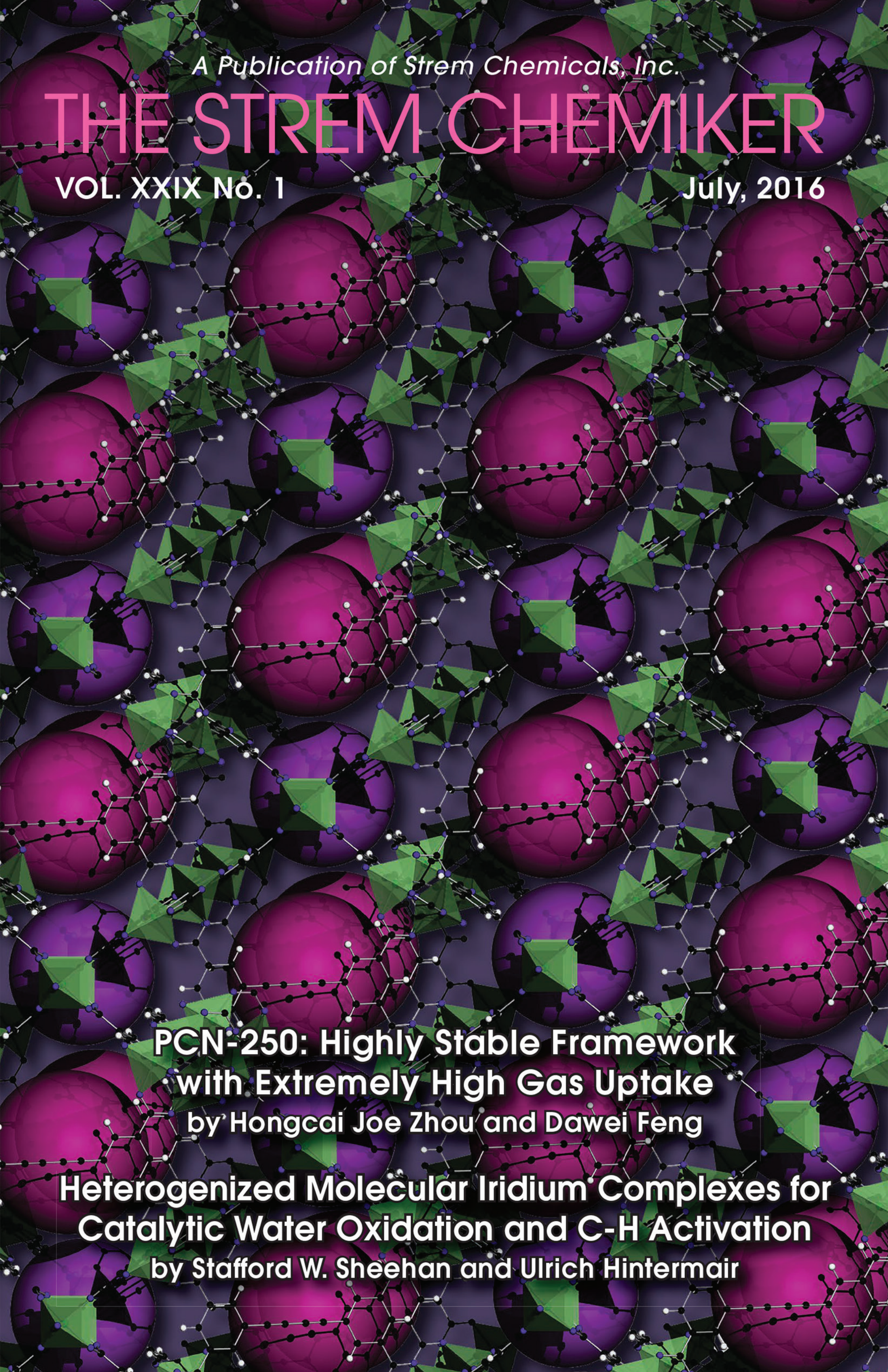

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PCN-250: Highly Stable Framework with Extremely High Gas Uptake

by Hongcai Joe Zhou and Dawei Feng

Heterogenized Molecular Iridium Complexes for Catalytic Water Oxidation and C-H Activation

by Stafford W. Sheehan and Ulrich Hintermair

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Biographical Sketches:

American Chemical Society Award for Distinguished Service in the Advancement of Inorganic Chemistry	2016	Prof. Vincent L. Pecoraro, University of Michigan
	2015	Prof. Kim R. Dunbar, Texas A&M University
	2014	Prof. T. Don Tilley, University of California, Berkeley
Canadian Society for Chemistry Award for Pure or Applied Inorganic Chemistry	2016	Prof. Curtis P. Berlinguette, University of British Columbia
	2015	Prof. Muralee Murugesu, University of Ottawa
	2014	Prof. Paul J. Ragogna, University of Western Ontario

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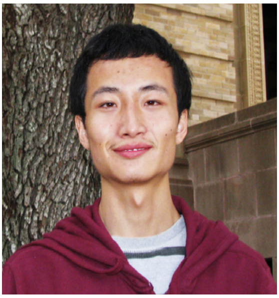
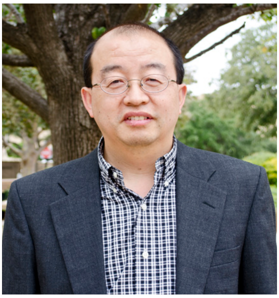
Biographical Sketches



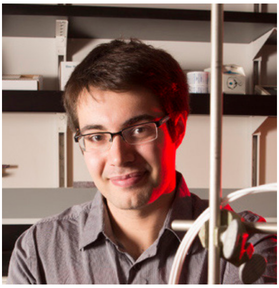
Dawei Feng

Dawei Feng graduated from Texas A&M University with a Ph.D. in 2015. At TAMU he was the Thomas J. Hairston Memorial Graduate Scholarship winner; his Ph.D. advisor was Dr. Hongcai Joe Zhou. He is now at Stanford University as a postdoctoral fellow with Dr. Zhenan Bao.



Hongcai Joe Zhou

Hongcai Joe Zhou graduated from Texas A&M University with a Ph.D. in 2000. At TAMU he was the George W. Kunze Prize winner; his Ph.D. advisor was Dr. F. A. Cotton. He then spent two years at Harvard University as a postdoctoral fellow with Dr. R. H. Holm before joining the faculty of Miami University in 2002. Professor Zhou's awards include a Research Innovation Award from Research Corporation in 2003, an NSF CAREER Award in 2005, a Cottrell Scholar Award from Research Corporation in 2005, the 2006 Miami University Distinguished Scholar - Young Investigator Award, and the 2007 Faculty Excellence Award from Air Products and Chemicals, Inc. Dr. Zhou and his research group moved to Texas A&M University in the summer of 2008. He is currently an Associate Editor for the ACS journal Inorganic Chemistry. He was appointed a full professor in 2008, a Davidson Professor in Science in 2014, and a Robert A. Welch Chair in Chemistry in 2015.



Stafford W. Sheehan founded and leads Catalytic Innovations (http://cat.aly.st/), a company that manufactures electrochemical materials and develops electrochemical process technologies with engineering partner Waste Hub (www.waste-hub.com). He holds a BS and MS in Chemistry from Boston College and Yale University, respectively, and completed his PhD in Physical Chemistry as an NSF Graduate Research Fellow at Yale University. Prior to his scientific career, he worked in IT and software development where he founded Dream8 Inc and, as its CEO, led it to a successful acquisition. He was an NSF awardee to the 63rd Lindau Nobel Laureate Meeting, one of the 2015 SciFinder Future Leaders in Chemistry, and named one of Forbes "30 under 30" in the Energy sector in 2016.

Ulrich Hintermair is an independent Whorrod Research Fellow at the Centre for Sustainable Chemical Technologies (CSCT) at the University of Bath, where he has been a faculty member since 2013. Dr. Hintermair's research group works on applied catalysis with metal complexes to develop more sustainable processes and alternative energy conversion schemes in a multi-disciplinary approach. He received a dual education in Chemistry and Chemical Engineering from schools in Germany, France and the UK. During his time at Yale University as Humboldt Postdoctoral Fellow with Prof. Robert Crabtree, he was involved in the development of Ir-based oxidation catalysts, a technology that was patented and spun out into Catalytic Innovations, for which he now acts as Chief Scientific Advisor.

PCN-250: Highly Stable Framework with Extremely High Gas Uptake

Dawei Feng, Kecheng Wang, Zhangwen Wei, Ying-Pin Chen, Cory M. Simon, Ravi K. Arvapally, Richard L. Martin, Mathieu Bosch, Tian-Fu Liu, Stephen Fordham, Daqiang Yuan, Mohammad A. Omary, Maciej Haranczyk, Berend Smit, & Hong-Cai Zhou

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Introduction

Metal–organic frameworks (MOFs), as inorganic-organic hybrid materials based on coordination bonds, are usually less stable than covalent bond based materials. Thus, the stability of MOFs plays a vital role in real world applications.[1-4]. The chemical stability of MOFs, which is defined as the resistance to reactive chemicals, is essential to a number of applications including separations, carbon capture, gas storage and catalysis[5-15]. MOFs that are robust, can be easily scaled up, are moisture resistant and possess high gas storage capacity are needed for the commercialization of MOFs. Nevertheless, synthesizing stable MOFs with appropriate porosity and internal surface properties has always been challenging. Moisture resistant MOFs, consisting of high-valence metals, have been made by 'one-pot' synthesis. That makes it hard to control the metal nodes and therefore the topology and structure of the MOFs[16].

Preparing robust MOFs via a conventional one-pot synthesis method may be problematic due to the fact that an unpredictable geometry of metal clusters could be generated and even amorphous products could be seen. That makes the rational design of MOFs difficult[17]. To solve these problems, we use a universal approach, which is based on the kinetic and thermodynamic control of MOF crystallization, of synthesizing Fe-MOF single crystals with pre-synthesized metal building blocks $[Fe_2M(\mu_3\text{-}O)(CH_3COO)_6]$ ($M=Fe^{2+,3+}$, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}). In summary, 34 different Fe-MOF large single crystals were synthesized. Among these MOFs, PCN-250(Fe_2Co) (PCN stands for porous coordination network), shows very high total H_2 volumetric uptakes of 60 g L^{-1} at 40 bar and 77 K. It also exhibits high total CH_4 uptakes of 200V STP/V at 35 bar and 298 K[18, 19].

Simplification of MOFs growth using preformed $[Fe_2M(\mu_3\text{-}O)(CH_3COO)_6]$

$M_3(\mu_3\text{-}O)(COO)_6$ (M= Cr, Al, Sc, V, In etc.) is one of the most common secondary building units (SBUs) that is a trivalent metal cluster in MOFs[20]. We used $[Fe_2M(\mu_3\text{-}O)(CH_3COO)_6]$ as the reactant and acetic acid as the competing reagent to synthesize Fe-MOFs. These metal clusters have great solubility in common solvents, which increases their feasibility as a reactant. In terms of stability, the strong electrostatic interaction between Fe^{3+} and $\mu_3\text{-}O^{2-}$, the $[Fe_2M(\mu_3\text{-}O)(CH_3COO)_6]$ cluster is inherently stable to preserve the integrity of the core during carboxylate substitution process on the periphery under solvothermal conditions. Moreover, the D_{3h} cluster has six carboxylate arms in a trigonal prismatic geometry, which enables formation of 3D frameworks through simple bridging.

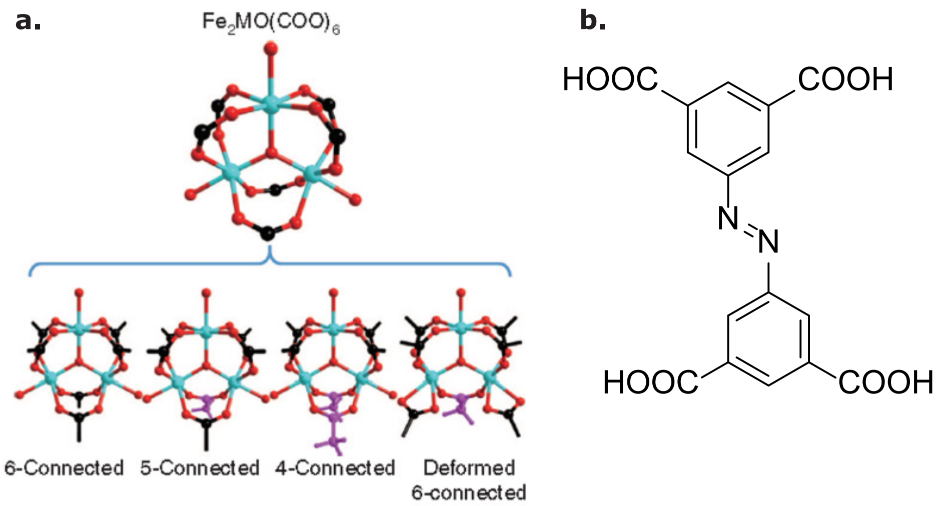


Figure 1: Different connecting modes and organic linkers used. (a) Four different connecting modes of the [$Fe_2M(\mu_3\text{-}O)$] cluster. Carboxylates on ligands and terminal acetates are represented by black and purple, respectively. (b) Ligand used in constructing PCN-250.

The amount of acetic acid, as the competing reagent, can easily adjust both the ligand substitution and dissociation processes. As a result, we successfully synthesized large single crystals of many Fe-MOFs, including PCN-250, with the [$Fe_2M(\mu_3\text{-}O)$] cluster.

Discussion on synthetic conditions of PCN-250

This novel synthetic approach could be regarded as a “dimensional augmentation” process. This means that pre-formed isolated clusters, or zero-dimensional nodes of [$Fe_2M(\mu_3\text{-}O)$], have been connected together to form three-dimensional nets of the MOF. Partial substitution on the [$Fe_2M(\mu_3\text{-}O)$] clusters has also happened when symmetry requirements or steric hindrance prohibits complete substitution.

Based on our hypothesis, the substitution rate of the MOF formation process would be lower with extra acetic acid, which indicates the kinetic control. Gels or amorphous products were obtained when the amount of acetic acid was much less than the optimal value. If the concentration of acetic acid is much higher than the optimal value, no crystal or even solid would be generated after a long time. If MOF crystallization is considered to be an equilibrium and the formation of clear solution is regarded as the point of transition to a positive Gibbs free energy, then the concentration of acetic acid is actually an indicator of the MOF’s ΔG of crystallization.

High volumetric gas uptake of PCN-250

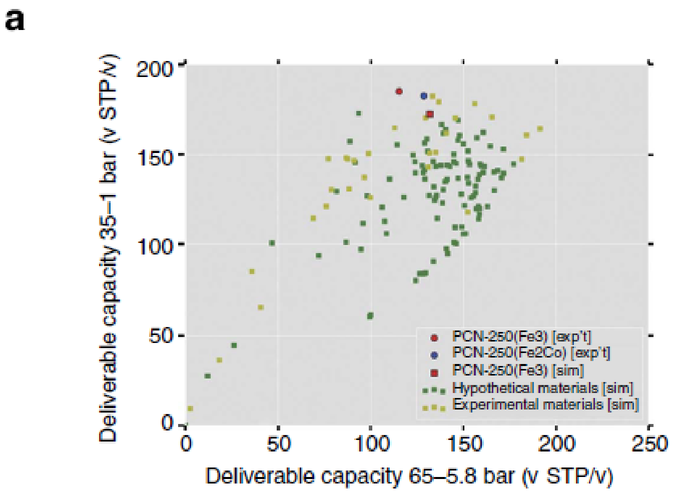
High methane uptake of PCN-250 is a key feature of this material. It is highly related to the structure of the MOF used[19]. Computational studies give a good prediction of its methane uptake. Figure 2a shows the simulated deliverable capacities of PCN-250(Fe_3), PCN-250(Fe_2Co) and other predicted structures. Our computational simulations indicate that PCN-250 is potentially an outstanding absorbent for methane storage using a pressure range between 1 and 35 bar. Our simulations also prove that PCN-250 has the highest methane loading of all structures considered in this analysis at 35 bar.

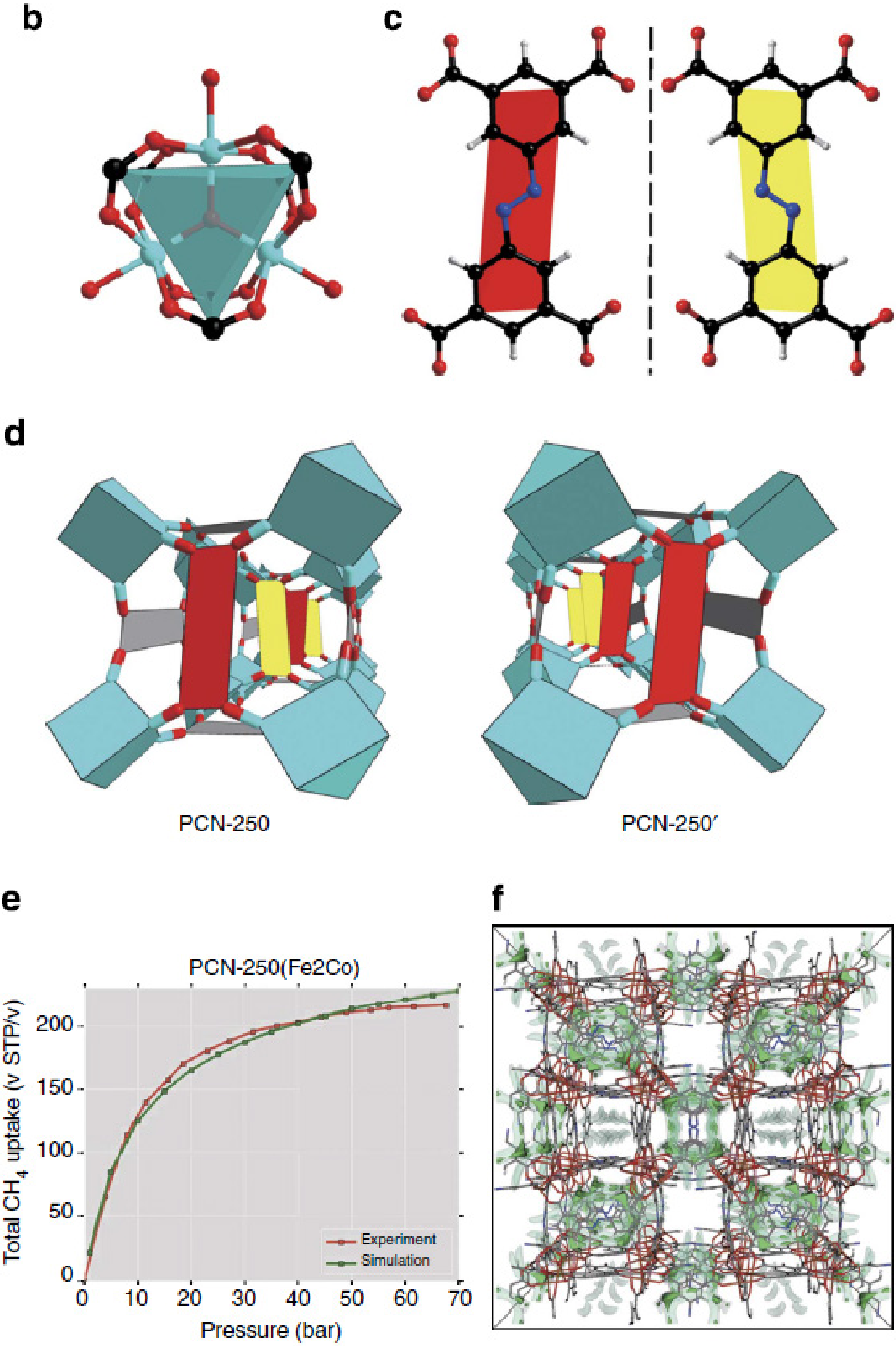
PCN-250 is made of 6-connected [$Fe_2M(\mu_3\text{-}O)$] SBUs and a rectangular tetratopic ligand (Fig. 2b–d), which is isostructural to a reported indium MOF[21]. It is interesting that PCN-250’, a MOF isomer of PCN-250, is formed in different solvothermal conditions. In PCN-250’, the ligand has the same configuration in the one cube and mirror configuration in the adjacent cubes along any axis. The isothermal data shows that PCN-250(Fe_2Co) has total methane uptake of 200 v/v at 35 bar and 298 K (Fig. 2e), which is one of the highest methane uptake among all the reported MOFs. PCN-250(Fe_2Co) also possesses a record high H_2 uptake of 3.07 wt% and 28 g L^{-1} at 1.2 bar and 77 K. In terms of hydrogen uptake, it also has one of the highest total volumetric H_2 uptakes, 60 g L^{-1}, at high pressure because of its high crystal density.

Both high uptake of methane and hydrogen results from the high valent open metal sites and suitable size of the pores in PCN-250 (Fig. 2f). As shown in Fig. 2b, the ligand covers the faces of every other cube in PCN-250 and highly charged open metal sites are around the channels between each cube. Thus, all of the inter space is available for gas adsorption. The interspace of PCN-250 has strong interaction with both H_2 and CH_4 molecules. Therefore, highly efficient space utilization for high volumetric gas uptake is achieved by inducing polarization of gas molecules via charge-induced dipole interaction. This high valence metal ion and induced dipole interaction is not limited within the first layer of gas molecules. Additional layers of gas molecules could be polarized, which would result in relatively insignificant adsorption enthalpy drop for multi-layer gas adsorption.

Extraordinary chemical stability of PCN-250

The PCN-250 series exhibits excellent chemical stability even after the replacement of the one iron atom to softer Lewis acid metal, M(II), in the μ_3-oxo cluster. PCN-250(Fe_2Co) is intact in a range of pH values from 1 to 11 for 24 h. This is shown in the PXRD results that the peaks remained sharp with the treatment of glacial acetic acid and pH=1 to pH=11 aqueous solutions for 24 h (Fig. 2g, h). Under neutral condition, PCN-250(Fe_2Co) remained robust in H_2O after 6 months (Fig. 2g, h). Additionally, with almost no change in N_2 adsorption isotherms of PCN-250(Fe_2Co) after all these pH treatments, we can conclude that no MOF decomposition or phase transition happened. The rare combination of high gas uptake and chemical robustness gives PCN-250 a reusability of the sorbent for real world applications. With its extraordinary stability, high gas uptake, and excellent scalability, PCN-250 is a promising material for natural gas storage for a variety of applications.




b
c
d
PCN-250
PCN-250′
e
PCN-250(Fe2Co)
Total CH4 uptake (v STP/v)
0
50
100
150
200
Pressure (bar)
0
10
20
30
40
50
60
70
Experiment
Simulation
f

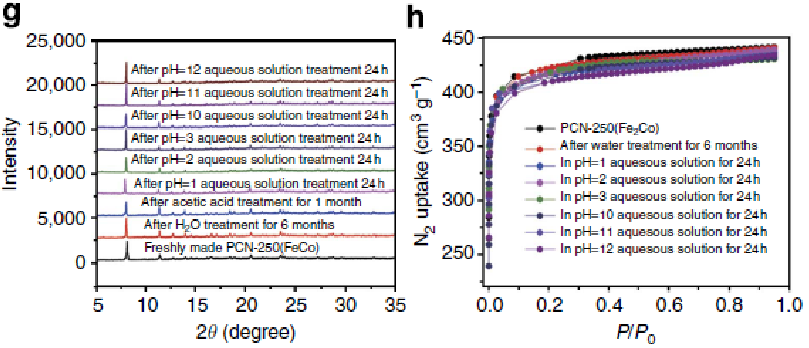


Figure 2: Simulated and experimental CH_4 adsorption of Fe-MOFs. (a) Performance plot of deliverable capacities using two different pressure swings. Shown are the predictions for the Fe-MOFs synthesized here (yellow) and in silico predicted structures (green). Red and blue points show PCN-250. (b–d) Structures of PCN-250 and PCN-250'. (e) Total CH_4 adsorption uptake of PCN-250 at 298 K and (f) contours of the computed potential energy surface of adsorbed CH_4 in PCN-250. (g) Powder X-ray patterns and (h) N_2 adsorption isotherms of PCN-250(Fe_2Co) after stability tests.

Conclusion

Highly stable metal–organic frameworks (MOFs) have been under investigation for a long period of time because of the interest in the material sustainability for real world applications. Nevertheless, synthesizing highly porous, chemically robust, and single crystalline MOFs has been extremely challenging. In this article, we report a novel robust porous Fe-MOF, PCN-250, prepared by kinetically tuned dimensional augmentation (KTDA) synthetic approach for the preparation of PCN-250. PCN-250(Fe_2Co) shows high volumetric uptake of H_2 and CH_4, and remains intact in water and aqueous solutions with a wide range of pH, which provides potential applications in gas storage for a variety of power systems and gas purification.

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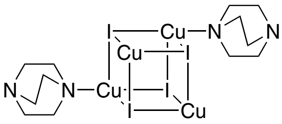
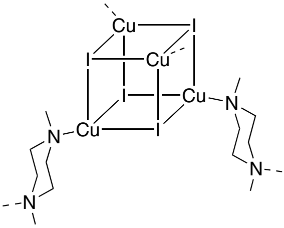
COPPER (Compounds)

29-3015
Bis(1,4-diazabicyclo [2.2.2] octane)tetra (copper(I) iodide) $(CuI)_4(DABCO)_2$ *(928170-42-7)*
$C_{12}H_{24}Cu_4I_4N_4$; FW: 986.15;
yellow pwdr.
air sensitive
Note: Ligand for MOF synthesis.



500mg
2g

29-0550
Bis(N,N'-dimethylpiperazine) tetra[copper(I) iodide], 98% MOF
(1401708-91-5)
$(CuI)_4(C_6H_{14}N_2)_2$; FW: 990.18;
white pwdr.
moisture sensitive, (store cold)



500mg
2g

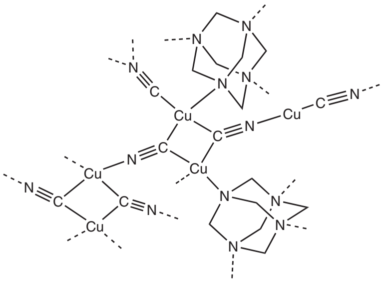
Technical Note:

1. The copper iodide, N,N'dimethylpiperazine complex is a 3D photoluminescent, fairly open network, with a lamda max excitation of 321 nm and a lamda max emission of 525nm.

References:

1. *Dalton Trans.,* **2012**, *41*, 11663

29-0565
(Hexamethylenetetramine)penta[copper(I) cyanide], 98% MOF
(1042093-98-0)
$C_6H_{12}N_4(CuCN)_5$;
FW: 588.00; white pwdr.
hygroscopic, (store cold)



500mg
2g

Technical Note:

1. The copper cyanide hexamethylenetetramine complex is a 3D photoluminescent, very densely-packed, network of tetradentate ligands with a lamda max excitation of 282 and 304 nm, and a lamda max emission of 417 and 522nm.

References:

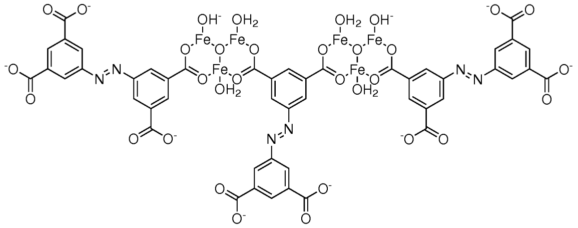
1. *Inorg. Chem.,* **2007**, *46*, 8897
2. *Inorg. Chem.,* **2008**, *47*, 6931
3. *Inorg. Chim. Acta.,* **2010**, *364*, 102
4. *Dalton Trans.,* **2012**, *41*, 11663

IRON (Compounds)

26-3725
NEW
Iron azobenzene tetracarboxylic, Porous [PCN-250(Fe)], CONEKTIC™ F250 *(1771755-22-6)*
$C_{48}H_{20}N_6O_{32}Fe_3$; Dark red-brown pwdr.
Note: Sold in collaboration with framergy for research purposes only.
PCT/GB2014/053506

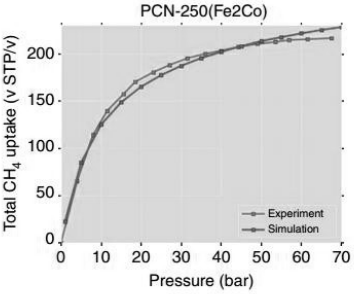
500mg
2g
10g

IRON (Compounds)



Technical Note:

1. Metal-Organic Framework (MOF) exhibiting superior uptake of hydrogen and methane. Stable in water and aqueous solutions.



Tech. Note (1)
Ref. (1)

References:

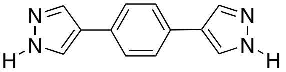
1. *Nat. Commun.,* **2014**, *5*, 5723
2. *Sci. Technol. Adv. Mater.,* **2015**, *16*, 054202

26-2340 **Iron(III) 1,3,5-benzenetricarboxylate hydrate, porous (F-free MIL-100(Fe), KRICT F100) [Iron trimesate]** *(1257379-83-1)*
$[Fe_3O(H_2O)_2(OH)\{C_6H_3(COO)_3\}_2]\cdot XH_2O$; red solid
Note: Sold under agreement with KRICT for research and development purposes only Patents US 8507399 B2, US 8252950 B2.

500mg
2g

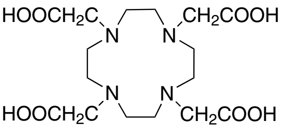
NITROGEN (Compounds)

07-0435 **1,4-Di(4'-pyrazolyl)benzene, min. 97% H_2BDP** *(1036248-62-0)*
$C_{12}H_{10}N_4$; FW: 210.24; pale yellow solid
Note: Ligand for MOF synthesis.



500mg
2g

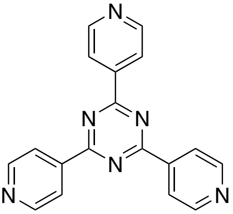
07-1942 **1,4,7,10-Tetraazacyclododecane-N,N',N",N'"-tetraacetic acid, min. 98% DOTA** *(60239-18-1)*
$C_{16}H_{28}N_4O_8$; FW: 404.42; white pwdr.
moisture sensitive, (store cold)
Note: Ligand for MOF synthesis.



