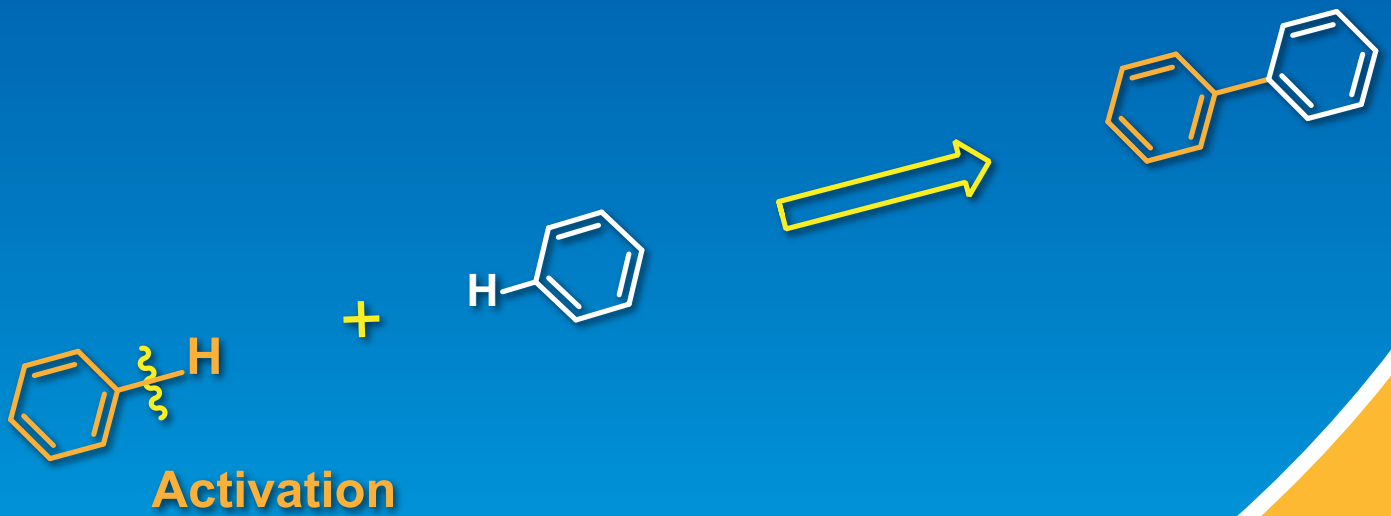


# C-H活性化反応

C-H Bond Activation Reaction



金属触媒

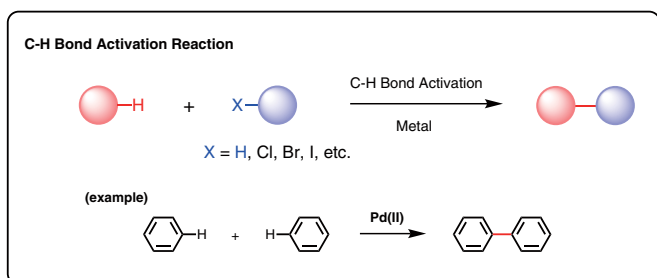
配位子

配向基導入試薬

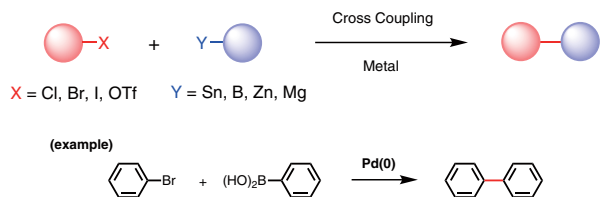
その他の添加剤

# C-H活性化反応

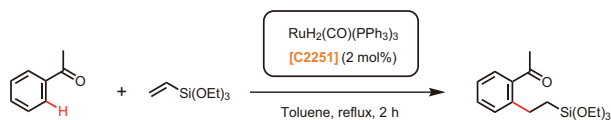
遷移金属触媒を用い、炭素-水素結合を活性化して直接官能基化する手法は“C-H活性化反応”と呼ばれ、近年盛んに研究されている分野です。従来のクロスカップリング反応では、ハロゲン等の脱離基、あるいは有機ホウ素や有機スズなどの官能基を導入する必要があるため、工程数が必然的に増えてしまいます。また使用済みの金属残渣の回収・廃棄が問題となります。一方、C-H活性化反応では、これらの工程の低減が可能であり、原子効率の観点からも低環境負荷型の反応(グリーンケミストリー)と言えます。



## cf. Traditional Cross Coupling Reaction



通常、炭素-水素結合の結合エネルギーは比較的大きく、炭素-水素結合を切断して新たな炭素-炭素あるいは炭素-ヘテロ結合を形成させることは困難であると考えられていました。1993年村井らは、触媒量のカルボニル(ジヒドリド)トリス(トリフェニルホスフィン)ルテニウム(II)[C2251]の存在下で芳香族ケトンのオルト位炭素-水素結合がオレフィンに位置選択的に付加することを報告しており<sup>1)</sup>、これを契機としてC-H活性化反応は飛躍的に開拓され始めました。



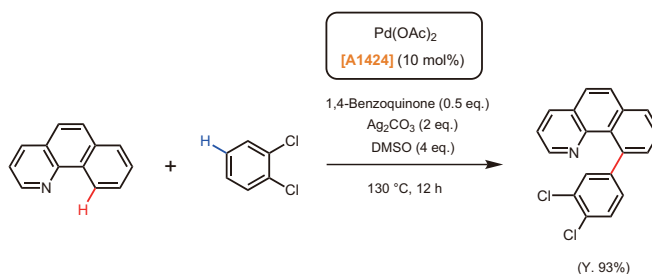
この反応はハロゲン化合物および有機ホウ素化合物あるいは有機金属化合物を用いる必要が無く、環境面・合成効率の両面で有利な反応システムと言えます。

一般にC-H活性化反応で用いられる触媒の種類としては、主にパラジウム(II)、ロジウム(I)、イリジウム(I)、ルテニウム(II)、銅(II)、鉄(II)などが知られており、適切な配位子の存在下で反応が進行します。以下にパラジウム触媒、イリジウム触媒および鉄触媒を用いた反応例を示します。

## ●パラジウム(II)触媒を用いるC-H活性化反応

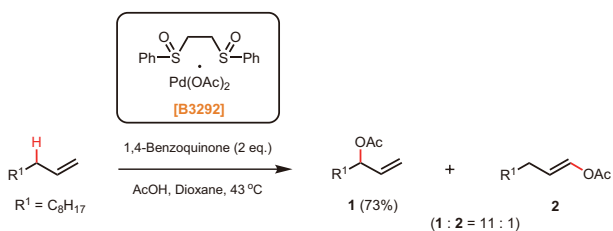
### 1) 7,8-ベンゾキノリンとアレーン類との位置選択的カップリング反応

Sanfordらは酢酸パラジウム(II)[A1424]を触媒に用い、7,8-ベンゾキノリンとアレーン類との直接的カップリング反応を報告しています<sup>2)</sup>。この反応では7,8-ベンゾキノリンの窒素原子が配向基として働き、キノリンの10位の炭素原子にアレーン基が導入されます。またアレーン類の反応点も位置選択的となります。なおこの反応では1,4-ベンゾキノンが反応のプロモーターとして働き、また炭酸銀(I)が生成したPd(0)を再酸化することで、Pd(II)/Pd(0)の触媒サイクルが形成されます。

