

## Reaction Intermediates in Organic Chemistry: the "Big Picture"

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FAX: 416-736-5936

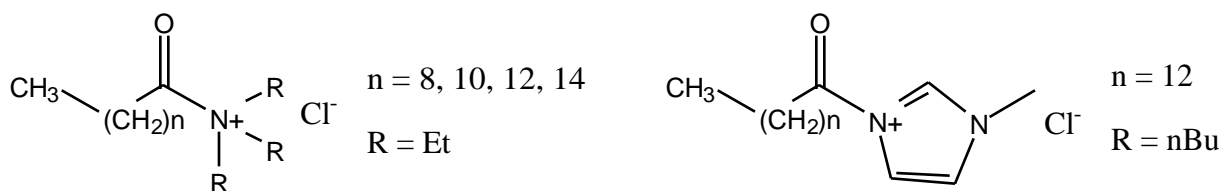
### Supplementary Material

**Table S6.** Table summarizing thermodynamically stable analogues of reaction intermediates

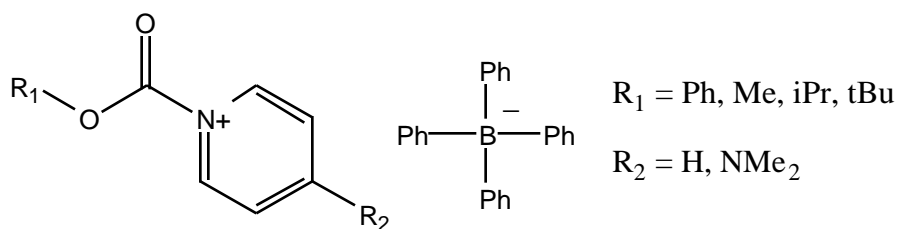
#### Acetoxonium ions

No stable analogues observed to date.

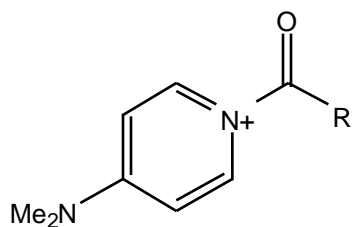
#### Acylammonium ions



Bhalerao, U.T.; Mathur, S.N.; Rao, S.N. *Synth. Commun.* **1992**, 22, 1645

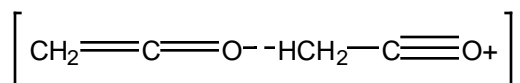


King, J.A. Jr.; Bryant, G.L. Jr. *J. Am. Chem. Soc.* **1992**, 57, 5136



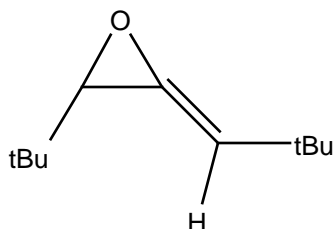
Katritzky, A.R.; Burton, R.D.; Shipkova, P.A.; Qi, M.; Watson, C.H.; Eyler, J.R. *J. Chem. Soc. Perkin Trans. 2* **1998**, 835

#### Acylium ions

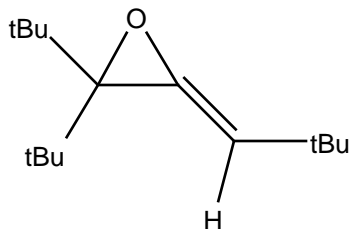


Tortajada, J.; Berthomieu, D.; Morizur, J.P.; Audier, H.E. *J. Am. Chem. Soc.* **1992**, 114, 10874

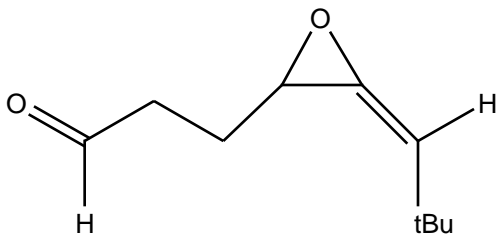
### Alleneoxides



Camp, R.L.; Greene, F.D. *J. Am. Chem. Soc.* **1968**, 90, 7349



Crandall, J.K.; Machleder, W.H. *J. Heterocyclic Chem.* **1969**, 6, 777

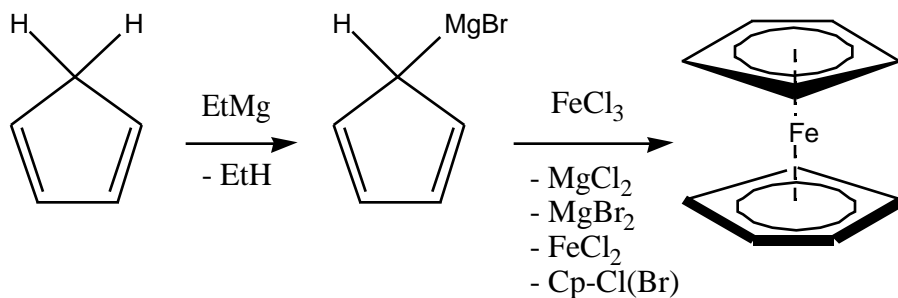


Erden, I.; Drummond, J.; Alstad, R.; Xu, F. *Tetrahedron Lett.* **1993**, 34, 1255

### Aromatic sigma and pi complexes

See Meisenheimer-Jackson and Janovsky complexes for negative aromatic sigma complexes.

See Wheland intermediates for positive aromatic sigma complexes.



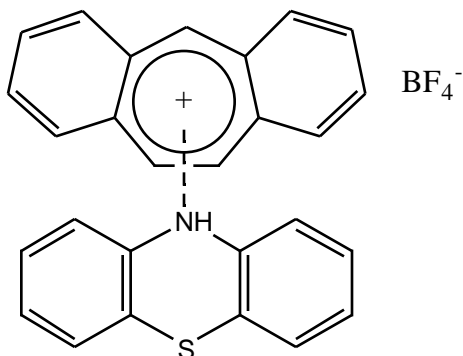
Kealy, T.J.; Pauson, P.L. *Nature* **1951**, 168, 1039

Wilkinson, G.; Rosenblum, M.; Whiting, M.C.; Woodward, R.B. *J. Am. Chem. Soc.* **1952**, 74, 2125

Woodward, R.B.; Rosenblum, M.; Whiting, M.C. *J. Am. Chem. Soc.* **1952**, 74, 3458

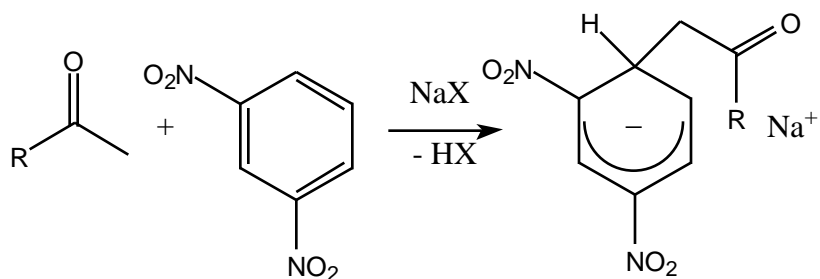
Eiland, P.F.; Pepinsky, R. *J. Am. Chem. Soc.* **1952**, 74, 4971

Wilkinson, G. *J. Am. Chem. Soc.* **1954**, 76, 209



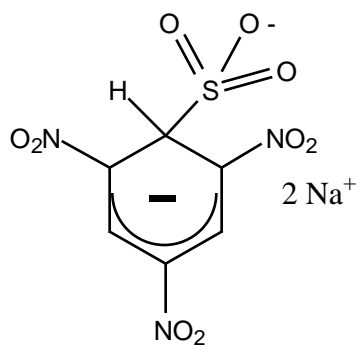
Feldman, M.; Jackson, J.A. *Tetrahedron Lett.* **1966**, 797

### (i) Janovsky complexes



Janovsky, J.V. *Chem. Ber.* **1886**, 19, 2155

### (ii) Meisenheimer-Jackson complexes



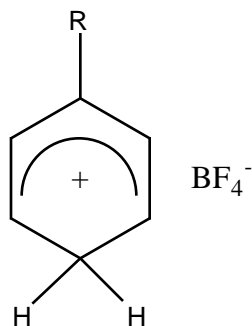
Jackson, C.L.; Robinson, W.S. *Am. Chem. J.* **1889**, 11, 93

Jackson, C.L.; Gazzolo, F.H. *Am. Chem. J.* **1900**, 23, 376

Jackson, C.L.; Earle, R.B. *Am. Chem. J.* **1903**, 29, 89

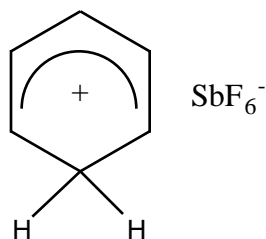
Meisenheimer, J., *Ann. Chem.* **1902**, 323, 205

### (iii) Wheland intermediates (arenium ions)

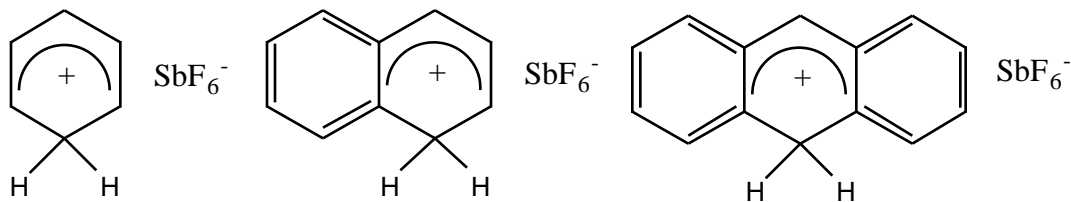


Olah, G.A.; Kuhn, S.J. *Nature* **1956**, 178, 693

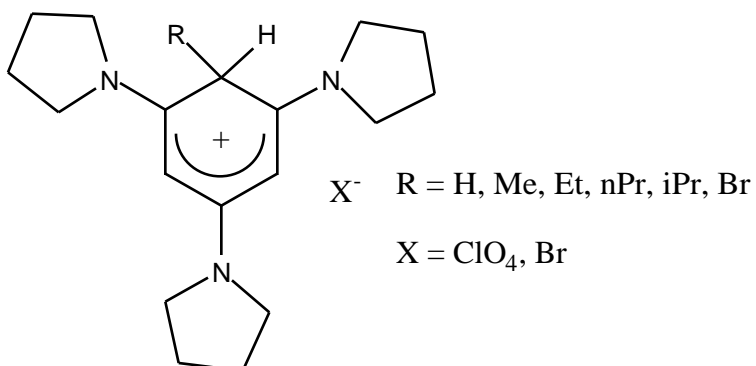
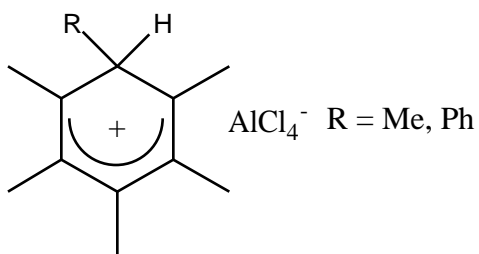
Olah, G.A.; Kuhn, S.J. *J. Am. Chem. Soc.* **1958**, 80, 6535



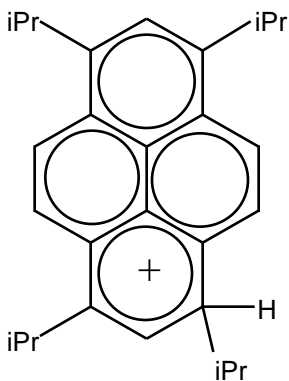
Olah, G.A.; Schlosberg, R.H.; Porter, R.D.; Mo, Y.K.; Kelly, D.P.; Mateescu, G.D. *J. Am. Chem. Soc.* **1972**, 94, 2034



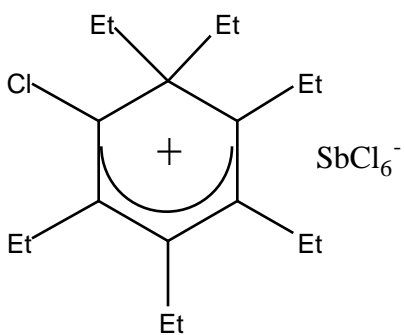
Olah, G.A.; Staral, J.S.; Asencio, G.; Liang, G.; Forsyth, D.A.; Mateescu, G.D. *J. Am. Chem. Soc.* **1978**, 100, 6299



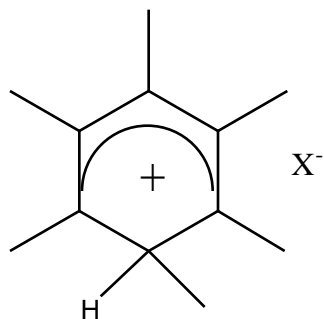
Effenberger, F.; Reisinger, F.; Schoenwaelder, K.H.; Baeuerle, P.; Stezowski, J.J.; Jogun, K.H.; Schoellkopf, K.; Stohrer, W.D. *J. Am. Chem. Soc.* **1987**, 109, 882



Laali, K.K.; Hansen, P.E. *J. Org. Chem.* **1991**, 56, 6795



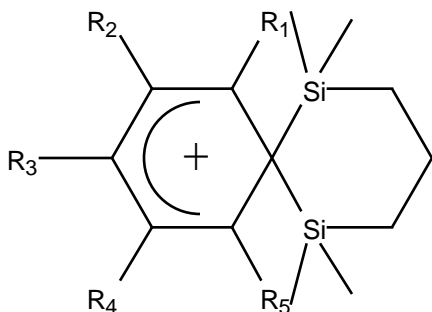
Rathore, R.; Hecht, J.; Kochi, J.K. *J. Am. Chem. Soc.* **1998**, 120, 13278



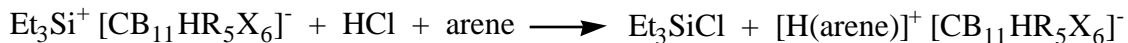
$X = [B(F_5Ph)_4], [CB_{11}H_6Cl_6]$

Reed, C.A.; Fackler, N.L.P.; Kim, K.C.; Stasko, D.; Evans, D.R. *J. Am. Chem. Soc.* **1999**, 121, 6314

Stasko, D.; Reed, C.A. *J. Am. Chem. Soc.* **2002**, 124, 1148

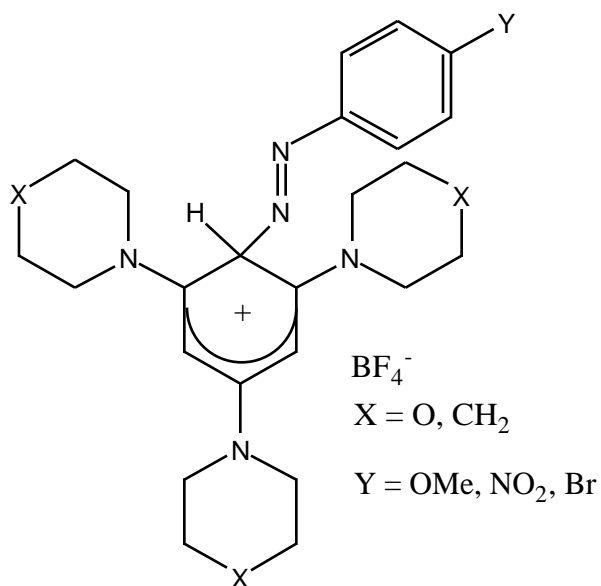


Meyer, R.; Werner, K.; Muller, T. *Chem. Eur. J.* **2002**, 8, 1163



R = H, Me; X = Cl, Br; arene = benzene, toluene, m-xylene, mesitylene, hexamethylbenzene

Reed, C.A.; Kim, K.C.; Stoyanov, E.S.; Stasko, D.; Tham, F.S.; Mueller, L.J.; Boyd, P.D.W. *J. Am. Chem. Soc.* **2003**, 125, 1796

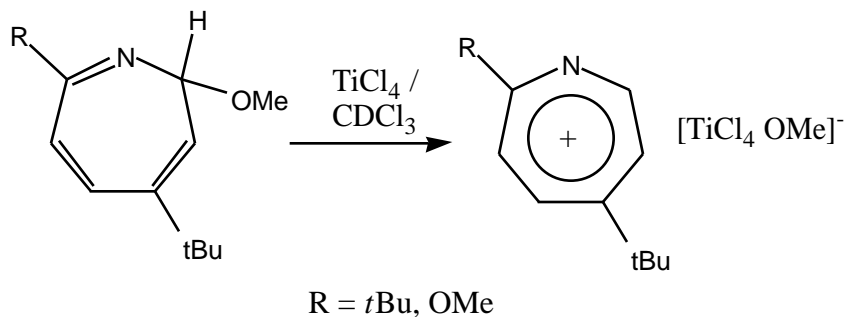


Boga, C.; Del Vecchio, E.; Forlani, L. *Eur. J. Org. Chem.* **2004**, 1567

### Arylium ions

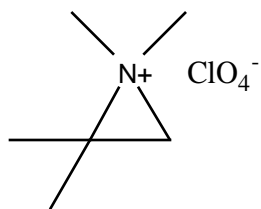
No stable analogues observed to date.