250mg
1g
5g

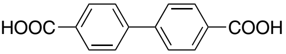
NITROGEN (Compounds)

07-3235 **2,4,6-(Tri-4-pyridinyl)-1,3,5-triazine, min. 97% TPT** *(42333-78-8)*
$C_{18}H_{12}N_6$; FW: 312.33; off-white pwdr.
Note: Ligand for MOF synthesis.
250mg
1g
5g

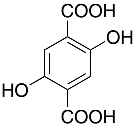


OXYGEN (Compounds)

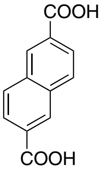
08-0175 **[1,1'-Biphenyl]-4,4'-dicarboxylic acid, min. 98%** *(787-70-2)*
$C_{14}H_{10}O_4$; FW: 242.23;
white to pale-yellow solid
Note: Ligand for MOF synthesis.
5g
25g



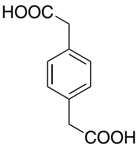
08-1220 **2,5-Dihydroxyterephthalic acid, 98% H_4DOBDC** *(610-92-4)*
$C_6H_2(OH)_2(COOH)_2$; FW: 198.13; white pwdr.
1g
5g
25g



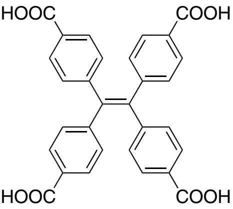
08-1235 **2,6-Naphthalenedicarboxylic acid, min. 98%**
(1141-38-4) $C_{10}H_6(COOH)_2$; FW: 216.19;
white pwdr.; m. p. >300°
Note: Ligand for MOF synthesis.
5g
25g



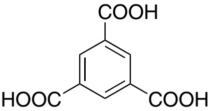
08-1165 **1,4-Phenylenediacetic acid, 97%** *(7325-46-4)*
$C_6H_4(CH_2COOH)_2$; FW: 194.18; white to off-white solid
Note: Ligand for MOF synthesis.
1g
5g



08-3060 **1,1,2,2-Tetra(4-carboxylphenyl) ethylene, 99% H_4TCPE** *(1351279-73-6)*
$C_{30}H_{20}O_8$; FW: 508.48; pale yellow pwdr.
Note: Ligand for MOF synthesis.
25mg
100mg

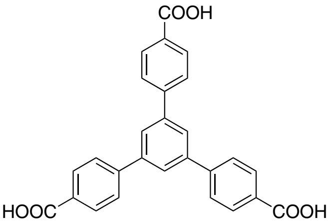


08-0195 **1,3,5-Tricarboxybenzene, min. 95% (Trimesic acid) BTC** *(554-95-0)*
$C_6H_3(COOH)_3$; FW: 210.14; white pwdr.
Note: Ligand for MOF synthesis.
50g
250g



OXYGEN (Compounds)

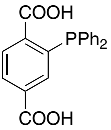
08-0635 **1,3,5-Tris(4-carboxyphenyl) benzene, min. 98% BTB**
(50446-44-1)
$C_{27}H_{18}O_6$; FW: 438.43;
white to yellow solid;
m. p. 322-327°
Note: Ligand for MOF synthesis.



1g
5g

PHOSPHOROUS (Compounds)

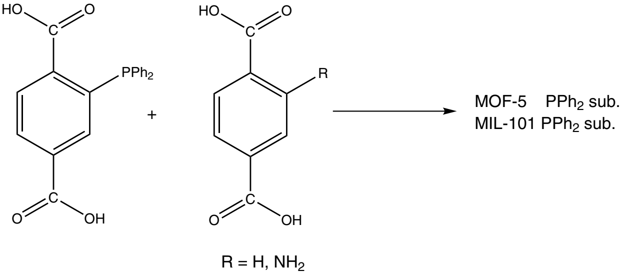
15-7170 **2-(Diphenylphosphino)terephthalic acid, 98%**
(1537175-69-1)
$C_{20}H_{18}O_4P$; FW: 350.30; white pwdr.
Note: Ligand for MOF synthesis. Developed at the Paul Scherrer Institute, Switzerland PCT/ EP2013/051405.



50mg
250mg

Technical Notes:

1. Starting material for the construction of diphenylphosphino-substituted MOFs.



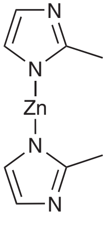
Tech. Note (1)
Ref. (1)

References:

1. *Ind. Eng. Chem. Res.,* **2014**, *53*, 9120.

ZINC (Compounds)

30-4015 **Zinc 2-methylimidazole MOF (ZIF-8)** *(59061-53-9)*
HAZ $C_8H_{10}N_4Zn$; FW: 227.58; white solid



1g
5g

Technical Notes:

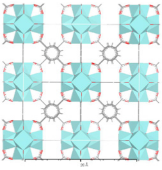
1. Use of ZIF-8 in the separation of alkanes, alkenes and aromatics
   a. Separation of xylene isomers
   Micropor. Mesopor. Mat., **2013**, *173*, 1.
   b. Separation of C6 Paraffins
   Ind. Eng. Chem. Res., **2012**, *51*, 4692.
   c. Effective separation of propylene/propane binary mixtures
   J. Membrane Sci., **2012**, *390-391*, 93.
2. Use of ZIF-8 as a catalyst and catalyst-suppo
   a. Catalytic activity of ZIF-8 in the synthesis of styrene carbonate
   Chem. Commun., **2013**, *32*, 36.
   b. Iridium nanoparticles stabilized by metal organic frameworks: synthesis, structural properties and catalytic performance
   Dalton Trans., **2012**, *41*, 12690.
   c. Zeolitic imidazole frameworks: Catalysts in the conversion of carbon dioxide to chloropropene carbonate
   ACS Catalysis, **2012**, *2*, 180.
   d. Expanding applications of metal-organic frameworks: zeolite imidazolate framework ZIF-8 as an efficient heterogeneous catalyst for the Knoevenagel reaction
   ACS Catalysis, **2011**, *1*, 120.

ZINC (Compounds)

3. Use of ZIF-8 in gas purification
    a. MOF-containing mixed-matrix membranes for CO_2/CH_4 and CO_2/N_2 binary gas mixture separations *Sep. Purif. Technol.*, **2011**, *81*, 31.
    b. Porous polyethersulfone-supported Zeolitic Imidazolate Framework Membranes for hydrogen separation *J. Phys.Chem. C.*, **2012**, *116*, 13264.

ZIRCONIUM (Compounds)

40-1105 **Zirconium 1,4-dicarboxybenzene MOF (UiO-66)** *(1072413-80-9)*
$C_{48}H_{24}O_{30}Zr_6$; white pwdr.; SA: > 1100m^2/g
Note: Sold under license from Inven2 AS for research purposes only. EP 09738396 and US 12/989,641.



500mg
2g

Technical Note:
1. Zirconium 1,4-dicarboxybenzene (UiO-66) is a versatile MOF that exhibits a number of favorable properties such as high surface area (ref. 1), high porosity and shear stability (ref. 2) and thermal stability (ref. 3).

References:
1. *J. Am. Chem. Soc.*, **2008**, *139*, 13850.
2. *J. Phys. Chem. Lett.,* **2013**, *4(6),* 925.
3. *Chemistry – An Asian Journal* **2011**, *6(12)*, 3270.

Heterogenized Molecular Iridium Complexes for Catalytic Water Oxidation and C-H Activation

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staff@catalytic-innovation.com; u.hintermair@bath.ac.uk

Introduction

Electrochemical oxidation reactions form the basis of many raw material streams in the chemical industry. Examples include the chlor-alkali process, non-ferrous metal purification, water electrolysis, electroplating, wastewater treatment, and many others.[1] These processes are generally performed in very harsh conditions as required for high throughput. In many cases, they incorporate highly acidic electrolytes, current densities on the order of amperes per square centimeter of anode geometric surface area, and high applied (over)potentials. These conditions pose fundamental challenges on the materials used in these processes in terms of stability and lifetime. Due to their privileged intrinsic electronic properties, iridium metal and iridium oxides have emerged as state-of-the-art catalytic and corrosion-resistant coating materials for anodes in these applications.[2] Widespread use of this rare and critical metal is due to its ability to withstand these harsh conditions without corroding, as well as low overpotential and high selectivity in a number of useful oxidation reactions, including water oxidation and chlorine production, on iridium-based anode surfaces.[3-6]

While heterogeneous catalysts consisting of thin films or nanoparticles of iridium oxide on conductive support materials are ubiquitous in the electrochemical industry, the study and application of molecular analogues of these materials is still developing.[7-12] In particular, the last decade has seen the emergence of iridium-based homogeneous complexes for water oxidation as a field of intense research due to its relevance to the generation of renewable fuels in artificial photosynthetic schemes.[13-15] Of these iridium-based compounds, organometallic complexes bearing carbonyl (CO), cyclooctadiene (cod), cyclopentadienyl (Cp), or pentamethylcyclopentadienyl (Cp*) ligands in particular have been investigated, mainly due to their synthetic accessibility.[16,17]

These organometallic complexes were initially believed to catalyze water oxidation directly due to high observed current densities in electrochemical oxidation experiments.[18] However, a number of studies later showed that loss of the organic ligand in Cp*Ir-based complexes occurred before the onset of oxygen evolution when driving water oxidation with chemical oxidants.[16,19-21] The high positive current flows observed in linear sweep or cyclic voltammograms, therefore, may be related to incipient oxidation of the Cp* ligand, with concomitant oxidative activation of the Cp*Ir-based precursor complex to form an activated species.[22] In most cases, these complexes fully degrade and polymerize into amorphous IrO_x-based materials as the true catalytic species.[23,24]

Yet, in the case that the precatalyst complex possesses a bidentate chelate ligand with high oxidative stability and electron donicity, degradation into IrO_x may be prevented and the oxidative transformation stopped at an intermediate molecular species.[19] In these cases, the chelate ligand allows oxidative removal of the sacrificial organic placeholder ligand and generation of Ir(IV) μ-oxo dimers reminiscent of IrO_x subunits, but remains bound to the Ir center to prevent polymerization and fine-tune the electronics of the active Ir site. The presence of IrO_x-type functionalities in these molecular systems give rise to similar spectroscopic features, such as an intense blue color, which initially made distinction of these molecular systems from IrO_x colloids difficult.[23] When precursor oxidation proceeds in the molecular regime by the correct choice of ligands and concentration, these activated iridium complexes are cationic and further stabilized by the anions in solution, both additive and generated from the oxidation of the organic ligand. In particular, when stabilized by iodate (IO_3^-), these complexes were found to spontaneously and irreversibly graft to the surface of metal oxide and carbon-based electrodes by the formation of a new chemical to the iridium center, forming a heterogenized molecular catalyst that retains the oxidation-resistant bidentate ligand.[25]

This family of heterogenized molecular catalysts is particularly promising for industrial application as they possess the tunability, activity, and atom-economic use of homogeneous catalysts, but may be used in processes requiring macroscopically heterogeneous oxide electrodes.[26] Rather than anchoring through an organic ligand with inherent oxidative susceptibility, these materials use a direct-binding motif with a metal-oxo bond from the iridium center to the scaffold. This imparts the stability of heterogeneous oxides on the anchored species, yet allows for tunability of the catalytic properties of the molecule by controlling the remaining ligands. In this scenario, the surface now acts as a ligand and influences the energetics of the surface species itself; therefore, the surface must be carefully matched with the catalyst to obtain high activity. However, for practical and industrial applications, the ease of preparation, economic use of the precious metal, and stability of the catalyst are of utmost importance.

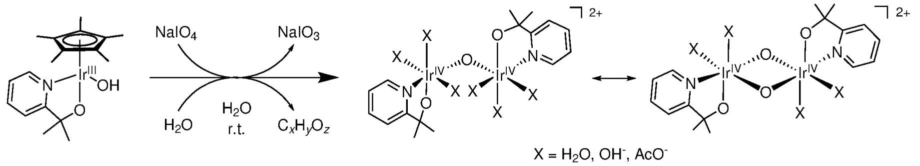
In the following we describe the properties and use of the surface-bound molecular catalyst in this family that possesses the highest activity and stability in applications where iridium or iridium oxide is typically employed. Specifically, we highlight applications as anode catalysts for water electrolysis and corrosion resistant coatings in metal purification and refining processes. We also briefly cover further applications that are improved by the molecular nature of this catalyst, namely the specialty chemicals, as well as for advanced oxidation processes in wastewater treatment.

Synthesis and Molecular Properties

When the organic placeholder ligand on an iridium-based molecular complex is removed by either electrochemical potential or chemical oxidant, a concentration-dependent mixture of molecular species is formed. While likely monomeric in early stages of the reaction, spectroscopic analyses have pointed to even-numbered oligomeric Ir(IV) compounds containing bridging oxo ligands, terminal aqua sites and one chelate ligand per metal as the resting state after full activation. These compounds are further stabilized by counter-anions in solution and exist as multiple isomers, but are molecular in nature as long as the bidentate chelate ligand is appropriately coordinating and oxidation-resistant and the iridium concentration low enough to prevent precipitation of amorphous particles. This dynamic feature has unfortunately prevented the isolation and crystallization of these species so far,[17,19] but extensive homogeneity tests, including time-resolved dynamic light scattering (DLS), electrochemical quartz crystal nanobalance (ECQN), electron microscopy, and kinetic analyses have confirmed the absence of heterogeneous particles under appropriate conditions.[27]

Over the course of multiple studies we found a ligand with high resistance to oxidation that promotes metal-centered oxidation and stabilization of the Ir(IV) oxidation state: a tertiary pyridyl alcohol, 2-(pyridine-2-yl)propan-2-ol (pyalc). The tertiary alkoxide is a strong electron donor which allows the stabilization of high valent states, while the benzylic carbon is protected by two methyl groups to prevent oxidative degradation.[28] Complexes synthesized with this ligand were found to have the greatest stability and activity when bound to metal oxide surfaces, therefore, our work incorporates this ligand on our iridium-based catalysts in most cases.

The formation of the activated iridium species from these precatalysts is depicted below in Scheme 1, for the case of a Cp*Ir(pyalc)OH precatalyst oxidized by an excess of $NaIO_4$ in aqueous solution. As mentioned above, the resulting cationic species is stabilized by acetate and iodate counter-anions in solution.



Scheme 1. Oxidation of a Cp*Ir(pyalc)OH precatalyst to form Ir(IV) dimers in solution. CxHyOz represents the mixture of organic species, predominantly acetate, that result from the oxidative degradation of the Cp*. These organic species exchange with water coordinated to the Ir(IV) centers.

While the exact mechanism of amorphous particle formation and how it relates to the ligands present has yet to be determined, the high sensitivity of this system to solution concentration of both iridium and organic anions requires consistency in experimental protocols. Table 1, below, shows the approximate critical concentration of iridium with precatalysts bearing ligands with varied oxidative susceptibility.[29] The critical concentration is defined as the concentration at which amorphous iridium-containing particles are formed by oxidative degradation of the molecular species present in solution. Their formation is consistent with the precipitation of an iridium-containing coordination polymer, and further experimental work is currently underway to analyze these solids.

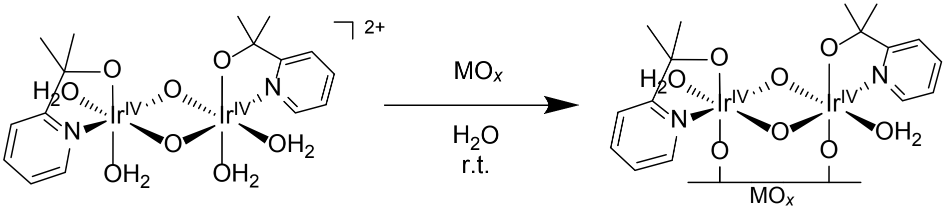
Precursor Compound	Oxidant	Approximate Iridium Critical Concentration
Cp*Ir(pyalc)OH	400 mM NaIO4	18 mM
[Cp*Ir(bisimidazole)OH]BF_4	400 mM NaIO4	16 mM
[Cp*Ir(2,2′-bipyridyl)OH]BF_4	300 mM NaIO4	13 mM
Cp*Ir(phenylpyridine)OH	200 mM NaIO4	9 mM
[Cp*Ir($H_2O)_3$]SO_4	100 mM NaIO4	0.7 mM

Table 1. Approximate critical concentrations at which heterogeneous amorphous particles are formed in aqueous solution for Cp*Ir-based precatalysts containing ligands of varied oxidative susceptibility.

Particle formation is important to consider in practical applications of these materials, since solutions prepared at concentrations above or near their critical concentration exhibit diminished surface-binding activity due to the decrease of available molecular complexes as iridium atoms are progressively sequestered into the precipitating solids.[30]

Surface-binding onto conductive electrode surfaces

Surface-binding of the activated iridium species likely occurs by a water-elimination mechanism as a blue shift of 20-30 nm is observed in the UV-vis upon binding, similar to the 15 nm shift observed when the bound aqua ligands are deprotonated to hydroxyls in solution. Although no iodine-containing species are left on the surface of the electrode after binding and washing with water, when no iodate is present surface binding activity is markedly decreased. If pH and iodate concentration are both adjusted correctly (in addition to suitable activation conditions that prevent particle formation), rapid and irreversible surface-binding occurs on a variety of oxidic surfaces at room temperature for which no applied potential, light, or heat-driven process is required.



Scheme 2. Binding mode and proposed surface structure for [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer species at 1 mM solution concentration in 0.1 M aqueous $NaIO_3$. MO_x represents a hydrated metal oxide surface.

In addition to the practical ease of surface-functionalization, this method has the advantage of affording a molecular monolayer on the electrode surface as binding of the activated dimer is self-limiting. This leaves the surface decorated with a uniform, minimally thin film of a highly active catalyst material sitting right at the interface of current collector and electrolyte. This promises highly effective use in electrocatalytic applications as well as corrosion protection.

Confirmation that the [2-(pyridine-2-yl)-2-propanato]iridium dimer binds to scaffold material as a monolayer comes from electrochemical, spectroscopic, and electron microscopic measurements. Furthermore, thermal removal of the organic ligand and destruction of the conformal surface coating can be followed by electron microscopy and electrochemistry (Figure 1). When heated to 500°C in an air atmosphere, the ligand is burned off and an amorphous iridium oxide layer is formed. While less active for water oxidation than the molecular species, as evident from the cyclic voltammograms, this is still a low-cost and effective way to deposit ultra-thin iridium oxide layers. Further heating to 700 °C induces clustering and crystallization rutile IrO_2 particles with much lower electrocatalytic activity.

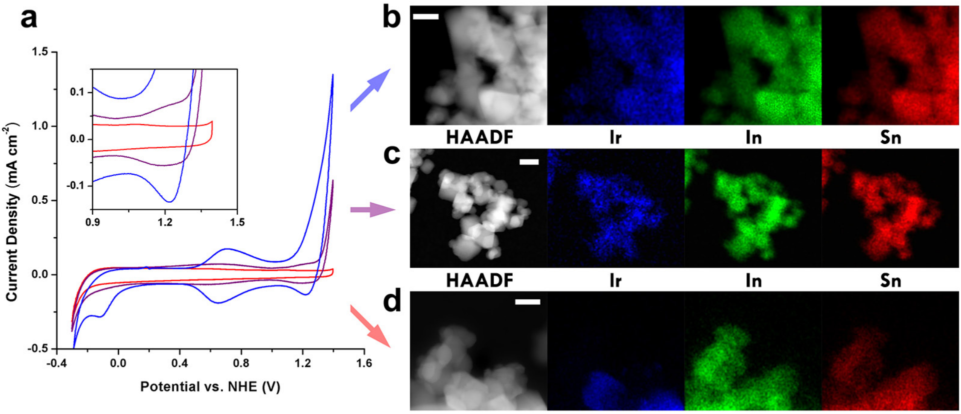


Figure 1. Comparison of iridium-based catalysts on mesoporous ITO films. a) CVs taken at 10 mV/s scan rate at pH 2.6 of a catalyst-coated ITO electrode corresponding to elemental maps taken in a transmission electron microscope on the right. b) An as-deposited monolayer of the [2-(pyridine-2-yl)-2-propanato]iridium dimer. c) The monolayer heated to 500°C, showing that the coating of iridium remains conformal. d) Heated to 700°C, showing aggregation of the surface species and nanoparticle formation. Scale bars are all 20 nm. Figure reproduced from reference 25, where it is presented in color.

Water Oxidation and Corrosion Resistance

As the electrochemistry of the activated complex in solution suggested, when bound to the surface of conductive electrode materials the [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer is a highly active and reversible electrocatalyst for water oxidation, also known as the oxygen evolution reaction (OER) in the forward direction, and oxygen reduction reaction (ORR) in the reverse, shown below.

$$2H_2O \rightleftharpoons O_2 + 4H^+ + 4e^- \qquad E^0 = 1.23\text{ V vs. RHE} \quad (1)$$

With our much overdue move towards low-carbon power from tidal, wind and solar sources, means of concentrating and storing these intermittent electricity supplies will become crucial for tomorrow's economy. Water electrolysis is the most benign, practical and feasible method of doing this by generating clean H_2 as sustainable chemical energy carrier for a variety of applications, including fuel production and chemical synthesis.[31] While the overpotential for the cathodic proton reduction reaction generating hydrogen is generally low on the surface of an appropriate catalyst material, such as platinum, the energetic bottleneck of water electrolysis is the relatively high overpotential for water oxidation on the anode surface due to it being a four electron process that is kinetically challenging.

Current state-of-the-art materials for water electrolysis are termed "dimensionally stable anodes" (DSAs) based on iridium oxide using titanium supports, which despite showing high activity and stability have the aforementioned drawback of scarcity and high cost. To retain the high activity of iridium oxide as the key component, yet use far less iridium, we can employ the surface-bound [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer also known as the "het-WOC". A monolayer of this iridium dimer species possesses Faradaic efficiency and OER overpotential comparable to iridium oxide, with an electroactivity much higher (Figure 2). Full utilization of the highly active and scarce metal is, thus, possible with this material and allows for higher activity than iridium oxide, especially when considered on a per-iridium atom basis.[32]

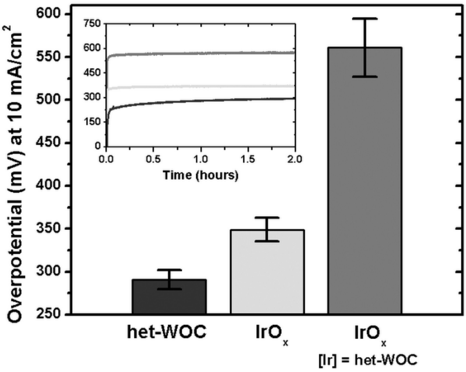


Figure 2. Comparison of the OER overpotential between the [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer "het-WOC" on a mesoporous conductive oxide scaffold (left bar) with iridium oxide possessing the same amount of iridium as the monolayer (right bar). Even when compared to IrO_x under optimized conditions containing orders of magnitude more iridium than the monolayer (middle bar), the het-WOC species possesses comparable overpotential. Inset shows raw chronopotentiometry data for each sample time at a 10 mA/cm^2 current density. Figure reproduced from reference 25.

While this catalytic monolayer is very attractive for application in high performance PEM electrolyzers,[33] it has also been shown to act as an effective water oxidation catalyst and corrosion-resistant layer in photoelectrochemical cells for research towards integrated devices for artificial photosynthesis.[34] As mentioned above, the only OER catalysts that are stable in acidic systems are iridium-based, which includes the [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer. Acidic systems are, furthermore, important to water electrolysis due to the high effectiveness and stability of polymeric proton exchange membranes in acids. In solar-driven water electrolysis schemes, hematite is an attractive photoanode candidate material for tandem cells due to its abundance, suitable 2.0 - 2.2 eV band gap and good visible light absorption characteristics.[35] One major drawback of hematite is its instability in acids; hematite is readily etched below pH 4 and could thus so far only be used in alkaline cells where proton reduction is sluggish and membrane stability low.

In a recent study, the [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer monolayer was successfully applied to a hematite photoanode and compared to iridium oxide, as shown in the transmission electron microscope (TEM) images below.

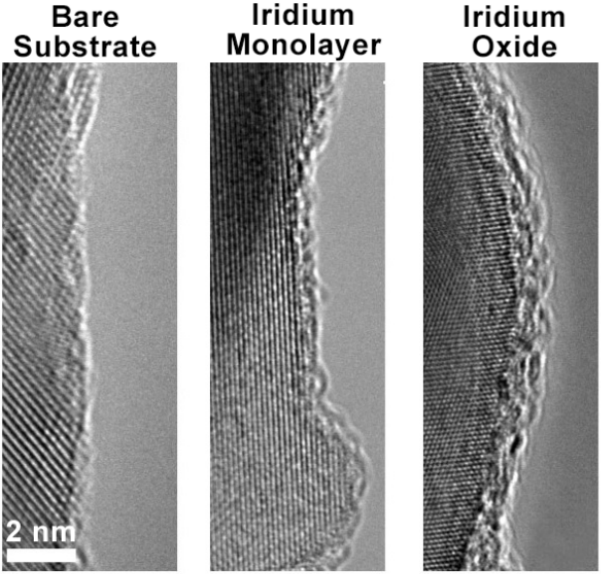


Figure 3. TEM images of a bare iron oxide scaffold (left) next to the same material coated with the [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer (middle). We can see in comparison to an ultrathin layer of iridium oxide (right) that the bulk material is thicker and more dense than a monolayer affords. Figure reproduced from reference 34.

It was found that the het-WOC monolayer not only acted as an effective barrier layer, preventing the underlying hematite from being etched, but also shifted the onset potential of hematite for water oxidation cathodically by 250 mV when under light illumination. 100% Faradaic yield for oxygen evolution was measured, with little decrease in activity for over 80 minutes. X-ray photoelectron spectroscopy (XPS) was used to monitor the binding of the iridium dimer species (Figure 4). While the monolayer was eventually removed by progressive etching of the underlying hematite, plausibly through acid attack at pin-hole sites, the [2-(pyridine-2-yl)-2-propanato]iridium dimer still enabled the use of iron oxide at pH 1 four times over the scale of hours. Importantly, the self-binding monolayer formation is applicable to nanostructured surfaces and does not interfere with light absorption itself, providing great promise for future use in improved photoelectrochemical cells.

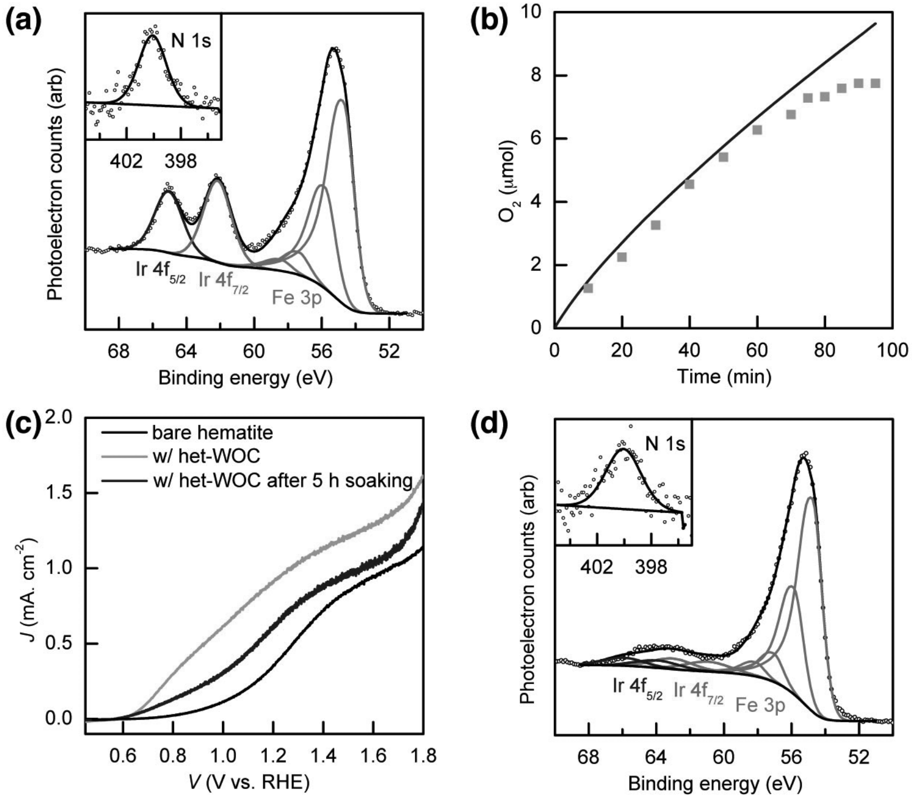


Figure 4. Surface studies of the het-WOC decorated hematite photoelectrode. a) XPS analysis confirming the attachment of Ir and the bidentate pyalc ligand. b) Dotted lines: oxygen detected from a het-WOC decorated hematite photoelectrode in pH 1.01, 0.1 M KNO3 electrolyte under 100 mW/cm^2, AM 1.5 illumination, with an applied potential of 1.23 V vs RHE. Solid line: theoretical O_2 evolved for 100% Faradaic efficiency based on charge passed through the electrode. c) Linear sweep voltammetry for photoelectrodes under the same lighting and electrolyte conditions as in (b). d) XPS spectrum after a 10 hour stability test, showing loss of Ir due to etching of underlying hematite. Figure reproduced from reference 34.

While water electrolysis for hydrogen generation is the most well-known industrial application of oxygen evolution catalysts, it is far from the most widespread. Electrorefining, or the electrochemical purification of metals by reducing them at a cathode with an anode reaction to provide the necessary charge balance, outputs tons of oxygen into the atmosphere and is used in a variety of sectors around the globe.[36] The materials used for anodes in some of these processes, such as zinc electrowinning, are frequently made of lead due to the high current densities achievable on a lead surface and its resistance to corrosion by strong acids.[37]

Additives are used in solution that, among other properties, prevent corrosion of the lead anode.[38] In many cases, it is speculated that these additives act as a water oxidation catalyst on the lead surface thus preventing the dissolution of high-valent lead ions. The [2-(pyridine-2-yl)-2-propanato]iridium(IV) dimer acts similarly on the surface of lead anodes, and is used commercially in this application. In general, the iridium dimer's high activity for oxygen evolution prevents the formation of high-valent metal species in any underlying scaffold material, therefore inhibiting redox-based corrosion. This effect is pronounced when used with a high surface-area scaffold to increase the amount of iridium accessible to the electrolyte solution. Toward that end, we have developed antimony-doped tin oxide scaffolds at 20 nm, 50 nm, and 100 nm particle sizes for use in electrochemical applications. These materials can be used without any post-processing in catalytic inks for membrane electrode assemblies. They also readily sinter together at 500 °C to form a highly conductive and acid-stable scaffold for electrolyzers, PEM fuel cells, electrowinning in acidic conditions, and wastewater treatment.