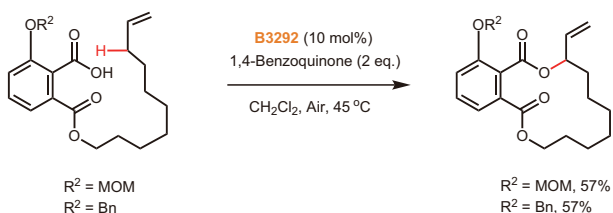


### 2) “White触媒”を用いるC-H酸化反応

1,2-ビス(フェニルスルフィニル)エタンパラジウム(II)ジASETART[B3292]はWhiteらにより開発されたパラジウム触媒で、開発者の名を冠して“White触媒”と呼ばれています<sup>3)</sup>。B3292を用いた触媒反応として、末端オレフィンのアリル位にアセチル基を選択的に挿入するアリル位C-H酸化反応が報告されており、他のパラジウム触媒には無い反応性を示します<sup>3)</sup>。

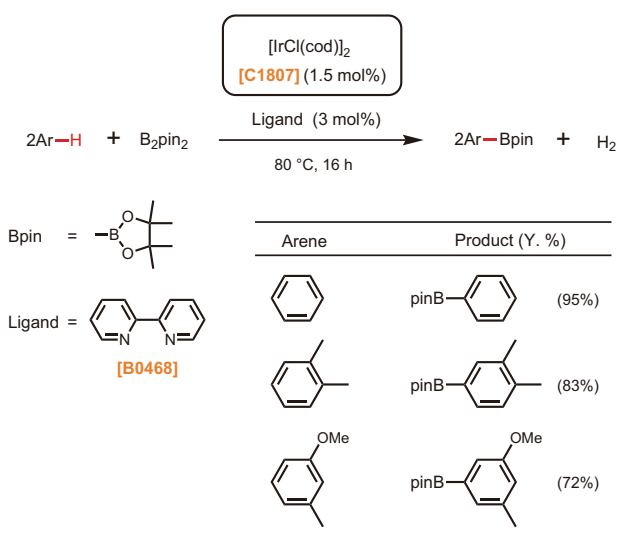


またWhiteらはこの反応を分子内アリル位C-H酸化にも応用し、マクロラクトン環形成反応も報告しています<sup>4)</sup>。



## ● イリジウム(I)触媒を用いるC-H活性化反応

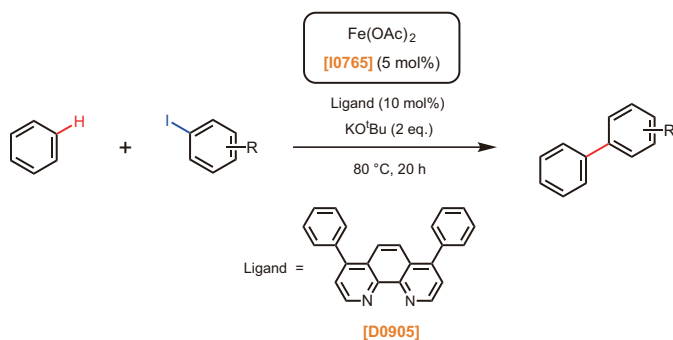
イリジウム触媒を用いたC-H活性化反応の例として最も有名なものは、2002年に宮浦、石山およびHartwigらによって発表されたC-Hホウ素化反応が挙げられます<sup>5)</sup>。この反応は大変実用的であり、これまでアリールボラート類の合成は、対応するアリールリチウムやアリールマグネシウム試薬とアルキルボラートを用いて合成されていましたが、簡便に一工程で合成することが可能になりました。


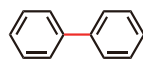
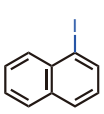
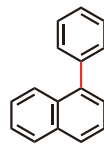
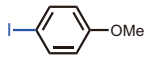
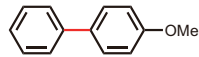
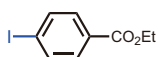
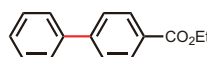

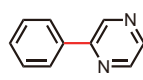


## ● 鉄(II)触媒を用いるC-H活性化反応

パラジウムを始め、ニッケル、白金などの遷移金属触媒は有機合成において幅広く用いられていますが、これらの金属は地殻中に数ppbから数十ppm程度存在するのみで、比較的高価な金属です<sup>6)</sup>。一方、鉄は地殻中に豊富に存在する金属であり、鉄を触媒に用いたクロスカップリング反応など、鉄を用いる有機合成が近年多数報告されています<sup>7)</sup>。

Charetteらは酢酸鉄(II) [I0765]を触媒に用い、ベンゼンとヨードアリール類との直接カップリング反応を報告しています<sup>8)</sup>。この反応はC-H活性化反応に安価な鉄触媒を適用した点で環境負荷が少なく、グリーンケミストリーの観点から今後の発展が期待される分野です。



Aryl iodide	Product (Y. %)
	 (89%)
	 (60%)
	 (93%)
	 (40%)
	 (79%)

このように、C-H活性化反応はクロスカップリング反応、オレフィンメタセシス反応に続く新しいC-C結合生成反応として幅広く研究されています。

本パンフレットではC-H活性化反応で利用できる遷移金属触媒、配位子および添加剤を収載しています。ぜひ、ご利用ください。

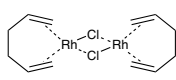
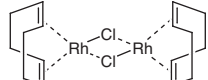
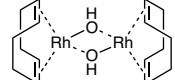
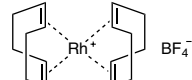
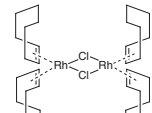
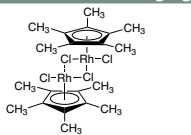
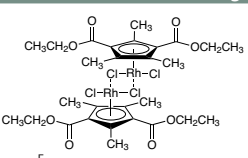
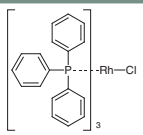
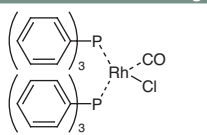
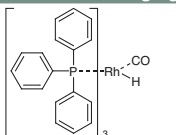
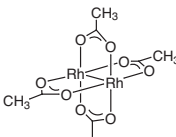
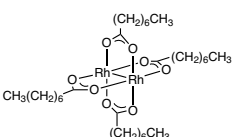
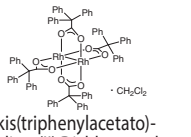
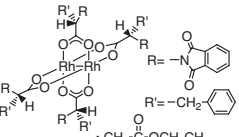
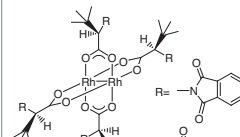
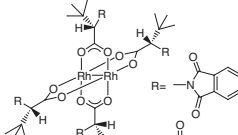
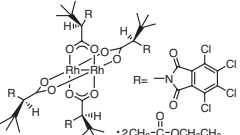
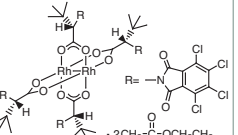
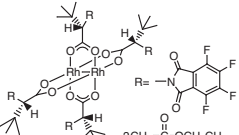
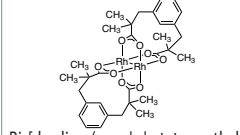
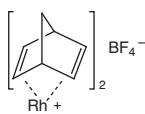
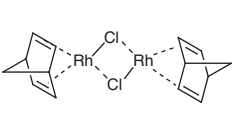
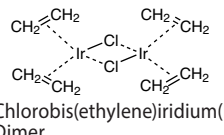
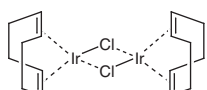
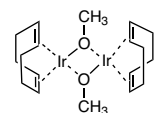
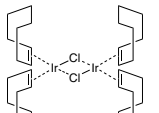
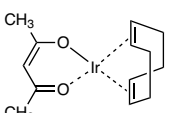
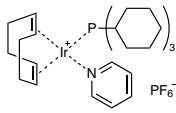
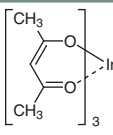
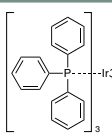
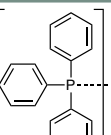
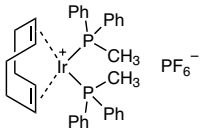
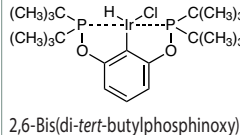
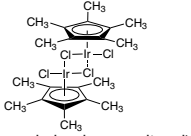
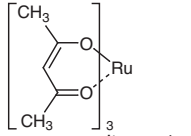
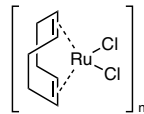
## 文 献