### Azepinium ions



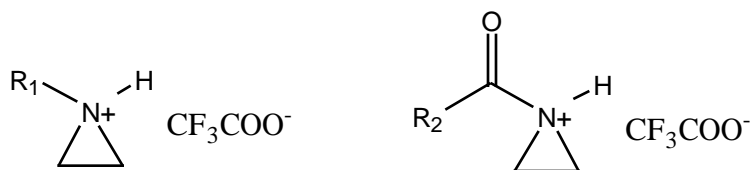
Satake, K.; Kubota, Y.; Cordonier, C.E.J.; Okamoto, H.; Kimura, M. *Angew. Chem. Int. Ed.* **2004**, 43, 736

### Aziridinium ions



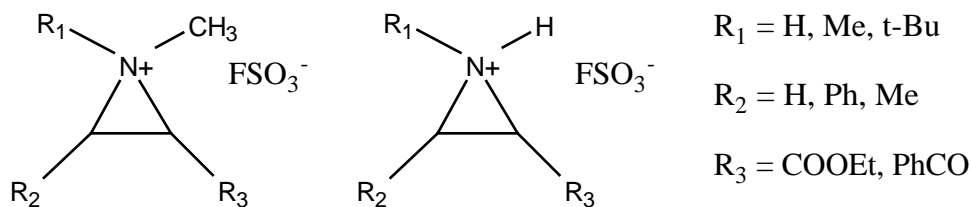
Leonard, N.J.; Jann, K. *J. Am. Chem. Soc.* **1960**, 82, 6418

Leonard, N.J.; Jann, K. *J. Am. Chem. Soc.* **1962**, 84, 4806



$R_1 = \text{H, Me, Et, t-Bu, Ph}$        $R_2 = \text{Me, Et, n-Pr, Ph, Np}$

Olah, G.A.; Szilagyi, P.J. *J. Am. Chem. Soc.* **1969**, 91, 2949



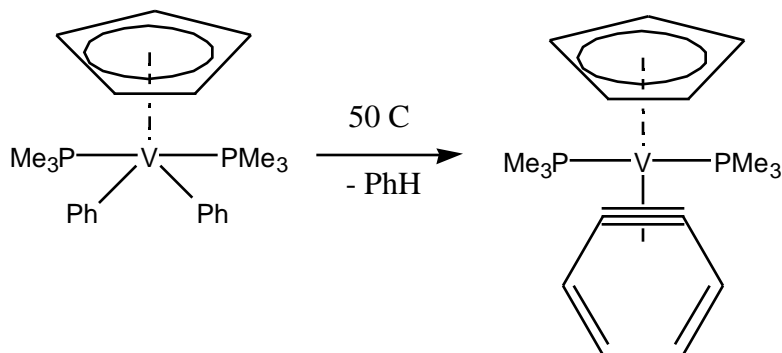
$R_1 = \text{H, Me, t-Bu}$

$R_2 = \text{H, Ph, Me}$

$R_3 = \text{COOEt, PhCO}$

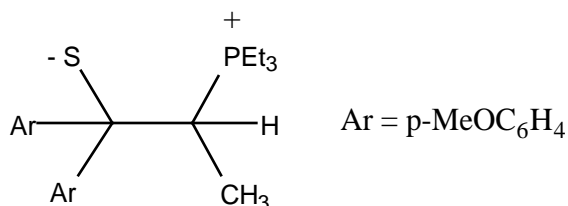
Baret, P.; Rivoirard, E.M.; Pierre, J.L. *J. Heterocyclic Chem.* **1980**, 17, 201

### Benzynes (arynes)



Buijink, J.K.F.; Kloetstra, R.K.; Meetsma, A.; Teuben, J.H. *Organometallics* **1996**, 15, 2523

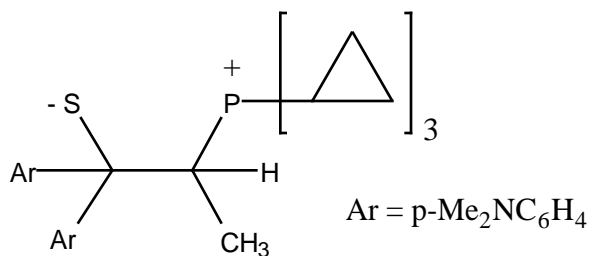
### Betaines (phosponium betaines)



$\text{Ar} = \text{p-MeOC}_6\text{H}_4$

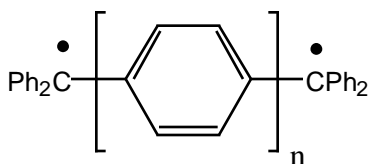
Puke, C.; Erker, G.; Aust, N.C.; Würthwein, E.U.; Fröhlich, F. *J. Am. Chem. Soc.* **1998**, 120, 4863

Erker, G.; Hock, R.; Wilker, S.; Laurent, C.; Puke, C.; Würthwein, E.U.; Aust, N.C.; Fröhlich, R. *Phosphorus, Sulfur, Silicon and the related elements* **1999**, 153-154, 79



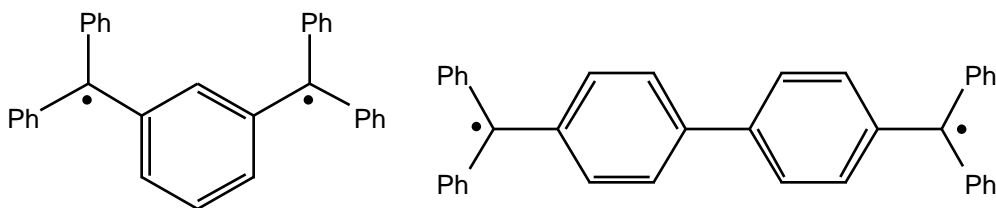
Puke, C.; Erker, G.; Wibbeling, B.; Fröhlich, R. *Eur. J. Org. Chem.* **1999**, 1831

### Biradicals



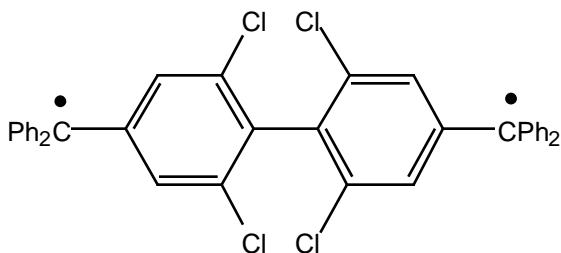
Thiele, J.; Balhorn, H. *Chem. Ber.* **1904**, 37, 1463 (n = 1)

Chichibabin, A.E. *Chem. Ber.* **1907**, 40, 1810 (n = 2)

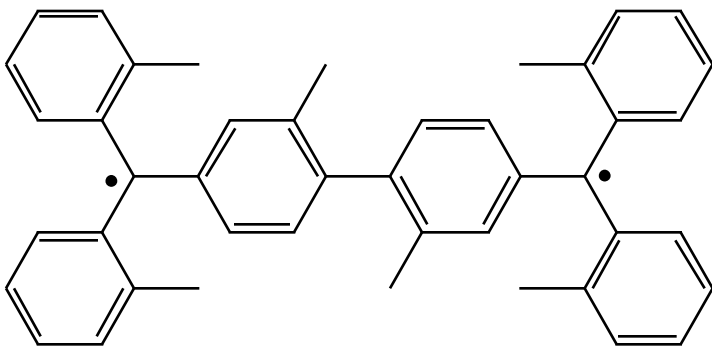


Schlenk, W.; Brauns, M. *Chem. Ber.* **1915**, 48, 661; 716

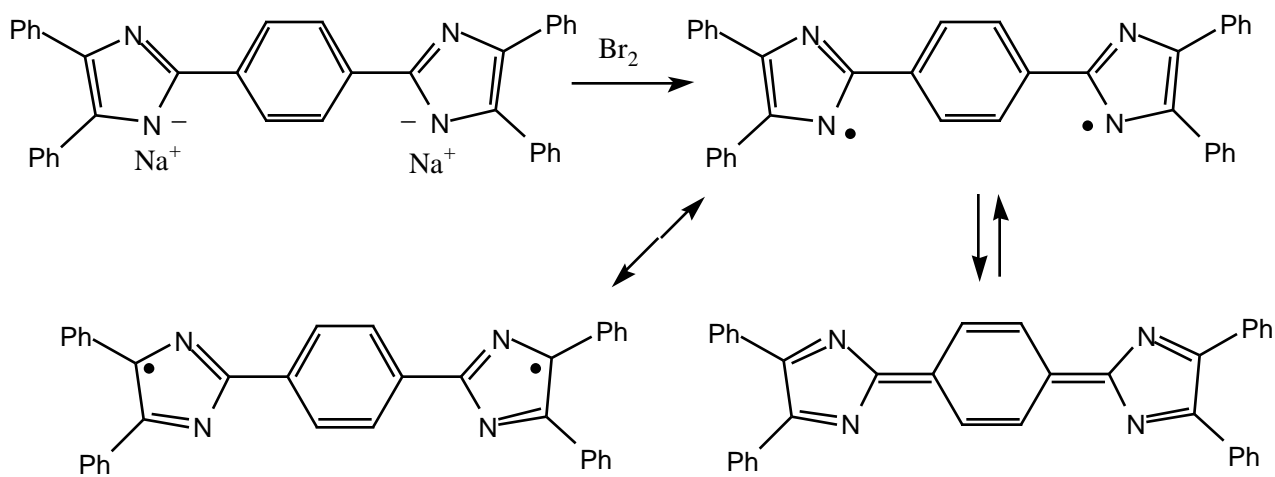
Müller, E.; Müller-Rodloff, I. *Ann. Chem.* **1935**, 517, 134



Müller, E.; Neuhoff, H. *Chem. Ber.* **1939**, 72, 2063

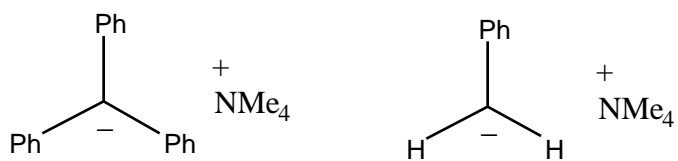


Schwab, G.M.; Baumel, A. *Z. Physik. Chem.* **1957**, 10, 347

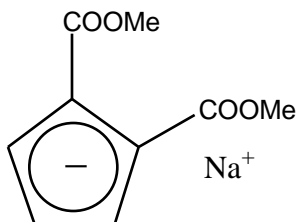


Mayer, U.; Baumgartel, H.; Zimmermann, H. *Angew. Chem. Int. Ed.* **1966**, 5, 311

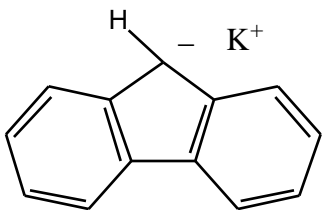
### Carbanions



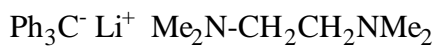
Schlenk, W. *Ann. Chem.* **1910**, 372, 1



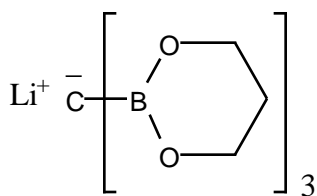
Peters, D. *J. Chem. Soc.* **1959**, 1757



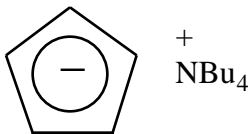
Janzen, E.G.; Gerlock, J.L. *J. Organometallic Chem.* **1967**, 8, 354



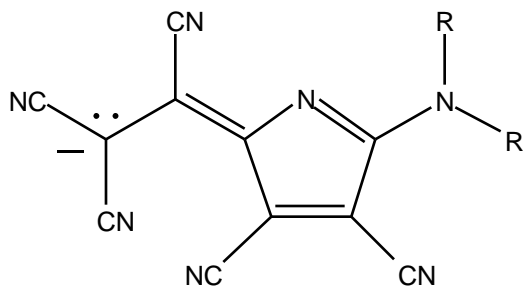
Brooks, J.J.; Stucky, G.D. *J. Am. Chem. Soc.* **1972**, 94, 7333



Matteson, D.S.; Hagelee, L.A. *J. Organometallic Chem.* **1975**, 93, 21



Reetz, M.F.; Huette, S.; Goddard, R. *Z. Naturforsch. B* **1995**, 50, 415



Fares, V.; Flamini, A.; Pasetto, P. *J. Chem. Soc. Perkin Trans. 1* **2000**, 4520

[MR(18-crown-6)]

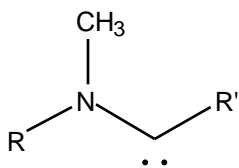
M = Rb, Cs

R = Cp, Me<sub>5</sub>Cp, fluorenyl, indenyl

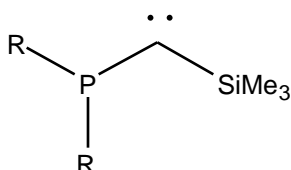
Neander, S.; Behrens, U.; Olbrich, F. *J. Organometallic Chem.* **2000**, 604, 59

## Carbenes

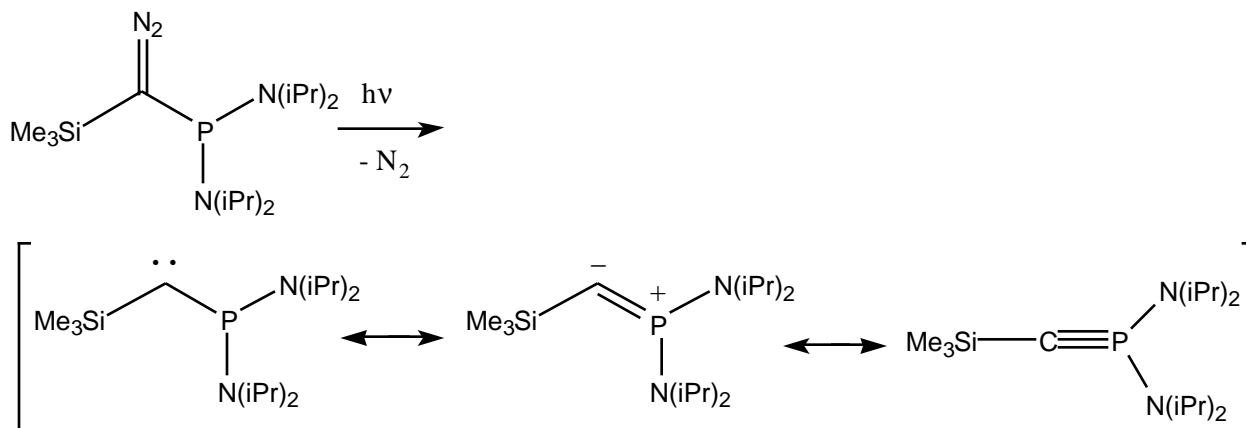
### (i) Carbenes - singlet



Cattoën, X.; Sole, S.; Pradel, C.; Gornitzka, H.; Migueu, K. *J. Org. Chem.* **2003**, 68, 911



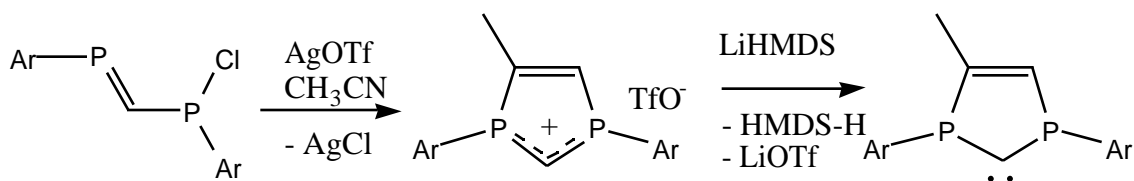
Goumri-Magnet, S.; Kato, T.; Gornitzka, H.; Baceiredo, A.; Bertrand, G. *J. Am. Chem. Soc.* **2000**, 122, 4464



Baceiredo, A.; Bertrand, G.; Sicard, G. *J. Am. Chem. Soc.* **1985**, 107, 4781

Igau, A.; Grützmacher, H.; Baceiredo, A.; Bertrand, G. *J. Am. Chem. Soc.* **1988**, 110, 6463

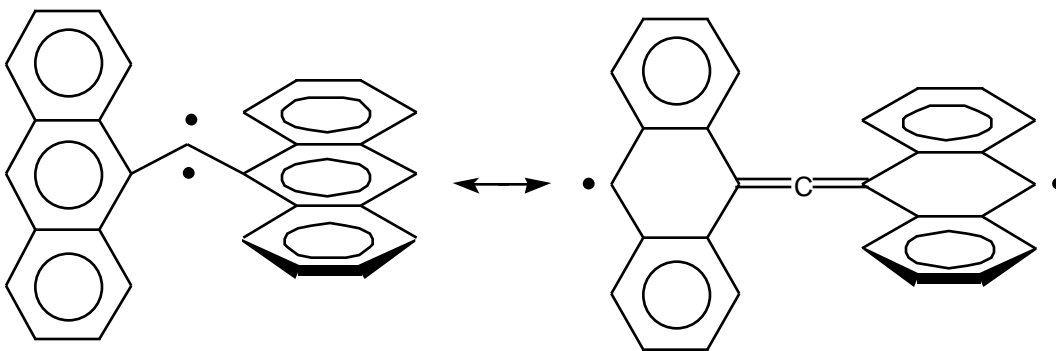
Igau, A.; Baceiredo, A.; Trinquier, G.; Bertrand, G. *Angew. Chem. Int. Ed.* **1989**, 28, 621



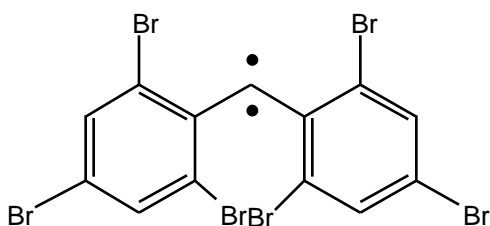
Ar = 2,4,6-tri-*t*-butylphenyl, HMDS = hexamethyldisilazide

Martin, D.; Baceiredo, A.; Gornitzka, H.; Schoeller, W.W.; Bertrand, G. *Angew. Chem. Int. Ed.* **2005**, 44, 1700

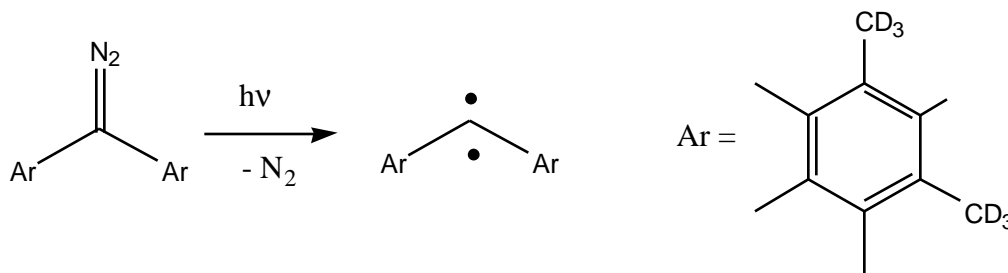
## (ii) Carbenes - triplet



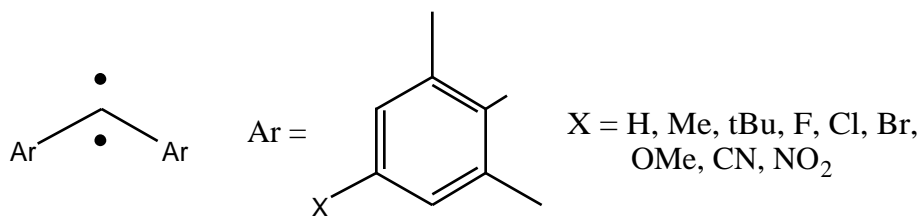
Wasserman, E.; Kuck, V.J.; Yager, W.A.; Hutton, R.S.; Greene, F.D.; Abegg, V.P.; Weinschenker, N.M. *J. Am. Chem. Soc.* **1971**, 93, 6335  
 Tomioka, H.; Nakijima, J.; Mizuno, H.; Iiba, E.; Hirai, K. *Can. J. Chem.* **1999**, 77, 1066  
 Itakura, H.; Tomioka, H. *Org. Lett.* **2000**, 2, 2995



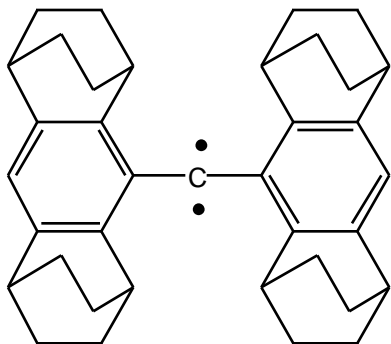
Tomioka, H.; Watanabe, T.; Hirai, K.; Furukawa, K.; Takui, T.; Itoh, K. *J. Am. Chem. Soc.* **1995**, 117, 6376  
 Tomioka, H.; Hattori, M.; Hirai, K. *J. Am. Chem. Soc.* **1996**, 118, 8723  
 Tomioka, H.; Watanabe, T.; Hattori, M.; Nomura, N.; Hirai, K. *J. Am. Chem. Soc.* **2002**, 124, 474  
 Nakajima, J.; Hirai, K.; Tomioka, H. *Org. Biomolec. Chem.* **2004**, 2, 1500