Selective C-H Oxidation

While the greatest value that this material brings for water oxidation and corrosion resistance is a reduction in the utilization of iridium, its capacity to selectively oxidize C-H bonds as a heterogeneous electrocatalyst is equally interesting. Current industrial applications developed include oxidation of organic contaminants in aqueous wastewater, such as lactic acid, to CO_2 for the removal of the aqueous contaminant and re-use of the CO_2.[39] Beyond this use, this molecular material further enables the selective oxidation of organic compounds for the electrosynthesis of specialty chemicals. An example, shown below, depicts the selective electro-oxidation of ethylbenzene-sulfonate (EBS) to the corresponding sulfonated acetophenone (APS) in aqueous solution using a conductive oxide anode decorated with the iridium dimer catalyst.

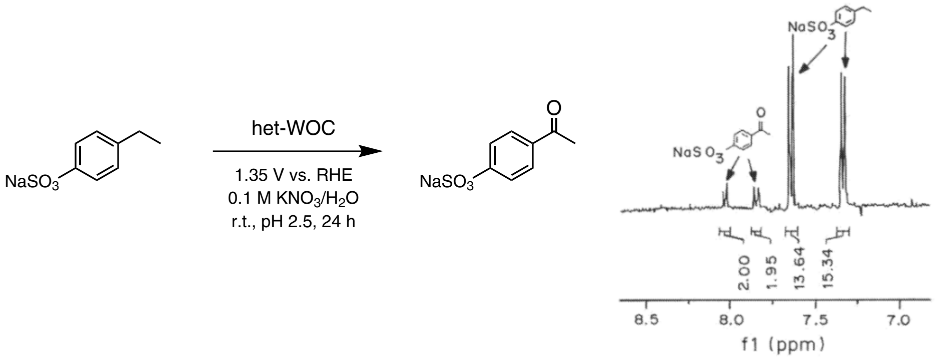


Figure 5. Left: reaction scheme for the electrochemical oxidation of EBS to APS by the surface-bound iridium dimer on a mesoporous ITO anode. Right: ^{1}H NMR spectrum after the reaction showing successful synthesis of the product. A TOF of approximately 32 s^{-1} for conversion to APS was measured. Figure reproduced from reference 40.

Further transformations, such as the oxidation of butanol to butyric acid, and tetrahydrofuran to butyrolactone, have also been successfully demonstrated at the proof-of-concept level. Previously, the longevity of the catalyst was limited by the stability of the mesoporous ITO scaffold.[41] With the antimony-doped tin oxide catalyst scaffolds developed at Catalytic Innovations that possess higher conductivity and stability, selective C-H oxidation in electrochemical cells is now enabled in continuous-flow processes at turnover numbers exceeding 10^8 in practical synthetic applications.

Conclusions

Industrial use of these surface-bound iridium complexes demonstrates that molecular catalysts may possess the stability required for long-term, practical applications under appropriate conditions. Their stability is dependent on the substrate that they are adhered to as well as the ligands present on the heterogenized species. Of these, 2-(pyridine-2-yl)propan-2-ol has emerged as a highly versatile, oxidation-resistant chelate ligand applicable to this and other catalytic systems that require the stabilization of highly oxidized metal centers. The iridium-based het-WOC briefly described here offers possibilities for increasing the economy of existing industrial processes by reducing the amount of iridium required, opening up new applications for corrosion-sensitive materials by increasing their lifetime, and new processes due to the improved selectivity of these molecular species for C-H bonds.

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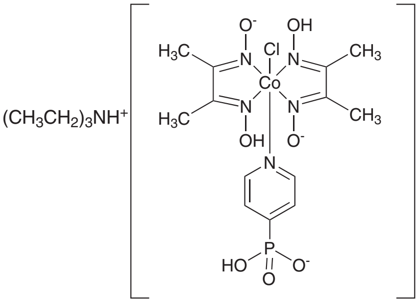
COBALT (Compounds)

27-3015 NEW

Triethylammonium {chlorobis(dimethylglyoximato)(4-hydrogenphosphonatepyridinyl) cobaltate(III)} *(1280199-86-1)*
$C_{19}H_{35}ClCoN_6O_7P$; FW: 584.88; light-brown solid

5mg
25mg



Technical Notes:
1. Synthetic cobaloxime catalyst for reduction of aqueous protons to hydrogen in the presence of atmospheric oxygen.
2. Catalyst containing phosphonate anchor groups for immobilization on metal oxide semiconductor surfaces, enabling light-driven hydrogen evolution.

References:
1. *Angew. Chem. Int. Ed.,* **2012**, *51*, 9381
2. *Angew. Chem. Int. Ed.,* **2012**, *51*, 12749
3. *Chem. Commun.,* **2011**, *47*, 1695
4. *Chem. Sci.,* **2015**, *6*, 2727

27-0477 NEW

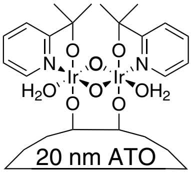
Cobalt-dppe heterogeneous water oxidation catalyst (~17% Co)
$Co_4(dppe)_2(CO)(OH)_9(H_2O)_9$; FW: $C_{26}H_{24}CoP_2$; light-brown pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150065339 A1.

100mg
500mg

IRIDIUM (Compounds)

77-0030 NEW

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 20 nm (conductive and acid-stable)blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.

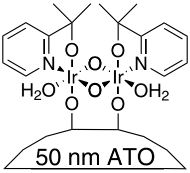


250mg
1g

Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 50-60 m^2/g
Resistivity: 0.3 – 0.7 Ω•cm

77-0035 NEW

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 50 nm (conductive and acid-stable)blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.



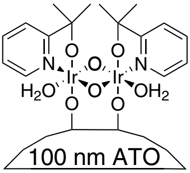
250mg
1g

Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 40-50 m^2/g
Resistivity: 0.05 – 0.08 Ω•cm

IRIDIUM (Compounds)

77-0040
NEW

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 100 nm (conductive and acid-stable)blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.

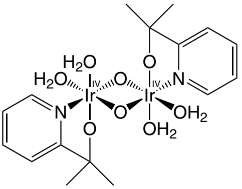


250mg
1g

Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 5-10 m^2/g
Resistivity: 0.05 – 0.08 Ω•cm

77-0025
NEW

[2-(Pyridine-2-yl)-2-propanato] iridium(IV) dimer solution 97% (1 mM in 0.1 Molar aqueous $NaIO_3$)
(1446713-81-0)
$C_{16}H_{28}IrNO_3$; FW: 728.84; blue liq.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.



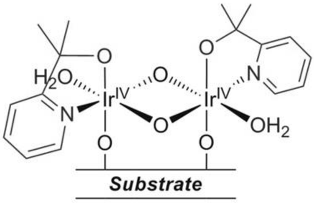
10ml
50ml

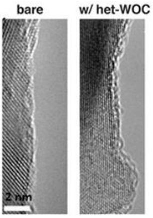
Technical Notes:
Standard Operating Procedure

Heterogenization of the material is straightforward and can be performed in air, at ambient temperature, with no additives, applied potential or other treatment required. For most carbon-based or metal oxide substrates:

1. Dip substrate in het-WOC deposition solution (or disperse powders, if powder).
2. Wait 4-12 hours (typically overnight).
3. Remove substrate from solution (or filter out powder) and rinse with clean water.

This will cause the monolayer Ir material to be deposited on the substrate, with a surface structure as shown[1] (TEM image on iron oxide shown to the right):



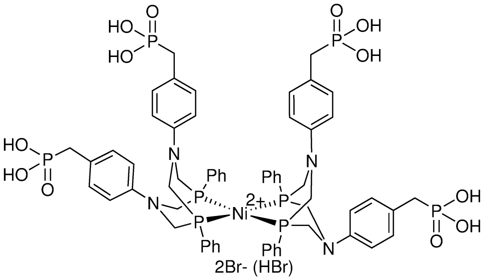


The het-WOC deposition solution may be diluted, in order to increase its coverage over large substrates. As stated in the SDS, the het-WOC deposition solution it is mostly comprised of water, therefore dilution with water is best. It can also be re-used repeatedly to load multiple substrates with the Ir monolayer – each loading only uses a small amount of the Ir present in solution, depending on surface area of substrate.

References:
1. *J. Am. Chem. Soc.*, **2013**, *135*, 10837.
2. *J. Am. Chem. Soc.*, **2014**, *136*, 13826.
3. *Nat. Commun.*, **2015**, *6*, 6469.
4. *Angew. Chem. Int. Ed.*, **2015**, *54*, 11428.
5. *Energy Environ. Sci.*, **2016**, *9*, 1794.

NICKEL (Compounds)

28-1720 NEW	**Bis{P,P'-1,5-diphenyl-3,7-bis[(4-hydrogenphosphonate) phenyl]-1,5,3,7-diazadiphosphocine} nickel(II) bromide (hydrogen bromide adduct)** *(1514896-39-9)* $C_{60}H_{69}Br_3N_4NiO_{12}P_8$; FW: 1584.41; red-brown xtls. *air sensitive, moisture sensitive*	5mg 25mg



Technical Notes:

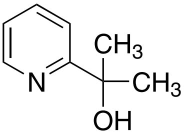
1. Synthetic nickel catalyst used for photocatalytic reduction of aqueous protons to hydrogen.
2. Catalyst containing phosphonate anchor groups for immobilation on metal oxide semiconductor surfaces, enabling light-driven hydrogen evolution.

References:

1. *Angew. Chem. Int. Ed.,* **2014**, *53*, 11538
2. *J. Amer. Chem. Soc.,* **2014**, *136*, 356

NITROGEN (Compounds)

07-3333 NEW	**2-(Pyridine-2-yl)propan-2-ol, min. 95%** **pyalc** *(37988-38-8)* $(C_5H_4N)C(CH_3)_2(OH)$; FW: 137.18; white xtl.	100mg 500mg 2g



ALUMINUM (Compounds)

13-1315 NEW	**Aluminum oxide, 1000nm powder, surface area 6 m^2/g, 99% (Grade APS 1 micron)** *(1344-28-1)* Al_2O_3; FW: 101.96; white solid	250g 1kg

AMMONIUM (Compounds)

26-3765 NEW	**Tetramethylammonium ferricyanide, 98%** *(14591-44-7)* *See* page 41	

BARIUM (Compounds)

56-8450 NEW amp HAZ	**Bis(pentamethylcyclopentadienyl)barium, 98%** *(112379-49-4)* $C_{20}H_{30}Ba$; FW: 407.78; white solid *air sensitive, moisture sensitive*	500mg 2g

Technical Note:

1. Barium precursor for Atomic Layer Deposition and Chemical Vapor Deposition (ALD/CVD)

References:

1. *J. Phys. Chem. A,* **2007**, *111*, 8147

BIOCATALYSTS (Compounds)

06-3110 NEW	**Alcalase® 2.4 L FG** *(9014-01-1)* brown liq.; d. 1.17 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 2.4 AU-A/g. Serine endoprotease that hydrolyzes internal peptide bonds. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3112 NEW	**Alcalase® 2.5 L** *(9014-01-1)* amber liq. (semitransparent); d. 1.08 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 2.5 AU-A/g. Serine endoprotease that hydrolyzes internal peptide bonds. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3115 NEW	**Esperase® 8.0 L** *(9014-01-1)* amber liq. (semitransparent); d. 1.07 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 8KNPU-E/g. Serine endoprotease that hydrolyzes internal peptide bonds. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3105 NEW	**Lipozyme® CALB L** *(9001-62-1)* yellow to light-brown liq.; d. 1.2 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 5000 LU/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g

BIOCATALYSTS (Compounds)

06-3155 NEW	**Lipozym® TL IM** *(9001-62-1)* off-white immobilized granulate; d. 0.4 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 250 IUN/g. Lipase that hydrolyzes ester bonds in glycerides. It is a 1,3 specific lipase which is immobilized on a non-compressible silica gel carrier into an immobilized granulate. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3140 NEW	**Lipozyme® TL 100 L** *(9001-62-1)* yellow liq.; d. 1.05 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 100 KLU/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3160 NEW	**Neutrase® 0.8 L** *(9080-56-2)* brown liq.; d. 1.26 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 0.8 AU/g. Kinetic resolution of amino esters is a neutral, zinc metallo endoprotease, that randomly hydrolyzes internal peptide bonds and also facilitates enzymatic synthesis of oligopeptides by the reverse proteolysis reaction with zinc metal as co-catalyst. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3100 NEW	**NovoCor® AD L** *(9001-62-1)* brown liq.; d. 1.17 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 6000 LU/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3123 NEW	**Novozyme® 435** *(9001-62-1)* off-white immobilized granulate; d. 0.4 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 10000 PLU/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	5g 25g
06-3120 NEW	**Novozym® 40086** *(9001-62-1)* brown immobilized granulate; d. 0.33 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 275 IUN/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	5g 25g

BIOCATALYSTS (Compounds)

06-3135 NEW	**Novozym® 51032** *(9001-62-1)* yellow to light-brown liq.; d. 1.04 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 15 KLU/g. Lipase that hydrolyzes ester bonds in glycerides. Product may be hazy and contain slight precipitate. This does not affect enzyme activity or performance. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3118 NEW	**Palatase® 20000 L** *(9001-62-1)* brown liq.; d. 1.19 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 20000 LU-MM/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	5g 25g 100g
06-3125 NEW	**Resinase® HT** *(9001-62-1)* yellow liq.; d. 1.05 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 50 KLU/g. Lipase that hydrolyzes ester bonds in glycerides. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3137 NEW	**Savinase® 12 T** *(9014-01-1)* off-white granulate; d. 1.3 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 12 KNPU-S/g. Serine endoprotease that hydrolyzes internal peptide bonds. The granulate contains enzyme concentrate, inorganic salt, binder and coating materials. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g
06-3150 NEW	**Savinase® 16 L** *(9014-01-1)* amber liq. (semitransparent); d. 1.16 *(store cold)* Note: Store at 0-10°C. DO NOT FREEZE. Declared activity 16 KNPU-S/g. A serine endoprotease that hydrolyzes internal peptide bonds. Color can vary from batch to batch. Color intensity is not an indication of enzyme activity. Packaging must be kept intact, dry and away from sunlight. Please follow the recommendations and use the product before the best before date to avoid the need for a higher dosage. Sold in collaboration with Novozymes A/S.	10g 50g 250g

BORON (Compounds)

05-0120 NEW	**Boron carbide, 0.1-1.5 microns (99.9+%-B)** *(12069-32-8)* B_4C; FW: 55.26; gray to black pwdr.; SA: 22-27 m^2/g; m. p. 2350°; b.p. >3500°; d. 2.52 Note: For sale in USA. For other countries contact Strem.	100g 500g

Technical Notes:

Chemical Characteristics:

B:C - 3.7-3.9 (ratio); C - min. 21.8%; N - max. 0.7%; O - max. 2.6%; Fe - max. 0.1%; Si - max. 0.15%; Al - max. 0.05%; M - max. 0.1%

BORON (Compounds)

05-0125
NEW
Boron nitride, hexagonal crystalline solid, min. 99% *(10043-11-5)*
BN; FW: 24.82; off-white pwdr.
50g
250g

CALCIUM (Compounds)

20-8450
NEW
HAZ
Bis(pentamethylcyclopentadienyl)calcium(II) tetrahydrofuran adduct, 98% *(101200-05-9)*
$[(CH_3)_5C_5]_2Ca(C_4H_8O)_2$; FW: 454.74; pale yellow pwdr.
air sensitive
500mg
2g

CARBON (Elemental Forms)

06-0310
NEW
Graphene film, monolayer, on Si/SiO_2 wafer (1cm x1cm), by CVD *(1034343-98-0)*
C; FW: 12.011; wafer
1pc

06-0222
NEW
Graphene nanoplatelets, (2-10nm thick x ~5 microns wide) *(1034343-98-0)*
C; black solid
5g
25g

06-0323
NEW
Graphene oxide (0.8-1.2nm thick x 1-15 microns wide, made by the Staudenmaier Method)
C; black pwdr.
250mg
1g

06-2545
NEW
Graphene oxide (4mg/ml water dispersion) *(1034343-98-0)*
yellow-brown liq. dispersion
50ml
250ml

Technical Notes:
Physical Properties:
Form: Dispersion of graphene oxide sheets; *Sheet dimension*: Variable; *Color*: Yellow-brown; *Dispersibility*: Polar solvents; *Solvent*: Water; *pH/: 2.2-2.5; Concentration*: 4 mg/mL; *Monolayer content (measured in 0.5 mg/mL)*: >95%*
*Note: 4 mg/mL tends to agglomerate the GO flakes and dilution followed by slight sonication is required in order to obtain a higher percentage of monolayer flakes
Elemental Analysis: (sample preparation: 2g of 4 wt% GO in water were dried under vacuum at 60°C overnight)
Carbon: 49-56%; *Hydrogen*: 0-1%; *Nitrogen: 0-1%; Oxygen*: 41-50%; *Sulfur*: 0-2%
Quality Control:
Amount of residue on evaporation
pH control
Elemental analysis
Applications: Graphene/polymer composite materials, batteries, biomedical, solar cells, supercapacitors, support for metallic catalysts, low permeability materials, biosensors, multifunctional materials, graphene research
References:
1. *J. Mater. Chem.*, **2011**, *21*, 9762.
2. *Environ. Sci. Technol.*, **2013**, *47*, 3715.
3. *Phys. Chem. Chem. Phys.*, **2013**, *15*, 2321.

06-2550
NEW
Graphene oxide, reduced *(1034343-98-0)* black pwdr.
250mg
1g

Technical Notes:
Physical Properties:
Form: powder; *Reduction method*: chemically reduced; *Sheet dimension*: variable; *Color*: black; *Solubility*: insoluble; *Dispersability*: <0.1 mg/mL in NMP, DMF, DMSO; *Humidity (Karl Fisher, TGA)*: 3.7-4.2%; *Electrical conductivity*: 666,7 S/m (measured in a 20 nm film thickness); *BET surface area*: 422.69 - 499.85 m^2/g; *Density*: 1.91 g/cm^3
Elemental Analysis: (sample preparation: 2g of 4 wt% GO in water were dried under vacuum at 60°C overnight)
Carbon: 77-87%; *Hydrogen*: 0-1%; *Nitrogen*: 0-1%; *Oxygen*: 13-22%; *Sulfur*: 0%
Quality Control: Elemental analysis
Applications: Batteries, biomedical, solar cells, supercapacitors, printable graphene electronics, graphene research
References:
1. *Nano Letters*, **2010**, *10*, 92.
2. *J. Phys. Chem. Lett.*, **2013**, *4*, 1347.

CARBON (Elemental Forms)

06-0313 NEW
Graphene powder (single layer, surface area 400-1000 m²/g) *(1034343-98-0)* 50mg
C; FW: 12.011; black pwdr.

06-0318 NEW
Graphene powder (1-5 layers thick x 0.5-5 microns wide, surface area 650-750 m²/g) *(1034343-98-0)* 250mg, 1g
C; FW: 12.011; black pwdr.

06-2510 NEW
Monolayer Graphene on Cu (10 mm x 10 mm) *(1034343-98-0)* 4pc
C; wafer

Technical Notes:
Physical Properties:
Growth Method: Chemical Vapor Deposition (CVD synthesis); *Appearance*: Transparent; *Transparency*: >97%; *Coverage*: 98%; *Layers*: 1; *Thickness (theoretical)*: 0.345 nm; *FET Electron Mobility on Al_2O_3*: 2000 cm²/Vs; *FET Electron Mobility on SiO_2*: 4000 cm²/Vs; *Sheet Resistance on SiO_2/Si*: 410-490 Ω/sq (1 cm x 1 cm); *Grain size*: Up to 10 µm
Substrate Cu foil:
Thickness: 18 µm
Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally
Applications: Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings
Quality Control: Raman Spectroscopy and Optical Microscopy
References:
1. *J. Electrochem. Soc.*, **2012**, *159*, A752.
2. *J. Mater. Chem. A.*, **2013**, *1*, 3177.

06-2518 NEW
Monolayer Graphene on Cu (60 mm x 40 mm) *(1034343-98-0)* 1pc
C; wafer

Technical Notes:
Physical Properties:
Growth Method: Chemical Vapor Deposition (CVD synthesis); *Appearance*: Transparent; *Transparency*: >97%; *Coverage*: 95%; *Layers*: 1; *Thickness (theoretical)*: 0.345 nm; *FET Electron Mobility on Al_2O_3*: 2000 cm²/Vs; *FET Electron Mobility on SiO_2*: 4000 cm²/Vs; *Sheet Resistance on SiO_2/Si*: 410-490 Ω/sq (1 cm x 1 cm); *Grain size*: Up to 10 µm
Substrate Cu foil:
Thickness: 18 µm
Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally
Applications: Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings
Quality control: Raman Spectroscopy and Optical Microscopy
References:
1. *J. Electrochem. Soc.*, **2012**, *159*, A752.
2. *J. Mater. Chem. A.*, **2013**, *1*, 3177.

06-2523 NEW
Monolayer Graphene on Cu with PMMA coating (60mm x 40mm) *(1034343-98-0)* 1pc
C; wafer

Technical Notes:
Physical Properties:
Growth Method: Chemical Vapor Deposition (CVD synthesis); *Appearance*: Transparent; *Transparency*: >97%; *Coverage*: 95%; *Layers*: 1; *Thickness (theoretical)*: 0.345 nm; *FET Electron Mobility on Al_2O_3*: 2000 cm²/Vs; *FET Electron Mobility on SiO_2*: 4000 cm²/Vs; *Sheet Resistance on SiO_2/Si*: 410-490 Ω/sq (1 cm x 1 cm); *Grain size*: Up to 10 µm
Substrate Cu foil:
Thickness: 18 µm
Pretreated for easier bottom layer removal: Monolayer graphene on the back side of Copper is partially removed, but not completely, so an additional treatment like RIE is needed before transfer to eliminate the bottom layer totally
Applications: Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings
Quality control: Raman Spectroscopy and Optical Microscopy

References:
1. *J. Electrochem. Soc.*, **2012**, *159*, A752.

CARBON (Elemental Forms)

2. *J. Mater. Chem. A.*, **2013**, *1*, 3177.

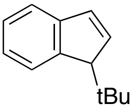
06-2534 NEW **Monolayer Graphene on SiO2/Si (10mm x 10mm)** *(1034343-98-0)* 4pc
C; wafer

Technical Notes:
Physical Properties:
Growth Method: Chemical Vapor Deposition (CVD synthesis); *Appearance*: Transparent; *Transparency*: >97%; *Coverage*: 95%; *Layers*: 1; *Thickness (theoretical)*: 0.345 nm; *FET Electron Mobility on Al_2O_3*: 2000 cm^2/Vs; *FET Electron Mobility on SiO_2*: 4000 cm^2/Vs; *Sheet Resistance on SiO_2/Si*: 410-490 Ω/sq (1 cm x 1 cm); *Grain size*: Up to 10 μm
Substrate Cu foil:
Dry Oxide Thickness: 285-315 nm; *Type/Dopant*: P/Bor; *Orientation*: <100>; *Resistivity*: <0.005 Ohm·cm; *Thickness*: 505-545 μm; *Front surface*: single side polished; *Back surface*: etched; *Particles*: <10@0.3 μm
Applications: Flexible batteries, electronics, aerospace, MEMS and NEMS, Microactuators, Conductive coatings
Quality control: Raman Spectroscopy and Optical Microscopy
References:

1. *J. Electrochem. Soc.,* **2012**, *159*, A752
2. *J. Mater. Chem. A.,* **2013**, *1*, 3177

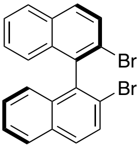
CARBON (Compounds)

06-0135 NEW **1-t-Butyl-1H-indene, min. 95%** *(40650-31-5)*
$C_{13}H_{16}$; FW: 172.27; colorless liq.



250mg
1g

06-0483 NEW **(1R)-2,2'-Dibromo-1,1'-binaphthalene, min. 98%** *(86688-08-6)*
$C_{20}H_{12}Br_2$; FW: 412.12; white to light-yellow solid
Note: Sold in collaboration with Daicel for research purposes only.



50mg
100mg

06-0484 NEW **(1S)-2,2'-Dibromo-1,1'-binaphthalene, min. 98%** *(150024-49-0)* 50mg 100mg
$C_{20}H_{12}Br_2$; FW: 412.12; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

06-3155 NEW **Lipozym® TL IM** *(9001-62-1)*
See page 26

06-3160 NEW **Neutrase® 0.8 L** *(9080-56-2)*
See page 26

06-3105 NEW **Lipozyme® CALB L** *(9001-62-1)*
See page 25

06-3100 NEW **NovoCor® AD L** *(9001-62-1)*
See page 26

06-3110 NEW **Alcalase® 2.4 L FG** *(9014-01-1)*
See page 25

06-3112 NEW **Alcalase® 2.5 L** *(9014-01-1)*
See page 25

CARBON (Compounds)

06-3115 NEW

Esperase® 8.0 L *(9014-01-1)*
See page 25

06-3118 NEW

Palatase® 20000 L *(9001-62-1)*
See page 27

06-3120 NEW

Novozym® 40086 *(9001-62-1)*
See page 26

06-3123 NEW

Novozyme® 435 *(9001-62-1)*
See page 26

06-3125 NEW

Resinase® HT *(9001-62-1)*
See page 27

06-3135 NEW

Novozym® 51032 *(9001-62-1)*
See page 27

06-3137 NEW

Savinase® 12 T *(9014-01-1)*
See page 27

06-3140 NEW

Lipozyme® TL 100 L *(9001-62-1)*
See page 26

06-3150 NEW

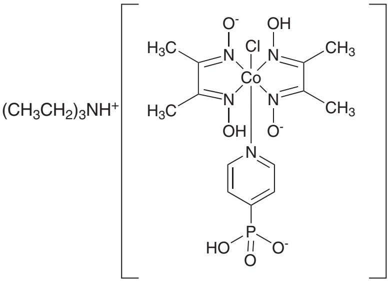
Savinase® 16 L *(9014-01-1)*
See page 27

COBALT (Compounds)

27-3015 NEW

Triethylammonium {chlorobis(dimethylglyoximato)(4-hydrogenphosphonatepyridinyl) cobaltate(III)} *(1280199-86-1)*
$C_{19}H_{35}ClCoN_6O_7P$; FW: 584.88; light-brown solid

5mg
25mg



Technical Notes:

1. Synthetic cobaloxime catalyst for reduction of aqueous protons to hydrogen in the presence of atmospheric oxygen.
2. Catalyst containing phosphonate anchor groups for immobilization on metal oxide semiconductor surfaces, enabling light-driven hydrogen evolution.

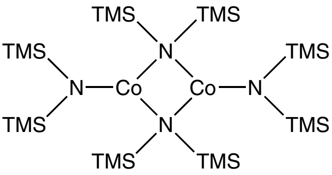
References:

1. *Angew. Chem. Int. Ed.,* **2012**, *51*, 9381
2. *Angew. Chem. Int. Ed.,* **2012**, *51*, 12749
3. *Chem. Commun.,* **2011**, *47*, 1695
4. *Chem. Sci.,* **2015**, *6*, 2727

COBALT (Compounds)

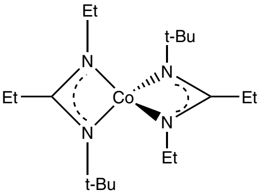
27-0477
NEW
Cobalt-dppe heterogeneous water oxidation catalyst (~17% Co)
$Co_4(dppe)_2(CO)(OH)_9(H_2O)_9$; FW: $C_{26}H_{24}CoP_2$; light-brown pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150065339 A1.
100mg
500mg

27-0515
NEW
Bis{[μ-[di(trimethylsilyl) amide]}bis{[di(trimethylsilyl) amide]}dicobalt(II), 98%
(93280-44-5)
$C_{24}H_{72}Co_2N_4Si_8$; FW: 759.41; brown solid
air sensitive, moisture sensitive
250mg
1g
5g



Technical Note:
1. Starting material for the synthesis of a variety of cobalt amines and alkoxides.

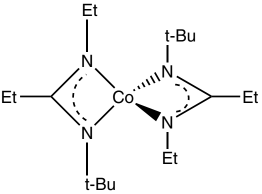
27-0468
NEW
Bis(N-t-butyl-N'-ethylpropanimid-amidato)cobalt(II), min. 98%
(1011477-51-2)
$C_{18}H_{38}CoN_4$; FW: 369.45; blue-green liq.
air sensitive, moisture sensitive
Note: Product sold under, use subject to, terms and conditions of label license at www.strem.com/harvard2
1g
5g



Technical Note:
1. Volatile cobalt complex for the Atomic Layer Deposition of cobalt metal.

References:
1. *Chemistry of Materials,* **2014**, *26*, 2642
2. *J. Phys. Chem. Lett.,* **2014**, *5*, 1091
3. *Dalton T.,* **2008**, *19*, 2592

27-0469
NEW
Bis(N-t-butyl-N'-ethylpropanimid-amidato)cobalt(II), min. 98% (99.99%-Co) PURATREM
(1011477-51-2)
$C_{18}H_{38}CoN_4$; FW: 369.45; blue-green liq.
air sensitive, moisture sensitive
Note: Product sold under, use subject to, terms and conditions of label license at www.strem.com/harvard2
1g
5g



Technical Note:
1. Volatile Cobalt precursor for ALD/CVD.