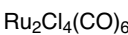
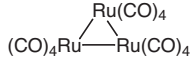
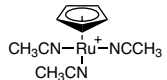
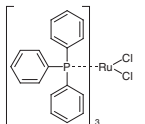
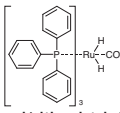
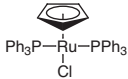
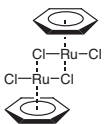
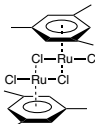
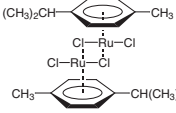
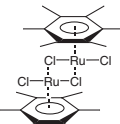
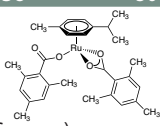
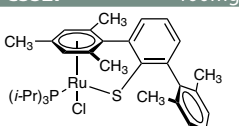
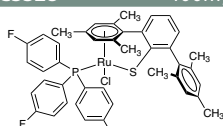
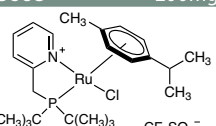
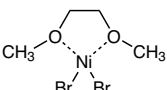
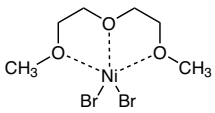
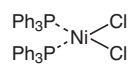
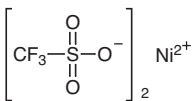
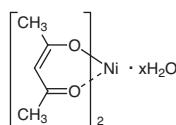
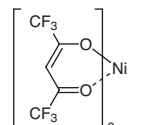
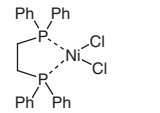
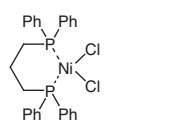
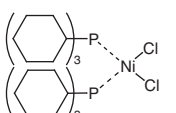
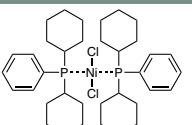
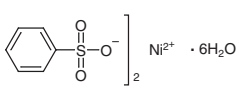
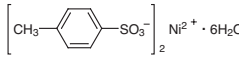
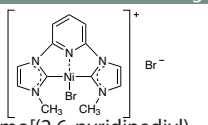
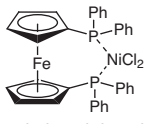
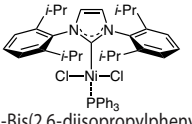
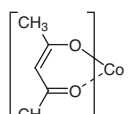
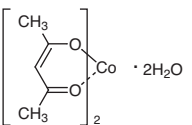
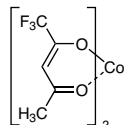
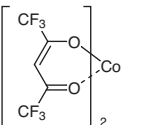
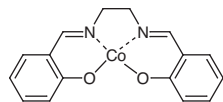
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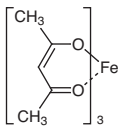
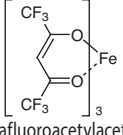
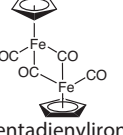
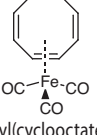
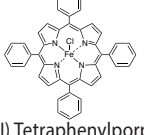
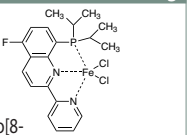
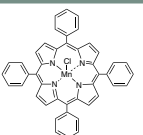
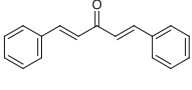
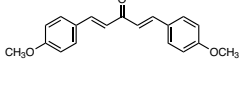
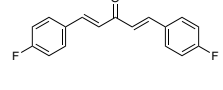
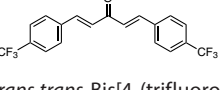
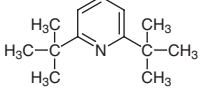
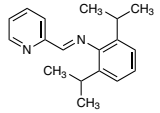
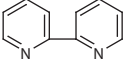
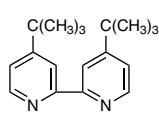
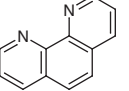
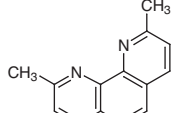
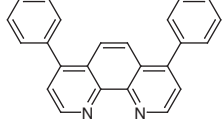
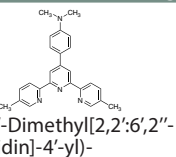
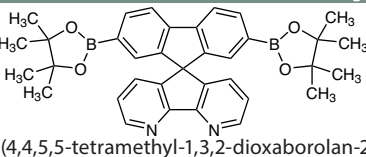
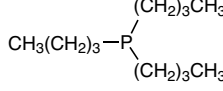
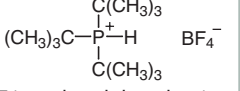
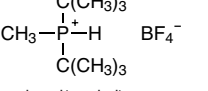
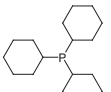
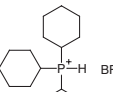
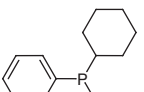
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				PdCl <sub>2</sub> Palladium(II) Chloride CAS RN: 7647-10-1	PdBr <sub>2</sub> Palladium(II) Bromide CAS RN: 13444-94-5
A1424 1g 5g	P2161 1g	P1870 1g 5g	B2018 1g 5g	B3292 200mg 1g	
Palladium(II) Acetate CAS RN: 3375-31-3	Palladium(II) Acetate(Purified) CAS RN: 3375-31-3	Palladium(II) Trifluoroacetate CAS RN: 42196-31-6	Palladium(II) Acetylacetonate CAS RN: 14024-61-4	White Catalyst CAS RN: 858971-43-4	
B1676 1g 5g	B1668 1g 5g	T3023 1g	B2055 1g 5g	B1374 1g 5g	
Bis(acetonitrile)palladium(II) Dichloride CAS RN: 14592-56-4	Bis(benzonitrile)palladium(II) Dichloride CAS RN: 14220-64-5	Tetrakis(acetonitrile)palladium(II) Ditriflate CAS RN: 68569-14-2	Bis(tricyclohexylphosphine)palladium(II) Dichloride CAS RN: 29934-17-6	Bis(dibenzylideneacetone)palladium(0) CAS RN: 32005-36-0	
T2184 1g 5g	T1350 1g 5g 25g	B1667 1g 5g 25g	B2026 1g 5g	B2042 1g 5g	
Pd <sub>2</sub> (dba) <sub>3</sub> CAS RN: 51364-51-3	Pd(PPh <sub>3</sub> ) <sub>4</sub> CAS RN: 14221-01-3	Bis(triphenylphosphine)palladium(II) Dichloride CAS RN: 13965-03-2	Bis(tri-o-tolylphosphine)palladium(II) Dichloride CAS RN: 40691-33-6	Bis(triphenylphosphine)palladium(II) Diacetate CAS RN: 14588-08-0	
B2161 1g	B3160 1g 5g	B2016 1g 5g	D5719 250mg	B2192 1g 5g	
Bis(methyldiphenylphosphine)palladium(II) Dichloride (cis- and trans- mixture) CAS RN: 52611-08-2	[1,1'-Bis(di-tert-butylphosphino)ferrocene]palladium(II) Dichloride CAS RN: 95408-45-0	[1,2-Bis(diphenylphosphino)ethane]palladium(II) Dichloride CAS RN: 19978-61-1	PdCl <sub>2</sub> (alaphos) CAS RN: 85719-56-8	[1,3-Bis(diphenylphosphino)propane]palladium(II) Dichloride CAS RN: 59831-02-6	
B2031 1g 5g	D4333 200mg 1g	B2064 1g 5g 25g	B5400 200mg 1g	B6199 1g 5g 25g	
[1,4-Bis(diphenylphosphino)butane]palladium(II) Dichloride CAS RN: 29964-62-3	Dichloro[9,9-dimethyl-4,5-bis(diphenylphosphino)xanthene]palladium(II) CAS RN: 205319-10-4	[1,1'-Bis(diphenylphosphino)ferrocene]palladium(II) Dichloride Dichloromethane Adduct CAS RN: 95464-05-4	Bis(1,10-phenanthroline)palladium(II) Bis(hexafluorophosphate) CAS RN: 113173-22-1	Organ's Catalyst CAS RN: 905459-27-0	
A1479 500mg 1g	P2017 200mg	B6327 200mg 1g 5g	D2604 1g 5g	N0842 1g	
Allylpalladium(II) Chloride Dimer CAS RN: 12012-95-2	Palladium(II)(π-cinnamyl) Chloride Dimer CAS RN: 12131-44-1	Herrmann Catalyst CAS RN: 172418-32-5	Dichloro(1,5-cyclooctadiene)palladium(II) CAS RN: 12107-56-1	2,5-Norbornadiene Palladium(II) Dichloride CAS RN: 12317-46-3	
C2734 1g	ロジウム 触媒		C2461 200mg	A2100 200mg	A2761 200mg 1g
Chloro[(tri-tert-butylphosphine)-2-(2-aminobiphenyl)]palladium(II) CAS RN: 1375325-71-5			Chlorobis(ethylene)rhodium(I) Dimer CAS RN: 12081-16-2	Acetylacetonatobis(ethylene)rhodium(I) CAS RN: 12082-47-2	(Acetylacetonato)(norbornadiene)rhodium(I) CAS RN: 32354-50-0

