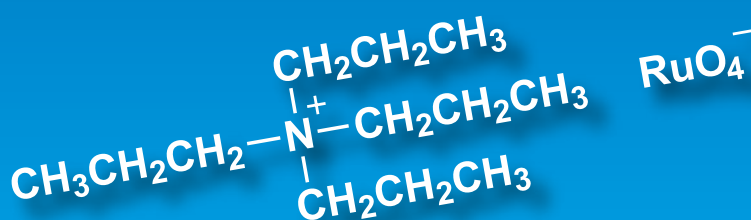
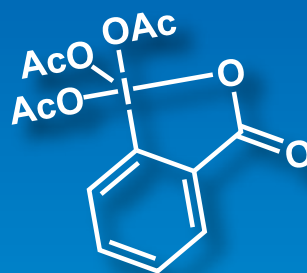
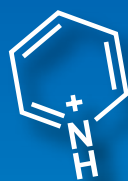


# Oxidizing Agents



Chromates

Hypochlorites

Perchlorates

Peroxides

Hypervalent Iodine

Sulfur Oxides

N-Oxides

Other Oxidizing Agents

Catalysts for Oxidation

# Oxidizing Agents

Oxidation, which makes its target substance lose electrons, is one of the most basic reactions in organic chemistry and is exemplified by the combination with oxygen or a dehydrogenation reaction. In particular, oxidizing agents have often been used for the transformation of alcohols to the corresponding aldehydes, ketones or carboxylic acids. Heavy metal compounds, such as chromium(VI) oxide and potassium permanganate, have been exploited for many years. Later, less harmful oxidizing agents without heavy metals were developed, such as Dess-Martin periodinane, the Mukaiyama oxidizing agent and oxoammonium salts. Moreover, oxidation reactions employing inexpensive cooxidants have been reported in the presence of oxidation catalysts like tetrapropylammonium perruthenate (TPAP) and TEMPO. In this way, oxidation reactions involving organic compounds have great diversity, and many books on oxidation have been published.<sup>1)</sup>

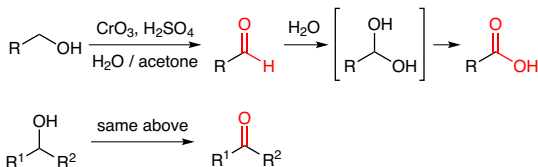
This brochure introduces a variety of oxidizing agents and catalysts for oxidation. We hope that it will be useful for your research in organic synthesis. In addition, we have prepared another brochure, "Reducing Agents", which is the reverse reaction to oxidation.

## ● Chromate Salts

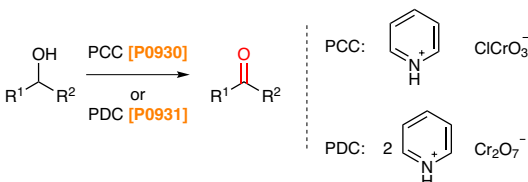
Jones *et al.* reported that a mixture of chromium oxide(VI) and diluted sulfuric acid was useful for the oxidation of alcohols, and this reaction is called Jones oxidation<sup>2)</sup> It can convert primary and secondary alcohols into carboxylic acids and ketones, respectively. Since this report, chromium oxidants have been improved to develop the Sarett-Collins oxidation<sup>3)</sup> process using complex chromium(VI) oxide-2py, pyridinium chlorochromate (PCC) [P0930]<sup>4)</sup> and pyridinium dichromate (PDC) [P0931].<sup>5)</sup> These reagents can oxidize primary alcohols to aldehydes without overreaction.

Caution: Chromium(VI) compounds and the chromium residue after the reaction are highly toxic, so they should be handled or discarded with consideration to the environment.

### Jones oxidation

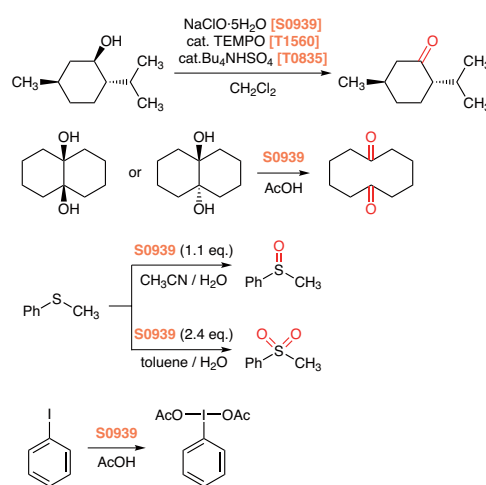


### PCC and PDC oxidation



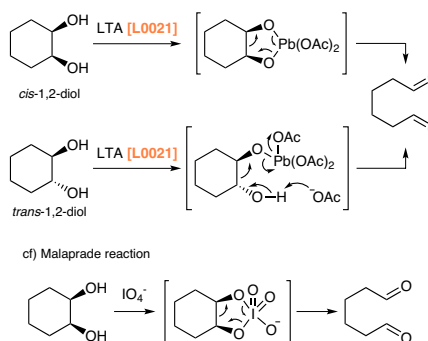
## ● Sodium Hypochlorite

Sodium hypochlorite pentahydrate ( $\text{NaClO} \cdot 5\text{H}_2\text{O}$ ) [S0939] is a stable crystalline solid and effective for the oxidation of hydroxy and sulfide groups. For instance, S0939 can oxidize secondary alcohols into ketones in the presence of a catalytic amount of TEMPO [T1560].<sup>6)</sup> S0939 is also utilized in the oxidative cleavage of 1,2-diols<sup>7)</sup> and oxidation of sulfides.<sup>8)</sup> Sulfoxides and sulfones can be synthesized in high yields by adjusting the equivalents of S0939. Furthermore, it has recently been reported that S0939 is useful for the convenient synthesis of hypervalent iodine compounds.<sup>9)</sup>