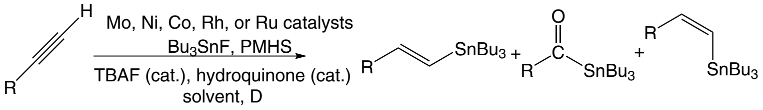
References:
1. *J. Phys. Chem. Lett.,* **2014**, *5*, 1091
2. *Chem. Mater.,* **2014**, *26*, 2642
3. *J. Mater. Chem. C.,* **2015**, *3*, 2500

27-0405
NEW
HAZ
Cobalt(II) chloride, anhydrous (99.999%-Co) PURATREM *(7646-79-9)*
$CoCl_2$; FW: 129.84; blue pwdr.
hygroscopic
1g
5g
25g

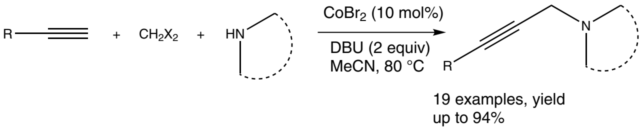
27-0575
NEW
Dichlorobis(triphenylphosphine)cobalt(II), 98% *(14126-40-0)*
$CoCl_2[P(C_6H_5)_3]_2$; FW: 654.41; blue pwdr.
air sensitive
1g
5g
25g

Technical Notes:
1. Catalyst used for hydrostannations.
2. Catalyst used for alkyne-dihalomethaneamine couplings. – an efficient route for propargylamines.
3. Cobalt-catalyzed transformation of alkynyl C-H bond: aldehyde-alkyne-amine coupling.

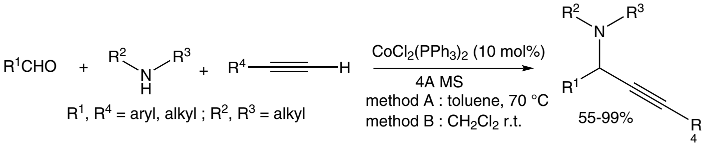
COBALT (Compounds)



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

References:

1. *Tetrahedron,* **2013**, *69*, 4000
2. *Tetrahedron Lett.,* **2012**, *53*, 6199
3. *SynLett.,* **2010**, *3*, 475

CYLINDERS (CVD/ALD) & Adapters

95-0281 NEW
Stainless steel cylinder, 125ml, horizontal in line, with angled Bellows valve (150°C), DOT 4B, UN stamped
Note: Compatible with Arradiance and GEMStar systems.
1cyl

GOLD (Elements)

79-7010 NEW
Gold Gemini Nanorods, CTAB Free (Wavelength 650 nm) *(7440-57-5)*
See page 43

79-7015 NEW
Gold Gemini Nanorods, CTAB Free (Wavelength 700 nm) *(7440-57-5)*
See page 43

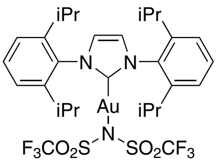
79-7025 NEW
Gold Gemini Nanorods, CTAB Free (Wavelength 800 nm) *(7440-57-5)*
See page 43

79-7020 NEW
Gold Gemini Nanorods, CTAB Free (Wavelength 750 nm) *(7440-57-5)*
See page 43

79-7030 NEW
Gold Gemini Nanorods, CTAB Free (Wavelength 850 nm) *(7440-57-5)*
See page 43

GOLD (Compounds)

79-0245 NEW
[1,3-Bis(2,6-di-i-propylphenyl)imidazol-2-ylidene][bis(trifluoromethanesulfonyl)imide]gold(I), min. 95% *(951776-24-2)*
$C_{29}H_{36}AuF_6O_4S_2$; FW: 824.69;
white to pale yellow solid
air sensitive

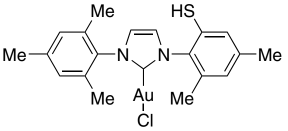


100mg
500mg

GOLD (Compounds)

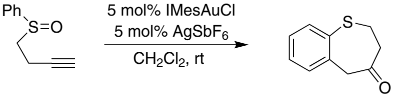
79-1200 **NEW** **Chloro[1,3-bis(2,4,6-trimethylphenyl) 2H-imidazol-2-ylidene]gold(I), 98%** *(852445-81-9)* $C_{21}H_{24}AuClN_2$; FW: 536.85; white pwdr. *air sensitive*

100mg
500mg

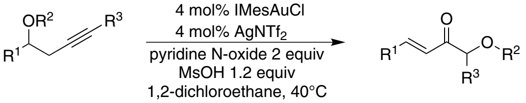


Technical Notes:

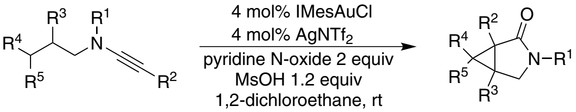
1. Catalyst for the rearrangement of alkynyl sulfoxides to benzothiepinones
2. Catalyst for the rearrangement of homopropargylic ethers to α,β-unsaturated carbonyl compounds
3. Catalyst for oxidative cyclopropanation of N-Allylynamides to 3-aza-bicyclo[3.1.0]-hexan-2-one derivatives
4. Catalyst for oxidative rearrangement of homopropargylic ethers to cyclobutanones



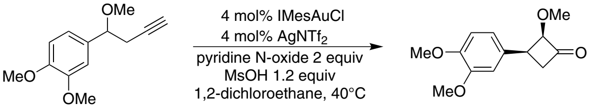
Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)



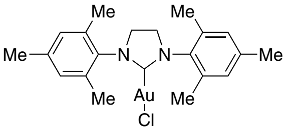
Tech. Note (4)
Ref. (4)

References:

1. *J. Am. Chem. Soc.,* **2007**, *129*, 4160
2. *Org. Lett.,* **2012**, *14*, 4902
3. *Org. Lett.,* **2013**, *15*, 2374
4. *Adv. Synth. Catal.,* **2013**, *355*, 2488

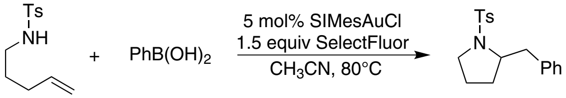
79-1205 **NEW** **Chloro[1,3-bis(2,4,6-trimethylphenyl)-4,5-dihydroimidazol-2-ylidene] gold(I), 98%** *(852445-82-0)* $C_{21}H_{26}AuClN_2$; FW: 538.86; white pwdr. *air sensitive*

100mg
500mg



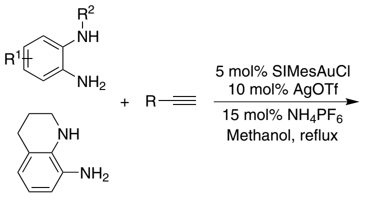
Technical Notes:

1. Catalyst for the carboheterofunctionalization of alkenes with arylboronic acids
2. Catalyst for the synthesis of 1-substituted benzo[b][1,4]diazepines



Tech. Note (1)
Ref. (1)

GOLD (Compounds)



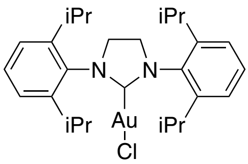
Tech. Note (2)
Ref. (2)

References:

1. *Tetrahedron,* **2013**, *69*, 10375
2. *J. Organomet. Chem.,* **2014**, *751*, 438

79-1210
NEW

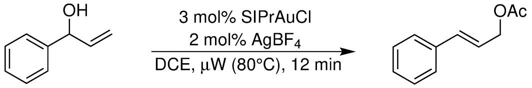
Chloro{1,3-bis[2,6-bis(1-methylethyl)phenyl]-4,5-dihydroimidazol-2-ylidene}gold(I), 98% SIPrAuCl
(852445-84-2)
$C_{27}H_{38}AuClN_2$; FW: 623.02;
white pwdr.
air sensitive



100mg
500mg

Technical Note:

1. Catalyst for the rearrangement of allylic acetates



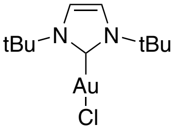
Tech. Note (1)
Ref. (1)

References:

1. *Org. Lett.,* **2007**, *9*, 2653

79-1215
NEW

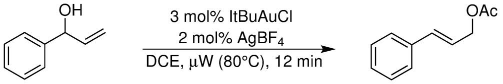
Chloro[1,3-bis(1,1'-dimethylethyl)2H-imidazol-2-ylidene]gold(I), 98% *(839722-07-5)*
$C_{11}H_{20}AuClN_2$; FW: 412.71; white pwdr.
air sensitive



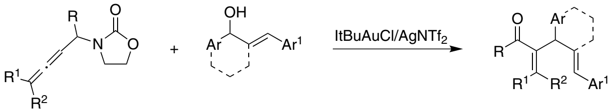
100mg
500mg

Technical Notes:

1. Catalyst for the rearrangement of allylic acetates
2. Catalyst for the α-allylation of enals and enones with alcohols



Tech. Note (1)
Ref. (1)



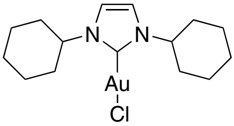
Tech. Note (2)
Ref. (2)

References:

1. *Org. Lett.,* **2007**, *9*, 2653
2. *Angew. Chem. Int. Ed.,* **2015**, *54*, 14885

79-1220
NEW

Chloro[1,3-bis(cyclohexyl)2H-imidazol-2-ylidene]gold(I), 98%
(852445-87-5)
$C_{15}H_{24}AuClN_2$; FW: 464.78;
white pwdr.
air sensitive

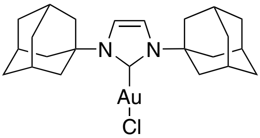


100mg
500mg

GOLD (Compounds)

79-1225 **NEW**

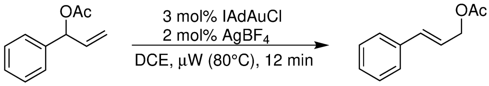
Chloro[1,3-bis(adamantyl)2H-imidazol-2-ylidene]gold(I), 98%
(852445-88-6)
$C_{23}H_{32}AuClN_2$; FW: 568.93;
white pwdr.
air sensitive



100mg
500mg

Technical Note:

1. Catalyst for the rearrangement of allylic acetates



Tech. Note (1)
Ref. (1)

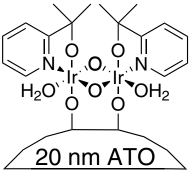
References:

1. *Org. Lett.*, **2007**, *9*, 2653

IRIDIUM (Compounds)

77-0030 **NEW**

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 20 nm (conductive and acid-stable) blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.

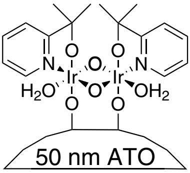


250mg
1g

Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 50 – 60 m^2/g
Resistivity: 0.3 – 0.7 Ω•cm

77-0035 **NEW**

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 50 nm (conductive and acid-stable) blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.

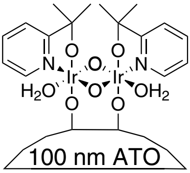


250mg
1g

Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 40 – 50 m^2/g
Resistivity: 0.05 – 0.08 Ω•cm

77-0040 **NEW**

Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 100 nm (conductive and acid-stable) blue pwdr.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.



250mg
1g

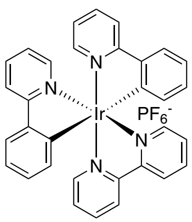
Technical Notes:
ATO Composition: 90% SnO_2, 10% Sb_2O_3 (w/w)
BET Surface Area: 5 – 10 m^2/g
Resistivity: 0.05 – 0.08 Ω•cm

IRIDIUM (Compounds)

77-0465

NEW

(2,2'-Bipyridine)bis[2-pyridinyl-kN)phenyl-kC]iridium(III) hexafluorophosphate, 99% *(106294-60-4)*
$[Ir(C_{10}H_8N_2)(C_{11}H_8N)_2]PF_6$; FW: 801.74; yellow pwdr.
Note: photocatalytic catalyst

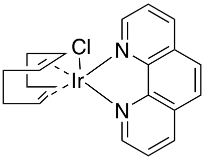


100mg
500mg

77-0258

NEW

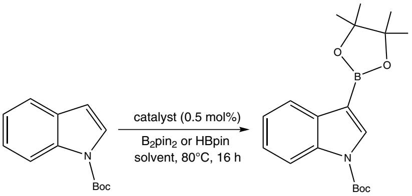
Chloro(1,5-cyclooctadiene)(1,10-phenanthroline)iridium(I) THF adduct, min. 98% *(41396-69-4)*
$C_{20}H_{20}ClIrN(C_4H_8O)$;
FW: 502.05 (574.16); purple solid
air sensitive



250mg
1g
5g

Technical Note:

1. Catalyst used in the C-H borylation of N-Boc-indoles.



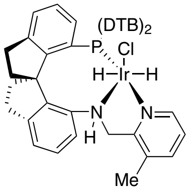
References:

1. *Organometallics,* **2014**, *33*, 3514

77-4035

NEW

Chlorodihydrido{(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane}iridium(III), >97% (>99% ee) Ir-(R)-DTB-SpiroPAP-3-Me *(1396201-63-0)*
$C_{52}H_{67}ClIrN_2P$; FW: 978.75; yellow-green solid

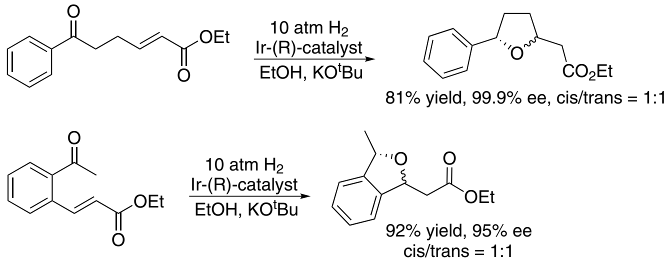


25mg
100mg

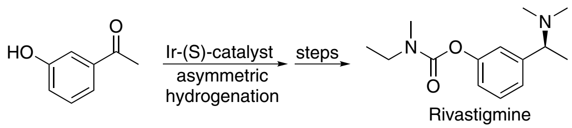
Technical Note:
This technical note is for both enantiomers 77-4035 [Ir-(R)-DTB-SpiroPAP-3-Me] and 77-4036 [Ir-(S)-DTB-SpiroPAP-3-Me]

1. Catalyst for the enantioselective synthesis of chiral disubstituted oxa-cyclic ethers
2. Catalyst for the enantioselective hydrogenation for the asymmetric synthesis of Rivastigmine
3. Catalyst for the asymmetric hydrogenation for the synthesis of Crizotinib
4. Catalyst for the asymmetric hydrogenation of α-keto acids
5. Catalyst for the kinetic resolution of racemic aliphatic alcohols via selective asymmetric hydrogenation

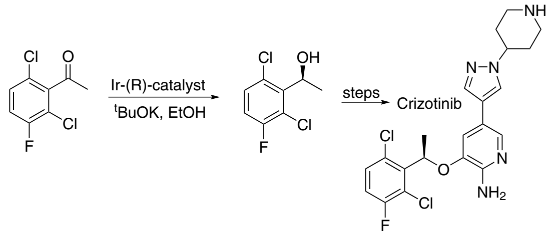
IRIDIUM (Compounds)



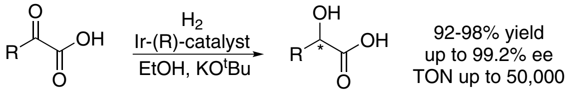
Tech. Note (1)
Ref. (1)



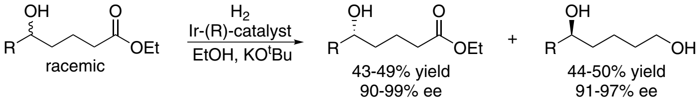
Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)



Tech. Note (4)
Ref. (4)



Tech. Note (5)
Ref. (5)

References:
1. *Org. Lett.,* **2012***, 14,* 4758.
2. *Org. Process. Res. Dev.,* **2013***, 17,* 307.
3. *Tetrahedron Lett.,* **2014***, 55,* 1528.
4. *Chem. Commun.,* **2014***, 50,* 15987.
5. *J. Am. Chem. Soc.,* **2014***, 136,* 17426.

77-4036
NEW

Chlorodihydrido{(S)-(-)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane}iridium(III), >97% (>99% ee) Ir-(S)-DTB-SpiroPAP-3-Me *(1418483-59-6)*
$C_{52}H_{67}ClIrN_2P$; FW: 978.75; yellow-green solid

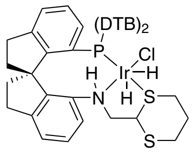
25mg
100mg

Technical Note: See 77-4035.

IRIDIUM (Compounds)

77-2510 **NEW**

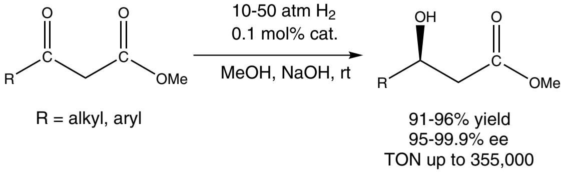
{(R)-(+)-7-[N-(1,3-dithian-2-yl)methylamino]-7'-[bis(3,5-di-t-butylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane} chlorodihydroiridium(III), 97+% [Ir-(R)-DTB-SpiroSAP]
$C_{50}H_{68}ClIrNPS_2$; FW: 1005.86;
pale yellow solid



25mg
100mg

Technical Note:

1. Catalyst used for the asymmetric hydrogenation of β-alkyl- β-ketoesters.



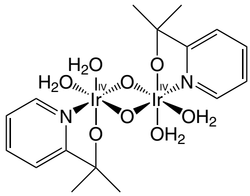
Tech. Note (1)
Ref. (1)

References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8791

77-0025 **NEW**

[2-(Pyridine-2-yl)-2-propanato] iridium(IV) dimer solution 97% (1 mM in 0.1 Molar aqueous $NaIO_3$)
(1446713-81-0)
$C_{16}H_{28}IrNO_3$; FW: 728.84; blue liq.
Note: Sold under license from Catalytic Innovations, LLC for research purposes only. US Patent Publication No. US20150021194 A1.



10ml
50ml

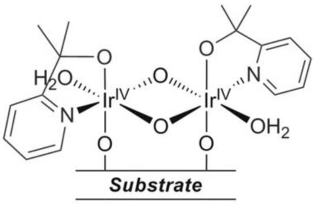
Technical Notes:

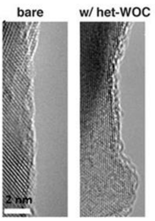
Standard Operating Procedure

Heterogenization of the material is straightforward and can be performed in air, at ambient temperature, with no additives, applied potential or other treatment required. For most carbon-based or metal oxide substrates:

1. Dip substrate in het-WOC deposition solution (or disperse powders, if powder).
2. Wait 4-12 hours (typically overnight).
3. Remove substrate from solution (or filter out powder) and rinse with clean water.

This will cause the monolayer Ir material to be deposited on the substrate, with a surface structure as shown[1] (TEM image on iron oxide shown to the right):





The het-WOC deposition solution may be diluted, in order to increase its coverage over large substrates. As stated in the SDS, the het-WOC deposition solution it is mostly comprised of water, therefore dilution with water is best. It can also be re-used repeatedly to load multiple substrates with the Ir monolayer – each loading only uses a small amount of the Ir present in solution, depending on surface area of substrate.

References:

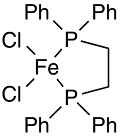
1. *J. Am. Chem. Soc.*, **2013**, *135*, 10837.
2. *J. Am. Chem. Soc.*, **2014**, *136*, 13826.
3. *Nat. Commun.*, **2015**, *6*, 6469.
4. *Angew. Chem. Int. Ed.*, **2015**, *54*, 11428.
5. *Energy Environ. Sci.*, **2016**, *9*, 1794.

IRON (Compounds)

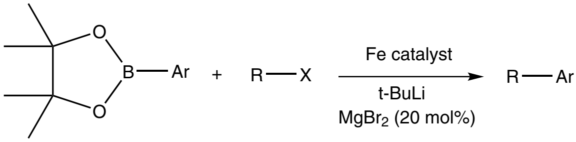
26-0923 NEW

Dichloro[1,2-bis(diphenylphosphino)ethane] iron(II), 98% *(41536-18-9)*
$C_{26}H_{24}Cl_2FeP_2$; FW: 525.17; white-gray xtls.
air sensitive

1g
5g



Technical Notes:
1. Catalyst used for the coupling of alkyl, benzyl and allyl halides with arylboronic esters.
2. Catalyst used for general cross-coupling reactions.



Tech. Note (1)
Ref. (1)

$$\text{alkyl}-\text{X} + \text{Ar}-\text{MY}_n \xrightarrow[\text{M = Zn, B, Al, In}]{\text{Fe catalyst}} \text{alkyl}-\text{Ar}$$

Tech. Note (2)
Ref. (2)

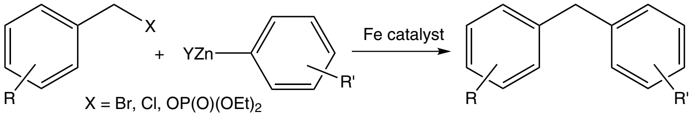
References:
1. *Chem. Eur. J.,* **2014**, *20*, 7935
2. *Angew. Chem. Int. Ed.,* **2013**, *52*, 1285

26-0945 NEW

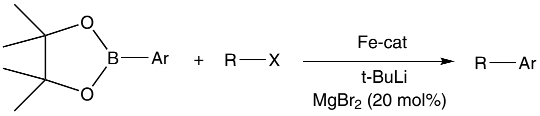
Dichloro[1,3-bis(diphenylphosphino)propane]iron(II), 98% *(106245-43-6)*
$C_{27}H_{26}Cl_2FeP_2$; FW: 539.19; white pwdr.
air sensitive

1g
5g

Technical Notes:
1. Iron precatalyst used in the cross-coupling of benzylhalides and phosphates.
2. Expedient iron-catalyzed coupling of alkyl, benzyl and allyl halides with arylboronic esters.



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

R = alkyl, benzyl, allyl

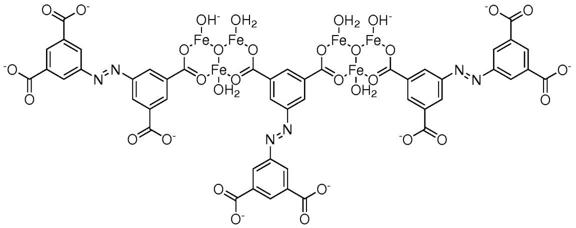
References:
1. *Chem. Commun.,* **2009**, *5*, 600
2. *Chem-Eur. J.,* **2014**, *20*, 7935

26-3725 NEW

Iron azobenzene tetracarboxylic, Porous [PCN-250(Fe)], CONEKTIC™ F250 *(1771755-22-6)*
$C_{48}H_{20}N_6O_{32}Fe_3$; Dark red-brown pwdr.
Note: Sold in collaboration with framergy for research purposes only.
PCT/GB2014/053506

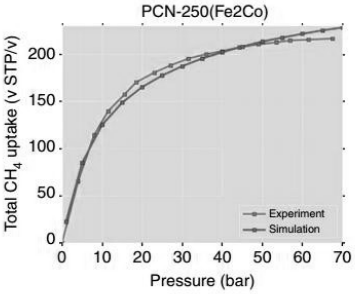
500mg
2g
10g

IRON (Compounds)



Technical Note:

1. Metal-Organic Framework (MOF) exhibiting superior uptake of hydrogen and methane. Stable in water and aqueous solutions.



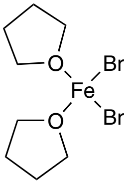
Tech. Note (1)
Ref. (1)

References:

1. *Nat. Commun.,* **2014**, *5*, 5723
2. *Sci. Technol. Adv. Mater.,* **2015**, *16*, 054202

26-0078 NEW

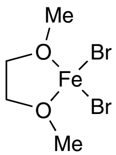
Iron(II) bromide, tetrahydrofuran adduct, min. 98% *(70317-91-8)*
$FeBr_2(C_4H_8O)_2$; FW: 359.86; light brown xtl.
air sensitive, moisture sensitive



1g
5g
25g

26-0065 NEW

Iron(II) bromide, dimethoxyethane adduct, min. 98% *(99611-53-7)*
$FeBr_2 \cdot CH_3O(CH_2)_2OCH_3$; FW: 305.77; light brown xtl.
moisture sensitive



1g
5g
25g

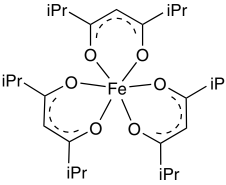
26-3765 NEW

Tetramethylammonium ferricyanide, 98% *(14591-44-7)*
$C_{18}H_{36}FeN_9$; FW: 434.38; yellow xtl.

100mg
500mg

26-3915 NEW

Tris(2,6-dimethyl-3,5-heptanedionato) iron(III), 98% Fe(dibm)3 *(24444-72-2)*
$C_{27}H_{45}FeO_6$; FW: 521.49; red-orange xtl.

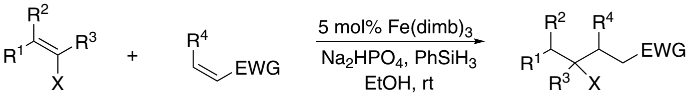


500mg
2g
10g

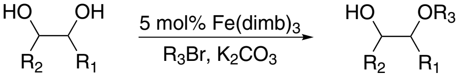
IRON (Compounds)

Technical Notes:

1. Iron catalyst for olefin cross-coupling
2. Iron catalyst for regioselective alkylation of diols and polyols



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

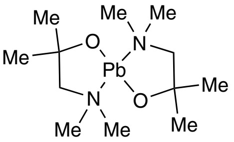
References:

1. *Nature*, **2014**, *516*, 343.
2. *Chem. Eur. J.*, **2016**, *22*, 2481.

LEAD (Compounds)

82-2155 NEW

Bis(1-dimethylamino-2-methyl-2-propanolate)lead(II), 98% Pb(DMAMP)$_2$ *(934302-16-6)*
$C_{12}H_{28}N_2O_2Pb$; FW: 439.56; white solid



250mg
1g
5g

Technical Note:

1. Volatile compound used in the Chemical Vapor Deposition of lead oxide.

References:

1. *Eur. J. Org. Chem.,* **2014**, *2014*, 1327

82-2180 NEW HAZ

Methylammonium triiodoplumbate(II) (40wt% solution in DMF) (99.99+%-Pb) *(69507-98-8)*
$[CH_3NH_3]^+PbI_3^-$; FW: 616.96; clear yellow liq.; d. 1.368

2g
10g

LUTETIUM (Compounds)

71-1080 NEW

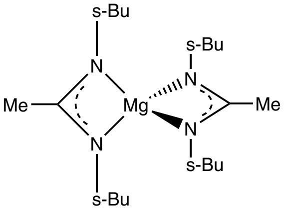
Tris(2,2,6,6-tetramethyl-3,5-heptanedionato)lutetium(III), 99% (99.9+%-Lu) (REO) [Lu(TMHD)$_3$] *(15492-45-2)*
$Lu(C_{11}H_{19}O_2)_3$; off-white xtl.

1g
5g
25g

MAGNESIUM (Compounds)

12-0845 NEW

Bis(N,N'-di-sec-butylacetamidinato)magnesium, 99%
$C_{20}H_{42}MgN_4$; FW: 362.88;
colorless to pale yellow liq.
moisture sensitive
Note: Product sold under, use subject to, terms and conditions of label license at www.strem.com/harvard2



1g
5g

MOLYBDENUM (Compounds)

42-9028 NEW	**Bis(acetonitrile)tetracarbonylmolybdenum(0), 98%** *(14126-87-5)* $C_8H_6N_2O_4Mo$; FW: 290.08; yellow solid *air sensitive*	250mg 1g 5g
42-1550 NEW	**Molybdenum disilicide, 0.4-5.0 microns (99+%-Mo)** *(12136-78-6)* $MoSi_2$; FW: 152.13; black solid	50g 250g

NANOMATERIALS (Elemental Forms)

79-7010 NEW	**Gold Gemini Nanorods, CTAB Free (Wavelength 650 nm)** *(7440-57-5)* Au; violet liq. *light sensitive, (store cold)* Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.	5ml 25ml
79-7015 NEW	**Gold Gemini Nanorods, CTAB Free (Wavelength 700 nm)** *(7440-57-5)* Au; blue liq. *light sensitive, (store cold)* Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.	5ml 25ml
79-7020 NEW	**Gold Gemini Nanorods, CTAB Free (Wavelength 750 nm)** *(7440-57-5)* Au; red-purple liq. *light sensitive, (store cold)* Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.	5ml 25ml
79-7025 NEW	**Gold Gemini Nanorods, CTAB Free (Wavelength 800 nm)** *(7440-57-5)* Au; red-orange liq. *light sensitive, (store cold)* Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.	5ml 25ml
79-7030 NEW	**Gold Gemini Nanorods, CTAB Free (Wavelength 850 nm)** *(7440-57-5)* Au; maroon-purple liq. *light sensitive, (store cold)* Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only. Gold Gemini Nanorods Kit component.	5ml 25ml

NANOMATERIALS (Elemental Forms)

06-0310 NEW	**Graphene film, monolayer, on Si/SiO$_2$ wafer (1cm x1cm), by CVD** *(1034343-98-0)* *See* page 28	
06-0222 NEW	**Graphene nanoplatelets, (2-10nm thick x ~5 microns wide)** *(1034343-98-0)* *See* page 28	
06-0323 NEW	**Graphene oxide (0.8-1.2nm thick x 1-15 microns wide, made by the Staudenmaier Method)** *See* page 28	
06-2545 NEW	**Graphene oxide (4mg/ml water dispersion)** *(1034343-98-0)* *See* page 28	
06-2550 NEW	**Graphene oxide, reduced** *(1034343-98-0)* *See* page 28	
06-0313 NEW	**Graphene powder (single layer, surface area 400-1000 m^2/g)** *(1034343-98-0)* *See* page 29	
06-0318 NEW	**Graphene powder (1-5 layers thick x 0.5-5 microns wide, surface area 650-750 m^2/g)** *(1034343-98-0)* *See* page 29	
06-2510 NEW	**Monolayer Graphene on Cu (10 mm x 10 mm)** *(1034343-98-0)* *See* page 29	
06-2518 NEW	**Monolayer Graphene on Cu (60 mm x 40 mm)** *(1034343-98-0)* *See* page 29	
06-2523 NEW	**Monolayer Graphene on Cu with PMMA coating (60mm x 40mm)** *(1034343-98-0)* *See* page 29	
06-2534 NEW	**Monolayer Graphene on SiO2/Si (10mm x 10mm)** *(1034343-98-0)* *See* page 30	
14-8820 NEW	**SBA-15 Molecular Sieve** *(7631-86-9)*	1g 5g

NANOMATERIALS (Compounds)

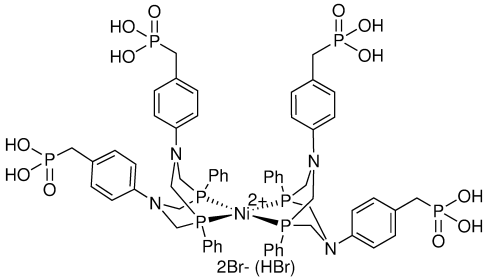
77-0030 NEW	**Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 20 nm (conductive and acid-stable)** *See* page 36	
77-0035 NEW	**Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 50 nm (conductive and acid-stable)** *See* page 36	
77-0040 NEW	**Antimony Tin Oxide/Iridium Het-WOC core/shell nanopowder, 100 nm (conductive and acid-stable)** *See* page 36	
50-0518 NEW	**Tin(IV) oxide, nanoparticle (30-60 nm), (99.7%-Sn)** *(18282-10-5)* SnO_2; FW: 150.69; white pwdr.; SA: 18.55; m. p. 1630°; d. 6.95	25g 100g

NICKEL(Compounds)

28-1720 t NEW

Bis{P,P'-1,5-diphenyl-3,7-bis[(4-hydrogenphosphonate) phenyl]-1,5,3,7-diazadiphosphocine} nickel(II) bromide (hydrogen bromide adduct) *(1514896-39-9)*
$C_{60}H_{69}Br_3N_4NiO_{12}P_8$; FW: 1584.41; red-brown xtls.
air sensitive, moisture sensitive

5mg
25mg



Technical Notes:

1. Synthetic nickel catalyst used for photocatalytic reduction of aqueous protons to hydrogen.
2. Catalyst containing phosphonate anchor groups for immobilization on metal oxide semiconductor surfaces, enabling light-driven hydrogen evolution.

