM catalysts). The widespread commercialization of homogeneous catalysis has been hindered by difficulties with separation of product from catalyst, and the reuse of the catalyst [17]. Recently improved separation methods have been devised so this is no longer such a problem. This section provides some of the underlying fundamental chemistry, and details some of the more important areas in which homogeneous catalysts have been used in both the laboratory and industry.

Table 1. Selected Examples of Industrial Processes Based on Homogeneous PGM Catalysts

Process	Reaction	PGM Catalyst	Comments
Acetic acid from methanol	$CH_3OH + CO \rightarrow CH_3CO_2H$	Cobalt, rhodium, iridium	Cobalt catalysts require high pressure and temperature, whereas the rhodium-catalyzed reaction can be operated even at atmospheric pressure and the iridium catalyzed reaction offers process advantages.
Hydroformylation of alkenes	$RCH{=}CH_2 + CO/H_2 \rightarrow$ RCH2CH2CHO	Cobalt, rhodium	Oldest large-scale process using homogeneous transition metal catalysts. Normally the aldehyde products are hydrogenated to alcohols.
Oxidation of ethylene to acetaldehyde	$CH_2{=}CH_2 + O_2 \rightarrow CH_3CHO$	Palladium with copper	The Wacker process, important when acetylene-based processes were being replaced, now almost obsolete.
Hydrogenation of alkenes and aromatics		Rhodium, cobalt	Very many transition metal complexes catalyze alkene hydrogenation. $RhCl(PPh_3)_3$ is the most studied catalyst; use of chiral ligands can afford high-purity optically active products, eg, *l*-DOPA.
Codimerization of ethylene and butadiene to *trans*-1,4-hexadiene	$CH_2{=}CH_2 + CH_2{=}CHCH{=}CH_2$	Rhodium, nickel	A special case of alkene oligomerization. Oligomerization of alkenes and dienes to form dimers, trimers etc. is used extensively.

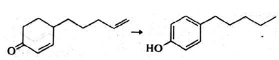
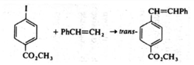
6.1 Background

What is commonly meant by “homogeneous catalysis” is a catalytic reaction where all of the components are in the liquid phase. Homogeneous catalysis by soluble transition metal complexes, and especially those containing platinum, palladium and rhodium, and increasingly ruthenium, is an area that has grown to be very important. They are used in small-scale laboratory preparations and increasingly in industrial areas especially in the pharmaceutical industry. Among the first industrial processes using these catalysts was alkene hydroformylation by a mixture of carbon monoxide and hydrogen [18]. This operated at very high pressures with a cobalt catalyst, and more recently with a rhodium catalyst that has greater selectivity and allows milder reaction conditions. Another large industrial scale process is the carbonylation of methanol to acetic acid that was introduced with a rhodium catalyst, and now has an improved iridium catalyst that offers process advantages.

6.2 Homogeneous Catalysis Advantages and Disadvantages

Homogeneous catalysis can provide many advantages, not the least being when it is the only way of achieving a transformation, as is the case with carbonylations [19]. Generally homogeneous catalysis provides an excellent choice where highly specific reactions are desired, that results from all of the active sites being the same. In contrast heterogeneous catalysts have many different kinds of surface sites, not all of which may lead to desired products. However, a heterogeneous catalyst is simple in use and separating it from product is straightforward. Separating product from a homogeneous catalyst can be more problematic because both are soluble in the solvent. Recent advances in process technologies have improved this situation, particularly in areas of product purification, catalyst separation and recycling. As a result the economics are changing in favor of homogeneous versus heterogeneous catalysis for routes to many fine chemicals. Table 2 shows some of the laboratory-scale transformations that can be achieved using homogeneous PGM catalysts. A wide variety of synthetically useful organic transformations can be achieved via homogeneous catalysis, and many preparative details have been collected together [9].

Table 2. Catalytic Applications of Selected Homogeneous PGM Catalysts - Illustrative Examples of Laboratory Scale Reactions

Transition metal catalyst	Reaction Type	Typical Conditions	Comments
$RhCl(PPh_3)_3$	$RCH{=}CH_2 + H \rightarrow RCH_2CH_3$	25°C, 1 bar	Excellent selectivity, insensitive to functional groups. Related catalysts with chiral ligands permit asymmetric hydrogenation of double bonds.
$RhCl_3{\cdot}3H_2O$		50-100°C, 1 bar, 2 h	$RhCl_3{\cdot}3H_2O$ in the presence of ethanol is a powerful catalyst for double-bond isomerizations forming conjugated systems.
$Pd(CH_3CO_2)_2$*		100°C, 2 h	One mole of base (eg, NEt_3) is needed to remove the HI. With bromides it is necessary to use $PdCl_2(PPh_3)_2$.
$PdCl_2(PPh_3)_2$	$(CH_3)_2CHNO_2 + 2CH_2{=}CHCH{=}CH_2 \rightarrow (CH_3)_2C(NO_2)CH{=}CH(CH_2)_3CH{=}CH_2$	50°C, 1 bar	General reaction of activated hydrogens, catalyzed by a number of palladium compounds.
$PdCl_2(PPh_3)_2$	$ArX + CO + ROH \rightarrow ArCO_2R + HX$	60-100°C	One mole of base (eg, NEt_3) needed to remove HX. Replacing the alcohol by an amine leads to formation of amides.

Generally diffusion of reactants in solution occurs more readily than diffusion into and out of the pores and within a supported catalyst in a liquid phase. Thus homogeneous catalysis is much more likely to be kinetically controlled than with a heterogeneous catalyst. There are several advantages of having kinetic control including better utilization of the active metal catalyst. The following is a summary of the main advantages of homogeneous catalysis:

(a) High selectivity - all of the catalytic sites are the same so they will all produce the same product, and by the correct choice of ligands it is possible to construct catalysts that can have extraordinary selectivity. For example, optically active products in at least 99% enantiomer excess can be obtained in some reactions when chiral catalysts are used.

(b) Effective metal utilization - being in solution, all of the catalytic metal centers are equally available to the reactants, and all of them participate in the catalytic cycles. In heterogeneous catalysts, only the surface, or near surface atoms are involved in catalysis.

(c) Tailored catalysts - by suitable modification of the ligands around the metal center it is possible to construct a selective catalyst for a specific reaction.

(d) Kinetically controlled reactions - having kinetic control, rather than mass transfer control of reaction rates, as is normally the case with heterogeneous catalysts, helps to provide better control of primary products.

(e) Temperature control - reactants, catalyst, and products are all in the liquid phase, so removal of heat is straightforward, and immediately affects the catalyzed reaction. As a result there is less chance of localized overheating.

6.3 Elementary Reactions

A huge amount of academic and industrial research has addressed the problem of understanding the interaction of metal coordination complexes with organic molecules. Extensive use has been made of analytical techniques in solution such as: nuclear magnetic resonance spectroscopy (NMR), infrared spectroscopy (IR), and Raman spectroscopy together with solid-state single-crystal X-ray studies. This has enabled a greater understanding of the interactions of ligands with metal centers and their overall contribution to increasing the rate and selectivities of catalytic processes. It is currently possible to improve these parameters systematically by altering the metal, its oxidation state, the ligands coordinated to the metal and the medium in which the reaction is carried out. There are eight elementary reactions that can be involved in homogeneous transition metal catalyzed reactions. These are detailed below together with alkene metathesis.

(a) Oxidative addition - Transition metals have access to different oxidation states, and they can reversibly acquire or supply electrons under mild conditions. For example, a sigma-antibonding orbital of an approaching molecule can accept electron density from a suitable metal orbital and form a three-center metal-ligand bond. Eventually complete dissociation of the original sigma-bond takes place and two new M-L bonds are formed between the metal and the resulting ligand fragments. The oxidation state of the metal center increases by two, and the overall reaction is referred to as “oxidative addition”. A concerted bond breaking and bond making mechanism is idealized, and many oxidative additions (especially with bonds to halogens) proceed via more complex ionic or radical mechanisms. Since both the coordination number and electron configuration of the metal increase in oxidative addition, the reaction is not possible for coordinatively saturated complexes. However, many coordinatively saturated complexes such as $Pd(PPh_3)_4$ undergo reversible dissociation in solution to give reactive unsaturated 16*e*- or 14*e*-complexes. The two-coordinate, 14*e*-complex $Pd(PPh_3)_2$, for example, although not isolable, is a key intermediate in an important series of catalytic reactions leading to aromatic carbonyl compounds. It is formed by dissociation either of $Pd(PPh_3)_4$ or of $Pd(PPh_3)_2(CO)_n$, and undergoes facile oxidative addition with bromo- and iodo-arenes.

(b) Nucleophilic attack by the metal - Although oxidative addition to a metal raises its formal oxidation state by two, the process also increases the total number of electrons associated with the metal by the same number. Oxidative addition cannot therefore occur if the metal center is already electronically saturated. If they are not also *coordinatively* saturated, such complexes can be metal-centered *nucleophiles* toward alkyl halides and other species containing electrophilic centers. The formal oxidation state of the metal again increases by two units, but the coordination of number increases by only one and the 18-electron configuration remains unchanged.

(c) Reductive elimination - This unimolecular decomposition is the reverse of oxidative addition; two “one-electron ligands” are lost from a metal center, and they combine to give a single elimination product. A concerted elimination clearly requires the combining ligands are *cis* to each other (although not all reductive eliminations are concerted), and in the product the coordination number and formal oxidation state of the metal are both reduced by two.

(d) Insertion - Carbon monoxide “insertion” into a metal-carbon bond was one of the first reactions of this type to be studied, and several other reactions in which a one-electron ligand migrates from the metal to an unsaturated ligand are now well established. In hydroformylation or hydroesterification a coordinated CO inserts itself into a metal-alkyl bond to give a M-(CO)-alkyl fragment. Similarly, alkyne ligands can insert into both M-H and M-C bonds, and the resulting vinyl ligands will then migrate to coordinated alkenes forming keto-alkyl ligands. The concerted mechanism of ligand migration requires a *cis* configuration of the combining ligands, and insertion is normally highly stereospecific. Insertion of carbon monoxide proceeds with complete retention of configuration at the migrating carbon atom, consistent with “front-side” attack implies by concerted migration. Insertion of alkenes or alkynes into M-H or M-C bonds should produce *syn* addition to the double or triple bond. Unless subsequent isomerizations intervene, insertion reactions can generate new organic molecules with a high degree of geometric and stereochemical specificity. There are, however, a number of insertion processes for which assignment of a concerted mechanism is inappropriate.

(e) α-and β-Eliminations - These elementary reactions are simply “reverse-insertions”, that is ligand-to-metal migrations. The description “α-” or “β-” refers to the number of carbon atoms from the metal at which ligand fragmentation occurs. Thus, reversal of the carbon monoxide insertion reaction involves migration of an alkyl or aryl ligand from the α-carbon to the metal and is therefore an α-elimination. Reversal of an alkene-hydride insertion, however, cleaves the alkyl ligand at the β-carbon and is thus a β-elimination. Both α- and β-eliminations increase the coordination number of the metal by one, so coordinatively saturated, kinetically stable complexes are not susceptible to this type of process. The presence of strongly bound ligands such as chelating phosphines and carbon monoxide in coordinatively saturated complexes can completely inhibit β-elimination of hydride from alkyl ligands. β-elimination generally occurs more readily, and is a major decomposition pathway for alkyl groups that have H substituents on the β-carbon atom. Other elimination reactions mostly occur when there is no H substituent on the β-carbon.

(f) Nucleophilic addition to a ligand - Coordination of a ligand enhances its susceptibility towards nucleophilic attack, and it should also be noted that the facility to delocalize charge over both metal and ligands results in a similarly enhanced reactivity to nucleophiles for many unsaturated ligands including alkenes, alkynes and arenes.

(g) Reductive displacement - Like reductive elimination and β-hydride elimination, reductive displacement is often the product-forming step of a catalytic cycle. It involves reductive cleavage of a metal-ligand bond and is a characteristic reaction of metal-acyl complexes under basic conditions. Depending on the system concerned, this reaction can result in formation of carboxylic acids, esters, amides, anhydrides, and acyl fluorides. The detailed machanism of reductive displacement varies from system to system: whereas reductive elimination of acyl halide, followed by hydrolysis or alcoholysis, occurs in some rhodium-catalyzed carbonylations, with certain palladium-based syntheses alcoholysis may occur at the metal *before* reductive elimination takes place.

(h) Ligand dissociation and replacement - A key step in any catalytic cycle is the simple metathetical replacement of one ligand by another. Examples are the replacement of a halide ligand by a carbanion or alkoxide anion, and the coordination of a carbon monoxide to a metal, which almost invariably requires displacement of another ligand, if only a solvent molecule. The facile exchange of neutral ligands such as phosphines, alkenes, and carbon monoxide at a kinetically labile metal center is in fact a prerequisite for effective homogeneous catalysis, and its occurrence in any catalytically active system can almost be taken for granted.

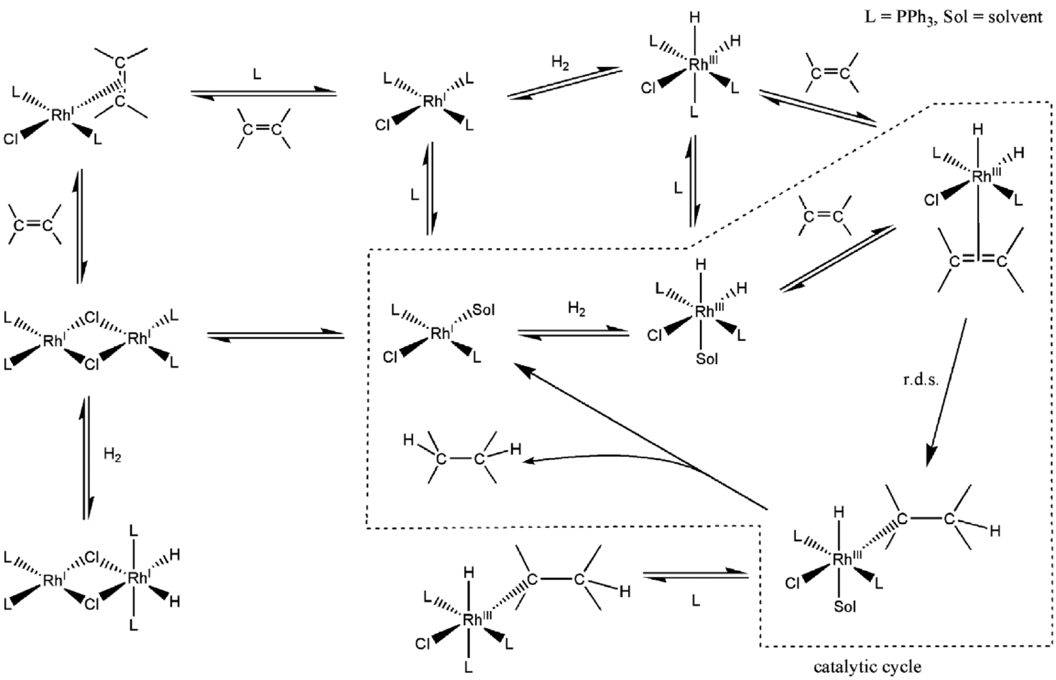
(i) Alkene metathesis - The formation and reactions of metallocyclobutane intermediates in alkene metathesis can be accounted for by a combination of elementary steps given above. It is included here because of the unique nature of the overall process. Alkene metathesis is of growing importance, especially because of the reactions of ruthenium complexes with highly tailored ligands that offer routes to a wide range of important products.

6.4 Catalytic Cycles

In this section examples of some important homogeneous catalytic cycles are given to illustrate the range of synthetic transformations that can be achieved with these systems. They show that although the elementary steps are simple and the essential catalytic cycle can be straightforward, in practice there are a number of other reactions involved that contribute to make the overall mechanistic scheme quite complex. For a metal complex to function in a catalytic cycle, as opposed to giving product in a stoichiometric reaction, the initial compound in the catalytic cycle must be reformed so reactants continuously form products. The homogeneous catalyst, or its precursor, is supplied as a chemical compound whose characteristics, such as purity, can be readily determined and controlled. Because it is used in solution its original physical form is not always important, unlike the situation with heterogeneous catalysts.

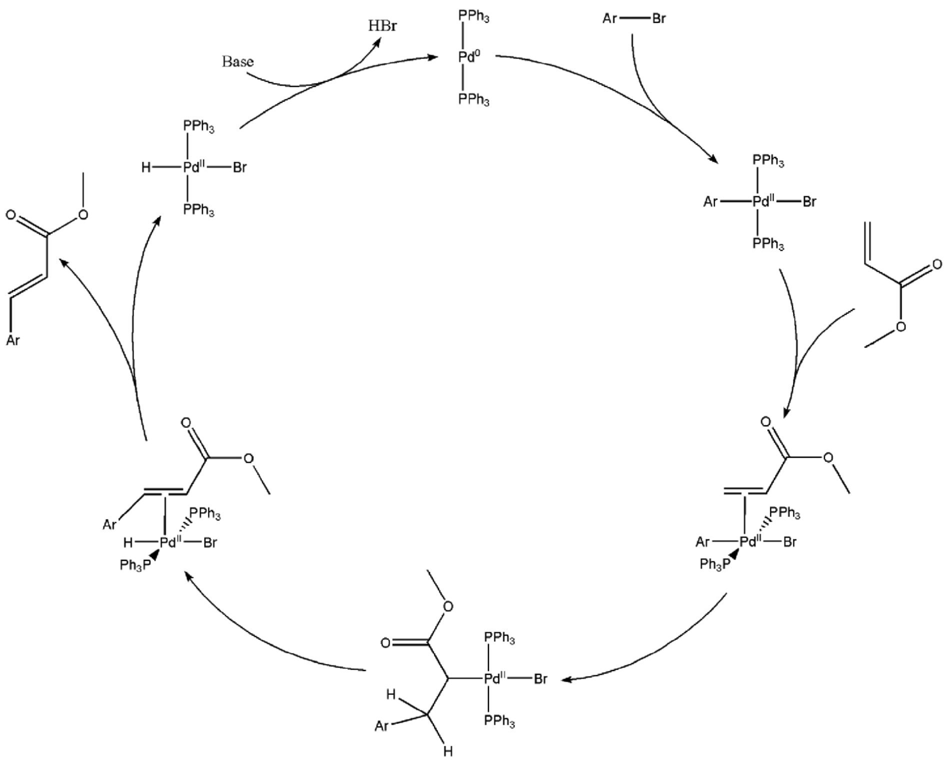
(a) Catalytic hydrogenation, Wilkinson’s Catalyst - The classic homogeneous hydrogenation catalyst, known as Wilkinson's Catalyst, $RhCl(PPh_3)_3$ was the first effective homogeneous catalyst for the hydrogenation of alkenes at room temperature and atmospheric pressure [20]. Only unhindered double bonds undergo reaction, so polyenes may be selectively hydrogenated. In the absence of hydrogen double bond migration may take place to give more thermodynamically stable products (eg conjugated species), and there are instances where this is a very facile process. The generally accepted mechanism for alkene hydrogenation with Wilkinson's Catalyst is shown in Scheme 1 [21]. Key in the catalytic cycle is reaction of an alkene with a rhodium *di*-hydride to give a hydride alkyl complex that undergoes reductive elimination forming the desired alkane and a four coordinate Rh(I) species. This undergoes oxidative addition with hydrogen to reform the rhodium *di*-hydride that reacts with more alkene.

Scheme 1



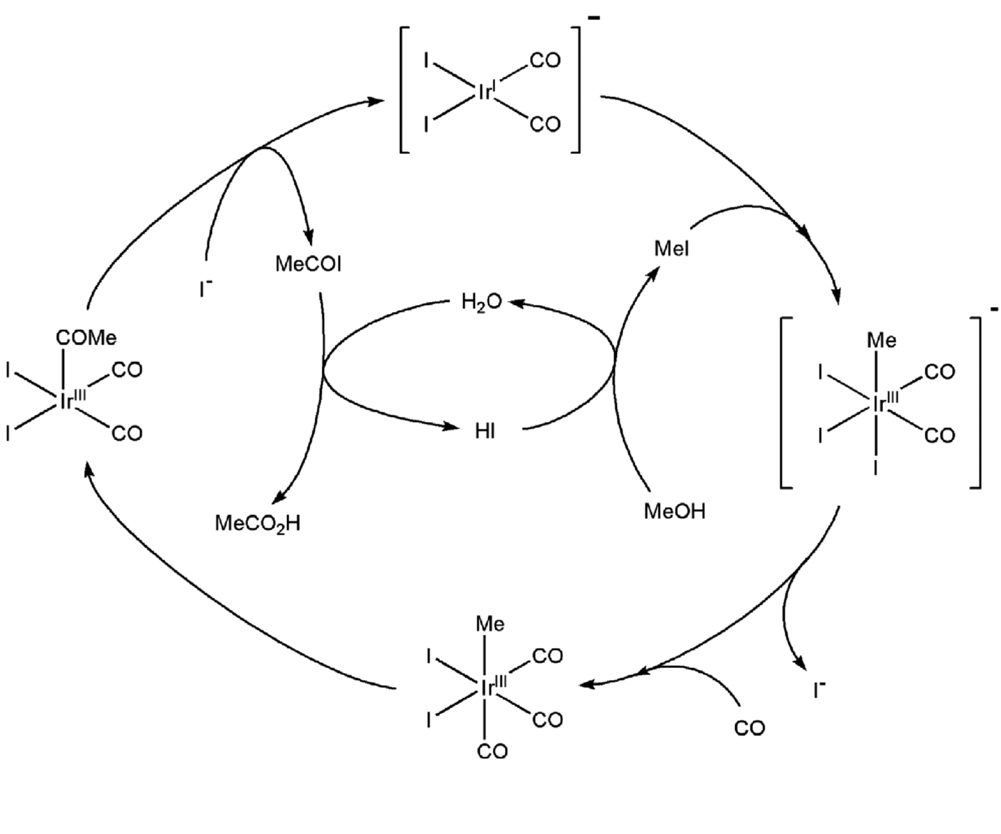
(b) Carbon-carbon bond formation, Heck Reaction - Carbon-carbon bond forming reaction are at the heart of synthetic organic chemistry and the Heck Reaction, in a variety of modified forms, is one of the most versatile. The classic Heck Reaction is the palladium-catalyzed reaction between an aryl or a vinyl halide and an activated alkene in the presence of a base that is typically NEt_3 [22,23]. Normally it affords exclusively *trans*-products. There are a number of extensions to the basic reaction, the best known of which is the Stille Reactions that involves transmetallation of an R group from a tin compound to the palladium center. Related coupling reactions catalyzed by palladium include the Karasch Reaction (RMgX), the Negishi Reaction (RZnX), the Suzuki Reaction (RB(OH)2) and the Hiyama Reaction (RSiR3). The key steps in the Heck catalytic cycle are illustrated in Scheme 2. Here an aryl halide oxidatively adds to a coordinatively unsaturated Pd(0) center. An activated alkene then forms a π-complex and the new coordinated alkene inserts into the Pd-Ar bond. This is followed by β-hydride elimination to form a new π-alkene complex that dissociates to give the desired product and a Pd(II) hydrido halide complex. Reductive elimination of HX in the presence of base then regenerates the original coordinately unsaturated Pd(0) complex.

Scheme 2



(c) Iridium catalyzed methanol carbonylation - the carbonylation of methanol to acetic acid has been an important industrial process for well over three decades. The original process used a homogenous cobalt catalyst requiring temperatures above 200°C and high pressures of carbon monoxide (about 700 bar). In the early 1970s a low-pressure rhodium catalyzed process was introduced that became the dominant technology [24]. More recently [25] an iridium-catalyzed process was introduced that has a number of industrial attractions. The mechanism of this process is illustrated in Scheme 3, which is rather more complicated than the previous rhodium catalyzed process. Iodide is added as a promoter, and the key step in the catalytic cycle is the formation of a *di*-iodo *bis*-carbonylfour coordinate Ir(I) complex to which methyl iodide (formed in-situ from methanol) oxidatively adds to form a six coordinate Ir(III) complex. This loses an iodide anion and obtains a further carbon monoxide ligand to give a methyl *di*-iodo *tris*-carbonyl Ir(III) complex. Migratory insertion of methyl into the Ir-CO bond produces a five coordinate acyl complex that reacts with iodide to form CH_3COI (that is hydrolyzed to the product acetic acid) and reforms the starting $[IrI_2(CO)_2]$ that undergoes further reaction with more methyl iodide.

Scheme 3



6.5 Separation of Product from Catalyst

An important consideration before using a homogeneous catalyst is to decide how to separate the product from the catalyst during the product work-up, and how the catalyst can be recycled. In the past this could present major difficulties, but the situation is now much better. A variety of separation techniques have been employed in full-scale commercial operations as well as on the laboratory scale, and these include:

(a) Distillation - usually this is done under the reduced pressure to remove the product from the final reaction mixture. In some instances it can be done continuously as the reaction proceeds provided the reactant has a higher boiling point than the product. Then it is possible to continuously add the reactant so the process is continuous.

(b) Liquid-liquid solvent extraction - this can be particularly appropriate in applications where the spent catalyst is rendered soluble in water. A special case of using two immiscible liquids involves phase transfer catalysis where the product is transferred from the phase in which it is formed to one in which it is collected. In principle this process can be made continuous.

(c) Crystallization/precipitation - precipitation of the product by addition of a solvent such as diethyl ether or a hydrocarbon such as hexane in which the catalyst is soluble but the product is not. In some situations this can be a very efficient separation method.

(d) Flash chromatography - can be an effective separation technique using neutral alumina or silica gel with a variety of solvents including acetone, hexane, ethyl acetate and mixtures of these. The spent catalyst is retained on the column while the desired product passes through and is collected and recovered by standard methods.

(e) Catalyst adsorption - using ion exchange polymers or high area materials such as activated carbons to selectively absorb the catalyst, followed by filtration. In some situations it is then possible to recover the catalyst and use it.

(f) Selectively precipitating the catalyst - that is followed by removing it from the reaction mixture by filtration. The desired product is then further purified by vacuum distillation or recrystallization.

For economic reasons it may be desirable to reuse the catalyst after it has been isolated from the reaction mixture. To do this the catalyst must be in an appropriate soluble form, and in some cases further processing might be essential. Such systems can be quite complex, but the chemical transformations that are made possible with homogeneous catalysis may justify this extra processing. However, in other cases the PGM homogeneous catalyst is so active that there is no economic need to reuse it. In these circumstances residues containing spent catalysts should be collected and periodically returned to Johnson Matthey for recycling and recovery of the PGM metal values. It can be an advantage to keep separate different metal residues.

7. Conclusions

The discovery of the phenomenon of heterogeneous catalysis caused excitement during the early part of the nineteenth century, and because of its very high activity platinum featured strongly during the early pioneering days. By the mid-1920s industrial catalytic processes were well established, for example both relatively small-scale hydrogenation of edible oils and fats, and huge-scale coal-based hydrogen, ammonia and methanol plants were in service that used large quantities of fixed bed catalysts. Later catalysts played increasingly important roles in processing mineral hydrocarbon feeds in refineries. Progress in heterogeneous catalysis continued, and made contributions vital to modern society through applications, for example, in petrochemical industries. A very strong interest in organometallic transition metal chemistry developed in the early 1960s, and this led to a wide range of soluble metal-based catalysts whose mechanisms could be investigated at the molecular level because the catalytic cycles involved molecular species. It is because the molecular species are well defined and they are all the same that homogeneous catalysis can provide well-defined selectivity. With some reactions chiral products at the 99%+ ee level can be obtained through the use of suitably designed ligands.

Just like the start of heterogeneous catalysis, the PGMs, and especially platinum, palladium, rhodium and ruthenium feature strongly in the new homogeneous catalysis. With them the directed synthesis of a complex organic intermediate can be performed catalytically to give a product that may not be available by other means, or a homogeneous catalytic route might improve the product quality or the overall economics of an existing process. Many proven heterogeneous and homogeneous catalysts are applicable to laboratory preparations, and these can be used in the development of routes to, for example, pharmaceuticals, flavors, fragrances, agricultural and some specific electronic chemicals. This catalog contains a wide variety of heterogeneous and homogeneous catalysts or their precursors that can be used to conveniently prepare a huge range of organic products.

If you have further questions, please call Alfa Aesar to speak with one of our technical service representatives. If there is a specification or item you do not see in our catalog, call to speak with a Specialty Sales representative.

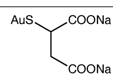
8. References

1. H. Davy, *Phil. Trans. Roy. Soc.*, 1817, 107, 77.
2. “Pervical Norton Johnson”, by D. McDonald, Johnson Matthey, 1951.
3. J.J. Berzelius, *Jahresberichte für Chemie*, 1836, 13, 237.
4. “Catalyst Handbook”, edited by M.V. Twigg, Manson Publishing, London, 1996, 470-489.
5. M.V. Twigg and D.E. Webster, in “Structure Catalysts and Reactors”, edited by A. Cybulski and J. Moulijn, CRC Taylor & Francis, Boca Raton, Second Edition, 2005, 71-108.
6. E. Davy, *Phil. Trans. Roy. Soc.*, 1820, 110, 108.
7. R. Willstatter and D. Hatt, *Berichte*, 1912, 45, 1471.
8. V. Voorhees and R. Adams, *J. Amer. Chem. Soc.*, 1922, 44, 1397. See also L.B. Hunt, Platinum Metals Rev., 1962, 6 150.
9. “New Pathways for Organic Synthesis - Practical Applications of Transition Metals” by H.M. Colquhoun, J. Holton, D.J. Thompson and M.V. Twigg, Springer, New York, 1984.
10. M.V. Twigg in “Catalysis and Chemical Processes”, edited by R. Pearce and W.R. Patterson, Leonard Hill, Glasgow, 1981, 11-33.
11. P.J. Denny and M.V. Twigg, “Catalyst Deactivation”, Studies in Surface Science and Catalysis 6, Edited by B. Delmon and G.F. Froment, Elsevier, Amsterdam, 1980, 577.
12. M.S. Spencer and M.V. Twigg, *Annual Rev. Mater. Res.*, 2005, 35, 427-464.
13. A.C. Cope and E. Ciganek, *Organic Syntheses*, Coll. 1963, 4, 612.
14. M. Ichikawa, *Bull. Chem. Soc. Japan*, 1978, 51, 2268; M. Ichikawa, *Bull. Chem. Soc. Japan*, 1978, 51, 2273; M. Ichikawa, K. Shikakura and M. Awai, *J. Mol. Catal.*, 1981, 11 167.
15. A.J. Bird in “Catalyst Supports and Supported Catalysts - Theoretical and Applied Concepts”, Edited by A.B. Stiles, Butterworths, London, 1987, Pages 107-137
16. H. Lindlar, Helv. Chim. Acta, 1952, 35, 446; H. Lindlar and R. Dubuis, *Organic Syntheses*, Coll., 1973, 5, 88.
17. “Homogeneous Catalysis - The Application and Chemistry of Catalysis by Soluble Transition Metal Complexes”, by G.W. Parshall, Second Edition, John Wiley, New York, 1992.
18. O. Roelen, German Patent, 1938, 849548
19. “Carbonylation - Direct Synthesis of Carbonyl Compounds”, by H.M. Colquhoun, D.J.

Thompson, and M.V. Twigg, Springer, New York, 1991.
20. F.H. Jardine, *Prog. Inorg. Chem.*, 1981, 28, 63.
21. For mechanistic discussion, especially in chiral systems, see: J. Halpern, *J. Science* 1982, 217, 401.
22. R.F. Heck and J.P. Nolley, Jr., *J. Org. Chem.*, 1972, 37, 2320.
23. R.F. Heck, *Org. React.* 1982, 27, 345.
24. D. Forster, *Advances Organometallic Chemistry*, 1979, 17, 255. See also C.M. Thomas and G. Suss-Fink, *Coord. Chem. Revs.*, 2003, 243, 125.
25. J.H. Jones, *Platinum Metals Review*, 2000, 44, 94.

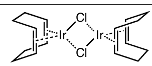
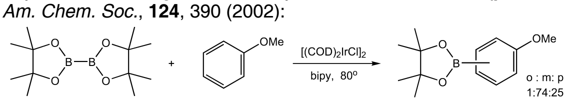
Gold

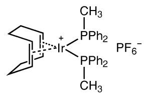
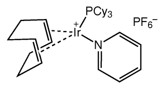
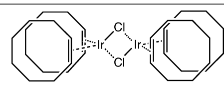
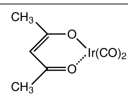
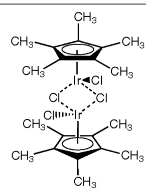
Stock #	Description	Standard Selling Sizes
40434	**Ammonium tetrachloroaurate(III) hydrate, Premion®, 99.99% (metals basis)** [13874-04-9], $(NH_4)AuCl_4 \cdot xH_2O$, F.W. 356.82(anhy), Crystalline powder, Solubility: Soluble in water and alcohol, UN3260, EINECS 250-476-0, MDL MFCD00011503, † H:H301-H314-H290-H412, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
41002	**Bromo(triphenylphosphine)gold(I), Premion®, 99.99% (metals basis)** [14243-65-3], $AuBr[P(C_6H_5)_3]$, F.W. 539.17, Powder, EINECS 238-118-1, MDL MFCD00049267 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
41007	**Chloro(triphenylphosphine)gold(I), Premion®, 99.99% (metals basis), Au 39.3% min** *[Triphenylphosphinegold(I) chloride]* [14243-64-2], $AuCl[P(C_6H_5)_3]$, F.W. 494.71, Powder, EINECS 238-117-6, MDL MFCD00009588 H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	500mg 1g 5g
39742	**Gold(III) acetate, 99.9% (metals basis)** [15804-32-7], $Au(O_2CCH_3)_3$, F.W. 374.10, Powder, MDL MFCD00210614	500mg 1g 5g
12162	**Gold(III) bromide, Premion®, 99.99% (metals basis), Au 44.6% min** [10294-28-7], $AuBr_3$, F.W. 436.69, Granular, m.p. ca 160° dec., UN3260, EINECS 233-654-2, MDL MFCD00014171, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
43365	**Gold(I) chloride, 99.9% (metals basis)** ◪ [10294-29-8], AuCl, F.W. 232.42, Powder, m.p. 289° dec., d. 7.57, Merck **14**,4515, UN3260, EINECS 233-655-8, MDL MFCD00046175, Note: Decomposes in water, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a Catalyzes the rapid cyclization of allenyl and propargyl ketones to 2,5-disubstituted furans. Also useful in the Michael addition of methyl vinyl ketone to 2-methylfuran in acetonitrile: *Agnew. Chem. Int. Ed.*, **39**, 2285 (2000). For use in the gold-cataylzed amination of allylic alcohols with arylamines and arylsulfonamides, see: *Synlett*, 964 (2007).	1g 5g
40432	**Gold(I) chloride, Premion®, 99.99% (metals basis), Au 84.2% min** ◪ [10294-29-8], AuCl, F.W. 232.42, Powder, m.p. 289° dec., d. 7.57, Merck **14**,4515, UN3260, EINECS 233-655-8, MDL MFCD00046175, Note: Decomposes in water, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	250mg 1g 5g
12163	**Gold(III) chloride, Au 64.4% min** ■ [13453-07-1], $AuCl_3$, F.W. 303.33, Crystalline, m.p. 160° dec., d. 3.90, Merck **14**,4521, UN3260, EINECS 236-623-1, MDL MFCD00014172, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	250mg 1g 5g
43360	**Gold(III) chloride, Premion®, 99.99% (metals basis), Au 64.4% min** ■ [13453-07-1], $AuCl_3$, F.W. 303.33, Crystalline, m.p. 160° dec., d. 3.90, Merck **14**,4521, UN3260, EINECS 236-623-1, MDL MFCD00014172, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
32031	**Gold(I) cyanide, Premion®, 99.99% (metals basis)** ◪ [506-65-0], AuCN, F.W. 222.98, Powder, m.p. dec., d. 7.14, Merck **14**,4516, UN1588, EINECS 208-049-1, MDL MFCD00003437, † H:H301-EUH032-H310-H330-H318-H290-H400-H410-H315, P:P301+P310-P304+P340-P305+P351+P338-P320-P330-P361-P405-P501a	250mg 1g 5g
12159	**Gold(III) hydroxide, Au 79% min** ▲ [1303-52-2], $Au(OH)_3$, F.W. 247.99, Powder, Merck **14**,4523, Application(s): Gold plating solutions, porcelain decoration, EINECS 215-120-0, MDL MFCD00046173, Note: Decomposed by light to metallic gold, †	1g 5g 10g
16617	**Gold(I) iodide, 99%** ◪ [10294-31-2], AuI, F.W. 323.87, Crystalline, m.p. 120° dec., d. 8.25, Solubility: Insoluble in water. Soluble in alkali iodide, cyanide solutions. Decomposes in warm acids, UN3260, EINECS 233-656-3, MDL MFCD00014175, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
12161	**Gold(III) oxide, Premion®, 99.99% (metals basis), Au 88.6% min** [1303-58-8], Au_2O_3, F.W. 441.93, Powder, m.p. 150° dec., Merck **14**,4524, Solubility: Insoluble in water. Soluble in HCl, HNO_3, and in NaCN solution, EINECS 215-122-1, MDL MFCD00014173, †	250mg 1g 5g
12552	**Gold(I) potassium cyanide, Premion®, 99.99% (metals basis), Au 67.8% min** *[Potassium dicyanoaurate(I), Potassium gold cyanide]* [13967-50-5], $KAu(CN)_2$, F.W. 288.33, Crystalline powder, m.p. dec., d. 3.45, Merck **14**,7628, UN1588, EINECS 237-748-4, BRN 6235525, MDL MFCD00011414, † H:H300-EUH032-H310-H330-H318-H290-H400-H410-H315, P:P301+P310-P304+P340-P305+P351+P338-P320-P330-P361-P405-P501a	1g 5g 25g