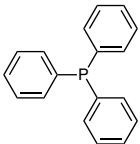
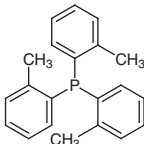
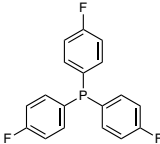
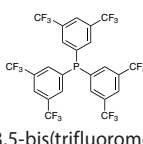
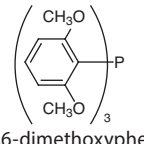
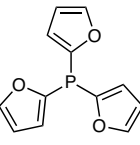
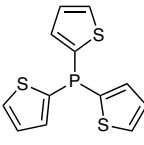
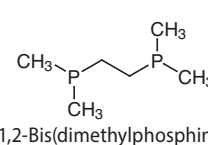
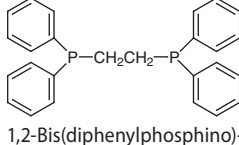
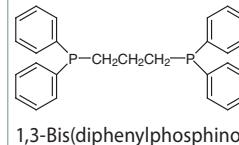
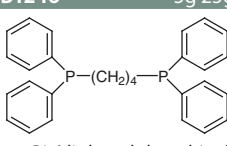
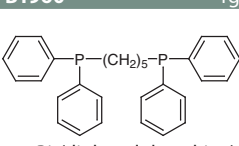
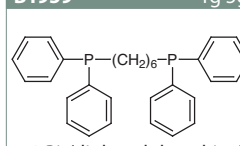
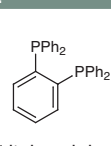
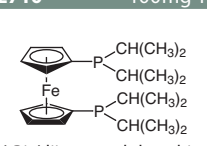
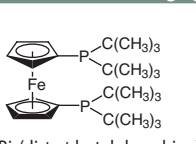
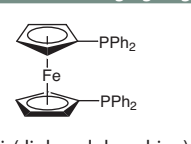
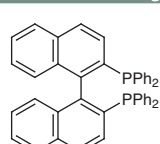
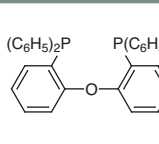
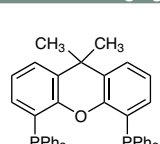
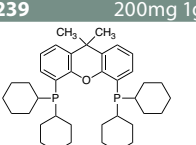
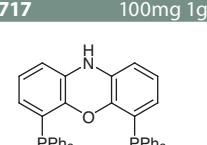
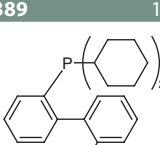
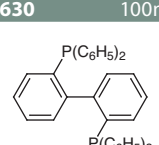
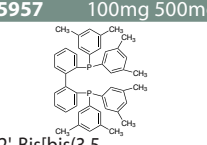
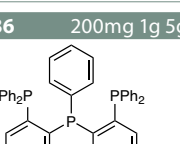
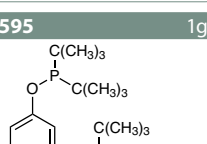
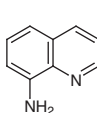
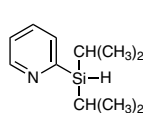
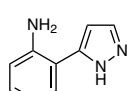
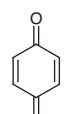
<p><b>C3194</b> 100mg</p>  <p>Chloro(1,5-hexadiene)-rhodium(I) Dimer CAS RN: 32965-49-4</p>	<p><b>B1045</b> 100mg 1g</p>  <p>Chloro(1,5-cyclooctadiene)-rhodium(I) Dimer CAS RN: 12092-47-6</p>	<p><b>H1562</b> 200mg 1g</p>  <p>Hydroxy(1,5-cyclooctadiene)-rhodium(I) Dimer CAS RN: 73468-85-6</p>	<p><b>B3961</b> 100mg 1g</p>  <p>Bis(1,5-cyclooctadiene)-rhodium(I) Tetrafluoroborate CAS RN: 35138-22-8</p>	<p><b>C2253</b> 100mg 500mg</p>  <p>Chlorobis(cyclooctene)-rhodium(I) Dimer CAS RN: 12279-09-3</p>	
<p><b>P1788</b> 200mg 1g</p>  <p>(Pentamethylcyclopentadienyl)-rhodium(III) Dichloride Dimer CAS RN: 12354-85-7</p>	<p><b>B6169</b> 200mg</p>  <p>[Cp<sup>*</sup>RhCl<sub>2</sub>]<sub>2</sub> CAS RN: 1352745-18-6</p>	<p><b>T0931</b> 1g</p>  <p>Tris(triphenylphosphine)-rhodium(I) Chloride CAS RN: 14694-95-2</p>	<p><b>B1692</b> 1g</p>  <p>Carbonylbis(triphenylphosphine)-rhodium(I) Chloride CAS RN: 13938-94-8</p>	<p><b>C1383</b> 1g 5g</p>  <p>Carbonylhydrottris(triphenylphosphine)rhodium(I) CAS RN: 17185-29-4</p>	
<p><b>R0069</b> 100mg 1g</p>  <p>Rhodium(II) Acetate Dimer CAS RN: 15956-28-2</p>	<p><b>R0161</b> 200mg 1g</p>  <p>Rhodium(II) Octanoate Dimer CAS RN: 73482-96-9</p>	<p><b>T1544</b> 100mg</p>  <p>Tetrakis(triphenylacetato)-dirhodium(II) Dichloromethane Adduct CAS RN: 142214-04-8</p>	<p><b>T1551</b> 100mg</p>  <p>Rh<sub>2</sub>(S-PTPA)<sub>4</sub> EtOAc CAS RN: 131219-55-1</p>	<p><b>T2054</b> 100mg</p>  <p>Rh<sub>2</sub>(R-PTTL)<sub>4</sub> 2EtOAc</p>	
<p><b>T2055</b> 100mg</p>  <p>Rh<sub>2</sub>(S-PTTL)<sub>4</sub> 2EtOAc</p>	<p><b>T2658</b> 50mg</p>  <p>Rh<sub>2</sub>(R-TCPTTL)<sub>4</sub> 2EtOAc CAS RN: 2001054-66-4</p>	<p><b>T2659</b> 100mg</p>  <p>Rh<sub>2</sub>(S-TCPTTL)<sub>4</sub> 2EtOAc CAS RN: 1816286-21-1</p>	<p><b>T2661</b> 100mg</p>  <p>Rh<sub>2</sub>(S-TFPTTL)<sub>4</sub> 2EtOAc CAS RN: 2635339-90-9</p>	<p><b>B4549</b> 100mg</p>  <p>Bis[rhodium(α,α,α',α'-tetramethyl-1,3-benzenedipropionic Acid)] CAS RN: 819050-89-0</p>	
<p><b>B2091</b> 100mg</p>  <p>Bis[η-(2,5-norbornadiene)]-rhodium(I) Tetrafluoroborate CAS RN: 36620-11-8</p>	<p><b>N0453</b> 100mg</p>  <p>Norbornadiene Rhodium(I) Chloride Dimer CAS RN: 12257-42-0</p>	<p><b>イリジウム 触媒</b></p>		<p><b>I0616</b> 1g 5g</p> <p>IrCl<sub>3</sub> · xH<sub>2</sub>O</p> <p>Iridium(III) Chloride Hydrate CAS RN: 14996-61-3</p>	<p><b>C3041</b> 100mg</p>  <p>Chlorobis(ethylene)iridium(I) Dimer CAS RN: 39722-81-1</p>
<p><b>C1807</b> 250mg 1g</p>  <p>Chloro(1,5-cyclooctadiene)-iridium(I) Dimer CAS RN: 12112-67-3</p>	<p><b>C2662</b> 200mg 1g</p>  <p>(1,5-Cyclooctadiene)(methoxy)-iridium(I) Dimer CAS RN: 12148-71-9</p>	<p><b>C2985</b> 200mg</p>  <p>Chlorobis(cyclooctene)-iridium(I) Dimer CAS RN: 12246-51-4</p>	<p><b>A2981</b> 200mg 1g</p>  <p>(Acetylacetonato)-(1,5-cyclooctadiene)iridium(I) CAS RN: 12154-84-6</p>	<p><b>C2824</b> 100mg</p>  <p>Crabtree's Catalyst CAS RN: 64536-78-3</p>	
<p><b>T2557</b> 1g</p>  <p>Tris(2,4-pentanedionato)-iridium(III) CAS RN: 15635-87-7</p>	<p><b>C3040</b> 200mg 1g</p>  <p>Carbonylhydrottris(triphenylphosphine)iridium(I) CAS RN: 17250-25-8</p>	<p><b>C2252</b> 200mg 1g</p>  <p>Vaska's Catalyst CAS RN: 14871-41-1</p>	<p><b>C1808</b> 200mg</p>  <p>[Ir(COD)(PPh<sub>2</sub>Me)<sub>2</sub>]PF<sub>6</sub> CAS RN: 38465-86-0</p>	<p><b>B5033</b> 200mg</p>  <p>2,6-Bis(di-tert-butylphosphinoxy)-phenylchlorohydroiridium(III) CAS RN: 671789-61-0</p>	
<p><b>P1763</b> 1g</p>  <p>(Pentamethylcyclopentadienyl)-iridium(III) Dichloride Dimer CAS RN: 12354-84-6</p>	<p><b>ルテニウム 触媒</b></p>		<p><b>R0074</b> 1g 5g</p> <p>RuCl<sub>3</sub> · xH<sub>2</sub>O</p> <p>Ruthenium(III) Chloride Hydrate CAS RN: 14898-67-0</p>	<p><b>T2183</b> 1g 5g</p>  <p>Tris(2,4-pentanedionato)-ruthenium(III) CAS RN: 14284-93-6</p>	<p><b>D4792</b> 1g 5g</p>  <p>[RuCl<sub>2</sub>(COD)]<sub>n</sub> CAS RN: 50982-12-2</p>