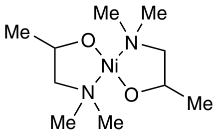
References:

1. *Angew. Chem. Int. Ed.,* **2014**, *53*, 11538
2. *J. Amer. Chem. Soc.,* **2014**, *136*, 356

28-0025 NEW

Bis[1-(N,N-dimethylamino)-2-propanolato] nickel(II), 99% NiDMAP *(200284-92-0)*
$C_{10}H_{24}N_2NiO_2$; FW: 263.00; green xtl.

500mg
2g



28-0110 NEW

Chlorobis(triphenylphosphino)phenylnickel(II), 98% *(33571-43-6)*
$C_{42}H_{35}ClNiP_2$; FW: 695.78; yellow pwdr.
air sensitive, moisture sensitive

500mg
2g

Technical Notes:

1. Self-immobilizing, binuclear neutral nickel catalyst for ethylene polymerization.
2. Ligand steric and electronic effects on β-ketiminato neutral nickel(II) olefin polymerization catalysts.
3. Accessible, highly active single-component β-ketiminato neutral nickel(II) catalysts for ethylene polymerization.
4. Highly active neutral nickel(II) catalysts for ethylene polymerization bearing modified β-ketoiminato ligands.

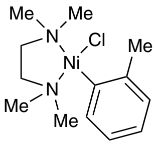
References:

1. *J. Mol.Catal A:Chem,.* **2013**, *380*, 139
2. *Organometallics,* **2012**, *31*, 966
3. *Organometallics,* **2010**, *29*, 2306
4. *Organometallics,* **2009**, *28*, 5697

28-0165 NEW

Chloro(2-methylphenyl)(N,N,N,N-tetramethyl-1,2-ethylenediamine)nickel(II), 99% (contains about 5% o-chlorotoluene) NiCl(o-tolyl)(TMEDA) *(1702744-45-3)*
$C_{13}H_{23}ClN_2Ni$; FW: 301.48; dark-orange pwdr.
air sensitive

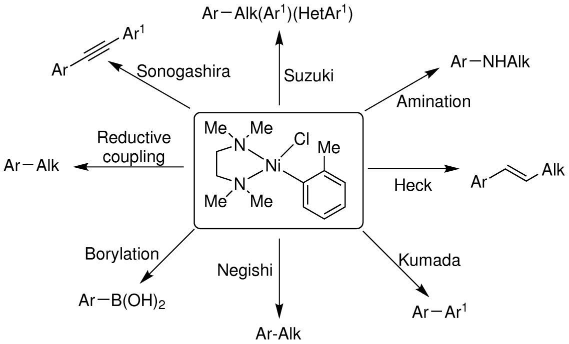
500mg
2g
10g



Technical Notes:

1. Air-Stable Nickel precatalyst for cross-coupling
2. Precatalyst allowing various ligands to be used (mono- and bidendate phosphines, diimines and NHCs)

NICKEL(Compounds)

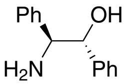


Tech. Note (1,2)
Ref. (1,2)

References:
1. *ACS Catal.,* **2015**, *5*, 3120
2. *Org. Lett.,* **2015**, *17*, 2166

NITROGEN (Compounds)

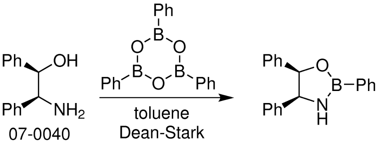
07-0040 NEW **(1R,2S)-2-Amino-1,2-diphenylethanol, min. 98%** *(23190-16-1)*
$C_{14}H_{15}NO$; FW: 213.28; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



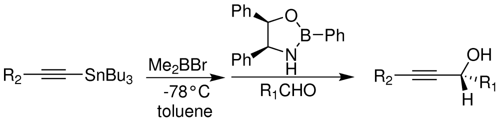
5g
25g

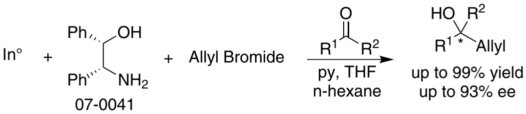
Technical Notes:
1. Ligand used to make chiral oxaborolidines for the enantioselective alkynylation of aldehydes
2. Ligand used in organoindium reagents for asymmetric Barbier-type allylations
3. Ligand used in organoindium reagents for asymmetric Barbier-type propargylations

Note: This technical note is for both enantiomers 07-0040 and 07-0041

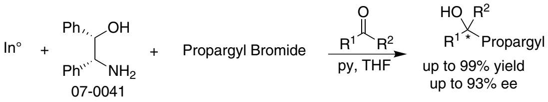


Tech. Note (1)
Ref. (1)





Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

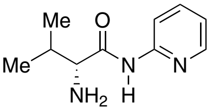
References:
1. *J. Am. Chem. Soc.,* **1994**, *116*, 3151
2. *J. Org. Chem.,* **2010**, *75*, 642
3. *J. Org. Chem.,* **2012**, *77*, 889

NITROGEN (Compounds)

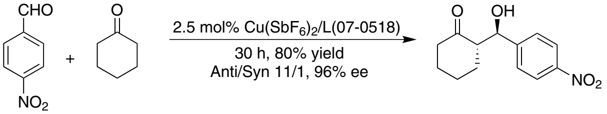
07-0041 **NEW**
(1S,2R)-2-Amino-1,2-diphenylethanol, min. 98% *(23364-44-5)*
$C_{14}H_{15}NO$; FW: 213.28; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
5g
25g

Technical Note: See 07-0040.

07-0519 **NEW**
(2R)-2-Amino-3-methyl-N-2-pyridinylbutanamide, min. 98% *(1568043-19-5)*
$C_{10}H_{15}N_3O$; FW: 193.25; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
100mg
500mg



Technical Note:
1. Ligand for the copper-catalyzed asymmetric aldol reaction
   *Reference shown is for (S)-enantiomer, 07-0518



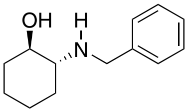
Tech. Note (1)
Ref. (1)

References:
1. *Chem. Commun.*, **2011**, *47*, 224

07-0518 **NEW**
(2S)-2-Amino-3-methyl-N-2-pyridinylbutanamide, min. 98% *(167261-43-0)*
$C_{10}H_{15}N_3O$; FW: 193.25; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
100mg
500mg

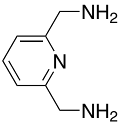
Technical Note: See 07-0519.

07-0637 **NEW**
(1R,2R)-2-Benzylamino-1-cyclohexanol, min. 98% *(141553-09-5)*
$C_{13}H_{19}NO$; FW: 209.30; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
500mg
2g

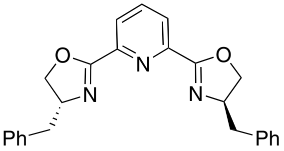


07-0638 **NEW**
(1S,2S)-2-Benzylamino-1-cyclohexanol, min. 98% *(322407-34-1)*
$C_{13}H_{19}NO$; FW: 205.30; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
500mg
2g

07-0650 **NEW**
2,6-Bis(aminomethyl)pyridine, min. 85% *(34984-16-2)*
$C_7H_{11}N_3$; FW: 137.18; low melting yellow solid
air sensitive
1g
5g



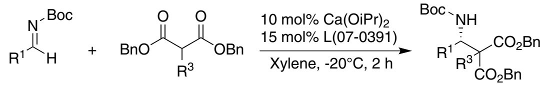
07-0390 **NEW**
2,6-Bis[(4R)-benzyl-2-oxazolin-2-yl]pyridine, min. 98% *(365215-38-9)*
$C_{25}H_{23}N_3O_2$; FW: 397.47; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
25mg
100mg



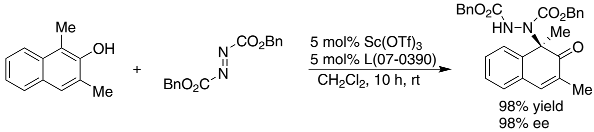
Technical Notes:
1. Ligand for the Calcium-catalyzed asymmetric Mannich reaction of malonates with imines
2. Ligand for the Scandium-catalyzed asymmetric dearomatization of 2-naphthols by electrophilic amination

Note: This technical note contains both enantiomers 07-0390 and 07-0391

NITROGEN (Compounds)



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

References:

1. *J. Org. Chem.*, **2010**, *75*, 963
2. *Angew. Chem. Int. Ed.*, **2015**, *54*, 2356

07-0391 NEW

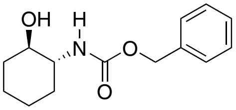
2,6-Bis[(4S)-benzyl-2-oxazolin-2-yl]pyridine, min. 98% *(151670-69-8)*
$C_{25}H_{23}N_3O_2$; FW: 397.47; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

Technical Note: See 07-0390.

25mg
100mg

07-1005 NEW

[(1R,2R)-2-Hydroxycyclohexyl] carbamic Acid Phenylmethyl Ester, min. 98% *(134108-76-2)*
$C_{14}H_{19}NO_3$; FW: 249.31; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



1g
5g

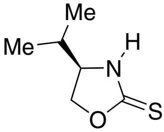
07-1006 NEW

[(1S,2S)-2-Hydroxycyclohexyl]carbamic Acid Phenylmethyl Ester, min. 98% *(198422-64-9)*
$C_{14}H_{19}NO_3$; FW: 249.31; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

1g
5g

07-0615 NEW

(R)-4-Isopropyl-2-oxazolidinethione, min. 98% *(1217463-35-8)*
$C_6H_{11}NOS$; FW: 145.22; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



500mg
2g

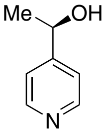
07-0616 NEW

(S)-4-Isopropyl-2-oxazolidinethione, min. 98% *(104499-08-3)*
$C_6H_{11}NOS$; FW: 145.22; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

500mg
2g

07-1160 NEW

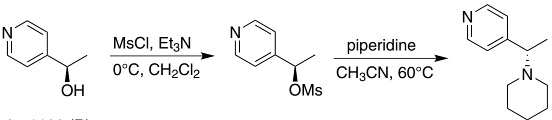
(R)-(+)-α-Methyl-4-pyridinemethanol, min. 98% *(27854-88-2)*
C_7H_9NO; FW: 123.15; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



50mg
100mg

Technical Notes:

1. Used for the synthesis of chiral 1-(4-pyridinyl)ethylamines
2. Precursor for intermediates of highly stable chiral (A)6-B Supramolecular Copolymers

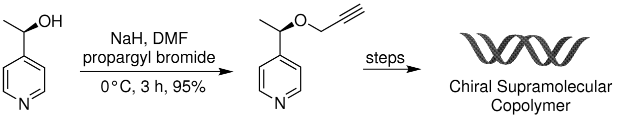


07-1160 (R)

(S)-N-1-(4-pyridyl)ethylpiperidine

Tech. Note (1)
Ref. (1)

NITROGEN (Compounds)



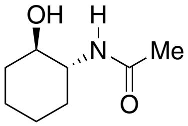
Tech. Note (2)
Ref. (2)

References:
1. *J. Org. Chem.,* **2004**, *69*, 6781
2. *J. Am. Chem. Soc.,* **2011**, *133*, 11124

07-1161 NEW **(S)-(-)-α-Methyl-4-pyridinemethanol, min. 98%** *(54656-96-1)* 50mg 100mg
C_7H_9NO; FW: 123.15; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

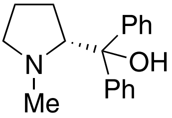
Technical Note: See 07-1160.

07-0785 NEW **N-[(1R,2R)-2-Hydroxycyclohexyl] acetamide, min. 98%** *(214348-95-5)* 1g 5g
$C_8H_{15}NO_2$; FW: 157.21; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

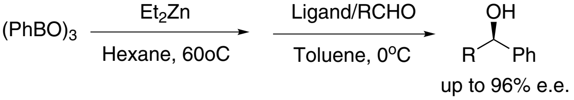


07-0786 NEW **N-[(1S,2S)-2-Hydroxycyclohexyl]acetamide, min. 98%** *(190848-36-3)* 1g 5g
$C_8H_{15}NO_2$; FW: 157.21; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

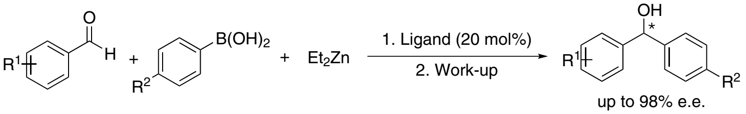
07-1170 NEW **(2R)-(-)-N-Methyl-α,α-diphenyl-2-pyrrolidine-methanol, min. 98%** *(144119-12-0)* 100mg 250mg
$C_{18}H_{21}NO$; FW: 267.37; white to light-yellow pwdr.; m. p. 68-71°
Note: Sold in collaboration with Daicel for research purposes only.



Technical Notes:
1. Chiral amino alcohol assisted asymmetric, enantioselective, aryl transfer of triphenylboroxin to a set of aryl aldehydes in the presence of chiral amino alcohols derived from (S)-proline.
2. Pyrrolidinylmethanol compound used for the zinc-catalyzed addition of arylboronic acids to aromatic aldehydes, proceeding in high yields and high enantioselectivities (up to 98% ee).



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

References:
1. *Tetrahedron Asymmetry* **2005**, *16*, 2299
2. *Tetrahedron Lett.,* **2005**, *46*, 7827

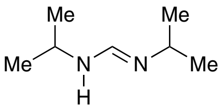
07-1171 NEW **(2S)-(+)-N-Methyl-α,α-diphenyl-2-pyrrolidinemethanol, min. 98%** *(110529-22-1)* 100mg 250mg
$C_{18}H_{21}NO$; FW: 267.37; white to pale-yellow pwdr.; m. p. 66-69°
Note: Sold in collaboration with Daicel for research purposes only.

Technical Note: See 07-1170.

NITROGEN (Compounds)

07-0240
NEW

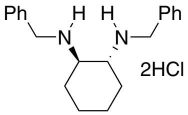
N,N'-Bis(1-methylethyl)methanimidamide, min. 98% *(44843-38-1)*
$C_7H_{16}N_2$; FW: 128.22; off-white pwdr.



1g
5g
25g

07-4073
NEW

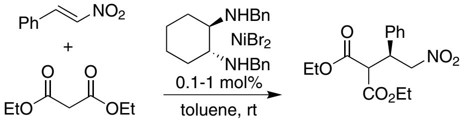
(1R,2R)-N,N'-Bis(phenylmethyl)-1,2-cyclohexanediamine dihydrochloride, min. 98%
(212611-88-6)
$C_{20}H_{26}N_2 \cdot 2HCl$; FW: 367.36; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



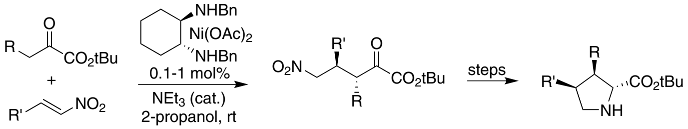
1g
5g

Technical Notes:

1. Ligand for Ni-catalyzed enantioselective Michael additions of 1,3-dicarbonyl compounds to nitroalkenes
2. Ligand for Ni-catalyzed enantioselective conjugate addition of α-Ketoesters to nitroalkenes



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

References:

1. *J. Am. Chem. Soc.,* **2007**, *129*, 11583
2. *J. Am. Chem. Soc.,* **2010**, *132*, 4036

07-4074
NEW

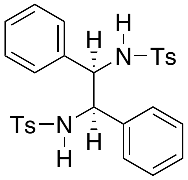
(1S,2S)-N,N'-Bis(phenylmethyl)-1,2-cyclohexanediamine dihydrochloride, min. 98%
$C_{20}H_{26}N_2 \cdot 2HCl$; FW: 367.36; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

Technical Note: See 07-4073.

1g
5g

07-4060
NEW

(1R,2R)-N,N'-Di-p-tosyl-1,2-diphenyl-1,2-ethylenediamine, min. 98% *(121758-19-8)*
$C_{28}H_{28}N_2O_4S_2$; FW: 520.67; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

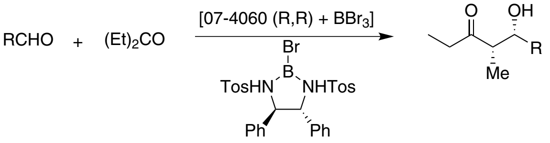


500mg
1g

Technical Notes:

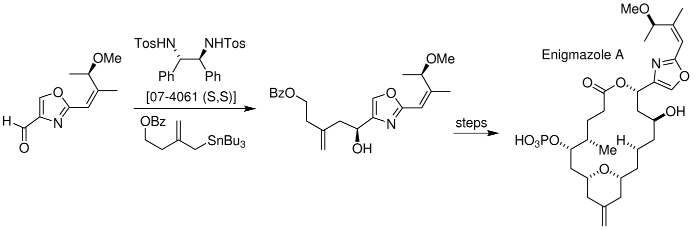
1. Chiral reagent used the natural product synthesis of the rice and corn weevil aggregation pheromone sitophilure
2. Chiral reagent used in the total synthesis of enigmazole A
3. Chiral reagent used in the enantioselective synthesis of Furan Lignan (+)-Sylvone

This tech note includes both enantiomers (R,R) # 07-4060 and (S,S) # 07-4061

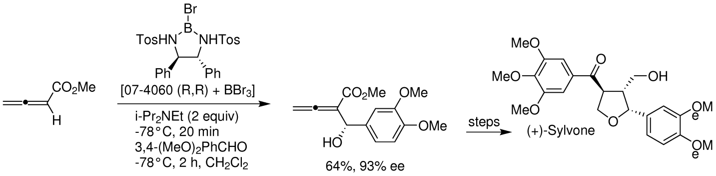


Tech. Note (1)
Ref. (1)

NITROGEN (Compounds)



Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

References:

1. *J. Am. Chem. Soc.,* **1989**, *111*, 5493
2. *J. Am. Chem. Soc.,* **2010**, *132*, 10286
3. *J. Org. Chem.,* **2015**, *80*, 10359

07-4061 **NEW**

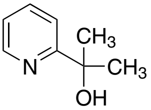
(1S,2S)-N,N'-Di-p-tosyl-1,2-diphenyl-1,2-ethylenediamine, min. 98%
(170709-41-8)
$C_{28}H_{28}N_2O_4S_2$; FW: 520.67; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

Technical Note: See 07-4060.

500mg
1g

07-3333 **NEW**

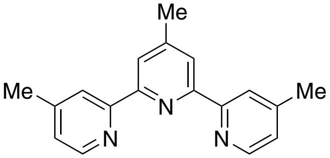
2-(Pyridine-2-yl)propan-2-ol, min. 95%
pyalc *(37988-38-8)*
$(C_5H_4N)C(CH_3)_2(OH)$; FW: 137.18; white xtl.



100mg
500mg
2g

07-2758 **NEW**

4,4',4"-Trimethyl-2,2':6',2"-terpyridine, 98%
(33354-75-5)
$C_{18}H_{17}N_3$; FW: 275.35;
white to off-white pwdr.

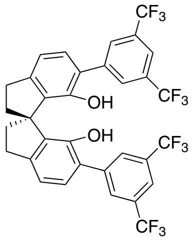


500mg
2g

OXYGEN (Compounds)

08-0163 **NEW**

(1R)-6,6'-Bis[3,5-bis(trifluoromethyl)phenyl]-2,2',3,3'-tetrahydro-1,1'-spirobi[1H-indene]-7,7'-diol, min. 98%
(1286189-16-9)
$C_{33}H_{20}F_{12}O_2$; FW: 676.49; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

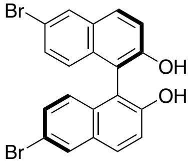


25mg
100mg

OXYGEN (Compounds)

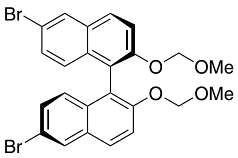
08-0164 NEW
(1S)-6,6'-Bis[3,5-bis(trifluoromethyl)phenyl]-2,2',3,3'-tetrahydro-1,1'-spirobi[1H-indene]-7,7'-diol, min. 98% *(1258327-01-3)*
$C_{33}H_{20}F_{12}O_2$; FW: 676.49; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
25mg
100mg

08-0185 NEW
(R)-(-)-6,6'-Dibromo-1,1'-bi-2-naphthol, 98% (99% ee) *(65283-60-5)*
$C_{20}H_{12}Br_2O_2$; FW: 444.12; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
500mg
2g



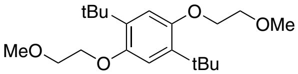
08-0186 NEW
(S)-(+)-6,6'-Dibromo-1,1'-bi-2-naphthol, 98% (99% ee) *(80655-81-8)*
$C_{20}H_{12}Br_2O_2$; FW: 444.12; white to light-yellow solid
Note: Sold in collaboration with Daicel for research purposes only.
500mg
2g

08-0152 NEW
(R)-(+)-6,6'-Dibromo-2,2'-bis(methoxymethoxy)-1,1'-binaphthalene, min. 98% (99% ee) *(179866-74-1)*
$C_{24}H_{20}Br_2O_4$; FW: 532.22;
white to light-yellow pwdr.; m. p. 133°
Note: Sold in collaboration with Daicel for research purposes only.
100mg
500mg



08-0153 NEW
(S)-(-)-6,6'-Dibromo-2,2'-bis(methoxymethoxy)-1,1'-binaphthalene, min. 98% (99% ee) *(211560-97-3)*
$C_{24}H_{20}Br_2O_4$; FW: 532.22; white to light-yellow pwdr.; m. p. 133°
Note: Sold in collaboration with Daicel for research purposes only.
100mg
500mg

08-0215 NEW
1,4-Di-t-butyl-2,5-bis(2-methoxyethoxy)benzene, 99+% Redox shuttle ANL-RS2 *(1350770-63-6)*
$C_{20}H_{34}O_4$; FW: 338.48; white to off-white pwdr.; m. p. 69-70°
air sensitive, moisture sensitive
Note: U.S. Patent: 8,609,287. European Patent App.: 11787270.5.
Chinese Patent App.: 11/80014192.6
1g
5g



Technical Notes:

Redox Shuttles for Lithium Ion Batteries

1. Provides a long term intrinsic overcharge protection of lithium-ion batteries.
2. Maintains the safe operation of lithium-ion batteries.
3. Highly-soluble in conventional non-aqueous, carbonate based electrolytes.
4. Increases battery long-term stability and oxidation potential.

Electrochemical Properties:

1. ANL-RS2 (abbreviated DBBB) redox shuttle, compared to other dimethoxybenzene-based shuttles, has demonstrated improved solubility in carbonate-based electrolytes. DBBB displays a reversible redox potential at 3.9 V [1]
2. In comparison to a variety of quinoxaline-based species, DBBB exhibits reversible single electron transfer at 4 V vs. Li/Li+. Quinoxaline and its derivatives demonstrate two redox events between 4-3 V vs. Li/Li+ [2]
3. DBBB enriched electrolyte was demonstrated as an effective protection against overcharge abuse in 18650 format $LiFePO_4$ based lithium ion batteries [3]
4. Due to excellent solubility in carbonate-based electrolytes and improved electrolyte conductivity, DBBB is compatible with modest battery technologies [4-5].

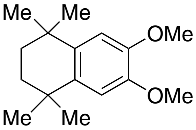
References:

1. *Energy Environ. Sci.,* **2012**, *5*, 8204
2. *Adv. Energy Mater.,* **2012**, *2*, 1390
3. *J. Power Sources,* **2014**, *247*, 1011
4. *J. Electrochem. Soc.,* **2014**, *161*, A1905
5. *J. Electrochem. Soc.,* **2016**, *163*, A1.

OXYGEN (Compounds)

08-0220
NEW

6,7-Dimethoxy-1,1,4,4-tetramethyl-1,2,3,4-tetrahydronaphthalene, 99+%
Redox shuttle ANL-RS21 *(22825-00-9)*
$C_{16}H_{24}O_2$; FW: 248.36; off-white solid
air sensitive, moisture sensitive
Note: U.S. Patent: 13/457,239.



1g
5g

Technical Notes:

Redox Shuttles for Lithium Ion Batteries

1. Provides a long term intrinsic overcharge protection of lithium-ion batteries.
2. Maintains the safe operation of lithium-ion batteries.
3. Highly-soluble in conventional non-aqueous, carbonate based electrolytes.
4. Increases battery long-term stability and oxidation potential.

Electrochemical Properties:

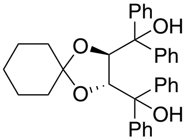
1. ANL-RS21 exhibits a redox potential of about 4.05V, in the electrolytes (5 mM in 1.2 M $LiPF_6$ in EC/EMC (3:7 Wt ratio). [1]
2. The redox shuttles in aprotic solvents can be used from -30° C. to 70° C, without freezing or boiling, and are stable in the electrochemical window in which the cell electrodes and redox shuttles operate. ANL-RS21 undergoes reversible electrochemical oxidation to form stable cation-radical salts [2]

References:

1. *US* **2013**, *0288137*, A1
2. *Org. Lett.,* **2009**, *11*, 2253

08-0611
NEW

(2R,3R)-1,4-Dioxaspiro[4.5]decane-2,3-diylbis(diphenylmethanol), min. 98%
(114026-76-5)
$C_{34}H_{34}O_4$; FW: 506.63; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



500mg
2g

08-0612
NEW

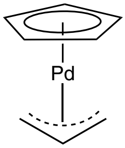
(2S,3S)-1,4-Dioxaspiro[4.5]decane-2,3-diylbis(diphenylmethanol), min. 98% *(123287-35-4)*
$C_{34}H_{34}O_4$; FW: 506.63; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

500mg
2g

PALLADIUM (Compounds)

46-0065
NEW

Allyl(cyclopentadienyl)palladium(II), 98%
(1271-03-0)
$C_8H_{10}Pd$; red solid
air sensitive, (store cold)



100mg
500mg
2g

Technical Notes:

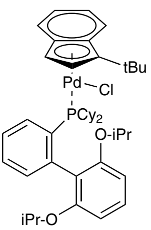
1. Volatile palladium catalyst with numerous uses in CVD and MOCVD applications.
   References:
   1. *Chem.Eur.J.,* **2012**, *19*, 13652
   2. *Catalysis Letters,* **2012**, *142*, 313
   3. *Chemistry of Materials,* **2009**, *21*, 2360
2. Starting material for the in situ generation of active palladium catalysts.
   References:
   1. *Syn. Lett.,* **2014**, *25*, 2488
   2. *Org. Lett.,* **2013**, *15*, 5932
   3. *Angew.Chem.Int.Ed.,***2013**, *52*, 4466

PALLADIUM (Compounds)

46-0440

NEW

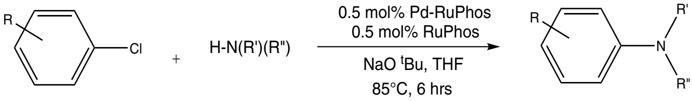
Chloro(1-t-butylindenyl)[2-(dicyclohexylphosphino)-2',6'-di-i-propoxy-1,1'-biphenyl]palladium(II)
$C_{43}H_{60}ClO_2PPd$; FW: 781.78; orange pwdr.
Note: For research and development only. Not for use in humans. Patents 62/061,319. US 6,395,916, US 6,307,087.



100mg
500mg

Technical Note:

1. Catalyst used in the Buchwald-Hartwig cross-coupling of substituted aryl chlorides with secondary amines.

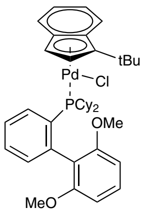


Tech. Note (1)

46-0435

NEW

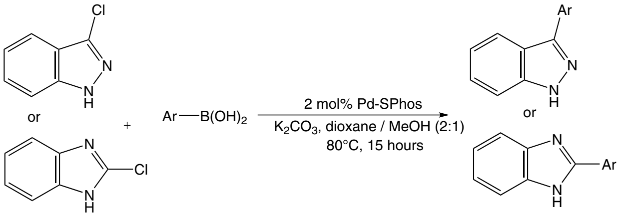
Chloro(1-t-butylindenyl)[2-(dicyclohexylphosphino)-2',6'-dimethoxy-1,1'-biphenyl]palladium(II)
$C_{39}H_{52}ClO_2PPd$; FW: 725.68; orange pwdr.
Note: For research and development only. Not for use in humans. Patents 62/061,319. US 6,395,916, US 6,307,087.