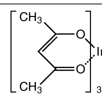
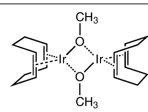
Stock #	Description	Standard Selling Sizes
12637	**Gold(I) sodium cyanide, 99.9% (metals basis), Au 72% min** *[Sodium gold cyanide, Sodium dicyanoaurate(I)]* [15280-09-8], $NaAu(CN)_2$, F.W. 271.99, Powder, Merck **14**,8610, UN1588, EINECS 239-320-2, MDL MFCD00050423, † H:H300-EUH032-H310-H330-H400-H410, P:P301+P310-P304+P340-P320-P330-P361-P405-P501a	**250mg** **1g** **5g**
39741	**Gold(I) sodium thiosulfate hydrate, 99.9% (metals basis)** *[Sodium gold(I) thiosulfate hydrate, Sodium aurothiosulfate(I) hydrate]* [15283-45-1], $Na_3Au(S_2O_3)_2{\cdot}xH_2O$, F.W. 490.19(anhy), Powder, m.p. dec., d. 3.09, Merck **14**,4519, Solubility: Soluble in water. Insoluble in ethanol and most other organic solvents, EINECS 239-324-4, MDL MFCD00046176, †	**1g** **5g** **25g**
40433	**Hydrogen tetrabromoaurate(III) hydrate, Premion®, 99.99% (metals basis), Au 32% min ■** *[Bromoauric acid]* $HAuBr_4{\cdot}xH_2O$ (x≈5), F.W. 517.61(anhy), Crystalline, m.p. ca 27°, Solubility: Soluble in water and alcohol, UN3260, MDL MFCD00054118, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**1g** **5g**
44744	**Hydrogen tetrachloroaurate(III), solution, Au 40-44% w/w (cont. Au) ▲** [16903-35-8], $HAuCl_4$, F.W. 339.79, Liquid, UN3264, EINECS 240-948-4, MDL MFCD00011322, † H:H314-H318-H290-H302-H335-H412, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**(c)1g** **(c)5g**
12325	**Hydrogen tetrachloroaurate(III) hydrate, 99.9% (metals basis), Au 49% min ▲■** *[Tetrachloroauric(III) acid, Chloroauric acid]* [27988-77-8], $HAuCl_4{\cdot}xH_2O$, F.W. 339.79(anhy), Crystalline, UN3260, EINECS 240-948-4, MDL MFCD00149903, † H:H314-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**1g** **5g** **25g** **100g**
36400	**Hydrogen tetrachloroaurate(III) trihydrate, ACS, 99.99% (metals basis), Au 49.5% min ▲■** *[Chloroauric acid]* [16961-25-4], $HAuCl_4{\cdot}3H_2O$, F.W. 393.83 (339.79anhy), Crystalline, UN3260, EINECS 240-948-4, MDL MFCD00149904, † Maximum level of impurities: Insoluble in ether 0.1%, Alkalies and other metals (as sulfates) 0.2% H:H314-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**1g** **5g**
42803	**Hydrogen tetrachloroaurate(III) hydrate, Premion®, 99.999% (metals basis), Au 49% min ▲■** [27988-77-8], $HAuCl_4{\cdot}xH_2O$, F.W. 339.79(anhy), Crystalline, UN3260, MDL MFCD00149903, † H:H314-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**1g** **5g**
40431	**Hydrogen tetranitratoaurate(III) hydrate, Premion®, 99.99% (metals basis), Au 38.9-40.1%** *[Nitratoauric acid]* $HAu(NO_3)_4{\cdot}xH_2O$ (x≈3), F.W. 445.99(anhy), Crystalline, m.p. ca 72° dec., Solubility: Decomposes in water. Soluble in HNO_3, UN1477, MDL MFCD00046178 H:H272-H315-H319, P:P221-P210-P305+P351+P338-P302+P352-P321-P501a	**1g** **5g**
40429	**Lithium tetrachloroaurate(III) hydrate, Premion®, 99.99% (metals basis)** $LiAuCl_4{\cdot}xH_2O$, F.W. 345.72(anhy), Crystalline to liquidous, MDL MFCD00798533 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g** **5g**
12664	**Potassium tetrabromoaurate(III) dihydrate, Premion®, 99.99% (metals basis), Au 33% min** *[Gold potassium bromide]* [14323-32-1], $KAuBr_4{\cdot}2H_2O$, F.W. 591.72 (555.69anhy), Crystalline, Solubility: Soluble in water and alcohol, EINECS 238-268-8, MDL MFCD00049650, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
12150	**Potassium tetrachloroaurate(III) hydrate, Premion®, 99.99% (metals basis), Au 49% min** *[Gold potassium chloride]* [27988-75-6], $KAuCl_4.xH_2O$, F.W. 377.88(anhy), Crystalline, m.p. 357° dec., Merck **14**,7681, Solubility: Soluble in water, UN3260, EINECS 237-190-1, MDL MFCD00043088, † H:H314-H290-H302-H412, P:P280-P303+P361+P353-P305+P351+P338-P310	**1g** **5g**
39740	**Sodium aurothiomalate(I), 99.9% (metals basis)** *[Gold sodium thiomalate]* [12244-57-4], $C_4H_3AuNa_2O_4S$, F.W. 390.08, Powder, Merck **14**,4518, Solubility: Very soluble in water. Practically insoluble in alcohol, ether, EINECS 235-479-7, MDL MFCD00064304  H:H302-H332-H317, P:P261-P280-P302+P352-P321-P304+P340-P501a	**1g** **5g**

Stock #	Description	Standard Selling Sizes
40428	**Sodium tetrabromoaurate(III) hydrate, Premion®, 99.99% (metals basis)** [10378-49-1], $NaAuBr_4 \cdot xH_2O$ (x≈2), F.W. 539.59(anhy), Crystalline, Solubility: Soluble in water, MDL MFCD00274624, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12148	**Sodium tetrachloroaurate(III) dihydrate, Premion®, 99.99% (metals basis), Au 49-50%** *[Sodium chloroaurate(III), Gold sodium chloride]* [13874-02-7], $NaAuCl_4$.2H2O, F.W. 397.80 (361.77anhy), Crystalline, m.p. 100° dec., d. 0.8, Merck **14**,8688, Solubility: Soluble in water, alcohol, ether, UN3260, EINECS 239-241-3, MDL MFCD00149162, † H:H314-H290-H302-H412, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a Catalyzes the addition of indoles to α,β-unsaturated ketones, to give 2- and 3-substituted indole derivatives: *Synlett*, 944 (2004).	1g 5g

Iridium

Stock #	Description	Standard Selling Sizes
12632	**Ammonium hexachloroiridate(III) hydrate ■** $(NH_4)_3IrCl_6 \cdot xH_2O$, F.W. 459.06(anhy), Crystalline powder, EINECS 239-842-0, MDL MFCD00003393, † H:H290-H302, P:P234-P264-P270-P301+P312-P406-P501a	1g 5g
10713	**Ammonium hexachloroiridate(III) hydrate, Premion®, 99.99% (metals basis) ■** $(NH_4)_3IrCl_6 \cdot xH_2O$, F.W. 459.06(anhy), Crystalline powder, EINECS 239-842-0, MDL MFCD00003393, † H:H290-H302, P:P234-P264-P270-P301+P312-P406-P501a	1g 5g
12326	**Ammonium hexachloroiridate(IV), 99% (metals basis), Ir 43% min ■** [16940-92-4], $(NH_4)_2IrCl_6$, F.W. 441.02, Crystalline powder, m.p. dec., d. 2.86, EINECS 241-007-0, MDL MFCD00010881, † H:H290-H302, P:P234-P264-P270-P301+P312-P406-P501a	1g 5g
10712	**Ammonium hexachloroiridate(IV), Premion®, 99.994% (metals basis), Ir 41% min ■** [16940-92-4], $(NH_4)_2IrCl_6$, F.W. 441.02, Crystalline powder, m.p. dec., d. 2.86, EINECS 241-007-0, MDL MFCD00010881, † H:H290-H302, P:P234-P264-P270-P301+P312-P406-P501a	100mg 1g 5g
39413	**Carbonylchlorobis(triphenylphosphine)iridium(I)** *[Vaska's catalyst, Chlorocarbonylbis(triphenylphosphine)iridium(I)]* [14871-41-1], $IrCl(CO)[P(C_6H_5)_3]_2$, F.W. 780.27, Crystalline, m.p. 215° dec., Solubility: Soluble in chloroform, toluene. Slightly soluble in acetone, alcohol, UN2811, EINECS 238-941-6, MDL MFCD00009590, † H:H302-H312-H332, P:P261-P280-P302+P352-P304+P340-P322-P501a	250mg 1g 5g
41005	**Carbonylhydridotris(triphenylphosphine)iridium(I), Ir 18.6% min ◪** *[Hydridocarbonyltris(triphenylphosphine)iridium(I), Carbonyltris(triphenylphosphine)iridium(I) hydride]* [17250-25-8], $IrH(CO)[P(C_6H_5)_3]_3$, F.W. 1008.11, Powder, m.p. 170°, Solubility: Soluble in chloroform and toluene, EINECS 241-282-7, MDL MFCD00015525, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12749	**Chloro(1,5-cyclooctadiene)iridium(I) dimer, Ir 57.2%**  *[Bis(1,5-cyclooctadiene)diiridium(I) dichloride]* [12112-67-3], $C_{16}H_{24}Cl_2Ir_2$, F.W. 671.71, Crystalline powder, m.p. 190° dec., Solubility: Soluble in chloroform, toluene. Slightly soluble in acetone, alcohol., EINECS 235-170-7, MDL MFCD00012414 Catalyst precursor for asymmetric hydrogenation: *Angew. Chem. Int. Ed.*, **37**, 2897 (1998). With catalytic amounts of dppp (**1,3-Bis(diphenylphosphino)propane**, **A12931**) and Cs_2CO_3, a transfer hydrogenation system with 2-propanol as the H source can reduce both olefinic double bonds and carbonyl groups; for α,β-unsaturated ketones, selective reduction to saturated ketones can be achieved: *J. Org. Chem.*, **66**, 4710 (2001). In the presence of a phosphite, catalyzes displacements by carbon nucleophiles at the more substituted position in allylic systems: *Angew Chem. Int. Ed.*, **36**, 263 (1997); *J. Am. Chem. Soc.*, **120**, 8647 (1998). Catalyst for Miyaura and Hartwig's direct boronylation of arenes with **Bis(pinacolato)diboron**, **L16088**: *J. Am. Chem. Soc.*, **124**, 390 (2002):  Effective catalyst for the reaction of alcohols with vinyl acetate to give vinyl ethers: *J. Am. Chem. Soc.*, **124**, 1590 (2002).	250mg 1g 5g

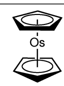
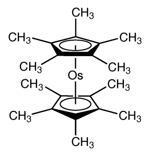
Stock #	Description	Standard Selling Sizes
41006	**Chloropentaammineiridium(III) chloride, 99.9% (metals basis), Ir 49.6% min** *[Pentaamminechloroiridium(III) chloride]* [15742-38-8], $[IrCl(NH_3)_5]Cl_2$, F.W. 383.73, Powder, m.p. dec., EINECS 239-833-1, MDL MFCD00798542 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g 5g
18809	**1,5-Cyclooctadienebis(methyldiphenylphosphine)iridium(I) hexafluorophosphate** △ ◪  [38465-86-0], $C_{34}H_{38}F_6IrP_3$, F.W. 845.79, Crystalline, m.p. 224° dec., Solubility: Soluble in acetone, Application(s): Hydrogenation, MDL MFCD00064800 H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	500mg 2g
42057	**1,5-Cyclooctadiene(pyridine)(tricyclohexylphosphine)iridium(I) hexafluorophosphate, 99%** ◪  *[Crabtree's catalyst, (Tricyclohexyphosphine)(1,5-cyclooctadiene)(pyridine)-iridium(I) hexafluorophosphate]* [64536-78-3], $C_{31}H_{50}F_6IrNP_2$, F.W. 804.89, Crystalline, m.p. 175° dec., Fieser **12**,151 **13**,88, Solubility: Slightly soluble in acetone, dichloromethane, ethanol, diethyl ether, MDL MFCD00075097 H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313 Homogeneous catalyst, introduced by Crabtree, which can be used in non-coordinating solvents (e.g. DCM), and is one of the most active catalysts for homogeneous hydrogenation, effective even for tetrasubstituted alkenes: *J. Organomet. Chem.*, **135**, 395; **141**, 205 (1977); *Acc. Chem. Res.*, **12**, 331 (1979). For a brief feature, see: *Synlett*, 160 (2001). Promotes stereoselective hydrogenations, directed by an adjacent OH: *J. Am. Chem. Soc.*, **105**, 1072 (1983), or carboxamide: *J. Org. Chem.*, **50**, 5905 (1985) group. For discussion of the influence of these and various other directing groups on the homogeneous hydrogenation of olefinic double bonds, see: *J. Org. Chem.*, **51**, 2655 (1986). Has also been applied to the directed hydroboration of alkenes: *J. Org. Chem.*, **55**, 5678 (1990); *J. Am. Chem. Soc.*, **113**, 4042 (1991).	50mg 250mg
44966	**Chlorobis(cyclooctene)iridium(I) dimer, Ir nominally 42.9%**  *[Di-μ-chlorobis(cyclooctene)iridium(I)]* [12246-51-4], $C_{32}H_{56}Cl_2Ir_2$, F.W. 896.00, MDL MFCD00213465 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
39411	**Dicarbonyl(2,4-pentanedionato)iridium(I)**  *[(Acetylacetonato)dicarbonyliridium(I)]* [14023-80-4], $C_7H_7IrO_4$, F.W. 347.35, Crystalline, UN3466, MDL MFCD00049135 H:H301-H315-H319-H335, P:P301+P310-P305+P351+P338-P302+P352-P321-P405-P501a	500mg
45565	**Dichloro(pentamethylcyclopentadienyl)iridium(III) dimer**  [12354-84-6], $C_{20}H_{30}Cl_4Ir_2$, F.W. 796.67, MDL MFCD00075435 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 2g 10g
41009	**Dihydrogen hexabromoiridate(IV) hexahydrate, 99.9% (metals basis), Ir 24.1% min** *[Bromoiridic Acid, Hydrogen hexabromoiridate(IV)]* $H_2IrBr_6 \cdot 6H_2O$, F.W. 781.76 (673.67anhy), Powder, UN3260, MDL MFCD00798543 H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
11031	**Dihydrogen hexachloroiridate(IV) hydrate, 99% (metals basis), Ir 38-42%** *[Hydrogen hexachloroiridate(IV), Chloroiridic acid]* [110802-84-1], $H_2IrCl_6 \cdot xH_2O$, F.W. 406.93(anhy), Lump, Solubility: Soluble in alcohol and water, UN3260, EINECS 241-012-8, MDL MFCD00011328, † H:H314-H290-H302, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g 25g
10505	**Dodecacarbonyltetrairidium, 98%** △ *[Tetrairidium dodecacarbonyl, Iridium carbonyl]* [11065-24-0], $Ir_4(CO)_{12}$, F.W. 1105.01, Powder, m.p. 195° dec., UN3466, MDL MFCD00011064 H:H301-H330, P:P301+P310-P304+P340-P320-P330-P405-P501a	1g 5g
12212	**Iridium(III) bromide hydrate, Ir 35.9% min** $IrBr_3 \cdot xH_2O$, F.W. 431.91(anhy), Crystalline, m.p. 100° -3H₂O, EINECS 233-174-3, MDL MFCD00049466, †	1g 5g
39493	**Iridium(IV) bromide, Premion®, 99.99% (metals basis), Ir 37.1% min** [7789-64-2], $IrBr_4$, F.W. 511.84, Crystalline, m.p. dec., Solubility: Soluble in water, EINECS 232-180-3, MDL MFCD00049467, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 2g

Stock #	Description	Standard Selling Sizes
11030	**Iridium(III) chloride hydrate, 99.9% (metals basis)** [14996-61-3], $IrCl_3 \cdot xH_2O$, F.W. 298.56(anhy), Crystalline, Merck **14**,5088, Solubility: Soluble in water and alcohol, EINECS 233-044-6, MDL MFCD00149750, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g 25g 50g
12158	**Iridium(III) chloride, anhydrous, Ir 62% min ■** [10025-83-9], $IrCl_3$, F.W. 298.56, Powder, m.p. 763° dec., Merck **14**,5088, Solubility: Insoluble in water, acids, alkalies, EINECS 233-044-6, MDL MFCD00011063, † H:H314-H290, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
43380	**Iridium(III) chloride, anhydrous, Premion®, 99.99% (metals basis), Ir 63.9% min ■** [10025-83-9], $IrCl_3$, F.W. 298.56, Powder, m.p. 763° dec., Merck **14**,5088, UN3260, EINECS 233-044-6, MDL MFCD00011063, † H:H314-H290, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
12184	**Iridium(IV) chloride, Premion®, 99.95% (metals basis), Ir 56.5% min ■** [10025-97-5], $IrCl_4$, F.W. 334.01, Glassy amorphous pieces/powder, m.p. dec., EINECS 233-048-8, MDL MFCD00016155, † H:H302, P:P264-P270-P301+P312-P330-P501a	250mg 1g 5g
40424	**Iridium(IV) iodide, Premion®, 99.95% (metals basis), Ir 27.0% min** [7790-45-6], IrI_4, F.W. 699.82, Powder, Solubility: Insoluble in water and alcohol. Soluble in aqueous KI, EINECS 232-206-3, MDL MFCD00049960, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
43051	**Iridium(IV) oxide dihydrate, Premion®, 99.99% (metals basis), Ir 73% min** [30980-84-8], $IrO_2 \cdot 2H_2O$, F.W. 260.23 (224.20anhy), Powder, EINECS 234-743-9, MDL MFCD00011065, †	1g 5g
43396	**Iridium(IV) oxide, Premion®, 99.99% (metals basis), Ir 84.5% min** [12030-49-8], IrO_2, F.W. 224.20, Powder, d. 11.7, UN1479, EINECS 234-743-9, MDL MFCD00011065, † H:H272-H413, P:P221-P210-P220-P280-P273-P501a	1g 5g
10514	**Iridium(III) 2,4-pentanedionate, Ir 37.5% min** *[Iridium(III) acetylacetonate]* [15635-87-7], $C_{15}H_{21}IrO_6$, F.W. 489.53, Crystalline, m.p. 269-271°, EINECS 239-711-8, MDL MFCD00015353 	250mg 1g 5g
44967	**Methoxy(cyclooctadiene)iridium(I) dimer, Ir nominally 58% ▲ △ ◪** *[Bis(1,5-cyclooctadiene)di-μ-methoxydiiridium(I), 1,5-Cyclooctadiene(methoxy)iridium(I) dimer]* [12148-71-9], $C_{18}H_{30}Ir_2O_2$, F.W. 662.88, Powder, MDL MFCD08459360  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a Catalyst used in combination with a bipyridine derivative for aromatic C-H borylation of arenes and heteroarenes with **Pinacolborane**, **L17558**: *Chem. Commun.*, 2924 (2003).	1g 5g
12651	**Potassium hexabromoiridate(IV), Ir 25.5% min ■** [19121-78-9], K_2IrBr_6, F.W. 749.86, Crystalline, EINECS 242-827-1, MDL MFCD00054221 H:H318-H290-H302, P:P280-P305+P351+P338-P310-P301+P312-P406-P501a	1g 5g
41012	**Potassium hexabromoiridate(IV), 99.9% (metals basis), Ir 25.2% min ■** [19121-78-9], K_2IrBr_6, F.W. 749.86, Crystalline, EINECS 242-827-1, MDL MFCD00054221, † H:H318-H290-H302, P:P280-P305+P351+P338-P310-P301+P312-P406-P501a	1g 5g
11887	**Potassium hexachloroiridate(III) hydrate, Ir 33.4% min** $K_3IrCl_6 \cdot xH_2O$, F.W. 522.22(anhy), Crystalline, EINECS 237-854-0, MDL MFCD00038699, †	1g 5g 25g
11888	**Potassium hexachloroiridate(IV), Ir 39% min ■** [16920-56-2], K_2IrCl_6, F.W. 483.12, Crystalline, m.p. dec., EINECS 240-976-7, MDL MFCD00011369, †	1g 5g 25g
10528	**Potassium hexanitroiridate(III), Ir 32.3% min** [38930-18-6], $K_3Ir(NO_2)_6$, F.W. 585.54, Micro Crystals, EINECS 254-191-2, MDL MFCD00049672 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12649	**Sodium hexabromoiridate(IV), Ir 24.1% min ■** [28529-99-9], Na_2IrBr_6, F.W. 717.63, Crystalline, m.p. >350°, EINECS 249-069-0, MDL MFCD00064675 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11889	**Sodium hexachloroiridate(III) hydrate, Ir 31.5% min ◪** $Na_3IrCl_6 \cdot xH_2O$, F.W. 473.89(anhy), Crystalline, EINECS 239-795-6, MDL MFCD00003508, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g

Precious Metal Compounds

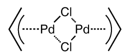
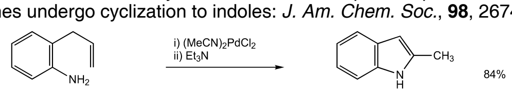
Stock #	Description	Standard Selling Sizes
11890	**Sodium hexachloroiridate(IV) hexahydrate, Ir 33.9% min** [19567-78-3], $Na_2IrCl_6 \cdot 6H_2O$, F.W. 558.99 (450.92anhy), Powder, m.p. 600° dec., EINECS 241-011-2, MDL MFCD00149169, † H:H290-H302-H319, P:P280-P305+P351+P338-P301+P312-P337+P313-P406-P501a	**1g** **5g**

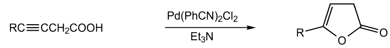
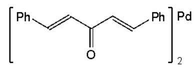
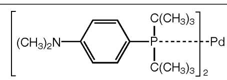
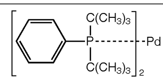
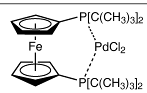
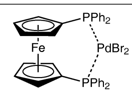
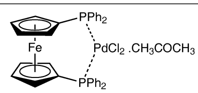
Osmium

Stock #	Description	Standard Selling Sizes
12648	**Ammonium hexabromoosmate(IV), 99.9% (metals basis), Os 26.5 % min ■** [24598-62-7], $(NH_4)_2OsBr_6$, F.W. 705.73, Powder, EINECS 246-340-5, MDL MFCD00049389, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
42874	**Ammonium hexachloroosmate(IV), 99.9% (metals basis), Os 42.5% min ■** [12125-08-5], $(NH_4)_2OsCl_6$, F.W. 438.99, Crystalline, m.p. 170° subl., d. 2.9, Merck **14**,536, Solubility: Soluble in water and in alcohol, EINECS 235-188-5, MDL MFCD00010883, † H:H302-H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	**1g** **5g**
10823	**Ammonium hexachloroosmate(IV), Premion®, 99.99% (metals bas is), Os 42.8% min ■** [12125-08-5], $(NH_4)_2OsCl_6$, F.W. 438.99, Powder, m.p. 170° subl., d. 2.9, Merck **14**,536, EINECS 235-188-5, MDL MFCD00010883, † H:H302-H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	**500mg** **1g** **5g**
39235	**Bis(cyclopentadienyl)osmium △ ◪** *[Osmocene, Cyclopentadienylosmium]* [1273-81-0], $C_{10}H_{10}Os$, F.W. 320.39, Crystalline, Packaged under argon, m.p. 226-228°, EINECS 215-055-8, MDL MFCD00058734  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g**
39239	**Bis(pentamethylcyclopentadienyl)osmium, 99% △ ◪** *[Decamethylosmocene, Pentamethylcyclopentadienylosmium]* [100603-32-5], $C_{20}H_{30}Os$, F.W. 462.64, Powder, Packaged in ampoules, EINECS 202-873-5, MDL MFCD00058711 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	**500mg**
42527	**Dihydrogen hexabromoosmate(IV) hydrate, 99.9% (metals basis)** *[Bromoosmic Acid, Hydrogen hexabromoosmate(IV)]* $H_2OsBr_6 \cdot xH_2O$, F.W. 352.02(anhy), Crystalline, m.p. dec., UN3260, MDL MFCD01863474 H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**250mg** **1g** **5g**
12178	**Dihydrogen hexachloroosmate(IV) hydrate, Premion®, 99.95% (metals basis), Os 37% min** *[Hydrogen hexachloroosmate(IV), Chloroosmic acid]* [27057-71-2], $H_2OsCl_6.xH_2O$, F.W. 404.93(anhy), Crystalline, m.p. dec., UN3260, EINECS 248-192-7, MDL MFCD00011329 H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**500mg** **1g** **5g**
13038	**Dodecacarbonyltriosmium, 99%** *[Triosmium dodecacarbonyl, Osmium carbonyl]* [15696-40-9], $Os_3(CO)_{12}$, F.W. 906.73, Crystalline, m.p. 224°, UN3466, EINECS 239-789-3, MDL MFCD00011149 H:H301-H330, P:P301+P310-P304+P340-P320-P330-P405-P501a	**500mg** **2g**
33480	**Osmium(III) chloride trihydrate, Premion®, 99.99% (metals basis), Os 52-56%** [135296-80-9], $OsCl_3 \cdot 3H_2O$, F.W. 350.60 (296.56anhy), Crystalline, m.p. dec., UN3260, EINECS 236-587-7, MDL MFCD00011148, † H:H314-H302-H312-H332, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**250mg** **1g** **5g**
39497	**Osmium(IV) oxide, Os 83% min** [12036-02-1], OsO_2, F.W. 222.20, Crystalline, d. 11.4, MDL MFCD00011150 H:H302, P:P264-P270-P301+P312-P330-P501a	**250mg** **1g** **5g**
45384	**Osmium(VIII) oxide, 2% aq. soln.** [20816-12-0], OsO_4, F.W. 254.10, Merck **14**,6893, EINECS 244-058-7, MDL MFCD00011150, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**2ml** **10ml**
45385	**Osmium(VIII) oxide, 4% aq. soln.** [20816-12-0], OsO_4, F.W. 254.10, Merck **14**,6893, EINECS 244-058-7, MDL MFCD00011150, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**2ml** **10ml**

Stock #	Description	Standard Selling Sizes
12103	**Osmium(VIII) oxide, 99.8% (metals basis), Os 74.4% min** *[Osmic acid, Osmium tetroxide]* [20816-12-0], OsO_4, F.W. 254.10, Crystalline, m.p. 40.6°, b.p. 130°, Merck **14**,6893, Solubility: Soluble in chloroform, alcohol and ethers, Application(s): Oxidation, catalyst in Sharpless dihydroxylations, UN2471, EINECS 244-058-7, MDL MFCD00011150, Note: Special handling precautions required. View MSDS prior to purchase. MSDS are available online at www.alfa.com, † H:H300-H310-H330-H314, P:P301+P310-P303+P361+P353-P304+P340-P305+P351+P338-P320-P330-P361-P405-P501a Reagent for the *cis*-dihydroxylation of double bonds via cyclic osmate esters. Reviews: *Synthesis*, 229 (1974); *Chem. Rev.*, **80**, 187 (1980). Because of the cost and toxicity of the osmium compounds, various co-oxidants have been used to regenerate the reagent, including: H_2O_2: *J. Am. Chem. Soc.*, **58**, 1302 (1936); **59**, 2345 (1937); $NaIO_4$: *J. Org. Chem.*, **21**, 478 (1956); *tert*-BuOOH in the presence of Bu_4NOH or Bu_4NOAc: *J. Am. Chem. Soc.*, **98**, 1986 (1976); *J. Org. Chem.*, **43**, 2063 (1978); Trimethylamine N-oxide in pyridine, permitting the dihydroxylation of hindered double bonds: *Tetrahedron Lett.*, **21**, 449 (1980); N-Methylmorpholine-N-oxide (NMMO): *Tetrahedron Lett.*, 1973 (1976); for examples using this system, with <1% catalyst, see: *Org. Synth. Coll.*, **6**, 342 (1988). Possible overoxidation of the diol can be avoided by trapping with **Benzeneboronic acid**, **A14257**: *Chem. Lett.*, 1721 (1988). Recyclable systems for Os, utilizing the ionic liquids **1-Ethyl-3-methyl-imidazolium tetrafluoroborate**, **L19763**: *Tetrahedron Lett.*, **43**, 6849 (2002), or **1-n-Butyl-3-methylimidazolium hexafluorophosphate**, **L19086**, and DMAP: *Org. Lett.*, **4**, 2197 (2002), have been reported to give excellent results. In conjunction with $NaIO_4$, oxidative cleavage of alkenes can be effected. For an improved procedure, see: *Org. Lett.*, **6**, 3217 (2004). Sharpless and others have developed techniques for catalytic asymmetric dihydroxylation (ADH), in the presence of chiral amines such as dihydroquinidine, with NMMO as stoichiometric oxidant: *J. Am. Chem. Soc.*, **102**, 4263 (1980); **110**, 1968 (1988); for practical details (stilbene to (R,R)-stilbenediol), see: *Org. Synth. Coll.*, **9**, 383 (1998). For a review of catalytic ADH, see: *Chem. Rev.*, **94**, 2483 (1994). Can also be used, in combination with **Chloramine-T trihydrate**, **A12044**, for vicinal oxyamination of olefins: *Org. Synth. Coll.*, **7**, 375 (1990). Using $KClO_4$ to regenerate the reagent, alkynes have been oxidized to α-diketones: *J. Org. Chem.*, **43**, 4245 (1978). Terminal alkynes can be converted to α-keto esters by hydroxylation of their 1-silyl derivatives: *Tetrahedron*, **46**, 2573 (1990). See also **Potassium osmium(VI) oxide dihydrate**, **12647**, p. 25.	500mg 1g 10x1g
39507	**Potassium hexabromoosmate, Premion®, 99.99% (metals basis)** [16903-69-8], K_2OsBr_6, F.W. 747.86, Powder, MDL MFCD00049658 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 2g
12177	**Potassium hexachloroosmate(IV), Os 38.7% min** ■ [16871-60-6], K_2OsCl_6, F.W. 481.12, Powder, m.p. dec., Merck **14**,7635, Solubility: Soluble in water. Sparingly soluble in alcohol, EINECS 240-893-6, MDL MFCD00011371, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g 5g
12647	**Potassium osmium(VI) oxide dihydrate, 99+%** ■ *[Potassium osmate dihydrate]* [10022-66-9], $K_2OsO_4{\cdot}2H_2O$, F.W. 368.43 (332.40anhy), Powder, Fieser **4**,412, Solubility: Soluble in water. Slowly decomposes in aqueous solution forming the tetroxide. Insoluble in alcohol, ether, UN3288, EINECS 243-247-1, MDL MFCD00149919, † H:H301-H330-H315-H319-H335, P:P301+P310-P304+P340-P305+P351+P338-P320-P330-P405-P501a	250mg 1g
40412	**Sodium hexabromoosmate(IV), Premion®, 99.95% (metals basis), Os 26.1% min** Na_2OsBr_6, F.W. 715.64, Crystalline Powder, m.p. dec., MDL MFCD00798532 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12176	**Sodium hexachloroosmate(IV) dihydrate, Os 38.7% min** △ ◪ [1307-81-9], $Na_2OsCl_6.2H2O$, F.W. 484.93 (448.90anhy), Crystalline, EINECS 215-152-5, MDL MFCD00014234 H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g 5g
41020	**Tetraamminedioxoosmium(VI) chloride, Os 52.2% min** [18496-70-3], $[OsO_2(NH_3)_4]Cl_2$, F.W. 361.23, Powder, MDL MFCD00798548 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g

Palladium

Stock #	Description	Standard Selling Sizes
10005	**Allylpalladium(II) chloride dimer, Pd 56.0% min** △ ◪ *[Bis(allyl)dichlorodipalladium(II)]*  [12012-95-2], $C_6H_{10}Cl_2Pd_2$, F.W. 365.85, Powder, m.p. 120° dec., Solubility: Very soluble in dichloromethane and dichloroethane. Slightly soluble in toluene, insoluble in water, EINECS 234-579-8, BRN 4124623, MDL MFCD00044874 H:H312-H332-H315, P:P261-P280-P302+P352-P321-P304+P340-P501a Reacts with lithium enolates of esters, in the presence of CO and excess TMEDA, to give good yields of α-cyclopropyl esters: *Angew. Chem. Int. Ed.*, **31**, 234 (1992). Used in combination with a chiral diamine to effect displacement of a mesylate with **Trimethylsilyl azide**, **L00173**, in the asymmetric synthesis of (+)-pancratistin: *J. Am. Chem. Soc.*, **117**, 10143 (1995).	**250mg** **1g** **5g**
44046	**Allylpalladium(II) trifluoroacetate, dimer** [32699-43-7], $[Pd(C_3H_5)(O_2CCF_3)]_2$, F.W. 521.02, Powder, MDL MFCD03788257	**5g**
43475	**Ammonium bis(oxalato)palladium(II) dihydrate, Premion®, 99.99% (metals basis)** $(NH_4)_2Pd(C_2O_4)_2 \cdot 2H_2O$, F.W. 354.57 (318.54anhy), Crystalline, UN3288, MDL MFCD02684521 H:H302-H312, P:P280-P302+P352-P322-P301+P312-P312-P501a	**1g** **5g**
11042	**Ammonium hexachloropalladate(IV), 99.9% (metals basis), Pd 29%** ■ [19168-23-1], $(NH_4)_2PdCl_6$, F.W. 355.20, Crystalline, d. 2.42, EINECS 242-854-9, MDL MFCD00015959, † H:H318-H302-H315, P:P280-P305+P351+P338-P302+P352-P321-P310-P501a	**2g** **10g**
11882	**Ammonium tetrachloropalladate(II), Pd 36% min** ■ *[Ammonium chloropalladite]* [13820-40-1], $(NH_4)_2PdCl_4$, F.W. 284.31, Powder, m.p. dec., d. 2.17, EINECS 237-498-6, MDL MFCD00010884, † H:H318-H302-H315, P:P280-P305+P351+P338-P302+P352-P321-P310-P501a	**1g** **5g**
10824	**Ammonium tetrachloropalladate(II), Premion®, 99.998% (metals basis), Pd 37%** ■ [13820-40-1], $(NH_4)_2PdCl_4$, F.W. 284.31, Powder, m.p. dec., d. 2.17, EINECS 237-498-6, MDL MFCD00010884, † H:H318-H302-H315, P:P280-P305+P351+P338-P302+P352-P321-P310-P501a	**1g** **5g** **25g**
10002	**Bis(acetonitrile)dichloropalladium(II), Pd 40.5%** *[cis-Dichlorobis(acetonitrile)palladium(II)]* [14592-56-4], $PdCl_2(CH_3CN)_2$, F.W. 259.41, Powder, Solubility: Soluble in acetonitrile, acetone, chloroform, Application(s): Olefin isomerization, preparation of acetals and hemiacetal esters, UN3439, EINECS 238-637-3, MDL MFCD00013122 H:H302-H312-H332-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a Organic-soluble complex for catalysis of a variety of reactions, with the advantage over **trans-Bis(benzonitrile)dichloropalladium(II)**, **10006**, p. 27, that the nitrile by-product, being volatile and water-miscible, is readily removed in the workup. In the presence of triethylamine, ortho-allylanilines undergo cyclization to indoles: *J. Am. Chem. Soc.*, **98**, 2674 (1976):  A 6:1 molar ratio of the high-temperature phase-transfer catalyst **Tetraphenylphosphonium chloride**, **A10575**, and the Pd complex, provides an effective catalyst for the Heck reaction of normally unreactive aryl halides, e.g. chlorobenzene with styrene to give stilbene. The reaction is performed at 140-150° in DMF or NMP in the presence of sodium acetate: *Angew. Chem. Int. Ed.*, **37**, 481 (1997). Effective alternative catalyst to **trans-Dichlorobis(triphenylphosphine)palladium(II)**, **10491**, p. 30, for the carbonylative cross-coupling of arylboronic acids with aryl iodides to give unsymmetrical benzophenones: *Tetrahedron Lett.*, **34**, 7595 (1993); see also **Appendix 5**. Catalyses the cleavage of phenolic TBDMS ethers under mild conditions: *Tetrahedron Lett.*, **37**, 153 (1996), and, in the presence of **2-Bromomesitylene**, **A12277**, promotes one-pot desilylation-oxidation of aliphatic silyl ethers to aldehydes or ketones: *J. Org. Chem.*, **61**, 2918 (1996); cf *J. Org. Chem.*, **48**, 1286 (1983).	**1g** **5g**

Stock #	Description	Standard Selling Sizes
10006	**trans-Bis(benzonitrile)dichloropalladium(II), Pd 27.1%** *[Dichlorobis(benzonitrile)palladium(II)]* [14220-64-5], $PdCl_2[(C_6H_5)(CN)]_2$, F.W. 383.57, Powder, Solubility: Soluble in acetone, chloroform, UN3439, EINECS 238-085-3, MDL MFCD00013123 H:H301-H311-H330, P:P301+P310-P304+P340-P320-P330-P361-P405-P501a Air-stable, organic-soluble Pd complex, which catalyzes a variety of reactions: Trimerization of alkynes to aromatic compounds: *J. Am. Chem. Soc.*, **84**, 2329 (1962); *Synthesis*, 659 (1986). Review: *Acc. Chem. Res.*, **9**, 93 (1976). Cyclopropanation of various allylic alcohols, ethers and amines by diazomethane: *Synthesis*, 246 (1990). In the presence of a *tert*-amine, catalyzes the cyclization of 3- and 4-alkynoic acids to unsaturated lactones in high yield: *Tetrahedron Lett.*, **25**, 5323 (1984):  Catalyst for the Ag_2O promoted Suzuki coupling of arylboronic acids with sensitive halides: *Org. Synth.*, **75**, 69 (1997); for reaction scheme, see **4-Methoxybenzeneboronic acid**, **A14462**. In combination with N,N-dimethylglycine, forms a highly active phosphine-free catalyst system for the Heck reaction of aryl bromides: *Tetrahedron Lett.*, **39**, 8449 (1998). In combination with CuI, terminal alkynes couple with vinyl chlorides to give conjugated enynes in high yield: *Tetrahedron Lett.*, **32**, 6109 (1991). This has been exploited in a synthesis of lipoxin B_4: *Synlett*, 217 (1993), and of *(Z)*- and *(E)*-enediynes from the isomeric 1,2-dichloroethylenes: *Tetrahedron Lett.*, **35**, 3543 (1994). In combination with $Ti(O\text{-}i\text{-}Pr)_4$, promotes the symmetrical coupling of arylsulfonyl chlorides to biaryls: *Chem. Lett.*, 459 (1990). For a brief feature on uses in synthesis, see: *Synlett*, 1449 (2006). See also **Bis(acetonitrile)dichloropalladium(II)**, **10002**, p. 26.	**500mg** **1g**
39233	**Bis[1,2-bis(diphenylphosphino)ethane]palladium(0)** [31277-98-2], $Pd[(C_6H_5)_2PCH_2CH_2P(C_6H_5)_2]_2$, F.W. 903.25, Powder, MDL MFCD00009880 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**500mg** **1g**
12764	**Bis(dibenzylideneacetone)palladium(0)**  [32005-36-0], $C_{34}H_{28}O_2Pd$, F.W. 575.00, Powder, Packaged under argon, m.p. 135° dec., Solubility: Slightly soluble in CH_2Cl_2, $CHCl_3$ and benzene, Application(s): Hydrogenation, isomerization, carbonylation, oxidation, C-C bond formation, MDL MFCD00051942	**250mg** **1g** **5g**
46000	**Bis[di-tert-butyl(4-dimethylaminophenyl)-phosphine]palladium(0), Pd 16.7%**  [1233717-68-4], $C_{32}H_{56}N_2P_2Pd$, F.W. 637.18, Crystalline, MDL MFCD15071402 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g**
45853	**Bis(di-tert-butyl-phenylphosphine)palladium(0), Pd 19.3%**  [52359-17-8], $C_{28}H_{46}P_2Pd$, F.W. 551.04, Crystalline, MDL MFCD15071400 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g**
44829	**1,1'-Bis(di-tert-butylphosphino)ferrocene palladium dichloride, Pd 16.3%**  [95408-45-0], $C_{26}H_{44}Cl_2FeP_2Pd$, F.W. 651.77, Crystalline, packaged under Argon, Application(s): Coupling reactions, Suzuki couplings, MDL MFCD08064219 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**100mg** **250mg** **1g**
44980	**[1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) bromide, Pd 12.9%**  [124268-93-5], $C_{34}H_{28}Br_2FeP_2Pd$, F.W. 820.62, Solid, MDL MFCD09953448 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
44972	**[1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) chloride, complex with acetone, Pd 13.0-15.0%**  [851232-71-8], $C_{34}H_{28}Cl_2FeP_2Pd\cdot(CH_3)_2CO$, F.W. 787.81, Application(s): Coupling reactions, carbonylation, MDL MFCD00792899 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g** **25g**

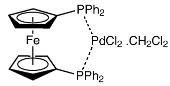
Precious Metal Compounds

Stock #	Description	Standard Selling Sizes

41225 **[1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) chloride, complex with dichloromethane (1:1), Pd 13%** — **1g, 5g, 25g**

[Dichloro[1,1'-bis(diphenylphosphino)ferrocene]palladium(II) dichloromethane complex]

[95464-05-4], $C_{34}H_{28}Cl_2FeP_2Pd.CH_2Cl_2$, F.W. 816.64, Powder, m.p. 275-280°, MDL MFCD00792899

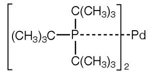


H:H351-H302-H332, P:P280h

Preferred catalyst for coupling of aryl halides and triflates to give arylamines or aryl ethers. For a review, see: *Angew. Chem. Int. Ed.*, **37**, 2046 (1998). Catalyst for boronylation reactions with **Bis(pinacolato)diboron**, **L16088**: *J. Org. Chem.*, **60**, 7508 (1995).