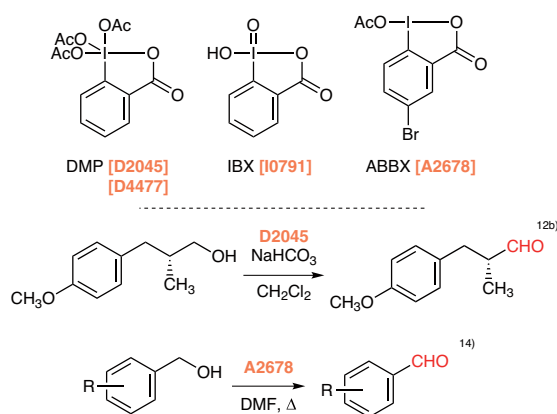
## ● Criegee Oxidation

Criegee oxidation gives two ketones or aldehydes from 1,2-diols by using lead(IV) tetraacetate (LTA) [L0021] as an oxidant.<sup>10)</sup> This reaction is different from the oxidative cleavage reaction using periodate salt (= Malprade reaction)<sup>11)</sup> and proceeds when applied to *trans*-1,2-diols, which would be difficult to pass through the five-membered intermediate. This indicates another reaction mechanism that does not pass through the cyclic transition state.



## ● Oxidation using Hypervalent Iodine Compounds

Dess-Martin periodinane (DMP)<sup>12)</sup> [D2045] [D4477] can oxidize primary and secondary alcohols into aldehydes and ketones, respectively. DMP has some advantages compared with chromate(VI) compounds: the reaction using DMP proceeds under mild conditions; the generality of reactive substrates is wide; the environmental impact is lower; and the treatment after the reaction is easy. 2-Iodoxybenzoic acid (IBX)<sup>13)</sup> [I0791] and 1-acetoxy-5-bromo-1,2-benziodoxol-3(1*H*)-one (ABBX)<sup>14)</sup> [A2678], which was developed by Togo, are also utilized as oxidants of alcohols as well as other hypervalent iodine compounds.<sup>15)</sup> These compounds are introduced in our brochure "Hypervalent Iodine Compounds".



## ● DMSO Oxidations and Odorless Swern Oxidants

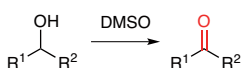
Kornblum *et al.* found that the carbonyl group was produced from benzyl halides and tosylates by the treatment of DMSO [D0798] in the presence of a base.<sup>16)</sup> After this report, various types of oxidations using DMSO have been reported as follows: Pfitzner-Moffatt oxidation<sup>17)</sup> using DCC [D0436] or DCC (granulated) [D4876]; Albright-Goldman oxidation<sup>18)</sup> using acetic anhydride [A2036]; Parikh-Doering oxidation<sup>19)</sup> using SO<sub>3</sub>-pyridine complex [P0998]; and Swern oxidation<sup>20)</sup> using oxalyl chloride [O0082]. These reactions are utilized widely from the laboratory scale to the industrial scale.

### Kornblum oxidation



X = halogen, TsO

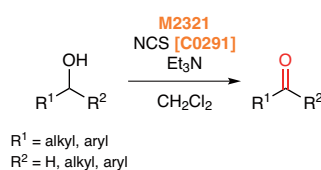
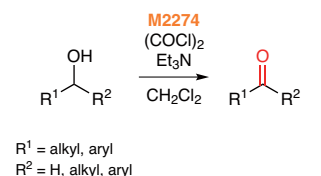
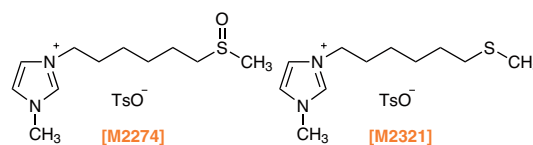
### Various DMSO oxidations



R<sup>1</sup> = alkyl, aryl  
R<sup>2</sup> = H, alkyl, aryl

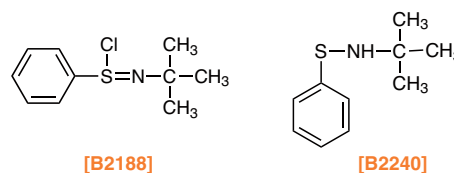
named reactions	reagents
Pfitzner-Moffatt oxid.	DCC [D0436] [D4876] TFA [T0431]
Albright-Goldman oxid.	Ac <sub>2</sub> O [A2036]
Parikh-Doering oxid.	SO <sub>3</sub> ·py [P0998], Et <sub>3</sub> N [T0424]
Swern oxid.	(COCl) <sub>2</sub> [O0082] or TFAA [T0433] Et <sub>3</sub> N [T0424]

One problem with DMSO oxidation is the odor of the byproduct dimethyl sulfide. To solve this problem, Togo *et al.* developed the odorless and recyclable imidazolium salts [M2274] and [M2321] for use in Swern oxidation<sup>21a)</sup> and Corey-Kim oxidation,<sup>21b)</sup> respectively.

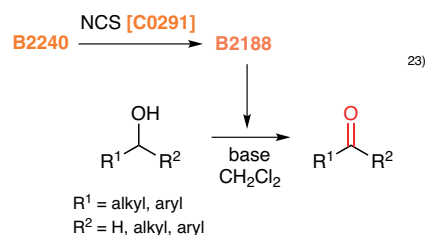


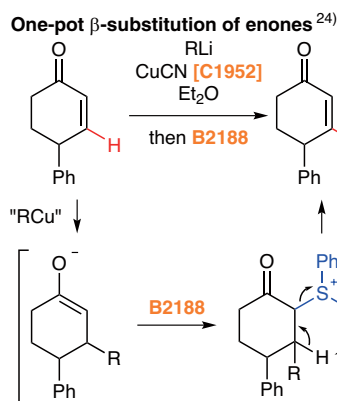
## ● Mukaiyama Oxidation Reaction

Mukaiyama's group reported two new oxidation reactions using *N*-*tert*-butylbenzenesulfinimidoyl chloride [B2188]<sup>22)</sup> and catalytic amounts of *N*-*tert*-butylbenzenesulfenamide [B2240] and NCS [C0291]<sup>23)</sup> respectively. It is considered that B2188 is generated *in situ* by the reaction of B2240 and NCS, and turns into B2240 after the reaction; thus B2240 works as a catalyst. B2188 is a stable solid and can give α,β-unsaturated ketones from an enolate by deprotonation at the α-position or 1,4-addition.<sup>24)</sup> In addition, the new method has been reported to afford a ketone from an aldehyde, an alkyllithium and B2188 in one pot.<sup>25)</sup>