100mg
500mg

Technical Note:

1. Catalyst used in the Suzuki cross-coupling of 3-chloroindazole or 3-chlorobenzimidazole with arylboronic acids.

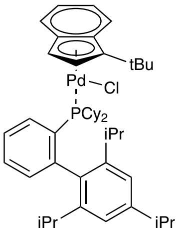


Tech. Note (1)

46-0437

NEW

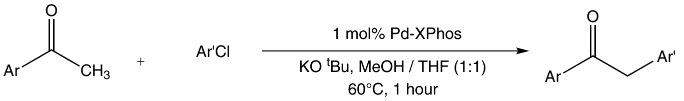
Chloro(1-t-butylindenyl)[2-(dicyclohexylphosphino)-2',4',6'-tri-i-propyl-1,1'-biphenyl]palladium(II)
$C_{46}H_{66}ClPPd$; FW: 791.86; orange pwdr.
Note: For research and development only. Not for use in humans. Patents 62/061,319. US 6,395,916, US 6,307,087.



100mg
500mg

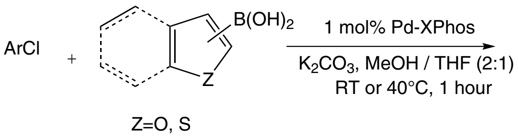
Technical Notes:

1. Catalyst used in the α-arylation of ketones.
2. Catalyst used in the Suzuki cross-coupling of aryl chlorides with boronic acid-substituted benzofurans.



Tech. Note (1)

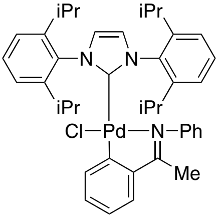
PALLADIUM (Compounds)



Tech. Note (2)

46-1058 **NEW**

Chloro{2-[(1-(N-phenyl)iminoethyl] phenyl}{[1,3-bis(2,6-di-i-propylphenyl] imidzole-2-ylidene}palladium(II)
$C_{41}H_{48}ClN_3OPd$; FW: 740.71;
pale yellow pwdr.



50mg
250mg

Technical Note:
1. Extremely active palladium catalyst for Suzuki-Miyaura coupling of aryl chlorides.

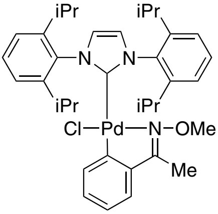
$$\text{Ar-Cl} + \text{Ar'B(OH)}_2 \xrightarrow[\text{KOH (1.5 equiv), }{}^i\text{PrOH-H}_2\text{O}]{\text{Pd cat. (0.005-0.05 mol\%), 80°}} \text{Ar—Ar'}$$

Tech. Note (1)
Ref. (1)

References:
1. *Tetrahedron Lett.*, **2014**, *55*, 3278

46-1050 **NEW**

Chloro{2-[1-(N-methoxy)iminoethyl] phenyl}{[1,3-bis(2,6-di-i-propylphenyl]imidzole-2-ylidene}palladium(II)
(1511859-41-8)
$C_{36}H_{46}ClN_3OPd$; FW: 678.64;
pale yellow pwdr.



50mg
250mg

Technical Note:
1. Extremely active palladium catalyst for Suzuki-Miyaura coupling of aryl chlorides.

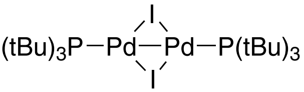
$$\text{Ar-Cl} + \text{Ar'B(OH)}_2 \xrightarrow[\text{KOH (1.5 equiv), }{}^i\text{PrOH-H}_2\text{O}]{\text{Pd cat. (0.005-0.05 mol\%), 80°}} \text{Ar—Ar'}$$

Tech. Note (1)
Ref. (1)

References:
1. *Tetrahedron Lett.*, **2014**, *55*, 3278

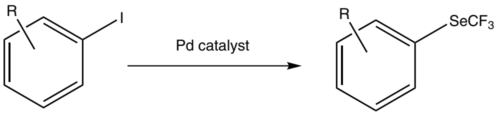
46-0310 **NEW**

Di-MU-iodobis(tri-t-butylphosphino)dipalladium(I), 98%
(166445-62-1)
$C_{24}H_{54}I_2P_2Pd_2$; FW: 871.28;
black solid
heat sensitive

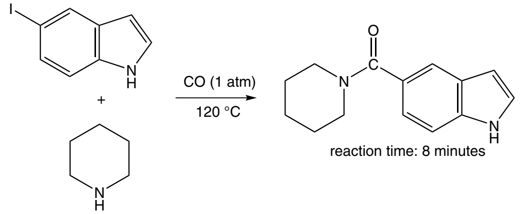


250mg
1g

Technical Notes:
1. Catalyst used for the highly efficient C-$SeCF_3$ coupling of aryl iodides.
2. Catalyst used for rapid carbonylative coupling reactions. .



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

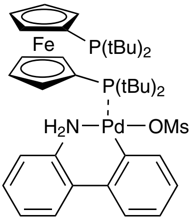
References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 10322
2. *Org. Biomol. Chem.,* **2011**, *9*, 3499

46-2158

NEW

Methanesulfonato(1,1'-bis(di-t-butylphosphino)ferrocene)(2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 98% [DTBPF Palladacycle Gen. 3]
$C_{39}H_{57}FeNO_3P_2PdS$; FW: 844.16; orange pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620

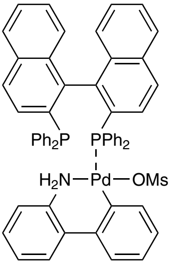


250mg
1g
5g

46-2153

NEW

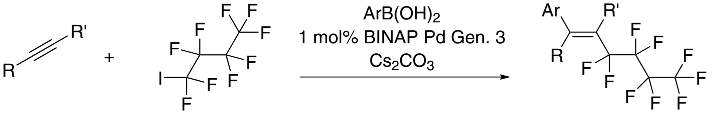
Methanesulfonato[2,2'-bis(diphenylphosphino)-1,1'-binaphthyl](2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 98% [BINAP Palladacycle Gen. 3]
$C_{57}H_{45}NO_3P_2PdS$; FW: 992.41; off-white pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620.



250mg
1g
5g

Technical Note:

1. Palladium catalyst for carboperfluoro-alkylation of terminal and internal alkynes to tri- and tetrasubstituted olefins.



Tech. Note (1)
Ref. (1)

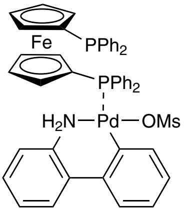
References:

1. *ACS Catal.,* **2016**, *6*, 3452.

46-2128

NEW

Methanesulfonato[1,1'-bis(diphenylphosphino)ferrocene)](2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 98% [DPPF Palladacycle Gen. 3] *(1445086-28-1)*
$C_{47}H_{41}FeNO_3P_2PdS$; FW: 924.11; yellow pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620



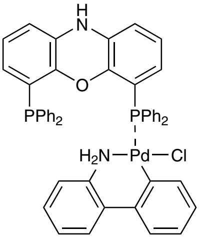
250mg
1g
5g

PALLADIUM (Compounds)

46-0959

NEW

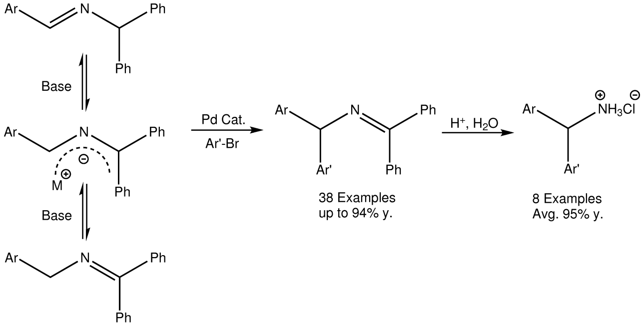
Methanesulfonato[4,6-bis(diphenylphosphino)phenoxazine](2'-amino-1,1'-biphenyl-2-yl)palladium(II), 98% [NiXantphos Palladacycle Gen. 3]
(1602922-03-1)
$C_{49}H_{40}N_2O_4P_2PdS$; FW: 921.29;
light green yellow solid
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620



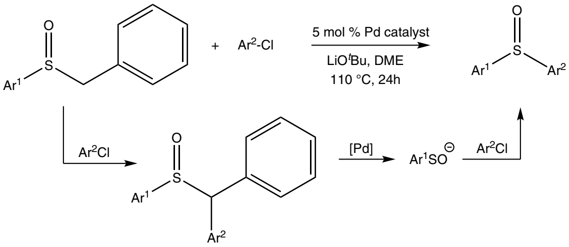
100mg
500mg
2g

Technical Notes:

1. Synthesis of diarylmethylamines via palladium-catalyzed arylation of 1,1,3-triaryl-2-azaallyl anions.
2. Catalyst used in the generation of diaryl sulfoxides from aryl benzyl sulfoxides and aryl chlorides.



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

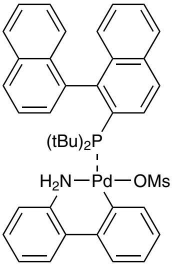
References:

1. *Chem Sci.* **2014**, *5*, 2383
2. *Org. Lett.,* **2015**, *17*, 1168

46-0357

NEW

Methanesulfonato(2-di-t-butylphosphino-1,1'-binaphthyl)(2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 95% [TrixiePhos Palladacycle Gen. 3]
$C_{41}H_{44}NO_3PPdS$; FW: 768.25;
white to off-white pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620



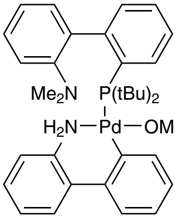
100mg
500mg
2g

PALLADIUM (Compounds)

46-2135

NEW

Methanesulfonato[2-(di-t-butylphosphino)-2'-(N,N-dimethylamino)-1,1'-biphenyl](2'-amino-1,1'-biphenyl-2-yl)palladium(II) dichloromethane adduct, min. 98% [t-BuDavePhos Palladacycle Gen. 3] *(1445085-92-6)*
$C_{35}H_{45}N_2O_3PPdS$; FW: 711.20; green-yellow pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620

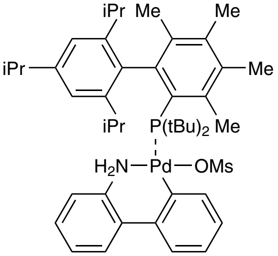


250mg
1g
5g

46-2163

NEW

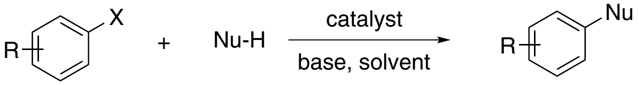
Methanesulfonato(2-di-t-butylphosphino-3,4,5,6-tetramethyl-2',4',6'-tri-i-propylbiphenyl)(2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 95% [Me4 t-ButylXPhos Palladacycle Gen. 3] *(1507403-85-1)*
C46H66NO3PPdS;
FW: 850.48; dark green pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620



100mg
500mg
2g

Technical Note:

1. Catalyst for cross-coupling reactions



Tech. Note (1)
Ref. (1)

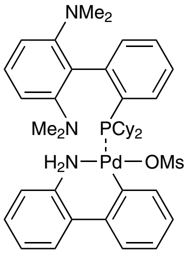
References:

1. *Org. Lett.* **2013**, *15*, 2876

46-0487

NEW

Methanesulfonato(2-dicyclohexylphosphino-2',6'-bis(dimethylamino)-1,1'-biphenyl)(2'-amino-1,1'-biphenyl-2-yl)palladium(II), 98% [CPhos Palladacycle Gen. 3] *(1447963-73-6)*
$C_{41}H_{54}N_3O_3PPdS$; FW: 806.35; white to off-white pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620.



100mg
500mg
2g

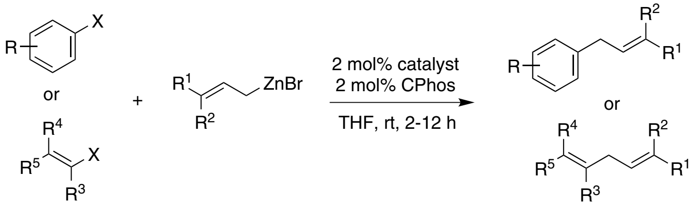
Technical Notes:

1. Catalyst for the highly selective cross-coupling of secondary alkylzinc reagents with heteroaryl halides
2. Catalyst for the completely linear-selective Negishi cross-coupling of allylzinc halides with aryl and vinyl electrophiles

$$\begin{array}{c}\text{HetAr-X}\\ +\\ \textit{sec}\text{-alkylZnBr}\cdot\text{LiCl}\end{array} \xrightarrow[\substack{\text{THF/toluene}\\ \text{0°C to rt, 1-12 hr}}]{\text{1 mol\% catalyst}} \text{HetAr-}\textit{sec}\text{-alkyl}$$

Tech. Note (1)
Ref. (1)

PALLADIUM (Compounds)



Tech. Note (2)
Ref. (2)

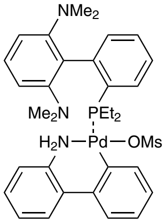
References:

1. *Org. Lett.,* **2014**, *16*, 4638
2. *Angew. Chem. Int. Ed.,* **2013**, *52*, 14098

46-0348

NEW

Methanesulfonato[2-diethylphosphino-2',6'-bis(dimethylamino)-1,1-biphenyl](2'-amino-1,1'-biphenyl-2-yl)palladium(II), min. 98% [EtCPhos Palladacycle Gen. 3]
$C_{33}H_{42}N_3O_3PPdS$; FW: 698.17;
white to off-white solid
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620



50mg
250mg

Technical Note:

1. Palladium catalyst for the cross-coupling of secondary alkylzinc reagents with heteroaryl halides

$$\text{HetAr-X} + \textit{sec}\text{-alkylZnBr•LiCl} \xrightarrow[\text{THF/toluene, 0°C to rt, 1-12 h}]{\text{1 mol\% catalyst}} \text{HetAr-}\textit{sec}\text{-alkyl}$$

excellent selectivity
for non-rearranged products

Tech. Note (1)
Ref. (1)

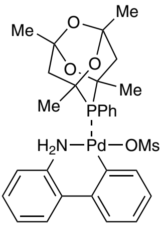
References:

1. *Org. Lett.,* **2014**, *16*, 4638

46-0392

NEW

Methanesulfonato(1,3,5,7-tetramethyl-8-phenyl-2,4,6-trioxa-8-phosphaadamantane)(2'-amino-1,1'-biphenyl-2-yl)palladium(II) dichloromethane adduct, min. 98% [MeCgPPh Palladacycle Gen. 3]
$C_{29}H_{34}NO_6PPdS$; FW: 662.04;
white to tan pwdr.
air sensitive, moisture sensitive
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620

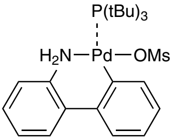


500mg
2g

46-0387

NEW

Methanesulfonato(tri-t-butylphosphino)(2'-amino-1,1'-biphenyl-2-yl)palladium(II), 98% [P(t-Bu)3 Palladacycle Gen. 3]
(1445086-17-8)
$C_{25}H_{40}NO_3PPdS$; FW: 572.05; white pwdr.
Note: Patents: PCT/US2013/030779, US Serial No. 13/799620.

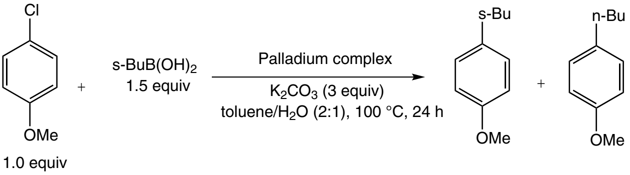


250mg
1g
5g

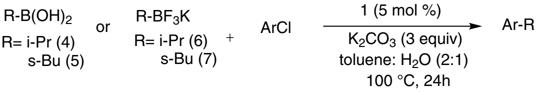
Technical Notes:

1. Pd-catalyzed cross-coupling reaction of s-BuB$(OH)_2$ and 4-chloroanisole.
2. Pd-catalyzed cross-coupling reaction of secondary alkylboronic acids and aryl chlorides.
3. Pd-catalyzed cross-coupling reaction of secondary alkyltrifluoroborates and aryl chlorides

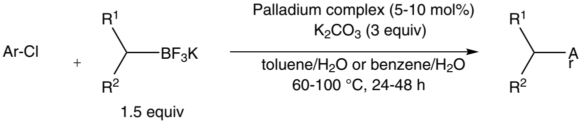
PALLADIUM (Compounds)



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (1)



Tech. Note (2)
Ref. (1)

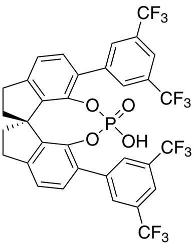
References:

1. *J. Am. Chem. Soc.,* **2014**, *136*, 14027

PHOSPHORUS (Compounds)

15-0527
NEW

(11aR)-3,7-Bis[3,5-bis(trifluoromethyl)phenyl]-10,11,12,13-tetrahydro-5-hydroxy-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1297613-76-3)*
$C_{33}H_{19}F_{12}O_4P$; FW: 738.46;
white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



25mg
100mg

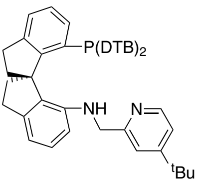
15-0528
NEW

(11aS)-3,7-Bis[3,5-bis(trifluoromethyl)phenyl]-10,11,12,13-tetrahydro-5-hydroxy-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1258327-07-9)*
$C_{33}H_{19}F_{12}O_4P$; FW: 738.46; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

25mg
100mg

15-5147
NEW

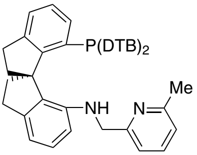
(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(4-t-butylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-4-t-Bu *(1298133-38-6)*
$C_{55}H_{71}N_2P$; FW: 791.14; white solid;
m.p. 86-88°
air sensitive



25mg
100mg

15-5148
NEW

(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(6-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-6-Me *(1298133-26-2)*
$C_{52}H_{65}N_2P$; FW: 749.06; white solid;
m.p. 153-155°
air sensitive

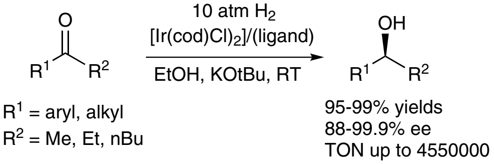


25mg
100mg

Technical Notes:

1. Extremely efficient chiral iridium catalyst used for the asymmetric hydrogenation of ketones.

PHOSPHORUS (Compounds)



Tech. Note (1)
Ref. (1)

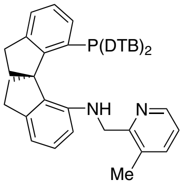
Reference:

1. *Angew. Chem Int. Ed.,* **2011**. *50,* 7329.

15-5158 NEW

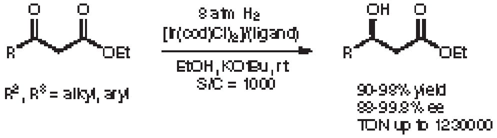
(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-yl-methyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-3-Me
(1298133-36-4)
$C_{52}H_{65}N_2P$; FW: 749.06;
white to off-white solid; m. p. 160-161°
air sensitive

25mg
100mg

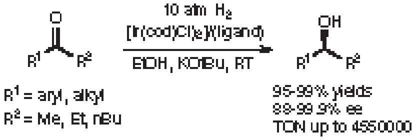


Technical Notes:

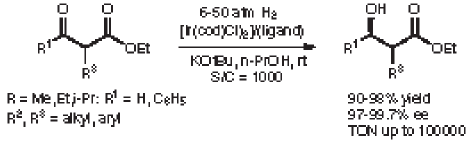
1. Iridium/ligand catalyst for the highly efficient, asymmetric hydrogenation of β-aryl and β-ketoesters.
2. Extremely efficient chiral iridium catalyst used for the asymmetric hydrogenation of ketones.
3. Iridium/ligand catalyst for the highly efficient, asymmetric hydrogenation of β-aryl and β-ketoesters.



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

Reference:

1. *Angew. Chem Int. Ed.*, **2011**, *50*, 7329.
2. *Angew. Chem Int. Ed.*, **2012**, *51*, 201.
3. *Org. Lett.*, **2012**, *14*, 6158.

15-5159 NEW

(S)-(-)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) S)-DTB-SpiroPAP-3-Me
$C_{52}H_{65}N_2P$; FW: 749.06; white to off-white solid; m. p. 162-164°
air sensitive

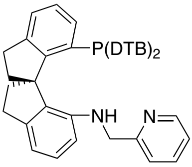
25mg
100mg

Technical Note: See 15-5158.

PHOSPHORUS (Compounds)

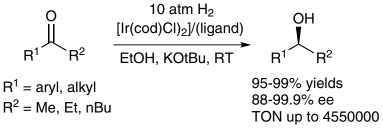
15-5166
NEW

(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(pyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP *(1298133-21-7)*
$C_{51}H_{63}N_2P$; FW: 735.03; white solid;
m. p. 172-174°
air sensitive



25mg
100mg

Technical Note:
1. Extremely efficient chiral iridium catalyst used for the asymmetric hydrogenation of ketones.



Tech. Note (1)
Ref. (1)

References:
1. *Angew. Chem Int. Ed,* **2011**, *50*, 7329.

15-5167
NEW

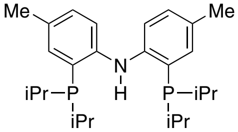
(S)-(-)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(pyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP *(1298133-21-7)*
$C_{51}H_{63}N_2P$; FW: 735.03; white solid;
m. p. 170-171°
air sensitive

25mg
100mg

Technical Note: See 15-5166.

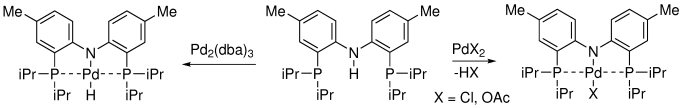
15-0670
NEW

Bis[2-(di-i-propylphosphino)-4-methylphenyl]amine, min. 98% *(666856-94-6)*
$C_{26}H_{41}NP_2$; FW: 429.56; white pwdr.
air sensitive



100mg
500mg

Technical Note:
1. Ligand for PNP pincer complexes of palladium

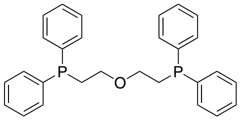


Tech. Note (1)
Ref. (1)

References:
1. *Organometallics,* **2004**, *23*, 326

15-0383
NEW

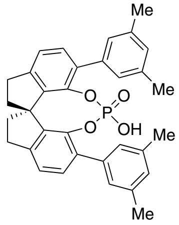
[Bis(2-diphenylphosphino)ethyl]ether, min. 98% *(50595-38-5)*
$C_{28}H_{28}OP_2$; FW: 442.47; pale yellow oil
air sensitive



1g
5g
25g

15-0542
NEW

(11aR)-3,7-Bis(3,5-dimethylphenyl)-10,11,12,13-tetrahydro-5-hydroxy-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1297613-75-2)*
$C_{33}H_{31}O_4P$; FW: 522.57; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.



25mg
100mg

PHOSPHORUS (Compounds)

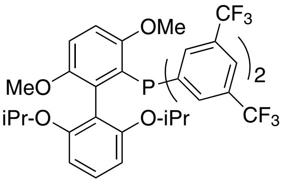
15-0543 NEW

(11aS)-3,7-Bis(3,5-dimethylphenyl)-10,11,12,13-tetrahydro-5-hydroxy-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1412439-82-7)*
$C_{33}H_{31}O_4P$; FW: 522.57; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

25mg
100mg

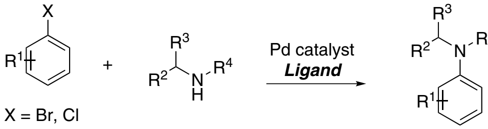
15-3020 NEW

2-[Bis(3,5-trifluoromethylphenylphosphino)-3,6-dimethoxy]-2',6'-di-i-propoxy-1,1'-biphenyl, 98% *(1810068-31-5)*
$C_{36}H_{31}F_{12}O_4P$; FW: 786.58;
white to off-white pwdr.
Note: Patents: US 6,395,916, US 6,307,087



250mg
1g
5g

Technical Note:
1. Ligand for the Palladium-catalyzed arylation of α-Branched Secondary Amines

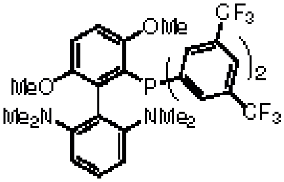


Tech. Note (1)
Ref. (1)

References:
1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8259

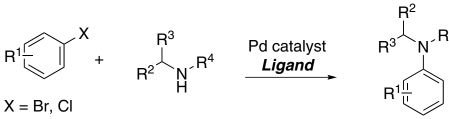
15-3015 NEW

2-[Bis(3,5-trifluoromethylphenylphosphino)-3,6-dimethoxy]-2',6'-dimethylamino-1,1'-biphenyl, 98% *(1810068-30-4)*
$C_{34}H_{29}F_{12}N_2O_2P$; FW: 756.56;
white to off-white pwdr.
Note: Patents: US 6,395,916, US 6,307,087



100mg
500mg
2g

Technical Note:
1. Ligand for the Palladium-catalyzed arylation of α-Branched Secondary Amines

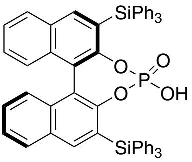


Tech. Note (1)
Ref. (1)

References:
1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8259

15-0340 NEW

(R)-(-)-3,3'-Bis(triphenylsilyl)-1,1'-binaphthyl-2,2'-diyl hydrogen phosphate, min. 98% [(R)-TiPSY] *(791616-55-2)*
$C_{56}H_{41}O_4PSi_2$; FW: 865.07; white to light-yellow pwdr.; m. p. 329-335°
Note: Sold in collaboration with Daicel for research purposes only.

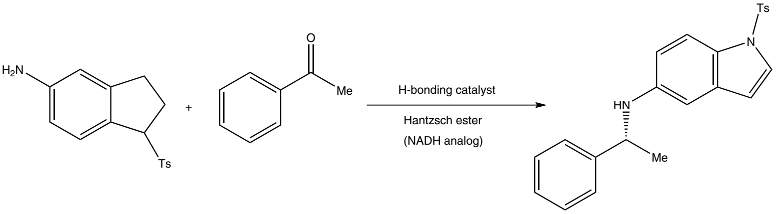


10mg
100mg

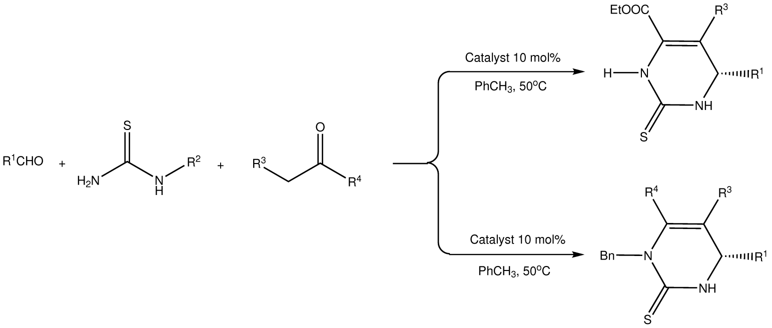
Technical Notes:
1. A chiral phosphoric acid catalyst providing a highly stereoselective method for the reductive amination of heterocyclic amines.
2. Chiral phosphoric acid used for the enantioselective Biginelli and Biginelli-like reactions.

PHOSPHORUS (Compounds)

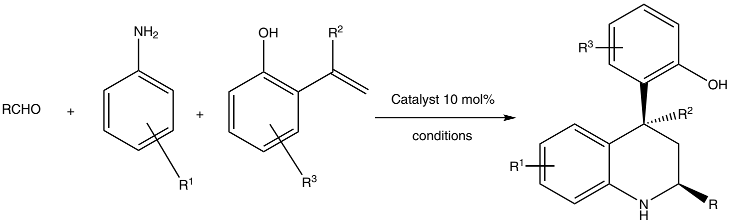
3. Chiral phosphoric acid organocatalyst used in the asymmetric, three-component Povarov reaction involving 2-hydroxystyrenes. An efficient method to access structurally diverse *cis*-disubstituted tetrahydroquinolines in high stereoselectivities of up to >99:1 dr and 97% ee.
4. A gold/chiral phosphoric acid catalyst used for the highly stereoselective, three-component reaction of salicylaldehydes, anilines, and alkynols to give aromatic spiroacetals in high yields and stereoselectivities.
5. aza-Pinacol Cyclization



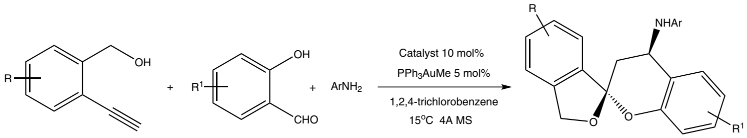
Tech. Note (1)
Ref. (1)



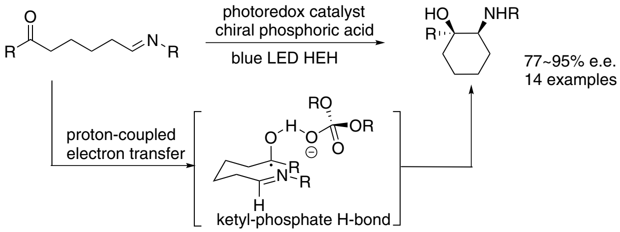
Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)



Tech. Note (4)
Ref. (4)



Tech. Note (5)
Ref. (5)

PHOSPHORUS (Compounds)

References:
1. *J. Am. Chem. Soc.* **2006**, *128*, 84
2. *J. Am. Chem. Soc.* **2009**, *131*, 15301
3. *J. Am. Chem. Soc.* **2012**, *134*, 6970
4. *Org. Lett.*, **2013**, *15*, 460
5. *J. Am. Chem. Soc.* **2013**, *135*, 17735

15-0341

NEW

(S)-(+)-3,3'-Bis(triphenylsilyl)-1,1'-binaphthyl-2,2'-diyl hydrogen phosphate, min. 98% [(S)-TiPSY] *(929097-92-7)*
$C_{56}H_{41}O_4PSi_2$; FW: 865.07; white to light-yellow solid; m. p. 329-335°
Note: Sold in collaboration with Daicel for research purposes only.