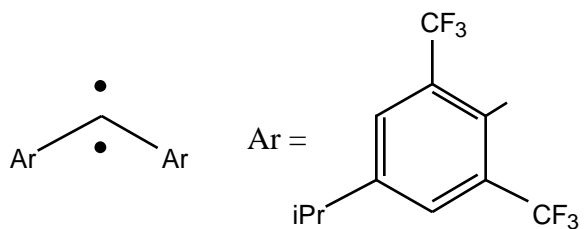
Tomioka, H.; Okada, H.; Watanabe, T.; Banno, K.; Komatsu, K.; Hirai, K. *J. Am. Chem. Soc.* **1997**, 119, 1582  
 Hu, Y.M.; Hirai, K.; Tomioka, H. *Chem. Lett.* **2000**, 94  
 Hu, Y.M.; Ishikawa, Y.; Hirai, K.; Tomioka, H. *Bull. Chem. Soc. Jpn.* **2001**, 74, 2207



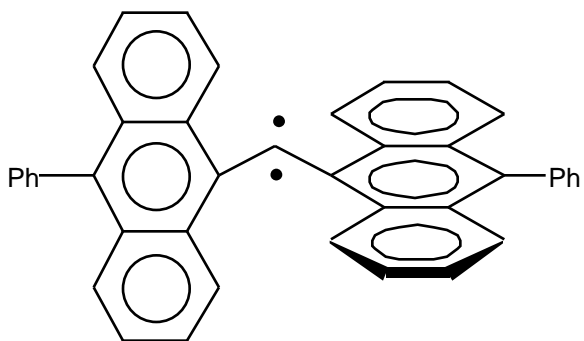
Tomioka, H.; Mizuno, H.; Itakura, H.; Hirai, K. *Chem. Commun.* **1997**, 2261  
 Itakura, H.; Mizuno, H.; Hirai, K.; Tomioka, H. *J. Org. Chem.* **2000**, 65, 8797



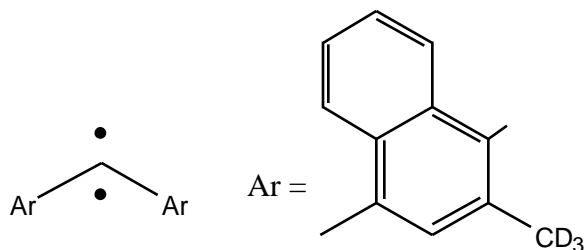
Tomioka, H.; Itakura, H.; Hirai, K. *Chem. Commun.* **1997**, 2261



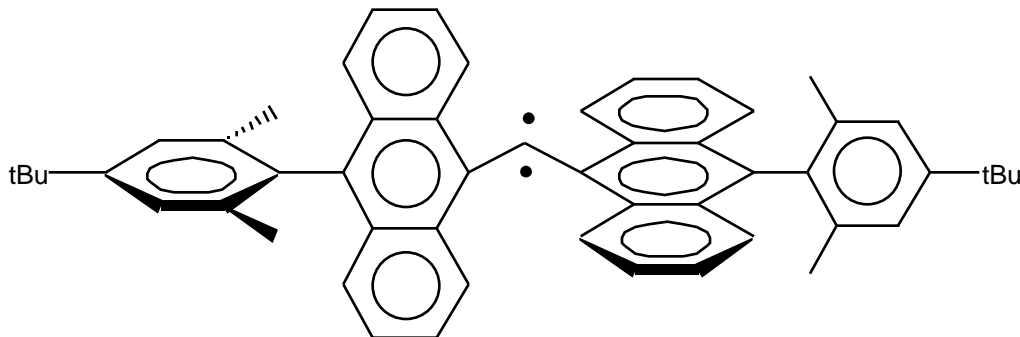
Hirai, K.; Tomioka, H. *J. Am. Chem. Soc.* **1999**, 121, 10213



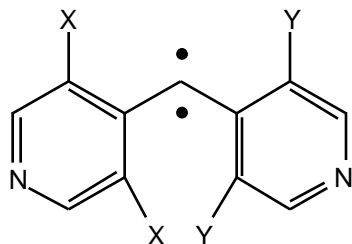
Tomioka, H.; Iwamoto, E.; Itakura, H.; Hirai, K. *Nature* **2001**, 412, 626



Tomioka, H. in *Carbene Chemistry: from fleeting intermediates to powerful reagents*, Marcel Dekker, Inc.: New York, 2002, Chapter 4, p. 139

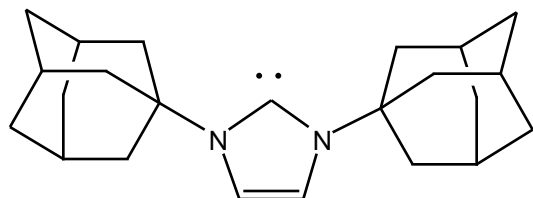


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Itoh, T.; Takada, A.; Hirai, K.; Tomioka, H. *Org. Lett.* **2005**, 7, 811

### (iii) Arduengo carbenes (imidazolylidenes)

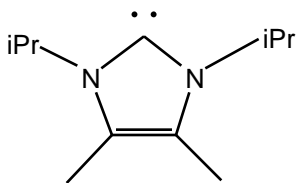


Arduengo, A.J. III; Harlow, R.L.; Kline, M. *J. Am. Chem. Soc.* **1991**, 113, 361

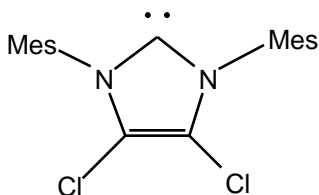
Dixon, D.A.; Arduengo, A.J. III *J. Phys. Chem.* **1991**, 95, 4180

Arduengo, A.J. III; Dias, H.V.R.; Harlow, R.L.; Kline, M. *J. Am. Chem. Soc.* **1992**, 114, 5530

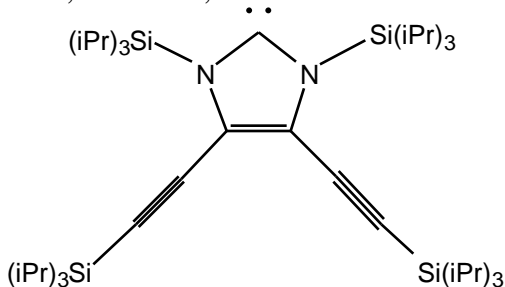
Arduengo, A.J. III *Tetrahedron* **1999**, 55, 14523



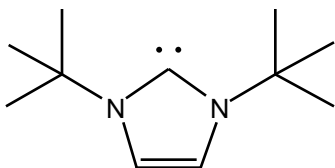
Kuhn, N.; Kratz, T. *Synthesis* **1993**, 561




Arduengo, A.J. III; Davidson, F.; Dias, H.V.R.; Goelrich, J.R.; Khasnis, D.; Marshall, W.J.; Prakasha, T.K. *J. Am. Chem. Soc.* **1997**, 119, 12742

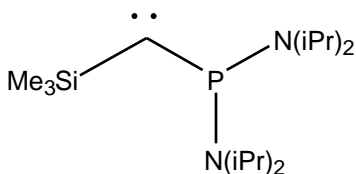


Faust; Göbelt *Chem. Commun.* **2000**, 919



 Denk, M.K.; Rodezno, J.M.; Gupta, S.; Lough, A.J. *J. Organometallic Chem.* **2001**, 617, 242

#### (iv) Bertrand carbenes

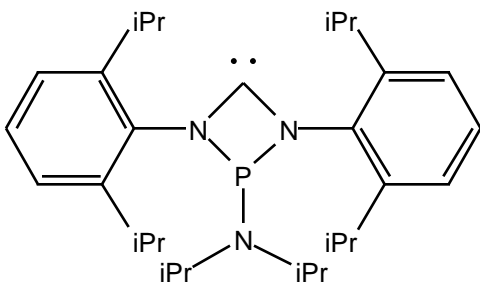


Baceiredo, A.; Bertrand, G.; Sicard, G. *J. Am. Chem. Soc.* **1985**, 107, 4781

Igau, A.; Grutzmacher, H.; Baceiredo, A.; Bertrand, G. *J. Am. Chem. Soc.* **1988**, 110, 6463

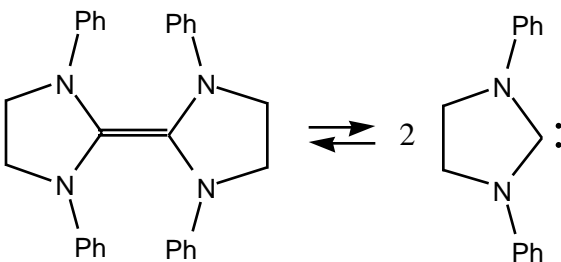
Igau, A.; Baceiredo, A.; Trinquier, G.; Bertrand, G. *Angew. Chem. Int. Ed.* **1989**, 28, 621

#### (v) Grubbs carbene

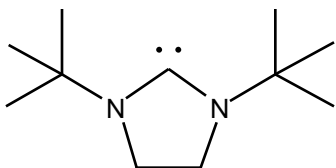


Despagnet-Ayoub, E.; Grubbs, R.H. *J. Am. Chem. Soc.* **2004**, 126, 10198

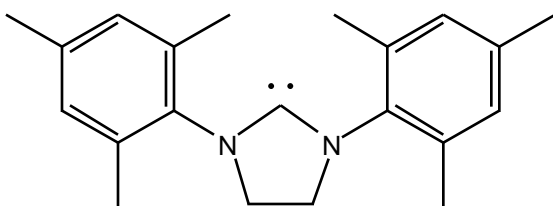
**(vi) Wanzlich carbenes (imidazolinyldenes)**



Wanzlich, H.W.; Schikora, E. *Angew. Chem.* **1960**, 72, 494



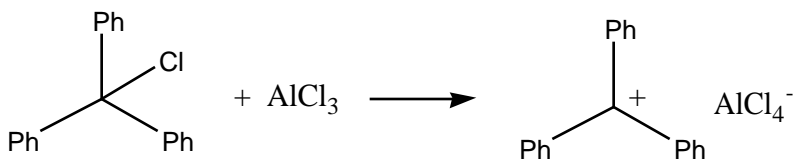
Denk, M.K.; Thadani, A.; Hatano, K.; Lough, A.J. *Angew. Chem. Int. Ed.* **1997**, 36, 2607



Arduengo, A.J. III; Calabrese, J.C.; Davidson, F.; Dias, H.V.R.; Goerlich, J.R.; Krafczyk, R.; Marshall, W.J.; Tamm, M.; Schmutzler, R. *Helv. Chim. Acta* **1999**, 82, 2348

Arduengo, A.J. III *Tetrahedron* **1999**, 55, 14523

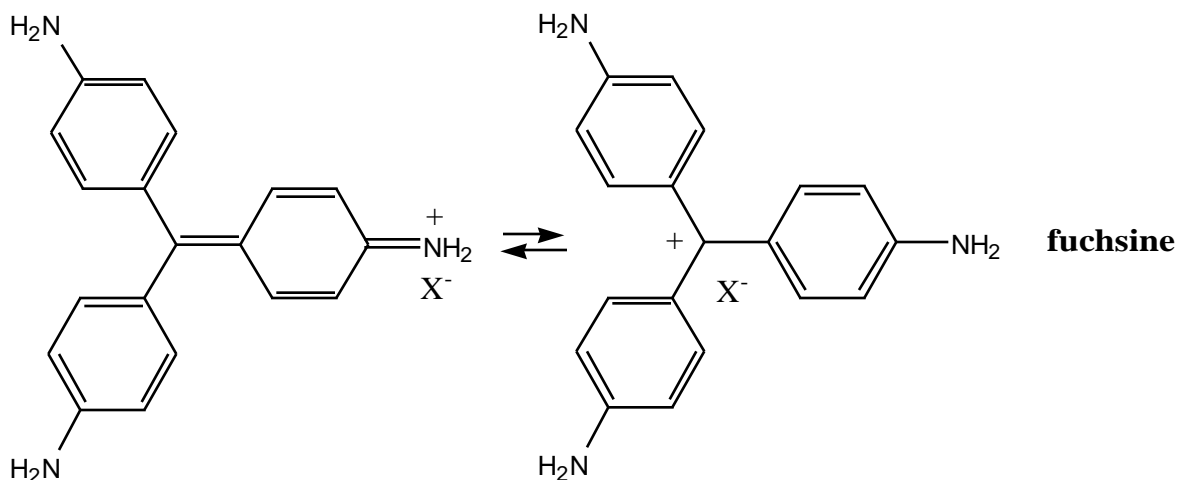
**Carbenium ions**



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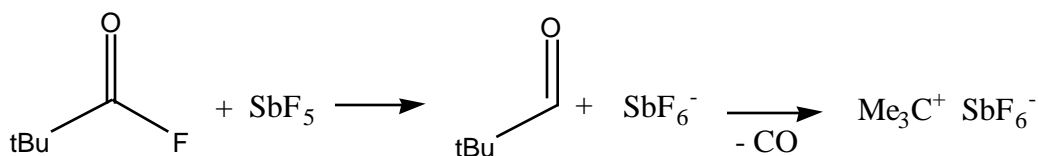


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Baeyer, A.; Villiger, V. *Chem. Ber.* **1901**, 35, 1189

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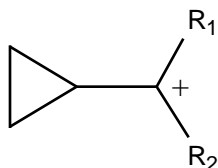
Baeyer, A. *Chem. Ber.* **1905**, 38, 3815



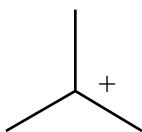
Olah, G.A.; Kuhn, S.J.; Tolgyesi, W.S.; Baker, E.B. *J. Am. Chem. Soc.* **1962**, 84, 2733

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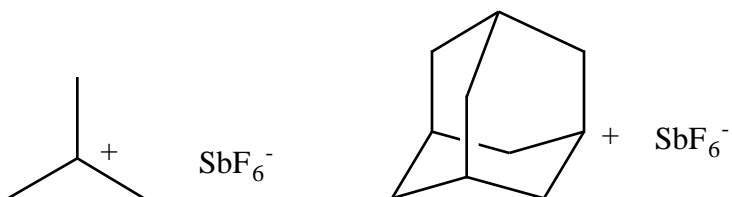
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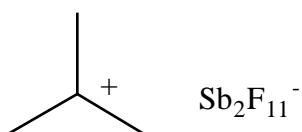
Pittman, C.U. Jr.; Olah, G.A. *J. Am. Chem. Soc.* **1965**, 87, 2998



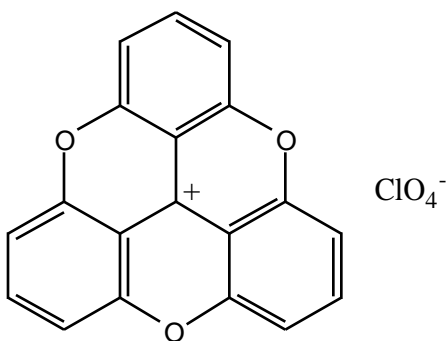
Olah, G.A.; Lukas, J. *J. Am. Chem. Soc.* **1967**, 89, 4739 (magic acid)



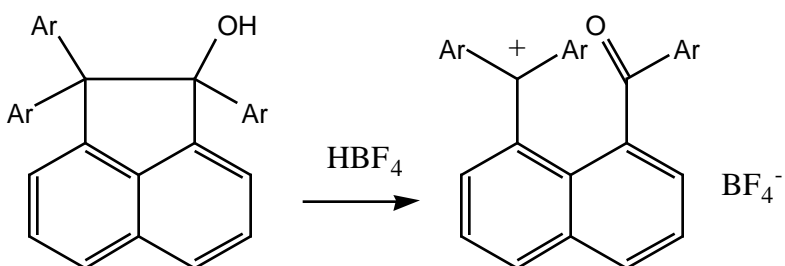
Olah, G.A.; Svoboda, J.J.; Ku, A.T. *Synthesis* **1973**, 492 (low temperature)



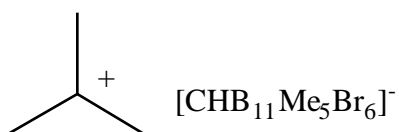
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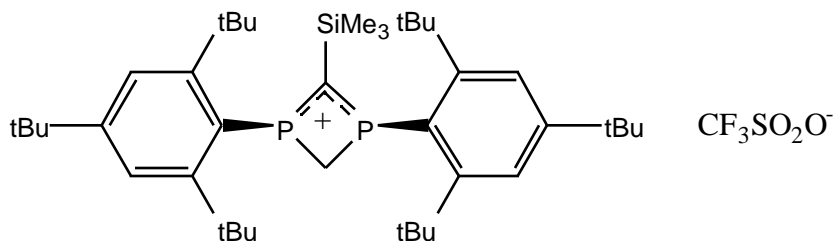
Dileeshi, S.; Gopidas, K.R. *Chem. Phys. Lett.* **2000**, 330, 397



Suzuki, T.; Nagasu, T.; Kawai, H.; Fujiwara, K.; Tsuji, T. *Tetrahedron Lett.* **2003**, 44, 6095

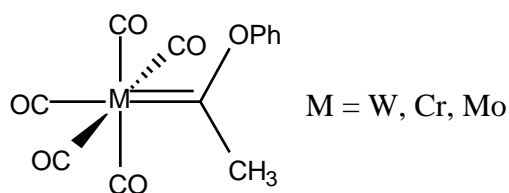


Kato, T.; Reed, C.A. *Angew. Chem. Int. Ed.* **2004**, 43, 2980

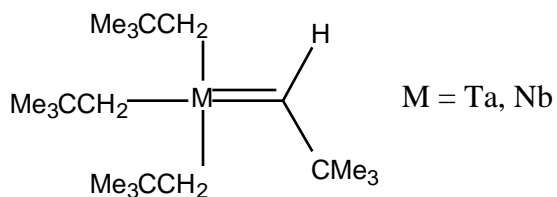


Sebastian, M.; Hoskin, A.; Nieger, M.; Nyulaszi, L.; Niecke, E. *Angew. Chem. Int. Ed.* **2005**, 44, 1405

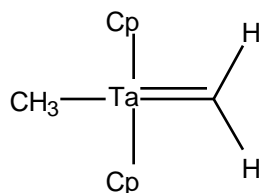
### Carbenoids (metallocarbenes)