### Oxidation of alcohols

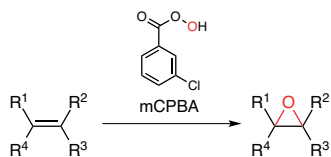




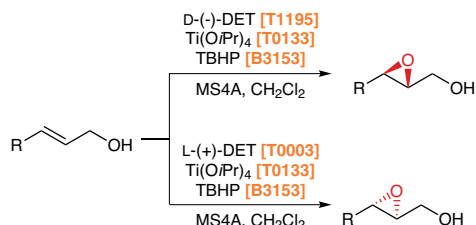
## ● Epoxidation Reaction

Epoxidation is also an oxidation reaction and the Prilezhaev (Prileschajew) reaction<sup>26)</sup> with mCPBA is regarded as a representative epoxidation. Furthermore, asymmetric epoxidation reactions have been reported such as Sharpless-Katsuki asymmetric epoxidation<sup>27)</sup> for allyl alcohols and Jacobsen-Katsuki asymmetric epoxidation<sup>28)</sup> of *cis*-olefins. Sharpless-Katsuki asymmetric epoxidation is often used in the total syntheses of natural products.

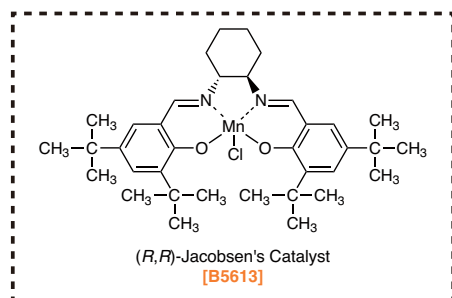
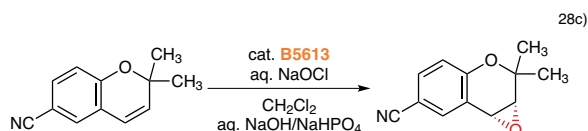
### Prilezhaev epoxidation



### Sharpless-Katsuki asymmetric epoxidation



### Jacobsen-Katsuki asymmetric epoxidation

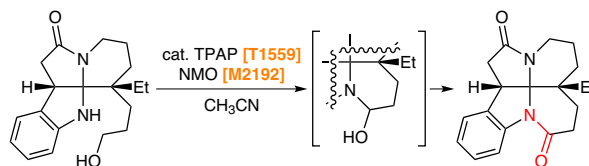
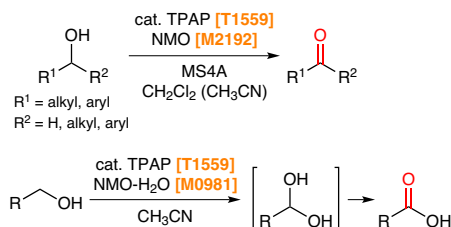


## ● Catalytic Oxidation Reactions

### 1. Oxidation with TPAP Catalyst

Tetrapropylammonium perruthenate (TPAP) [T1559] catalyst can oxidize alcohols into aldehydes and ketones by the addition of 4-methylmorpholine *N*-oxide (= NMO) [M2192] as a cooxidant (Ley-Griffith oxidation).<sup>29)</sup> This reaction proceeds under very mild conditions to give the corresponding product in high yield even when applied to unstable substances. Moreover, this reaction can oxidize primary alcohols to carboxylic acids in the presence of water by hydration of the aldehyde to form a *gem*-diol and subsequent reoxidation.<sup>30)</sup> TPAP and NMO are often applied in the syntheses of natural products. Gaich's group, for instance, have reported the total synthesis of (-)-leuconoxine by ingeniously applying this reaction at the last step.<sup>31)</sup>

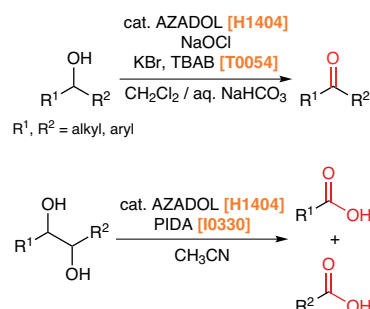
#### Ley-Griffith oxidation



### 2. Oxidation Using AZADOL<sup>®</sup>

AZADOL<sup>®</sup> [H1404], known as the precursor of an oxidation catalyst, is a hydroxyamine developed by Iwabuchi *et al.*<sup>32)</sup> The oxidizing ability of H1404 is superior to that of TEMPO [T1560], particularly for secondary alcohols. In addition, 1,2-diols are oxidatively cleaved by the treatment of a catalytic amount of PIDA [I0330] to afford two carboxylic acids. H1404 is anticipated as a green catalyst for oxidation since sodium hypochlorite, sodium chlorite and even oxygen in air can be utilized as cooxidants.

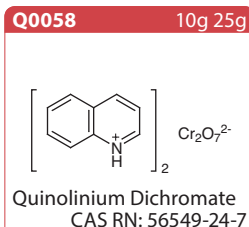
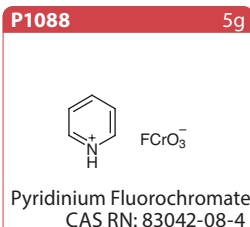
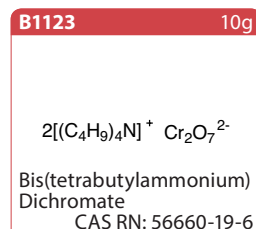
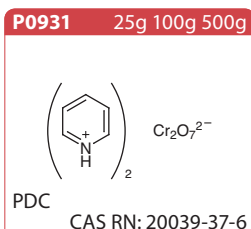
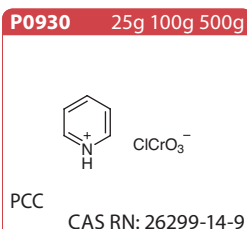
AZADOL<sup>®</sup> is a registered trademark of Nissan Chemical Corporation.