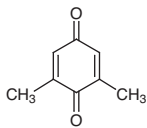
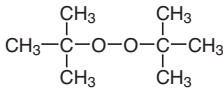
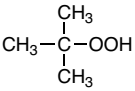
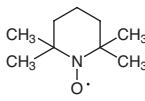
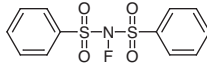
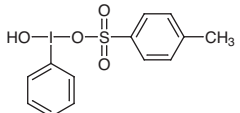
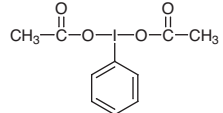
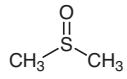
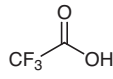
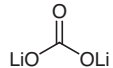
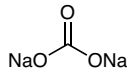
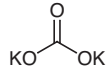
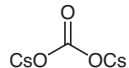
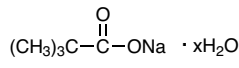
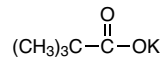
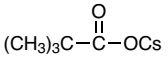
<b>T3812</b> 200mg  $\text{Ru}_2\text{Cl}_4(\text{CO})_6$ CORM-2 CAS RN: 22594-69-0	<b>T2181</b> 100mg 1g  $(\text{CO})_4\text{Ru}-\text{Ru}(\text{CO})_4$ Triruthenium Dodecacarbonyl CAS RN: 15243-33-1	<b>T3079</b> 200mg  $\text{CH}_3\text{CN}-\text{Ru}^+-\text{NCCH}_3$ $\text{PF}_6^-$ Tris(acetonitrile)-cyclopentadienylruthenium(II) Hexafluorophosphate CAS RN: 80049-61-2	<b>D1997</b> 1g 5g  Tris(triphenylphosphine)-ruthenium(II) Dichloride CAS RN: 15529-49-4	<b>C2251</b> 250mg 1g  Carbonyl(dihydro)-tris(triphenylphosphine)-ruthenium(II) CAS RN: 25360-32-1
<b>C2201</b> 1g 5g  $\text{Ph}_3\text{P}-\text{Ru}-\text{PPh}_3$ Cyclopentadienyl-bis(triphenylphosphine)-ruthenium(II) Chloride CAS RN: 32993-05-8	<b>B1902</b> 1g 5g  $\text{Cl}-\text{Ru}-\text{Cl}$ $\text{Cl}-\text{Ru}-\text{Cl}$ Benzeneruthenium(II) Chloride Dimer CAS RN: 37366-09-9	<b>D5524</b> 250mg 1g  $\text{Cl}-\text{Ru}-\text{Cl}$ $\text{Cl}-\text{Ru}-\text{Cl}$ Mesityleneruthenium(II) Chloride Dimer CAS RN: 52462-31-4	<b>D2751</b> 1g 5g  $(\text{CH}_3)_2\text{CH}-\text{Ru}-\text{CH}_3$ $\text{Cl}-\text{Ru}-\text{Cl}$ $\text{Cl}-\text{Ru}-\text{Cl}$ $\text{CH}_3-\text{Ru}-\text{CH}(\text{CH}_3)_2$ Dichloro( <i>p</i> -cymene)ruthenium(II) Dimer CAS RN: 52462-29-0	<b>H1010</b> 1g  $\text{Cl}-\text{Ru}-\text{Cl}$ $\text{Cl}-\text{Ru}-\text{Cl}$ (Hexamethylbenzene)-ruthenium(II) Dichloride Dimer CAS RN: 67421-02-7
<b>C3456</b> 500mg  ( <i>p</i> -Cymene)-bis(mesitylcarboxylato)-ruthenium(II) CAS RN: 1251667-99-8	<b>C3327</b> 100mg  $(\text{-i-Pr})_3\text{P}-\text{Ru}-\text{Cl}$ $[(\text{DmpSR}')\text{RuCl}(\text{P}(\text{-i-Pr})_3)]$ CAS RN: 1621182-04-4	<b>C3328</b> 100mg  $[(\text{DmpSR}')\text{RuCl}(\text{P}(\text{-4-Fluorophenyl})_3)]$ CAS RN: 1420299-84-8	<b>C3668</b> 200mg  $(\text{CH}_3)_3\text{C}-\text{P}(\text{C}(\text{CH}_3)_3)_2$ $\text{CF}_3\text{SO}_3^-$ $[\text{Ru}(\text{-}p\text{-cymene})(\text{tBMPP})\text{Cl}]\text{-OTf}$ CAS RN: 2058252-91-6	<div style="text-align: center;"> <h2>ニッケル 触媒</h2> </div>
<b>N0850</b> 25g 500g $\text{NiCl}_2$ Nickel(II) Chloride Anhydrous CAS RN: 7718-54-9	<b>N0851</b> 25g 500g $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ Nickel(II) Chloride Hexahydrate CAS RN: 7791-20-0	<b>N1298</b> 1g 10g  $\text{NiBr}_2(\text{dme})$ CAS RN: 28923-39-9	<b>N1049</b> 1g 10g  $\text{NiBr}_2$ Nickel(II) Bromide 2-Methoxyethyl Ether Complex CAS RN: 312696-09-6	<b>B1571</b> 10g 100g  $\text{Ph}_3\text{P}-\text{Ni}-\text{Cl}$ $\text{Ph}_3\text{P}-\text{Ni}-\text{Cl}$ Bis(triphenylphosphine)-nickel(II) Dichloride CAS RN: 14264-16-5
<b>N0861</b> 1g 5g  $[\text{CF}_3-\text{SO}_3^-]_2 \text{Ni}^{2+}$ Nickel(II) Triflate CAS RN: 60871-84-3	<b>N0096</b> 25g 100g 500g  $[\text{CH}_3-\text{O}-\text{C}(\text{O})-\text{CH}_2-\text{C}(\text{O})-\text{O}-\text{Ni}]_2 \cdot x\text{H}_2\text{O}$ Bis(2,4-pentanedionato)-nickel(II) Hydrate CAS RN: 120156-44-7	<b>H0558</b> 1g 5g  $[\text{CF}_3-\text{C}(\text{O})-\text{CH}=\text{C}(\text{O})-\text{O}-\text{Ni}]_2$ Bis(hexafluoroacetylacetonato)-nickel(II) CAS RN: 14949-69-0	<b>B2225</b> 1g 5g 25g  $[\text{Ph}-\text{P}(\text{Ph})_2-\text{Ni}-\text{Cl}]_2$ [1,2-Bis(diphenylphosphino)ethane]nickel(II) Dichloride CAS RN: 14647-23-5	<b>B1313</b> 5g 25g  $[\text{Ph}-\text{P}(\text{Ph})_2-\text{Ni}-\text{Cl}]_2$ [1,3-Bis(diphenylphosphino)propane]dichloronickel(II) CAS RN: 15629-92-2
<b>B3534</b> 1g 5g  $(\text{C}_6\text{H}_{11})_3\text{P}-\text{Ni}-\text{Cl}$ $(\text{C}_6\text{H}_{11})_3\text{P}-\text{Ni}-\text{Cl}$ Bis(tricyclohexylphosphine)-nickel(II) Dichloride CAS RN: 19999-87-2	<b>D5369</b> 250mg  $\text{Cl}-\text{Ni}-\text{Cl}$ Dichlorobis(dicyclohexylphenylphosphine)nickel(II) CAS RN: 19232-03-2	<b>B0034</b> 25g  $[\text{C}_6\text{H}_5-\text{SO}_3^-]_2 \text{Ni}^{2+} \cdot 6\text{H}_2\text{O}$ Nickel(II) Benzenesulfonate Hexahydrate CAS RN: 39819-65-3	<b>T0276</b> 5g 25g  $[\text{CH}_3-\text{C}_6\text{H}_4-\text{SO}_3^-]_2 \text{Ni}^{2+} \cdot 6\text{H}_2\text{O}$ Nickel(II) <i>p</i> -Toluenesulfonate Hexahydrate CAS RN: 6944-05-4	<b>B3354</b> 1g  $[\text{Br}-\text{Ni}(\text{pyridine})_2(\text{imidazole})_2] \text{Br}^-$ Bromo[(2,6-pyridinediyl)-bis(3-methyl-1-imidazolyl)-2-ylidene]nickel Bromide CAS RN: 894102-11-5
<b>B2226</b> 1g 5g  $\text{Ph}-\text{P}(\text{Ph})_2-\text{Ni}-\text{Cl}$ $\text{Ph}-\text{P}(\text{Ph})_2-\text{Ni}-\text{Cl}$ [1,1'-Bis(diphenylphosphino)ferrocene]nickel(II) Dichloride CAS RN: 67292-34-6	<b>B3235</b> 200mg 1g  $\text{Cl}-\text{Ni}-\text{Cl}$ [1,3-Bis(2,6-diisopropylphenyl)imidazol-2-ylidene]triphenylphosphine Nickel(II) Dichloride CAS RN: 903592-98-3	<div style="text-align: center;"> <h2>コバルト 触媒</h2> </div>	<b>C3863</b> 50g 250g $\text{CoCl}_2$ Cobalt(II) Chloride CAS RN: 7646-79-9	<b>C2388</b> 250g $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ Cobalt(II) Chloride Hexahydrate CAS RN: 7791-13-1
<b>B2681</b> 25g  $[\text{CH}_3-\text{C}(\text{O})-\text{CH}=\text{C}(\text{O})-\text{O}-\text{Co}]_2$ Acetylacetonate Cobalt(II) Salt CAS RN: 14024-48-7	<b>C0373</b> 25g 500g  $[\text{CH}_3-\text{O}-\text{C}(\text{O})-\text{CH}_2-\text{C}(\text{O})-\text{O}-\text{Co}]_2 \cdot 2\text{H}_2\text{O}$ Bis(2,4-pentanedionato)-cobalt(II) Dihydrate CAS RN: 123334-29-2	<b>T0746</b> 1g 5g  $[\text{F}_3\text{C}-\text{C}(\text{O})-\text{CH}=\text{C}(\text{O})-\text{O}-\text{Co}]_2$ Bis(trifluoro-2,4-pentanedionato)cobalt(II) CAS RN: 16092-38-9	<b>H0553</b> 5g  $[\text{CF}_3-\text{C}(\text{O})-\text{CH}=\text{C}(\text{O})-\text{O}-\text{Co}]_2$ Bis(hexafluoroacetylacetonato)-cobalt(II) CAS RN: 19648-83-0	<b>S0318</b> 25g 100g 500g  Salcomine CAS RN: 14167-18-1