44845 **Bis(tri-tert-butylphosphine)palladium(0), Pd 20.9%** ▲△◪ — **250mg, 1g**

[53199-31-8], $C_{24}H_{54}P_2Pd$, F.W. 511.06, Powder, packaged under inert atmosphere, Application(s): Coupling reactions, Heck couplings, MDL MFCD03094580, Note: Decomposes in water

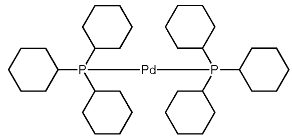


H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

---

45792 **Bis(tricyclohexylphosphine)palladium(0), Pd 15.9%** △ — **250mg, 1g**

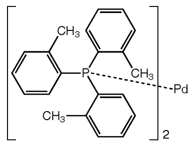
[33309-88-5], $C_{36}H_{66}P_2Pd$, F.W. 667.29, Crystalline, MDL MFCD01073796



H:H315-H319-H335,
P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

45814 **Bis(tri-o-tolylphosphine)palladium(0), Pd 14.9%** △ — **250mg, 1g**

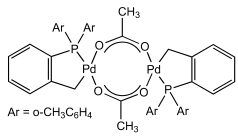
[69861-71-8], $C_{42}H_{42}P_2Pd$, F.W. 715.16, Crystalline, MDL MFCD12911908



L16948 **trans-Di-mu-acetatobis[2-(di-o-tolylphosphino)benzyl-]dipalladium(II), 94%** — **250mg, 1g**

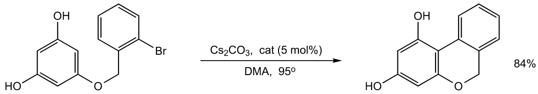
[Herrmann's Catalyst]

[172418-32-5], $C_{46}H_{46}O_4P_2Pd_2$, F.W. 937.66, m.p. ca 230°, Fieser **21**,310, MDL MFCD01075746



H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

'Palladacycle' catalyst, developed by W. A. Herrmann *et al*, which has been reported to surpass all previously known catalysts in the Heck coupling of aryl halides with olefins, with turnover numbers of up to 200,000: *Angew. Chem. Int. Ed.*, **34**, 1844 (1995); DE 4,421,730 (1995 to Hoechst A.-G.); *Tetrahedron Lett.*, **37**, 6535 (1996). Also highly effective in the Suzuki coupling of arylboronic acids with aryl halides (see **Appendix 5**), with turnover numbers up to 74,000: *Angew. Chem. Int. Ed.*, **34**, 1848 (1995); EP 690,046 (1996 to Hoechst A.-G.). Superior catalyst for anion-accelerated intramolecular coupling of phenols with aryl halides: *J. Org. Chem.*, **62**, 2 (1997):



Catalyst for the first reported Pd catalyzed amination of an aryl chloride: *Tetrahedron Lett.*, **38**, 2073 (1997).
For use in the Heck reaction in quaternary salt ionic liquids, see: *J. Organomet. Chem.*, **572**, 141 (1999).
For a review of palladacycles as reactive intermediates, see: *Chem. Ber./ Recl.*, **130**, 1567 (1997). For a brief review of applications of the catalyst, see: *Synlett*, 878 (2001).

44032 **Diacetatobis(triphenylphosphine)palladium(II), Pd 14.2%** — **5g**

[14588-08-0], $Pd(OOCCH_3)_2[P(C_6H_5)_3]_2$, F.W. 749.09, Powder, EINECS 238-628-4, MDL MFCD00010013

39249 **trans-Diamminedibromopalladium(II), Premion®, 99.99% (metals basis), Pd 34.7% min** — **1g**

[14591-90-3], $Pd(NH_3)_2Br_2$, F.W. 300.28, Powder, m.p. 290° dec., d. 2.5, MDL MFCD00058860

H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

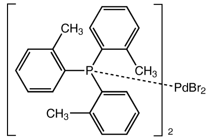
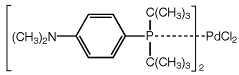
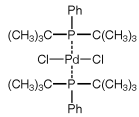
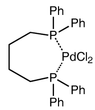
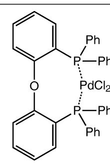
---

11037 **trans-Diamminedichloropalladium(II), Premion®, 99.95% (metals basis), Pd 49.9% min** — **500mg, 2g, 10g**

[Dichlorodiamminepalladium(II)]

[14323-43-4], $Pd(NH_3)_2Cl_2$, F.W. 211.37, Crystalline powder, d. 2.5, Solubility: Slightly soluble in water. Soluble in NH_4OH. Insoluble in chloroform, acetone, EINECS 238-269-3, MDL MFCD00011621, †

H:H302-H413, P:P273-P264-P270-P301+P312-P330-P501a

Stock #	Description	Standard Selling Sizes
11038	**Diamminepalladium(II) nitrite solution, Pd 8-10% w/w (cont. Pd)** *[Diamminedinitritopalladate(II)]* [28068-05-5], $(NH_3)_2Pd(NO_2)_2$, F.W. 232.47(anhy), Liquid, UN2672, MDL MFCD00038712, † H:H318-H302, P:P280-P264-P305+P351+P338-P310-P301+P312-P501a	(c)0.5g (c)2g
13704	**trans-Dibromobis(triphenylphosphine)palladium(II), Pd 13.4%** ■ [22180-53-6], $Br_2Pd[P(C_6H_5)_3]_2$, F.W. 790.80, Powder, Solubility: Soluble in chloroform, toluene and benzene, Application(s): Hydrogenation, MDL MFCD00134175	2g 10g
44979	**Dibromobis(tri-o-tolylphosphine)palladium(II), Pd 12%** △ ◪ [24554-43-6], $C_{42}H_{42}Br_2P_2Pd$, F.W. 874.98, Solid, MDL MFCD09953447, Note: Slowly decomposes in air and moisture H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a  	1g 5g
45511	**Dichlorobis[di-tert-butyl(4-dimethylaminophenyl)-phosphino]palladium(II), Pd 15%** *[Bis[di-tert-butyl(4-dimethylaminophenyl)-phosphine]dichloropalladium(II), PdCl2(Amphos)2]*  [887919-35-9], $C_{32}H_{56}Cl_2N_2P_2Pd$, F.W. 708.08, Crystalline, MDL MFCD09265123 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g
45453	**Dichlorobis(di-tert-butylphenylphosphine)palladium(II), Pd 17.1%** △ ◪ [34409-44-4], $C_{28}H_{46}Cl_2P_2Pd$, F.W. 621.95, Solid, m.p. dec., MDL MFCD09953450 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a  	250mg 1g
44971	**Dichloro[bis(1,4-diphenylphosphino)butane]palladium(II), Pd 17.6%** [29964-62-3], $C_{28}H_{28}Cl_2P_2Pd$, F.W. 603.80, Lump, MDL MFCD02093437 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a  	1g 5g
18779	**Dichloro[bis(1,2-diphenylphosphino)ethane]palladium(II), Pd 18.5%** ■ [19978-61-1], $C_{26}H_{24}Cl_2P_2Pd$, F.W. 575.73, Powder, m.p. >360°, MDL MFCD00015702	2g 10g
44977	**Dichloro[bis(diphenylphosphinophenyl)ether]palladium(II), Pd 14.8%** [205319-06-8], $C_{36}H_{28}Cl_2OP_2Pd$, F.W. 715.88, MDL MFCD09953446 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a  	1g 5g
44844	**Dichlorobis(tricyclohexylphosphine)palladium(II), Pd 14.4%** [29934-17-6], $PdCl_2[P(C_6H_{12})_3]_2$, F.W. 744.24, Powder, MDL MFCD00191830 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a Catalyzes the efficient Pd-catalyzed Heck coupling of aryl chlorides with alkenes, in the presence of cesium carbonate; the corresponding triphenylphosphine complex is ineffective: *Tetrahedron Lett.*, **47**, 2573 (2006).	1g
39823	**trans-Dichlorobis(triethylphosphine)palladium(II)** ■ [28425-04-9], $PdCl_2[P(C_2H_5)_3]_2$, F.W. 413.63, Solubility: Soluble in chloroform, toluene and benzene, Application(s): Coupling of C-C bonds, UN3464, MDL MFCD00191831 H:H301-H311-H332-H319, P:P301+P310-P305+P351+P338-P361-P302+P352-P405-P501a	250mg 1g 5g

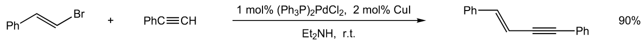
Precious Metal Compounds

Stock #	Description	Standard Selling Sizes

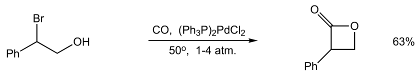
10491 **trans-Dichlorobis(triphenylphosphine)palladium(II), Pd 14.0% min** ■ — **1g**, **5g**, **25g**

[Bis(triphenylphosphine)dichloropalladium(II)]
[13965-03-2], $PdCl_2[P(C_6H_5)_3]_2$, F.W. 701.91, Crystalline, m.p. ca 310° dec., Application(s): Hydrogenation, hydrosilation, carbonylation, oxidation, and C-C bond formation, EINECS 237-744-2, MDL MFCD00009593
H:H413, P:P273-P501a

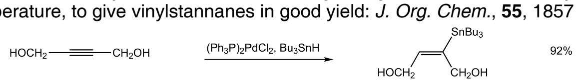
Catalyst for a wide range of coupling reactions:
In combination with CuI and an amine, catalyzes the Sonogashira coupling of terminal alkynes with aryl, vinyl, styryl and 2-pyridyl halides: *Tetrahedron Lett.*, 4467 (1975):



An improved procedure uses triethylamine in THF with catalytic amounts of CuI and the complex, avoiding the need for excess of the acetylene, and gives good yields under mild conditions, even with unreactive aryl bromides: *J. Org. Chem.*, **63**, 8551 (1998).
Catalyst for the Heck reaction (see **Palladium(II) acetate**, **10516**, p. 31). For effect of high pressure in accelerating the reaction, see: *Tetrahedron Lett.*, **36**, 5547 (1995).
For use as catalyst in the Stille coupling of arylstannanes, see **Tri-n-butyltin chloride**, **A10746.**
For examples of the Stille coupling of arylstannanes with aryl triflates to give unsymmetrical biaryls, see: *Org. Synth. Coll.*, **9**, 553 (1998). For reviews, see: *Adv. Met.-Org. Chem.*, **5**, 1 (1996); *Org. React*, **50**, 1 (1997).
Catalyst for the carbonylation of benzyl halides with CO in an alcohol, in the presence of a base, e.g. **1,8-Bis(dimethylamino)naphthalene**, **L00313**, to give arylacetic esters: *J. Org. Chem.*, **40**, 532 (1975). Similarly, allylic chlorides are carbonylated to give predominantly β, -unsaturated acids at atmospheric pressure: *Chem. Lett.*, 957 (1988), and bromo alkanols give lactones: *J. Am. Chem. Soc.*, **102**, 4193 (1980):



Also catalyzes the low-pressure carbonylative cross-coupling of arylboronic acids with iodoarenes to give unsymmetrical biaryl ketones: *Tetrahedron Lett.*, **34**, 7595 (1993); *J. Org. Chem.*, **63**, 4726 (1998).
Catalyzes the exclusively *cis*-addition of **Tri-n-butyltin hydride**, **A13298**, to alkynes at room temperature, to give vinylstannanes in good yield: *J. Org. Chem.*, **55**, 1857 (1990):



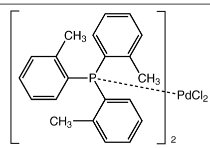
Terminal alkynes give a mixture of regioisomers.
In combination with acetic anhydride and triphenylphosphine, catalyzes the selective conversion of carboxylic acids to 1-alkenes of one less carbon atom: *J. Org. Chem.*, **58**, 29 (1993).

41245 **trans-Dichlorobis(triphenylphosphine)palladium(II), Premion®, 99.95% (metals basis), Pd 14.7% min** ■ — **1g**, **5g**, **25g**

[13965-03-2], $PdCl_2[P(C_6H_5)_3]_2$, F.W. 701.89, Powder, m.p. ca 310° dec., EINECS 237-744-2, MDL MFCD00009593
H:H413, P:P273-P501a

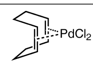
44976 **Dichlorobis(tri-o-tolylphosphine)palladium(II), 98%** △ ◪ — **1g**, **5g**

[40691-33-6], $C_{42}H_{42}Cl_2P_2Pd$, F.W. 786.08, Powder, MDL MFCD00274659



10493 **Dichloro(1,5-cyclooctadiene)palladium(II), Pd 36.7%** ■ — **1g**, **5g**

[12107-56-1], $C_8H_{12}Cl_2Pd$, F.W. 285.49, Crystalline, Solubility: Soluble in dichloromethane, EINECS 235-161-8, MDL MFCD00012412, †



10496 **Dichloro(ethylenediamine)palladium(II), Pd 44.8%** ■ — **1g**, **5g**

[15020-99-2], $PdCl_2(H_2NCH_2CH_2NH_2)$, F.W. 237.41, Crystalline, MDL MFCD00044991
H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

---

44865 **Dihydrogen dinitrosulfatopalladate(II) solution, Pd 3.9-4.1% w/v (cont. Pd)** — **(c)0.5g**, **(c)2g**, **(c)10g**

[Palladium DNS solution, Dinitrosulfatopalladium(II)]
$H_2Pd(NO_2)_2SO_4$, F.W. 296.51(anhy), Liquid, UN3264, MDL MFCD08064221
H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

---

17316 **Lithium tetrachloropalladate(II)** ◪ — **1g**, **5g**

[15525-45-8], Li_2PdCl_4, F.W. 262.09, Crystalline, EINECS 239-567-6, MDL MFCD00011082
H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

Stock # | Description | Standard Selling Sizes

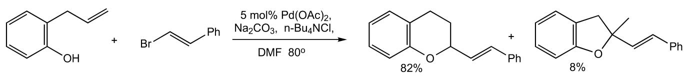
10516 **Palladium(II) acetate, trimer, Pd 45.9-48.4%** — **1g, 5g, 25g**

[Acetic acid palladium(II) salt, Palladium diacetate]
[3375-31-3], $[Pd(C_2H_3O_2)_2]_3$, F.W. 673.46, Needles, m.p. ca 205° dec., Merck **14**,6991, Solubility: Soluble as monomer in glacial acetic acid or as trimer in benzene, Application(s): Carbonylation, oxidation and C-C bond formation, EINECS 222-164-4, MDL MFCD00012453, †

H:H318-H317-H413, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a

Widely used as catalyst, in the presence of a phosphine ligand and a base, in the Heck (or Mizoroki-Heck) reaction, for coupling of aryl or vinyl halides with alkenes. Reviews: *Org. React.*, **27**, 345 (1982); *Acc. Chem. Res.*, **12**, 146 (1979); **28**, 2 (1995); *Angew. Chem. Int. Ed.*, **33**, 2379 (1994); *Chem. Rev.*, **100**, 3009 (2000). In many reactions, e.g. the arylation of α,β-unsaturated esters, **Tri(o-tolyl)phosphine**, **A12093** is superior to triphenylphosphine: *J. Org. Chem.*, **43**, 2952 (1978).
For the Heck-type reaction of arenediazonium salts with alkenes, see **p-Anisidine**, **A10946.**

o-Allylic or *o*-vinylic phenols undergo phosphine-free Pd-catalyzed cross-coupling with vinylic halides and triflates, giving dihydrobenzopyrans and dihydrobenzofurans respectively: *Tetrahedron Lett.*, **39**, 237 (1998):



In the presence of TBAB, catalyzes direct homocoupling of aryl halides: *Tetrahedron Lett.*, **39**, 2559 (1998).
Use in an improved "Wacker" oxidation of terminal alkenes to 2-alkanones, with **p-Benzoquinone**, **A13162**, as the co-oxidant, gives rates up to 50 times higher than earlier procedures: *J. Org. Chem.*, **55**, 2924 (1990).
Also catalyzes the allylic acetoxylation of cycloalkenes: *Org. Synth. Coll.*, **8**, 137 (1993).
For catalysis of the efficient "ligandless" Suzuki cross-coupling of arylboronic acids with aryl iodides, see: *J. Org. Chem.*, **59**, 5034 (1994); *Org. Synth.*, **75**, 61 (1997).
For a brief feature on uses of palladium acetate in synthesis, see: *Synlett*, 329 (2006).

43086 **Palladium(II) acetate, trimer, 99.98% (metals basis), Pd 47% min** — **1g, 5g**

[3375-31-3], $[Pd(C_2H_3O_2)_2]_3$, F.W. 673.46, Powder, m.p. ca 205° dec., Merck **14**,6991, EINECS 222-164-4, MDL MFCD00012453, †

H:H318-H317-H413, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a

---

11878 **Palladium(II) bromide, Premion®, 99.99% (metals basis), Pd 39.5% min ■** — **2g, 10g**

[13444-94-5], $PdBr_2$, F.W. 266.22, Powder, m.p. dec., EINECS 236-588-2, MDL MFCD00011170, †

H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

---

43697 **Palladium(II) bromide, Premion®, 99.998% (metals basis), Pd 39.5% min** — **1g, 5g**

[13444-94-5], $PdBr_2$, F.W. 266.22, Powder, m.p. dec., EINECS 236-588-2, MDL MFCD00011170, †

H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

---

12623 **Palladium(II) chloride, solution, Pd 9.0-11.0% w/w (cont. Pd)** — **(c)1g, (c)5g**

[7647-10-1], $PdCl_2$, F.W. 177.31, Liquid, UN3264, EINECS 231-596-2, MDL MFCD00003558, †

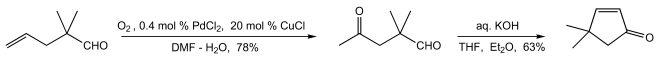
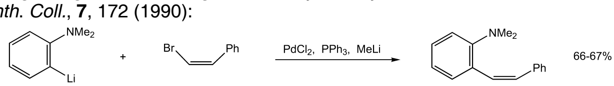
H:H290-H312-H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P322-P501a

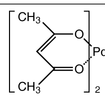
---

40019 **Palladium(II) chloride, solution, Pd 20-25% w/w (cont. Pd)** — **(c)1g, (c)5g**

[7647-10-1], $PdCl_2$, F.W. 177.31, Liquid, UN3264, EINECS 231-596-2, MDL MFCD00003558, †

H:H314-H290-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

Stock #	Description	Standard Selling Sizes
11034	**Palladium(II) chloride, 99.9% (metals basis), Pd 59.5% min** [7647-10-1], $PdCl_2$, F.W. 177.31, Crystalline, m.p. 675° dec., d. 4.0, Merck **14**,6990, Solubility: Soluble in dilute mineral acids, aqueous metal halides, Application(s): Catalyst precursor, EINECS 231-596-2, MDL MFCD00003558, † H:H318-H290-H317, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a Terminal olefins can be oxygenated to ketones using a Cu(I) catalyst in the presence of a catalytic amount of $PdCl_2$ (the Wacker process): *Org. Synth. Coll.*, **7**, 137 (1990). For an example in which the product is readily cyclized to give a useful terpenoid synthon, see: *Org. Synth. Coll.*, **8**, 208 (1993):  In combination with benzoquinone as reoxidant, N-methylarylamines add to Michael acceptors to give enamines: *J. Org. Chem.*, **46**, 2561 (1981). In the presence of triphenylphosphine and MeLi, a Pd(0) species is generated which catalyzes the coupling of organolithium reagents with aryl or vinyl halides. For tabulated results, see: *Org. Synth. Coll.*, **7**, 172 (1990):  For use in the microwave accelerated Heck coupling reaction of aryl halides in the ionic liquid **1-n-Butyl-3-methylimidazolium hexafluorophosphate**, **L19086**, see: *J. Org. Chem.*, **67**, 6243 (2002).	**500mg** **2g** **10g** **50g** **100g** **250g**
43085	**Palladium(II) chloride, Premion®, 99.999% (metals basis), Pd 59.5% min** [7647-10-1], $PdCl_2$, F.W. 177.31, Powder, m.p. 675° dec., d. 4.0, Merck **14**,6990, EINECS 231-596-2, MDL MFCD00003558, † H:H318-H290-H317, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a	**1g** **5g** **25g**
11879	**Palladium(II) cyanide, Pd 66%** [2035-66-7], $Pd(CN)_2$, F.W. 158.74, Powder, m.p. dec., UN1588, EINECS 217-999-6, MDL MFCD00016282, † H:H300-EUH032-H310-H330-H400-H410, P:P301+P310-P304+P340-P320-P330-P361-P405-P501a	**1g** **5g**
39496	**Palladium hydroxide, 99%** [12135-22-7], $Pd(OH)_2$, F.W. 140.42, Powder, EINECS 235-219-2, MDL MFCD00064599, † H:H413, P:P273-P501a	**250mg** **1g** **5g**
45576	**Palladium hydroxide, Pd 5% on carbon, nominally 50% water** [12135-22-7], Black powder, EINECS 235-219-2, MDL MFCD00064599, †	**2g** **10g**
42578	**Palladium hydroxide, Pd 20% on carbon, nominally 50% water, Pearlman's Catalyst** *[Pearlman's Catalyst]* [12135-22-7], Application(s): Hydrogenolysis of benzyl-nitrogen bonds, EINECS 235-219-2, MDL MFCD00064599, Note: Sold on a dry weight basis. Unit weight excludes water weight, † Preferred catalyst for hydrogenolysis of benzylamines. For use in the catalytic transfer hydrogenolysis of allylic acetates, see: *Tetrahedron Lett.*, **30**, 1405 (1989). Gave superior yields to Pd on carbon as catalyst for the heterogeneous hydrostannylation of alkenes with tri-n-butyltin hydride: *Angew. Chem. Int. Ed.*, **35**, 1329 (1996).	**2g** **10g** **50g**
11881	**Palladium(II) iodide, 99.9% (metals basis), Pd 28% min** [7790-38-7], PdI_2, F.W. 360.23, Powder, m.p. 350° dec., d. 6.003, EINECS 232-203-7, MDL MFCD00011171, † H:H317, P:P261-P280-P302+P352-P321-P363-P501a	**2g** **10g**
43084	**Palladium(II) iodide, Premion®, 99.998% (metals basis), Pd 29% min** [7790-38-7], PdI_2, F.W. 360.23, Powder, m.p. 350° dec., d. 6.003, EINECS 232-203-7, MDL MFCD00011171, † H:H317, P:P261-P280-P302+P352-P321-P363-P501a	**2g** **10g**
45512	**Palladium(II) nitrate, solution, Pd 4-5% w/w (cont. Pd)** [10102-05-3], $Pd(NO_3)_2$, F.W. 230.43, Liquid, UN3264, EINECS 233-265-8, MDL MFCD00011169, † H:H314-H318-H290-H400-H410-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**(c)1g** **(c)5g** **(c)25g**
12621	**Palladium(II) nitrate, solution, Pd 8.5% w/w (cont. Pd)** [10102-05-3], $Pd(NO_3)_2$, F.W. 230.43, Liquid, UN3264, EINECS 233-265-8, MDL MFCD00011169, † H:H314-H318-H290-H400-H410-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**(c)1g** **(c)5g** **(c)25g**

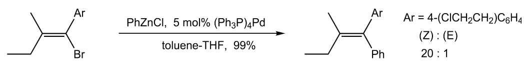
Stock #	Description	Standard Selling Sizes
41647	**Palladium(II) nitrate, solution, Pd 12-16% w/w (cont. Pd)** [10102-05-3], $Pd(NO_3)_2$, F.W. 230.43, Liquid, UN3264, EINECS 233-265-8, MDL MFCD00011169, † H:H314-H318-H290-H400-H410-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	(c)1g (c)5g (c)25g
11035	**Palladium(II) nitrate hydrate, 99.9% (metals basis), Pd 39% min** ■ [10102-05-3], $Pd(NO_3)_2.xH_2O$, F.W. 230.43(anhy), Crystalline, m.p. dec., Merck **14**,6992, Solubility: Soluble in water with turbidity, precipitating a brown basic salt. Completely soluble in dilute HNO_3, UN1477, EINECS 233-265-8, MDL MFCD00011169, † H:H272-H400-H410-H315-H319-H317, P:P221-P210-P305+P351+P338-P302+P352-P321-P501a	2g 10g 50g
11041	**Palladium(II) oxide monohydrate, 99.9% (metals basis), Pd 73% min** [64109-12-2], $PdO{\cdot}H_2O$, F.W. 140.41 (122.40anhy), Powder, m.p. dec., Merck **14**,6993, EINECS 215-218-3, MDL MFCD00011172, †	2g 10g
11040	**Palladium(II) oxide, anhydrous, 99.9% (metals basis), Pd 85% min** [1314-08-5], PdO, F.W. 122.40, -22 Mesh Powder, m.p. 870°, d. 8.70, Merck **14**,6993, Solubility: Insoluble in water, acids. Slightly soluble in aqua regia, Application(s): Catalytic reduction, in organic synthesis, EINECS 215-218-3, MDL MFCD00011172, † H:H303, P:P312	1g 5g
10517	**Palladium(II) 2,4-pentanedionate, Pd 34.7%** *[Palladium(II) acetylacetonate, Bis(acetylacetonato)palladium(II)]* [14024-61-4], $C_{10}H_{14}O_4Pd$, F.W. 304.92, Powder, m.p. 210° dec., Solubility: Soluble in benzene and chloroform, Application(s): Carbonylation, oligomerization, EINECS 237-859-8, MDL MFCD00000025, †  H:H318, P:P280-P305+P351+P338-P310	1g 5g
12622	**Palladium(II) sulfate, solution, Pd 6% w/w (cont. Pd)** [13566-03-5], $PdSO_4$, F.W. 202.46(anhy), Liquid, UN3264, EINECS 236-957-8, MDL MFCD00011173, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	(c)1g (c)5g
42529	**Palladium(II) sulfate dihydrate, 99% (metals basis)** ■ [13444-98-9], $PdSO_4.2H2O$, F.W. 238.51 (202.48anhy), Crystalline, m.p. dec., Solubility: Soluble in cold water; decomposes in hot water, UN3260, EINECS 236-957-8, MDL MFCD00011173, † H:H314-H290-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
12165	**Palladium(II) sulfate dihydrate, Premion®, 99.95% (metals basis), Pd 44.1% min** ■ [13444-98-9], $PdSO_4.2H2O$, F.W. 238.51 (202.48anhy), Crystalline, m.p. dec., UN3260, EINECS 236-957-8, MDL MFCD00011173, † H:H314-H290-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	250mg 1g 5g
43698	**Palladium(II) sulfate dihydrate, Premion®, 99.999% (metals basis)** ■ [13444-98-9], $PdSO_4.2H2O$, F.W. 238.51 (202.48anhy), Powder, m.p. dec., UN3260, EINECS 236-957-8, MDL MFCD00011173, † H:H314-H290-H302-H317, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
12674	**Palladium(II) sulfide, 99% (metals basis), Pd 72% min** [12125-22-3], PdS, F.W. 138.46, Crystalline, m.p. 950° dec., d. 6.60, EINECS 235-190-6, MDL MFCD00016285, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
44446	**Dibromobis(tri-tert-butylphosphine)dipalladium(I)** △ *[Palladium(I) tri-tert-butylphosphine bromide dimer]* [185812-86-6], $[Pd(C_4H_9)_3PBr]_2$, F.W. 777.29, Powder, Solubility: Soluble in benzene and toluene, Application(s): Coupling reactions. Will activate aryl chloride and sterically hindered or electron rich aryl/vinyl bromides and iodides. Especially active in difficult aminations, MDL MFCD04114019 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	100mg 500mg 2g
39448	**Palladium(II) trifluoroacetate, 97%** ■ [42196-31-6], $Pd(O_2CCF_3)_2$, F.W. 332.44, Powder, m.p. 210° dec., MDL MFCD00013204 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a Readily forms π-allylpalladium dimers with acyclic alkenes: *J. Am. Chem. Soc.*, **102**, 3572 (1980). See also **Allylpalladium(II) chloride dimer**, **10005**, p. 26. In combination with a phosphine ligand, particularly **Tri(2-furyl)phosphine**, **L13329**, has been found to give superior results to **Palladium(II) acetate**, **10516**, p. 31, or **Tris(dibenzylideneacetone)-dipalladium(0)**, **12760**, p. 36, as a Pd source in Heck, Stille and Suzuki coupling reactions carried out in supercritical CO_2: *Tetrahedron Lett.*, **40**, 2221 (1999).	1g 5g
43473	**Potassium bis(oxalato)palladate(II) dihydrate, Premion®, 99.99% (metals basis)** $K_2Pd(C_2O_4)_2{\cdot}2H_2O$, F.W. 396.69 (360.66anhy), Crystalline, UN3288, MDL MFCD00061538 H:H302-H312, P:P280-P302+P352-P322-P301+P312-P312-P501a	1g 5g
12629	**Potassium dinitrosulfatopalladate(II), solution, Pd 5% (cont. Pd)** [67859-45-4], $K_2Pd(NO_2)_2SO_4$, F.W. 372.69, Liquid, EINECS 267-395-1, MDL MFCD00064669	(c)1g (c)5g

Precious Metal Compounds

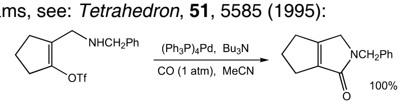
Stock #	Description	Standard Selling Sizes
41011	**Potassium disulfitopalladate(II), Premion®, 99.95% (metals basis), Pd 30.4% min** *[Potassium palladium sulfite]* $K_2Pd(SO_3)_2$, F.W. 344.75, Powder, MDL MFCD00792331 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
43947	**Potassium hexabromopalladate(IV), Premion®, 99.999% (metals basis), Pd 15.5% min** [16919-74-7], K_2PdBr_6, F.W. 664.04, Crystalline, MDL MFCD03093651 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11884	**Potassium hexachloropalladate(IV), Pd 26.3% min ■** [16919-73-6], K_2PdCl_6, F.W. 397.32, Crystalline, m.p. dec., d. 2.738, EINECS 240-974-6, MDL MFCD00043081, † H:H318-H302-H315, P:P280-P305+P351+P338-P302+P352-P321-P310-P501a	1g 5g 25g
11883	**Potassium tetrabromopalladate(II), Pd 21.1% ■** [13826-93-2], K_2PdBr_4, F.W. 504.21, Crystalline, EINECS 237-535-6, MDL MFCD00049659, † H:H318-H302, P:P280-P264-P305+P351+P338-P310-P301+P312-P501a	1g 5g
11885	**Potassium tetrachloropalladate(II), Premion®, 99.99% (metals basis), Pd 32.2% min ■** [10025-98-6], K_2PdCl_4, F.W. 326.42, Crystalline, m.p. 105° dec., d. 2.67, EINECS 233-049-3, MDL MFCD00011373, † H:H290-H302-H319, P:P280-P305+P351+P338-P301+P312-P337+P313-P406-P501a	2g 10g
10535	**Potassium tetracyanopalladate(II) hydrate** [14516-46-2], $K_2[Pd(CN)_4]\cdot xH_2O$, F.W. 288.68(anhy), Crystalline, EINECS 238-520-7, MDL MFCD00150431, † H:H302-H332, P:P261-P264-P304+P340-P301+P312-P312-P501a	1g
10537	**Potassium tetranitropalladate(II), Pd 28.3% min** [13844-89-8], $K_2Pd(NO_2)_4$, F.W. 368.63, Crystalline, m.p. 310° dec., EINECS 237-568-6, MDL MFCD00049788, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11039	**Sodium hexachloropalladate(IV) hydrate, 99.9% (metals basis)** $Na_2PdCl_6\cdot xH_2O$, F.W. 365.10(anhy), Crystalline, EINECS 258-809-1, MDL MFCD00014235 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g 25g
40407	**Sodium tetrabromopalladate(II), Premion®, 99.95% (metals basis), Pd 22.0% min** [50495-13-1], Na_2PdBr_4, F.W. 472.02, Powder, EINECS 256-605-7, MDL MFCD00046199, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g 10g
11886	**Sodium tetrachloropalladate(II) hydrate, 99.95% (metals basis), Pd 30% ■** *[Sodium chloropalladate(II), Palladium sodium chloride]* [13820-53-6], $Na_2PdCl_4.xH_2O$ ($x\approx_3$), F.W. 294.20(anhy), Crystalline, EINECS 237-502-6, MDL MFCD00003487, † H:H318-H290-H302, P:P280f-P305+P351+P338-P406 For use as a catalyst in the carbonylation of allylic halides to give β, -unsaturated esters, see: *Chem. Lett.*, 1873 (1989). In the presence of CsF in aqueous MeOH, catalyzes the cross-coupling of aryl boronates with aryldiazonium salts to give biaryls; no reaction occurs in anhydrous solvents: *Tetrahedron Lett.*, **41**, 6271 (2000).	2g 10g 50g
43945	**Sodium tetrachloropalladate(II) hydrate, Premion®, 99.999% (metals basis), Pd 30% min ■** [13820-53-6], $Na_2PdCl_4.xH_2O$ ($x\approx_3$), F.W. 294.20(anhy), Crystalline, EINECS 237-502-6, MDL MFCD00003487, † H:H318-H290-H302, P:P280f-P305+P351+P338-P406	1g 5g
41021	**Tetraamminepalladium(II) bromide, Premion®, 99.95% (metals basis), Pd 31.3% min** [44463-62-9], $(NH_3)_4PdBr_2$, F.W. 334.34, Powder, m.p. >150° dec., MDL MFCD00797352 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11036	**Tetraamminepalladium(II) chloride monohydrate, 99.9% (metals basis), Pd 39% min ■** [13933-31-8], $Pd(NH_3)_4Cl_2\cdot H_2O$, F.W. 263.45 (245.43anhy), Crystalline, m.p. 120° dec., d. 1.91, UN3077, MDL MFCD00151033, † H:H290-H400-H410-H302-H317-H319, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a	2g 10g
35749	**Tetraamminepalladium(II) nitrate solution, 99.9% (metals basis), Pd 5.0% max (cont. Pd)** [13601-08-6], $(NH_3)_4Pd(NO_3)_2$, F.W. 298.63, Liquid, UN3218, EINECS 237-078-2, MDL MFCD00011591, † H:H272-H319-H317-H411-EUH044, P:P221-P210-P305+P351+P338-P302+P352-P321-P501a	(c)2g (c)10g

Stock #	Description	Standard Selling Sizes
44956	**Tetraamminepalladium(II) sulfate, 99.9% (metals basis), Pd 37.4% min** [13601-06-4], $(NH_3)_4PdSO_4$, F.W. 270.61, Crystalline, MDL MFCD09953444	**1g** **5g** **25g**
39447	**Tetraamminepalladium(II) tetrachloropalladate(II)** [13820-44-5], $[Pd(NH_3)_4][PdCl_4]$, F.W. 422.80, Powder, m.p. 192° dec., d. 2.489, EINECS 237-500-5, MDL MFCD00049783, † ! H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
39446	**Tetrakis(acetonitrile)palladium(II) tetrafluoroborate, Pd 23.9%** △ [21797-13-7], $[Pd(CH_3CN)_4](BF_4)_2$, F.W. 444.22, Powder, m.p. 230° dec., Solubility: Soluble in water, UN2811, MDL MFCD00043297 ! H:H302-H312-H332, P:P261-P280-P302+P352-P304+P340-P322-P501a	**250mg** **1g**
10548	**Tetrakis(triphenylphosphine)palladium(0), 99.8% (metals basis), Pd 9% min** △ *[Palladium(0) tetrakis(triphenylphosphine)]* [14221-01-3], $Pd[P(C_6H_5)_3]_4$, F.W. 1155.57, Crystalline, m.p. 100-105°, Solubility: Soluble in benzene, ethanol and chloroform, Application(s): Hydrosilation, isomerization, carbonylation, oxidation, and C-C bond formation, EINECS 238-086-9, BRN 6704828, MDL MFCD00010012, Note: Heat sensitive, † H:H413, P:P273-P501a	**500mg** **2g** **10g**

Homogeneous catalyst for a wide variety of organometallic coupling reactions.
Numerous methods have been developed for the synthesis of unsymmetrical biaryls, many of which are catalyzed by this Pd(0) complex. Aryl halides or triflates can be coupled with, e.g. Grignard reagents: *Tetrahedron*, **42**, 2111 (1986), arylzinc halides: *Org. Synth. Coll.*, **8**, 430 (1993), organotin reagents (Stille): *Angew. Chem. Int. Ed.*, **25**, 508 (1986); *J. Am. Chem. Soc.*, **109**, 5478 (1987), or boronic acids (Suzuki-Miyaura): *Synth. Commun.*, **11**, 513 (1981); *Chem. Rev.*, **95**, 257 (1995); see **Benzeneboronic acid**, **A14257**, and **Appendix 5**.
Vinyl iodides couple stereoselectively with alkyl, aryl or vinyl Grignards: *Tetrahedron Lett.*, 191 (1978). For stereoselective arylation of a vinylic bromide with an arylzinc chloride in a synthesis of the anti-estrogen agent *(Z)*-tamoxifen and derivatives, see: *J. Org. Chem.*, **55**, 6184 (1990):

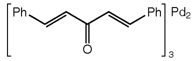
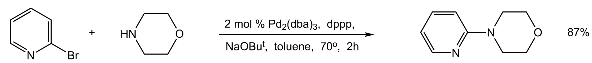
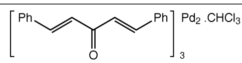


For an example of the coupling of a terminal acetylene with a vinyl bromide by the Sonogashira method using **Copper(I) iodide**, **11606**, see: *Org. Synth. Coll.*, **9**, 117 (1998).
The conversion of aryl halides or triflates to benzonitriles can be much improved by the use of the catalyst in combination with $Zn(CN)_2$ in DMF or NaCN/CuI (cat) in acetonitrile, giving good yields at lower temperatures than the classical Rosenmund-von Braun method (see **Copper(I) cyanide**, **12135**): *Tetrahedron Lett.*, **39**, 2907 (1998); *J. Org. Chem.*, **63**, 8224 (1998). Vinyl bromides or iodides with KCN/18-crown-6 give acrylonitriles in high yield with retention of configuration: *Tetrahedron Lett.*, 4429 (1977). Vinyl triflates with LiCN can also be used: *J. Chem. Soc., Chem. Commun.*, 756 (1989). For a review of palladium- and copper-catalyzed cyanation reactions, see: *Eur. J. Inorg. Chem.*, 3513 (2004).
Allylic esters, halides, etc. form organopalladium intermediates equivalent to allyl cations and react with various nucleophiles, e.g. amines: *J. Am. Chem. Soc.*, **98**, 8516 (1976); *J. Org. Chem.*, **44**, 3451 (1979); *Tetrahedron Lett.*, **24**, 2745 (1983); *Org. Synth. Coll.*, **8**, 13 (1993). For stereoselective introduction of an amino group using sodium azide, see: *J. Org. Chem.*, **54**, 3292 (1989).
Catalyst for a variety of carbonylation reactions. Aryl, vinyl, benzylic and allylic halides with CO (1-3 atm) in the presence of Bu_3SnH give aldehydes: *J. Am. Chem. Soc.*, **105**, 7175 (1983); **108**, 452 (1986). For carbonylative intramolecular cyclization of aminomethyl vinyl triflates to α,β-unsaturated lactams, see: *Tetrahedron*, **51**, 5585 (1995):



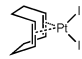
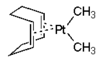
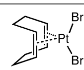
Acyl halides can be coupled with organometallic reagents to give ketones, e.g. organozinc halides: *Tetrahedron Lett.*, **24**, 5181 (1983); *Org. Synth. Coll.*, **8**, 274 (1993), organotin reagents: *Org. Synth. Coll.*, **8**, 268 (1993), or arylboronic acids: *Tetrahedron Lett.*, **40**, 3109 (1999).