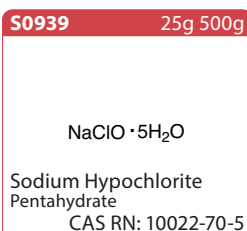
## References

- 1) a) T. J. Donohoe, *Oxidation and Reduction in Organic Synthesis* Oxford Univ Pr on Demand, **2000**.
- b) A. H. Haines, *Methods for the Oxidation of Organic Compounds: Alcohols, Alcohol Derivatives, Alkyl Halides, Nitroalkanes, Alkyl Azides, Carbonyl Compounds, Hydroxyarenes and Aminoarenes*, **1988**.
- c) G. Tojo, M. I. Fernandez, *Oxidation of Alcohols to Aldehydes and Ketones: A Guide to Current Common Practice* Springer, **2005**.
- d) L. Kürti, B. Czakó, *Strategic Applications of Named Reactions in Organic Synthesis*, Elsevier, **2005**.
- 2) K. Bowden, I. M. Heilbron, E. R. H. Jones, B. C. L. Weedon, *J. Chem. Soc.* **1946**, 39.
- 3) a) G. I. Poos, G. E. Arth, R. E. Beyler, L. H. Sarett, *J. Am. Chem. Soc.* **1953**, 75, 422.
- b) J. C. Collins, W. W. Hess, F. J. Frank, *Tetrahedron Lett.* **1968**, 9, 3363.
- 4) E. J. Corey, J. W. Suggs, *Tetrahedron Lett.* **1975**, 16, 2647.
- 5) E. J. Corey, G. Schmidt, *Tetrahedron Lett.* **1979**, 20, 399.
- 6) T. Okada, T. Asawa, Y. Sugiyama, M. Kirihara, T. Iwai, Y. Kimura, *Synlett* **2014**, 25, 596.
- 7) M. Kirihara, R. Osugi, K. Saito, K. Adachi, K. Yamazaki, R. Matsushima, Y. Kimura, *J. Org. Chem.* **2019**, 84, 8330.
- 8) T. Okada, H. Matsumuro, S. Kitagawa, T. Iwai, K. Yamazaki, Y. Kinoshita, Y. Kimura, M. Kirihara, *Synlett* **2015**, 26, 2547.
- 9) A. Watanabe, K. Miyamoto, T. Okada, T. Asawa, M. Uchiyama, *J. Org. Chem.* **2018**, 83, 14262.
- 10) R. Criegee, *Ber.* **1933**, 64, 260.
- 11) a) L. Malaprade, *Bull. Soc. Chim. Fr.* **1934**, 3, 833.
- b) P. Karrer, R. Hirohata, *Helv. Chim. Acta* **1933**, 16, 959.
- 12) a) D. B. Dess, J. C. Martin, *J. Org. Chem.* **1983**, 48, 4155.
- b) V. Beghetto, A. Scriveranti, M. Bertoldini, M. Aversa, A. Zancanaro, U. Matteoli, *Synthesis* **2015**, 47, 272.
- 13) M. Frigerio, M. Santagostino, *Tetrahedron Lett.* **1994**, 35, 8019.
- 14) M. Iinuma, K. Moriyama, H. Togo, *Eur. J. Org. Chem.* **2014**, 772.
- 15) review: a) H. Tohma, Y. Kita, *Adv. Synth. Catal.* **2004**, 346, 111.
- b) A. Yoshimura, V. V. Zhdankin, *Chem. Rev.* **2016**, 116, 3328.
- 16) a) N. Kornblum, J. W. Powers, G. J. Anderson, W. J. Jones, H. O. Larson, O. Levand, W. M. Weaver, *J. Am. Chem. Soc.* **1957**, 79, 6562.
- b) N. Kornblum, W. J. Jones, G. J. Anderson, *J. Am. Chem. Soc.* **1959**, 81, 4113.
- 17) a) K. E. Pfitzner, J. G. Moffatt, *J. Am. Chem. Soc.* **1963**, 85, 3027.
- b) K. E. Pfitzner, J. G. Moffatt, *J. Am. Chem. Soc.* **1965**, 87, 5661.
- c) K. E. Pfitzner, J. G. Moffatt, *J. Am. Chem. Soc.* **1965**, 87, 5670.
- 18) J. D. Albright, L. Goldman, *J. Am. Chem. Soc.* **1967**, 89, 2416.
- 19) J. R. Parikh, W. v. E. Doering, *J. Am. Chem. Soc.* **1967**, 89, 5505.
- 20) a) A. K. Sharma, D. Swern, *Tetrahedron Lett.* **1974**, 15, 1503.
- b) K. Omura, A. K. Sharma, D. Swern, *J. Org. Chem.* **1976**, 41, 957.
- c) L. Huang, D. Swern, *J. Org. Chem.* **1978**, 43, 4537.
- d) K. Omura, D. Swern, *Tetrahedron* **1978**, 34, 1651.
- 21) a) D. Tsuchiya, K. Moriyama, H. Togo, *Synlett* **2011**, 2701.
- b) D. Tsuchiya, M. Tabata, K. Moriyama, H. Togo, *Tetrahedron* **2012**, 68, 6849.
- 22) T. Mukaiyama, J. Matsuo, D. Iida, H. Kitagawa, *Chem. Lett.* **2001**, 30, 846.
- 23) T. Mukaiyama, J. Matsuo, M. Yanagisawa, *Chem. Lett.* **2000**, 29, 1072.
- 24) a) J. Matsuo, Y. Aizawa, *Chem. Comm.* **2005**, 2399.
- b) W. J. Kerr, C. M. Pearson, G. J. Thurston, *Org. Biomol. Chem.* **2006**, 4, 47.
- 25) J. J. Crawford, K. W. Henderson, W. J. Kerr, *Org. Lett.* **2006**, 8, 5073.
- 26) N. Prileschajew, *Ber.* **1909**, 42, 4811.
- 27) a) T. Katsuki, K. B. Sharpless, *J. Am. Chem. Soc.* **1980**, 102, 5974.
- b) review: A. Pfenniger, *Synthesis* **1986**, 89.
- 28) a) W. Zhang, J. L. Loebach, S. R. Wilson, E. N. Jacobsen, *J. Am. Chem. Soc.* **1980**, 102, 5974.
- b) R. Irie, K. Noda, Y. Ito, T. Katsuki, *Tetrahedron Lett.* **1991**, 32, 1055.
- c) N. H. Lee, A. R. Muci, E. N. Jacobsen, *Tetrahedron Lett.* **1991**, 32, 5055.
- 29) W. P. Griffith, S. V. Ley, G. P. Whitcombe, A. D. White, *J. Chem. Soc., Chem. Commun.* **1987**, 1625.
- 30) A.-K. C. Schmidt, C. B. W. Stark, *Org. Lett.* **2011**, 13, 4164.
- 31) M. Pfaffenbach, T. Gaich, *Chem. Eur. J.* **2015**, 21, 6355.
- 32) a) M. Shibuya, Y. Sasano, M. Tomizawa, T. Hamada, M. Kozawa, N. Nagahama, Y. Iwabuchi, *Synthesis* **2011**, 21, 3418.
- b) review: Y. Iwabuchi, *Chem. Pharm. Bull.* **2013**, 61, 1197.
- 33) M. Shibuya, T. Shibuta, H. Fukuda, Y. Iwabuchi, *Org. Lett.* **2012**, 14, 5010.