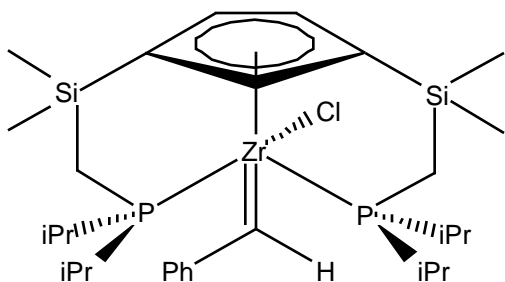
Fischer, E.O.; Maasbol, A. *Angew. Chem. Int. Engl. Ed.* **1964**, 3, 580  
Fischer, E.O. *Adv. Organomet. Chem.* **1976**, 14, 1





Schrock, R.R.; Meakin, P. *J. Am. Chem. Soc.* **1974**, 96, 5288  
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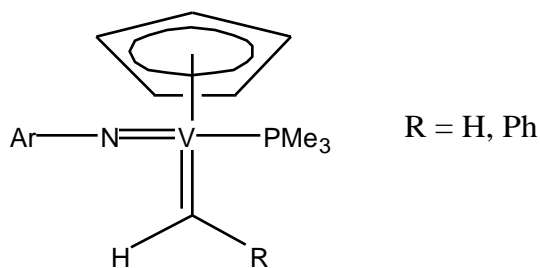
Schrock, R.R. *J. Am. Chem. Soc.* **1975**, 97, 6577  
Schrock, R.R.; Guggenberger, L.J. *J. Am. Chem. Soc.* **1975**, 97, 6578  
Schrock, R.R.; Fellmann, J.D. *J. Am. Chem. Soc.* **1978**, 100, 3359  
Schrock, R.R. *J. Organometallic Chem.* **1976**, 122, 209  
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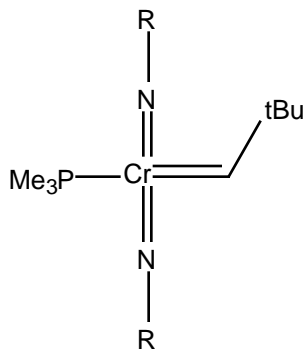
 Fryzuk, M.D.; Mao, S.S.H.; Zaworotko, M.J.; MacGillivray, L.R. *J. Am. Chem. Soc.* **1993**, 115, 5336

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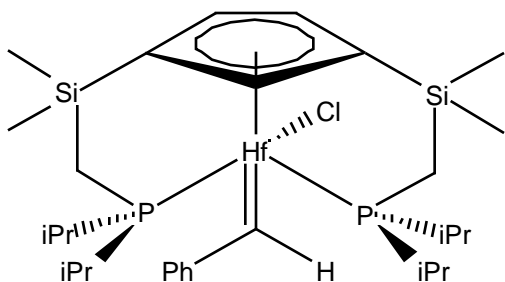
 Fryzuk, M.D.; Duval, P.B.; Mao, S.S.H.; Zaworotko, M.J.; MacGillivray, L.R. *J. Am. Chem. Soc.* **1999**, 121, 2478




Buijink, J.K.; Teuben, J.H.; Kooijman, H.; Spek, L. *Organometallics* **1994**, 13, 2922

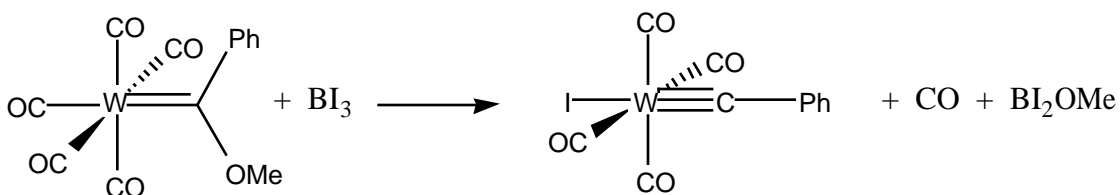


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 Fryzuk, M.D.; Duval, P.B.; Patrick, B.O.; Rettig, S.J. *Organometallics* **2001**, 20, 1608

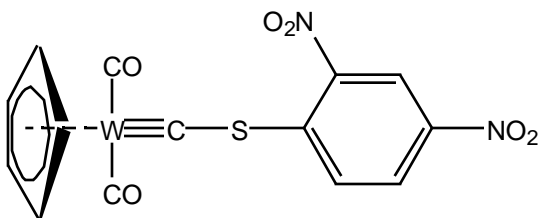
### Carbynes



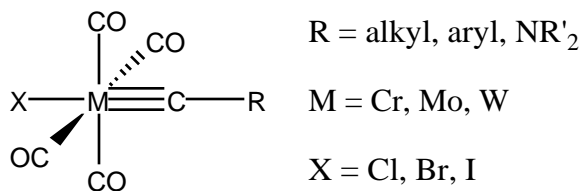
Fischer, E.O.; Kreis, G.; Kreiter, C.G.; Cornelius, G.; Müller, J.; Huttner, G.; Lorenz, H. *Angew. Chem.* **1973**, 85, 618

Fischer, E.O.; Kreiter, C.G.; Müller, J.; Huttner, G.; Lorenz, H. *Angew. Chem. Int. Ed.* **1973**, 12, 564

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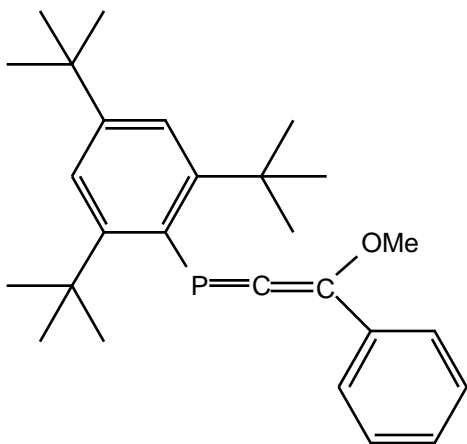
Greaves, W.W.; Angelici, R.J. *Inorg. Chem.* **1981**, 20, 2983



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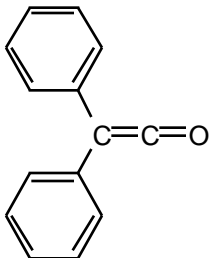
### Cumulenes

#### (i) heteroallenes



Ito, S.; Sekuguchi, S.; Yoshifuji, M. *J. Org. Chem.* **2004**, 69, 4181

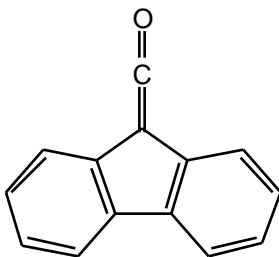
**(ii) ketenes**



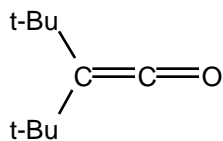
Staudinger, H. *Chem. Ber.* **1905**, 38, 1735

Smith, L.I.; Hoehn, H.H. *Org. Synth. Coll. Vol.* **1955**, 3, 356

Taylor, E.C.; McKillop, A.; Hawks, G.H. *Org. Synth.* **1972**, 52, 36



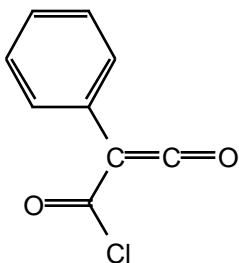
Alborz, M.; Douglas, K.T. *J. Chem. Soc. Perkin Trans. 2* **1982**, 331



Newman, M.S.; Arkell, A. *J. Org. Chem.* **1959**, 24, 385

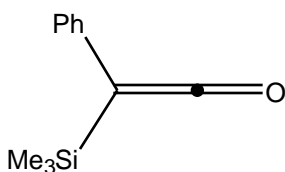
Newman, M.S.; Arkell, A.; Fukunaga, T. *J. Am. Chem. Soc.* **1960**, 82, 2498

Kabir, S.H.; Seikaly, H.R.; Tidwell, T.T. *J. Am. Chem. Soc.* **1979**, 101, 1059

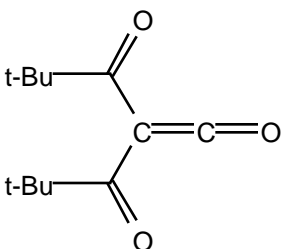


Ziegler, E.; Sterk, H. *Monatsh. Chem.* **1967**, 98, 1104

Finnerty, J.; Andraos, J.; Yamamoto, Y.; Wong, M.W.; Wentrup, C. *J. Am. Chem. Soc.* **1998**, 120, 1701



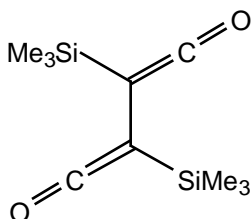
Brady, W.T.; Cheng, T.C. *J. Organometallic Chem.* **1977**, 137, 287



Kappe, C.O.; Evans, R.A.; Kennard, C.H.L.; Wentrup, C. *J. Am. Chem. Soc.* **1991**, 113, 4234

Kappe, C.O.; Faerber, G.; Wentrup, C.; Kollenz, G. *J. Org. Chem.* **1992**, 57, 7078


Kollenz, G.; Dalvi, T.S.; Kappe, C.O.; Wentrup, C. *ARKIVOC* **2000**, 1, 84

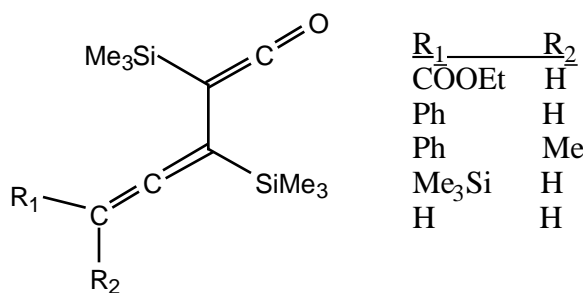



🍁 Zhao, D.C.; Tidwell, T.T. *J. Am. Chem. Soc.* **1992**, 114, 10980

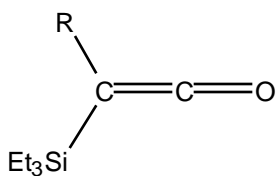
🍁 Allen, A.D.; Moore, P.A.; Missiha, S.; Tidwell, T.T. et al. *J. Org. Chem.* **1999**, 64, 4690

🍁 Allen, A.D.; Huang, W.; Moore, P.A.; Far, A.R. Tidwell, T.T. *J. Org. Chem.* **2000**, 65, 5676

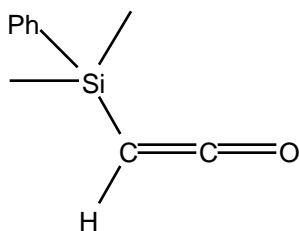
 Huang, W.; Moore, P.A.; Far, A.R.; Tidwell, T.T. et al. *J. Org. Chem.* **2000**, 65, 3877



 Huang, W.; Fang, D.; Temple, K.; Tidwell, T.T. *J. Am. Chem. Soc.* **1997**, 119, 2832

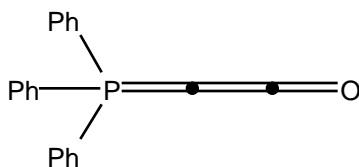


Marsden, S.P.; Pang, W.K. *Chem. Commun.* **1999**, 1199



 Allen, A.D.; Tidwell, T.T. *J. Org. Chem.* **1999**, 64, 266

### (iii) ketenylidene phosphoranes

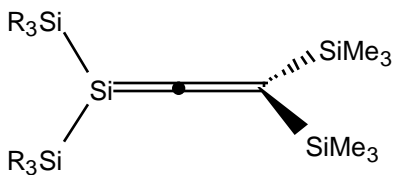


Matthews, C.N.; Birum, G.H. *Tetrahedron Lett.* **1966**, 5707

Daly, J.J.; Wheatley, P.J. *J. Chem. Soc. A* **1966**, 1703

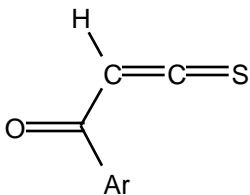
Matthews, C.N.; Birum, G.H. *Acc. Chem. Res.* **1969**, 2, 373

### (iv) silaallenes



Ichinohe, M.; Hayata, Y.; Akira, S. *Chem. Lett.* **2002**, 1074

### (v) acylthioketenes



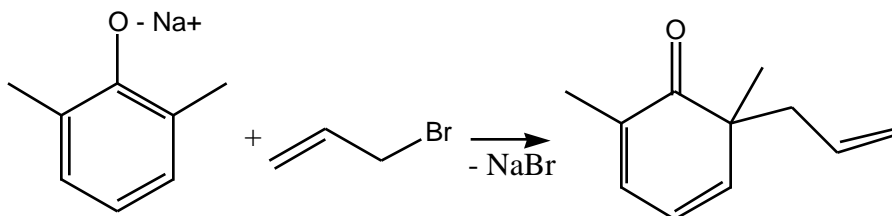
Ammann, J.R.; Flammang, R.; Wong, M.W.; Wentrup, C. *J. Org. Chem.* **2000**, 65, 2706

### 2,4- and 2,5-Cyclohexadienones

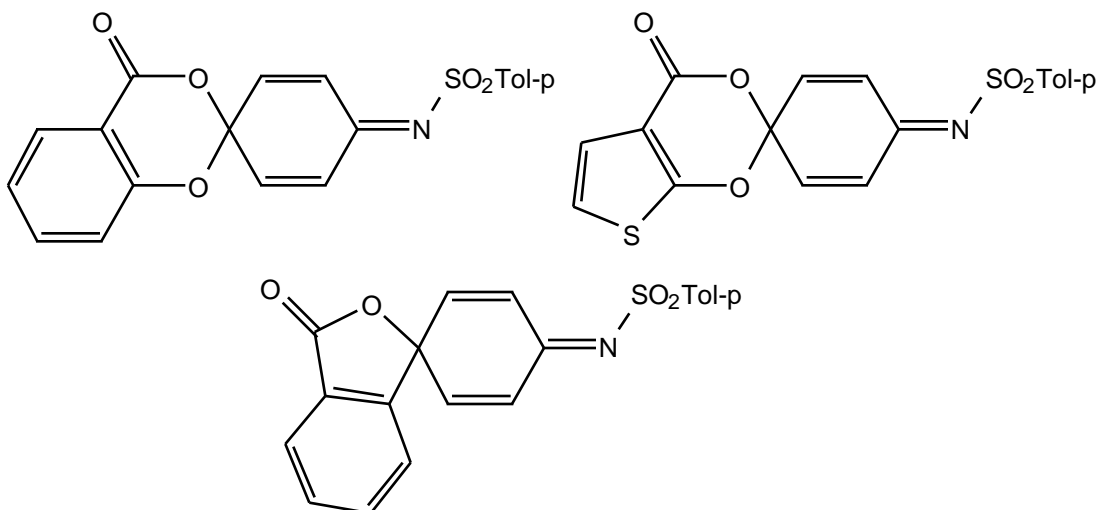
### 2,4- and 2,5-Cyclohexadienimines

Crowther, H.L.; McCombie, H. *J. Chem. Soc.* **1913**, 103, 536

Crowther, H.L.; McCombie, H. *Proc. Chem. Soc.* **1913**, 29, 68

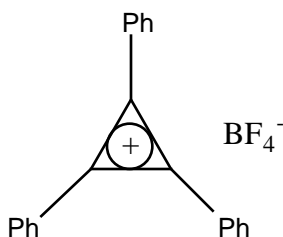


Curtin, D.Y.; Crawford, R.J. *Chem. Ind.* **1956**, 313



Coutts, I.G.C.; Culbert, N.J.; Edwards, M.; Hadfield, J.A.; Musto, D.R.; Pavlidis, V.H.; Richards, D.J. *J. Chem. Soc. Perkin Trans. 1* **1985**, 1829

### Cyclopropenyl cations

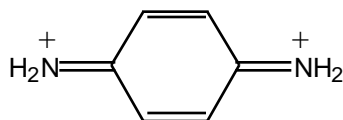


Breslow, R. *J. Am. Chem. Soc.* **1957**, 79, 5318

Breslow, R.; Yuan, C. *J. Am. Chem. Soc.* **1958**, 80, 5991

Breslow, R.; Höver, H. *J. Am. Chem. Soc.* **1960**, 82, 2644

### Dications



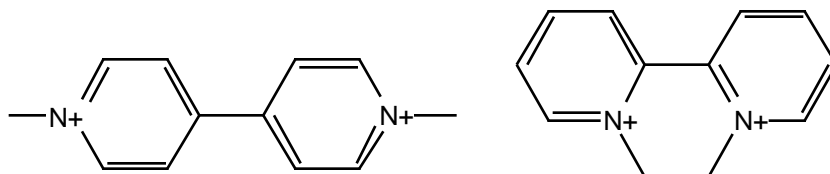
Wurster, C. *Chem. Ber.* **1879**, 12, 522

Wurster, C.; Sendtner, R. *Chem. Ber.* **1879**, 12, 1803

Wurster, C.; Schobig, E. *Chem. Ber.* **1879**, 12, 1807

Wurster, C. *Chem. Ber.* **1879**, 12, 2071

Wurster, C. *Chem. Ber.* **1886**, 19, 3195



2 Cl<sup>-</sup>

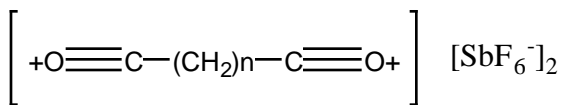
2 Br<sup>-</sup>

Brian, R.C.; Homer, R.F.; Stubbs, J.; Jones, R.L. *Nature* **1958**, 181, 446

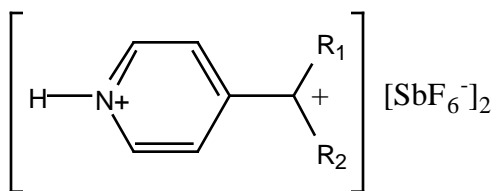
Fielden, R.J.; Homer, R.F.; Jones, R.L. GB 785,732 ICI (1958-02-18)

Brian, R.C.; Driver, G.W.; Homer, R.F.; Jones, R.L. GB 813,531 ICI (1959-05-21)