<b>D4940</b> 2g  Dicarbonyl-cyclopentadienylcobalt(I) CAS RN: 12078-25-0	<b>D3213</b> 5g 25g  Dicobalt Octacarbonyl (stabilized with 1-5% Hexane) CAS RN: 10210-68-1	<b>D5924</b> 1g 5g  Co(dmgh) <sub>2</sub> Cl <sub>2</sub> CAS RN: 23638-66-6	<b>C3718</b> 1g  Co(dmgh) <sub>2</sub> PyCl CAS RN: 23295-32-1	<b>C3711</b> 1g  Co(dmgh) <sub>2</sub> (DMAP)Cl CAS RN: 483979-48-2
<b>B3374</b> 1g 5g  [1,1'-Bis(diphenylphosphino)-ferrocene]cobalt(II) Dichloride CAS RN: 67292-36-8	<b>C3579</b> 1g  Cobalt(II) Tetraphenylporphyrin CAS RN: 14172-90-8	<b>金触媒</b>		<b>T2994</b> 200mg 1g  (Triphenylphosphine)-gold(I) Chloride CAS RN: 14243-64-2
<b>銀触媒</b>		<b>I1183</b> 5g 25g AgCl Silver(I) Chloride CAS RN: 7783-90-6	<b>S0463</b> 5g 25g AgSbF <sub>6</sub> Silver Hexafluoroantimonate(V) CAS RN: 26042-64-8	<b>S0981</b> 1g 5g AgPF <sub>6</sub> Silver Hexafluorophosphate CAS RN: 26042-63-7
<b>C2373</b> 200mg 1g  Chloro[1,3-bis(2,6-diisopropylphenyl)-imidazol-2-ylidene]silver CAS RN: 873297-19-9	<b>銅触媒</b>		<b>T2666</b> 1g 5g 25g (CH <sub>3</sub> CN) <sub>4</sub> Cu <sup>+</sup> BF <sub>4</sub> <sup>-</sup> Tetrakis(acetonitrile)copper(I) Tetrafluoroborate CAS RN: 15418-29-8	<b>T2665</b> 5g (CH <sub>3</sub> CN) <sub>4</sub> Cu <sup>+</sup> PF <sub>6</sub> <sup>-</sup> Tetrakis(acetonitrile)copper(I) Hexafluorophosphate CAS RN: 64443-05-6
<b>S0898</b> 1g 5g Ag <sup>+</sup> (CF <sub>3</sub> SO <sub>2</sub> ) <sub>2</sub> N <sup>-</sup> Silver Triflimide CAS RN: 189114-61-2	<b>T3905</b> 1g 5g (CH <sub>3</sub> CN) <sub>4</sub> Cu <sup>+</sup> CF <sub>3</sub> SO <sub>3</sub> <sup>-</sup> Tetrakis(acetonitrile)copper(I) Triflate CAS RN: 58452-28-1	<b>C1952</b> 25g 300g CuCN Copper(I) Cyanide CAS RN: 544-92-3	<b>C2162</b> 25g 100g 500g CuCl Copper(I) Chloride CAS RN: 7758-89-6	<b>C3714</b> 25g 500g CuCl <sub>2</sub> Copper(II) Chloride Anhydrous CAS RN: 7447-39-4
<b>A1540</b> 5g 25g  Copper(I) Acetate CAS RN: 598-54-9	<b>C2346</b> 25g 500g  Copper(II) Acetate Monohydrate CAS RN: 6046-93-1	<b>T1292</b> 5g 25g  Copper(II) Trifluoromethanesulfonate CAS RN: 34946-82-2	<b>T1442</b> 1g 5g  Copper(I) Triflate Benzene Complex CAS RN: 42152-46-5	<b>C0384</b> 25g 250g  Bis(2,4-pentanedionato)-copper(II) CAS RN: 13395-16-9
<b>H0554</b> 1g 5g  Bis(hexafluoroacetylacetonato)-copper(II) CAS RN: 14781-45-4	<b>D2542</b> 5g 25g  Di-μ-hydroxo-bis[(N,N,N',N'-tetramethylethylenediamine)-copper(II)] Chloride CAS RN: 30698-64-7	<b>D3891</b> 1g 5g  Dichloro(1,10-phenanthroline)copper(II) CAS RN: 14783-09-6	<b>C2312</b> 1g 5g  CuTC CAS RN: 68986-76-5	<b>C2422</b> 200mg 1g  Chloro(1,3-dimesitylimidazol-2-ylidene)copper(I) CAS RN: 873779-78-3
<b>C2304</b> 200mg 1g  Chloro[1,3-bis(2,6-diisopropylphenyl)imidazol-2-ylidene]copper(I) CAS RN: 578743-87-0	<b>B3351</b> 200mg 1g  [1,3-Bis(2,6-diisopropylphenyl)imidazol-2-ylidene](1,3-diphenyl-1,3-propanedionato)copper(I) CAS RN: 920739-11-3	<b>鉄触媒</b>		<b>F1338</b> 5g 25g FeBr <sub>2</sub> Iron(II) Bromide CAS RN: 7789-46-0
<b>I0765</b> 5g 25g  Iron(II) Acetate CAS RN: 3094-87-9				