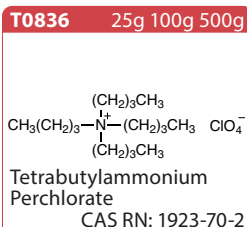
## Chromates



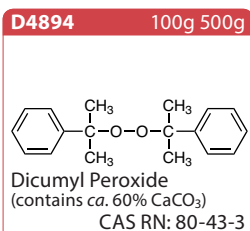
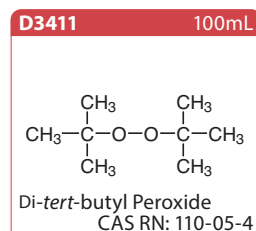
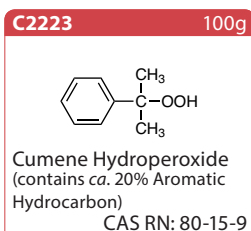
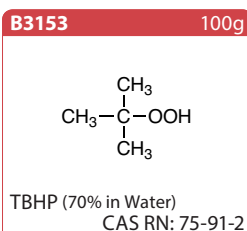
## Hypochlorites



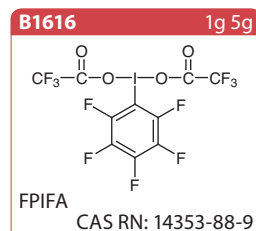
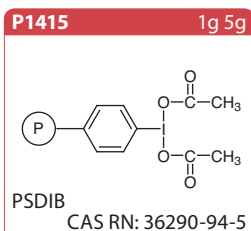
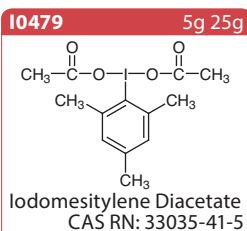
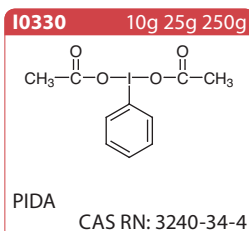
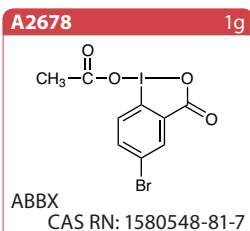
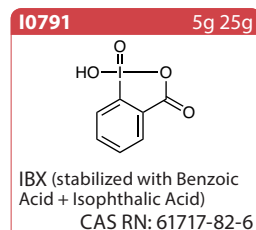
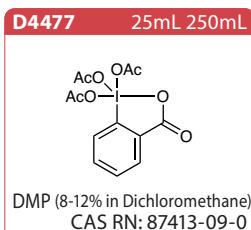
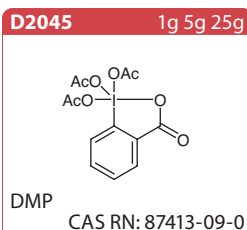
## Perchlorates

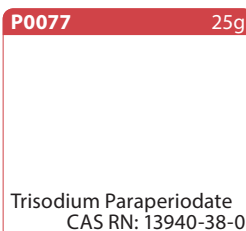
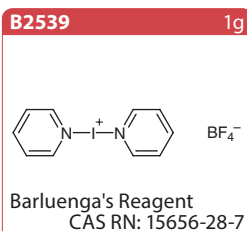
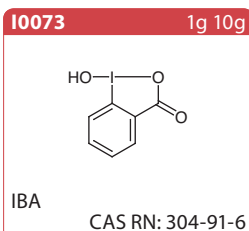
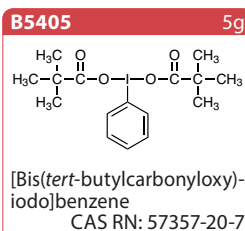


## Peroxides

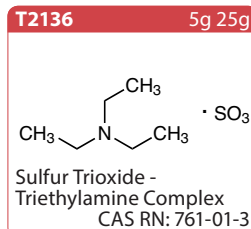
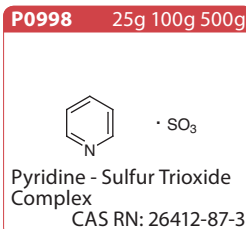
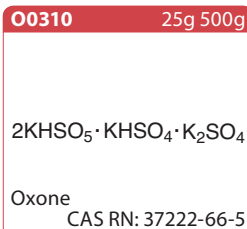