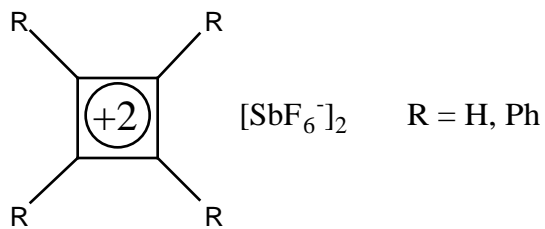
Boon, W.R. *Endeavour* **1967**, 26, 27



Olah, G.A.; Comisarow, M.B. *J. Am. Chem. Soc.* **1966**, 88, 3313

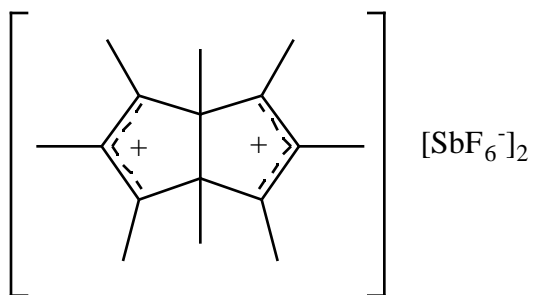


Olah, G.A.; Calin, M. *J. Am. Chem. Soc.* **1968**, 90, 943

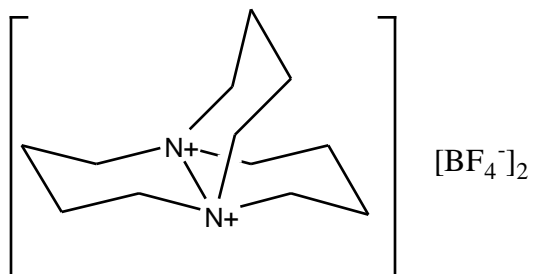


Olah, G.A.; Bollinger, J.M.; White, A.M. *J. Am. Chem. Soc.* **1969**, 91, 3667

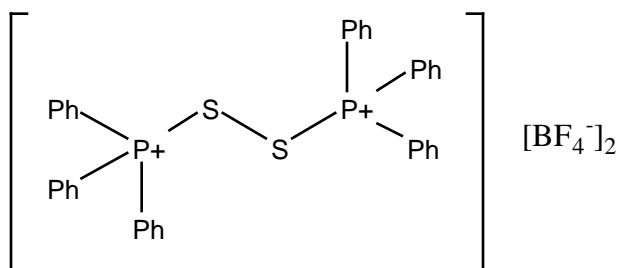
Olah, G.A.; Mateescu, G.D. *J. Am. Chem. Soc.* **1970**, 92, 1430



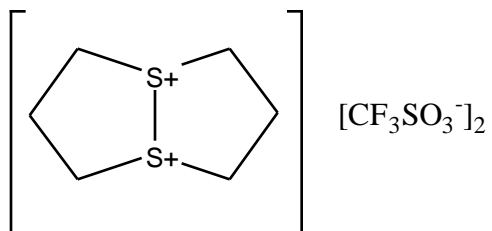
Bollinger, J.M.; Olah, G.A. *J. Am. Chem. Soc.* **1969**, 91, 3380



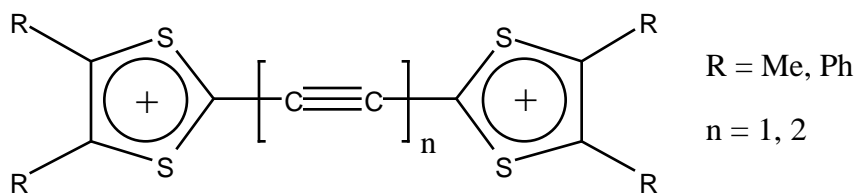
Alder, R.W.; Sessions, R.B. *J. Am. Chem. Soc.* **1979**, 101, 3651



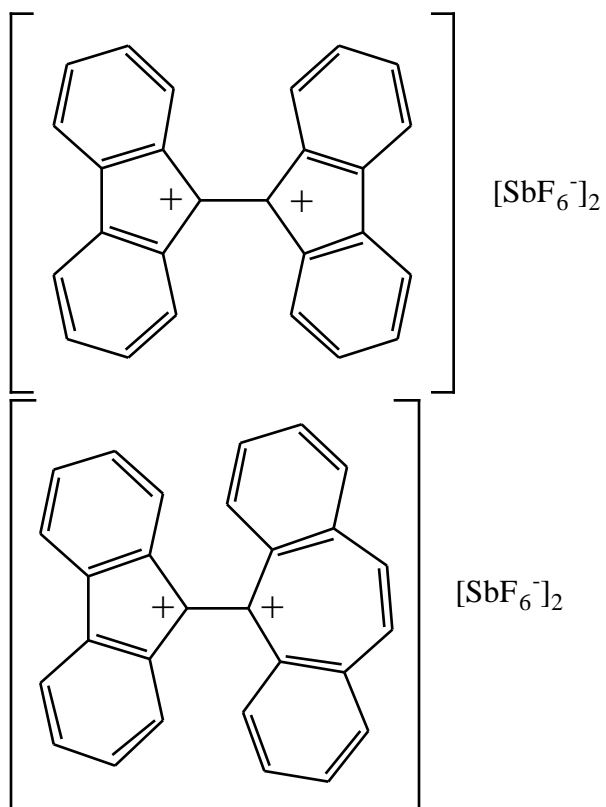
Blankespoor, R.L.; Doyle, M.P.; Smith, D.J.; van Dyke, D.A.; Waldyke, M.J. *J. Org. Chem.* **1983**, 48, 1176



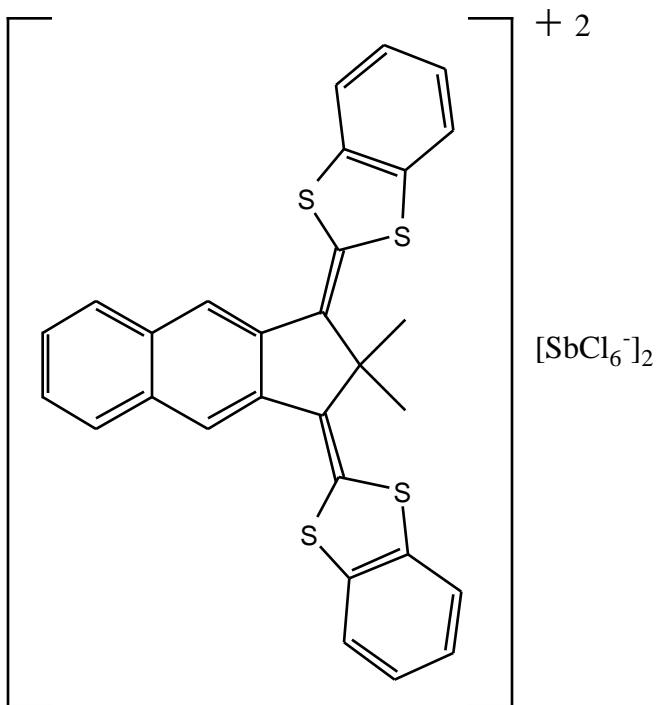
Fujihara, H.; Akaishi, R.; Furukawa, N. *Chem. Commun.* **1987**, 930



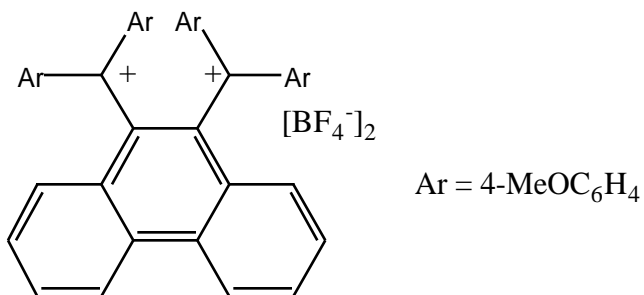
Awaji, H.; Sugimoto, T.; Yoshida, Z.I. *J. Phys. Org. Chem.* **1988**, 1, 47





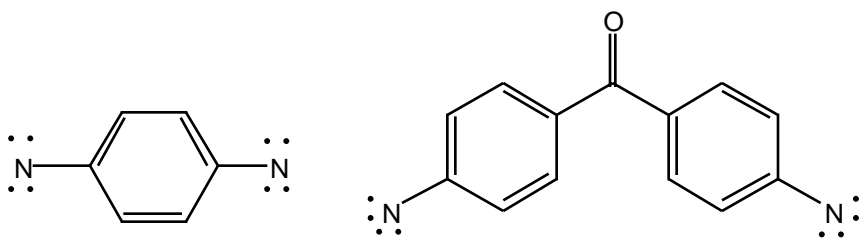


Suzuki, T.; Yoshino, T.; Ohkita, M.; Tsuji, T. *J. Chem. Soc. Perkin Trans. 1* **2000**, 3417



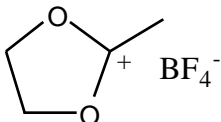
Iwashita, S.; Ohta, E.; Higuchi, H.; Kawai, H.; Fujiwara, K.; Ono, K.; Takenaka, M.; Suzuki, T. *Chem. Commun.* **2004**, 2076

### Dinitrenes

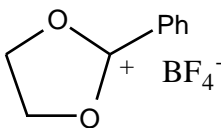


Ichimura, A.S.; Sato, K.; Kinoshita, T.; Takui, T.; Itoh, K.; Lahti, P.M. *Molec. Crystals Liquid Crystals Sci. Tech. Sect. A: Molec. Crystals Liquid Crystals* **1995**, *272*, 279

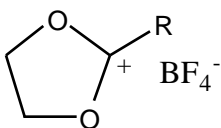
### 1,3-Dioxolenium salts



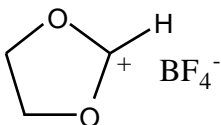
Meerwein, H.; Wunderlich, K. *Angew. Chem.* **1957**, 69, 481



Meerwein, H.; Allendorfer, H.; Beckmann, P.; Kunert, F.; Morschel, H.; Pawellek, F.; Wunderlich, K. *Angew. Chem.* **1958**, 70, 211



Meerwein, H.; Hederich, V.; Wunderlich, K. *Arch. Pharm.* **1958**, 291, 541



Meerwein, H.; Hederich, V.; Morschel, H.; Wunderlich, K. *Ann. Chem.* **1960**, 635, 1

## 1,3-Dipoles

### (i) azomethine imines

No stable analogues observed to date.

### (ii) azonium imines

No stable analogues observed to date.

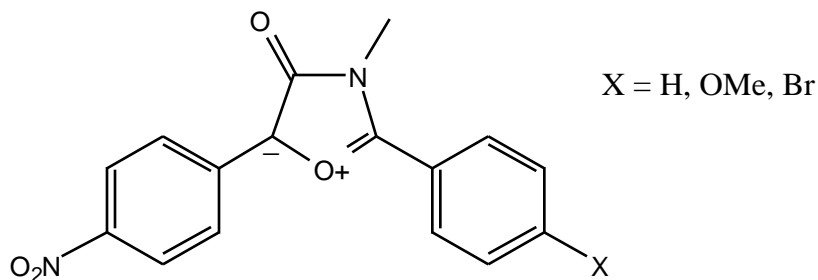
### (iii) carbonyl imines

No stable analogues observed to date.

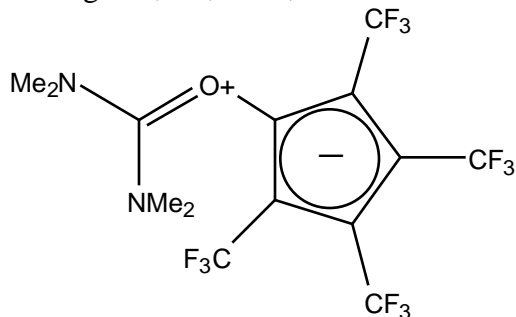
### (iv) carbonyl oxides

No stable analogues observed to date.

### (v) carbonyl ylides



Hamaguchi, M.; Iбата, T. *Tetrahedron Lett.* **1974**, 4475



Januillis, E.P. Jr.; Arduengo, A.J. III *J. Am. Chem. Soc.* **1983**, 105, 5929

#### (vi) nitrile ylides

Hegarty, A.F.; Eustace, S.J.; Tynan, N.M.; Pham-Tran, N.N.; Nguyen, M.T. *J. Chem. Soc. Perkin Trans. 2* **2001**, 1239

#### (vii) nitrilimines

No stable analogues observed to date.

#### (viii) nitrosoimines

Bamberger, E.; Padova, R.; Ormerod, E. *Ann. Chem.* **1925**, 446, 269

Scott, F.L.; Lalor, F.J. *Chem. Ind.* **1966**, 420

Vis, J.H.; Meinke, P. *J. Heterocyclic Chem.* **1970**, 7, 1417

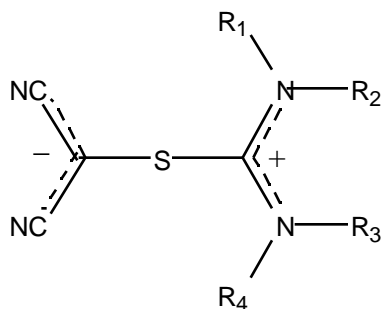
Akiba, K.; Matsunami, S.; Eguchi, C.; Inamoto, N. *Bull. Chem. Soc. Jpn* **1974**, 47, 935

Bravo, P.; Ticozzi, C. *Gazz. Chim. Ital.* **1975**, 105, 91

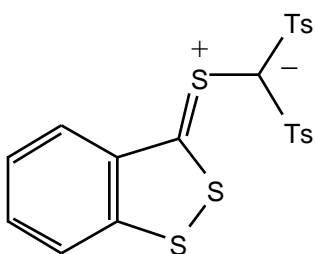
#### (ix) thiocarbonyl imines

No stable analogues observed to date.

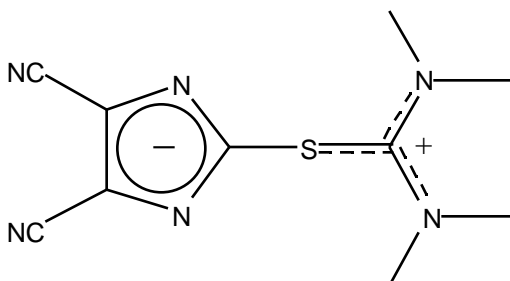
#### (x) thiocarbonyl ylides



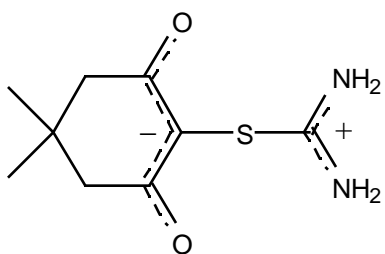
Middleton, W.J. *J. Org. Chem.* **1966**, 31, 3731



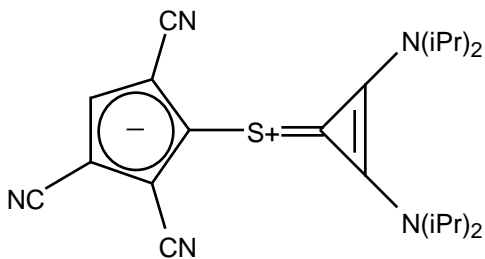
Tamagaki, S.; Oae, S. *Tetrahedron Lett.* **1972**, 1159



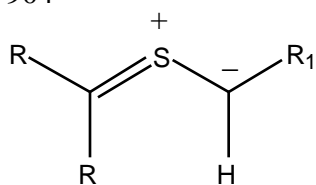
Gronski, P.; Hartke, K. *Tetrahedron Lett.* **1976**, 4139



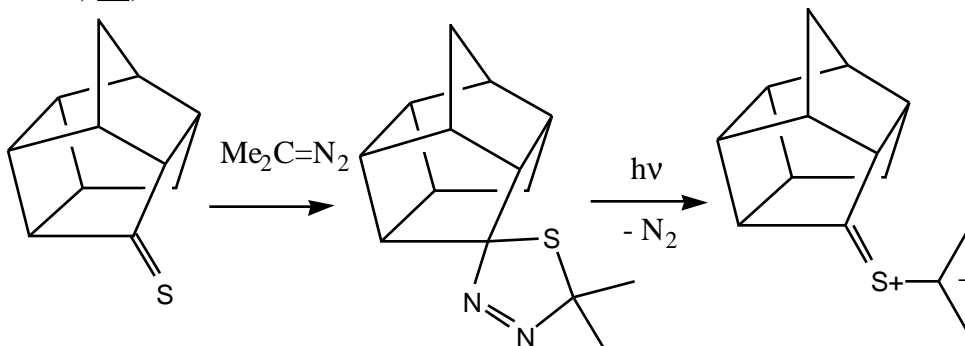
Koser, G.F.; Yu, S.M. *J. Org. Chem.* **1976**, 41, 125



Nakasuji, K.; Nishino, K.; Murata, I.; Ogoshi, H.; Yoshida, Z. *Angew. Chem.* **1977**, 89, 904

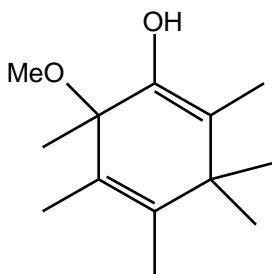


Huisgen, R.; Li, X.; Mloston, G.; Knorr, R.; Huber, H.; Stephenson, D.S. *Tetrahedron* **1999**, 55, 12783

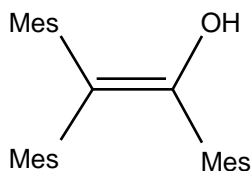


Romanski, J.; Mloston, G.; Szynekiewicz, S. *Synthesis* **2003**, 2259

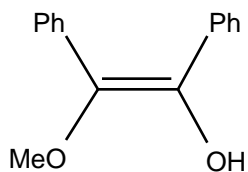
### Enols



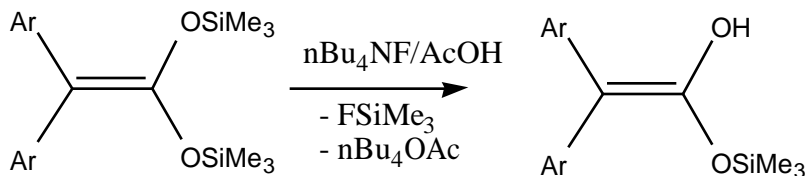
Hart, H.; Swatton, D.W. *J. Am. Chem. Soc.* **1967**, 89, 1874



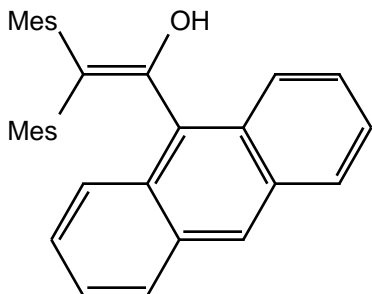
Biali, S.E.; Rappoport, Z. *J. Am. Chem. Soc.* **1983**, 103, 7350



McGarrity, J.F.; Cretton, A.; Pinkerton, A.A.; Schwarzenbach, D.; Flack, H.D. *Angew. Chem.* **1983**, 95, 426

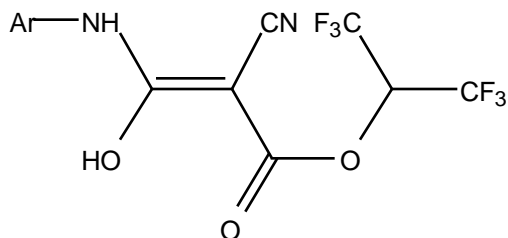


O'Neill, P.; Hegarty, A.F. *Chem. Commun.* **1987**, 744

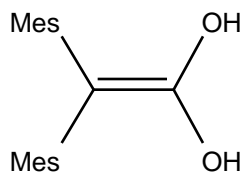


Mes = mesityl (2,4,6-trimethylphenyl)