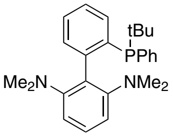
10mg
100mg

Technical Note: See 15-0340.

15-3010

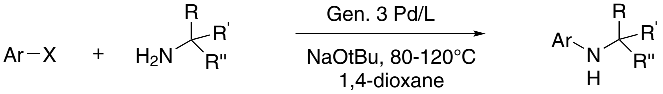
NEW

2-(t-Butylphenylphosphino)-2',6'-dimethylamino-1,1'-biphenyl, 98% (t-Bu)PhCPhos *(1660153-91-2)*
$C_{26}H_{33}N_2P$; FW: 404.53;
white to off-white pwdr.
Note: Patents: US 6,395,916, US 6,307,087



250mg
1g
5g

Technical Note:
1. Ligand for the Palladium-catalyzed Buchwald-Hartwig cross-coupling of hindered primary amines and aryl halides



Tech. Note (1)
Ref. (1)

References:
1. *J. Am. Chem. Soc.*, **2015**, *137*, 3085

15-0690

NEW

HAZ

Chloro(t-butyl)phenylphosphine, 97% *(29949-69-7)*
$C_{10}H_{14}ClP$; FW: 200.65; colorless liq.
air sensitive, moisture sensitive

1g
5g

28-0110

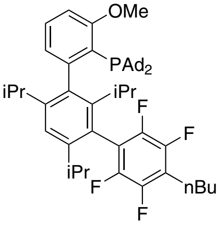
NEW

Chlorobis(triphenylphosphino)phenylnickel(II), 98% *(33571-43-6)*
See page 45

15-2065

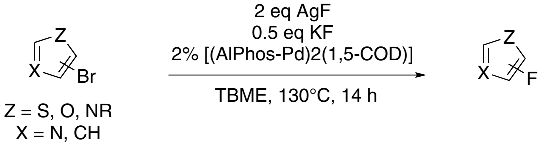
NEW

2-(Diadamantylphosphino)-3-methoxy-2',4',6'-tri-i-propyl-3'-(2,3,5,6-tetrafluoro-4-butylphenyl)-1,1'-biphenyl AlPhos *(1805783-60-1)*
$C_{52}H_{67}F_4OP$; FW: 815.06;
white to yellow pwdr.
air sensitive
Note: Patents: US 6,395,916, US 6,307,087



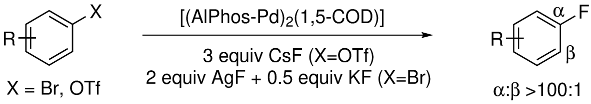
100mg
500mg
2g

Technical Notes:
1. Ligand for the Palladium-Catalyzed Fluorination of Five-Membered Heteroaryl Bromides
2. Ligand for the Palladium-Catalyzed Fluorination of Aryl Triflates and Bromides



Tech. Note (1)
Ref. (1)

PHOSPHORUS (Compounds)



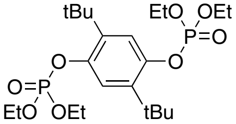
Tech. Note (2)
Ref. (2)

References:

1. *Organometallics,* **2015**, *34*, 4775
2. *J. Am. Chem. Soc.* **2015**, *137*, 13433

15-1375 **NEW** **2,5-Di-t-butyl-1,4-phenylene tetraethyl bis(phosphonate), 99+% Redox shuttle ANL-RS6** *(1350767-15-5)*
$C_{22}H_{40}O_8P_2$; FW: 494.50; white solid
air sensitive, moisture sensitive
Note: U.S. Patents: 8,969,625

500mg
2g



Technical Notes:

Redox Shuttles for Lithium Ion Batteries

1. Provides a long term intrinsic overcharge protection of lithium-ion batteries.
2. Maintains the safe operation of lithium-ion batteries.
3. Highly-soluble in conventional non-aqueous, carbonate based electrolytes.
4. Increases battery long-term stability and oxidation potential.

Electrochemical Properties:

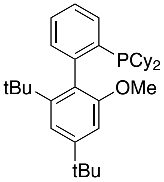
1. ANL-RS6 exhibits a reversible redox potential of about 4.8V vs Li/Li$^+$ (1.2 M $LiPF_6$ in mixture of ethylene carbonate and ethyl methyl carbonate (3:7 by weight) with 0.01M ANL-RS6 [1]
2. In cell tests using $LiMn_2O_4$ and $Li_{1.2}Ni_{0.15}Co_{0.1}Mn_{0.55}O_2$ as the cathode materials, overcharge protection was provided at 4.75 V vs. Li/Li$^+$.

References:

1. *Energy Environ. Sci.,* **2011**, *4*, 2858

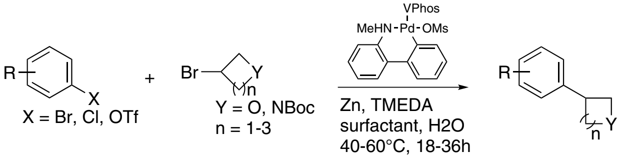
15-1105 **NEW** **2-Dicyclohexylphosphino-2'-methoxy-4',6'-di-t-butyl-1,1'-biphenyl, min. 98% VPhos** *(1848244-75-6)*
$C_{33}H_{49}OP$; FW: 492.72; white to off-white solid
Note: Patents: US 6,395,916, US 6,307,087

250mg
1g
5g



Technical Note:

1. Ligand for the palladium catalyzed aqueous Lipshutz-Negishi cross-coupling of alkyl halides with aryl electrophiles.



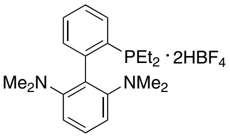
Tech. Note (1)
Ref. (1)

References:

1. *Angew. Chem. Int. Ed.,* **2016**, *55*, 1849

15-1151 **NEW** **2-Diethylphosphino-2',6'-bis(dimethylamino)-1,1'-biphenyl di(hydrogen tetrafluoroborate) salt, min. 98% EtCPhos**
$C_{20}H_{29}N_2P{\cdot}2(HBF_4)$; FW: 504.01;
white pwdr.
Note: Patents: US 6,395,916, US 6,307,087.

100mg
500mg

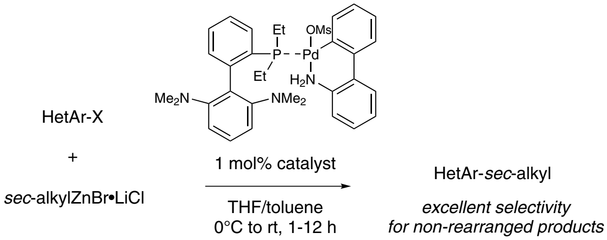


Technical Note:

1. Ligand used in palladium-catalyzed cross-coupling of secondary alkylzinc reagents with heteroaryl halides

Note: Technical note shown is for 46-0348, EtCPhos Palladacycle Gen. 3

PHOSPHORUS (Compounds)



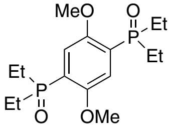
Tech. Note (1)
Ref. (1)

References:

1. *Org. Lett.,* **2014**, *16*, 4638

15-1372 NEW

(2,5-Dimethoxy-1,4-phenylene)bis(diethylphosphine oxide), 99+% Redox shuttle ANL-RS51 *(1802015-49-1)*
$C_{16}H_{28}O_4P_2$; FW: 402.45; white solid
air sensitive, moisture sensitive
Note: U.S. Patent: 14/171,556



500mg
2g

Technical Notes:

Redox Shuttles for Lithium Ion Batteries

1. Provides a long term intrinsic overcharge protection of lithium-ion batteries.
2. Maintains the safe operation of lithium-ion batteries.
3. Highly-soluble in conventional non-aqueous, carbonate based electrolytes.
4. Increases battery long-term stability and oxidation potential.

Electrochemical Properties:

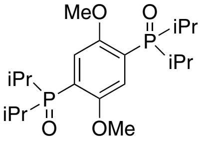
1. ANL-RS51 exhibits a reversible redox potential of about 4.6V vs Li/Li+ (1.2 M $LiPF_6$ in 3:7 wt/wt mixture of ethylene carbonate and ethyl methyl carbonate).

References:

1. *US* 20150221982, *A1*, 6, Aug, 2015

15-1365 NEW

(2,5-Dimethoxy-1,4-phenylene) bis(di-i-propylphosphine oxide), 99+% Redox shuttle ANL-RS5 *(1426397-81-0)*
$C_{20}H_{36}O_4P_2$; FW: 402.45; white pwdr.
air sensitive, moisture sensitive
Note: U.S. Patent: 14/171,556



250mg
1g

Technical Notes:

Redox Shuttles for Lithium Ion Batteries

1. Provides a long term intrinsic overcharge protection of lithium-ion batteries.
2. Maintains the safe operation of lithium-ion batteries.
3. Highly-soluble in conventional non-aqueous, carbonate based electrolytes.
4. Increases battery long-term stability and oxidation potential.

Electrochemical Properties:

1. ANL-RS5 (abbreviated BPDB) exhibits a reversible redox potential of about 4.5V vs Li/Li^+ (1.2 M $LiPF_6$ in 3:7 wt/wt mixture of ethylene carbonate and ethyl methyl carbonate) [1]
2. Provides stable overcharge protection for 4V MCMB (mesocarbon microbead)/LMO ($LiMn_2O_4$) cells delivering 95 cycles of 100% overcharge at room temperature [1]

References:

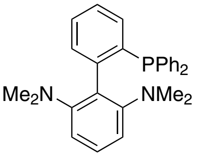
1. *J. Mater. Chem., A,* **2015**, *3*, 10710.2
2. *J. Power Sources,* **2014**, *247*, 1011
3. *J. Electrochem. Soc.* **2014**, *161*, A1905
4. *J. Electrochem. Soc.* **2016**, *163*, A1

PHOSPHORUS (Compounds)

15-1125
NEW

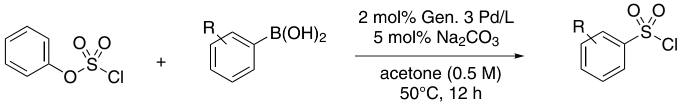
2-Diphenylphosphino-2',6'-bis(dimethylamino)-1,1'-biphenyl, min. 98%
PhCPhos *(1447963-71-4)*
$C_{28}H_{29}N_2P$; FW: 424.52; tan solid
Note: Patents: US 6,395,916, US 6,307,087

100mg
500mg

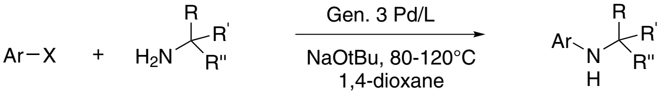


Technical Notes:

1. Ligand for the Palladium catalyzed chlorosulfonylation of aryl boronic acids
2. Ligand for the Palladium-catalyzed Buchwald-Hartwig cross-coupling of hindered primary amines and aryl halides



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)

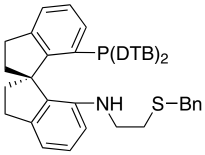
References:

1. *J. Am. Chem. Soc.,* **2013**, *135*, 10638
2. *J. Am. Chem. Soc.,* **2015**, *137*, 3085

15-1613
NEW

(R)-(+)-7-[N-(2-benzylthio)ethylamino]-7'-[bis(3,5-di-t-butylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP-Bn] *(1809609-52-6)*
$C_{54}H_{68}NPS$; FW: 794.16; off-white solid
air sensitive

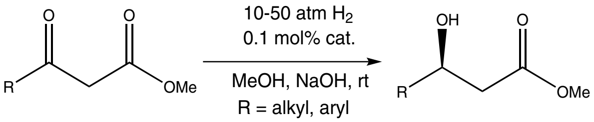
25mg
100mg



Technical Note:

1. Catalyst used for the asymmetric hydrogenation of β-alkyl- β-ketoesters.

*This technical note is for the iridium complex 77-2510. This is an analogous ligand included in the reference below.



Tech. Note (1)
Ref. (1)

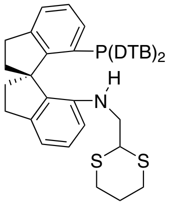
References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8791

15-1638
NEW

(R)-(+)-7-[N-(1,3-dithian-2-yl)methylamino]-7'-[bis(3,5-di-t-butylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP]
(1809609-53-7)
$C_{50}H_{66}NPS_2$; FW: 776.17;
white to off-white solid; m. p. 95-97°
air sensitive

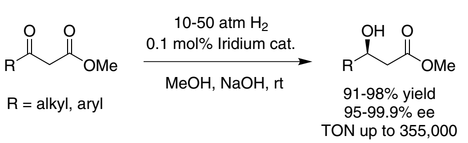
25mg
100mg

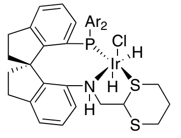


Technical Note:

1. Chiral P-N-S Spiro Ligand used in the Iridium-catalyzed asymmetric Hydrogenation of Ketoesters

PHOSPHORUS (Compounds)





Iridium catalyst (77-2150)

Tech. Note (1)
Ref. (1)

References:

1. *Angew. Chem. Int. Ed.* **2015**, *54*, 8791

15-1639 **NEW**

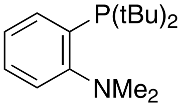
(S)-(-)-7-[N-(1,3-dithian-2-yl)methylamino]-7'-[bis(3,5-di-t-butylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(S)-DTB-SpiroSAP]
$C_{50}H_{66}NPS_2$; FW: 776.17; white to off-white solid; m. p. 95-97°
air sensitive

25mg
100mg

Technical Note: See 15-1638.

15-1260 **NEW**

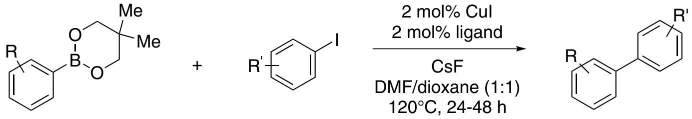
[2-(N,N-Dimethylamino)phenyl]di-t-butylphosphine, min. 95% *(415941-58-1)*
C16H28NP; FW: 265.37;
white to light-brown xtl.; m. p. 50-53°
Note: Ligand used in the copper-catalyzed coupling of arylboronate esters with aryl and heteroaryl halides.



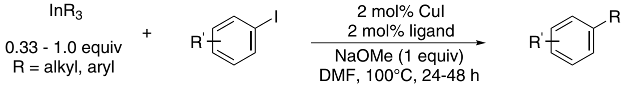
1g
5g

Technical Notes:

1. Ligand for the Copper-Catalyzed Suzuki-Miyaura Coupling of Arylboronate Esters and Aryl Iodides
2. Ligand for the Copper-Catalyzed Coupling of Triaryl- and Trialkylindium reagents with Aryl Iodides and Bromides



Tech. Note (1)
Ref. (1)



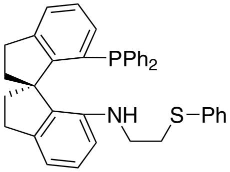
Tech. Note (2)
Ref. (2)

References:

1. *Org. Lett.*, **2014**, *16*, 1264
2. *Angew. Chem. Int. Ed.*, **2014**, *53*, 11620

15-1643 **NEW**

(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7'-[diphenylphosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(R)-Ph-SpiroSAP-Ph] *(1809609-40-2)*
$C_{37}H_{34}NPS$; FW: 555.71; off-white solid; m. p. 55-58°
air sensitive



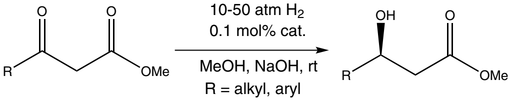
25mg
100mg

Technical Note:

1. Catalyst used for the asymmetric hydrogenation of β-alkyl- β-ketoesters.

*This technical note is for the iridium complex 77-2510. This is an analogous ligand included in the reference below.

PHOSPHORUS (Compounds)



Tech. Note (1)
Ref. (1)

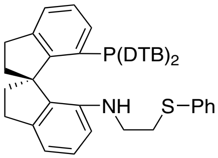
References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8791

15-1605

NEW

(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7'-[bis(3,5-di-t-butylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP-Ph] *(1809609-38-8)*
$C_{53}H_{66}NPS$; FW: 780.14; off-white solid; m. p. 58-60°
air sensitive

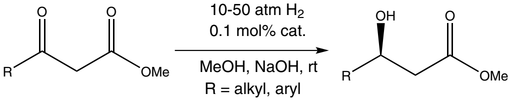


25mg
100mg

Technical Note:

1. Catalyst used for the asymmetric hydrogenation of β-alkyl- β-ketoesters.

*This techical note is for the iridium complex 77-2510. This is an analogous ligand included in the reference below.



Tech. Note (1)
Ref. (1)

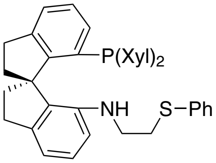
References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8791

15-1645

NEW

(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7'-[bis(3,5-dimethylphenyl)phosphino]-2,2',3,3'-tetrahydro-1,1'-spirobindane, 97+% (>99% ee) [(R)-Xyl-SpiroSAP-Ph] *(1809609-39-9)*
$C_{41}H_{42}NPS$; FW: 611.82; off-white solid; m. p. 58-60°
air sensitive

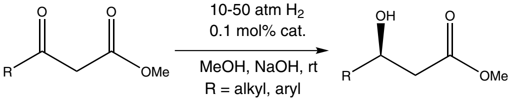


25mg
100mg

Technical Note:

1. Catalyst used for the asymmetric hydrogenation of β-alkyl- β-ketoesters.

*This technical note is for the iridium complex 77-2510. This is an analogous ligand included in the reference below.



Tech. Note (1)
Ref. (1)

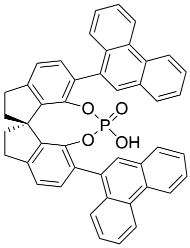
References:

1. *Angew. Chem. Int. Ed.,* **2015**, *54*, 8791

15-1363

NEW

(11aR)-10,11,12,13-Tetrahydro-5-hydroxy-3,7-di-9-phenanthrenyl-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1372719-93-1)*
$C_{45}H_{31}O_4P$; FW: 666.70; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.

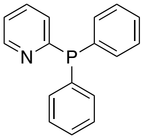


25mg
100mg

PHOSPHORUS (Compounds)

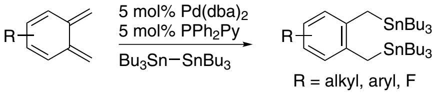
15-1364 **NEW**
(11aS)-10,11,12,13-Tetrahydro-5-hydroxy-3,7-di-9-phenanthrenyl-5-oxide-diindeno[7,1-de:1',7'-fg][1,3,2]dioxaphosphocin, min. 98% *(1585988-92-6)*
$C_{45}H_{31}O_4P$; FW: 666.70; white to light-yellow pwdr.
Note: Sold in collaboration with Daicel for research purposes only.
25mg
100mg

15-1780 **NEW**
2-Diphenylphosphinopyridine, min. 97% *(37943-90-1)*
$C_{17}H_{14}NP$; FW: 263.27; white to off-white solid
5g
25g

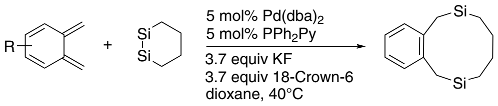


Technical Notes:

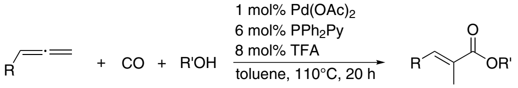
1. Ligand for the palladium-catalyzed distannylation of ortho-quinodimethanes
2. Ligand for the palladium-catalyzed disilylation of o-quinodimethanes to synthesize 9- and 10-membered disilacarbocycles
3. Ligand for the palladium-catalyzed alkoxycarbonylation of allenes



Tech. Note (1)
Ref. (1)



Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

References:

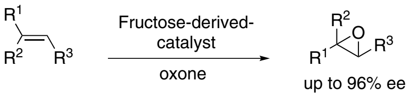
1. *Org. Lett.*, **2006**, *8*, 4157
2. *Org. Lett.*, **2008**, *10*, 4319
3. *J. Am. Chem. Soc.*, **2015**, *137*, 8556

POTASSIUM (Compounds)

19-5395 **NEW**
HAZ
Potassium monoperoxysulfate OXONE® *(70693-62-8)*
$2KHSO_5\cdot KHSO_4\cdot K_2SO_4$; FW: 307.37; white solid
25g
100g

Technical Notes:

1. Reagent for the catalytic asymmetric Shi epoxidation
2. Reagent for the synthesis of nitro heteroaromatics in water
3. Reagent for the syntheses of benzoxazoles and benzothiazoles using aryl iodides via C-H functionalization and C-O/S bond formation
4. Reagent used for bromolactonization in the asymmetric total synthesis of (+)-Dubiusamine C
5. Reagent for the benzofuran oxidative dearomatization cascade in the total synthesis of Integrastatin B

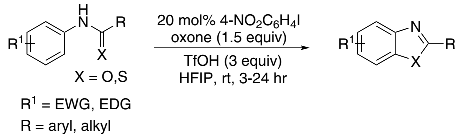


Tech. Note (1)
Ref. (1)

POTASSIUM (Compounds)

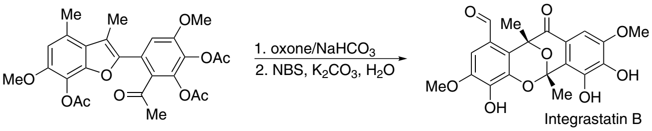
$$\text{HetAr-NH}_2 \xrightarrow[\text{40°C, 18 hr}]{\text{oxone, water}} \text{HetAr-NO}_2$$

Tech. Note (2)
Ref. (2)



Tech. Note (3)
Ref. (3)

Tech. Note (4)
Ref. (4)



Tech. Note (5)
Ref. (5)

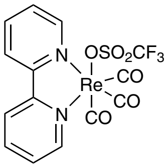
References:

1. *J. Am. Chem. Soc.,* **1997***, 119,* 11224.
2. *J. Org. Chem.,* **2006***, 71,* 1715.
3. *J. Org. Chem.,* **2007***, 72,* 4093.
4. *J. Org. Chem.,* **2008***, 73,* 9539.
5. *Org. Lett.,* **2009***, 11,* 5150.
6. *J. Org. Chem.,* **2009***, 74,* 6335.
7. *Org. Process Res. Dev.,* **2014***, 18,* 886.
8. *J. Org. Chem.,* **2014***, 79,* 7502.
9. *J. Org. Chem.,* **2015***, 80,* 9132.
10. *Org. Lett.,* **2016***, 18,* 1458.

RHENIUM (Compounds)

75-2385
NEW

Trifluoromethylsulfonatotricarbonyl(2,2'-bipyridine)rhenium(I), 99%
(97170-94-0)
$C_{14}H_8F_3N_2O_6ReS$; FW: 575.49;
light yellow pwdr.

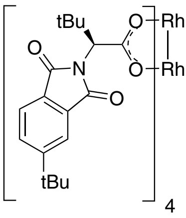


100mg
500mg

RHODIUM (Compounds)

45-2105
NEW

Tetrakis[N-5-t-butyl-phthaloyl-(S)-tert-leucinato]dirhodium bis(ethyl acetate) adduct Rh2(S-tertPTTL)4
$C_{72}H_{88}N_4O_{16}Rh_2$; FW: 1471.30; green pwdr.
Note: Sold for research and development purposes only. Patent 2014. 2014903620.

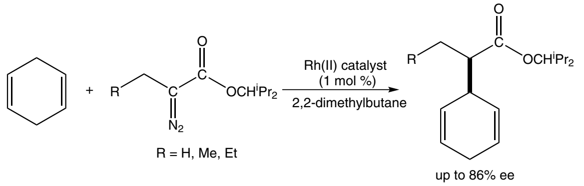


50mg
250mg

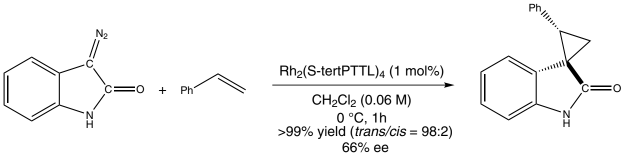
Technical Notes:

RHODIUM (Compounds)

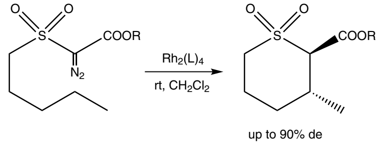
1. Catalyst used for the asymmetric, intermolecular C-H insertion of 1,4-cyclohexadiene with α-alkyl-α-diazoesters.
2. Catalyst used for a catalytic cyclopropanation using diazooxindole..
3. Catalyst used for the asymmetric, intramolecular C-H insertion of sulfonyldiazoacetates.
4. Catalyst used for the enantioselective synthesis of 2-arylbicyclo[1.1.0]butane carboxylates.
5. Access to the [3.2.2] nonatriene structural frameworks via an intramolecular cyclopropenation/ Buchner reaction/Cope rearrangement cascade.
6. Catalyst used for the cyclopropanation of styrene with dimethyl-α-diazobenzylphosphonate.



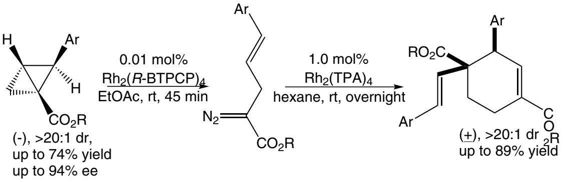
Tech. Note (1)
Ref. (1)



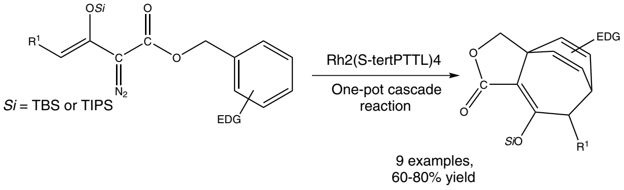
Tech. Note (2)
Ref. (2)



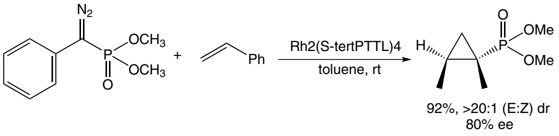
Tech. Note (3)
Ref. (3)



Tech. Note (4)
Ref. (4)



Tech. Note (5)
Ref. (5)



Tech. Note (6)
Ref. (6)

RHODIUM (Compounds)

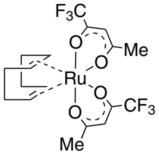
References:

1. *Heterocycles,* **2012**, *86*, 1647
2. *SynLett,* **2013**, *24*, 29
3. *Tetrahedron-Asymmetry,* **2013**, *24*, 151
4. *Org. Lett.,* **2013**, *15*, 310
5. *Org. Lett.,* **2015**, *17*, 790
6. *Tetrahedron Lett.,* **2016**, *57*, 852
7. *Chem. Eur. J.,* **2016**, *22*, 1

RUTHENIUM (Compounds)

44-8165
NEW

Bis(1,1,1-trifluoro-2,4-pentanedionato)(1,5-cyclooctadiene)ruthenium(II), 98%
(38704-78-8)
$C_{18}H_{20}F_6O_4Ru$; FW: 515.41;
red-brown low melting solid;
b.p. 120-160/1 mm



50mg
250mg

44-0610
NEW

Hexaammineruthenium(II) chloride, 98% *(15305-72-3)*
$Ru(NH_3)_6Cl_2$; FW: 274.16; pale yellow pwdr.
air sensitive, moisture sensitive,

250mg
1g
5g

SILICON (Compounds)

98-8810
NEW
HAZ

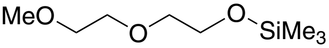
Bis(diethylamino)silane, 99% (99.999%-Si) BDEAS PURATREM
(27804-64-4)
$SiH_2[N(CH_2CH_3)_2]_2$; FW: 174.36; colorless liq.
air sensitive, moisture sensitive

5g
25g

14-1925
NEW

2,2-Dimethyl-3,6,9-trioxa-2-siladecane, 99+% Electrolyte Solvent ANL-1NM2 *(62199-57-9)*
$C_8H_{20}O_3Si$; FW: 192.33; colorless liq.
air sensitive, moisture sensitive
Note: U.S. Patent: 8,475,688

500mg
2g



Technical Notes:

Organosilicon Electrolytes for Lithium Ion Batteries

1. Silicon based electrolytes with polyethylene glycol oligomers improve thermal and electrochemical stability of lithium-ion batteries
2. Increases battery long-term stability
3. Are less flammable then conventional organic carbonate-based solvents and maintain the safe operation of batteries
4. Improves conductivity and kinetics of the lithium salts

Electrochemical and Physical Properties

1. **Viscosity:** 0.9 cP at 25°C; **Conductivity:** 1.2×10^{-3} S cm^{-1} at 25°C (1.0 M LiTFSI); **Boiling point:** 190-191°C; **Glass transition temperature:** -129°C [1-3].
2. Soluble electrolytic lithium salt LiTFSI; Less soluble LiBOB.
3. Silylated electrolytes show much better electrochemical stability than its carbon and germanium analogues [3].
4. Compare to other trimethylsilylated polyethyleneoxide oligomers, the chain with two and three (see also ANL-1NM3; product # 14-1930). Ethylene oxide units in certain electrolytic blends are advantageous for the conductivity and the kinetics of the lithium salts [3-4].

References:

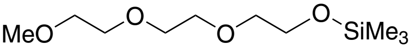
1. *Electrochem. Commun.,* **2006**, *8*, 429
2. *J. Phys. Chem. C,* **2008**, *112*, 2210
3. *J. Mater. Chem.,* **2008**, *18*, 3713
4. *J. Power Sources,* **2014**, *272*, 190

SILICON (Compounds)

14-1930 NEW **2,2-Dimethyl-3,6,9,12-tetroxa-2-silatridecane, 99+% Electrolyte Solvent ANL-1NM3** *(864079-62-9)* 1g 5g

$C_{10}H_{24}O_4Si$; FW: 236.38; colorless liq.