Precious Metal Compounds

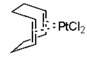
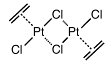
Stock #	Description	Standard Selling Sizes
12760	**Tris(dibenzylideneacetone)dipalladium(0), Pd 21.5% min** △ ◪ *[Bis[tris(dibenzylideneacetone)palladium(0)], $Pd_2(dba)_3$]*  [51364-51-3], $C_{51}H_{42}O_3Pd_2$, F.W. 915.74, Powder, m.p. 152-155°, Fieser **9**,46 **12**,56 **14**,38 **15**,33 **17**,394 **18**,389 **19**,388 **20**,417 **21**,469, Solubility: Soluble in chlorinated solvents, MDL MFCD00013310 Stable source of phosphine-free Pd(0), useful in a variety of coupling reactions. Literature references to the use of either "$Pd(dba)_2$" or "$Pd_2(dba)_3$" can normally be regarded as interchangeable since the catalyst is of somewhat variable composition depending on the exact method of preparation. For use in the coupling of aryl- or vinyltin reagents with allyl halides, see: *J. Am. Chem. Soc.*, **105**, 7173 (1983). For Suzuki coupling of boronic acids with carbapenem triflates, see: *Tetrahedron Lett.*, **34**, 3211 (1993). Catalyzes the reduction of terminal allylic acetates or carbonates to 1-alkenes, with virtually complete regioselectivity: *Synthesis*, 623 (1986). In the presence of allyl bromide, catalyzes the coupling of terminal alkynes to symmetrical diynes under phase-transfer conditions. The reaction is thought to involve a π-allyl Pd intermediate: *Tetrahedron*, **52**, 1337 (1996). In the presence of a chelating phosphine ligand and NaO-*t*-Bu, bromopyridines can be aminated: *J. Org. Chem.*, **61**, 7240 (1996):  Catalyst for Stille and Heck coupling reactions in supercritical CO_2, in combination with, e.g. **Tris[3,5-bis(trifluoromethyl)phenyl]phosphine**, **L06941**: *Chem. Commun.*, 1397 (1998). Catalyzes the hydroxycarbonylation of aryl and vinyl halides or triflates by lithium formate, to give carboxylic acids: *Org. Lett.*, **5**, 4269 (2003).	**1g** **5g**
44969	**Tris(dibenzylideneacetone)dipalladium(0), complex with chloroform, Pd 20.6%** △ ◪  [52522-40-4], $Pd_2(C_{17}H_{14}O)_3.CHCl_3$, F.W. 1035.11, Powder, m.p. 131-135°, Fieser **11**,508 **13**,9 **14**,339 **15**,353 **16**,372 **17**,394 **19**,390 **20**,420 **21**,474, MDL MFCD00075479 H:H351-H373-H315, P:P260-P280-P302+P352-P321-P405-P501a	**1g** **5g**

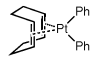
Platinum

Stock #	Description	Standard Selling Sizes
12619	**Ammonium hexabromoplatinate(IV), 99.9% (metals basis), Pt 28%** ■ [17363-02-9], $(NH_4)_2PtBr_6$, F.W. 710.62, Powder, m.p. 145° dec., EINECS 241-394-6, MDL MFCD00044261, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
12882	**Ammonium hexachloroplatinate(IV), Pt 43.4% min** ■ *[Ammonium platinic chloride]* [16919-58-7], $(NH_4)_2PtCl_6$, F.W. 443.89, Powder, m.p. dec., d. 3.06, Merck **14**,548, Solubility: Slightly soluble in water. Insoluble in alcohol, Application(s): Electroplating of platinum, manufacturing of platinum sponge, UN3288, EINECS 240-973-0, MDL MFCD00010886, † H:H301-H334-H318-H290-H400-H410-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g**
40406	**Ammonium hexathiocyanatoplatinate(IV), Premion®, 99.95% (metals basis), Pt 33.2% min** ▲ [19372-45-3], $(NH_4)_2Pt(SCN)_6$, F.W. 579.66, Powder, EINECS 243-002-9, MDL MFCD00798530, † H:H302-EUH032-H312-H332-H412, P:P280h-P273-P301+P310-P315-P420a	**1g** **5g**
11046	**Ammonium tetrachloroplatinate(II), 99.9% (metals basis), Pt 51% min** *[Ammonium chloroplatinate]* [13820-41-2], $(NH_4)_2PtCl_4$, F.W. 372.98, Crystalline, m.p. 145° dec., d. 2.936, UN3288, EINECS 237-499-1, MDL MFCD00010885, † H:H301-H334-H318-H290-H315-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g**
12679	**Barium tetracyanoplatinate(II) tetrahydrate, Pt 38%** *[Barium platinocyanide, Barium cyanoplatinate(II)]* [13755-32-3], $BaPt(CN)_4{\cdot}4H_2O$, F.W. 508.56 (436.50anhy), Powder, m.p. 100° dec., d. 3.05, Merck **14**,991, Application(s): Radiography (making x-ray screens), UN1564, EINECS 209-238-1, MDL MFCD00014183 H:H301-EUH032-H400-H410, P:P273-P264-P301+P310-P321-P405-P501a	**1g** **5g**

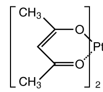
Stock #	Description	Standard Selling Sizes
39463	**Barium tetracyanoplatinate(II) tetrahydrate, Premion®, 99.99% (metals basis)** [13755-32-3], $BaPt(CN)_4 \cdot 4H_2O$, F.W. 508.56 (436.50anhy), Powder, m.p. 100° dec., d. 3.05, Merck **14**,991, UN1564, EINECS 209-238-1, MDL MFCD00014183, † H:H301-EUH032-H400-H410, P:P273-P264-P301+P310-P321-P405-P501a	1g 5g
10004	**Bis(benzonitrile)dichloroplatinum(II), Pt 40% min** [14873-63-3], $PtCl_2[(C_6H_5)(CN)]_2$, F.W. 472.25, Powder, Solubility: Slightly soluble in acetone, chloroform, UN3439, EINECS 238-943-7, MDL MFCD00013125 H:H301-H311-H330-H334-H317, P:P301+P310-P304+P340-P320-P330-P361-P405-P501a	500mg 1g 5g
44041	**(1,5-Cyclooctadiene)diiodoplatinum(II)** [12266-72-7], $C_8H_{12}I_2Pt$, F.W. 557.07, Powder, EINECS 235-538-7, MDL MFCD00050491  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g
13735	**(1,5-Cyclooctadiene)dimethylplatinum(II), Pt 58.5%** [12266-92-1], $C_{10}H_{18}Pt$, F.W. 333.30, Powder, m.p. 103-105°, MDL MFCD00064719, †  H:H334-H335-H315-H319, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g
10471	**cis-Diamminedichloroplatinum(II), Pt 64.5% min** *[Cisplatin]* [15663-27-1], $PtCl_2(NH_3)_2$, F.W. 300.06, Micro Crystals, m.p. 270° dec., Merck **14**,2317, Solubility: Soluble in DMF. Insoluble in most common solvents, Application(s): Potent anticancer agent that blocks DNA synthesis, UN3288, EINECS 239-733-8, MDL MFCD00011623, Note: Special handling precautions required. View MSDS prior to purchase. MSDS are available online at www.alfa.com, † H:H300-H334-H350-H315-H319-H317-H335, P:P201-P301+P310-P308+P313	250mg 1g 5g
10472	**trans-Diamminedichloroplatinum(II), Pt 64.5% min** *[Dichlorodiammineplatinum(II), Transplatin]* [14913-33-8], $PtCl_2(NH_3)_2$, F.W. 300.06, Crystalline, m.p. 340° dec., EINECS 238-980-9, MDL MFCD00011623 H:H334-H341-H335-H315-H319-H317, P:P261-P280h-P262-P305+P351+P338-P308+P313	250mg 1g 5g
10475	**trans-Diamminetetrachloroplatinum(IV), Pt 52.6%** ■ [16893-06-4], $PtCl_4(NH_3)_2$, F.W. 370.96, Crystalline, MDL MFCD00050045 H:H334-H341-H335-H315-H319-H317, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	
39282	**Dibromo(1,5-cyclooctadiene)platinum(II), Pt 41.6% min** ■ [12145-48-1], $C_8H_{12}Br_2Pt$, F.W. 463.09, Powder, MDL MFCD00058724  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
10482	**cis-Dichlorobis(diethylsulfide)platinum(II), Pt 43.7%** [15442-57-6], $Pt[(C_2H_5)_2S]_2Cl_2$, F.W. 446.37, Crystalline, Solubility: Soluble in acetone, alcohol and benzene, Application(s): Hydrogenation, EINECS 239-454-1, MDL MFCD00050943 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 1g
10484	**trans-Dichlorobis(diethylsulfide)platinum(II), Pt 43.7%** [15337-84-5], $Pt[(C_2H_5)_2S]_2Cl_2$, F.W. 446.37, Crystalline, Solubility: Soluble in acetone, alcohol and benzene, Application(s): Hydrosilation, EINECS 239-373-1, MDL MFCD00050943 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
39667	**cis-Dichlorobis(ethylenediamine)platinum(II), 99.9% (metals basis)** ■ $Pt(C_2H_8N_2)_2Cl_2$, F.W. 386.19, Crystalline, MDL MFCD00009881 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
39284	**cis-Dichlorobis(triethylphosphine)platinum(II)** ■ [15692-07-6], $PtCl_2[P(C_2H_5)_3]_2$, F.W. 502.32, Powder, m.p. 139-142°, MDL MFCD00058821 H:H334-H335-H315-H319-H317, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	500mg
10492	**cis-Dichlorobis(triphenylphosphine)platinum(II), Pt 24.2% min** ■ [15604-36-1], $PtCl_2[P(C_6H_5)_3]_2$, F.W. 790.58, Crystalline, m.p. 310° dec., Solubility: Slightly soluble in chloroform, hexane toluene, MDL MFCD00010825 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g
41008	**cis-Dichlorobis(triphenylphosphine)platinum(II), Premion®, 99.95% (metals basis), Pt 24.2% min** ■ [15604-36-1], $PtCl_2[P(C_6H_5)_3]_2$, F.W. 790.58, Powder, m.p. 310° dec., MDL MFCD00010825 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
44038	**cis-Dichlorobis(triphenylphosphite)platinum(II)** [30053-58-8], $Pt[P(OC_6H_5)_3]_2Cl_2$, F.W. 886.56, Powder, MDL MFCD00010825 H:H334-H335-H315-H319, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 1g 5g

Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
12739	**Dichloro(1,5-cyclooctadiene)platinum(II), Pt 51.6-52.6% ■** [12080-32-9], $C_8H_{12}Cl_2Pt$, F.W. 374.18, Solid, m.p. 250° dec., Solubility: Soluble in dichloromethane, EINECS 235-144-5, MDL MFCD00012413, †  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g** **5g**
44033	**Di-mu-chlorodichlorobis(cyclohexene)diplatinum(II)** [60134-75-0], $[PtCl_2(C_6H_{10})]_2$, F.W. 692.26, Powder, EINECS 262-073-7, MDL MFCD00050944 H:H334-H335-H315-H319-H317, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	**5g**
39285	**Di-mu-chlorodichlorobis(ethylene)diplatinum(II), 97%** [12073-36-8], $C_4H_8Cl_4Pt$, F.W. 588.10, Crystalline, EINECS 235-135-6, MDL MFCD00058713  H:H334-H335-H315-H319-H317, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g**
10497	**Dichloro(ethylenediamine)platinum(II), Pt 59.7% min ■** [14096-51-6], $PtCl_2(H_2NCH_2CH_2NH_2)$, F.W. 326.10, Crystalline/Powder, EINECS 237-943-4, MDL MFCD00000011 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g**
44035	**Dichloro(norbornadiene)platinum(II)** [12152-26-0], $PtCl_2(C_7H_8)$, F.W. 358.13, Crystalline, EINECS 235-271-6, MDL MFCD00213423	**5g**
12627	**Dihydrogen dinitrosulfatoplatinate(II) solution, Pt 4-6% (cont. Pt)** *[Dinitrosulfatoplatinum(II), Hydrogen dinitrosulfatoplatinate(II)]* [12033-81-7], $H_2Pt(NO_2)_2SO_4$, F.W. 384.17(anhy), Liquid, UN3264, MDL MFCD00064668, Note: Pt DNS Solution, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**(c)0.5g** **(c)2g** **(c)10g**
12617	**Dihydrogen hexabromoplatinate(IV) nonahydrate, 99.9% (metals basis), Pt 23.7% min** *[Bromoplatinic acid, Platinic bromide]* [20596-34-3], $H_2Br_6Pt{\cdot}9H_2O$, F.W. 838.67 (676.56anhy), Crystalline, UN3260, EINECS 243-903-7, MDL MFCD00049645, † H:H334-H314-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	**1g** **5g**
40177	**Dihydrogen hexachloroplatinate(IV) solution, Pt 20% (cont. Pt)** [16941-12-1], H_2PtCl_6, F.W. 409.82(anhy), Liquid, Merck **14**,7526, UN3264, EINECS 241-010-7, MDL MFCD00011330, † H:H300-H334-H314-H290-H317, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a	**(c)0.5g** **(c)2g** **(c)10g**
11051	**Dihydrogen hexachloroplatinate(IV) hexahydrate, 99.9% (metals basis) ■** *[CPA, Chloroplatinic acid]* [18497-13-7], $H_2PtCl_6{\cdot}6H_2O$, F.W. 517.91 (409.82anhy), Crystalline, m.p. 60° dec., d. 2.430, Merck **14**,7526, Fieser **1**,890 **4**,87 **13**,145 **15**,135, Solubility: Soluble in water, alcohol, acetone, ethyl acetate and ether, Application(s): Catalysis, electroplating, photography, platinum mirrors, printing for etching of zinc, producing fine color in glass and porcelain, indelible ink, microscopy, UN2507, EINECS 241-010-7, MDL MFCD00149910, † H:H301-H334-H314-H290-H400-H410-H317, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a Hydrosilylation catalyst. For use in intramolecular hydrosilylation of an alkyne, see: *Tetrahedron Lett.*, **29**, 6955 (1988). In combination with $CuCl_2$, catalyzes the photooxygenation of alcohols to aldehydes or ketones: *J. Am. Chem. Soc.*, **107**, 6116 (1985).	**1g** **5g** **25g** **100g**
36259	**Dihydrogen hexachloroplatinate(IV) hexahydrate, ACS, Premion®, 99.95% (metals basis), Pt 37.5% min ■** [18497-13-7], $H_2PtCl_6.6H_2O$, F.W. 517.91 (409.82anhy), Lump, m.p. 60° dec., d. 2.430, Merck **14**,7526, Fieser **1**,890 **4**,87 **13**,145 **15**,135, UN2507, EINECS 241-010-7, MDL MFCD00149910, † Maximum level of impurities: Solubility in alcohol P.T., Alkali and other salts (as sulfates) 0.05%, Suitability for potassium determinations P.T. H:H301-H334-H314-H290-H400-H410-H317, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a	**1g** **5g** **25g**
42815	**Dihydrogen hexachloroplatinate(IV) hexahydrate, low nitrate, Premion®, 99.95% (metals basis), Pt 37.5% min ■** [18497-13-7], $H_2PtCl_6{\cdot}6H_2O$, F.W. 517.91 (409.82anhy), Lump, m.p. 60° dec., d. 2.430, Merck **14**,7526, Fieser **1**,890 **4**,87 **13**,145 **15**,135, UN2507, EINECS 241-010-7, MDL MFCD00149910, † H:H301-H334-H314-H290-H400-H410-H317, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a	**1g** **5g** **25g**

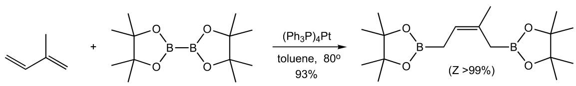
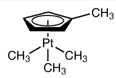
Stock #	Description	Standard Selling Sizes
43696	**Dihydrogen hexachloroplatinate(IV) hydrate, Premion®, 99.999% (metals basis)** ■ *[Hexachloroplatinic acid hydrate]* [26023-84-7], $H_2PtCl_6 \cdot xH_2O$, F.W. 409.82(anhy), Crystalline, m.p. 60° dec., Merck **14**,7526, Fieser **1**,890 **4**,87 **13**,145 **15**,135, UN2507, EINECS 241-010-7, MDL MFCD00149909, † H:H301-H334-H314-H290-H400-H410-H317, P:P260-P301+P310-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
11052	**Dihydrogen hexahydroxyplatinate(IV), 99.9% (metals basis), Pt 61.0% min** ■ *[Hexahydroxyplatinic acid, Hydrogen hexahydroxyplatinate(IV)]* [51850-20-5], $H_2Pt(OH)_6$, F.W. 299.17, Crystalline, m.p. dec., EINECS 257-471-2, MDL MFCD00058744 H:H319, P:P280-P264-P305+P351+P338-P337+P313	500mg 1g 5g
44039	**Diphenyl(1,5-cyclooctadiene)platinum(II)** [12277-88-2], $C_{20}H_{22}Pt$, F.W. 457.47, Powder, MDL MFCD03788255 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	1g 5g
39286	**Iodotrimethylplatinum(IV)** ▲△ [14364-93-3], $(CH_3)_3PtI$, F.W. 367.09, Crystalline, MDL MFCD00013702 H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	500mg 1g
12172	**Platinum(II) bromide, 99.9% (metals basis), Pt 54.5% min** [13455-12-4], $PtBr_2$, F.W. 354.91, Crystalline, m.p. 250° dec., EINECS 236-648-8, MDL MFCD00011180, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12171	**Platinum(IV) bromide, 99.99% (metals basis), Pt 37.1% min** [68938-92-1], $PtBr_4$, F.W. 514.73, Crystalline, m.p. 180° dec., UN3260, EINECS 273-151-5, MDL MFCD00016289, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	1g 5g
11044	**Platinum(II) chloride, 99.9% (metals basis), Pt 73% min** [10025-65-7], $PtCl_2$, F.W. 266.00, Crystalline, m.p. 581° dec., d. 5.87, Merck **14**,7528, Solubility: Insoluble in water, alcohol, ether. Soluble in HCl, NH_4OH, UN3261, EINECS 233-034-1, MDL MFCD00011181, † H:H334-H314-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
43090	**Platinum(II) chloride, Premion®, 99.99+% (metals basis), Pt 73% min** [10025-65-7], $PtCl_2$, F.W. 266.00, Powder, m.p. 581° dec., d. 5.87, Merck **14**,7528, UN3260, EINECS 233-034-1, MDL MFCD00011181, † H:H334-H314-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
11045	**Platinum(IV) chloride, 99.9% (metals basis), Pt 57% min** ■ [13454-96-1], $PtCl_4$, F.W. 336.90, Crystalline, m.p. 370° dec., UN3260, EINECS 236-645-1, MDL MFCD00011182, † H:H334-H341-H314-H302-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
43703	**Platinum(IV) chloride, Premion®, 99.99+% (metals basis), Pt 57% min** ■ [13454-96-1], $PtCl_4$, F.W. 336.90, Crystalline, m.p. 370° dec., UN3260, EINECS 236-645-1, MDL MFCD00011182, † H:H334-H341-H314-H302-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
44503	**Platinum(IV) chloride, Premion®, 99.99+% (metals basis), Pt 57% min** ■ [13454-96-1], $PtCl_4$, F.W. 336.90, Crystalline Soluble, m.p. 370° dec., UN1759, EINECS 236-645-1, MDL MFCD00011182, † H:H334-H341-H314-H302-H317, P:P260-P285-P303+P361+P353-P305+P351+P338-P405-P501a	1g 5g
41508	**Platinum (0)-1,3-divinyl-1,1,3,3-tetramethyldisiloxane complex, soln. in vinyl terminated polydimethylsiloxane** ◪ [68478-92-2], $(C_8H_{18}OSi_2)_{1.5}Pt$, F.W. 474.68, Liquid, f.p. >110°(230°F), d. 0.984, Application(s): Catalyst for Si-H addition to olefins silicone vinyl addition room temperature cure catalyst, MDL MFCD00151662, † H:H413, P:P273-P501a	1g 5g 25g
12170	**Platinum(II) iodide, Premion®, 99.99% (metals basis), Pt 43.0% min** [7790-39-8], PtI_2, F.W. 448.90, Powder, m.p. 325° dec., Solubility: Insoluble in water, alkali iodides, EINECS 232-204-2, MDL MFCD00011183, † H:H315-H319-H317-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	250mg 1g 5g
40401	**Platinum(IV) iodide, Premion®, 99.95% (metals basis), Pt 27.3% min** [7790-46-7], PtI_4, F.W. 702.70, Powder, m.p. 130° dec., d. 6.06, Solubility: Decomposes in water. Soluble in alcohol, acetone, alkali, HI, KI, liquid NH_3, UN3260, EINECS 232-207-9, MDL MFCD00016292, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	250mg 1g 5g

Precious Metal Compounds

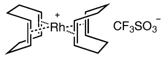
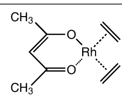
Stock #	Description	Standard Selling Sizes
12278	**Platinum(IV) oxide monohydrate, Adams Catalyst, Pt 75% min** *[Adams' Catalyst]* [12137-21-2], $PtO_2.H_2O$, F.W. 245.10 (227.09anhy), Powder, S.A. >85m^2/g, m.p. 450°, Merck **14**,7527, Solubility: Insoluble in water, acid, aqua regia, Application(s): Hydrogenation catalyst. Suitable for the reduction of double and triple bonds, aromatics, carbonyls, nitriles, and nitro groups, UN1479, EINECS 215-223-0, MDL MFCD00066964, Note: Electrochemically prepared for catalyst use, † H:H272, P:P221-P210-P220-P280-P370+P378a-P501a Hydrogenation catalyst. Used in the conversion of ketones to methylenes by hydrogenolysis of enol triflates under neutral conditions: *Tetrahedron Lett.*, **23**, 117 (1982). Catalyst for hydrosilylation of olefins with various alkyl dialkoxy silanes: *Org. Lett.*, **4**, 2117 (2002).	**1g** **5g**
11049	**Platinum(IV) oxide hydrate, 99.9% (metals basis), Pt 71-75%** [52785-06-5], $PtO_2.xH_2O$, F.W. 227.09(anhy), Powder, Merck **14**,7527, Fieser **1**,890 **2**,332 **15**,268 **21**,353, UN1479, EINECS 215-223-0, MDL MFCD00066964, † H:H272, P:P221-P210-P220-P280-P370+P378a-P501a	**250mg** **1g** **5g** **25g**
40402	**Platinum(IV) oxide, anhydrous, Premion®, 99.95% (metals basis), Pt 84.4% min** [1314-15-4], PtO_2, F.W. 227.09, Powder, m.p. 450°, d. 10.2, Merck **14**,7527, UN1479, EINECS 215-223-0, MDL MFCD00011184, † H:H272, P:P221-P210-P220-P280-P370+P378a-P501a	**250mg** **1g** **5g**
10526	**Platinum(II) 2,4-pentanedionate, Pt 48.0% min** *[Platinum(II) acetylacetonate]* [15170-57-7], $C_{10}H_{14}O_4Pt$, F.W. 393.31, Needles, m.p. 250-252°, Solubility: Very soluble in chloroform, EINECS 239-223-5, MDL MFCD00000028, †  H:H302-H332-H315-H319-H317, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a	**1g** **5g**
13992	**Platinum(IV) sulfide, Pt 74.8% min** [12038-21-0], PtS_2, F.W. 259.22, Powder, m.p. 225-250° dec., EINECS 234-876-2, MDL MFCD00016293, †	**1g** **5g**
12169	**Potassium hexachloroplatinate(IV), Pt 39.6% ■** [16921-30-5], K_2PtCl_6, F.W. 486.01, Crystalline powder, m.p. 250°dec., d. 3.50, n_D^{20} ≈1.825, Merck **14**,7636, Solubility: Soluble in hot water. Slightly soluble in cold water. Practically insoluble in alcohol, UN3288, EINECS 240-979-3, MDL MFCD00011389, † H:H301-H334-H318-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	**250mg** **1g** **5g**
12678	**Potassium hexacyanoplatinate(IV)** [16920-94-8], $K_2Pt(CN)_6$, F.W. 429.40, Powder, EINECS 240-978-8, MDL MFCD00058745 H:H302-H332-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g** **5g**
41014	**Potassium hexahydroxyplatinate(IV), Premion®, 99.95% (metals basis), Pt 51.5% min** [12285-90-4], $K_2Pt(OH)_6$, F.W. 375.34, Powder, EINECS 235-554-4, MDL MFCD00064671, † H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	**1g** **5g**
12642	**Potassium hexaiodoplatinate(IV), Pt 18.2% min** [16905-14-9], K_2PtI_6, F.W. 1034.72, Crystalline, EINECS 240-954-7, MDL MFCD00049660 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
11048	**Potassium tetrachloroplatinate(II), 99.9% (metals basis), Pt 46.0% min** [10025-99-7], K_2PtCl_4, F.W. 415.11, Crystalline, m.p. dec., d. 3.38, Merck **14**,7682, Solubility: Soluble in water, UN3288, EINECS 233-050-9, MDL MFCD00011378, † H:H301-H334-H318-H290-H315-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g** **25g** **50g**
43946	**Potassium tetrachloroplatinate(II), Premion®, 99.99% (metals basis), Pt 46.4% min** [10025-99-7], K_2PtCl_4, F.W. 415.11, Crystalline, m.p. dec., d. 3.38, Merck **14**,7682, UN3288, EINECS 233-050-9, MDL MFCD00011378, † H:H301-H334-H318-H290-H315-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g** **25g**
10536	**Potassium tetracyanoplatinate(II) trihydrate, 99.9% (metals basis), Pt 44.9% min** [14323-36-5], $K_2[Pt(CN)_4].3H_2O$, F.W. 431.42 (377.37anhy), Crystalline, Merck **14**,7685, Solubility: Soluble in hot water, EINECS 209-236-0, MDL MFCD00149921, † H:H302-H332, P:P261-P264-P304+P340-P301+P312-P312-P501a	**1g** **5g**
10538	**Potassium tetranitroplatinate(II), Pt 42.6% min** [13815-39-9], $K_2Pt(NO_2)_4$, F.W. 457.32, Crystalline, EINECS 237-491-8, MDL MFCD00011375, †	**1g** **5g**
39433	**Potassium trichloroammineplatinate(II)** *[Potassium amminetrichloroplatinate(II)]* [13820-91-2], $K(PtCl_3NH_3)$, F.W. 357.56, Crystalline, MDL MFCD00145154 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**500mg**

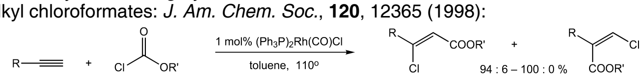
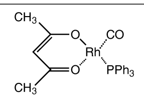
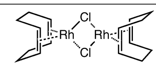
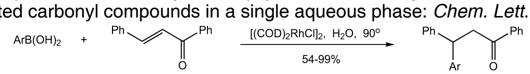
Stock #	Description	Standard Selling Sizes
44028	**Potassium trichloro(ethylene)platinate(II) monohydrate, Pt 50.5% min ■** [16405-35-9], $K[PtCl_3(C_2H_4)].H_2O$, F.W. 386.61 (368.59anhy), Solid, m.p. 220° dec., EINECS 234-577-7, MDL MFCD00150524, Note: Zeise's salt	1g 5g
88966	**Sodium hexabromoplatinate(IV) hexahydrate** [39277-13-9], $Na_2PtBr_6{\cdot}6H_2O$, F.W. 828.49 (720.49anhy), Crystalline, EINECS 254-398-8, MDL MFCD00014237, † H:H334-H335-H315-H319-H317, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11047	**Sodium hexachloroplatinate(IV) hexahydrate** *[Sodium chloroplatinate(IV)]* [19583-77-8], $Na_2PtCl_6{\cdot}6H_2O$, F.W. 561.88 (453.79anhy), Crystalline, m.p. 110° -$6H_2O$, d. 2.50, Merck **14**,8623, Solubility: Soluble in water, alcohol. Insoluble in ether, Application(s): Catalyst, UN3288, EINECS 240-983-5, MDL MFCD00149172, † H:H301-H334-H318-H290-H400-H410-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	1g 5g
44043	**Sodium hexahydroxyplatinate(IV) solution, Pt 7-10% w/v (cont. Pt)** [12325-31-4], $Na_2Pt(OH)_6$, F.W. 343.10, Liquid, MDL MFCD00014236, † H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	5g
12620	**Sodium hexahydroxyplatinate(IV), 99.9% (metals basis)** [12325-31-4], $Na_2Pt(OH)_6$, F.W. 343.10, Crystalline, m.p. 150° dec., EINECS 235-590-0, MDL MFCD00014236, Note: Pt 57%, † H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	1g 5g
41018	**Sodium hexaiodoplatinate(IV) hexahydrate, Premion®, 99.95% (metals basis), Pt 17.1% min** $Na_2PtI_6{\cdot}6H_2O$, F.W. 1110.58 (1002.50anhy), Powder, MDL MFCD00798546 H:H315-H319-H317-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
12168	**Sodium tetrachloroplatinate(II) hydrate, Premion®, 99.95% (metals basis), Pt 42.4% min** *[Sodium platinum chloride, Sodium chloroplatinate(II)]* [207683-21-4], $Na_2PtCl_4{\cdot}xH_2O$ ($x\approx3$), F.W. 382.88(anhy), Crystalline, m.p. 100°, EINECS 233-051-4, MDL MFCD00150188, † H:H301-H334-H318-H315-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	1g 5g
40400	**Sodium tetracyanoplatinate(II) hydrate, Premion®, 99.95% (metals basis), Pt 48.4% min** $Na_2Pt(CN)_4{\cdot}xH_2O$ ($x\approx3$), F.W. 345.14(anhy), Crystalline Powder, MDL MFCD00798527 H:H302-H332, P:P261-P264-P304+P340-P301+P312-P312-P501a	1g 5g
44045	**Tetraammineplatinum(II) chloride solution, Pt 8-10% w/w (cont. Pt)** [13933-32-9], $[Pt(NH_3)_4]Cl_2$, F.W. 334.11(anhy), Liquid, EINECS 237-706-5, MDL MFCD00011475, † H:H290-H315-H319-H412, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	(c)1g (c)5g
10544	**Tetraammineplatinum(II) chloride monohydrate ■** [13933-33-0], $Pt(NH_3)_4Cl_2{\cdot}H_2O$, F.W. 352.13 (334.11anhy), Crystalline, m.p. 250° dec., d. 2.74, EINECS 237-706-5, MDL MFCD00149947, † H:H290-H315-H319-H412, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	1g 5g 25g
10836	**Tetraammineplatinum(II) chloride monohydrate, Premion®, 99.995% (metals basis) ■** [13933-33-0], $Pt(NH_3)_4Cl_2{\cdot}H_2O$, F.W. 352.13 (334.11anhy), Crystalline, m.p. 250°dec., d. 2.74, EINECS 237-706-5, MDL MFCD00149947, † H:H290-H315-H319-H412, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	1g 5g
44042	**Tetraammineplatinum(II) hydrogen carbonate** [123439-82-7], $[Pt(NH_3)_4](HCO_3)_2$, F.W. 385.24, Crystalline, m.p. 236° dec., d. 2.7^4, EINECS 426-730-3, MDL MFCD03788256, † H:H318-H302-H412, P:P280-P273-P305+P351+P338-P310-P301+P312-P501a	1g 5g
44076	**Tetraammineplatinum(II) hydrogen phosphate solution, Pt 0.5% w/w (cont. Pt)** *[5Q Salt]* [127733-98-6], $[Pt(NH_3)_4]HPO_4$, F.W. 359.18(anhy), Liquid, MDL MFCD03788258 H:H334-H317, P:P285-P261-P280-P302+P352-P321-P501a	(c)1g (c)5g
44047	**Tetraammineplatinum(II) hydrogen phosphate solution, Pt 2% w/w (cont. Pt)** *[20Q Salt]* [127733-98-6], $[Pt(NH_3)_4]HPO_4$, F.W. 359.18(anhy), Liquid, MDL MFCD03788258 H:H334-H317, P:P285-P261-P280-P302+P352-P321-P501a	(c)1g (c)5g
42918	**Tetraammineplatinum(II) hydroxide solution, Pt 8-11% w/w (cont. Pt)** [38201-97-7], $(NH_3)_4Pt(OH)_2$, F.W. 297.23, Liquid, EINECS 253-823-4, MDL MFCD00050044, † H:H317, P:P261-P280-P302+P352-P321-P363-P501a	(c)1g (c)5g (c)25g
12167	**Tetraammineplatinum(II) nitrate solution, Pt 3-4% w/w (cont. Pt)** [20634-12-2], $(NH_3)_4Pt(NO_3)_2$, F.W. 387.21, Liquid, d. 1.05, UN3218, EINECS 243-929-9, MDL MFCD00011624 H:H240-H272-H315-H319-EUH001-EUH044, P:P221-P210-P305+P351+P338-P302+P352-P410-P501a	(c)0.5g (c)2g

Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
88960	**Tetraammineplatinum(II) nitrate** [20634-12-2], $(NH_3)_4Pt(NO_3)_2$, F.W. 387.21, Powder/chunks, m.p. 262° dec., UN1477, EINECS 243-929-9, MDL MFCD00011624 H:H272-H319-H317-H335, P:P221-P210-P305+P351+P338-P302+P352-P405-P501a	1g 5g
39444	**Tetraammineplatinum(II) tetrachloroplatinate(II)** *[Magnus Green salt]* [13820-46-7], $[Pt(NH_3)_4][PtCl_4]$, F.W. 600.12, Powder, m.p. 320° dec., d. 4.000, EINECS 237-501-0, MDL MFCD01459899, † H:H301-H334-H318-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	1g
10549	**Tetrakis(triphenylphosphine)platinum(0), Pt 15.2% min** △ *[Platinum(0) tetrakis(triphenylphosphine)]* [14221-02-4], $Pt[P(C_6H_5)_3]_4$, F.W. 1244.21, Crystalline Powder, Solubility: Soluble in benzene, Application(s): Hydrosilation and oxidation, EINECS 238-087-4, MDL MFCD00010014, † H:H302, P:P264-P270-P301+P312-P330-P501a Catalyst for the diboronylation of alkynes with **Bis(pinacolato)diboron**, **L16088**, to give *cis*-bis-boryl alkenes: *Organometallics*, **15**, 713 (1996), and of 1,3-dienes to give 1,4-bis-boryl-2-alkenes: *Chem. Commun.*, 2073 (1996):  Similarly, allenes are converted to 2,3-bis-borylalkenes: *Tetrahedron Lett.*, **39**, 2357 (1998).	1g 5g
43474	**Trimethylbenzylammoniumhexachloroplatinate(IV), Premion®, 99.99% (metals basis)** $[C_6H_5CH_2N(CH_3)_3]_2PtCl_6$, F.W. 708.28, Powder, MDL MFCD00054403 H:H301-H334-H318-H317, P:P285-P301+P310-P305+P351+P338-P302+P352-P405-P501a	1g 5g
98158	**Trimethyl(methylcyclopentadienyl)platinum(IV)** [94442-22-5], $C_9H_{16}Pt$, F.W. 319.32, Powder/Pieces, m.p. 28-31°, b.p. 23°/0.053mm subl., MDL MFCD00079665, † 	500mg

Rhodium

Stock #	Description	Standard Selling Sizes
12645	**Ammonium aquopentachlororhodate(III), Rh 30% min** *[Ammonium pentachlororhodate]* [63771-33-5], $(NH_4)_2[RhCl_5(H_2O)]$, F.W. 334.26, Powder, m.p. 210-230° dec., EINECS 264-455-9, MDL MFCD00064673, † H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11812	**Ammonium hexachlororhodate(III) hydrate, Premion®, 99.99% (metals basis)** ■ $(NH_4)_3RhCl_6 \cdot xH_2O$ (x≈1) (formula not proven), F.W. 369.74(anhy), Powder, m.p. dec., EINECS 239-364-2, MDL MFCD00003394, † H:H318, P:P280-P305+P351+P338-P310	250mg 1g 5g
10849	**Ammonium hexachlororhodate(III) hydrate, Premion®, 99.995% (metals basis)** ■ $(NH_4)_3RhCl_6 \cdot xH_2O$ (x≈1) (formula not proven), F.W. 369.74(anhy), Powder, m.p. dec., EINECS 239-364-2, MDL MFCD00003394, † H:H318, P:P280-P305+P351+P338-P310	500mg 1g 5g
44031	**Bis(1,5-cyclooctadiene)rhodium(I) tetrafluoroborate** [35138-22-8], $[Rh(C_8H_{12})_2]BF_4$, F.W. 406.08, Powder, MDL MFCD00075045	1g 5g
39289	**Bis(1,5-cyclooctadiene)rhodium(I) trifluoromethanesulfonate** △ *[Bis(1,5-cyclooctadiene)rhodium(I)trifluoromethanesulfonate]* [99326-34-8], $C_{17}H_{24}F_3O_3RhS$, F.W. 468.34, Crystalline, Packaged under argon, Solubility: Soluble in chloroform, MDL MFCD00143752 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	500mg 2g
44546	**(+)-1,2-Bis((2S,5S)-2,5-diethylphospholano)benzene(cyclooctadiene)rhodium(I) trifluoromethanesulfonate** △ ◪ [142184-30-3], $Rh(C_8H_{12})(C_{22}H_{36}P_2)CF_3SO_3$, F.W. 722.63, Crystalline, Packaged under argon, Application(s): Catalytic asymmetric cycloisomerization and enantio selections hydrogenation reactions, MDL MFCD00269861	50mg 250mg
39288	**Bis(ethylene)(2,4-pentanedionato)rhodium(I), Rh 39.9% min** △ *[(Acetylacetonato)bis(ethylene)rhodium(I)]* [12082-47-2], $C_9H_{15}O_2Rh$, F.W. 258.13, Crystalline, Solubility: Soluble in dichloromethane, chloroform, EINECS 235-147-1, MDL MFCD00015354 	250mg 1g

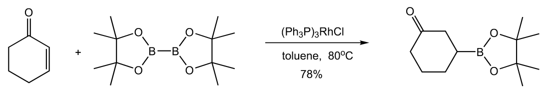
Stock #	Description	Standard Selling Sizes
44036	**Bis(norbornadiene)rhodium(I) tetrafluoroborate** △ ◪ [36620-11-8], $[Rh(C_7H_8)_2]BF_4$, F.W. 373.99, Powder, MDL MFCD00671775 H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
39821	**Bromotris(triphenylphosphine)rhodium(I), 99.95% (metals basis), Rh 10.1% min** [14973-89-8], $RhBr[(C_6H_5)_3P]_3$, F.W. 969.69, Crystalline, Solubility: Soluble in chlorinated solvents, Application(s): Hydrogenation, EINECS 239-050-5, MDL MFCD00009828	250mg 1g 5g
41004	**Carbonylbromobis(triphenylphosphine)rhodium(I), Premion®, 99.95% (metals basis), Rh 13.5% min** *[Bromocarbonylbistriphenylphosphinerhodium(I)]* [14056-79-2], $RhBr(CO)[P(C_6H_5)_3]_2$, F.W. 735.41, Powder, Solubility: Soluble in chloroform, EINECS 237-897-5, MDL MFCD00064608 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
39822	**Carbonylchlorobis(triphenylphosphine)rhodium(I), Rh 14.9% min** *[Carbonylbis(triphenylphosphine)rhodium(I) chloride]* [13938-94-8], $RhCl(CO)[P(C_6H_5)_3]_2$, F.W. 690.71, Crystalline, Fieser **5**,46 **6**,105 **15**,69, Solubility: Soluble in acetone, chloroform, ethanol, EINECS 237-712-8, MDL MFCD00044273 H:H302-H312-H332, P:P261-P280-P302+P352-P304+P340-P322-P501a Catalyst for the decarbonylation of aldehydes and acyl halides: *J. Am. Chem. Soc.*, **89**, 2338 (1967); **90**, 99 (1968); *Tetrahedron Lett.*, 4713 (1966). Effective catalyst for the high-yield, stereoselective chloroesterification of terminal alkynes with alkyl chloroformates: *J. Am. Chem. Soc.*, **120**, 12365 (1998): 	250mg 1g 5g
10016	**Carbonylhydridotris(triphenylphosphine)rhodium(I), Rh 10.0% min** ◪ *[Tris(triphenylphosphine)rhodium carbonyl hydride, Carbonyltris(triphenylphosphine)rhodium(I) hydride]* [17185-29-4], $RhH(CO)[P(C_6H_5)_3]_3$, F.W. 918.80, Powder, m.p. 138° dec, d. 1.33, Merck **14**,9758, Solubility: Soluble in hydrocarbons (e.g. benzene and toluene) with dissociation of phosphine ligands, Application(s): Hydrogenation, hydrosilation, isomerization, carbonylation, hydroformylation, oxidation, EINECS 241-230-3, MDL MFCD00151644, † H:H413, P:P273-P501a	100mg 1g 5g
10458	**Carbonyl-2,4-pentanedionato(triphenylphosphine)rhodium(I), Rh 21%** [25470-96-6], $C_{24}H_{22}O_3PRh$, F.W. 492.32, Crystals, Merck **14**,356, Solubility: Soluble in acetone and chlorinated solvents, Application(s): Hydroformylation, EINECS 247-015-0, MDL MFCD00064611, † H:H413, P:P273-P501a 	250mg 1g 5g
39291	**Chlorobis(ethylene)rhodium(I) dimer, 99%** △ [12081-16-2], $[RhCl(C_2H_4)_2]_2$, F.W. 388.93, Powder, EINECS 235-145-0, MDL MFCD00013206	1g
10466	**Chloro(1,5-cyclooctadiene)rhodium(I) dimer** △ ■ *[Bis(1,5-cyclooctadiene)dirhodium(I) dichloride]* [12092-47-6], $C_{16}H_{24}Cl_2Rh_2$, F.W. 493.08, Crystalline, m.p. 243° dec., Solubility: Sparingly soluble in most common solvents, EINECS 235-157-6, MDL MFCD00012415, Note: Slowly decomposes in air, † Homogeneous catalyst and catalyst precursor. For use in the preparation of a chiral BINAP alkene isomerization catalyst, see: *Org. Synth. Coll.*, **8**, 183 (1993). Catalyzes the dehydrogenative coupling reaction of styrenes with **Pinacolborane**, **L17558**, to give the corresponding vinylboronates: *Tetrahedron Lett.*, **40**, 2585 (1999); *Bull. Chem. Soc. Jpn.*, **75**, 825 (2002). The complex has also been found to promote the atmospheric pressure carbonylation of benzylic halides to give good yields of phenylacetic acids: *Tetrahedron Lett.*, **41**, 7601 (2000). Miyaura has reported the Rh-catalyzed conjugate addition of arylboronic acids to α,β-unsaturated carbonyl compounds in a single aqueous phase: *Chem. Lett.*, 722 (2001): 	250mg 1g
10519	**Chloropentaamminerhodium(III) chloride, Rh 34.5% min** ■ [13820-95-6], $[RhCl(NH_3)_5]Cl_2$, F.W. 294.42, Micro Crystals, m.p. dec., EINECS 237-505-2, MDL MFCD00135665, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 1g 5g