## Hypervalent Iodine

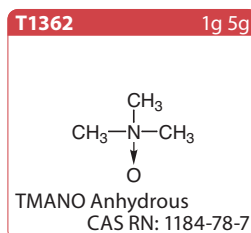
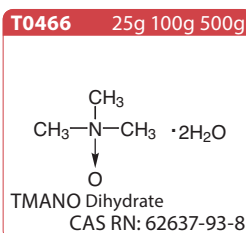
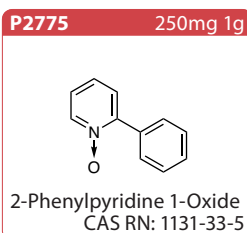
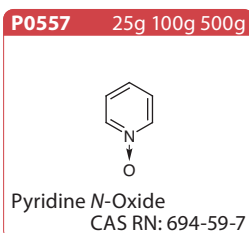
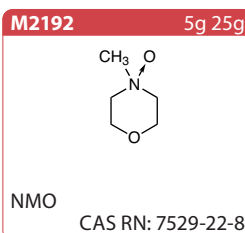
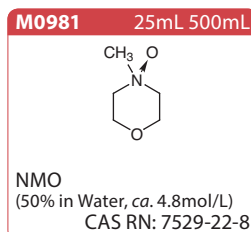
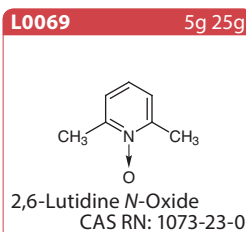
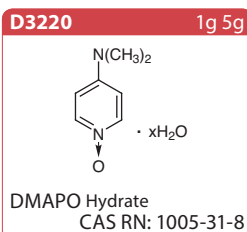
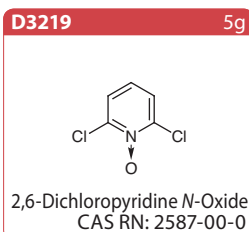
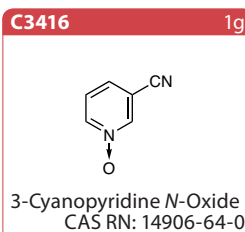
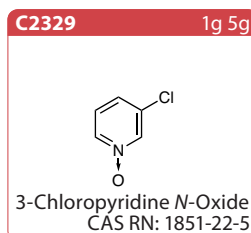
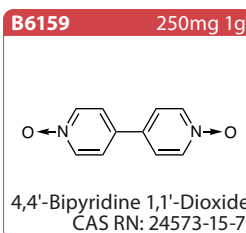
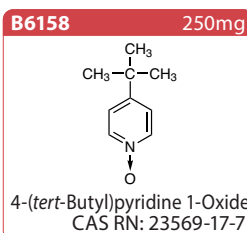




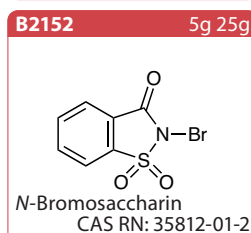
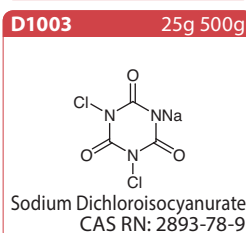
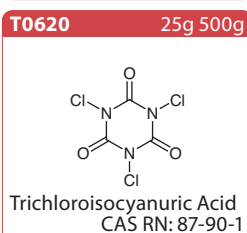
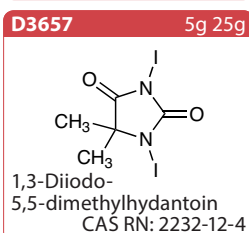
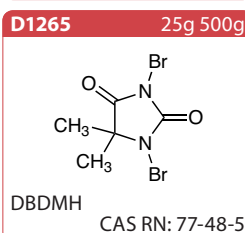
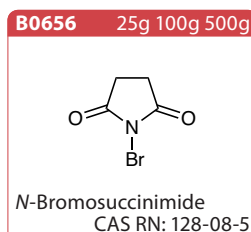
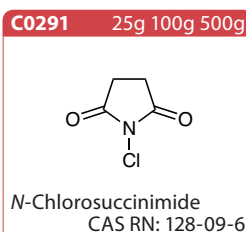
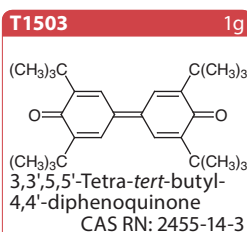
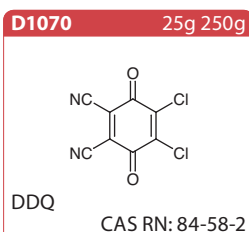
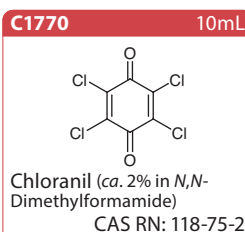
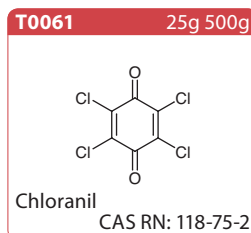
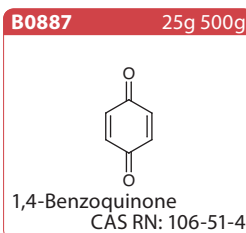
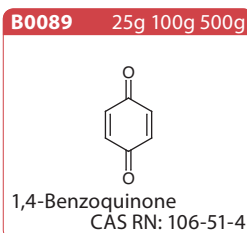
## Sulfur Oxides