Rochlin, E.; Rappoport, Z. *J. Org. Chem.* **2003**, 68, 216

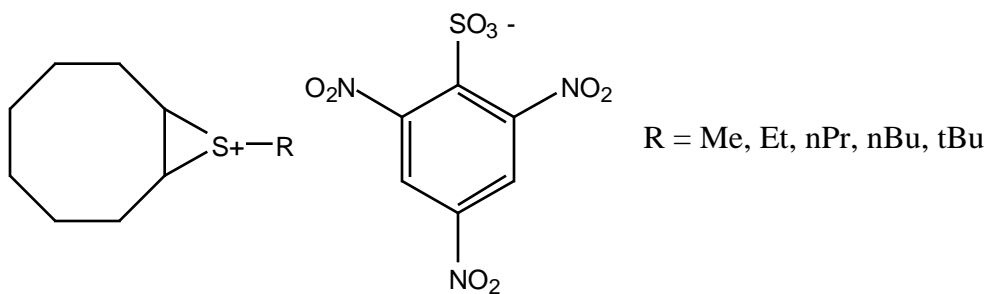


Lei, Y.X.; Casarini, D.; Cerioni, G. Rappoport, Z. *J. Org. Chem.* **2003**, 68, 947



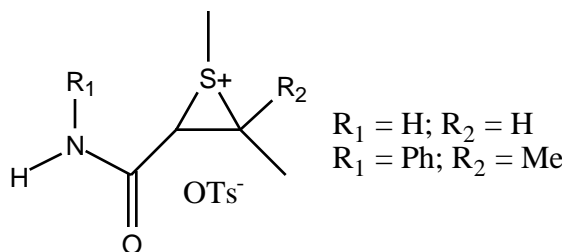
Allen, B.M.; Hegarty, A.; O'Neill, P. *J. Chem. Soc. Perkin Trans. 2* **1997**, 2733

### Episulfonium ions

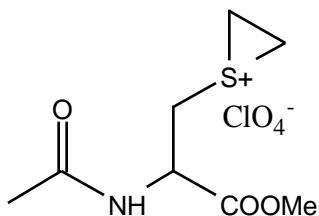


Pettitt, D.J.; Helmkamp, G.K. *J. Org. Chem.* **1964**, 29, 2702

Owsley, D.C.; Helmkamp, G.K.; Rettig, M.F. *J. Am. Chem. Soc.* **1969**, 91, 3606; 5239

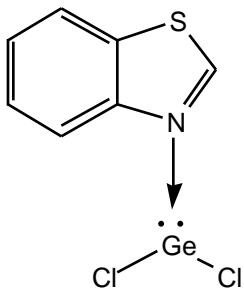


Kil'disheva, O.V; Lin'kova, M.G.; Rasteikiene, L.; Zabelaite, V.; Pociute, N.; Knunyants, I.L. *Dokl. Akad. Nauk SSR* **1972**, 203, 1072



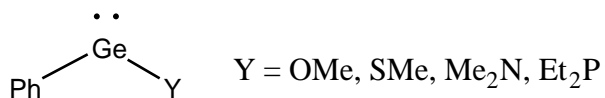
Henkel, J.G.; Amato, G.S. *J. Med. Chem.* **1988**, 31, 1279

### Germynes

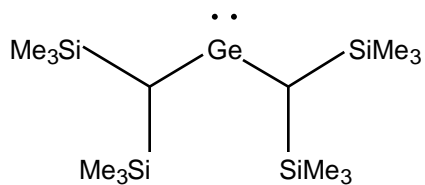


Jutzi, P.; Hoffmann, H.J.; Brauer, D.J.; Krueger, C. *Angew. Chem.* **1973**, 85, 1116

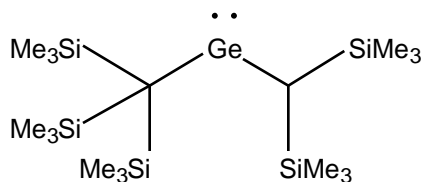
Jutzi, P.; Hoffmann, H.J.; Wyes, K.H. *J. Organometallic Chem.* **1974**, 81, 341



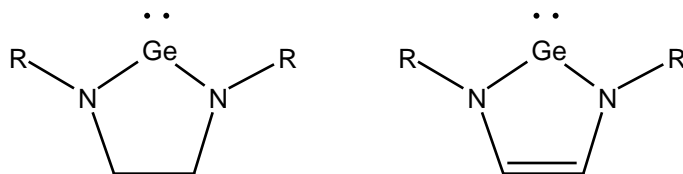
Riviere, P.; Satge, J.; Dousse, G.; Riviere-Baudet, M.; Couret, C. *J. Organometallic Chem.* **1974**, 72, 339



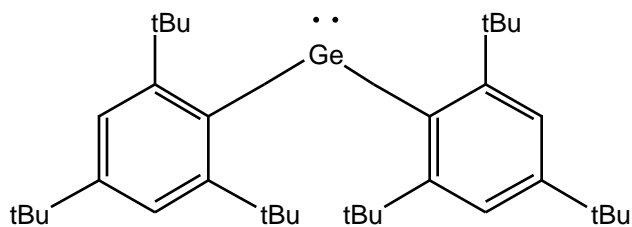
Davidson, P.J.; Harris, D.H.; Lappert, M.F. *J. Chem. Soc. Dalton Trans.* **1977**, 2268



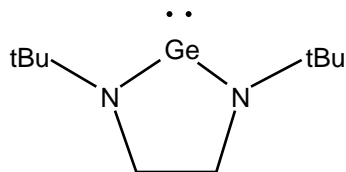
Jutzi, P.; Becker, A.; Stammler, H.G.; Neumann, B. *Organometallics* **1991**, 10, 1647



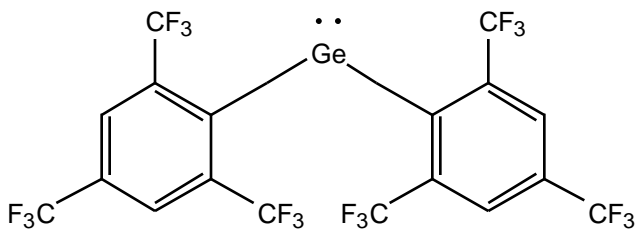
Herrmann, W.A.; Denk, M.; Behm, J.; Scherer, W.; Klingan, F.R.; Bock, H.; Solouki, B.; Wagner, M. *Angew. Chem. Int. Ed.* **1992**, 31, 1485



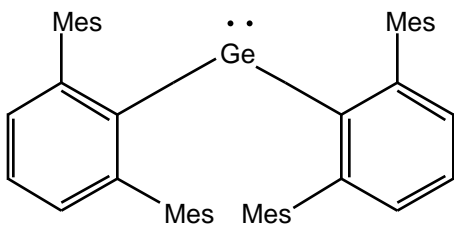
Jutzi, P.; Schmidt, H.; Neumann, B.; Stammler, H.G. *Organometallics* **1997**, 15, 741



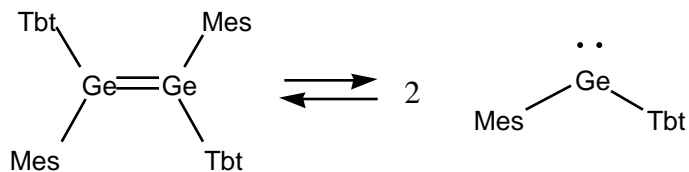
Schaefer, A.; Saak, W.; Weidenbruch, M.; Marsmann, H.; Henkel, G. *Chem. Ber.* **1997**, 130, 1733



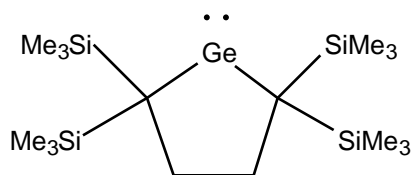
Bender, J. IV; Holl, M.M.B.; Kamp, J.W. *Organometallics* **1997**, 10, 1647



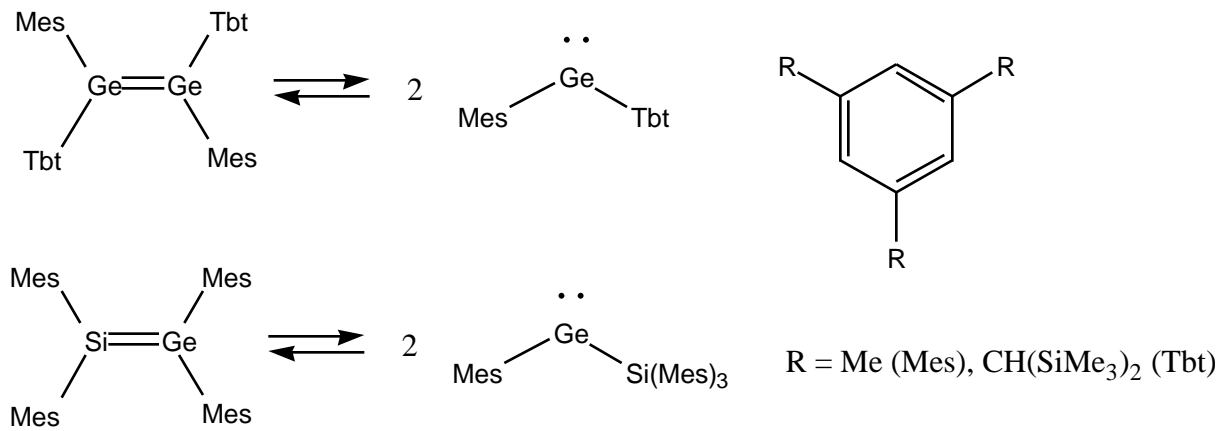
Simons, R.S.; Pu, L.; Olmstead, M.M.; Power, P.P. *Organometallics* **1997**, 16, 1920



Kishikawa, K.; Tokitoh, N.; Okazaki, R. *Chem. Lett.* **1998**, 239  
(first spectroscopic observation of equilibrium)

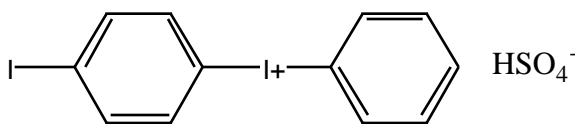


Kira, M.; Ishida, S.; Iwamoto, T.; Ichinohe, M.; Kabuto, C.; Ignatovich, L.; Sakurai, H. *Chem. Lett.* **1999**, 263

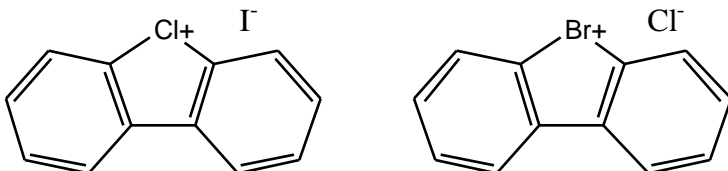


Weidenbruch, M. *Eur. J. Inorg. Chem.* **1999**, 373

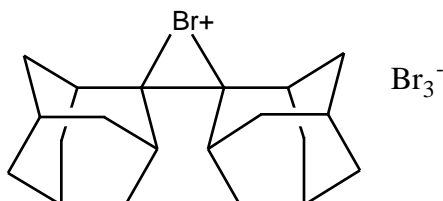
### Halonium ions



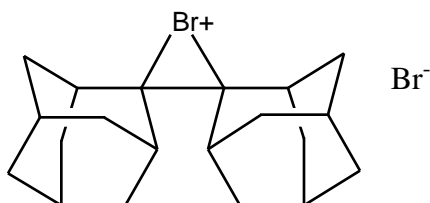
Hartmann, C.; Meyer, V. *Chem. Ber.* **1894**, 27, 426



🍁 Sandin, R.B.; Hay, A.S. *J. Am. Chem. Soc.* **1952**, 74, 274

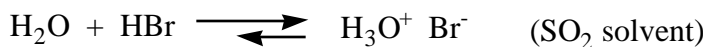


Strating, J.; Wieringa, J.H.; Wynberg, H. *Chem. Commun.* **1969**, 907

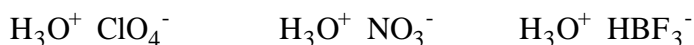


Bortolini, O.; Chiappe, C.; Conte, V.; Carraro, M. *Eur. J. Org. Chem.* **1999**, 3237

### Hydronium ion



Bagster, L.S.; Cooling, G. *J. Chem. Soc.* **1920**, 117, 693



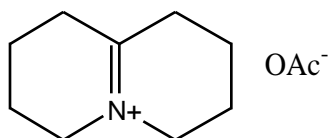
Volmer, M. *Ann. Chem.* **1924**, 440, 200

Klinkenberg, L.J.; Ketelaar, J.A.A. *Rec. Trav. Chim.* **1935**, 54, 959

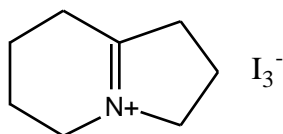
Richards, R.E.; Smith, J.A.S. *Trans. Faraday Soc.* **1951**, 47, 1261

Kakiuchi, H.; Shono, H.; Komatsu, K.; Kigoshi, K. *J. Chem. Phys.* **1951**, 19, 1069

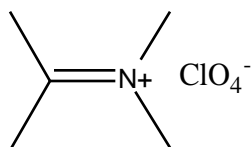
Bethell, D.E.; Sheppard, N. *J. Chem. Phys.* **1953**, 21, 1421

**Iminium ions**

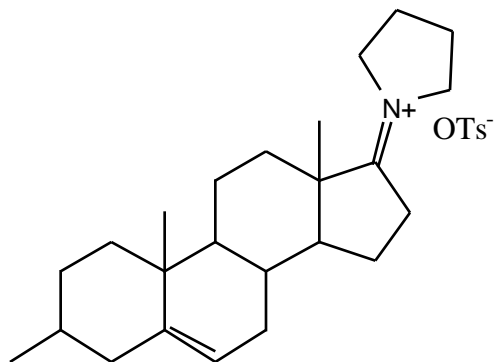
Leonard, N.J.; Hay, A.S.; Fulmer, R.W.; Gash, V.W. *J. Am. Chem. Soc.* **1955**, 77, 439



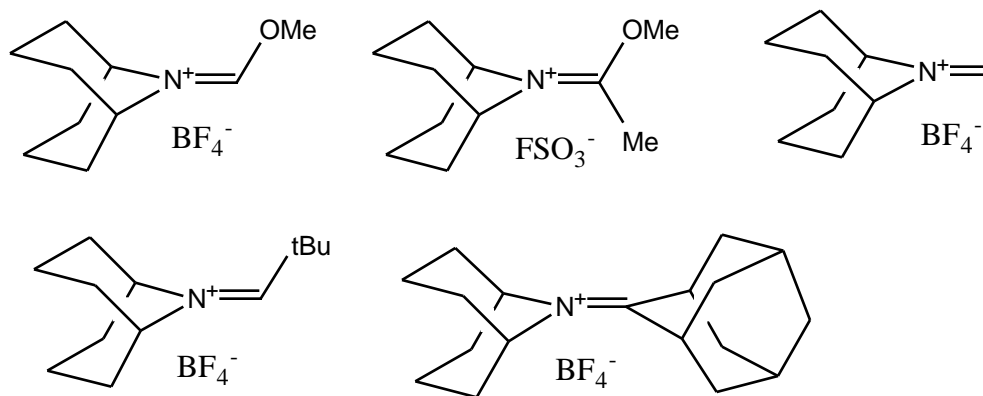
Leonard, N.J.; Hay, A.S. *J. Am. Chem. Soc.* **1956**, 78, 1984



Leonard, N.J.; Paukstelis, J.V. *J. Am. Chem. Soc.* **1963**, 28, 3021

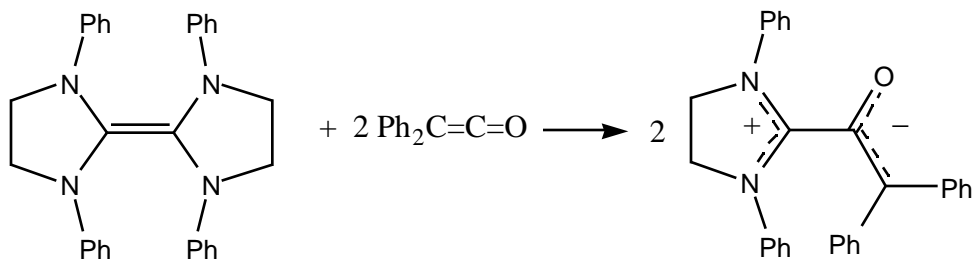


Scribner, R.M. *J. Org. Chem.* **1965**, 30, 3203

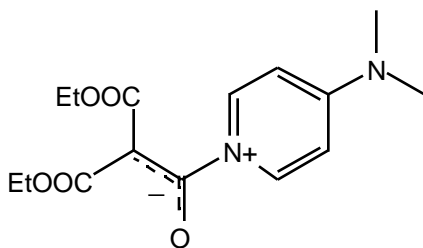


Nelsen, S.F.; Kessel, C.R.; Brien, D.J. *J. Am. Chem. Soc.* **1980**, 102, 702

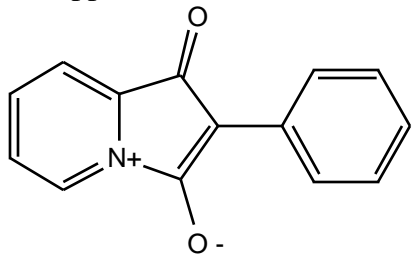
### Ketene zwitterions



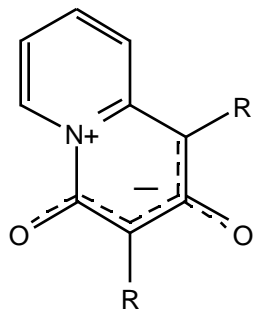
Regitz, M.; Hocker, J.; Weber, B. *Angew. Chem. Int. Ed.* **1970**, *9*, 375



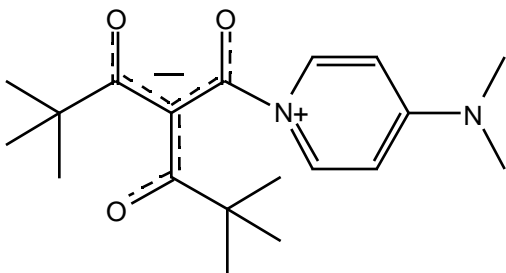
Gompper, R.; Wolf, U. *Ann. Chem.* **1979**, 1388



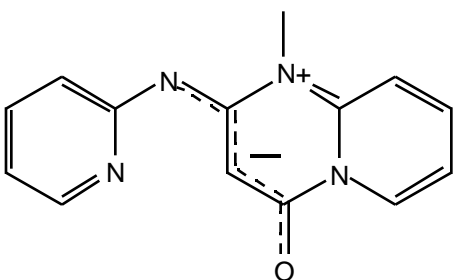
🍁 Ye, X.; Andraos, J.; Bibas, H.; Wong, M.W.; Wentrup, C. *J. Chem. Soc., Perkin Trans. 1* **2000**, 401



Fiksdahl, A.; Plüg, C.; Wentrup, C. *J. Chem. Soc. Perkin Trans. 2* **2000**, 1841