Stock #	Description	Standard Selling Sizes

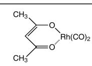
10468 **Chlorotris(triphenylphosphine)rhodium(I), 97%** — 1g, 5g

[Wilkinson's catalyst, Tris(triphenylphosphine)rhodium(I) chloride]
[14694-95-2], $RhCl[(C_6H_5)_3P]_3$, F.W. 925.23, Micro Crystals, m.p. ca 250° dec., Merck **14**,10047, Solubility: Soluble in most solvents (e.g. benzene, ethanol, chloroform, dichloromethane) but with phosphine dissociation. Reacts with O_2 in solution, EINECS 238-744-5, MDL MFCD00010016, Note: Slowly decomposes in air, †
H:H413, P:P273-P501a

Homogeneous hydrogenation catalyst: *J. Chem. Soc.(A)*, 1711 (1966), useful e.g. for the selective reduction of an unhindered alkene, of an unconjugated in the presence of a conjugated alkene: *Org. Synth. Coll.*, **6**, 459 (1988), or an alkene in the presence of a nitro group: *J. Org. Chem.*, **67**, 3163 (2002). Hydroxyl groups protected as their allyl ethers may be deprotected by isomerization with Wilkinson's Catalyst to the more readily-hydrolyzed 1-propenyl ether: *J. Org. Chem.*, **38**, 3224 (1973).
Aldehydes undergo decarbonylation with the complex: *Tetrahedron Lett.*, 3969 (1965); *J. Am. Chem. Soc.*, **93**, 5465 (1971). The need for stoichiometric amounts of the complex, due to formation of an inactive Rh carbonyl complex, is a serious disadvantage. However, in the presence of **Diphenylphosphonic azide**, **A12124**, which regenerates the catalyst from the carbonyl complex, decarbonylations can be carried out catalytically at room temperature, providing a much more cost-effective and attractive method for this type of transformation: *J. Org. Chem.*, **57**, 5075 (1992).
Catalyst for hydrosilylation reactions, e.g. with **Triethylsilane**, **A10320**, including α,β-unsaturated ketones to silyl enol ethers, which can be hydrolyzed to saturated ketones: *Organometallics*, **1**, 1390 (1982), and α,β-unsaturated esters to silyl ketene acetals with high *(Z)*-selectivity: *Synth. Commun.*, **17**, 1 (1989).
Used by Grigg for the catalytic [2+2+2] cyclotrimerization of alkynes, providing an efficient route to benzene-fused ring systems. See, e.g.: *J. Chem. Soc., Perkin 1*, 1357 (1988). For an intermolecular example with reaction scheme, see **1,6-Heptadiyne**, **A11318**.
Intramolecular assembly of suitably constructed triynes can also be accomplished to form benzene rings: *Tetrahedron*, **45**, 6239 (1989). Also catalyzes the [5+2] cycloaddition of vinylcyclopropanes and alkynes: *J. Am. Chem. Soc.*, **117**, 4720 (1995); **120**, 1940 (1998).
Co-catalyst giving improved results in intramolecular Heck coupling reactions catalyzed by $Pd(OAc)_2$: *J. Org. Chem.*, **64**, 3461 (1999).
Electron-deficient olefins undergo Rh-catalyzed 1,4-addition with **Bis(pinacolato)diboron**, **L16088**, e.g. 2-cyclohexen-1-one to the β-borylcyclohexanone: *Tetrahedron Lett.*, **43**, 2323 (2002):

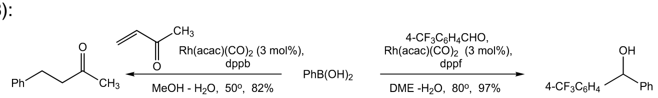


39295 **Dicarbonyl(2,4-pentanedionato)rhodium(I), 99%** — 250mg, 1g, 5g



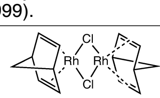
[(Acetylacetonato)dicarbonylrhodium(I), Acetylacetonatorhodium(I) dicarbonyl]
[14874-82-9], $C_7H_7RhO_4$, F.W. 258.04, Crystalline, m.p. 144-147° subl., Fieser **19**,119 **20**,134 **21**,1, Solubility: Soluble in acetone, UN2926, EINECS 238-947-9, MDL MFCD00009884
H:H301-H228-H319-H317-H412, P:P210-P241-P301+P310-P305+P351+P338-P405-P501a

Catalyst for hydroformylation of alkenes with CO/H_2 at atmospheric pressure to give enals: *Angew. Chem. Int. Ed.*, **34**, 1760 (1995).
Miyaura has utilized this complex, in combination with a chelating phosphine ligand, for the conjugate addition of arylboronic acids to enones, to give saturated ketones: *Organometallics*, **16**, 4339 (1997). Addition of aryl- and alkenylboronic acids to aldehydes to give secondary alcohols can also be brought about under similar conditions: *Angew. Chem. Int. Ed.*, **37**, 3279 (1998):



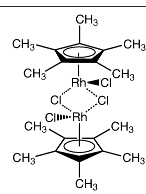
An extension of these reactions to the addition of potassium alkenyl- and aryltrifluoroborates to aldehydes and enones has also been reported: *Org. Lett.*, **1**, 1683 (1999).

10467 **Di-mu-chlorobis(norbornadiene)dirhodium(I), Rh 44% min** — 500mg, 1g

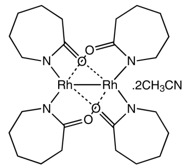
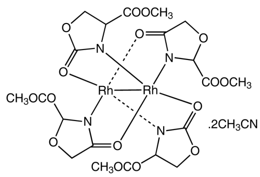
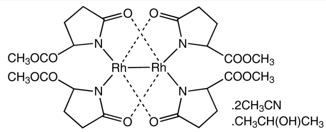
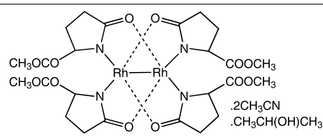


[Chloro(norbornadiene)rhodium(I) dimer]
[12257-42-0], $C_{14}H_{16}Cl_2Rh_2$, F.W. 461.01, Powder, EINECS 235-510-4, MDL MFCD00198060
H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

33657 **Dichloro(pentamethylcyclopentadienyl)rhodium(III) dimer, 99%** — 250mg, 1g

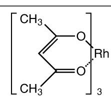


[Pentamethylcyclopentadienylrhodium(III) chloride dimer]
[12354-85-7], $C_{10}H_{15}Cl_4Rh_2$, F.W. 618.08, Powder, m.p. >300°, MDL MFCD00061552
H:H334-H335-H315-H319, P:P285-P305+P351+P338-P302+P352-P321-P405-P501a

Stock #	Description	Standard Selling Sizes
44686	**Dirhodium(II) tetrakis(caprolactam), complex with acetonitrile (1:2)** *[$Rh_2(capy)_4$]* [138984-26-6], $C_{24}H_{40}N_4O_4Rh_2 \cdot 2CH_3CN$, F.W. 736.52, Powder, MDL MFCD00467690, Note: Nominal rhodium content=31.54% 	**25mg** **100mg** **500mg**
44552	**Dirhodium(II) tetrakis(methyl 2-oxazolidone-4(S)-carboxylate), acetonitrile (1:2) complex** ◪ *[Doyle dirhodium catalyst, $Rh_2(4S\text{-}MEOX)_4$]* [167693-36-9], $C_{20}H_{24}N_4O_{16}Rh_2 \cdot 2CH_3CN$, F.W. 864.34, Powder, Packaged under argon, m.p. 293° dec., UN2811, MDL MFCD00467689, Note: Rh 23.81%  H:H302-H312-H332-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**100mg**
44707	**Dirhodium(II) tetrakis(methyl 2-pyrrolidinone-5(R)-carboxylate)acetonitrile, 2-propanol complex** *[$Rh_2(5R\text{-}MEPY)_4$]* [131796-58-2], $C_{24}H_{32}N_4O_{12}Rh_2 \cdot 2CH_3CN \cdot CH_3CH(OH)CH_3$, F.W. 871.46, Powder, Packaged under argon, UN2811, MDL MFCD00192122, Note: Rh nominally 26.58%  H:H302-H312-H332, P:P261-P280-P302+P352-P304+P340-P322-P501a	**100mg** **500mg**
44638	**Dirhodium(II) tetrakis(methyl 2-pyrrolidinone-5(S)-carboxylate)acetonitrile, 2-propanol complex, Rh nominally 25.5%** *[$Rh_2(5S\text{-}MEPY)_4$]* [132435-65-5], $C_{24}H_{32}N_4O_{12}Rh_2 \cdot 2CH_3CN \cdot CH_3CH(OH)CH_3$, F.W. 871.46, Powder, Packaged under argon, MDL MFCD00192123  H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**100mg** **500mg**
43004	**Hexa(acetato)-mu-oxotris(aqua)trirhodium(III) acetate** *[Rhodium(III) acetate]* [42204-14-8], $[Rh_3(OOCCH_3)_6\text{-}\mu\text{-}O(H_2O)_3]OAc$, F.W. 792.07, Powder, Solubility: Soluble in water, acetic acid, EINECS 255-707-9, MDL MFCD01074923 H:H341-H319, P:P280-P281-P305+P351+P338-P308+P313-P405-P501a	**1g** **5g**
44030	**Hydridotetrakis(triphenylphosphine)rhodium(I), Rh 8.9% min** △ [18284-36-1], $RhH[P(C_6H_5)_3]_4$, F.W. 1153.09, Powder, m.p. 145-147° dec., Solubility: Soluble in chloroform, toluene, MDL MFCD00015867 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
41013	**Potassium hexachlororhodate(III), Premion®, 99.99% (metals basis), Rh 23.3% min** ■ [13845-07-3], K_3RhCl_6, F.W. 432.93, Powder, EINECS 237-569-1, MDL MFCD00192414, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**250mg** **1g** **5g**
40410	**Potassium hexanitrorhodate(III), Premion®, 99.99% (metals basis), Rh 20.2% min** [17712-66-2], $K_3Rh(NO_2)_6$, F.W. 496.23, Powder, m.p. dec., EINECS 241-716-5, MDL MFCD00049776, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
11053	**Potassium pentachlororhodate(III) hydrate, 99.9% (metals basis), Rh 29%** $K_2RhCl_5 \cdot xH_2O$, F.W. 358.37(anhy), Powder, MDL MFCD00049661 H:H302-H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	**1g** **5g**
40409	**Potassium pentachlororhodate(III), Premion®, 99.99% (metals basis), Rh 28.2% min** K_2RhCl_5, F.W. 358.37, Powder, Solubility: Slightly soluble in cold water. Insoluble in alcohol, MDL MFCD00049661 H:H302-H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P501a	**1g** **5g**

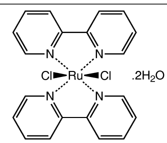
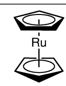
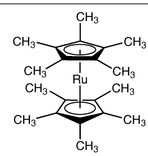
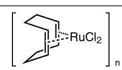
Precious Metal Compounds

Precious Metal Compounds

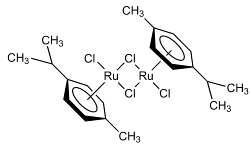
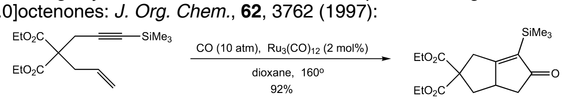
Stock #	Description	Standard Selling Sizes
L15152	**Rhodium(II) acetate, dimer, 98+%** *[Tetrakis(aceto)dirhodium(II), Dirhodium tetraacetate]* [15956-28-2], $[Rh(CO_2CH_3)_2]_2$, F.W. 441.99, m.p. 205°, Fieser **5**,571 **8**,434 **13**,266 **15**,278 **16**,289 **17**,298 **18**,306 **20**,318 **21**,367, EINECS 240-084-8, MDL MFCD00003538 Catalyst for various cyclization reactions involving α-diazo carbonyl groups. Promotes the formation of macrocyclic lactones via intramolecular cyclopropanation and carbon-hydrogen insertion: *J. Am. Chem. Soc.*, **117**, 7181 (1995). For a brief feature on uses of the reagent in synthesis, see: *Synlett*, 3169 (2005).	**100mg** **500mg** **2g**
10560	**Rhodium(II) acetate, dimer, Premion®, 99.99% (metals basis), Rh 46.2% min** *[Tetrakis(aceto)dirhodium(II), Dirhodium tetraacetate]* [15956-28-2], $[Rh(CO_2CH_3)_2]_2$, F.W. 441.99, Powder, m.p. 205°, Fieser **5**,571 **8**,434 **13**,266 **15**,278 **16**,289 **17**,298 **18**,306 **20**,318 **21**,367, Solubility: Slightly soluble in ethanol, Application(s): Cyclopropanation of alkenes, EINECS 240-084-8, MDL MFCD00003538	**250mg** **1g** **5g**
11816	**Rhodium(III) bromide hydrate ■** [123333-87-9], $RhBr_3 \cdot xH_2O$, F.W. 342.62(anhy), Crystalline, EINECS 239-687-9, MDL MFCD00149837, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
	$Rh_2(capy)_4$, see Dirhodium(II) tetrakis(caprolactam), 44686, p. 45	
11032	**Rhodium(III) chloride hydrate, Rh 38.5-45.5% ■** *[Rhodium trichloride hydrate]* [20765-98-4], $RhCl_3 \cdot xH_2O$, F.W. 209.26(anhy), Crystalline, m.p. 100° dec., Merck **14**,8188, Solubility: Soluble in alcohol, water. Slightly soluble in acetone, MDL MFCD00149839, † H:H318-H290-H341-H302, P:P280-P281-P305+P351+P338-P310-P405-P501a	**250mg** **1g** **5g** **25g**
43702	**Rhodium(III) chloride hydrate, Premion®, 99.99% (metals basis) ■** [20765-98-4], $RhCl_3 \cdot xH_2O$, F.W. 209.26(anhy), Crystalline, m.p. 100° dec., Merck **14**,8188, EINECS 233-165-4, MDL MFCD00149839, † H:H318-H290-H341-H302, P:P280-P281-P305+P351+P338-P310-P405-P501a	**1g** **5g**
11815	**Rhodium(III) chloride, anhydrous, 99.9% (metals basis), Rh 48.7% min ■** [10049-07-7], $RhCl_3$, F.W. 209.26, Powder, Merck **14**,8188, EINECS 233-165-4, MDL MFCD00011204, † H:H318-H290-H341-H302-H413, P:P280-P281-P305+P351+P338-P310-P405-P501a	**250mg** **1g** **5g**
11029	**Rhodium(III) iodide, 99.9% (metals basis), Rh 20.8% min ■** [15492-38-3], RhI_3, F.W. 483.62, Crystalline, EINECS 239-521-5, MDL MFCD00016311, † H:H341-H413, P:P281-P273-P201-P308+P313-P405-P501a	**250mg** **1g** **5g**
	$Rh_2(5R\text{-}MEPY)_4$, see Dirhodium(II) tetrakis(methyl 2-pyrrolidinone-5(R)-carboxylate)acetonitrile, 44707, p. 45	
12633	**Rhodium(III) nitrate solution, Rh 10-15% w/w (cont. Rh)** [10139-58-9], $Rh(NO_3)_3$, F.W. 288.92, Liquid, UN3093, EINECS 233-397-6, MDL MFCD00011202, † H:H272-H314-H318-H290-H400-H302-H317, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**(c)0.5g** **(c)2g**
39825	**Rhodium octanoate dimer** [73482-96-9], $[Rh[CH_3(CH_2)_6CO_2]_2]_2$, F.W. 778.62, Powder, Solubility: Soluble in hot alcohol, dichloromethane, toluene and acetic acid, slightly soluble in alcohol, MDL MFCD00064724	**1g** **5g**
12667	**Rhodium(III) oxide pentahydrate, Premion®, 99.99% (metals basis), Rh 59% min** [39373-27-8], $Rh_2O_3 \cdot 5H_2O$, F.W. 343.88 (253.81anhy), Powder, m.p. dec., EINECS 234-846-9, MDL MFCD00149843, †	**250mg** **1g** **5g**
11814	**Rhodium(III) oxide, anhydrous, 99.9% (metals basis), Rh 80.6% min ■** [12036-35-0], Rh_2O_3, F.W. 253.81, Powder, m.p. 1100° dec., d. 8.20, EINECS 234-846-9, MDL MFCD00011205, †	**500mg** **2g**
10561	**Rhodium(III) 2,4-pentanedionate, Premion®, 99.99% (metals basis), Rh 25.2% min** *[Rhodium(III) acetylacetonate]* [14284-92-5], $C_{15}H_{21}O_6Rh$, F.W. 400.23, Crystalline, m.p. 263-264°, Solubility: Very soluble in chloroform. Soluble in alcohol, EINECS 238-192-5, MDL MFCD00083144, †  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**500mg** **1g** **5g**
12635	**Rhodium(III) sulfate, bright plating solution, Rh 5% (cont. Rh)** [10489-46-0], $Rh_2(SO_4)_3$, F.W. 493.99, Liquid, d. 1.4, UN3264, EINECS 234-014-5, MDL MFCD00016309, † H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**(c)0.5g** **(c)2g** **(c)5g**
41016	**Rhodium(III) sulfate tetrahydrate, Premion®, 99.99% (metals basis), Rh 35.9% min** [15274-78-9], $Rh_2(SO_4)_3.4H_2O$, F.W. 566.05 (493.99anhy), Crystalline, UN3261, EINECS 234-014-5, MDL MFCD00798544, † H:H314-H290, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a	**250mg** **1g** **5g**

Stock #	Description	Standard Selling Sizes
44029	**Rhodium(II) trifluoroacetate, dimer** [31126-95-1], $[Rh(CF_3CO_2)_2]_2$, F.W. 657.88, Powder, MDL MFCD00209611	1g 5g
40408	**Sodium hexabromorhodate(III) hydrate, Premion®, 99.99% (metals basis), Rh 11.4% min** $Na_3RhBr_6{\cdot}xH_2O$ (x≈12), F.W. 384.59(anhy), Crystalline Powder, MDL MFCD00798531 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11809	**Sodium hexachlororhodate(III) dodecahydrate, Rh 17.1%** [14972-70-4], $Na_3RhCl_6{\cdot}12H_2O$, F.W. 600.77 (384.59anhy), Crystalline, m.p. 900° dec., EINECS 239-047-9, MDL MFCD00003509, †	1g 5g
10547	**Tetracarbonyldi-mu-chlorodirhodium(I), Rh 50.1-52.9%** △ ◪ *[Rhodium carbonyl chloride]* [14523-22-9], $[RhCl(CO)_2]_2$, F.W. 388.76, Crystalline, m.p. 121°, Merck **14**,8187, UN3466, EINECS 238-540-6, MDL MFCD00135610 H:H301-H330, P:P301+P310-P304+P340-P320-P330-P405-P501a	250mg 1g
10553	**Tris(ethylenediamine)rhodium(III) chloride trihydrate, Rh 23.2%** *[Trichlorotris(ethylenediamine)rhodium(III)]* [15004-86-1], $Rh(H_2NCH_2CH_2NH_2)_3Cl_3{\cdot}3H_2O$, F.W. 443.61 (389.56anhy), Crystalline, m.p. 280° dec., EINECS 237-846-7, MDL MFCD00149661 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 1g 5g

Ruthenium

Stock #	Description	Standard Selling Sizes
11874	**Ammonium hexachlororuthenate(IV), Ru 28.4% min** ■ [18746-63-9], $(NH_4)_2RuCl_6$, F.W. 349.87, Crystalline powder, EINECS 242-552-7, MDL MFCD00015962, †	1g 5g
12778	**cis-Bis-(2,2'-bipyridine)dichlororuthenium(II) dihydrate, Ru 19% min** *[cis-Dichlorobis(2,2'-bipyridine)ruthenium(II) dihydrate]* [15746-57-3], $C_{20}H_{16}Cl_2N_4Ru{\cdot}2H_2O$, F.W. 520.38 (484.35anhy), Crystalline, MDL MFCD00012040 	1g 5g
12781	**Bis(cyclopentadienyl)ruthenium, Ru 43.2% min** △ ◪ *[Ruthenocene]* [1287-13-4], $C_{10}H_{10}Ru$, F.W. 231.26, Crystalline, Packaged under argon, m.p. 194-198°, EINECS 215-065-2, MDL MFCD00001442 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	1g 5g
39297	**Bis(pentamethylcyclopentadienyl)ruthenium** △ ◪ *[Decamethylruthenocene]* [84821-53-4], $C_{20}H_{30}Ru$, F.W. 371.53, Crystalline, Packaged in ampoules, MDL MFCD00058889 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	500mg
40524	**Carbonyldihydridotris(triphenylphosphine)ruthenium(II), 99%** ▲ ◪ [25360-32-1], $Ru(CO)(H_2)[P(C_6H_5)_3]_3$, F.W. 917.97, Crystalline, m.p. 161-163°, MDL MFCD00015870 H:H302-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	500mg 2g 10g
10520	**Chloropentaammineruthenium(III) chloride, Ru 33.5% min** ■ *[Pentaamminechlororuthenium(III) chloride]* [18532-87-1], $[RuCl(NH_3)_5]Cl_2$, F.W. 292.58, Micro Crystals, EINECS 242-408-3, MDL MFCD00011529 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
10494	**Dichloro(1,5-cyclooctadiene)ruthenium(II), polymer** ■ [50982-12-2], $[RuCl_2(C_8H_{12})]_n$, Powder, MDL MFCD00171304 	1g 5g

Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
L19126	**Dichloro(p-cymene)ruthenium(II) dimer, 98%** *[Bis(p-cymene)diruthenium(II) tetrachloride, Di-μ-chlorobis[(p-cymene)chlororuthenium(II)]]* [52462-29-0], $C_{20}H_{28}Cl_4Ru_2$, F.W. 612.40, Fieser **19**,120 **21**,52, EINECS 435-530-5, MDL MFCD00064793  H:H318-H302-H317, P:P261-P280-P305+P351+P338-P302+P352-P321-P501a Catalyst for highly stereoselective hydrosilylation of terminal alkynes: *Org. Lett.*, **2**, 1887 (2000). Also promotes the aerobic oxidation of benzylic and allylic alcohols to the corresponding aldehydes: *Tetrahedron Lett.*, **41**, 7507 (2000). In the presence of pyrrolidine, catalyzes the 1,4-addition of terminal alkynes to enones to give , δ-ynones: *Org. Lett.*, **3**, 2089 (2001). Effective catalyst for dehydration of aldoximes to nitriles: *Org. Lett.*, **3**, 4271 (2001). Verstaile catayst for C-C bond formation by C-H bond activation, for example in the coupling of vinylsilanes with aromatic C-H bonds to give arylethyl silanes: *Angew. Chem. Int. Ed.*, **45**, 8232 (2006).	500mg 2g 10g
10504	**Dichlorotris(triphenylphosphine)ruthenium(II), Premion®, 99.95% (metals basis), Ru 10.2% min** △ ◪ *[Tris(triphenylphosphine)ruthenium(II) chloride]* [15529-49-4], $RuCl_2[P(C_6H_5)_3]_3$, F.W. 958.86, Crystalline powder, m.p. 132-134°, Fieser **4**,564 **14**,130 **15**,128 **16**,126 **18**,309 **19**,123 **20**,136 **21**,164, Solubility: Very slightly soluble (with dissociation) in acetone, alcohol, chloroform, ethyl acetate, and toluene, EINECS 239-569-7, MDL MFCD00013077	1g 5g
10507	**Dodecacarbonyltriruthenium, 99%** *[Ruthenium carbonyl, Triruthenium dodecacarbonyl]* [15243-33-1], $Ru_3(CO)_{12}$, F.W. 639.33, Crystalline, m.p. ca 150° dec., Solubility: Sparingly soluble in hydrocarbons (e.g. hexane, cyclohexane, benzene) and acetone. Solutions undergo some decomposition on strong heating, Application(s): Carbonylation, UN3466, EINECS 239-287-4, MDL MFCD00011209, † H:H330, P:P260-P284-P304+P340-P320-P405-P501a 1,6-Enynes undergo cyclocondensation with CO under pressure, to give bicyclo[3.3.0]octenones: *J. Org. Chem.*, **62**, 3762 (1997):  On heating under pressure with norbornene and CO, alkynes undergo aromatization to give condensed hydroquinones: *Organometallics*, **17**, 766 (1998). For reaction scheme, see **2-Hexyne**, **B22405**.	1g 5g
10511	**Hexaammineruthenium(III) chloride, Ru 32.1% min** [14282-91-8], $Ru(NH_3)_6Cl_3$, F.W. 309.61, Powder, UN3288, EINECS 238-176-8, MDL MFCD00011478 H:H301-H311, P:P301+P310-P361-P302+P352-P321-P405-P501a	250mg 1g 5g
44803	**(S)-Paraphos RutheniumCl₂ (R,R)-DPEN** $C_{74}H_{66}Cl_2N_2OP_2Ru$, F.W. 1233.27, Powder, MDL MFCD08064217	100mg
44800	**(R)-P-Phos Ruthenium (acac)₂** [316829-35-3], $C_{48}H_{48}N_2O_8P_2Ru$, F.W. 945.94, Powder, MDL MFCD08064214	100mg
41716	**Potassium aquapentachlororuthenate(III), Premion®, 99.99% (metals basis), Ru 26.4% min** [14404-33-2], $K_2(RuCl_5)(H_2O)$, F.W. 374.55 (356.53anhy), Crystalline, EINECS 238-374-4, MDL MFCD00058747 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
44547	**Potassium hexachlororuthenate(III), Premion®, 99.99% (metals basis), Ru 23% min** [25443-63-4], K_3RuCl_6, F.W. 431.09, Crystalline, EINECS 246-983-1, MDL MFCD00011390, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
40399	**Potassium hexachlororuthenate(IV), Premion®, 99.95% (metal basis), Ru 25.3% min** [23013-82-3], K_2RuCl_6, F.W. 391.99, Cystalline Powder, EINECS 245-381-6, MDL MFCD00050159, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	1g 5g
11876	**Potassium hexacyanoruthenate(II) hydrate, Ru 23.0% min** [339268-21-2], $K_4Ru(CN)_6.xH_2O$, F.W. 413.57(anhy), Crystalline, UN1588, EINECS 239-097-1, MDL MFCD00168064 H:H302-H332-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	200mg 2g 10g

Stock #	Description	Standard Selling Sizes
10534	**Potassium pentachloronitrosylruthenate(II), Ru 25.8%** [14854-54-7], $K_2RuCl_5(NO)$, F.W. 386.55, Crystalline, m.p. 220° dec., EINECS 238-919-6, MDL MFCD00049789, †	**250mg** **1g**

H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a

12173	**Potassium pentachlororuthenate(III) hydrate, 99.95% (metals basis), Ru 25.4% min** $K_2RuCl_5{\cdot}xH_2O$, F.W. 356.54(anhy), Crystalline, MDL MFCD00058747, †	**1g** **5g**
11877	**Potassium perruthenate(VII), 97%** [10378-50-4], $KRuO_4$, F.W. 204.17, Crystalline, m.p. 440° dec., UN1479, EINECS 233-835-6, MDL MFCD00061333, †	**1g** **5g**

H:H272-H315-H319-H335, P:P221-P210-P305+P351+P338-P302+P352-P405-P501a

12628	**Ruthenium(III) bromide hydrate, Ru 25% min ■** [14014-88-1], $RuBr_3{\cdot}xH_2O$ (x≈3), F.W. 340.78(anhy), Crystalline, Solubility: Soluble in alcohol, Application(s): Oxidation, UN3260, EINECS 237-829-4, MDL MFCD00016314, †	**1g** **5g**

H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

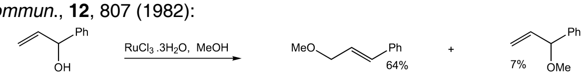
11807	**Ruthenium(III) bromide, Ru 29% min ■** [14014-88-1], $RuBr_3$, F.W. 340.78, Powder, d. 5.30, UN3260, EINECS 237-829-4, MDL MFCD00016314, †	**1g** **5g**

H:H314, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

11043	**Ruthenium(III) chloride hydrate, 99.9% (PGM basis), Ru 38% min ■** [14898-67-0], $RuCl_3.xH_2O$, F.W. 207.43(anhy), Crystalline Soluble, m.p. 100°dec, Merck **14**,8302, Solubility: Very soluble in water. Soluble in alcohol, acetone, Application(s): Oxidation, UN3260, EINECS 233-167-5, MDL MFCD00149844, †	**2g** **10g** **50g**

H:H314-H318-H290-H302-H412, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

In the presence of NaOH, is a catalyst for the high-yield rearrangement of *sec*-allylic alcohols to saturated ketones: *J. Chem. Soc., Chem. Commun.*, 594 (1980). In MeOH, allyl alcohols are converted to allyl ethers. The thermodynamically more stable isomer predominates: *Synth. Commun.*, **12**, 807 (1982):



In the presence of 2,2'-bipyridine, catalyzes the stereospecific epoxidation of alkenes. The configuration of the alkene is retained: *Tetrahedron Lett.*, **25**, 3187 (1984).
Used catalytically, in the presence of a suitable reoxidant, such as periodate or sometimes hypochlorite, $RuCl_3$ is a source of the powerful oxidizing agent, ruthenium(VIII) oxide, RuO_4: *J. Org. Chem.*, **46**, 3936 (1981); *J. Am. Chem. Soc.*, **103**, 464 (1981).
Oxidations by RuO_4 include: Alkenes to carboxylic acids: *J. Am. Chem. Soc.*, **103**, 464 (1981); *Org. Synth. Coll.*, **8**, 377 (1993). In biphasic solvent systems, the reaction can also be controlled to give good yields of *syn*-diols: *Angew. Chem. Int. Ed.*, **33**, 2312 (1994); *Chem. Eur. J.*, **2**, 50 (1996). For an improved protocol, employing only 0.5 mol% catalyst, see: *Org. Lett.*, **5**, 3353 (2003). For oxidation of diols to carboxylic acids: *J. Org. Chem.*, **53**, 5185 (1988). à,á-Enones to carboxylic acids: *J. Org. Chem.*, **52**, 689 (1987). Alkynes to à-diketones: *Helv. Chim. Acta*, **71**, 237 (1988). Ethers to esters: *Tetrahedron Lett.*, **24**, 3829 (1983). Amines to amides: *Chem. Pharm. Bull.*, **36**, 3125 (1988). Methylbenzenes to benzoic acids: *J. Org. Chem.*, **51**, 2880 (1986). For the oxidation of alkenes, alcohols and aromatic rings to carboxylic acids in a biphasic system, see: *J. Org. Chem.*, **55**, 1928 (1990). For discussion of the mechanism of oxidation of hydrocarbons and ethers, see: *J. Phys. Org. Chem.*, **9**, 310 (1996). In many of these oxidations, acetonitrile has been found to be superior to other solvents due to its effective coordination to the metal. Review: J. L. Courtney in *Organic Syntheses by Oxidation with Metal Complexes*, W. J. Mijs *et al*, Eds., Plenum Press, London (1986), p 445. For a review of RuO_4-catalyzed dihydroxylation, ketohydroxylation and mono oxidation, in the synthesis of diols and à-hydroxy ketones, see: *Org. Biomol. Chem.*, **2**, 2403 (2004).
For a brief survey of uses of RuC_3 in Organic synthesis, see: *Synlett*, 1974 (2007).

43364	**Ruthenium(III) chloride hydrate, Premion®, 99.99% (metals basis) ■** [14898-67-0], $RuCl_3{\cdot}xH_2O$, F.W. 207.43(anhy), Crystalline, m.p. 100°dec, Merck **14**,8302, UN3260, EINECS 233-167-5, MDL MFCD00149844, †	**2g** **10g**

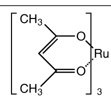
H:H314-H318-H290-H302-H412, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

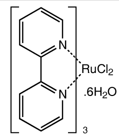
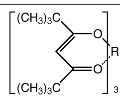
11808	**Ruthenium(III) chloride, anhydrous, Premion®, 99.99% (metals basis), Ru 48.2% min ■** [10049-08-8], $RuCl_3$, F.W. 207.43, Powder, m.p. >500° dec., d. 3.110, Merck **14**,8302, Solubility: Insoluble in cold water. Decomposes in hot water, UN3260, EINECS 233-167-5, MDL MFCD00011208, †	**2g** **10g**

H:H314-H290-H302-H413, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a

11806	**Ruthenium(III) chloride oxide, ammoniated, Ru 35.0% min** *[Tetraamminechlorohydroxoruthenium(III) chloride, Ruthenium Red]* [11103-72-3], $[(NH_3)_5RuORu(NH_3)_4ORu(NH_3)_5]Cl_6$, F.W. 786.35, Crystalline, m.p. >500° dec., d. 3.110, Merck **14**,8300, Solubility: Soluble in water, ammonia, Application(s): Microscopic stain, MDL MFCD00011479	**1g** **5g**

Precious Metal Compounds

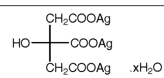
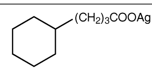
Stock #	Description	Standard Selling Sizes
11805	**Ruthenium(III) iodide, anhydrous, Ru 20.5% min ■** [13896-65-6], RuI_3, F.W. 481.78, Powder, m.p. 590° dec., EINECS 237-664-8, MDL MFCD00016316, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
43435	**Ruthenium(III) nitrosylacetate, Premion®, 99.99% (metals basis)** $Ru(NO)(OOCCH_3)_3$, F.W. 308.18, Powder, MDL MFCD02684507 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
43089	**Ruthenium(III) nitrosylchloride hydrate** [32535-76-5], $Ru(NO)Cl_3{\cdot}xH_2O$, F.W. 237.44(anhy), Crystalline, m.p. 180° dec., MDL MFCD00049765, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
16622	**Ruthenium(III) nitrosylchloride, Ru 42.1% min ■** [18902-42-6], $Ru(NO)Cl_3$, F.W. 237.44, Crystalline, EINECS 242-651-5, MDL MFCD00049765, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
12630	**Ruthenium(III) nitrosylnitrate solution, Ru 1.5% w/v** [34513-98-9], $Ru(NO)(NO_3)_3$, F.W. 317.09, Liquid, d. 1.1, UN3218, EINECS 252-068-8, MDL MFCD00016313, Note: n_D^{25}1.1, † H:H272-H318-H315, P:P221-P210-P305+P351+P338-P302+P352-P321-P501a	**50ml** **250ml** **1L**
12175	**Ruthenium(III) nitrosylnitrate, Ru 31.3% min** [34513-98-9], $Ru(NO)(NO_3)_3$, F.W. 317.09, Crystalline, m.p. dec., UN1477, EINECS 252-068-8, MDL MFCD00016313, † H:H272-H314-H290, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**1g** **5g** **25g**
43436	**Ruthenium(III) nitrosylsulfate, Premion®, 99.99% (metals basis)** $[Ru(NO)]_2(SO_4)_3$, F.W. 550.34, Powder, Solubility: Soluble in water, Application(s): Electroplating, coating, MDL MFCD02684508 H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
11803	**Ruthenium(IV) oxide hydrate, Ru 54% min** [32740-79-7], $RuO_2.xH_2O$, F.W. 133.07(anhy), Powder, m.p. 1200° subl., Solubility: Insoluble in water. Soluble in HCl, Application(s): Oxidation, EINECS 234-840-6, MDL MFCD00149846, † H:H319, P:P280-P264-P305+P351+P338-P337+P313 Precursor for *in situ* generation of the powerful oxidant ruthenium(VIII) oxide (see **Ruthenium(III) chloride hydrate**, **11043**, p. 49): *Helv. Chim. Acta*, **71**, 237 (1988). With Oxone® as stoichiometric oxidant in an acetonitrile/ ethyl acetate/ water solvent system, both terminal and internal alkynes can be cleaved to carboxylic acids in high yield: *J. Org. Chem.*, **69**, 2221 (2004). Mediates the electrooxidation of primary and secondary alcohols to aldehydes and ketones: *Chem. Lett.*, 369 (1995).	**1g** **5g** **25g**
43403	**Ruthenium(IV) oxide hydrate, Premion®, 99.99% (metals basis), Ru 54-58%** [32740-79-7], $RuO_2{\cdot}xH_2O$, F.W. 133.07(anhy), Powder, m.p. 1200° subl., EINECS 234-840-6, MDL MFCD00149846, † H:H319, P:P280-P264-P305+P351+P338-P337+P313	**1g** **5g** **25g**
11804	**Ruthenium(IV) oxide, anhydrous, Premion®, 99.95% (metals basis), Ru 75.2% min ■** *[Ruthenium dioxide]* [12036-10-1], RuO_2, F.W. 133.07, Powder, m.p. 1200° subl., d. 6.97, Solubility: Insoluble in water, acids. Soluble in fused alkalis, UN1479, EINECS 234-840-6, MDL MFCD00011210, † H:H271, P:P221-P283-P210-P306+P360-P371+P380+P375-P501a	**500mg** **2g** **10g**
40336	**Ruthenium(IV) oxide, Electronic Grade, Premion®, 99.95% (metals basis), Ru typically 74% ■** *[Ruthenium dioxide]* [12036-10-1], RuO_2, F.W. 133.07, Sub-micron Powder, Surface Area 45-65m^2/g, m.p. 1200° subl., d. 6.97, Application(s): Semiconductor industry for the manufacture of resistor pastes, UN1479, EINECS 234-840-6, MDL MFCD00011210, † H:H271, P:P221-P283-P210-P306+P360-P371+P380+P375-P501a	**500mg** **2g** **10g**
10568	**Ruthenium(III) 2,4-pentanedionate, Ru 24% min** *[Ruthenium(III) acetylacetonate, Tris(acetylacetonato)ruthenium(III)]* [14284-93-6], $C_{15}H_{21}O_6Ru$, F.W. 398.40, Crystalline, m.p. 260° dec., Solubility: Soluble in acetone, chlorinated hydrocarbons, alcohols, cyclohexane and benzene, Application(s): Hydrogenation, EINECS 238-193-0, MDL MFCD00000030, †  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g** **5g**
43098	**Ruthenium(IV) sulfide, 99.9% (metals basis)** [12166-20-0], RuS_2, F.W. 165.19, Powder, UN3178, EINECS 235-318-0, MDL MFCD00799846, † H:H228-H315-H319-H335-EUH029-EUH031, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g**