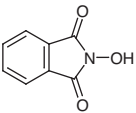
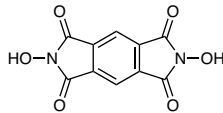
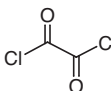
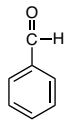
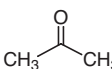
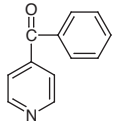
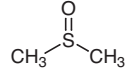
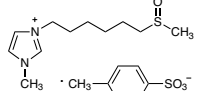
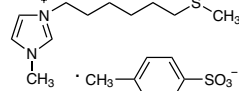
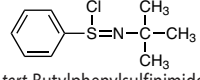
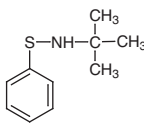
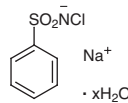

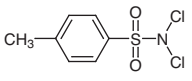
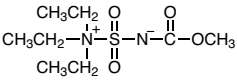
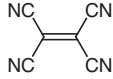
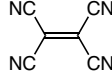
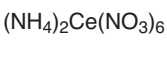
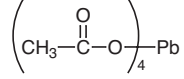
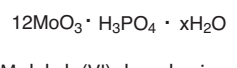
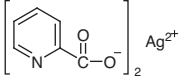
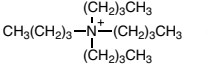
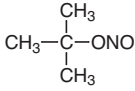

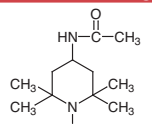
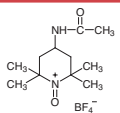
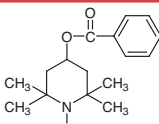
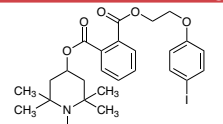
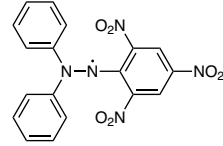
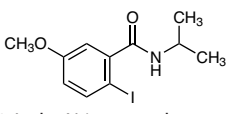
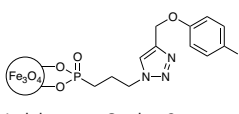
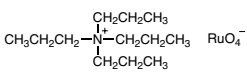
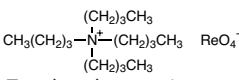

## N-Oxides



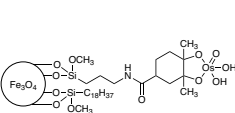
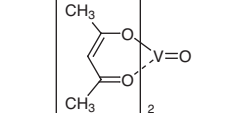
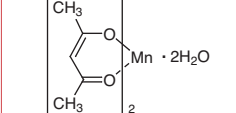
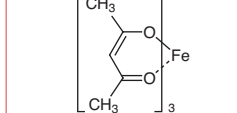
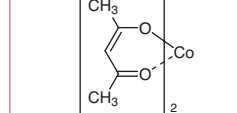
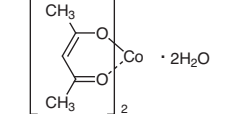
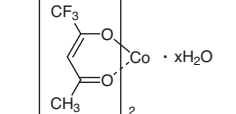
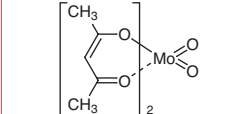
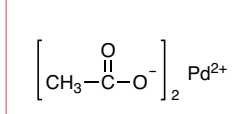
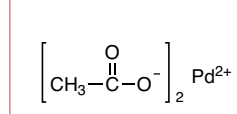
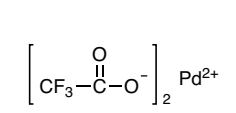
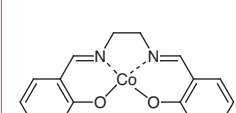
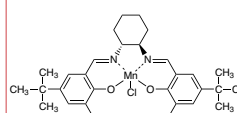
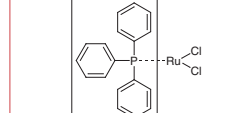
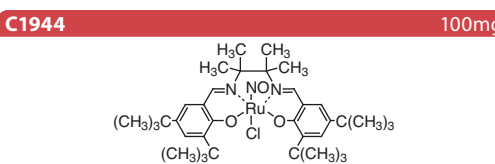
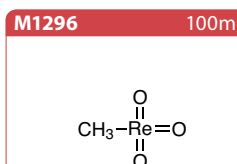
## Other Oxidizing Agents