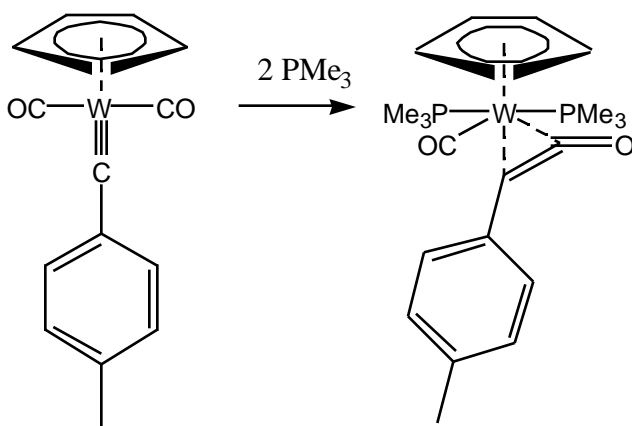


Kollenz, G.; Holzer, S.; Kappe, C.O.; Dalvi, T.S.; Fabian, W.M.F.; Sterk, H.; Wong, M.W.; Wentrup, C. *Eur. J. Org. Chem.* **2001**, 1315

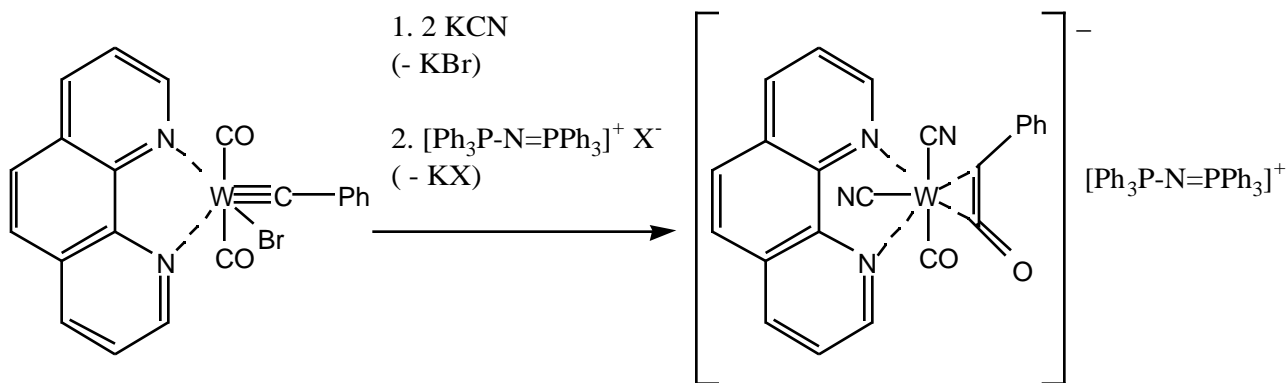


Andersen, H.G.; Mitschke, U.; Wentrup, C. *J. Chem. Soc. Perkin Trans. 2* **2001**, 602

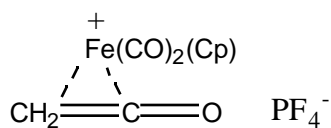
### Ketenyl transition metal complexes



Kreissl, F.R.; Frank, A.; Schubert, U.; Lindner, T.L.; Hutner, G. *Angew. Chem.* **1976**, 88, 649

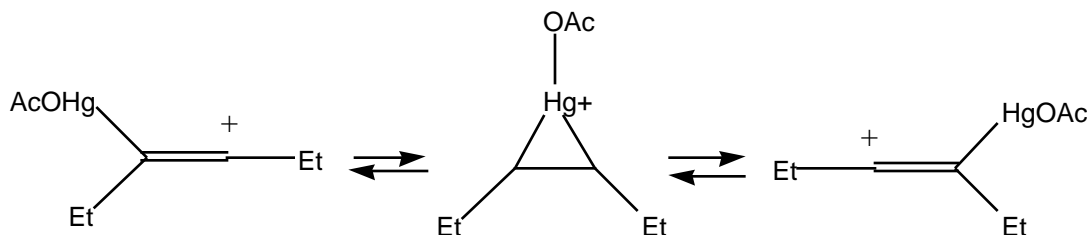


Fischer, E.O.; Filippou, A.C.; Alt, H.G.; Ackermann, K. *J. Organometallic Chem.* **1983**, 254, C21

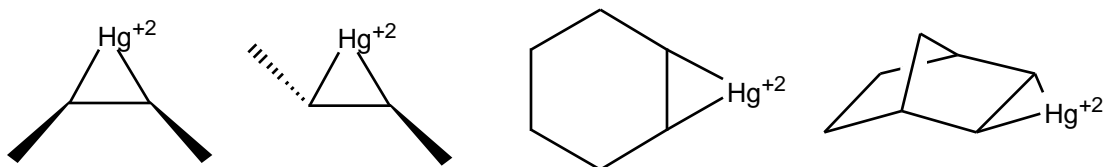


Bodnar, T.W.; Cutler, A.R. *J. Am. Chem. Soc.* **1983**, 105, 5926

### Mercurinium ions



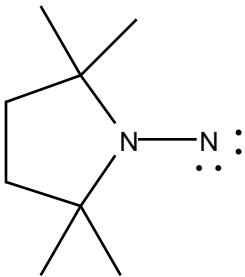
Lemaire, H.; Lucas, H.J. *J. Am. Chem. Soc.* **1955**, 77, 939



Olah, G.A.; Clifford, P.R. *J. Am. Chem. Soc.* **1973**, 95, 6067

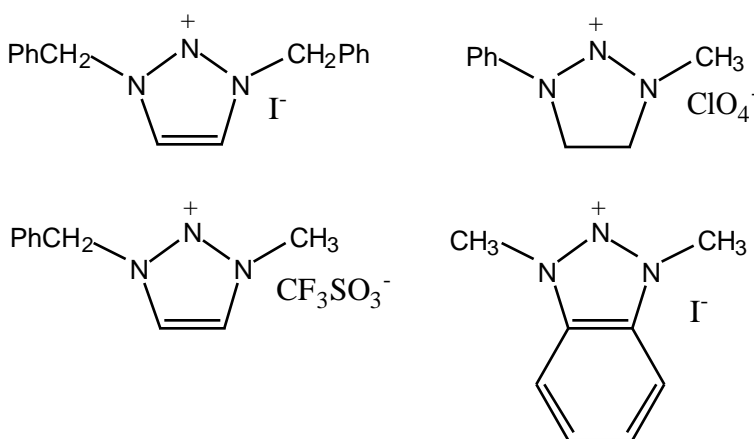
Olah, G.A.; Clifford, P.R. *J. Am. Chem. Soc.* **1971**, 93, 2320

### Nitrenes

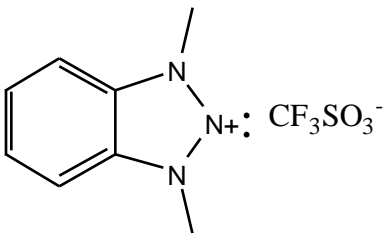


Hinsberg, W.D.; Dervan, P.B. *J. Am. Chem. Soc.* **1978**, 100, 1608  
 Shultz, P.G.; Dervan, P.B. *J. Am. Chem. Soc.* **1982**, 104, 6460; 6466  
 Sylvester, A.P.; Dervan, P.B. *J. Am. Chem. Soc.* **1984**, 106, 4648

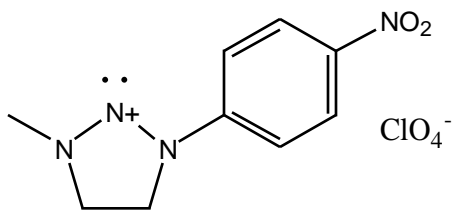
### Nitrenium ions



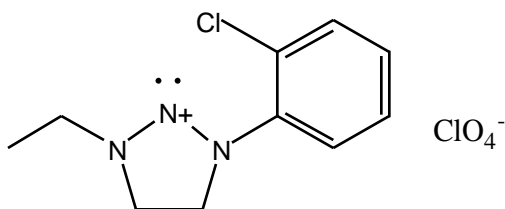
Boche, G.; Rangappa, K.; Harms, K.; Marsch, M. *Z. Kristallogr.* **1996**, 211, 581  
 Boche, G.; Rangappa, K.; Harms, K.; Willeke, C.; Marsch, M. *Z. Kristallogr.* **1996**, 211, 583  
 Boche, G.; Andrews, P.; Harms, K.; Marsch, K.; Rangappa, K.S.; Schimeczek, M.; Willeke, C. *J. Am. Chem. Soc.* **1996**, 118, 4925  
 Robert, M.; Neudeck, A.; Boche, G.; Willeke, C.; Rangappa, K.S.; Andrews, P. *New J. Chem.* **1998**, 1437



Rangappa, K.S.; Mallesha, H.; Kumar, N.V.A.; Lokanath, N.K.; Sridhar, M.A.; Prasad, J.S. *Molecular Crystals Liquid Crystals Sci. Tech. A* **2001**, 357, 291



Doreswamy, B.H.; Mahendra, M.; Sridhar, M.A.; Prasad, J.S.; Mantelingu, K.; Basappa, K.; Rangappa, S. *Molecular Crystals Liquid Crystals Sci. Tech. A* **2003**, 403, 67



Mantelingu, K.; Rangappa, K.S.; Basappa; Doreswamy, B.H.; Mahendra, M.; Sridhar, M.A.; Prasad, J.S. *J. Chem. Crystallography* **2004**, 34, 141

### Nitrilium ions

No stable analogues observed to date.

### Nitronium ions



X = BF<sub>4</sub>, PF<sub>6</sub>, AsF<sub>6</sub>, SbF<sub>6</sub>, AuF<sub>4</sub>      X = SnF<sub>6</sub>

Woolf, A.A.; Emeleus, H.J. *J. Chem. Soc.* **1950**, 1050; 1053


Olah, G.A.; Kuhn, S.J.; Flood, S.H. *J. Am. Chem. Soc.* **1961**, 83, 4581

Olah, G.A.; Kuhn, S.J. *J. Am. Chem. Soc.* **1962**, 84, 3684

Olah, G.A.; Kuhn, S.J.; Flood, S.H.; Evans, J.C. *J. Am. Chem. Soc.* **1962**, 84, 3687

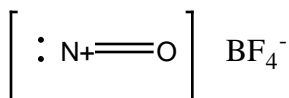


X = BF<sub>4</sub>, PF<sub>6</sub>, AsF<sub>6</sub>, SbF<sub>6</sub>      X = SiF<sub>6</sub>, SnF<sub>6</sub>

 Kuhn, S.J. *Can. J. Chem.* **1967**, 45, 3207

Kuhn, S.J. US 3,375,084 Dow Chemical Co. (1968-03-26)

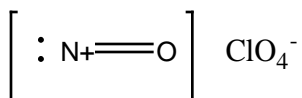
### Nitrosonium ions



Wilke-Dorfurt, E.; Balz, G. *Z. Anorg. Allgem. Chem.* **1926**, 159, 197

Welte, F. *Die Nitrosylborfluorids*, Stuttgart, 1930

Olah, G.; Noszko, L.; Kuhn, I.; Szelke, M. *Chem. Ber.* **1956**, 89, 2374



Hofmann, K.A.; Zedtwitz, A. *Chem. Ber.* **1909**, 42, 2031

Olah, G.A.; Overchuk, N.A.; Lapierre, J.C. *J. Am. Chem. Soc.* **1965**, 87, 5785

Olah, G.A.; Friedman, N. *J. Am. Chem. Soc.* **1966**, 88, 5330



X = BF<sub>4</sub>, PF<sub>6</sub>, AsF<sub>6</sub>, SbF<sub>6</sub>

X = SiF<sub>6</sub>, SnF<sub>6</sub>

Kuhn, S.J. *Can. J. Chem.* **1967**, 45, 3207

Kuhn, S.J. US 3,375,084 Dow Chemical Co. (1968-03-26)

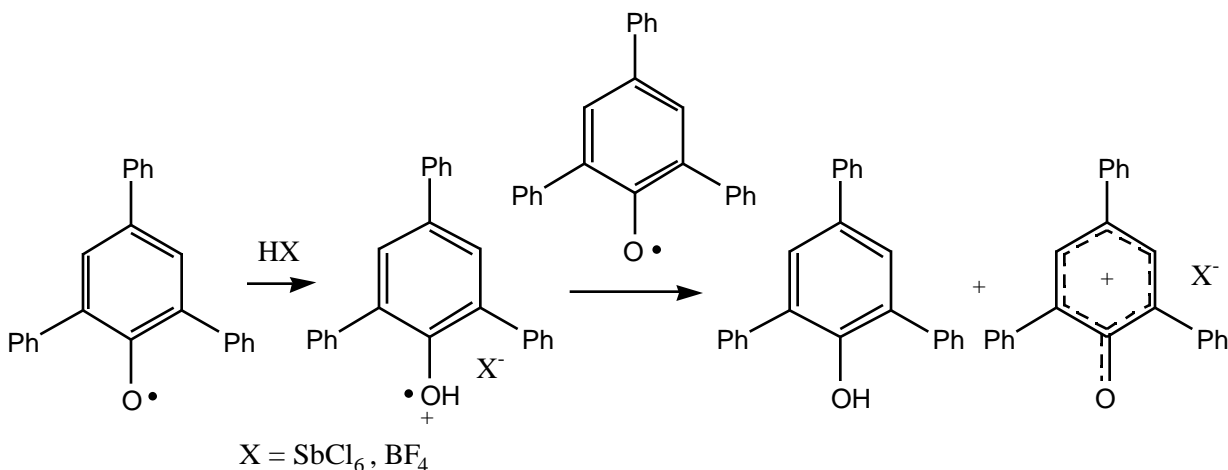
### Non-classical carbocations

No stable analogues observed to date.

### Organometallic esters

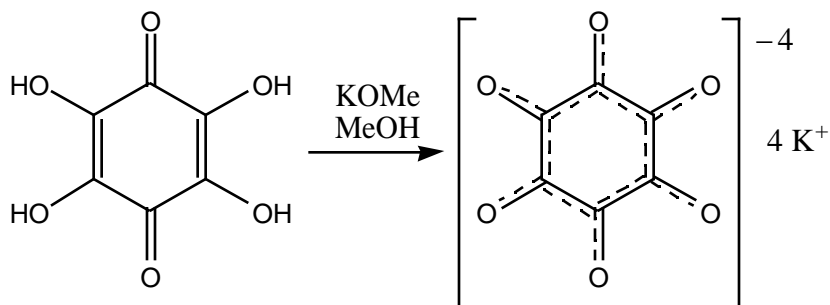
No stable analogues observed to date.

### Oxenium ions



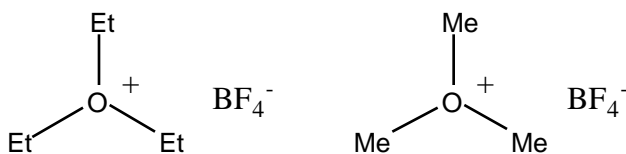
Dimroth, K.; Umbach, W.; Thomas, H. *Chem. Ber.* **1967**, 100, 132

### Oxocarbons



West, R.; Niu, H.Y. *J. Am. Chem. Soc.* **1962**, 84, 1324

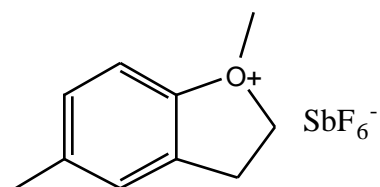
### Oxonium ions



Meerwein, H.; Hinz, G.; Hofmann, P.; Kronig, E.; Pfeil, E. *J. Prakt. Chem.* **1937**, 147, 257

Meerwein, H.; Battenberg, E.; Gold, H.; Pfeil, E.; Willfang, G. *J. Prakt. Chem.* **1940**, 154, 83

Meerwein, H. *Org. Synth.* **1966**, 46, 120



Manner, J.A.; Cook, J.A. Jr.; Ramsey, B.G. *J. Org. Chem.* **1974**, 39, 1199

### Ozonides

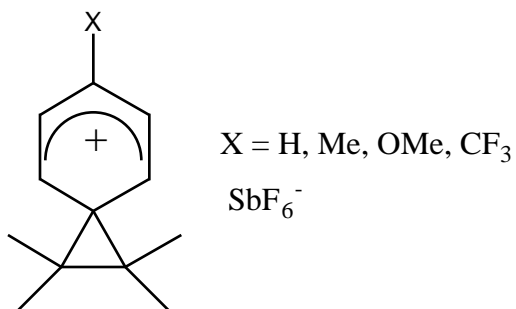
No stable analogues observed to date.

### Paterno-Buchi biradicals

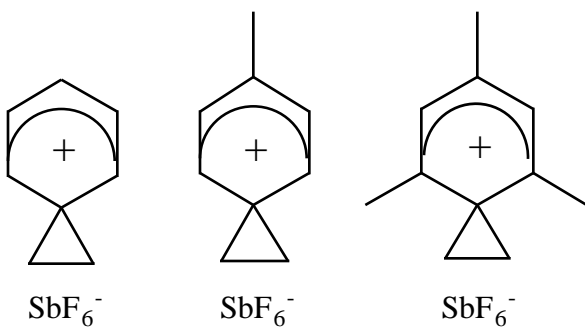
No stable analogues observed to date.

### Phenonium ions

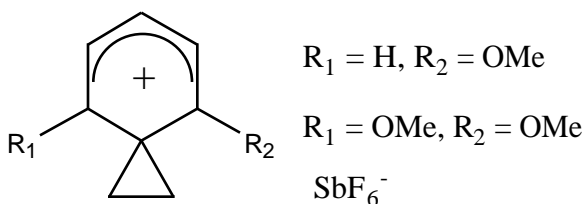
Seidl, G.; Huisgen, R.; Wimmer, I. *Ann. Chem.* **1964**, 677, 34



Olah, G.A.; Comisarow, M.B.; Kim, C.J. *J. Am. Chem. Soc.* **1969**, 91, 1458

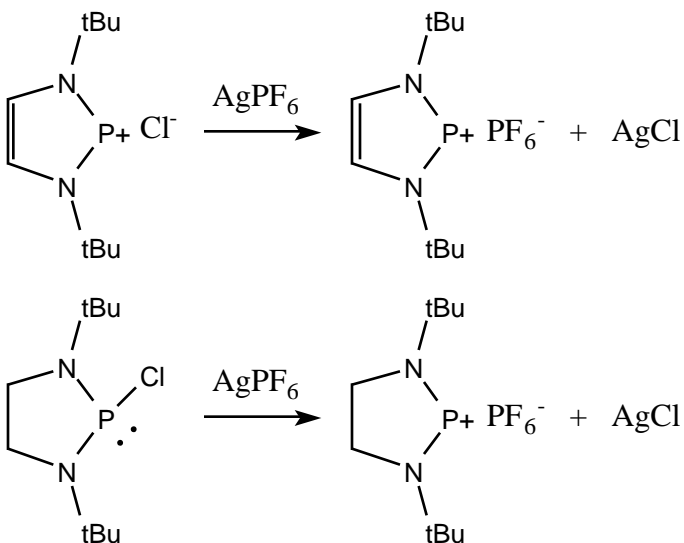


Olah, G.A.; Porter, R.D. *J. Am. Chem. Soc.* **1971**, 93, 6877



Manner, J.A.; Cook, J.A. Jr.; Ramsey, B.G. *J. Org. Chem.* **1974**, 39, 1199

### Phosphenium ions

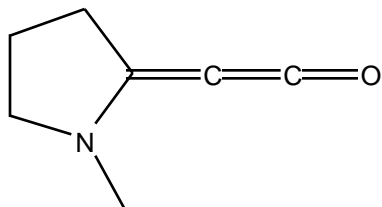


Denk, M.K.; Gupta, S.; Lough, A.J. *Eur. J. Inorg. Chem.* **1999**, 41

### Phosphonium ions

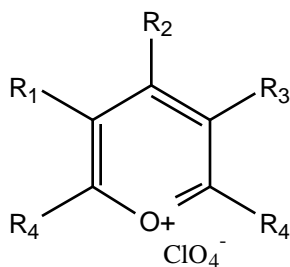
No stable analogues observed to date.