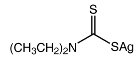
Stock #	Description	Standard Selling Sizes
B24511	**Tetra-n-propylammonium perruthenate(VII), 98%** ■ *[TPAP]* [114615-82-6], $(CH_3(CH_2)_2)_4NRuO_4$, F.W. 351.43, m.p. 160° dec., Fieser **14**,302 **16**,325 **18**,351 **20**,370 **21**,1610, UN1479, MDL MFCD00074914 H:H272-H315-H319-H335, P:P221-P210-P305+P351+P338-P302+P352-P405-P501a Selective, catalytic oxidant introduced by Ley. Normally used in combination with N-methylmorpholine-N-oxide as the stoichiometric reoxidant and 4A molecular sieves to remove water. Preferred solvents are dichloromethane and acetonitrile. Primary and secondary alcohols are oxidized to aldehydes and ketones in high yield: *J. Chem. Soc., Chem. Commun.*, 1625 (1987). For an example of alcohol to aldehyde oxidation in the partial synthesis of the acyl tetronic acid ionophore tetronasin, see: *Tetrahedron Lett.*, **35**, 319 (1994). Also useful for a number of other oxidations such as lactols to lactones and sulfides to sulfones. For oxidation of secondary amines to imines, and of hydroxylamines to nitrones, see: *Tetrahedron Lett.*, **35**, 6567, 6571 (1994). For a comprehensive review of this reagent, see: *Synthesis*, 639 (1994). For a review of ruthenium oxo-complexes as organic oxidants, see: *Chem. Soc. Rev.*, **21**, 179 (1992). For a brief feature on uses in synthesis, see: *Synlett*, 824 (2007).	**100mg** **500mg**
10503	**Tricarbonyldichlororuthenium(II) dimer** [22594-69-0], $[RuCl_2(CO)_3]_2$, F.W. 512.02, Crystalline, UN3466, MDL MFCD00011528 H:H302-H312-H332-H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**1g**
12783	**Tris(2,2'-bipyridine)ruthenium(II) chloride hexahydrate** *[Tris(2,2'-bipyridyl)dichlororuthenium(II)]* [50525-27-4], $C_{30}H_{24}Cl_2N_6Ru \cdot 6H_2O$, F.W. 748.63 (640.54anhy), Crystalline, m.p. 63-66°, EINECS 238-266-7, MDL MFCD00149670, † H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313 	**500mg** **2g**
44006	**Tris(2,2,6,6-tetramethyl-3,5-heptanedionato)ruthenium(III), 99%** ■ *[Ruthenium(III)-DPM, Ru(TMHD)$_3$]* [38625-54-6], $C_{33}H_{57}O_6Ru$, F.W. 650.88, Powder, m.p. 200-203°, b.p. 250° dec., MDL MFCD00269841, Note: Sublimes at 120°/0.5mm H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	**500mg** **2g**
44802	**(R)-Xyl-P-Phos RutheniumCl$_2$ (R,R)-DPEN** $C_{60}H_{66}Cl_2N_4O_4P_2Ru$, F.W. 1141.13, Powder, MDL MFCD08064216	**100mg**

Silver

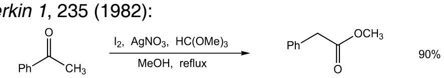
Stock #	Description	Standard Selling Sizes
39306	**Mercury(II) silver iodide** ▲ [7784-03-4], Ag_2HgI_4, F.W. 923.95, Powder, UN2025, EINECS 232-045-9, MDL MFCD00046160 H:H300-H310-H330-H373-H400-H410, P:P301+P310-P304+P340-P320-P330-P361-P405-P501a	**5g** **25g** **100g**
12551	**Potassium silver cyanide, 99.9% (metals basis), Ag 54.2%** ▲ *[Potassium dicyanoargentate, Silver(I) potassium cyanide]* [506-61-6], $KAg(CN)_2$, F.W. 199.01, Powder, d. 2.36, Merck **14**,7669, Solubility: Soluble in water, Application(s): Silver plating, UN1588, EINECS 208-047-0, MDL MFCD00036297, † H:H300-EUH032-H310-H330-H318-H290-H400-H410-H315, P:P301+P310-P304+P340-P305+P351+P338-P320-P330-P361-P405-P501a	**25g** **100g** **500g**
11660	**Silver acetate, anhydrous, 99%** ▲ [563-63-3], $AgOOCCH_3$, F.W. 166.92, Crystalline, m.p. dec., d. 3.26, Merck **14**,8505, Solubility: Soluble in dilute HNO_3. Water solubility increases with temperature, UN3077, EINECS 209-254-9, MDL MFCD00012446, † H:H400-H410-H315, P:P280-P273-P302+P352-P321-P362-P501a	**25g** **100g**
44228	**Silver arsenate, 99.99% (metals basis)** ▲ [13510-44-6], Ag_3AsO_4, F.W. 462.53, Powder/Lumps, UN1557, EINECS 236-841-7, MDL MFCD00046163, † H:H301-H331-H350-H400-H410, P:P261-P281-P301+P310-P321-P405-P501a	**5g** **25g** **100g**
45494	**Silver(I) behenate** ▲ [2489-05-6], $AgO_2C(CH_2)_{20}CH_3$, F.W. 447.44, Powder, m.p. dec., EINECS 219-641-4, MDL MFCD00059001, †	**5g** **25g** **100g**
11896	**Silver benzoate hydrate** ▲ [532-31-0], $C_6H_5CO_2Ag.xH_2O$, F.W. 228.89(anhy), Powder, EINECS 208-533-2, MDL MFCD00013030, †	**5g** **25g** **100g**

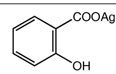
Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
11425	**Silver bromide, 99.9% ▲** [7785-23-1], AgBr, F.W. 187.78, Powder, m.p. 432°, d. 6.47, Merck **14**,8506, Solubility: Practically insoluble in water. Insoluble in alcohol and acids. Partially soluble in ammonia, UN3077, EINECS 232-076-8, MDL MFCD00003398, † H:H400-H410, P:P273-P391-P501a	**5g** **25g** **100g**
12110	**Silver bromide, Premion®, 99.998% (metals basis) ▲** [7785-23-1], AgBr, F.W. 187.78, Crystalline, m.p. 432°, d. 6.47, Merck **14**,8506, UN3077, EINECS 232-076-8, MDL MFCD00003398, † H:H400-H410, P:P273-P391-P501a	**5g** **25g** **100g**
18202	**Silver carbonate on Celite®, ≈0.7 mmole Ag_2CO_3/g reagent ▲** [534-16-7], Ag_2CO_3/Celite, Powder, Application(s): Oxidizing agent for alcohols, diols/triols, hydroquinones, and amines., EINECS 208-590-3, MDL MFCD00003403, † H:H351-H373-H319, P:P280h-P305+P351+P338	**15mmo** **75mmo**
11420	**Silver carbonate, 99.5% (metals basis) ▲** [534-16-7], Ag_2CO_3, F.W. 275.75, Powder, m.p. 218° dec., d. 6.08, Merck **14**,8507, Solubility: Insoluble in water. Freely soluble in dilute HNO_3, ammonia, UN3077, EINECS 208-590-3, MDL MFCD00003403, † H:H318-H400-H410, P:P280-P273-P305+P351+P338-P310-P391-P501a	**25g** **100g**
87342	**Silver chloride, 95% ▲** [7783-90-6], AgCl, F.W. 143.32, Coarse Powder, m.p. 455°, b.p. 1550°, d. 5.56, n_D^{20} 2.071, Merck **14**,8509, Solubility: Practically insoluble in water. Soluble in ammonia, solutions of alkali cyanides, thiosulfates, ammonium carbonates. Insoluble in alcohol, dilute acids, Application(s): Silver plating, UN3077, EINECS 232-033-3, MDL MFCD00003399, † H:H290-H400-H410, P:P273-P234-P390-P391-P406-P501a	**25g** **100g** **500g**
11421	**Silver chloride, 99.9% (metals basis) ▲** [7783-90-6], AgCl, F.W. 143.32, Crystalline, m.p. 455°, b.p. 1550°, d. 5.56, n_D^{20} 2.071, Merck **14**,8509, UN3077, EINECS 232-033-3, MDL MFCD00003399, † H:H290-H400-H410, P:P273-P234-P390-P391-P406-P501a	**25g** **100g** **500g** **3x500g**
10857	**Silver chloride, Premion®, 99.997% (metals basis) ▲** [7783-90-6], AgCl, F.W. 143.32, Coarse Powder, m.p. 455°, b.p. 1550°, d. 5.56, n_D^{20} 2.071, Merck **14**,8509, UN3077, EINECS 232-033-3, MDL MFCD00003399, † H:H290-H400-H410, P:P273-P234-P390-P391-P406-P501a	**5g** **25g** **100g**
35715	**Silver chloride, ultra dry, 99.997% (metals basis) ▲** [7783-90-6], AgCl, F.W. 143.32, -10 Mesh Beads, Ampouled under argon, m.p. 455°, b.p. 1550°, d. 5.56, n_D^{20} 2.071, Merck **14**,8509, UN3077, EINECS 232-033-3, MDL MFCD00003399, † H:H290-H400-H410, P:P273-P234-P390-P391-P406-P501a	**1g** **5g**
40107	**Silver chromate, 99% min ▲** [7784-01-2], Ag_2CrO_4, F.W. 331.73, Powder, d. 5.63, Merck **14**,8510, Solubility: Slightly soluble in water. Soluble in HNO_3 and ammonia, UN1479, EINECS 232-043-8, MDL MFCD00003402, † H:H350-H272-H400-H410-H317, P:P221-P210-P302+P352-P321-P405-P501a	**25g** **100g**
45495	**Silver(I) chromate, 99.9% (metals basis) ▲** [7784-01-2], Ag_2CrO_4, F.W. 331.73, Powder, d. 5.63, Merck **14**,8510, UN1479, MDL MFCD00003402, † H:H350-H272-H400-H410-H317, P:P221-P210-P302+P352-P321-P405-P501a	**5g** **25g** **100g**
45496	**Silver(I) citrate hydrate ▲** *[Citric acid trisilver salt hydrate]* [206986-90-5], $C_6H_5O_7Ag_3.xH_2O$, F.W. 512.70(anhy), Powder, m.p. 170° dec., MDL MFCD00150589, †  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**5g** **25g** **100g**
11424	**Silver cyanide, 99% ▲** [506-64-9], AgCN, F.W. 133.84, Powder, m.p. 320° dec., d. 3.95, n_D^{20} 1.685, Merck **14**,8512, Solubility: Insoluble in water, dilute acids, and alcohol. Soluble in alkali cyanides and boiling concentrated HNO_3, Application(s): Silver plating, UN1684, EINECS 208-048-6, MDL MFCD00003409, † H:H300-EUH032-H310-H330-H318-H290-H400-H410-H315, P:P301+P310-P304+P340-P305+P351+P338-P320-P330-P361-P405-P501a	**25g** **100g**
43708	**Silver cyclohexanebutyrate ▲** *[Cyclohexanebutyric acid silver salt, 4-Cyclohexylbutyric acid silver salt]* [62638-04-4], $C_{10}H_{17}AgO_2$, F.W. 277.11, Powder, m.p. ca 255° dec., EINECS 263-667-9, MDL MFCD00036396, Note: Ag 38-40%, † 	**1g** **5g** **25g**

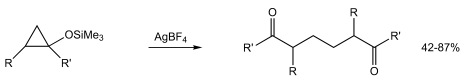
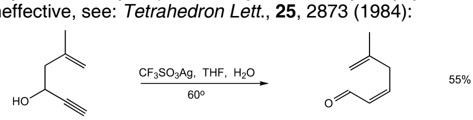
Stock #	Description	Standard Selling Sizes
11898	**Silver diethyldithiocarbamate, ACS ▲**  [1470-61-7], $C_5H_{10}AgNS_2$, F.W. 256.14, Powder, m.p. 172-175°, EINECS 216-003-7, MDL MFCD00004929, † Specifications: Solubility in pyridine P.T., Suitability for determination of arsenic P.T. H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**10g** **50g**
11609	**Silver(I) fluoride, 98% ▲ ◪ ■** [7775-41-9], AgF, F.W. 126.87, Crystalline, m.p. 435°, b.p. ca 1150°, d. 5.852, Merck **14**,8514, Solubility: Soluble in HF, ammonia, CH_3CN, UN3260, EINECS 231-895-8, MDL MFCD00003410, † H:H314-H400-H302-H312-H332, P:P280-P273-P303+P361+P353-P305+P351+P338-P310	**5g** **25g**
11610	**Silver(II) fluoride, 98+% ▲ ◪** *[Silver difluoride]* [7783-95-1], AgF_2, F.W. 145.87, Crystalline, m.p. 690°, d. 4.6, Merck **14**,8513, UN3084, EINECS 232-037-5, MDL MFCD00003411, † H:H272-H314-H400-H302-H312-H332-EUH014, P:P221-P280-P273-P303+P361+P353-P305+P351+P338-P310	**2g** **10g** **50g**
11538	**Silver hexafluoroantimonate, 99% ▲ ■** [26042-64-8], $AgSbF_6$, F.W. 343.41, Powder, Fieser **5**,577 **7**,320 **11**,467, UN3260, EINECS 247-429-1, MDL MFCD00003401, † H:H314-H302-H332-H411, P:P260-P303+P361+P353-P305+P351+P338-P301+P330+P331-P405-P501a Lewis acid catalyst. Catalyst for electrophilic halogenation of alkanes: *J. Am. Chem. Soc.*, **95**, 7680, 7686 (1973). See also **Antimony(V) fluoride**, **33484**. Promotes rearrangement of 3-bromoflavanones to isoflavones: *J. Chem. Soc., Chem. Commun.*, 151 (1976); and remote hydroxylation of α-bromo keto steroids: *J. Org. Chem.*, **47**, 4268 (1982).	**1g** **5g** **25g**
11608	**Silver hexafluoroarsenate, 98+% ◪** [12005-82-2], $AgAsF_6$, F.W. 296.78, Powder, UN1557, MDL MFCD00014142 H:H301-H331-H400-H410, P:P261-P301+P310-P321-P304+P340-P405-P501a	**2g** **10g**
11873	**Silver hexafluorophosphate, 98% ▲** [26042-63-7], $AgPF_6$, F.W. 252.83, Powder, m.p. 102° dec., UN3260, EINECS 247-428-6, MDL MFCD00003415, † H:H314-H400, P:P280-P273-P303+P361+P353-P305+P351+P338-P310	**1g** **5g** **25g**
40129	**Silver hydrogen fluoride, 99% min ▲ ■** *[Silver bifluoride]* [12249-52-4], $AgHF_2$, F.W. 146.87, Crystalline, m.p. dec., UN1740, MDL MFCD00042145 H:H314-H400-H302-EUH032-H312-H332, P:P280-P273-P303+P361+P353-P305+P351+P338-P310	**10g** **50g**
40109	**Silver iodate, 99% ▲** [7783-97-3], $AgIO_3$, F.W. 282.77, Powder, m.p. >200°, d. 5.53, Merck **14**,8515, Solubility: Practically insoluble in water. Soluble in aqueous ammonia, UN1479, EINECS 232-039-6, MDL MFCD00014150, † H:H272-H315-H319-H335, P:P221-P210-P305+P351+P338-P302+P352-P405-P501a	**25g** **100g**
11419	**Silver iodide, 99.9% (metals basis) ▲** [7783-96-2], AgI, F.W. 234.77, Crystalline, m.p. 558°, d. 5.67, Merck **14**,8516, Solubility: Insoluble in water, acids, ammonium carbonate. Freely soluble in alkali cyanides and iodides, UN3077, EINECS 232-038-0, MDL MFCD00003412, † H:H400-H410, P:P273-P391-P501a An efficient palladium-free Sonogashira coupling reaction of terminal alkynes with aryl bromides and iodides has been reported, catalyzed by silver iodide in the presence of triphenylphosphine: *Synlett*, 2261 (2006).	**25g** **100g**
12111	**Silver iodide, Premion®, 99.999% (metals basis) ▲** [7783-96-2], AgI, F.W. 234.77, Powder, m.p. 558°, d. 5.67, Merck **14**,8516, UN3077, EINECS 232-038-0, MDL MFCD00003412, † H:H400-H410, P:P273-P391-P501a	**5g** **25g** **100g**
44858	**Silver lactate solution, Ag 4-5% w/w (cont. Ag) ▲** [128-00-7], $CH_3CH(OH)CO_2Ag$, F.W. 196.94, Liquid, MDL MFCD00043279 H:H402, P:P273	**(c)1g** **(c)5g** **(c)25g**
20835	**Silver lactate ▲** [128-00-7], $CH_3CH(OH)CO_2Ag$, F.W. 196.94, Powder, m.p. 120-122°, Merck **14**,8517, UN3077, MDL MFCD00043279 H:H400-H315-H319-H335, P:P280g-P273-P305+P351+P338	**10g** **50g**
44828	**Silver metavanadate ▲** *[Silver vanadium trioxide]* [13497-94-4], $AgVO_3$, F.W. 206.81, Powder, UN3285, EINECS 236-820-2, MDL MFCD00041760, † H:H301-H315-H319-H335, P:P280h-P305+P351+P338-P309-P310	**5g** **25g**

Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
18641	**Silver methanesulfonate ▲** [2386-52-9], $Ag(SO_3CH_3)$, F.W. 202.97, Powder, UN3077, EINECS 219-199-2, MDL MFCD00064795, † H:H318-H400-H335-H315, P:P280b-P273-P305+P351+P338-P337+P313	**10g** **50g**
39650	**Silver molybdenum oxide, 99% ▲** *[Silver(I) molybdate]* [13765-74-7], Ag_2MoO_4, F.W. 375.68, Powder, m.p. 483°, d. 6.18, EINECS 237-374-1, MDL MFCD00053384, †	**250mg** **1g**
11414	**Silver nitrate, ACS, 99.9+% (metals basis) ▲** [7761-88-8], $AgNO_3$, F.W. 169.87, Crystalline, m.p. 212°, d. 4.352, Merck **14**,8518, Solubility: Freely soluble in water, alcohol, ammonia water. Slightly soluble in ether, Application(s): Silver plating, photography, manufacturing of other silver compounds, mirrors, as an analytical lab reagent, in coloring porcelain, UN1479, EINECS 231-853-9, MDL MFCD00003414, † Maximum level of impurities: Clarity of solution P.T., Cl 5ppm, Free acid P.T., Substances not precipitated by hydrochloric acid 0.01%, SO_4 0.002%, Cu 2ppm, Fe 2ppm, Pb 0.001% H:H272-H314-H290-H400-H410, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**5g** **25g** **100g** **500g** **6x500g**
43087	**Silver nitrate, Premion®, 99.995% (metals basis), Ag 63% min ▲** [7761-88-8], $AgNO_3$, F.W. 169.87, Crystalline, m.p. 212°, d. 4.352, Merck **14**,8518, UN1479, EINECS 231-853-9, MDL MFCD00003414, † H:H272-H314-H290-H400-H410, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**5g** **25g** **100g**
10858	**Silver nitrate, Premion®, 99.9995% (metals basis) ▲** [7761-88-8], $AgNO_3$, F.W. 169.87, Powder, m.p. 212°, d. 4.352, Merck **14**,8518, UN1479, EINECS 231-853-9, MDL MFCD00003414, † H:H272-H314-H290-H400-H410, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**5g** **25g** **100g**
11418	**Silver nitrite, 99% (metals basis) ▲** [7783-99-5], $AgNO_2$, F.W. 153.88, Crystalline, m.p. 140° dec., d. 4.45, Merck **14**,8519, UN2627, EINECS 232-041-7, MDL MFCD00003413, † H:H272-H400-H410-H315-H319, P:P221-P280g-P273-P305+P351+P338-P501a Forms complexes with alkenes, used in the separation of mixtures; see, e.g.: *Org. Synth. Coll.*, **5**, 315 (1973). Promotes the reactivity of NCS in the cleavage of 2-acylated 1,3-dithianes: *Synthesis*, 17 (1969), and of NBS in the 1-bromination of terminal alkynes: *Angew. Chem. Int. Ed.*, **23**, 727 (1984). In combination with Br_2 or I_2 in refluxing methanol, brings about the rearrangement of acetophenones to methyl arylacetates, a reaction previously induced by thallium(III) nitrate: *J. Chem. Soc., Perkin 1*, 235 (1982):  The Hunsdiecker reaction of Ag salts of carboxylic acids with Br_2 provides alkyl bromides with one less carbon atom which is lost as CO_2; see, e.g.: *Org. Synth. Coll.*, **3**, 578 (1955). Reviews: *Chem. Rev.*, **56**, 219 (1956); *Org. React.*, **9**, 332 (1957). Compare also **Mercury(II) oxide**, **A16157**. For the alkylation of substrates by radicals derived from decarboxylation of acids, see **Trimethylacetic acid**, **A10776**. For a brief feature on uses of the reagent in synthesis, see: *Synlett*, 3016 (2005).	**10g** **50g**
43268	**Silver(I) oxide, Electrical Grade ▲** [20667-12-3], Ag_2O, F.W. 231.74, -325 Mesh Powder, m.p. 230° dec., d. 7.2, Merck **14**,8521, Solubility: Soluble in dilute HNO_3 and ammonia. Practically insoluble in water. Insoluble in alcohol, Application(s): For battery plates, pollution control filters, UN1479, EINECS 243-957-1, MDL MFCD00003404, † H:H271-H318-H400-H410, P:P221-P283-P210-P305+P351+P338-P306+P360-P501a	**250g** **1kg**
11407	**Silver(I) oxide, 99+% (metals basis) ▲** [20667-12-3], Ag_2O, F.W. 231.74, Powder, m.p. 230° dec., d. 7.2, Merck **14**,8521, Application(s): Polishing glass, coloring glass yellow, catalyst, purifying drinking water, lab reagent, UN1479, EINECS 243-957-1, MDL MFCD00003404, † H:H271-H318-H400-H410, P:P221-P283-P210-P305+P351+P338-P306+P360-P501a Reagent for conversion of quaternary methiodides to their hydroxides, prior to Hofmann elimination. For the conversion of the methiodide of N,N-dimethylcyclooctylamine to *cis*- and *trans*-cyclooctene, see: *Org. Synth. Coll.*, **5**, 315 (1973). Review: *Org. React.*, **11**, 317 (1960). Promotes the oxidative coupling of silyl enol ethers to give 1,4-diketones: *J. Am. Chem. Soc.*, **97**, 649 (1975). For use in the preparation of mevalonolactone ^{13}C, see: *Org. Synth. Coll.*, **7**, 386 (1990). For use as a mild base in the Suzuki coupling of boronic acids with sensitive halides, see: *Org. Synth.*, **75**, 69 (1997); for reaction scheme, see **4-Methoxybenzeneboronic acid**, **A14462**.	**25g** **100g** **500g**

Stock #	Description	Standard Selling Sizes
42577	**Silver(I) oxide, 99.99% (metals basis) ▲** [20667-12-3], Ag_2O, F.W. 231.74, Powder, m.p. 230° dec., d. 7.2, Merck **14**,8521, UN1479, EINECS 243-957-1, MDL MFCD00003404, † H:H271-H318-H400-H410, P:P221-P283-P210-P305+P351+P338-P306+P360-P501a	**1g** **5g** **25g** **4x25g**
22695	**Silver(II) oxide, 98% ▲ ◪** *[Silver peroxide, Silver suboxide]* [1301-96-8], AgO, F.W. 123.87, Powder, m.p. >100° dec., d. 7.44, Merck **14**,8522, Solubility: Insoluble in water. Soluble in alkalies, ammonium hydroxide with decomposition and N_2 formation, Application(s): Manufacturing of silver oxide-zinc alkali batteries, UN3085, EINECS 215-098-2, MDL MFCD00044285, † H:H272-H314, P:P221-P280-P303+P361+P353-P305+P351+P338-P310	**5g** **25g** **100g**
40187	**Silver(II) oxide, 99.9% (metals basis), Ag 86.6% min ▲ ◪** [1301-96-8], AgO, F.W. 123.87, -100 Mesh Powder, m.p. >100° dec., d. 7.44, Merck **14**,8522, UN3085, EINECS 215-098-2, MDL MFCD00044285, † H:H272-H314, P:P221-P210-P303+P361+P353-P305+P351+P338-P405-P501a	**5g** **25g** **100g**
11624	**Silver perchlorate monohydrate, 99.9% (metals basis) ▲ ■** [14242-05-8], $AgClO_4 \cdot H_2O$, F.W. 225.34 (207.32anhy), Crystalline, m.p. 485° dec., d. 2.800, Merck **14**,8523, Fieser **2**,369 **7**,142 **9**,413 **10**,354 **11**,469 **15**,121 **16**,300 **18**,321 **20**,341, UN1481, EINECS 232-035-4, MDL MFCD00149128, † H:H272-H314-H400, P:P221-P280-P273-P303+P361+P353-P305+P351+P338-P310	**2g** **10g** **50g** **250g**
42209	**Silver perchlorate, anhydrous ▲ ■** [7783-93-9], $AgClO_4$, F.W. 207.32, Crystalline, m.p. 485° dec., d. 2.806, Merck **14**,8523, Solubility: Soluble in water and many organic solvents (benzene, toluene, pyridine), UN1481, EINECS 232-035-4, MDL MFCD00003400, † H:H272-H314-H400, P:P221-P280-P273-P303+P361+P353-P305+P351+P338-P310	**5g** **25g** **100g**
44480	**Silver perrhenate, 99.99% (metals basis) ▲** [20654-56-2], $AgReO_4$, F.W. 358.10, Powder, m.p. 430°, d. 7.05, UN1479, MDL MFCD00014144 H:H272-H400-H315-H319-H335, P:P221-P280g-P273-P305+P351+P338	**1g** **5g** **25g**
11415	**Silver phosphate, 99% ▲** *[Silver orthophosphate, Trisilver phosphate]* [7784-09-0], Ag_3PO_4, F.W. 418.58, Powder, m.p. 849°, d. 6.37, Merck **14**,8525, Solubility: Practically insoluble in water. Slightly soluble in dilute acetic acid. Freely soluble in dilute HNO_3, ammonia, ammonium carbonate, alkali cyanides and thiosulfates, Application(s): In photography, UN3077, EINECS 232-049-0, MDL MFCD00014148, † H:H318-H400-H410, P:P280-P273-P305+P351+P338-P310-P391-P501a	**5g** **25g**
18585	**Silver salicylate hydrate ▲** [528-93-8], $C_7H_5AgO_3 \cdot xH_2O$, F.W. 244.99(anhy), Powder, MDL MFCD00013976  H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**5g** **25g**
11417	**Silver sulfate, ACS, 98% ▲** [10294-26-5], Ag_2SO_4, F.W. 311.80, Powder, m.p. 657°, b.p. 1085° dec., d. 5.45, Merck **14**,8529, Solubility: Partially soluble in water. Water solubility increases with temperature. Soluble in HNO_3, ammonia, conc. H_2SO_4, UN3077, EINECS 233-653-7, MDL MFCD00003407, † Maximum level of impurities: Insoluble matter and silver chloride 0.02%, NO_3 0.001%, Substances not precipitated by hydrochloric acid 0.03%, Fe 0.001% H:H318-H400-H410, P:P280-P273-P305+P351+P338-P310-P391-P501a	**25g** **100g**
41443	**Silver sulfate, Premion®, 99.99% (metals basis), Ag 68.9% min ▲** [10294-26-5], Ag_2SO_4, F.W. 311.80, Powder, m.p. 657°, b.p. 1085° dec., d. 5.45, Merck **14**,8529, UN3077, EINECS 233-653-7, MDL MFCD00003407, † H:H318-H400-H410, P:P280-P273-P305+P351+P338-P310-P391-P501a	**25g** **100g**
12112	**Silver sulfate, Premion®, 99.999% (metals basis) ▲** [10294-26-5], Ag_2SO_4, F.W. 311.80, Powder, m.p. 657°, b.p. 1085° dec., d. 5.45, Merck **14**,8529, UN3077, EINECS 233-653-7, MDL MFCD00003407, † H:H318-H400-H410, P:P280-P273-P305+P351+P338-P310-P391-P501a	**5g** **25g** **100g**
11416	**Silver sulfide, 99%** [21548-73-2], Ag_2S, F.W. 247.80, Powder, m.p. 825°, d. 7.317, Merck **14**,8530, Solubility: Soluble in HNO_3, alkali cyanide solutions. Insoluble in water, UN3077, EINECS 244-438-2, MDL MFCD00003406, † H:H400-H410, P:P273-P391-P501a	**5g** **25g** **100g**
89473	**Silver sulfide, 99.9+% (metals basis)** [21548-73-2], Ag_2S, F.W. 247.80, Crystalline Powder, m.p. 825°, d. 7.317, Merck **14**,8530, UN3077, EINECS 244-438-2, MDL MFCD00003406, † H:H400-H410, P:P273-P391-P501a	**5g** **25g**

Precious Metal Compounds

Stock #	Description	Standard Selling Sizes
12113	**Silver sulfide, Premion®, 99.998% (metals basis)** [21548-73-2], Ag_2S, F.W. 247.80, Powder, m.p. 825°, d. 7.317, Merck **14**,8530, UN3077, EINECS 244-438-2, MDL MFCD00003406, † H:H400-H410, P:P273-P391-P501a	**5g** **25g**
11539	**Silver tetrafluoroborate, 99% ▲ ■** *[Tetrafluoroboric acid silver salt]* [14104-20-2], $AgBF_4$, F.W. 194.67, Crystalline, m.p. 200° dec., Fieser **1**,1015 **4**,428 **5**,587 **6**,519 **8**,443 **9**,414 **11**,471 **18**,322 **21**,394, UN3260, EINECS 237-956-5, MDL MFCD00003408, † H:H314-H302, P:P280-P303+P361+P353-P305+P351+P338-P310 Silver salt soluble in many organic solvents; useful, e.g. in promotion of the leaving ability of halogens. Promotes the conversion of α-bromo aldehydes and ketones to their α-fluoro equivalents: *Tetrahedron Lett.*, 3357 (1979). For use in the preparation of stable, non-hygroscopic, crystalline acylammonium salts, see: *J. Org. Chem.*, **57**, 5136 (1992). In the presence of $AgBF_4$, acetals of phenacyl halides undergo rearrangement to esters of arylacetic acids: *J. Chem. Soc., Perkin 1*, 2575 (1982); compare **Silver nitrate**, **11414**, p. 54. Mediates the oxidative coupling of silylated cyclopropanols to 1,6-diones: *J. Am. Chem. Soc.*, **105**, 7192 (1983): 	**10g** **50g**
11897	**Silver thiocyanate ▲** [1701-93-5], AgSCN, F.W. 165.95, Crystalline, m.p. dec., Solubility: Very slightly soluble in water. Insoluble in ethanol, acetone, acid. Soluble in NH_4OH, Application(s): Preparation of nonmetallic thiocyanates, analytical reagent, in photographic emulsions, as an organic intermediate, UN3077, EINECS 216-934-9, MDL MFCD00003416, † H:H400-H410-H302-EUH032-H312-H332, P:P261-P280-P302+P352-P304+P340-P322-P501a	**10g** **50g**
13933	**Silver trifluoroacetate, 98% ▲ ■** [2966-50-9], $AgOOCCF_3$, F.W. 220.88, Powder, m.p. 257-260° dec., UN3077, EINECS 221-004-0, MDL MFCD00013199, † H:H400-H315-H319-H335, P:P280g-P273-P305+P351+P338	**5g** **25g**
88722	**Silver trifluoromethanesulfonate, 98% ▲** *[Silver triflate]* [2923-28-6], $AgOSO_2CF_3$, F.W. 256.93, Crystalline, m.p. 356°, UN3260, EINECS 220-882-2, MDL MFCD00013226, † H:H314-H400, P:P280-P273-P303+P361+P353-P305+P351+P338-P310 Silver salt soluble in ether, fairly soluble in benzene and toluene, less soluble in acetonitrile and insoluble in chloroform and dichloromethane; useful, e.g. in promotion of the leaving ability of halogens. For use in the conversion of alkyl halides to triflates, see: *J. Chem. Soc.*, 173 (1956); *J. Am. Chem. Soc.*, **90,** 1598 (1968); *Tetrahedron Lett.*, 3159 (1970); *J. Chem. Soc., Perkin 1*, 2887 (1980). Review: *Synthesis*, 85 (1982). Acyl halides are converted to acyl triflates, powerful acylating reagents, which can bring about Friedel-Crafts-type acylation without added Lewis acid catalyst: *Chem. Ber.*, **116**, 1195 (1983). Reaction with chlorosilanes gives silyl triflates, powerful silylating reagents, and, likewise trialkyltin halides are converted to the corresponding triflates: *Chem. Ber.*, **103**, 868 (1970). For use as a catalyst for the oxy-Cope rearrangement of allyl alkynyl carbinols, where other silver salts are ineffective, see: *Tetrahedron Lett.*, **25**, 2873 (1984): 	**2g** **10g** **50g**
39661	**Silver tungsten oxide, 99% ▲** *[Silver tungstate]* [13465-93-5], Ag_2WO_4, F.W. 463.58, Powder, Solubility: Insoluble in water. Soluble in potassium cyanide, ammonium hydroxide and nitric acid, EINECS 236-708-3, MDL MFCD00014147	**10g** **50g**

Asymmetric Hydrogenation Ligand/Catalyst Kit

Alfa Aesar offers a 12-piece kit containing 500mg of both enantiometers of ligand and 100mg of each preformed catalysts suited for asymmetric hydrogenation applications. The kit offers the flexibility to make a variety of catalysts from a wide selection of ligands. General application recommendations are included. The kit includes:

Ligands
Both R and S supplied in each kit:
(R)-P-Phos
(R)-Xyl-P-Phos
(S)-Xyl-PhanePhos
(R)-(S)-Me-BoPhoz

Catalysts
(S)-Paraphos $RuCl_2$ (R,R)-DPEN
(R)-Xyl-P-Phos $RuCl_2$ (R,R)-DPEN
(S)-Paraphos Rh(NBD)BF_4
(R)-P-Phos $Ru(acac)_2$

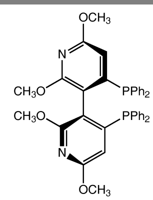
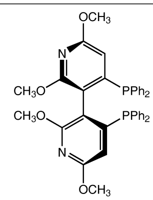
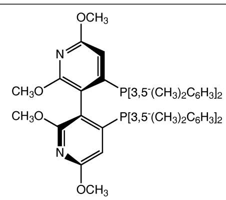
Xyl = 3,5-Dimethylphenyl

Note: These materials may be handled and weighed in air but are best stored under inert conditions. Controlled reaction conditions are required, i.e. degassed solvents. It is recommended that the catalysts are studied in a selection of solvents. The Ru-diamine catalysts should be tested under anhydrous conditions with a selection of bases in isopropanol.

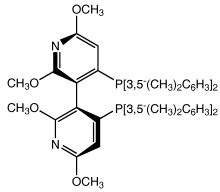
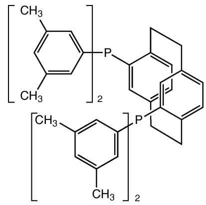
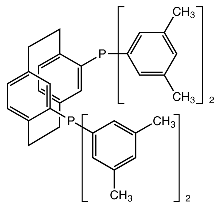
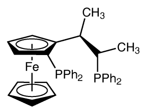
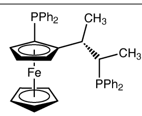
Stock #	Description	Standard Selling Sizes
44780	**Asymmetric Hydrogenation Ligand/Catalyst Kit**	**1each**

Individual Ligands and Catalysts

Products included in the Asymmetric Hydrogenation Ligand/Catalyst Kit are also offered individually and are listed below.

Stock #	Description		Standard Selling Sizes
44610	**(R)-(+)-2,2',6,6'-Tetramethoxy-4,4'-bis(diphenyl-phosphino)-3,3'-bipyridine** *[(R)-P-Phos]* [221012-82-4], $C_{38}H_{34}N_2O_4P_2$, F.W. 644.64, Powder, packaged under argon, m.p. 261-265°, Application(s): Asymmetric hydrogenation, MDL MFCD04038734		**100mg** **500mg**
44609	**(S)-(-)-2,2',6,6'-Tetramethoxy-4,4'-bis(diphenyl-phosphino)-3,3'-bipyridine** *[(S)-P-Phos]* [362524-23-0], $C_{38}H_{34}N_2O_4P_2$, F.W. 644.64, Powder, packaged under argon, m.p. 261-265°, Application(s): Asymmetric hydrogenation, MDL MFCD04038734		**100mg** **500mg**
44613	**(R)-(+)-2,2',6,6'-Tetramethoxy-4,4'-bis(di(3,5-xylyl)-phosphino)-3,3'-bipyridine** *[(R)-Xylyl-P-Phos]* [442905-33-1], $C_{46}H_{50}N_2O_4P_2$, F.W. 756.86, Powder, packaged under argon, m.p. 190-194°, Application(s): Asymmetric hydrogenation, MDL MFCD04974235 ! H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a		**100mg** **500mg**

Individual Ligands and Catalysts

Stock #	Description	Standard Selling Sizes
44614	**(S)-(-)-2,2',6,6'-Tetramethoxy-4,4'-bis(di(3,5-xylyl)-phosphino)-3,3'-bipyridine** *[(S)-Xylyl-P-Phos]* [443347-10-2], $C_{46}H_{50}N_2O_4P_2$, F.W. 756.86, Powder, packaged under argon, m.p. 158-162°, Application(s): Asymmetric hydrogenation, MDL MFCD04974235 ! H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a 	**100mg** **500mg**
44615	**(R)-(-)-4,12-Bis(di-3,5-xylylphosphino)[2.2]paracyclophane, CTH-(R)-3,5-xylyl-PHANEPHOS** [325168-89-6], $C_{48}H_{50}P_2$, F.W. 688.87, Powder, packaged under argon, $[\alpha]^{20}_{D}$ -98° (c=1 in dichloromethane), Application(s): Asymmetric hydrogenation, MDL MFCD03840578 	**100mg** **500mg**
44616	**(S)-(+)-4,12-Bis(di-3,5-xylylphosphino)[2.2]paracyclophane, CTH-(S)-3,5-xylyl-PHANEPHOS** [325168-88-5], $C_{48}H_{50}P_2$, F.W. 688.87, Powder, packaged under argon, Application(s): Asymmetric hydrogenation, MDL MFCD03840578 	**100mg** **500mg**
44684	**(R)-N-Diphenylphosphino-N-methyl-[(S)-2-(diphenylphosphino)-ferrocenyl]ethylamine, (R)-Methyl BoPhoz™** △ *[(R)-Methyl BoPhoz™]* [406680-94-2], $C_{37}H_{35}FeNP_2$, F.W. 611.50, Solid, m.p. 80-82°, Application(s): Asymmetric hydrogenation, MDL MFCD05865220, Note: Sold in collaboration with JM Catalysts for research purposes only. US patent US 6,590,115 and patents arising therefrom. Patent: Boaz, Neil W.; Debenham, Sheryl D. US Patent No. 6,590,115, July 8, 2003 	**100mg** **500mg**
44685	**(S)-N-Diphenylphosphino-N-methyl-[(R)-2-(diphenylphosphino)-ferrocenyl]ethylamine, (S)-Methyl BoPhoz™** △ *[(S)-Methyl BoPhoz™]* [406681-09-2], $C_{37}H_{35}FeNP_2$, F.W. 611.50, Solid, m.p. 80-82°, Application(s): Asymmetric hydrogenation, MDL MFCD05865220, Note: Sold in collaboration with JM Catalysts for research purposes only. US patent US 6,590,115 and patents arising therefrom. Patent: Boaz, Neil W.; Debenham, Sheryl D. US Patent No. 6,590,115, July 8, 2003 	**100mg** **500mg**
44803	**(S)-Paraphos RutheniumCl₂ (R,R)-DPEN** $C_{74}H_{66}Cl_2N_2OP_2Ru$, F.W. 1233.27, Powder, MDL MFCD08064217	**100mg**
44802	**(R)-Xyl-P-Phos RutheniumCl₂ (R,R)-DPEN** $C_{60}H_{66}Cl_2N_4O_4P_2Ru$, F.W. 1141.13, Powder, MDL MFCD08064216	**100mg**
44800	**(R)-P-Phos Ruthenium (acac)₂** [316829-35-3], $C_{48}H_{48}N_2O_8P_2Ru$, F.W. 945.94, Powder, MDL MFCD08064214	**100mg**

Stock No. 45471 Advanced Coupling Kit

Designed for challenging C-C coupling reactions, amination, alpha ketone arylation, etc., using sterically hindered substrates. This kit includes a Catalytic Reaction & Coupling Reference Guide and contains 1 gram each of:

44829 1,1'-Bis(di-tert-butylphosphino)ferrocenepalladium(II) chloride, Pd 16.3%

44446 Palladium(I) tri-tert-butylphosphine bromide, dimmer

44977 Dichloro[bis(diphenylphosphinophenyl)ether]palladium(II), Pd 14.8%

44844 Dichlorobis(tricyclohexylphosphine)palladium(II), Pd 14.4%

44730 Palladium anchored homogeneous catalyst, FibreCatTM 1032

44978 1,1'-Bis(diisopropylphosphino)ferrocenepalladium(II) chloride

44845 Bis(tri-tert-butylphosphine)palladium(0), Pd 20.9%

12760 Tris(dibenzylideneacetone)dipalladium(0), Pd 21.5% min*

44618 1,2,3,4,5-Pentaphenyl-1'-(di-tert-butylphosphino)ferrocene, QPhos, 95%*

45453 Dichlorobis(di-tert-butylphenylphosphine)palladium(II)

For pricing and availability, please call to speak with a Specialty Sales representative.