<b>I0079</b> 25g 100g 500g  Iron(III) Acetylacetonate CAS RN: 14024-18-1	<b>H0555</b> 1g  Tris(hexafluoroacetylacetonato)iron(III) CAS RN: 17786-67-3	<b>C1592</b> 5g  Cyclopentadienyliron Dicarboxyl Dimer CAS RN: 12154-95-9	<b>T1775</b> 1g  Tricarbonyl(cyclooctatetraene)iron CAS RN: 12093-05-9	<b>I0937</b> 200mg 1g  Iron(III) Tetraphenylporphyrin Chloride CAS RN: 16456-81-8
<b>D5886</b> 100mg  Dichloro[8-(diisopropylphosphino)-5-fluoro-2-(2-pyridinyl)quinoline]iron(II) CAS RN: 2247605-87-2	<b>M2621</b> 1g 5g  Manganese(III) Tetraphenylporphyrin Chloride CAS RN: 32195-55-4	<b>M3581</b> 25g 100g MnBr <sub>2</sub> Manganese(II) Bromide CAS RN: 13446-03-2	<b>M3448</b> 100g 500g MnO <sub>2</sub> Manganese(IV) Oxide CAS RN: 1313-13-9	
<b>D5880</b> 1g [Mn(CO) <sub>5</sub> ] <sub>2</sub> Manganese Carbonyl CAS RN: 10170-69-1	<b>マンガン 触媒</b>			
<b>配位子</b>				
<b>D0903</b> 25g 250g  <i>trans,trans</i> -Dibenzylideneacetone CAS RN: 35225-79-7	<b>B4467</b> 200mg 1g  <i>trans,trans</i> -Bis(4-methoxybenzylidene)acetone CAS RN: 37951-12-5	<b>B2283</b> 5g  <i>trans,trans</i> -Bis(4-fluorobenzylidene)acetone CAS RN: 53369-00-9	<b>B4468</b> 200mg  <i>trans,trans</i> -Bis[4-(trifluoromethyl)benzylidene]acetone CAS RN: 103836-71-1	<b>D1804</b> 5g 25g  2,6-Di- <i>tert</i> -butylpyridine CAS RN: 585-48-8
<b>D4652</b> 1g  <i>trans</i> -2,6-Diisopropyl- <i>N</i> -(2-pyridylmethylene)aniline CAS RN: 908294-68-8	<b>B0468</b> 25g 100g 500g  2,2'-Bipyridyl CAS RN: 366-18-7	<b>D3134</b> 1g 5g  4,4'-Di- <i>tert</i> -butyl-2,2'-bipyridyl CAS RN: 72914-19-3	<b>P0221</b> 1g 25g  1,10-Phenanthroline Monohydrate CAS RN: 5144-89-8	<b>D0771</b> 1g  Neocuproine Hemihydrate CAS RN: 34302-69-7
<b>D0905</b> 1g 5g  Bathophenanthroline CAS RN: 1662-01-7	<b>D6165</b> 100mg  4-(5,5'-Dimethyl[2,2':6',2''-terpyridin]-4'-yl)- <i>N,N</i> -dimethylaniline CAS RN: 2876806-74-3	<b>B6552</b> 100mg 500mg  2,7-Bis(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)spiro[cyclopenta[2,1- <i>b</i> :3,4- <i>b'</i> ]dipyridine-5,9'-fluorene] CAS RN: 2763205-15-6	<b>T0361</b> 25mL 100mL 500mL  Tributylphosphine CAS RN: 998-40-3	
<b>T2584</b> 1g 5g  Tri- <i>tert</i> -butylphosphonium Tetrafluoroborate CAS RN: 131274-22-1	<b>D4731</b> 1g 5g  Di- <i>tert</i> -butyl(methyl)phosphonium Tetrafluoroborate CAS RN: 479094-62-7	<b>T1165</b> 25mL  Tricyclohexylphosphine (contains Tricyclohexylphosphine Oxide) (ca. 18% in Toluene, ca. 0.60mol/L) CAS RN: 2622-14-2	<b>T2585</b> 1g 5g  Tricyclohexylphosphonium Tetrafluoroborate CAS RN: 58656-04-5	<b>D2411</b> 1g 5g  Dicyclohexylphenylphosphine CAS RN: 6476-37-5