Note: Use for batteries for medical devices expressly excluded. U.S. Patent: 8,076,032



Technical Notes:

Organosilicon Electrolytes for Lithium Ion Batteries

1. Silicon based electrolytes with polyethylene glycol oligomers improve thermal and electrochemical stability of lithium-ion batteries
2. Increases battery long-term stability.
3. Are less flammable as conventional organic carbonate-based solvents and maintain the safe operation of batteries.
4. Improves conductivity and kinetics of the lithium salts

Electrochemical and Physical Properties:

1. **Viscosity:** 1.4 cP at 25°C, doped with 0.8M LiBOB electrolyte 1.9 cP at 25°C; **Conductivity:** of 0.8M LiBOB doped electrolyte: 1.18 x 10^{-3}S cm^{-1} at 25°C; **Thermally stable** up to 400°C. **Boiling point** 233-234°C; **Glass transition temperature** -116°C [1, 2].
2. Soluble electrolytic lithium salts: LiBOB, LiPF6 (03-0325), $LiBF_4$ (03-0325 Strem product - not battery grade) and LiTFSI
3. ANL-1NM3 electrolytes show excellent charge/discharge cycling behavior in lithium-ion cells. Silane-based electrolytes with certain lithium salts are stable to 4.4 V [1]
4. Compared to other trimethylsilylated polyethyleneoxide oligomers the chain with two (see also ANL-1NM2; product # 14-1925) and three ethylene oxide units in certain electrolytic blends is advantageous for the conductivity and the kinetics of the lithium salts [2]. In some cases ANL-1NM3 is more preferable material because of higher boiling point (233-234°C vs 190-191°C of ANL-1NM2)and a low viscosity.
5. ANL-1NM3 doped with Lithium salts exhibit high ionic conductivity (more than 10^{-3}S cm^{-1}) at room temperature. Lithium bis(oxalate)borate (LiBOB) salt blended silicon electrolyte is showing most stable and higher electrochemical performance [3-5]. In addition silylated electrolytes show much better electrochemical stability than its carbon and germanium analogues [6].
6. Organosilicon electrolyte helps to enhance the transport properties of other electrolytes [7], shows excellent thermal and electrochemical stability [8] and also applicable for Li-air batteries [9]

References:

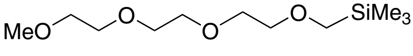
1. *Electrochem. Commun.,* **2006**, *8*, 429
2. *Phys. Chem. C,* **2008**, *112*, 2210
3. *J. Power Sources,* **2011**, *196*, 2255
4. *J. Power Sources,* **2011**, *196*, 8301
5. *J. Phys. Chem. C,* **2011**, *115*, 24013
6. *J. Mater. Chem.,* **2008**, *18*, 3713
7. *J. Phys. Chem. C,* **2010**, *114*, 20569
8. *J. Power Sources,* **2013**, *241*, 311
9. *J. Phys. Chem. C,* **2011**, *115*, 25535

14-1946 NEW **2,2-Dimethyl-4,7,10,13-tetraoxa-2-silatetradecane, 99+% Electrolyte Solvent ANL-1S1M3** *(864079-63-0)* 1g 5g

$C_{11}H_{26}O_4Si$; FW: 250.41; colorless liq.

air sensitive, moisture sensitive

Note: Use for batteries for medical devices expressly excluded. U.S. Patent: 8,076,032



Technical Notes:

Organosilicon Electrolytes for Lithium Ion Batteries

1. Silicon based electrolytes with polyethylene glycol oligomers improve thermal and electrochemical stability of lithium-ion batteries
2. Increases battery long-term stability
3. Are less flammable as conventional organic carbonate-based solvents and maintain the safe operation of batteries
4. Improves conductivity and kinetics of the lithium salts;

Electrochemical and Physical Properties:

1. **Viscosity** 2.0 cP at 25°C; **Conductivity** of 0.8M LiBOB electrolyte: 1.29 x 10^{-3} S cm^{-1}at 25°C. **Boiling point** 245°C; **Glass transition temperature** -110°C [1, 2].
2. Soluble electrolytic lithium salts: LiBOB, $LiPF_6$ (03-0325), and LiTFSI
3. ANL-1S1M3 is non-hydrolyzable and less flammable than their alkoxysilane counterparts [2].

SILICON (Compounds)

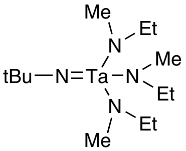
4. ANL-1S1M3 electrolyte cell test showed good cycling performance in lithium-ion batteries. The cell was charged and discharged at a C/5 rate and cycled between 3.0 and 4.2 V at room temperature. It exhibits excellent cycling performance with only 9% capacity loss over 200 cycles [2].

References:

1. *Electrochem. Commun.,* **2006**, *8*, 429
2. *J. Mater. Chem.,* **2010**, *20*, 8224

14-7126 **NEW**	**Silicon carbide (alpha phase), 0.2-1.2 microns (99%-Si)** *(409-21-2)* SiC; FW: 40.10; light-gray pwdr.	100g 500g
14-7120 **NEW**	**Silicon carbide (>90% beta phase), 0.1-1.2 microns (99%-Si)** *(409-21-2)* SiC; FW: 40.10; gray pwdr.	50g 250g
14-7123 **NEW**	**Silicon carbide (>90% beta phase), 0.2-5.0 microns (99+%-Si)** *(409-21-2)* SiC; FW: 40.10; light-gray pwdr.	50g 250g
14-7410 **NEW**	**Silicon nitride (>90% alpha phase), 0.2-4.0 microns (99%-Si)** *(12033-89-5)* Si_3N_4; FW: 140.28; gray pwdr.	100g 500g
14-7423 **NEW**	**Silicon nitride, 0.2-2.5 microns (99.99%-Si) PURATREM** *(12033-89-5)* Si_3N_4; FW: 140.28; light gray pwdr.	50g 250g
14-6990 **NEW** HAZ	**Tetrakis(ethylmethylamino)silane, 98%, TEMAS** *(477284-75-6)* [CH3(CH2CH2)N]4Si; FW: 260.57; colorless liq.; b.p. 40°C; d. 0.89 *moisture sensitive*	1g 5g 25g

TANTALUM (Compounds)

73-0735 **NEW**	**(t-Butylimido)tris(ethylmethylamino) tantalum(V), min. 98%** *(511292-99-2)* $C_{13}H_{33}N_4Ta$; FW: 426.38; yellow liq. *air sensitive, moisture sensitive*		1g 5g 25g

TIN (Compounds)

50-5022 **NEW** HAZ	**Tin(IV) chloride, anhydrous (99.99-Sn%) PURATREM** *(7646-78-8)* $SnCl_4$; FW: 260.50; colorless liq.; m. p. -33°; b.p. 114.1°; d. 2.226 *air sensitive, moisture sensitive*	25g 100g
50-0518 **NEW**	**Tin(IV) oxide, nanoparticle (30-60 nm), (99.7%-Sn)** *(18282-10-5)* *See* page 44	

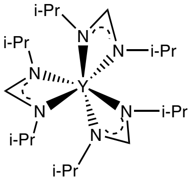
TITANIUM (Compounds)

22-1060 NEW amp HAZ	**Tetrakis(ethylmethylamino)titanium, 99% (99.99%-Ti) PURATREM** *(308103-54-0)* $C_{12}H_{32}N_4Ti$; FW: 280.28; yellow to orange liq. *moisture sensitive*	2g 10g
22-1175 NEW	**Titanium boride, hexagonal crystalline solid, 0.7-10.0 microns, 99%** *(12045-63-5)* TiB_2; FW: 69.52; dark-gray pwdr.	50g 250g
22-1190 NEW	**Titanium nitride, 1.3-1.9 microns (99+%-Ti)** *(25583-20-4)* TiN; FW: 61.91; gray pwdr.; m. p. 2930°; d. 5.22	100g 500g

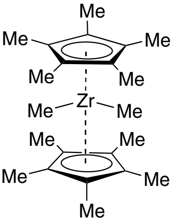
TUNGSTEN (Compounds)

74-1910 NEW	**Bis(acetonitrile)tetracarbonyltungsten(0)** *(16800-45-6)* $C_8H_6N_2O_4W$; FW: 377.98; yellow solid *air sensitive*	1g 5g
74-3180 NEW	**Tungsten(VI) oxychloride, 98%** *(13520-78-0)* $WOCl_4$; FW: 341.65; orange needles *air sensitive, moisture sensitive*	1g 5g 25g

YTTRIUM (Compounds)

39-1550 NEW amp	**Tris(N,N'-di-i-propylformamidinato) yttrium(III), 97%** $C_{21}H_{45}N_6Y$; FW: 470.53; light beige-yellow solid *air sensitive, moisture sensitive* *Note: Product sold under, use subject to, terms and conditions of label license at www.strem.com/harvard2*		250mg 1g 5g
39-2990 NEW	**Yttrium(III) oxide, 0.5-2.0 microns (99.95%- Y)** *(1314-36-9)* Y_2O_3; FW: 225.81; white pwdr.; m. p. 2410°; d. 5.01		50g 250g

ZIRCONIUM (Compounds)

40-1054 NEW	**Bis(pentamethylcyclopentadienyl)dimethylzirconium(IV), 99%** *(67108-80-9)* $[(CH_3)_5C_5]_2Zr(CH_3)_2$; FW: 391.75; white to off-white xtl. *air sensitive, moisture sensitive*		250mg 1g 5g

Technical Note:

1. Zirconium complex used as a polymerization catalyst.

References:

1. *J. Am. Chem. Soc.*, **2009**, *131*, 16658.
2. *Organometallics*, **2005**, *24*, 6013.

Novozymes Lipase and Endoprotease Screening Kits

96-0224 **Novozymes Endoprotease Screening Kit (contains 6 endoprotease enzymes)**

NEW

Components available for individual sale. This kit contains the following products:

06-3110	Alcalase® 2.4 L FG *(9014-01-1)*	10g	See page 25
06-3112	Alcalase® 2.5 L *(9014-01-1)*	10g	See page 25
06-3115	Esperase® 8.0 L *(9014-01-1)*	10g	See page 25
06-3137	Savinase® 12 T *(9014-01-1)*	10g	See page 27
06-3150	Savinase® 16 L *(9014-01-1)*	10g	See page 27
06-3160	Neutrase® 0.8 L *(9014-01-1)*	10g	See page 26

Note: Store at 0-10°C. DO NOT FREEZE. Sold in collaboration with Novozymes A/S

96-0220 **Novozymes Lipase Screening Kit (contains 9 lipase enzymes)**

NEW

Components available for individual sale. This kit contains the following products:

06-3105	Lipozyme® CALB L *(9001-62-1)*	10g	See page 25
06-3100	NovoCor® AD L *(9001-62-1)*	10g	See page 26
06-3118	Palatase® 20000 L *(9001-62-1)*	5g	See page 27
06-3120	Novozym® 40086 *(9001-62-1)*	5g	See page 26
06-3123	Novozyme® 435 *(9001-62-1)*	5g	See page 26
06-3125	Resinase® HT *(9001-62-1)*	10g	See page 27
06-3135	Novozym® 51032 *(9001-62-1)*	10g	See page 27
06-3140	Lipozyme® TL 100 L *(9001-62-1)*	10g	See page 26
06-3155	Lipozym® TL IM *(9001-62-1)*	10g	See page 26

Note: Store at 0-10°C. DO NOT FREEZE. Sold in collaboration with Novozymes A/S

Gold Gemini Nanorods Kit, CTAB Free

96-1549 **Gold Gemini Nanorods Kit, CTAB Free (Wavelength 650-850 nm)**

NEW

Components available for individual sale. This kit contains the following products:

79-7010	Gold Gemini Nanorods, CTAB Free (Wavelength 650nm)	5ml	See page 43
79-7015	Gold Gemini Nanorods, CTAB Free (Wavelength 700nm)	5ml	See page 43
79-7020	Gold Gemini Nanorods, CTAB Free (Wavelength 750nm)	5ml	See page 43
79-7025	Gold Gemini Nanorods, CTAB Free (Wavelength 800nm)	5ml	See page 43
79-7030	Gold Gemini Nanorods, CTAB Free (Wavelength 850nm)	5ml	See page 43

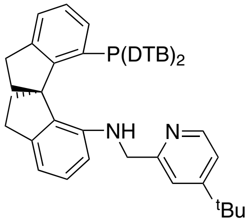
Note: Rods are synthesized without CTAB. Store at 4°C - 8°C. Do not freeze. At storage temperature the product may appear opaque. Follow the procedure for re-dispersing surfactants as described in the technical note. Complete this process before use to dissolve precipitated stabilizer. Sold in Collaboration with SONA Nanotech for research purposes only.

Chiral SpiroPAP and SpiroSAP Ligand Kits

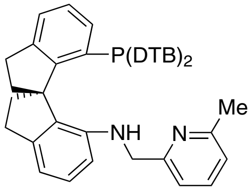
96-0445 **Chiral SpiroPAP Ligand Kit**

NEW

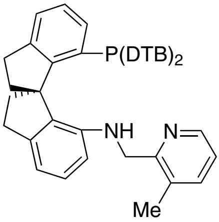
Components available for individual sale. This kit contains the following products:



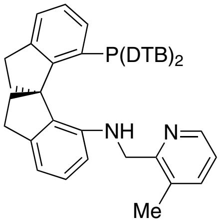
15-5147 25mg



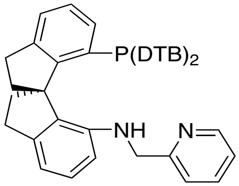
15-5148 25mg



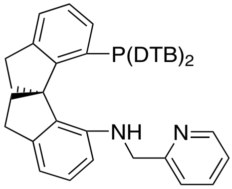
15-5158 25mg



15-5159 25mg



15-5166 25mg



15-5167 25mg

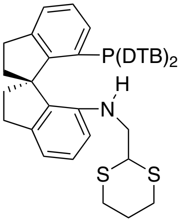
15-5147	(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(4-t-butylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-4-t-Bu *(1298133-38-6)*	25mg	See page 60
15-5148	(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(6-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-6-Me *(1298133-26-2)*	25mg	See page 60
15-5158	(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP-3-Me *(1298133-36-4)*	25mg	See page 61
15-5159	(S)-(-)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(3-methylpyridine-2-ylmethyl)amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (S)-DTB-SpiroPAP-3-Me	25mg	See page 61
15-5166	(R)-(+)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(pyridine-2-ylmethyl) amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (R)-DTB-SpiroPAP *(1298133-21-7)*	25mg	See page 62
15-5167	(S)-(-)-7-Bis(3,5-di-t-butylphenyl)phosphino-7'-[(pyridine-2-ylmethyl) amino]-2,2',3,3'-tetrahydro-1,1'-spirobiindane, min. 98% (>99% ee) (S)-DTB-SpiroPAP *(1415636-82-6)*	25mg	See page 62
Note: Also available: 77-4035 [Ir-(R)-DTB-SpiroPAP-3-Me] and 77-4036 [Ir-(S)-DTB-SpiroPAP-3-Me] (not part of the kit)			

Chiral SpiroPAP and SpiroSAP Ligand Kits

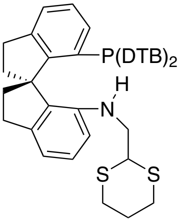
96-0070 **Chiral SpiroSAP Ligand Kit**

NEW

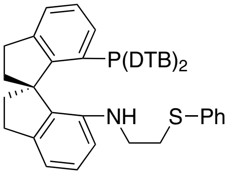
Components available for individual sale. This kit contains the following products:



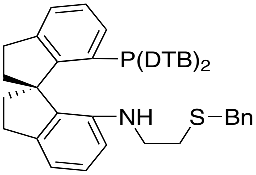
15-1638 25mg



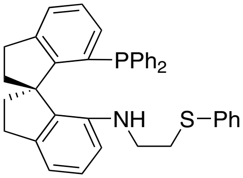
15-1639 25mg



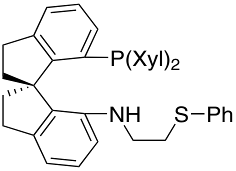
15-1605 25mg



15-1613 25mg



15-1643 25mg



15-1645 25mg

15-1638	(R)-(+)-7-[N-(1,3-dithian-2-yl)methylamino]-7’-[bis(3,5-di-t-butylphenyl) phosphino]-2,2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP] *(1809609-53-7)*	25mg	See page 68
15-1639	(S)-(-)-7-[N-(1,3-dithian-2-yl)methylamino]-7’-[bis(3,5-di-t-butylphenyl) phosphino]-2,2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(S)-DTB-SpiroSAP]	25mg	See page 69
15-1605	(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7’-[bis(3,5-di-t-butylphenyl) phosphino]-2,2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP-Ph] *(1809609-38-8)*	25mg	See page 70
15-1613	(R)-(+)-7-[N-(2-benzylthio)ethylamino]-7’-[bis(3,5-di-t-butylphenyl) phosphino]-2,2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(R)-DTB-SpiroSAP-Bn] *(1809609-52-6)*	25mg	See page 68
15-1643	(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7’-[diphenylphosphino]-2, 2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(R)-Ph-SpiroSAP-Ph] *(1809609-40-2)*	25mg	See page 69
15-1645	(R)-(+)-7-[N-(2-phenylthio)ethylamino]-7’-[bis(3,5-dimethylphenyl) phosphino]-2,2’,3,3’-tetrahydro-1,1’-spirobindane, 97+% (>99% ee) [(R)-Xyl-SpiroSAP-Ph] *(1809609-39-9)*	25mg	See page 70
Note: Also available: 77-2510 [Ir-(R)-DTB-SpiroSAP] and 77-2511 [Ir-(S)-DTB-SpiroSAP] (not part of the kit)			

Strem Catalog #	Description	Appearance	Particle Size Range (micron)	Optimal Storage Condition
Enzyme Carrier Resins				
06-0810	Enzyme carrier Lifetech™ ECR8204F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 8°C)
06-0813	Enzyme carrier Lifetech™ ECR8204M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 8°C)
06-0817	Enzyme carrier Lifetech™ ECR8209F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 8°C)
06-0820	Enzyme carrier Lifetech™ ECR8209M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 8°C)
06-0823	Enzyme carrier Lifetech™ ECR8215F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 8°C)
06-0826	Enzyme carrier Lifetech™ ECR8215M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 8°C)
06-0828	Enzyme carrier Lifetech™ ECR8285	White to off white spherical beads	250 - 1000	Keep in dry conditions (2 - 8°C)
07-1512	Enzyme carrier Lifetech™ ECR8309F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
07-1515	Enzyme carrier Lifetech™ ECR8309M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
07-1518	Enzyme carrier Lifetech™ ECR8315F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
07-1520	Enzyme carrier Lifetech™ ECR8315M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
07-1523	Enzyme carrier Lifetech™ ECR8409F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
07-1525	Enzyme carrier Lifetech™ ECR8409M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
07-1528	Enzyme carrier Lifetech™ ECR8415F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
07-1530	Enzyme carrier Lifetech™ ECR8415M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
07-1532	Enzyme carrier Lifetech™ ECR8806F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
07-1535	Enzyme carrier Lifetech™ ECR8806M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
06-0905	Enzyme carrier Lifetech™ ECR1090F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
06-0913	Enzyme carrier Lifetech™ ECR1090M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
06-0918	Enzyme carrier Lifetech™ ECR1091F	White to off white spherical beads	150-300	Keep in dry conditions (2 - 20°C)
06-0922	Enzyme carrier Lifetech™ ECR1091M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
06-0925	Enzyme carrier Lifetech™ ECR1030M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
06-0928	Enzyme carrier Lifetech™ ECR1061M	White to off white spherical beads	300-710	Keep in dry conditions (2 - 20°C)
07-2215	Enzyme carrier Lifetech™ ECR1504	White to off white spherical beads	300-1200	Keep in dry conditions (2 - 20°C)
07-2220	Enzyme carrier Lifetech™ ECR1508	White to off white spherical beads	300-1200	Keep in dry conditions (2 - 20°C)
07-2224	Enzyme carrier Lifetech™ ECR1604	White to off white spherical beads	300-1200	Keep in dry conditions (2 - 20°C)
07-2230	Enzyme carrier Lifetech™ ECR1640	White to off white spherical beads	300-1200	Keep in dry conditions (2 - 20°C)

Strem Catalog #	Description	Appearance	Particle Size Range (micron)	Optimal Storage Condition
Enzyme Carrier Resins (cont.)				
96-0255	Enzyme carrier Lifetech™ ECRKIT1	n.a.	n.a.	Keep in dry conditions (2 - 20°C)
Chelating Resins				
06-1501	Chelating/scavenger resin with N-methylglucamine - S108	Spherical beads	425 - 630	Keep in dry conditions (2 - 20°C)
06-1508	Chelating/scavenger resin with aminoxime - S910	Spherical beads	300 - 1200	Keep in dry conditions (2 - 20°C)
06-1512	Chelating/scavenger resin with thiourea - S914	Spherical beads	300 - 1200	Keep in dry conditions (2 - 20°C)
06-1514	Chelating/scavenger resin with isothiouronium - S920Plus	Spherical beads	300 - 1200	Keep in dry conditions (2 - 20°C)
06-1518	Chelating/scavenger resin with thiol - S924	Spherical beads	300 - 1000	Keep in dry conditions (2 - 20°C)
06-1520	Chelating/scavenger resin with iminodiacetic - S930Plus	Spherical beads	425 - 1000	Keep in dry conditions (2 - 20°C)
06-1522	Chelating/scavenger resin with aminophosphonic - S940	Spherical beads	425 - 850	Keep in dry conditions (2 - 20°C)
06-1525	Chelating/scavenger resin with aminophosphonic - S950	Spherical beads	300-1000	Keep in dry conditions (2 - 20°C)
06-1528	Chelating/scavenger resin with phosphonic and sulfonic acid - S957	Spherical beads	425 - 1000	Keep in dry conditions (2 - 20°C)
06-1530	Chelating/scavenger resin with bispicolylamine - S960	Spherical beads	425 - 1000	Keep in dry conditions (2 - 20°C)
06-1532	Chelating/scavenger resin with polyamine - S985	Spherical Beads	300 - 1200	Keep in dry conditions (2 - 20°C)
Immobilized Enzymes				
07-3130	CalB immo Plus™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-710	Keep in dry conditions (2 - 8°C)
07-3133	CalB immo Plus Food Grade™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-710	Keep in dry conditions (2 - 8°C)
07-3142	CalB immo 8285™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	100-710	Keep in dry conditions (2 - 8°C)
07-3148	CalB immo 8806™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-710	Keep in dry conditions (2 - 8°C)
07-3152	CalB immo 5587™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-710	Keep in dry conditions (2 - 8°C)
07-3155	CalB immo 1090™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-710	Keep in dry conditions (2 - 8°C)
07-3159	CalB immo 5872™ - Immobilized enzyme	White to slightly yellow spherical beads, free from foreign matter	300-1500	Keep in dry conditions (2 - 8°C)
96-4050	CalB immo KIT™ - Immobilized enzyme	n.a.	n.a.	Keep in dry conditions (2 - 8°C)

CARBON (Compounds)

06-3545 **Carbon tetrachloride (99.999%-C) PURATREM** *(56-23-5)*
CCl_4; FW: 153.82; colorless liq.

CHROMIUM (Compounds)

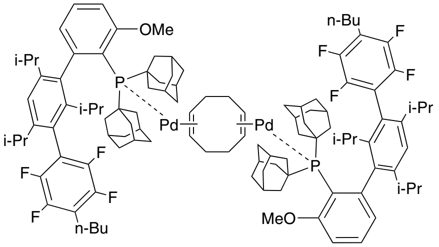
24-2405 **Chromium(II) chloride, anhydrous (99.99%-Cr) PURATREM** *(10049-05-5)*
$CrCl_2$; FW: 122.90; off-white to pale green pwdr.

NICKEL (Compounds)

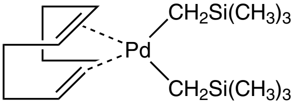
28-1165 **Nickel(II) chloride, anhydrous, (99.99+%-Ni) PURATREM** *(7718-54-9)*
Cl_2Ni; FW: 129.62; yellow pwdr.

PALLADIUM (Compounds)

46-0241 **Bis{[2-(Diadamantylphosphino)-3-methoxy-2',4',6'-tri-i-propyl-3'-(2,3,5,6-tetrafluoro-4-butylphenyl)-1,1'-biphenyl]palladium(0)} 1,5-cyclooctadiene, [AlPhos Palladium complex]**
(1805783-51-0)
$C_{112}H_{146}F_8O_2P_2Pd_2$
FW: 1951.13; yellow-green solid

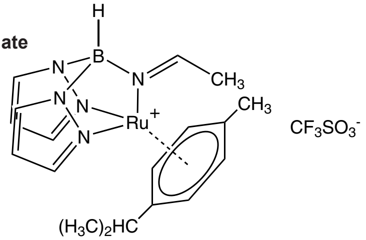


46-0308 **Bis[(trimethylsilyl)methyl](1,5-cyclooctadiene) palladium(II), 98%** *(225931-80-6)*
$C_{16}H_{34}PdSi_2$; FW: 389.03; gray pwdr.

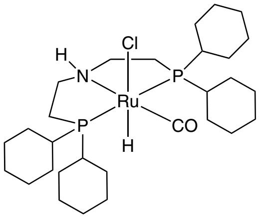


RUTHENIUM (Compounds)

44-0355 **[Bis(pyrazol-1-yl)(acetimino)hydridoborato] (p-cymene)ruthenium(II) trifluoromethanesulfonate**
(1607436-49-6)
$C_{19}H_{25}BF_3N_5O_3RuS$; FW: 572.38; yellow pwdr.

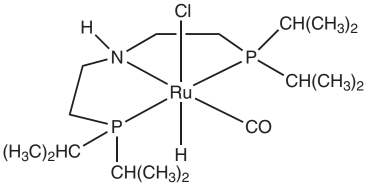


44-1043 **Carbonylchlorohydrido[bis(2-dicyclohexylphosphinoethyl)amine] ruthenium(II), min. 97%** *(1421060-11-8)*
$C_{29}H_{54}ClNOP_2Ru$; FW: 631.22; white solid

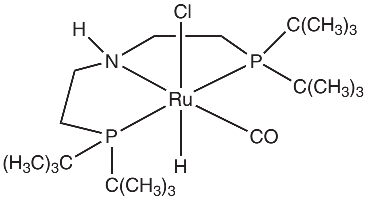


RUTHENIUM (Compounds)

44-1032 **Carbonylchlorohydrido[bis(2-di-i-propylphosphinoethyl)amine] ruthenium(II), min. 97%** *(1311164-69-8)*
$C_{17}H_{38}ClNOP_2Ru$;
FW: 470.96; off-white solid

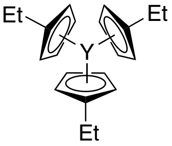


44-1035 **Carbonylchlorohydrido[bis(2-di-t-butylphosphinoethyl)amine]ruthenium(II), min. 97%** *(1421060-10-7)*
$C_{21}H_{46}ClNOP_2Ru$; FW: 527.07; off-white solid



YTTRIUM (Compounds)

39-5055 **Tris(ethylcyclopentadienyl)yttrium, 97%**
(476364-59-7)
$(C_2H_5C_5H_4)_3Y$; FW: 368.34; yellow xtls.



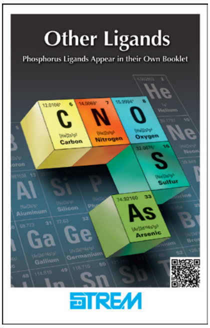
Available Booklets


Metal Catalysts for Organic Synthesis

Many New Products!

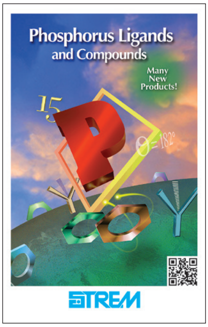
Including Organocatalysts

STREM


Other Ligands

Phosphorus Ligands Appear in their Own Booklet

STREM


Phosphorus Ligands and Compounds

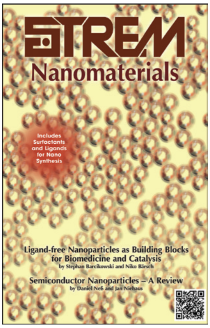
Many New Products!

STREM


Kits

now includes Biocatalyst Kits

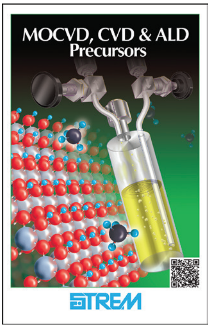
STREM


STREM Nanomaterials

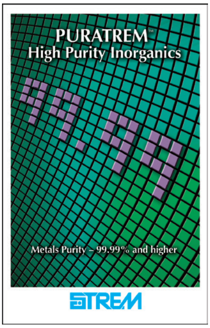
Includes Surfactants and Ligands for Nano Synthesis

Ligand-free Nanoparticles as Building Blocks for Biomedicine and Catalysis
by Stephan Barcikowski and Niko Bärsch

Semiconductor Nanoparticles – A Review
by Daniel Neß and Jan Niehaus


MOCVD, CVD & ALD Precursors

STREM

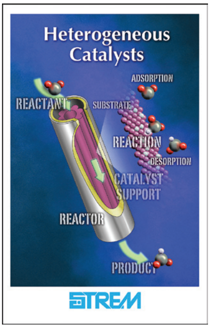

PURATREM High Purity Inorganics

Metals Purity – 99.99% and higher

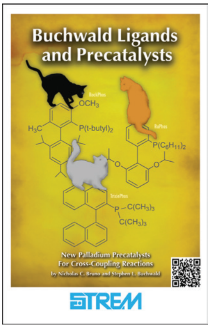
STREM


New Products

STREM


Heterogeneous Catalysts

STREM


Buchwald Ligands and Precatalysts

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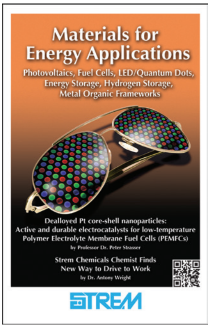
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