*Palladium catalyst (12760) must be used in conjunction with ligand (44618)

Stock No. 45475 Mini Advanced Coupling Kit

This scaled down version of our Advanced Coupling Kit (Stock# 45471) contains our most active catalysts and is designed for challenging C-C coupling reactions, amination, alpha ketone arylation, etc., using sterically hindered substrates, aryl chlorides and electron rich substrates. This kit includes a Catalytic Reaction & Coupling Reference Guide and contains 1 gram each of:

44829 1,1'-Bis(di-tert-butylphosphino)ferrocenepalladium(II) chloride, Pd 16.3%

45453 Dichlorobis(di-tert-butylphenylphosphine)palladium(II)

10516 Palladium(II) acetate, trimer, Pd 45.9-48.4%*

44618 1,2,3,4,5-Pentaphenyl-1'-(di-tert-butylphosphino)ferrocene, QPhos, 95%*

44730 Palladium anchored homogeneous catalyst, FibreCatTM1032

For pricing and availability, please contact our Specialty Sales department.

*Palladium catalyst (10516) must be used in conjunction with ligand (44618)

Iridium

Stock #	Description	Standard Selling Sizes
38327	**Iridium, 0.5% on activated carbon powder, reduced, nominally 50% water wet** MDL MFCD00011062, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38330	**Iridium, 1% on activated carbon powder, reduced, nominally 50% water wet** MDL MFCD00011062, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
41305	**Iridium, 5% on calcium carbonate powder** $Ir/CaCO_3$, Powder, Application(s): Selective hydrogenation of olefins to alkanes, carbonyls to alcohols, MDL MFCD00011062, † H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	5g 25g 100g

Palladium

Stock #	Description	Standard Selling Sizes
42206	**Palladium, 0.12%, Ruthenium, 0.12%; on 3mm alumina tablets** Application(s): Reduction of nitrogen oxides to N_2 with H_2 in the presence of CO and CO_2, MDL MFCD03613602, †	10g 50g 250g
38786	**Palladium, 0.5% on 1/8in alumina pellets, reduced** MDL MFCD03613602, †	25g 100g 500g
89114	**Palladium, 0.5% on 1/8in alumina pellets, unreduced** MDL MFCD03613602, †	25g 100g 500g
41383	**Palladium, 0.5% on 2-4 mm alumina spheres** Spherical powder, Application(s): Gas purification (O_2, O_3), MDL MFCD03613602, †	25g 100g
38289	**Palladium, 0.5% on granular carbon, reduced** 4x8 Mesh, 900-1100m^2/g, Application(s): Hydrogenation of olefins, MDL MFCD03457879, †	25g 100g
11711	**Palladium, 1% on alumina powder, reduced** 300m^2/g, MDL MFCD03613602, †	25g 100g
44820	**Palladium, 1% on 1-2 mm alumina spheres, reduced** Spherical powder, MDL MFCD03613602, †	100g 500g
38527	**Palladium, 1% on activated carbon powder, eggshell, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38292	**Palladium, 1% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	10g 50g
38293	**Palladium, 1% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
11691	**Palladium, 3% on activated carbon powder, eggshell, reduced** 900-1100m^2/g, UN3178, MDL MFCD03457879, † H:H228, P:P210-P241-P280-P240-P370+P378c	5g 25g 100g
38295	**Palladium, 3% on activated carbon powder, eggshell, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38296	**Palladium, 3% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38297	**Palladium, 3% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
41825	**Palladium, 5% on 3mm alumina pellets** Application(s): Hydrogen removal "getter", MDL MFCD03613602, †	5g 25g 100g

Stock #	Description	Standard Selling Sizes
11721	**Palladium, 5% on barium carbonate powder, reduced** UN1564, MDL MFCD03427451, † H:H301, P:P264-P270-P301+P310-P321-P405-P501a	**5g** **25g** **100g**
11722	**Palladium, 5% on barium sulfate powder, reduced** MDL MFCD03613605, †	**2.5g** **25g** **100g**
21162	**Palladium, 5% on barium sulfate powder, unreduced** Pale brown powder, Application(s): Hydrodehalogenation, Rosenmund reduction, asymetric hydrogenation, MDL MFCD03613605, † Deactivated hydrogenation catalyst, useful for selective reductions. For use in conjunction with quinoline and sulfur for the Rosenmund reduction of acid chlorides to aldehydes, see: *Org. Synth. Coll.*, **3**, 551 (1955). Review: *Org. React.*, **4**, 362 (1948). For use in presence of quinoline for the partial hydrogenation of an acetylene to a *cis*-olefin, see: *Org. Synth. Coll.*, **8**, 609 (1993); see also **Palladium**, **43172**, p. 61. Effective for the deprotection of O-benzyl hydroxamates to give peptide hydroxamic acids: *Tetrahedron Lett.*, **36**, 197 (1995).	**10g** **50g**
11723	**Palladium, 5% on calcium carbonate powder, reduced** MDL MFCD03427452, †	**5g** **25g** **100g**
43172	**Palladium, 5% on calcium carbonate, Type A306060-5, lead poisoned** *[Lindlar catalyst]* Powder, Application(s): Selective hydrogenation, UN3077, MDL MFCD03427452, † H:H360-H411-EUH201, P:P281-P273-P308+P313-P391-P405-P501a	**5g** **25g** **100g**
11713	**Palladium, 5% on γ alumina powder, reduced** Dark grey powder, MDL MFCD03613602, †	**5g** **25g** **100g**
11694	**Palladium, 5% on activated carbon powder, Type A503023-5, eggshell, reduced, nominally 50% water wet** 900-1100m^2/g, Application(s): Debenzylation, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
38299	**Palladium, 5% on activated carbon powder, Type A401102-5, eggshell unreduced, nominally 50% water wet** 900-1100m^2/g, Application(s): Aromatic nitro group hydrogenation, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
38300	**Palladium, 5% on activated carbon powder, Type A102023-5, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
44142	**Palladium, 5% on activated carbon powder, standard, reduced, acidic catalyst, nominally 50% water wet** 900-1100m^2/g, Application(s): Hydrogenation of aromatic and aliphatic nitro groups, reductive alkylation/amination, hydrogenation of aromatic carbonyls, olefins, nitriles, MDL MFCD03457879, †	**10g** **50g** **250g**
38301	**Palladium, 5% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
45421	**Palladium, 5% on activated carbon powder, Type A102038-5, standard, reduced, nominally 50% water wet , †**	**bulk-g**
45497	**Palladium, 5% on activated carbon powder, Type A103038, sulfided, nominally 50% water wet** Powder, MDL MFCD03457879	**10g** **50g** **250g**
45051	**Palladium, 5% on activated carbon powder, Type A405023-5, nominally 50% water wet** Notes: Sold on a dry weight basis, MDL MFCD00011167, †	**5g** **25g** **100g**
45499	**Palladium, 5% on activated carbon powder, Type A405032-5, nominally 50% water wet** Powder, MDL MFCD03457879, †	**5g** **25g** **100g**
45430	**Palladium, 5% on activated carbon powder, Type A405038-5, eggshell, unreduced, nominally 50% water wet** MDL MFCD03457879, †	
44337	**Palladium, 5% on charcoal paste, Type 39, 50-65% water wet** 900-1100m^2/g, Application(s): Debenzylation, C-N and C-O cleavage, alkene hydrogenation, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
45132	**Palladium, 5% on charcoal paste, Type 58, nominally 50% water wet** MDL MFCD03457879, †	**5g** **25g** **100g**

Heterogeneous Catalysts

Stock #	Description	Standard Selling Sizes
39819	**Palladium, 5% on strontium carbonate powder, reduced** MDL MFCD00192595, †	2g 10g 50g
42208	**Palladium, 8%, Platinum, 2%; on activated carbon powder, nominally 50% water wet** Application(s): Selective hydrogenation of nitrates to hydroxylamines, reduction of nitrogen oxides to N_2 with H_2 in the presence of CO and CO_2, MDL MFCD01074898, Note: Sold on dry weight basis. Unit weight excludes water weight, †	2g 10g 50g
45558	**Palladium, 10% on activated carbon powder, eggshell, unreduced, Type 394, nominally 50% water wet** [7440-05-3], Pd/C, Black powder, EINECS 231-115-6, †	5g 25g
38303	**Palladium, 10% on activated carbon powder, eggshell, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 50g
38304	**Palladium, 10% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
44350	**Palladium, 10% on activated carbon powder, Type 58, standard, reduced, nominally 50% water wet** Application(s): Hydrogenation of aromatic and aliphatic nitro groups, reductive alkylation/amination, hydrogenation of aromatic nitrites to 1° amines, MDL MFCD03457879, †	5g 25g 100g
38305	**Palladium, 10% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
46789	**Palladium, 10% on activated carbon powder, Type A402023-10, nominally 50% water wet** Sold on a dry weight basis, MDL MFCD03457879, †	2g 10g 50g
38306	**Palladium, 20% on activated carbon powder, eggshell, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38307	**Palladium, 20% on activated carbon powder, eggshell, unreduced, nominally 50% water wet** 900-1100m^2/g, Application(s): Debenzylation, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g
38308	**Palladium, 20% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	250mg 2g 10g 50g
38309	**Palladium, 20% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD03457879, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	5g 25g 100g

Platinum

Stock #	Description	Standard Selling Sizes
42205	**Platinum, 0.1% on 2-4mm alumina spheres** Spheres, Application(s): VOC removal from vent streams by combination with O_2, MDL MFCD00011179, †	5g 25g 100g
39826	**Platinum, 0.3% on 2.7-3.3mm (0.11-0.13in) alumina pellets, reduced** Application(s): Selective hydrogenation, gas purifications: e.g. Oxidation of carbon monoxide to carbon dioxide, hydrogen removal from oxygen or carbon dioxide, EINECS 215-691-6, MDL MFCD00011179, †	25g 100g
44796	**Platinum, 0.5% on 1.4-2.8mm (0.055-0.11in) alumina spheres, reduced** Sphere, MDL MFCD03458043, †	50g 250g 1kg
89106	**Platinum, 0.5% on 2.7-3.3mm (0.11-0.13in) alumina pellets, reduced** Application(s): Selective hydrogenations; gas purifications: e.g. Oxidation of carbon monoxide to carbon dioxide, hydrogen removal from oxygen or carbon dioxide, EINECS 215-691-6, MDL MFCD00011179, †	25g 100g 500g
38344	**Platinum, 0.5% on granular carbon, reduced** 2-5mm granules, UN1325, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378a	5g 25g

Stock #	Description	Standard Selling Sizes
43407	**Platinum, 1% on polyethyleneimine/SiO_2** [7440-06-4], 20-40 Mesh Bead, Application(s): Reduction reactions, MDL MFCD00011179, † H:H332-H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**5g** **25g**
43408	**Platinum, 1% on polyethyleneimine/SiO_2 powder** [7440-06-4], 40-200 Mesh Powder, Application(s): Reduction reactions, MDL MFCD00011179, † H:H332-H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**5g** **25g**
11797	**Platinum, 1% on γ alumina powder, reduced** 300m^2/g, MDL MFCD00011179, †	**5g** **25g** **100g**
38343	**Platinum, 1% on granular carbon, reduced, nominally 50% water wet** 4x10 Mesh, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**25g** **100g**
38312	**Platinum, 1% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**25g** **100g**
38313	**Platinum, 1% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, Application(s): Schiff's base and nitrohydrogenation, hydrosilation, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
45519	**Platinum, 1% on charcoal paste, Type 18MA** MDL MFCD00011179 H:H317, P:P261-P280-P302+P352-P321-P363-P501a	**25g** **100g**
38316	**Platinum, 3% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
38317	**Platinum, 3% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
44222	**Platinum, 5% on alumina powder, reduced,** MDL MFCD03458043, Note: Low surface area, †	**5g** **25g** **100g**
38318	**Platinum, 5% on alumina powder, reduced, <20% water wet** 150m^2/g, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
45445	**Platinum, 5% on activated carbon powder, Type B103032-5, standard, reduced, nominally 50% water wet** MDL MFCD00011179, †	**5g** **25g**
46306	**Platinum, 5% on activated carbon powder, Type B105022-5, standard, reduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD00011179, †	**5g** **25g** **100g**
45443	**Platinum, 5% on activated carbon powder, Type B109032-5, standard, reduced, nominally 60% water wet, sulfided** MDL MFCD00011179, †	**bulk-g**
43905	**Platinum, 5% on activated carbon powder, sulfided, 0.5% S (as sulfide)** Powder, UN1325, MDL MFCD00011179 H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**10g** **50g**
44365	**Platinum, 5% on graphite** Application(s): Material for gas sensors, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**5g** **25g** **100g**
38325	**Platinum, 10% on activated carbon powder, standard, reduced, nominally 50% water wet** 900-1100m^2/g, Application(s): Aromatic ring hydrogenation, aliphatic aldehydes and ketones to alcohols, conversion of -CH=CH- to -CH_2-CH_2-, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
38326	**Platinum, 10% on activated carbon powder, standard, unreduced, nominally 50% water wet** 900-1100m^2/g, MDL MFCD00011179, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**

Heterogeneous Catalysts

Stock #	Description	Standard Selling Sizes
43876	**Platinum, nominally 10% on carbon black** HiSPEC™ 2000, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**500mg** **2g** **10g** **50g**
35849	**Platinum, nominally 20% on carbon black** HiSPEC™ 3000, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g** **25g**
40473	**Platinum, nominally 20%, Ruthenium, nominally 10% on carbon black** HiSPEC™ 5000, Powder, UN1325, MDL MFCD00798552, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**250mg** **1g** **5g** **25g**
43990	**Platinum, nominally 30%, Ruthenium, nominally 15% on carbon black** HiSPEC™ 7000, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g** **5g** **25g**
44172	**Platinum, nominally 40%, Ruthenium, nominally 20% on carbon black** HiSPEC™ 10000, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**2g** **10g** **50g**
42204	**Platinum, nominally 40% on carbon black** HiSPEC™ 4000, Powder, UN1325, MDL MFCD00011179, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**1g** **5g** **25g**
43989	**Platinum, nominally 50%, on carbon black** HiSPEC™ 8000, Powder, UN1325, MDL MFCD00011179, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**1g** **5g** **25g**

Rhodium

Stock #	Description	Standard Selling Sizes
45639	**Rhodium, 0.5% on 1mm(.040in) alumina spheres** [7440-16-6], Spheres,, EINECS 231-125-0, MDL MFCD00011201, †	**10g** **50g**
42507	**Rhodium, 0.5% on 3mm alumina pellets** [7440-16-6], Application(s): Hydrogenation of aromatics, EINECS 231-125-0, MDL MFCD00011201, †	**10g** **50g**
43410	**Rhodium, 1% on Polyethyleneimine/SiO_2** [7440-16-6], Bead, EINECS 231-125-0, MDL MFCD00011201, Note: 20-40 mesh, † H:H332-H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**5g**
43409	**Rhodium, 1% on Polyethyleneimine/SiO_2 powder** [7440-16-6], Powder, 40-200 mesh, EINECS 231-125-0, MDL MFCD00011201, † H:H332-H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**5g** **25g**
11769	**Rhodium, 1% on alumina powder, reduced** [7440-16-6], EINECS 231-125-0, MDL MFCD00011201, † H:H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**10g** **50g**
11770	**Rhodium, 5% on alumina powder, reduced** [7440-16-6], EINECS 231-125-0, MDL MFCD00011201, † H:H335, P:P261-P304+P340-P312-P405-P403+P233-P501a Useful catalyst for hydrogenation of tetrasubstituted alkenes conjugated to a carbonyl group: *Synlett*, 117 (1997).	**2g** **10g** **50g**
11761	**Rhodium, 5% on activated carbon powder, Type C101038-5, reduced, nominally 50% water wet** [7440-16-6], EINECS 231-125-0, MDL MFCD00011201, Note: Sold on a dry weight basis. Unit weight excludes water weight, †	**1g** **10g** **50g**
44863	**Rhodium, 5% on activated carbon powder, Type 23, standard, reduced, nominally 50% water wet** [7440-16-6], EINECS 231-125-0, MDL MFCD03458392, †	**2g** **10g**
45425	**Rhodium, 5% on activated carbon powder, Type C101023-5, standard, reduced, nominally 50% water wet** MDL MFCD03458392, †	**1g** **5g** **bulk-g**
44124	**Rhodium 10%, Palladium 1% on activated carbon powder** UN1325, MDL MFCD03792580, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**5g** **25g** **100g**

Contact us for pricing on bulk sizes

Ruthenium

Stock #	Description	Standard Selling Sizes
42206	**Palladium, 0.12%, Ruthenium, 0.12%; on 3mm alumina tablets** Application(s): Reduction of nitrogen oxides to N_2 with H_2 in the presence of CO and CO_2, MDL MFCD03613602, †	**10g** **50g** **250g**
38332	**Ruthenium, 0.5% on granular carbon** [7440-18-8], 4-12 Mesh, 900-1100m^2/g, UN1325, EINECS 231-127-1, MDL MFCD00011207, † H:H228, P:P210-P241-P280-P240-P370+P378a	**25g** **100g**
44575	**Ruthenium, 2% on 1/8in alumina pellets** [7440-18-8], S.A. nominally 200m^2/g, EINECS 231-127-1, MDL MFCD00011207, †	**25g** **100g** **500g**
43048	**Ruthenium, 0.5% on 3 mm alumina tablets** [7440-18-8], Tablets, Application(s): CO or CO_2 from H_2 by methanation to CH_4, EINECS 231-127-1, MDL MFCD00011207, †	**25g** **100g**
44593	**Ruthenium, 4% on 1/4in alumina rings** [7440-18-8], EINECS 231-127-1, MDL MFCD00011207, †	**500g**
11749	**Ruthenium, typically 5% on alumina powder, reduced** [7440-18-8], Application(s): Hydrogenation of aliphatic carbonyls and aromatic rings, especially bulky molecules, EINECS 231-127-1, MDL MFCD00011207, † H:H335, P:P261-P304+P340-P312-P405-P403+P233-P501a	**5g** **25g** **100g**
11748	**Ruthenium, 5% on activated carbon powder, reduced** [7440-18-8], Application(s): Aromatic ring hydrogenation, UN1362, EINECS 231-127-1, MDL MFCD00011207, † H:H228-H252-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**5g** **25g** **100g**
44338	**Ruthenium, 5% on activated carbon powder, reduced, nominally 50% water wet** [7440-18-8], EINECS 231-127-1, MDL MFCD03458417, Note: Sold on dry weight basis. Unit weight excludes water weight, †	**5g** **25g** **100g**
45439	**Ruthenium, 5% on activated carbon powder, Type D101023-5, standard, reduced, nominally 50% water wet** MDL MFCD03458417, †	
11757	**Ruthenium, 10% on activated carbon powder, reduced** [7440-18-8], Fieser **1**,983 **5**,574, UN1362, EINECS 231-127-1, MDL MFCD00011207, † H:H228-H252-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**5g** **25g** **100g**

Heterogeneous Catalysts

Heterogeneous Catalyst Screening Kit

Stock No. 44735 Heterogeneous Catalyst Screening Kit

This kit provides instant availability to 40 catalyst types with varying characteristics and metal distribution. Supplied with an applications table and 40 data sheets numbered as 1-40 referring to each catalyst that allows for easy identification of prime candidates for catalytic processes. Excellent tool for screening and research projects. All samples are commercially available. The kit includes 5g (on a dry weight basis) of each catalyst listed below. For pricing and availability, please speak with a Specialty Sales representative.

Heterogeneous Catalyst Screening Kit

Stock #	Description	Carbon Type	Kit Location
38299	Palladium, 5% on activated carbon powder, eggshell, unreduced, nominally 50% water wet	A401102-5	1
45426	Palladium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	A109047-5	2
45422	Palladium, 5% on activated carbon powder, eggshell, unreduced, nominally 50% water wet	A405028-5	3
45430	Palladium, 5% on activated carbon powder, eggshell, unreduced, nominally 50% water wet	A405032-5	4
45435	Palladium, 5% on activated carbon powder, eggshell, unreduced, nominally 50% water wet	A405038-5	5
11694	Palladium, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet	A503023-5	6
45420	Palladium, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet	A503032-5	7
45437	Palladium, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet	A503038-5	8
38300	Palladium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	A102023-5	9
45421	Palladium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	A102038-5	10
45442	Palladium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet; Sulfided	A103038-5	11
45451	Palladium, 5% on alumina powder, standard, reduced, dry	A30211-5	12

Heterogeneous Catalyst Screening Kit (cont.)

Stock #	Description	Carbon Type	Kit Location
45427	Palladium, 5% on alumina powder, standard, reduced, dry	A30299-5	13
11723	Palladium, 5% on calcium carbonate powder, standard, reduced, dry	A303060-5	14
45440	Palladium, 5% on calcium carbonate powder, standard, reduced, dry; Lead poisoned	A305060-5	15
43172	Palladium, 5% on calcium carbonate powder, standard, reduced, dry; Lead poisoned	A306060-5	16
45444	Palladium, 5% on barium sulfate powder, standard, reduced, dry	A308053-5	17
45423	Palladium, 4%, Platinum, 1% on activated carbon powder, standard, reduced, nominally 50% water wet	E101049-4/1	18
45447	Palladium, 4%, Platinum, 1% on activated carbon powder, standard, reduced, nominally 50% water wet	E101023-4/1	19
45434	Palladium, 4.5%, Rhodium, 0.5% on activated carbon powder, standard, reduced, nominally 50% water wet	F101023-4.5/0.5	20
45449	Palladium, 4.5%, Rhodium, 0.5% on activated carbon powder, standard, reduced, nominally 50% water wet	F101038-4.5/0.5	21
45428	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	B102022-5	22
45445	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	B103032-5	23
45431	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	B103018-5	24
45438	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	B103014-5	25
45424	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	B104032-5	26
45441	Platinum, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet	B501032-5	27

Heterogeneous Catalyst Screening Kit (cont.)

Stock #	Description	Carbon Type	Kit Location
45446	Platinum, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet	B501018-5	28
45432	Platinum, 5% on activated carbon powder, eggshell, reduced, nominally 50% water wet; Bismuth poisoned	B503032-5	29
45443	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet; Sulfided	B109032-5	30
45436	Platinum, 5% on activated carbon powder, standard, reduced, nominally 50% water wet; Sulfided	B106032-5	31
45450	Platinum, 5% on alumina, standard, reduced, dry	B301013-5	32
45429	Platinum, 5% on alumina, standard, reduced, dry	B301099-5	33
45425	Rhodium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	C101023-5	34
11761	Rhodium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	C101038-5	35
11770	Rhodium, 5% on alumina, standard, reduced, dry	C301011-5	36
45439	Ruthenium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	D101023-5	37
11748	Ruthenium, 5% on activated carbon powder, standard, reduced, nominally 50% water wet	D101038-5	38
45448	Ruthenium, 5% on alumina, standard, reduced, dry	D302011-5	39
45433	Ruthenium, 5%, Palladium, 0.25% on activated carbon, standard, reduced, nominally 50% water wet	G101038-5/0.25	40

Unsupported Catalysts

Iridium

Stock #	Description	Standard Selling Sizes
12071	**Iridium black, 99.8% (metals basis)** [7439-88-5], S.A. >20m^2/g, UN3089, EINECS 231-095-9, MDL MFCD00011062, † H:H228, P:P210-P241-P280-P240-P370+P378a	500mg 2g 10g
43051	**Iridium(IV) oxide dihydrate, Premion®, 99.99% (metals basis), Ir 73% min** [30980-84-8], $IrO_2 \cdot 2H_2O$, F.W. 260.23 (224.20anhy), Powder, EINECS 234-743-9, MDL MFCD00011065, †	1g 5g

Palladium

Stock #	Description	Standard Selling Sizes
00659	**Palladium black, 99.9% (metals basis)** [7440-05-3], S.A. typically 20m^2/g, UN3089, EINECS 231-115-6, MDL MFCD00011167, † H:H228, P:P210-P241-P280-P240-P370+P378a	1g 5g
11041	**Palladium(II) oxide monohydrate, 99.9% (metals basis), Pd 73% min** [64109-12-2], $PdO \cdot H_2O$, F.W. 140.41 (122.40anhy), Powder, m.p. dec., Merck **14**,6993, EINECS 215-218-3, MDL MFCD00011172, †	2g 10g
11040	**Palladium(II) oxide, anhydrous, 99.9% (metals basis), Pd 85% min** [1314-08-5], PdO, F.W. 122.40, -22 Mesh Powder, m.p. 870°, d. 8.70, Merck **14**,6993, Solubility: Insoluble in water, acids. Slightly soluble in aqua regia, Application(s): Catalytic reduction, in organic synthesis, EINECS 215-218-3, MDL MFCD00011172, † H:H303, P:P312	1g 5g

Platinum

Stock #	Description	Standard Selling Sizes
12076	**Platinum black** [7440-06-4], S.A. 10m^2/g, UN3089, EINECS 231-116-1, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378a	100mg 1g 5g
12755	**Platinum black** [7440-06-4], HiSPEC™ 1000, S.A. nominally 27m^2/g, UN3089, EINECS 231-116-1, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378a	250mg 1g 5g 25g
43838	**Platinum black, high surface area** [7440-06-4], S.A. 25.0-30.4m^2/g, UN3089, EINECS 231-116-1, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378a	250mg 1g 5g 25g
41171	**Platinum Ruthenium black, nominally Pt 50%, Ru 50% (Atomic wt%)** Pt:Ru; 50:50 atomic %, HiSPEC™ 6000, UN3089, MDL MFCD00798552, † H:H228, P:P210-P241-P280-P240-P370+P378a	250mg 1g 5g 25g
11049	**Platinum(IV) oxide hydrate, 99.9% (metals basis), Pt 71-75%** [52785-06-5], $PtO_2.xH_2O$, F.W. 227.09(anhy), Powder, Merck **14**,7527, Fieser **1**,890 **2**,332 **15**,268 **21**,353, UN1479, EINECS 215-223-0, MDL MFCD00066964, † H:H272, P:P221-P210-P220-P280-P370+P378a-P501a	250mg 1g 5g 25g
12278	**Platinum(IV) oxide monohydrate, Adams Catalyst, Pt 75% min** *[Adams' Catalyst]* [12137-21-2], $PtO_2.H_2O$, F.W. 245.10 (227.09anhy), Powder, S.A. >85m^2/g, m.p. 450°, Merck **14**,7527, Solubility: Insoluble in water, acid, aqua regia, Application(s): Hydrogenation catalyst. Suitable for the reduction of double and triple bonds, aromatics, carbonyls, nitriles, and nitro groups, UN1479, EINECS 215-223-0, MDL MFCD00066964, Note: Electrochemically prepared for catalyst use, † H:H272, P:P221-P210-P220-P280-P370+P378a-P501a Hydrogenation catalyst. Used in the conversion of ketones to methylenes by hydrogenolysis of enol triflates under neutral conditions: *Tetrahedron Lett.*, **23**, 117 (1982). Catalyst for hydrosilylation of olefins with various alkyl dialkoxy silanes: *Org. Lett.*, **4**, 2117 (2002).	1g 5g

Unsupported Catalysts

Rhodium

Stock #	Description	Standard Selling Sizes
12353	**Rhodium black, 99.9% (metals basis)** [7440-16-6], Black powder, UN3089, EINECS 231-125-0, MDL MFCD00011201, † H:H228, P:P210-P241-P280-P240-P370+P378b	**500mg** **2g** **10g**
12667	**Rhodium(III) oxide pentahydrate, Premion®, 99.99% (metals basis), Rh 59% min** [39373-27-8], $Rh_2O_3 \cdot 5H_2O$, F.W. 343.88 (253.81anhy), Powder, m.p. dec., EINECS 234-846-9, MDL MFCD00149843, †	**250mg** **1g** **5g**
11814	**Rhodium(III) oxide, anhydrous, 99.9% (metals basis), Rh 80.6% min ■** [12036-35-0], Rh_2O_3, F.W. 253.81, Powder, m.p. 1100° dec., d. 8.20, EINECS 234-846-9, MDL MFCD00011205, †	**500mg** **2g**

Ruthenium

Stock #	Description	Standard Selling Sizes
12354	**Ruthenium black, 99.9% (metals basis)** [7440-18-8], UN3089, EINECS 231-127-1, MDL MFCD00011207, † H:H228, P:P210-P241-P280-P240-P370+P378b	**2g** **10g**
11803	**Ruthenium(IV) oxide hydrate, Ru 54% min** [32740-79-7], $RuO_2.xH_2O$, F.W. 133.07(anhy), Powder, m.p. 1200° subl., Solubility: Insoluble in water. Soluble in HCl, Application(s): Oxidation, EINECS 234-840-6, MDL MFCD00149846, † H:H319, P:P280-P264-P305+P351+P338-P337+P313 Precursor for *in situ* generation of the powerful oxidant ruthenium(VIII) oxide (see **Ruthenium(III) chloride hydrate**, **11043**, p. 49): *Helv. Chim. Acta*, **71**, 237 (1988). With Oxone® as stoichiometric oxidant in an acetonitrile/ ethyl acetate/ water solvent system, both terminal and internal alkynes can be cleaved to carboxylic acids in high yield: *J. Org. Chem.*, **69**, 2221 (2004). Mediates the electrooxidation of primary and secondary alcohols to aldehydes and ketones: *Chem. Lett.*, 369 (1995).	**1g** **5g** **25g**
43403	**Ruthenium(IV) oxide hydrate, Premion®, 99.99% (metals basis), Ru 54-58%** [32740-79-7], $RuO_2 \cdot xH_2O$, F.W. 133.07(anhy), Powder, m.p. 1200° subl., EINECS 234-840-6, MDL MFCD00149846, † H:H319, P:P280-P264-P305+P351+P338-P337+P313	**1g** **5g** **25g**
11804	**Ruthenium(IV) oxide, anhydrous, Premion®, 99.95% (metals basis), Ru 75.2% min ■** *[Ruthenium dioxide]* [12036-10-1], RuO_2, F.W. 133.07, Powder, m.p. 1200° subl., d. 6.97, Solubility: Insoluble in water, acids. Soluble in fused alkalis, UN1479, EINECS 234-840-6, MDL MFCD00011210, † H:H271, P:P221-P283-P210-P306+P360-P371+P380+P375-P501a	**500mg** **2g** **10g**

HiSPEC™ Fuel Cell Catalysts

Johnson Matthey, the world leader in fuel cell catalysts, offers the following line of catalysts specially formulated for PEM fuel cells. They have been used with success in both anodes and cathodes. The HiSpec™ catalysts are all made to a consistently high quality on a commercial scale, and are readily available in gram and kilogram quantities. They are supported on a conducting high surface area carbon, and are particularly suited to the manufacture of active electrode structures.

Stock #	Description	Standard Selling Sizes
12755	**Platinum black** [7440-06-4], HiSPEC™ 1000, S.A. nominally 27m^2/g, UN3089, EINECS 231-116-1, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378a	**250mg 1g 5g 25g**
41171	**Platinum Ruthenium black, nominally Pt 50%, Ru 50% (Atomic wt%)** Pt:Ru; 50:50 atomic %, HiSPEC™ 6000, UN3089, MDL MFCD00798552, † H:H228, P:P210-P241-P280-P240-P370+P378a	**250mg 1g 5g 25g**
43876	**Platinum, nominally 10% on carbon black** HiSPEC™ 2000, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**500mg 2g 10g 50g**
35849	**Platinum, nominally 20% on carbon black** HiSPEC™ 3000, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g 5g 25g**
42204	**Platinum, nominally 40% on carbon black** HiSPEC™ 4000, Powder, UN1325, MDL MFCD00011179, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**1g 5g 25g**
43989	**Platinum, nominally 50%, on carbon black** HiSPEC™ 8000, Powder, UN1325, MDL MFCD00011179, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**1g 5g 25g**
44728	**Platinum, nominally 60% on high surface area advanced carbon support** HiSPEC™ 9100, UN1325, MDL MFCD00011179, † H:H228, P:P210-P241-P280-P240-P370+P378c	**1g 5g 25g**
45041	**Platinum, nominally 70% on high surface area advanced carbon support** HiSPEC™ 13100, HISPEC™ 13100, UN1325, MDL MFCD00011179, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g 5g**
40473	**Platinum, nominally 20%, Ruthenium, nominally 10% on carbon black** HiSPEC™ 5000, Powder, UN1325, MDL MFCD00798552, † H:H228-H351, P:P210-P241-P280-P281-P405-P501a	**250mg 1g 5g 25g**
43990	**Platinum, nominally 30%, Ruthenium, nominally 15% on carbon black** HiSPEC™ 7000, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g 5g 25g**
44172	**Platinum, nominally 40%, Ruthenium, nominally 20% on carbon black** HiSPEC™ 10000, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**2g 10g 50g**
45039	**Platinum, nominally 40%, Ruthenium nominally 20% on 50% compressed carbon black** HiSPEC™ 10300, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g 5g**
45040	**Platinum, nominally 50%, Ruthenium nominally 25% on high surface area advanced carbon support** HiSPEC™ 12100, UN1325, MDL MFCD00798552, † H:H228-H315-H319-H335, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**1g 5g**

HiFUEL Catalysts

HiFUEL™ Catalysts

Alfa Aesar is proud to introduce Johnson Matthey's range of HiFUEL™ fuel processing catalysts and gas treatment products.

These base metal catalysts are ideal for use in fuel cell and other distributed hydrogen production applications. Their small size, high geometric surface areas, and high volumetric activity make them well suited to compact reactor designs. Reformer, water gas shift and purification products are available.

A complementary range of precious metal catalysts are also available for fuel processing applications. Please contact HiFUEL.coatedcatalysts@matthey.com for more information.

The HiFUEL™ range of catalysts complement the Johnson Matthey HiSPEC™ fuel cell catalyst products.

Stock #	Description	Standard Selling Sizes
45466	**Copper based low temperature water gas shift catalyst, HiFUEL™ W220** Pellets, 3.1mm x 3.1mm, UN3077, † H:H400-H410, P:P273-P391-P501a	**500g** **1kg** **2.5kg**
45470	**Copper based medium temperature water gas shift catalyst, HiFUEL™ W230** Pellets, 5.2mm x 3.0mm, UN3077, † H:H400-H410-H302-H315-H319-H335, P:P280h-P273-P305+P351+P338-P501a	**500g** **1kg** **2.5kg**
45468	**Copper based methanol reforming catalyst, HiFUEL™ R120** Pellets, 5.2mm x 3.0mm, UN3077, † H:H400-H410-H302, P:P273-P264-P270-P301+P312-P330-P501a	**500g** **1kg** **2.5kg**
45467	**Iron-chrome based high temperature gas shift catalyst, HiFUEL™ W210** Pellets, 5.4mm x 3.6mm, † H:H340-H350-H332-H315-H319-H317-H335-H412, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**500g** **1kg** **2.5kg**
45465	**Nickel based steam reforming catalyst, HiFUEL™ R110** 4-hole, 4-flute domed cylinders, † H:H350-H317-H413, P:P261-P280-P302+P352-P321-P405-P501a	**500g** **1kg** **2.5kg**
45469	**Zinc oxide based sulfur removal material, HiFUEL™ A310** Spheres, 2-5mm dia, MDL MFCD00011300, †	**500g** **1kg** **2.5kg**

Fuel Cell Components

Alfa Aesar is proud to introduce a new line of fuel cell components. Products types include:

- Nafion™ membranes
- Toray Carbon paper
- Cathodes and anodes for Hydrogen, DMFC and Reformate fuel cells
- MEAs for Hydrogen, DMFC and Reformate fuel cells

Stock #	Description	Standard Selling Sizes
45036	**Nafion® membrane, 0.05mm thick** [31175-20-9], NRE-212, Note: Nafion® NRE-212 perfluorosulfonic acid-PTFE copolymer, nominally 50 microns thick, standard exchange capacity 0.92meq/g. Membrane is positioned between a backing film and a cover sheet., †	**15x15cm** **30x30cm** **60x60cm**
42179	**Nafion® membrane, 0.125mm thick** ■ [66796-30-3], Note: Nafion® N-115 perfluorosulfonic acid-PTFE copolymer, nominally 125 microns thick, standard exchange capacity 0.9meq/g	**15x15cm** **30x30cm** **60x60cm**
42180	**Nafion® membrane, 0.180mm thick** ■ [31175-20-9], Note: Nafion® N-117 perfluorosulfonic acid-PTFE copolymer, nominally 180 microns thick, standard exchange capacity 0.9meq/g, †	**15x15cm** **30x30cm** **60x60cm**
45356	**Toray Carbon Paper, TGP-H-60, 19x19cm , †** H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**each**
45365	**Toray Carbon Paper, PTFE treated, TGP-H-60, 19x19cm , †** H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**each**
45360	**Toray Carbon Paper, Baselayered, TGP-H-60, 12x12cm , †** H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**each**
45359	**Direct Methanol Fuel Cell (DMFC) Anode, 25cm** Fuel cell component	**each**
45367	**Direct Methanol Fuel Cell (DMFC) Anode, 50cm** Fuel cell component	**each**
45374	**Direct Methanol Fuel Cell (DMFC) Anode, 100cm** Fuel cell component	**each**
45361	**Direct Methanol Fuel Cell (DMFC) Cathode, 25cm** Fuel cell component	**each**
45368	**Direct Methanol Fuel Cell (DMFC) Cathode, 50cm** Fuel cell component H:H351-H319-H335, P:P261-P280-P281-P305+P351+P338-P405-P501a	**each**
45375	**Direct Methanol Fuel Cell (DMFC) Cathode, 100cm** Fuel cell component H:H315-H319, P:P280-P305+P351+P338-P302+P352-P321-P362-P332+P313	**each**
45357	**Hydrogen Electrode/Reformate Cathode, 25cm**	**each**
45452	**Hydrogen Electrode/Reformate Cathode, 50cm**	**each**
45372	**Hydrogen Electrode/Reformate Cathode, 100cm** Fuel cell component	**each**
45358	**Reformate Anode, 25cm** Fuel cell component	**each**
45366	**Reformate Anode, 50cm**	**each**
45373	**Reformate Anode, 100cm** Fuel cell component	**each**
45364	**Direct Methanol Fuel Cell (DMFC) Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 25cm , plus membrane** Fuel cell component	**each**
45371	**Direct Methanol Fuel Cell (DMFC) Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 50cm , plus membrane** Fuel cell component	**each**
45378	**Direct Methanol Fuel Cell (DMFC) Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 100cm , plus membrane** Fuel cell component	**each**
45362	**Hydrogen Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 25cm , plus membrane border**	**each**
45369	**Hydrogen Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 50cm , plus membrane border** Fuel cell component	**each**
45376	**Hydrogen Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 100cm , plus membrane border** Fuel cell component	**each**

Fuel Cell Components

Stock #	Description	Standard Selling Sizes
45363	**Reformate Screener Membrane Electrode Assembly (MEA-5 layer), Active area 25cm , plus membrane border** Fuel cell component	**each**
45370	**Reformate Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 50cm , plus membrane border** Fuel cell component	**each**
45377	**Reformate Screener Membrane Electrode Assembly (MEA-5 layer), Active Area 100cm , plus membrane border** Fuel cell component	**each**

Gauzes

Stock #	Description	Standard Selling Sizes
40930	**Gold gauze, 52 mesh woven from 0.102mm (0.004in) dia wire, 99.99% (metals basis)** Wire Cloth, Application(s): Electrodes, Note: Open area: 62.7%; Width of opening: 0.015in, †	**25x25mm 50x50mm 50x100mm 100x100mm 100x150mm**
40586	**Gold gauze, 82 mesh woven from 0.06mm (0.0025in) dia wire, 99.9% (metals basis)** Wire Cloth, Note: Open area: 63.2%; Width of opening: 0.0097in, †	**25x25mm 50x50mm**
40931	**Gold gauze, 100 mesh woven from 0.064mm (0.0025in) dia wire, 99.99% (metals basis)** Wire Cloth 100x100mm ~4.9g, Note: Open area: 56.3%; Width of opening: 0.0075in, †	**25x25mm 50x50mm 50x100mm 100x100mm**
41814	**Platinum gauze, 45 mesh woven from 0.198mm (0.0078in) dia wire, 99.9% (metals basis)** ≈1.61g/25x25mm, Wire Cloth, Note: Open area: 42.1%; Width of opening: 0.014in, †	**25x25mm 50x50mm 100x100mm**
10283	**Platinum gauze, 52 mesh woven from 0.1mm (0.004in) dia wire, 99.9% (metals basis)** ≈0.47g/25x25mm, Wire Cloth, Note: Open area: 62.7%; Width of opening: 0.015in, †	**25x25mm 50x50mm 50x75mm 75x75mm 100x100mm**
10282	**Platinum gauze, 100 mesh woven from 0.0762mm (0.003in) dia wire, 99.9% (metals basis)** ≈0.53g/25x25mm, Wire Cloth, Note: Open area: 49%; Width of opening: 0.007in, †	**25x25mm 50x50mm 100x100mm**
44449	**Silver gauze, 20 mesh woven from 0.356mm (0.014in) dia wire** Wire Cloth, Application(s): Filtration, electrodes, contacts, Note: Open area: 51.8%; width of opening: 0.036in, †	**75x75mm 150x150mm 300x300mm**
40935	**Silver gauze, 50 mesh woven from 0.0764mm (0.003in) dia wire** Wire Cloth, Note: Open area: 72.3%; Width of opening: 0.017in, †	**75x75mm 150x150mm 300x300mm**
40936	**Silver gauze, 80 mesh woven from 0.115mm (0.0045in) dia wire, 99.9% (metals basis)** Wire Cloth, Note: Open area: 41%; Width of opening: 0.008in, †	**25x25mm 75x75mm 150x150mm 300x300mm**

FibreCat®
Anchored Homogeneous Catalysts

The FibreCat® name represents a new generation of polymer-anchored homogeneous catalysts that combine the selectivity of homogeneous catalysts with the ease of handling and separation of heterogeneous catalysts. The catalysts are anchored to a series of functionalised fibres, the composition of the fibres can be modified to ensure compatibility with a wide range of solvent and reaction systems. FibreCat® catalysts demonstrate activities that are comparable to the homogeneous catalysts. FibreCat® disperses well during agitation in a wide variety of reaction media but is not degrated by stirring. After reaction is complete, FibreCat® is easily removed, leaving a metal-free reaction product.