<b>T0519</b> 25g 100g 500g  Triphenylphosphine CAS RN: 603-35-0	<b>T1024</b> 5g 25g  Tri(o-tolyl)phosphine CAS RN: 6163-58-2	<b>T2900</b> 5g  Tris(4-fluorophenyl)phosphine CAS RN: 18437-78-0	<b>T2526</b> 1g 5g  Tris[3,5-bis(trifluoromethyl)phenyl]phosphine CAS RN: 175136-62-6	<b>T1614</b> 5g 25g  Tris(2,6-dimethoxyphenyl)phosphine CAS RN: 85417-41-0
<b>T1643</b> 1g 5g  Tri(2-furyl)phosphine CAS RN: 5518-52-5	<b>T1666</b> 1g 5g  Tri(2-thienyl)phosphine CAS RN: 24171-89-9	<b>B1174</b> 1g  1,2-Bis(dimethylphosphino)ethane CAS RN: 23936-60-9	<b>B1137</b> 10g 25g  1,2-Bis(diphenylphosphino)ethane CAS RN: 1663-45-2	<b>B1138</b> 5g 25g  1,3-Bis(diphenylphosphino)propane CAS RN: 6737-42-4
<b>B1246</b> 5g 25g  1,4-Bis(diphenylphosphino)butane CAS RN: 7688-25-7	<b>B1960</b> 1g  1,5-Bis(diphenylphosphino)pentane CAS RN: 27721-02-4	<b>B1959</b> 1g 5g  1,6-Bis(diphenylphosphino)hexane CAS RN: 19845-69-3	<b>B3372</b> 1g 5g  1,2-Bis(diphenylphosphino)benzene CAS RN: 13991-08-7	<b>B2710</b> 100mg 1g  1,1'-Bis(diisopropylphosphino)ferrocene CAS RN: 97239-80-0
<b>B2711</b> 100mg 1g  1,1'-Bis(di-tert-butylphosphino)ferrocene CAS RN: 84680-95-5	<b>B2027</b> 1g 5g 25g  1,1'-Bis(diphenylphosphino)ferrocene CAS RN: 12150-46-8	<b>B2383</b> 5g 25g  (±)-BINAP CAS RN: 98327-87-8	<b>B2867</b> 5g 25g  DPEphos CAS RN: 166330-10-5	<b>B2709</b> 1g 5g 25g  Xantphos CAS RN: 161265-03-8
<b>B5239</b> 200mg 1g  4,5-Bis(dicyclohexylphosphino)-9,9-dimethylxanthene CAS RN: 940934-47-4	<b>B2717</b> 100mg 1g  4,6-Bis(diphenylphosphino)phenoxazine CAS RN: 261733-18-0	<b>D3389</b> 1g 5g  DavePhos CAS RN: 213697-53-1	<b>B2630</b> 100mg 1g  2,2'-Bis(diphenylphosphino)biphenyl CAS RN: 84783-64-2	<b>B5957</b> 100mg 500mg  2,2'-Bis[bis(3,5-dimethylphenyl)phosphino]-1,1'-biphenyl CAS RN: 325773-62-4
<b>B6436</b> 200mg 1g 5g  Bis[2-(diphenylphosphino)phenyl]phenylphosphine CAS RN: 53103-03-0	<b>B4595</b> 1g  1,3-Bis[(di-tert-butylphosphino)oxy]benzene CAS RN: 338800-20-7			
<b>配向基導入試薬</b>		<b>A0419</b> 5g 25g 100g  8-Aminoquinoline CAS RN: 578-66-5	<b>D4264</b> 1g 5g  2-(Diisopropylsilyl)pyridine CAS RN: 1232692-92-0	<b>P1902</b> 1g  2-(1H-Pyrazol-5-yl)aniline CAS RN: 111562-32-4
		<b>その他の添加剤</b>		<b>B0089</b> 25g 100g 500g  p-Benzoquinone CAS RN: 106-51-4

<p><b>D2234</b> 1g 5g 25g</p>  <p>2,6-Dimethyl-1,4-benzoquinone CAS RN: 527-61-7</p>	<p><b>D3411</b> 100mL</p>  <p>Di-tert-butyl Peroxide CAS RN: 110-05-4</p>	<p><b>B3153</b> 100g</p>  <p>tert-Butyl Hydroperoxide (70% in Water) CAS RN: 75-91-2</p>	<p><b>T1560</b> 5g 25g</p>  <p>TEMPO Free Radical CAS RN: 2564-83-2</p>	<p><b>F0335</b> 5g 25g</p>  <p>NFSI CAS RN: 133745-75-2</p>
<p><b>P1015</b> 5g 25g</p>  <p>Koser Reagent CAS RN: 27126-76-7</p>	<p><b>I0330</b> 10g 25g 250g</p>  <p>Iodobenzene Diacetate CAS RN: 3240-34-4</p>	<p><b>D0798</b> 25g 500g</p>  <p>Dimethyl Sulfoxide CAS RN: 67-68-5</p>	<p><b>T0431</b> 25g 100g 500g</p>  <p>Trifluoroacetic Acid CAS RN: 76-05-1</p>	<p><b>O0310</b> 25g 500g</p> <p>2KHSO<sub>5</sub> · KHSO<sub>4</sub> · K<sub>2</sub>SO<sub>4</sub>  Potassium Peroxymonosulfate CAS RN: 37222-66-5</p>
<p><b>L0224</b> 25g 500g</p>  <p>Lithium Carbonate CAS RN: 554-13-2</p>	<p><b>S0560</b> 300g</p>  <p>Sodium Carbonate CAS RN: 497-19-8</p>	<p><b>P1748</b> 300g</p>  <p>Potassium Carbonate CAS RN: 584-08-7</p>	<p><b>C2160</b> 25g 100g</p>  <p>Cesium Carbonate CAS RN: 534-17-8</p>	<p><b>T2052</b> 100mL 500mL</p> <p>TiCl<sub>4</sub> Titanium(IV) Chloride (14% in Dichloromethane, ca. 1.0mol/L) CAS RN: 7550-45-0</p>
<p><b>T3238</b> 100mL 500mL</p> <p>TiCl<sub>4</sub> Titanium(IV) Chloride (ca. 19% in Toluene, ca. 1.0mol/L) CAS RN: 7550-45-0</p>	<p><b>S0463</b> 5g 25g</p> <p>AgSbF<sub>6</sub> Silver Hexafluoroantimonate(V) CAS RN: 26042-64-8</p>	<p><b>S0898</b> 1g 5g</p> <p>Ag<sup>+</sup> (CF<sub>3</sub>SO<sub>2</sub>)<sub>2</sub>N<sup>-</sup> Silver Triflimide CAS RN: 189114-61-2</p>	<p><b>S0978</b> 5g 25g</p>  <p>Sodium Pivalate Hydrate CAS RN: 143174-36-1</p>	<p><b>P2354</b> 5g 25g</p>  <p>Potassium Pivalate CAS RN: 19455-23-3</p>
<p><b>C3230</b> 1g 5g</p>  <p>Cesium Pivalate CAS RN: 20442-70-0</p>				

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