## Oxidizing Agents

<b>H0395</b> 25g 100g 500g  NHPH CAS RN: 524-38-9	<b>D4413</b> 1g 5g  NDHPH CAS RN: 57583-53-6	<b>O0082</b> 25g 100g 500g  Oxalyl Chloride CAS RN: 79-37-8	<b>B2379</b> 500g  Benzaldehyde CAS RN: 100-52-7	<b>A0054</b> 500mL  Acetone CAS RN: 67-64-1
<b>B0306</b> 25g  4-Benzoylpyridine CAS RN: 14548-46-0	<b>D0798</b> 25g 500g  Dimethyl Sulfoxide CAS RN: 67-68-5	<b>M2274</b> 1g 5g  1-Methyl-3-[6-(methylsulfinyl)-hexyl]imidazolium <i>p</i> -Toluenesulfonate CAS RN: 1352947-66-0	<b>M2321</b> 1g 5g  1-Methyl-3-[6-(methylthio)-hexyl]imidazolium <i>p</i> -Toluenesulfonate CAS RN: 1352947-63-7	<b>B2188</b> 1g 5g  <i>N</i> - <i>tert</i> -Butylphenylsulfonimidoyl Chloride CAS RN: 49591-20-0
<b>B2240</b> 1g 5g 25g  <i>N</i> - <i>tert</i> -Butylbenzenesulfenamide CAS RN: 19117-31-8	<b>C0075</b> 25g 100g 500g  Chloramine B Hydrate CAS RN: 304655-80-9	<b>C0076</b> 25g 500g  Chloramine T Trihydrate CAS RN: 7080-50-4	<b>D0318</b> 25g 100g 500g  Dichloramine T CAS RN: 473-34-7	<b>M1279</b> 1g 5g 25g  Burgess Reagent CAS RN: 29684-56-8
<b>T0077</b> 5g 25g  TCNE CAS RN: 670-54-2	<b>T3264</b> 1g 5g  TCNE (purified by sublimation) CAS RN: 670-54-2	<b>C1806</b> 50g 500g  CAN CAS RN: 16774-21-3	<b>L0021</b> 25g 500g  LTA (contains Acetic Acid) CAS RN: 546-67-8	<b>P1910</b> 25g 100g 500g  Molybdo(VI)phosphoric Acid Hydrate CAS RN: 51429-74-4
<b>S0815</b> 1g 5g  Picolinic Acid Silver(II) Salt CAS RN: 14783-00-7	<b>T3651</b> 5g 25g  Tetrabutylammonium Nitrate CAS RN: 1941-27-1	<b>N0357</b> 25mL 250mL  <i>tert</i> -Butyl Nitrite CAS RN: 540-80-7	<b>I0604</b> 25g 500g  Iodine CAS RN: 7553-56-2	
<h1>Catalysts for Oxidation</h1>				
<b>A1348</b> 5g 25g  4-Acetamido-TEMPO Free Radical CAS RN: 14691-89-5	<b>A2065</b> 5g  4-Acetamido-2,2,6,6- tetramethyl-1-oxopiperidinium Tetrafluoroborate CAS RN: 219543-09-6	<b>H0878</b> 1g 5g  4-Benzoyloxy-TEMPO Free Radical CAS RN: 3225-26-1	<b>I0908</b> 100mg  4-[2-[2-(4-Iodophenoxy)ethoxy]- carbonyl]benzoyloxy-2,2,6,6- tetramethylpiperidin-1-oxyl	<b>D4313</b> 1g 5g  DPPH Free Radical CAS RN: 1898-66-4
<b>I1117</b> 100mg  2-Iodo- <i>N</i> -isopropyl- 5-methoxybenzamide CAS RN: 1820802-04-7	<b>M2721</b> 100mg  Iodobenzene Catalyst Supported on Magnetic Iron Oxide Nanoparticle (0.6-0.8mmol/g)	<b>T1559</b> 1g 5g  TPAP CAS RN: 114615-82-6	<b>T1803</b> 1g 5g  Tetrabutylammonium Perrhenate CAS RN: 16385-59-4	<b>O0308</b> 10mL  Osmium Tetroxide (4% in Water) CAS RN: 20816-12-0



<b>O0414</b> 1g  Osmium Catalyst supported on Magnetite (0.07-0.09mmol/g)	<b>V0016</b> 25g  Vanadyl Acetylacetonate CAS RN: 3153-26-2	<b>M0042</b> 25g  Manganese(II) Acetylacetonate Dihydrate CAS RN: 22033-51-8	<b>I0079</b> 25g 100g 500g  Acetylacetonate Iron(III) Salt CAS RN: 14024-18-1	<b>B2681</b> 25g  Cobalt(II) Acetylacetonate CAS RN: 14024-48-7
<b>C0373</b> 25g 500g  Cobalt(II) Acetylacetonate Dihydrate CAS RN: 123334-29-2	<b>T0746</b> 5g  Cobalt(II) Trifluoroacetylacetonate Hydrate CAS RN: 16092-38-9	<b>M0464</b> 5g 25g  Molybdenum(VI)dioxo Acetylacetonate CAS RN: 17524-05-9	<b>A1424</b> 1g 5g  Palladium(II) Acetate CAS RN: 3375-31-3	<b>P2161</b> 1g  Palladium(II) Acetate (Purified) CAS RN: 3375-31-3
<b>P2106</b> 1g 5g $[\text{Pd}(\text{CH}_3\text{COO})_2]_3$ Palladium(II) Acetate Trimer CAS RN: 53189-26-7	<b>P1870</b> 1g 5g  Palladium(II) Trifluoroacetate CAS RN: 42196-31-6	<b>S0318</b> 25g 100g 500g  Salcomine CAS RN: 14167-18-1	<b>B5613</b> 1g 5g  (R,R)-Jacobsen's Catalyst CAS RN: 138124-32-0	<b>D1997</b> 1g 5g  Tris(triphenylphosphine)ruthenium(II) Dichloride CAS RN: 15529-49-4
<b>P1939</b> 1g 5g $\text{KReO}_4$ Potassium Perrhenate CAS RN: 10466-65-6	<b>C1944</b> 100mg  Chloronitrosyl[N,N'-bis(3,5-di-tert-butylsalicylidene)-1,1,2,2-tetramethylethylenediaminato]ruthenium(IV) CAS RN: 386761-71-3	<b>M1296</b> 100mg  Methyltrioxorhenium(VII) CAS RN: 70197-13-6		

---

**Ordering and  
Customer Service**

**TCI AMERICA**

Tel : 800-423-8616 / 503-283-1681  
Fax : 888-520-1075 / 503-283-1987  
E-mail : Sales-US@TCIchemicals.com

**TCI EUROPE N.V.**

Tel : +32 (0)3 735 07 00  
Fax : +32 (0)3 735 07 01  
E-mail : Sales-EU@TCIchemicals.com

**TCI Deutschland GmbH**

Tel : +49 (0)6196 64053-00  
Fax : +49 (0)6196 64053-01  
E-mail : Sales-DE@TCIchemicals.com

**Tokyo Chemical Industry UK Ltd.**

Tel : +44 (0)1865 784560  
Fax : +44 (0)1865 784561  
E-mail : Sales-UK@TCIchemicals.com

**TCI Chemicals (India) Pvt. Ltd.**

Tel : 1800 425 7889 / 044-2262 0909  
Fax : 044-2262 8902  
E-mail : Sales-IN@TCIchemicals.com

**梯希爱(上海)化成工业发展有限公司**

Tel : 800-988-0390 / 021-67121386  
Fax : 021-6712-1385  
E-mail : Sales-CN@TCIchemicals.com

**TOKYO CHEMICAL INDUSTRY CO., LTD.**

Tel : +81 (0)3-5640-8878  
Fax : +81 (0)3-5640-8902  
E-mail : globalbusiness@TCIchemicals.com

Availability, price or specification of the listed products are subject to change without prior notice. Reproduction forbidden without the prior written consent of Tokyo Chemical Industry Co., Ltd.