Unlike traditional support material, FibreCat® is an open comb-like structure that allows easy assess of reagents to the active sites (figure 1). This allows easy catalylic, products to and from the catalytic site.

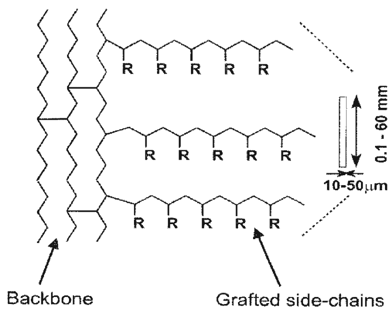


Figure 1:- Schematic of FibreCat® structure

The benefits of FibreCat® over a conventional homogeneous catalyst include:

- Selectivity
- Efficient use of precious metal
- Ease of separation of catalysts from product stream
- Efficient precious metal recovery
- Opportunity for catalyst recycling

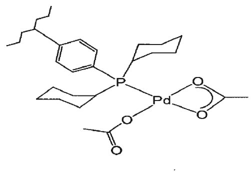
The method used in the preparation of FibreCat® catalysts allows a range of fibre lengths to be prepared to suit a variety of reactor configurations and types, although the length supplied as standard is 0.25-0.3mm.

The polymer fibre is stable at high temperatures and can be used at temperatures up to 120°C, use at higher temperatures may result in some melting.

Johnson Matthey has developed and tested the following 4 series of FibreCat® anchored homogeneous catalysts:

- 1000 series: Cross-coupling reactions
- 2000 series: Hydrogenation reactions
- 3000 series: Oxidation reactions
- 4000 series: Hydrosilylation reactions

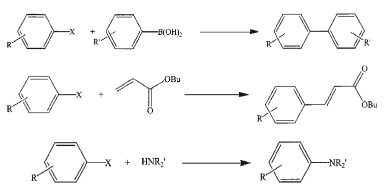
Palladium anchored homogeneous catalyst, FibreCat™ 1007
Stock No. 44110



Orange Powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

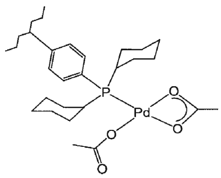
Typical phosphorus and palladium loading is 1mmol/g

Technical Note:
1. Used as a catalyst for cross coupling reactions such as Suzuki, Heck and aminations. Particularly useful for chloro-
aromatic substrates



References: *J. Org. Chem.*, (2000), 65, 1158; *J. Org. Chem.*, (1997), 62, 1568; *J. Mol. Catal A: Chemical*, (1995), 103, 133. *J. Org. Chem.*, (1999), 64, 10.

Palladium anchored homogeneous catalyst, FibreCat™ 1001
Stock No. 44111



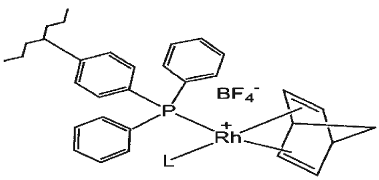
Orange Powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

Typical phosphorus and palladium loading is approx. 1mmol/g

Technical Note:
1. Used as a catalysts for cross coupling reactions such as Suzuki, Heck and aminations.
2. Useful for bromo and iodo- coupling

Examples and references as above.

Rhodium anchored homogeneous catalyst, FibreCat™ 2003
Stock No. 44113

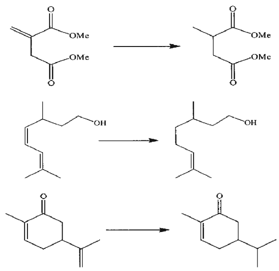


Note: 2000-D3 is a mixture of species with L = polymer-PPh2 or alkene

Orange Powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

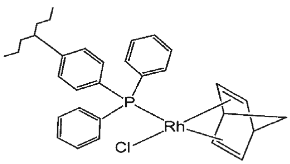
Typical phosphorus loading of approx. 1mmol/g and rhodium loading is approx. 0.5 mmol/g

Technical Note:
1. Used as catalysts in reactions such as hydrogenation of dimethylitaconate, carvone and geraniol at low pressures (around 3-4 bar).
2. Useful for the selective hydrogenation of unhindered alkenes.



References: *J.Chem. Soc* (A) (1966), 1711; *Org. Synth. Coll.*, (1988), 6, 459

Rhodium anchored homogeneous catalyst, FibreCat™ 2006
Stock No. 44114



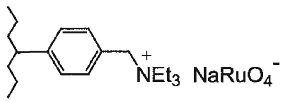
Orange Powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

Typical phosphorus loading of approx. 1mmol/g and rhodium loading is approx. 0.5 mmol/g

Technical Note:
1. Used as catalysts in reactions such as hydrogenation of dimethylitaconate, carvone and geraniol at low pressures (around 3-4 bar).

Examples and references as above.

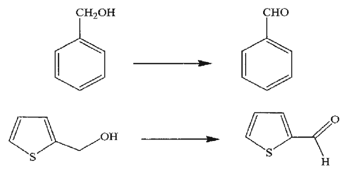
Ruthenium anchored homogeneous catalyst, FibreCat™ 3002
Stock No. 44116



Black powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

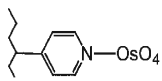
Typical ruthenium loading is approx. 0.4mmol/g.

Technical Note:
1. Used as a catalyst for selective oxidation of alcohols to aldehydes and ketones under mild conditions, includina the use of air as oxidant.



References: *Synthesis* (1994) 639; *Chem. Soc Rev* (1992), Vol 21, 179; *Adv. Synth. Catal* (2003), no. 4, 345. *Synthesis* (1998) 977; *J. Chem. Soc Perkin Trans. I*, (1998), 1.

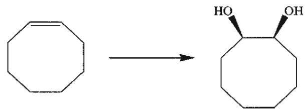
Osmium anchored homogeneous catalyst, FibreCat™ 3003
Stock No. 44117



Yellow powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

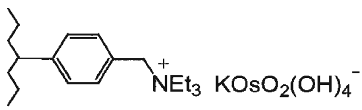
Typical osmium loading is approx. 0.4 mmol/g

Technical Notes:
1. Used as catalysts for the cis-dihydroxylation of double bonds via cyclic osmate ester.
2. Used in conjunction with co-oxidants such as morphaline N-oxide and tri methylamine N-oxide.
3. Unlike its homogeneous equivalent, supported OsO4 is considered non-toxic.



References: *Chem. Rev.* (1980), 80, 187; *Chem Rev* (1994), 94, 2483; *Synthesis*, (1989), 45.

Osmium anchored homogeneous catalyst, FibreCat™ 3004
Stock No. 44118



Dark purple powder. Insoluble in common organic solvents such as toluene, hexane, xylene, ethanol and methanol.

Typical osmium loading is approx. 0.4mmol/g

Technical Notes:
1. Used as catalysts for the cis-dihydroxylation of double bonds via cyclic osmate ester.
2. Used in conjunction with co-oxidants such as morphaline N-oxide and tri methylamine N-oxide.

Examples and references as above.

Stock #	Description	Standard Selling Sizes
44111	**Palladium anchored homogeneous catalyst, FibreCat™ 1001** Application(s): Bromo/Iodo coupling, MDL MFCD04040828	**5g** **25g** **100g**
44110	**Palladium anchored homogeneous catalyst, FibreCat™ 1007** Orange/brown fibres, Application(s): Chloro coupling, MDL MFCD04040827	**5g** **25g** **100g**
44981	**Palladium anchored homogeneous catalyst, FibreCat™ 1026** MDL MFCD06202019	**1g** **5g**
44983	**Palladium anchored homogeneous catalyst, FibreCat™ 1030** Fibers	**5g** **25g** **100g**
44982	**Palladium anchored homogeneous catalyst, FibreCat™ 1031** Fibers	**5g** **25g** **100g**
46322	**Palladium anchored homogeneous catalyst, FibreCat™ 1037** [1073551-12-8], Fibers - packaged under argon, Solubility: Insoluble in all common solvents, Application(s): Cross-coupling reactions	**1g** **5g**
44730	**Palladium anchored homogeneous catalyst, FibreCat™ 1032** △ MDL MFCD08064489	**5g**
46325	**Palladium anchored homogeneous catalyst, FibreCat™ 1045** [1073551-23-1], Gold fibers - Packaged under argon, Solubility: Insoluble in all common solvents, Application(s): Cross-coupling reactions, Note: [Dicyclohexyl(phenyl)phosphine]palladium functionalized fibers	**1g** **5g**
44113	**Rhodium anchored homogeneous catalyst, FibreCat™ 2003** △ Application(s): Hydrogenation, MDL MFCD04040829	**5g** **25g** **100g**
44114	**Rhodium anchored homogeneous catalyst, FibreCat™ 2006** △ Application(s): Hydrogenation, MDL MFCD04040830	**5g** **25g**

Stock #	Description	Standard Selling Sizes
44117	**Osmium anchored homogeneous catalyst, FibreCat™ 3003** △ Application(s): Dihydroxylation, MDL MFCD04040832 ! H:H319-H335, P:P261-P280-P305+P351+P338-P304+P340-P405-P501a	**5g** **25g** **100g**

Precious Metal Scavenger Systems

Alfa Aesar is pleased to offer a broad range of precious metal scavenger systems in conjunction with Johnson Matthey Scavenging Technologies. Smopex®, QuadraPure™ and QuadraSil™ products have the following benefits:

- Scavengers filed with the FDA and with regulatory support files for use in direct contact with APIs.
- Pre-packed laboratory scale columns include SP2, Flash, Thales and Omnifit models.
- Full screening and optimisation service to accelerate the development stage.
- Pilot and plant scale “plug and play” engineering solutions such as continuous flow cartridges and portable skid units.
- Technical specialists located around the world on hand to help with your scavenging needs on site. Full refining service to enable valuable metal to be recovered from product or waste streams.
- Unique combination of products can give enhanced performance in many applications.
- Strength of manufacturing and scavenging development at Johnson Matthey Finland Oy.

Smopex® Precious Metal Scavenger Systems
For purification of pharmaceutical process streams

The use of metal catalysts within the pharmaceutical industry allows the efficient transformation or combination of molecules that would otherwise be unfeasible. These metals, however can then become an impurity in the final product, where only very low levels of Platinum Group Metals (PGM's) are permitted. One of the most efficient ways to remove these impurities is by using a metal scavenger - Smopex. Additionally, PGM's can often be found in waste liquors, again allowing further opportunity for metal removal with Smopex.

Features
- Smopex is offered with a range of functionalities to allow tailoring of the scavenger to the customer process.
- Smopex fibres are insoluble polymers that can easily be used in all organic solvents and across the pH range in aqueous systems.
- Smopex can be used at temperatures up to 120C, with elevated temperatures often further increasing its extraction capabilities.
- Smopex can be used in both batch and fixed bed processes, allowing it to easily fit into the customers existing process
- Smopex is offered with different backbones, each having specific physical characteristics suitable for different process streams.

Benefits
- Functional groups are located on the exterior surface of the fibre. Their accessibility ensures that reaction kinetics are fast and not diffusion limited.
- This increased accessibility allows very high metal loadings to be achieved on the fibre.
- The activity of Smopex means that it is possible to recover metal down to parts per billion (ppb) levels in solution
- All core products are available from lab scale to multi-ton quantites.
- Four of the listed products have DMF files allowing the customer to safely use Smopex in late stage Active Pharmaceutical Ingredient (API) syntheses.

Stock #	Description	Standard Selling Sizes
44568	**Smopex®-101** *[Styrene sulfonic acid grafted polyolefin fiber]* Powder, m.p. 120°, d. 0.3, Application(s): Recovery of precious metals from catalyst process streams, MDL MFCD06202258, Note: Chopped fibers. Strong cation action exchanger. Exchange capacity 2-4 mmol/g	**5g** **25g** **100g**
44705	**Smopex®-102** *[Acrylic acid grafted polyolefin fiber]* Powder, d. 0.3, Application(s): Recovery of precious metals, MDL MFCD06202259, Note: Chopped fibers-Weak acid cation exchanger. Exchange capacity 7-10 mmol/g	**5g** **25g** **100g**
44706	**Smopex®-103** *[Styryl dimethylamine grafted polyolefin fiber]* Powder, Application(s): Recovery of precious metal complexes, MDL MFCD06202260, Note: Strong base (trimethylammonium functional group) anion exchanger. Exchange capacity 2-3.5 mmol/g	**5g** **25g** **100g**
44710	**Smopex®-105** *[Vinyl pyridine grafted polyolefin fiber]* Powder, Application(s): Recovery of negatively charged precious metals complexes used in complex reactions (Suzuki, Heck, Sonagashira), MDL MFCD06202261, Note: Weak base (pyridine functional group) anion exchanger. Exchange capacity 4-6 mmol/g	**5g** **25g** **100g**
44724	**Smopex®-110** *[Styryl thiourea grafted polyethylene fiber]* Powder, d. 0.3, Application(s): In precious metal recovery from Suzuki, Heck, Sonagashira and Shille type reactions, MDL MFCD06202263, Note: Chelating anion exchanger (Isothiouronium functional group). Exchange capacity 2-3 mmol/g	**2g** **10g** **50g**
45027	**Smopex®-111** *[Styryl thiol grafted polyethylene fiber]* Powder, d. 0.3, Application(s): Recovery of precious metals from catalyst processes, Note: Chopped fibres. Ligand exchanger (thiol functional group). Functional group capacity 2.5mmol/g	**5g** **25g**

Stock #	Description	Standard Selling Sizes
45474	**Smopex®-112v** *[Acrylate based "α"-hydroxyl thiol grafted polyolefin fiber]* Powder, d. 0.3, Application(s): Recovery of precious metals from catalyst processes, Note: Chopped fibres. Ligand exchanger (thiol functional group). Functional group capacity 3.7mmol/g	**5g** **25g**
44984	**Smopex®-234** *[Mercaptoethylacrylate grafted polyolefin fiber]* Powder, d. 0.3, Application(s): Recovery of precious metals from catalyst processes, Note: Chopped fibres. Ligand exchanger (thiol functional group). Functional group capacity 3-4 mmol/g	**1g** **5g** **25g**
45043	**Smopex® kit 1** Powder, Note: Contains 10g each of Smopex 101, 102, 103, 105, 111, 112v and 234.	**1each**

Stock No. 45043 Smopex® Kit

Smopex is a unique metal scavenging system, where metal binding functionality is grafted onto fibres, allowing for the effective recovery of precious metals from process streams. These products may be used for a variety of applications. Guidelines are provide with each kit detailing the product functionality and recommended usage.

This kit contains 10g of each of the following product

44568	Smopex-101
44705	Smopex-102
44706	Smopex-103
45472	Smopex-105
45473	Smopex-110
45027	Smopex-111
45474	Smopex-112v
44984	Smopex-234

Call to speak with a Specialty Sales representative for pricing and availability.

QuadraPure™

Johnson Matthey Scavenging Technologies QuadraPure™ polymer-based spherical scavengers offer cost-effective removal of precious metal catalyst residues for high purity products.

Advantageously, the very low levels of extractable impurities make QuadraPure™ products particularly suitable for GMP-compliant applications in both batch and continuous processing. Regulatory Support Files are available for each of the macroporous QuadraPure™ products to support their use in GMP-standard applications. The QuadraPure™ series can be used in loose resin bead format at R&D through to large-scale bulk process applications.

Stock #	Description	Standard Selling Sizes
46244	**QuadraPure™ AEA, 100-400 micron** *[QuadraPure™ Aminoethyl aminobut-2-enoate ester]* Beads, Application(s): Metal Scavenger: Pd, Rh, V, Cu, Fe	**5g** **25g**
46283	**QuadraPure™ AK, 50-90 mesh** *[2,4-Butanedione resin, Activated ketone, polymer-bound]* Beads, Application(s): Scavenger for Hydrazines and Primary Amines	**5g** **25g**
45917	**QuadraPure™ AMPA, 350-750 micron** *[QuadraPure™ Aminomethylphosphonic acid]* Beads, Application(s): Metal Scavenger: Fe, Cu, Ni, V, Al, Co, UN3077 H:H411, P:P273-P391-P501a	**5g** **25g** **100g** **1kg**
46008	**QuadraPure™ BDZ, 400-750 micron** *[QuadraPure™ Bis(propyl-1H-imidazole)]* Beads, Application(s): Metal Scavenger: Rh, Co, Pd, Ni	**5g** **25g** **100g**
45989	**QuadraPure™ BZA, 400-1100 micron** *[QuadraPure™ Benzylamine]* Beads, Application(s): Metal Scavenger: Rh, Pd, Cu, Co, Ni	**5g** **25g** **100g**
46297	**QuadraPure™ C, 0.3-0.8mm** Beads, Application(s): High-capacity, carbon-based adsorbent in the form of spherical particles used for scavenging of trace organic impurities. Free-flowing and free of dust, QuadraPureε C is easily removed from reaction mixtures by filtration.	**50g** **250g** **1kg**
46083	**QuadraPure™ DET, 450-650 micron** *[QuadraPure™ Bis(ethyl mercaptan)]* Beads, Application(s): Metal Scavenger: Pd in acidic media and with phosphines, Co, Fe, Ni, Rh	**5g** **25g** **100g**
46326	**QuadraPure™ DMA, 400-800 micron** *[QuadraPure™ Dimethylamine]* Beads, Application(s): Metal scavenger: Ag, Au, Cu, Fe, Ir, Ni, Pd, Pt, Rh, Note: Functionality: Tertiary amine. Capacity: 4-5mmole/g	**5g** **25g** **100g**
46044	**QuadraPure™ EDA, 500-800 micron** *[QuadraPure™ Bis(ethylamine)]* Beads, Application(s): Metal Scavenger: Pd in basic media and with phosphines, Co, Ni, Rh	**5g** **25g** **100g**
45952	**QuadraPure™ IDA, 350-750 micron** *[QuadraPure™ Iminodiacetate]* F.W. 0.73, Beads, Application(s): Metal Scavenger: Fe, Al, Ga, In, Cu, V, Pb, Ni, Zn, Cd, Be, Mn, Co, Sr, Ba H:H228-H412, P:P210-P241-P280-P240-P273-P501a	**5g** **25g** **100g**
46133	**QuadraPure™ IMDAZ, 100-400 micron** *[QuadraPure™ Imidazol-1-yl propylaminobut-2-enoate ester]* Beads, Application(s): Metal Scavenger: Pd, Ru, Os, Co, Ni, Rh, V, Fe, Cu, Sn H:H411, P:P273-P391-P501a	**5g** **25g**
46198	**QuadraPure™ MPA, 100-400 micron** *[QuadraPure™ Mercaptophenylaminobut-2-enoate ester]* Beads, Application(s): Metal Scavenger: Pd, Ru, Rh, Hg, Au, Ag, Cu, Ni, Sn, Pb, Pt, Cd, UN3175, † H:H228-H411, P:P210-P241-P280-P240-P273-P501a	**5g** **25g** **100g**
46102	**QuadraPure™ PHE, 400-1100 micron** *[QuadraPure™ phenolic functionalized polystyrene]* Beads, Application(s): Metal scavenger: Fe(III), Pd(II), Rh(III), UN3175 H:H228-H315-H319-H335-H411, P:P210-P241-P305+P351+P338-P302+P352-P405-P501a	**5g** **25g**

Stock #	Description	Standard Selling Sizes
46392	**QuadraPure™ SA, 400-850 micron** *[QuadraPure™ Sulfonic acid]* Beads, UN3175 H:H228-H318-H411, P:P210-P241-P280-P305+P351+P338-P310-P501a	**5g** **25g** **100g**
45898	**QuadraPure™ TU, 400-600 micron** *[QuadraPure™ Thiourea]* Beads, Application(s): Metal Scavenger: Pd, Pt, Ru, Rh, Au, Ag, Cu, Hg, Pb, Cd, Ni, Co, Fe, V, Zn H:H315-H319-H335, P:P261-P305+P351+P338-P302+P352-P321-P405-P501a	**5g** **25g** **100g**

QuadraSil™

The Johnson Matthey QuadraSil™ range of metal scavengers offers an attractive solution to metal contamination problems associated with pharmaceutical and fine chemical processing, complementing the Smopex® fibre and QuadraPure™ scavenger resin ranges.

The QuadraSil™ products are functionalized silicas specifically designed for extraction of metal contaminants from organic and aqueous systems. As with the Smopex® and QuadraPure™ range, the very low levels of extractable impurities make these products particularly suitable for GMP-compliant applications in both batch and continuous processing. The QuadraSil™ series are ideal for use in R&D applications as they offer extremely fast scavenging and are easy to isolate by filtration.

Stock #	Description	Standard Selling Sizes
46303	**QuadraSil™ AP, 20-100 micron** *[QuadraSil™ Aminopropyl]* Powder or Beads, Application(s): Metal scavenger: Co, Cu, Cd, Fe, Ni, Pd, Rh, Ru, Pb, Hg, Zn	**5g** **25g** **100g**
46259	**QuadraSil™ MP, 20-100 micron** *[QuadraSil™ Mercaptopropyl]* Powder or Beads, Application(s): Metal scavenger: Pd (with or without phosphines), Rh, Cu, Ru, Pt, Pb, Ag, Hg	**5g** **25g** **100g**
46188	**QuadraSil™ MTU, 20-100 micron** *[QuadraSil™ Methylthiourea]* Powder or Beads, Application(s): Metal scavenger: Co, Cu, Fe, Pb, Pd, Rh, Ru, Ag, Au, Pt, Hg	**5g** **25g** **100g**
46094	**QuadraSil™ PHI, 20-100 micron** *[QuadraSil™ phenolic functionalized silica gel]* Powder or Beads, Application(s): Metal scavenger: Fe(III), Pd(II), Rh(III), UN3175	**5g** **25g** **100g**
46218	**QuadraSil™ TA, 20-100 micron** *[QuadraSil™ Triamine]* Powder or Beads, Application(s): Metal scavenger: Au, Cd, Co, Cu, Fe, Pd, Pt, Rh, Ru, V, Zn, Pb	**5g** **25g** **100g**

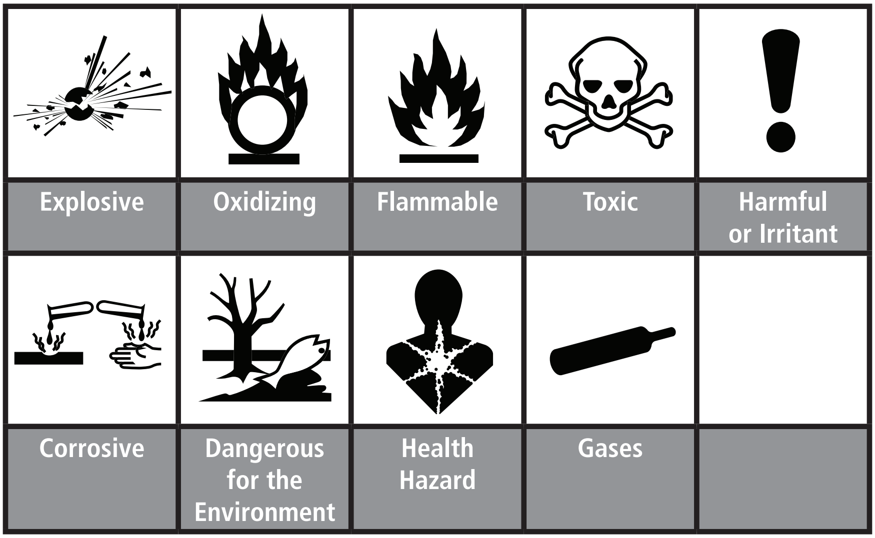
Trademarks

The following trademarks are acknowledged™, and are accurate to the best of our knowledge at the time of printing.

Accufluor®	Allied Signal Corp.
Aliquat®	Cognis Corporation
Amberlite®	Rohm & Haas Co.
Amberlyst	Rohm & Haas Co.
Ambersep®	Dow Chemical Co.
BoPhoz™	Eastman Chemical
Carborundum™	Saint-Gobain Abrasvies, Inc.
Carbowax®	Dow Chemical Co.
Celite®	Celite Corp.
Cellosolve®	Union Carbide Corp.
Chipros®	BASF
ColorpHast®	Merck KGaA
Dabco®	Air Products and Chemicals Inc.
Dowanol®	Dow Chemical Co.
Dowex®	Dow Chemical Co.
Drierite®	W.A. Hammond DRIERITE Co.
ECOENG®	Solvent Innovation GmbH
Eriochrome®	Huntsman International LLC Corp.
Evanohm®	Carpenter Technology Co.
Ficoll®	GE Healthcare Bio-Sciences
Florisil®	U.S. Silica Co.
Fluorolink®	Ausimont Inc.
Fomblin®	Ausimont Inc.
Friatec-Degussit®	Friatec-Degussit
Glassclad®	United Chemical Technologies
Harborlite®	Manville Filtration
Hastelloy C®	Haynes International
Highlink®	Clariant Group
HP®	Hewlett Packard
Hyamine®	Rohm & Haas Co.
Hyflo Super-cel®	Manville Filtration
I2R®	Glas-Col, LLC
Inconel®	Huntington Alloys
Invar®	Imphy Alloys
Ionac®	Lanxess Corp.
Irganox®	Ciba Speciality Chemicals
Manganin®	Isabellenhutte Hester GmbH & -Co KG
Monel®	Huntington Alloys
MuMetal®	Magnetic Shield Co.
Nafion®	E.I. DuPont de Nemours & Co. Inc.
NanoArc®	Nanophase Technologies Corp.
NanoDur®	Nanophase Technologies Corp.
NanoGard®	Nanophase Technologies Corp.
NanoShield®	Nanophase Technologies Corp.
NanoTek®	Nanophase Technologies Corp.
Oxone®	E.I. Dupont de Nemours & Co. Inc.
Oxynitrox®	Arkema Co.
Quant®	Merck KGaA
Raney®	W.R. Grace & Co.
SPAN®	ICI Americas, Inc.
Swagelok®	Swagelok Co. Corp.
SELECTFLUOR®	Air Products and Chemicals Inc.
T3P®	Archimica
Toray™	Toray Industries Inc.
Triton®	Union Carbide Chemicals
Tween®	ICI Americas Inc.
Wig-L-Bug®	Dentsply International Inc.

Precautionary & Hazard Statements

GHS Hazard Symbols - Pictograms



GHS Precautionary and Hazard Statements

Hazardous products listed in this catalogue are marked with P and H numbers as assigned to the Precautionary and Hazard statements under UN legislation.

Precautionary Statements

General precautionary statements

P101	If medical advice is needed, have product container or label at hand
P102	Keep out of reach of children
P103	Read label before use

Prevention precautionary statements

P201	Obtain special instructions before use
P202	Do not handle until all safety precautions have been read and understood
P210	Keep away from heat/sparks/open flames/hot surfaces – No smoking
P211	Do not spray on an open flame or other ignition source
P220	Keep/Store away from clothing/…/combustible materials
P221	Take any precaution to avoid mixing with combustibles
P222	Do not allow contact with air
P223	Keep away from any possible contact with water, because of violent reaction and possible flash fire
P230	Keep wetted with …
P231	Handle under inert gas
P232	Protect from moisture
P233	Keep container tightly closed
P234	Keep only in original container
P235	Keep cool
P240	Ground/bond container and receiving equipment
P241	Use explosion-proof electrical/ventilating/light/…/equipment
P242	Use only non-sparking tools
P243	Take precautionary measures against static discharge
P244	Keep reduction valves free from grease and oil
P250	Do not subject to grinding/shock/…/friction
P251	Pressurized container – Do not pierce or burn, even after use
P260	Do not breathe dust/fume/gas/mist/vapours/spray
P261	Avoid breathing dust/fume/gas/mist/vapours/spray
P262	Do not get in eyes, on skin, or on clothing
P263	Avoid contact during pregnancy/while nursing
P264	Wash … thoroughly after handling
P270	Do not eat, drink or smoke when using this product
P271	Use only outdoors or in a well-ventilated area
P272	Contaminated work clothing should not be allowed out of the workplace
P273	Avoid release to the environment
P280	Wear protective gloves/protective clothing/eye protection/face protection
P281	Use personal protective equipment as required
P282	Wear cold insulating gloves/face shield/eye protection
P283	Wear fire/flame resistant/retardant clothing

P284	Wear respiratory protection
P285	In case of inadequate ventilation wear respiratory protection
P231+232	Handle under inert gas. Protect from moisture
P235+410	Keep cool. Protect from sunlight

Response precautionary statements

P301	IF SWALLOWED:
P302	IF ON SKIN:
P303	IF ON SKIN (or hair):
P304	IF INHALED:
P305	IF IN EYES:
P306	IF ON CLOTHING:
P307	IF exposed:
P308	IF exposed or concerned:
P309	IF exposed or you feel unwell:
P310	Immediately call a POISON CENTER or doctor/physician
P311	Call a POISON CENTER or doctor/physician
P312	Call a POISON CENTER or doctor/physician if you feel unwell
P313	Get medical advice/attention
P314	Get Medical advice/attention if you feel unwell
P315	Get immediate medical advice/attention
P320	Specific treatment is urgent (see … on this label)
P321	Specific treatment (see … on this label)
P322	Specific measures (see … on this label)
P330	Rinse mouth
P331	Do NOT induce vomiting
P332	If skin irritation occurs:
P333	If skin irritation or a rash occurs:
P334	Immerse in cool water/wrap in wet bandages
P335	Brush off loose particles from skin
P336	Thaw frosted parts with lukewarm water. Do not rub affected area
P337	If eye irritation persists:
P338	Remove contact lenses if present and easy to do. Continue rinsing
P340	Remove victim to fresh air and keep at rest in a position comfortable for breathing
P341	If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing
P342	If experiencing respiratory symptoms:
P350	Gently wash with plenty of soap and water
P351	Rinse continuously with water for several minutes
P352	Wash with plenty of soap and water
P353	Rinse skin with water/shower
P360	Rinse immediately contaminated clothing and skin with plenty of water before removing clothes
P361	Remove/Take off immediately all contaminated clothing
P362	Take off contaminated clothing and wash before reuse
P363	Wash contaminated clothing before reuse
P370	In case of fire:
P371	In case of major fire and large quantities:
P372	Explosion risk in case of fire
P373	DO NOT fight fire when fire reaches explosives
P374	Fight fire with normal precautions from a reasonable distance
P375	Fight fire remotely due to the risk of explosion
P376	Stop leak if safe to do so
P377	Leaking gas fire – do not extinguish, unless leak can be stopped safely
P378	Use … for extinction
P380	Evacuate area
P381	Eliminate all ignition sources if safe to do so
P390	Absorb spillage to prevent material damage
P391	Collect spillage
P301+310	IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
P301+312	IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
P301+330+331	IF SWALLOWED: Rinse mouth. Do NOT induce vomiting
P302+334	IF ON SKIN: Immerse in cool water/wrap in wet bandages
P302+350	IF ON SKIN: Gently wash with plenty of soap and water
P302+352	IF ON SKIN: Wash with plenty of soap and water
P303+361+353	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower
P304+312	IF INHALED: Call a POISON CENTER or doctor/physician if you feel unwell
P304+340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing
P304+341	IF INHALED: If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing
P305+351+338	IF IN EYES: Rinse continuously with water for several minutes. Remove contact lenses if present and easy to do – continue rinsing
P306+360	IF ON CLOTHING: Rinse immediately contaminated clothing and skin with plenty of water before removing clothes
P307+311	IF exposed: Call a POISON CENTER or doctor/physician
P308+313	IF exposed or concerned: Get medical advice/attention
P309+311	IF exposed or you feel unwell: Call a POISON CENTER or doctor/physician
P332+313	If skin irritation occurs: Get medical advice/attention
P333+313	If skin irritation or a rash occurs: Get medical advice/attention
P335+334	Brush off loose particles from skin. Immerse in cool water/wrap in wet bandages
P337+313	If eye irritation persists: Get medical advice/attention
P342+311	If experiencing respiratory symptoms: Call a POISON CENTER or doctor/physician
P370+376	In case of fire: Stop leak if safe to do so
P370+378	In case of fire: Use … for extinction
P370+380	In case of fire: Evacuate area
P370+380+375	In case of fire: Evacuate area. Fight fire remotely due to the risk of explosion
P371+380+375	In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion

Storage precautionary statements

P401	Store …
P402	Store in a dry place
P403	Store in a well ventilated place
P404	Store in a closed container
P405	Store locked up
P406	Store in a corrosive resistant/… container with a resistant inner liner
P407	Maintain air gap between stacks/pallets
P410	Protect from sunlight

P411 Store at temperatures not exceeding … °C/… °F
P412 Do not expose to temperatures exceeding 50 °C/122 °F
P413 Store bulk masses greater than ... kg/ ... lbs at temperatures not exceeding … °C/… °F
P420 Store away from other materials
P422 Store contents under …
P402+404 Store in a dry place. Store in a closed container
P403+233 Store in a well ventilated place. Keep container tightly closed
P403+235 Store in a well ventilated place. Keep cool
P410+403 Protect from sunlight. Store in a well ventilated place
P410+412 Protect from sunlight. Do not expose to temperatures exceeding 50 °C/122 °F
P411+235 Store at temperatures not exceeding… °C/… °F. Keep cool

Disposal precautionary statements

P501 Dispose of contents/container to …

Hazard Statements

Physical hazards

H200 Unstable explosive
H201 Explosive; mass explosion hazard
H202 Explosive; severe projection hazard
H203 Explosive; fire, blast or projection hazard
H204 Fire or projection hazard
H205 May mass explode in fire
H220 Extremely flammable gas
H221 Flammable gas
H222 Extremely flammable material
H223 Flammable material
H224 Extremely flammable liquid and vapour
H225 Highly flammable liquid and vapour
H226 Flammable liquid and vapour
H227 Combustible liquid
H228 Flammable solid
H240 Heating may cause an explosion
H241 Heating may cause a fire or explosion
H242 Heating may cause a fire
H250 Catches fire spontaneously if exposed to air
H251 Self-heating; may catch fire
H252 Self-heating in large quantities; may catch fire
H260 In contact with water releases flammable gases which may ignite spontaneously
H261 In contact with water releases flammable gas
H270 May cause or intensify fire; oxidizer
H271 May cause fire or explosion; strong oxidizer
H272 May intensify fire; oxidizer
H280 Contains gas under pressure; may explode if heated
H281 Contains refrigerated gas; may cause cryogenic burns or injury
H290 May be corrosive to metals

Health hazards

H300 Fatal if swallowed
H301 Toxic if swallowed
H302 Harmful if swallowed
H303 May be harmful if swallowed
H304 May be fatal if swallowed and enters airways
H305 May be harmful if swallowed and enters air ways
H310 Fatal in contact with skin
H311 Toxic in contact with skin
H312 Harmful in contact with skin
H313 May be harmful in contact with skin
H314 Causes severe skin burns and eye damage
H315 Causes skin irritation
H316 Causes mild skin irritation
H317 May cause an allergic skin reaction
H318 Causes serious eye damage
H319 Causes serious eye irritation
H320 Causes eye irritation
H330 Fatal if inhaled
H331 Toxic if inhaled
H332 Harmful if inhaled
H333 May be harmful if inhaled
H334 May cause allergy or asthma symptoms of breathing difficulties if inhaled
H335 May cause respiratory irritation
H336 May cause drowsiness or dizziness
H340 May cause genetic defects
H341 Suspected of causing genetic defects
H350 May cause cancer
H351 Suspected of causing cancer
H360 May damage fertility or the unborn child
H361 Suspected of damaging fertility or the unborn child
H362 May cause harm to breast-fed children
H370 Causes damage to organs
H371 May cause damage to organs
H372 Causes damage to organs through prolonged or repeated exposure
H373 May cause damage to organs through prolonged or repeated exposure

Environmental hazards

H400 Very toxic to aquatic life
H401 Toxic to aquatic life
H402 Harmful to aquatic life
H410 Very toxic to aquatic life with long lasting effects
H411 Toxic to aquatic life with long lasting effects
H412 Harmful to aquatic life with long lasting effects
H413 May cause long lasting harmful effects to aquatic life

EUH Statements

All H statements listed before are internationally valid. The following EUH statements are only valid in all countries within the EU.

EUH001 Explosive when dry.
EUH006 Explosive with or without contact with air.
EUH014 Reacts violently with water.
EUH018 In use may form flammable/explosive vapour/air mixture.
EUH019 May form explosive peroxides.
EUH044 Risk of explosion if heated under confinement.
EUH029 Contact with water liberates toxic gas.
EUH031 Contact with acids liberates toxic gas.
EUH032 Contact with acids liberates very toxic gas.
EUH066 Repeated exposure may cause skin dryness/cracking.
EUH070 Toxic by eye contact.
EUH071 Corrosive to the respiratory tract.
EUH059 Hazardous to the ozone layer.
EUH201 Contains lead. Should not be used on surfaces liable to being chewed or sucked.
EUH201A Warning! Contains lead.
EUH202 Cryanoacrylate. Danger. Bonds skin and eyes in seconds. Keep out of the reach of children.
EUH203 Contains chromium (VI). May produce an allergic reation.
EUH204 Contains isocyanates. May produce an allergic reaction.
EUH205 Contains epoxy constituents.
EUH206 Warning! Do not use together with other products. May release dangerous gases (chlorine).
EUH207 Warning! Contains cadmium. Dangerous fumes are formed during use. See information supplied by the manufaturer. Comply with the safety instructions.
EUH208 Contains <name of sensitising substance>. May produce an allergic reaction.
EUH209 Can become highly flammable in use.
EUH209A Can become flammable in use.
EUH210 Safety data sheet available on request.
EUH401 To avoid risks to human health and the environment, comply with the instructions for use.