### Propadienones



Lorenca, P.; Pommelet, J.C.; Chuche, J.; Wentrup, C. *Chem. Commun.* **1986**, 369

### Pyrylium ions



Collie, J.N.; Tickle, T. *J. Chem. Soc. Trans.* **1899**, 75, 710

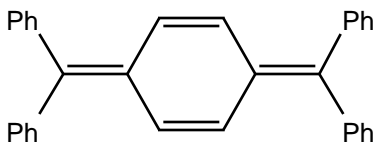
Balaban, A.T.; Nenitzescu, C.D. *Ann. Chem.* **1959**, 625, 74

Balaban, A.T.; Nenitzescu, C.D. *J. Chem. Soc.* **1961**, 3553; 3561; 3564

Praill, P.F.G.; Whitear, A.L. *J. Chem. Soc.* **1961**, 3573

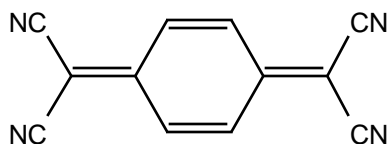
Praill, P.F.G.; Whitear, A.L. *Proc. Chem. Soc.* **1961**, 312

### o-Quinodimethanes (o-xylylenes) and p-Quinodimethanes (p-xylylenes)

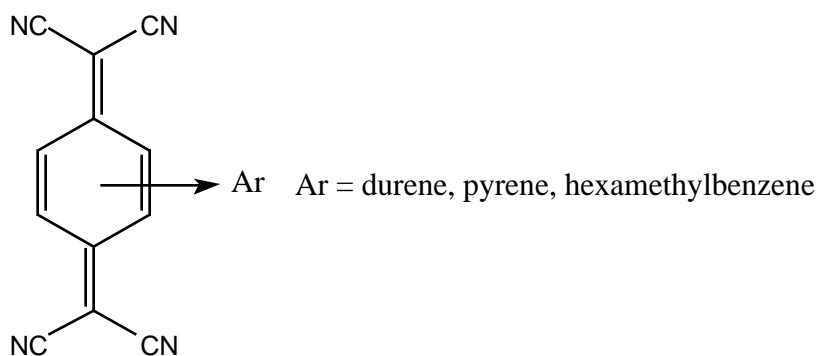


Thiele; Balhorn *Chem. Ber.* **1904**, 37, 1469

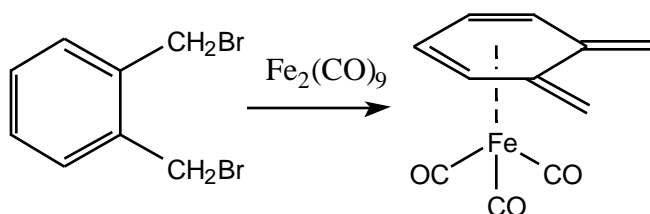
Schönberg, A.; Michaelis, R. *J. Chem. Soc.* **1935**, 1403



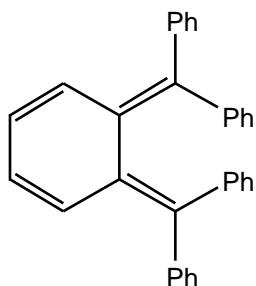
Acker, D.S.; Hertler, W.R. *J. Am. Chem. Soc.* **1962**, 84, 3370



Melby, L.R.; Harder, R.J.; Hertler, W.R.; Mahler, W.; Benson, R.E.; Mochel, W.E. *J. Am. Chem. Soc.* **1962**, 84, 3374



Roth, W.R.; Meier, J.D. *Tetrahedron Lett.* **1967**, 2053

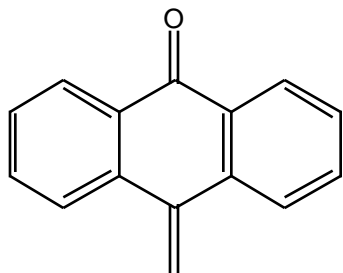


Quinkert, G.; Wiersdorff, W.W.; Finke, M.; Opitz, K. *Tetrahedron Lett.* **1966**, 2193

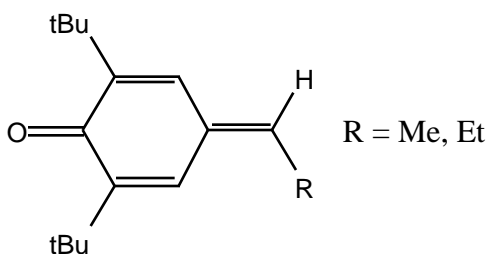
Quinkert, G.; Wiersdorff, W.W.; Finke, M.; Opitz, K.; van der Haar, F.G. *Chem. Ber.* **1968**, 101, 2302

Grellmann, K.H.; Palmowski, J.; Quinkert, G. *Angew. Chem. Int. Ed.* **1971**, 10, 196

### **o-Quinonemethides and p-Quinonemethides**

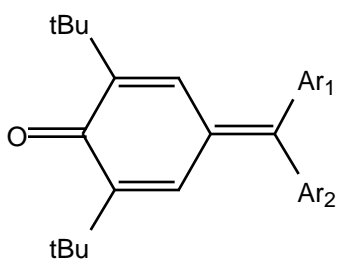


Heymann, H.; Trowbridge, L. *J. Am. Chem. Soc.* **1950**, 72, 84



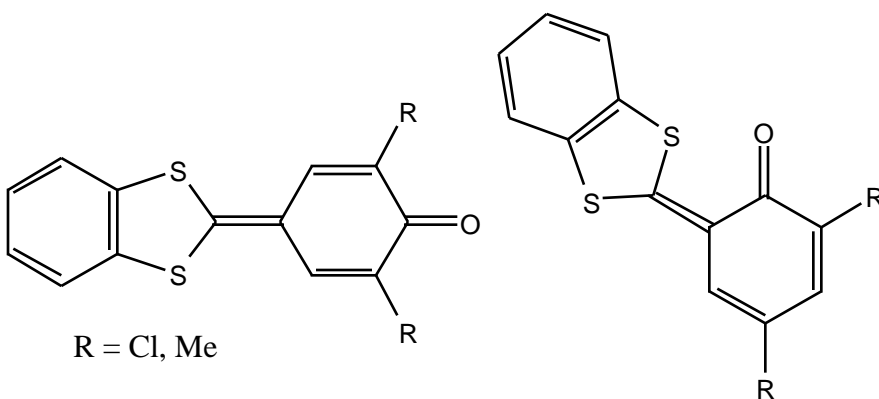
Cook, C.D.; Norcross, B.E. *J. Am. Chem. Soc.* **1956**, 78, 3797

Cook, C.D.; Norcross, B.E. *J. Am. Chem. Soc.* **1959**, 81, 1176



Hünig, S.; Schwartz, H. *Ann. Chem.* **1956**, 599, 131

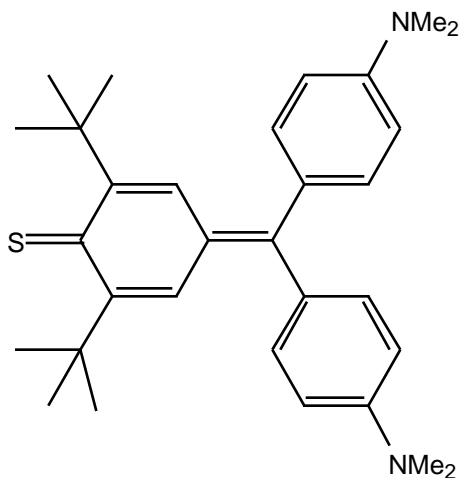
Musil, L.; Koutek, B.; Vereck, J.; Soucek, M. *Collect. Czech. Chem. Commun.* **1984**, 49, 1949



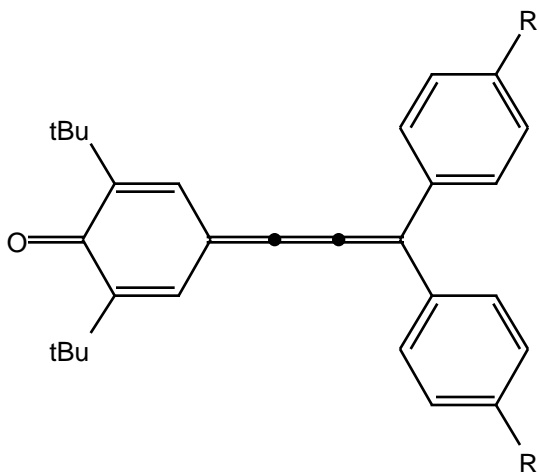
Nakayama, J.; Yamashita, K.; Hoshino, M.; Takemasa, T. *Chem. Lett.* **1977**, 789



Meier, H.; Kuenzi, H.; Fuhrer, H.; Rist, G. *Helv. Chim. Acta* **1994**, 77, 655

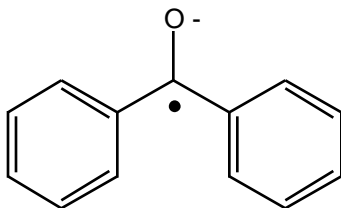


Suzuki, R.; Kurata, H.; Kawase, T.; Oda, M. *Chem. Lett.* **1999**, 571  
(p-thioquinonemethides)

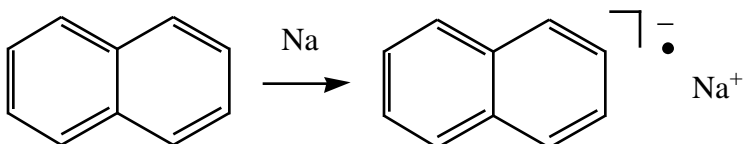


Kawase, T.; Nishigaki, N.; Kurata, H.; Oda, M. *Eur. J. Org. Chem.* **2004**, 3090

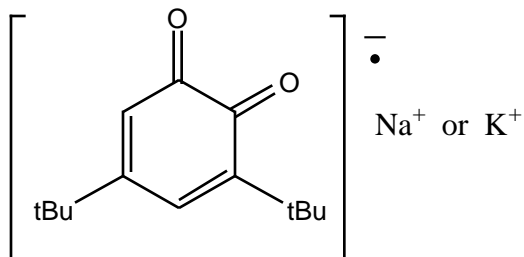
### Radical anions



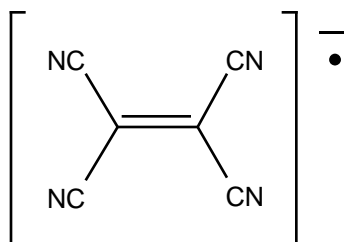
Schlenk, W.; Weichel, T. *Chem. Ber.* **1911**, 44, 1182  
Schlenk, W.; Thal, A. *Chem. Ber.* **1913**, 46, 2840



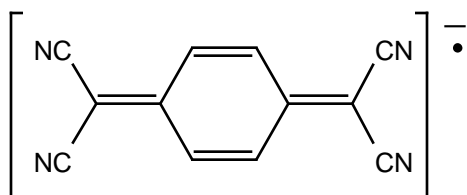
Lipkin, D.; Paul, D.E.; Townsend, J.; Weissman, S.I. *Science* **1953**, 117, 534  
 Weissman, S.I.; Townsend, J.; Paul, D.E.; Pake, G.E. *J. Chem. Phys.* **1953**, 21, 2227  
 Chu, T.L.; Yu, S.C. *J. Am. Chem. Soc.* **1954**, 76, 3367



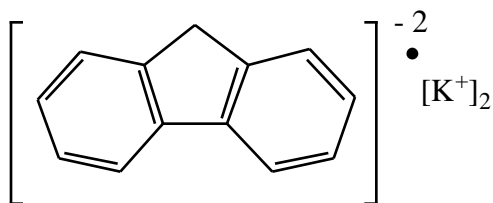
Ley, K.; Müller, E. *Angew. Chem.* **1958**, 70, 469



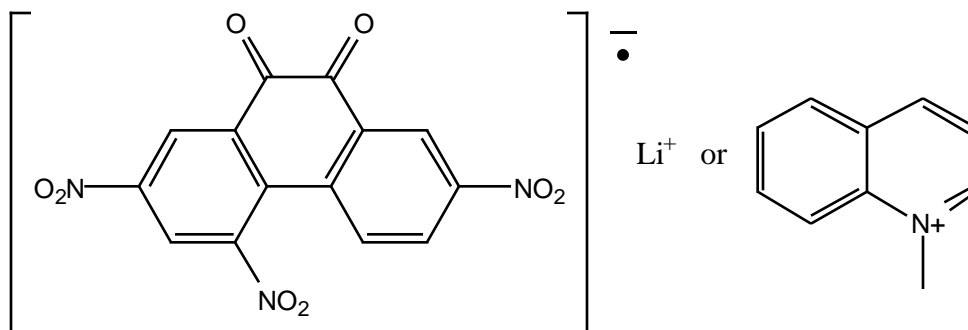
Webster, O.W.; Mahler, W.; Benson, R.E. *J. Am. Chem. Soc.* **1962**, 84, 3678



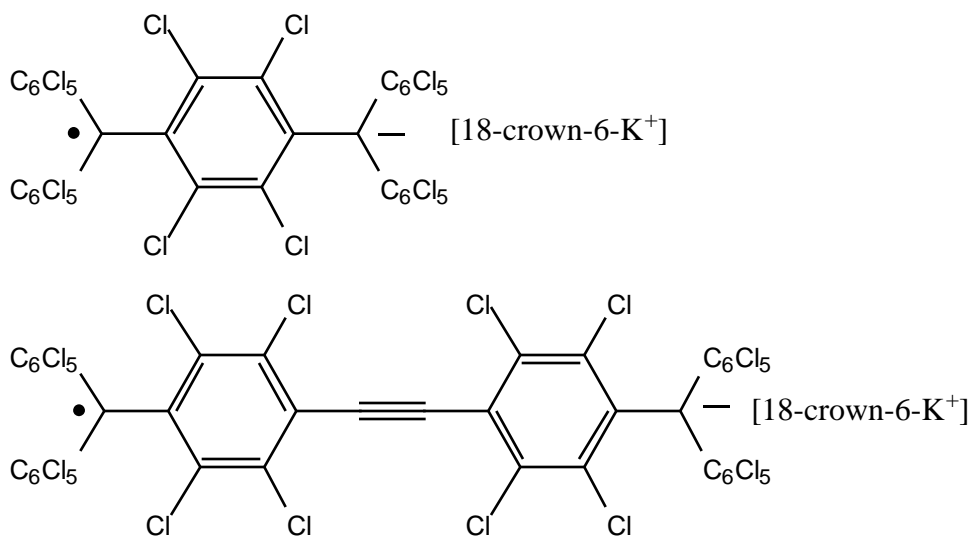
✻ Fischer, P.H.H.; McDowell, C.A. *J. Am. Chem. Soc.* **1963**, 85, 2694  
 Acker, D.S.; Harder, R.J.; Hertler, W.R.; Mahler, W.; Meley, L.R.; Benson, R.E.;  
 Mochel, W.E. *J. Am. Chem. Soc.* **1960**, 82, 6408



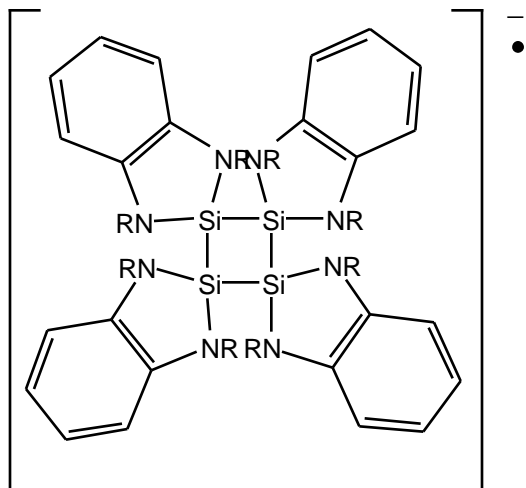
Janzen, E.G.; Gerlock, J.L. *J. Organometallic Chem.* **1967**, 8, 354



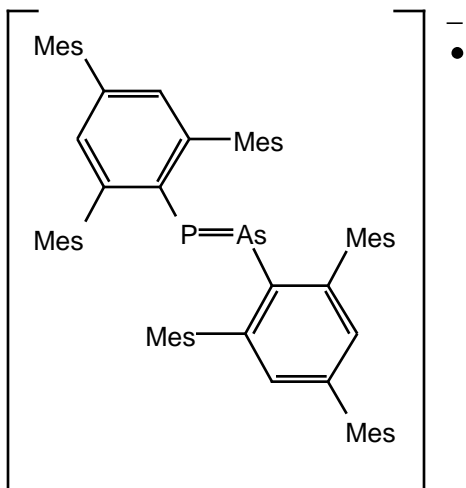
Mukherjee, T.K. *J. Phys. Chem.* **1967**, 71, 2277



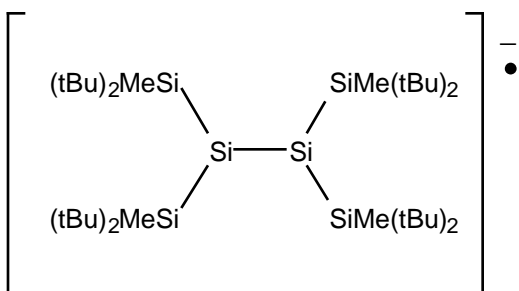
Domingo, V.M.; Castaner, J.; Riera, J.; Brillas, E.; Molins, E.; Martinez, B.; Knight, B. *Chem. Mater.* **1997**, 9, 1620



Gehrhus, B.; Hitchcock, P.B.; Zhang, L. *Angew. Chem. Int. Ed.* **2004**, 43, 1124

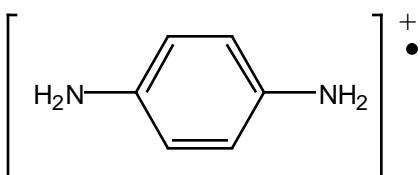


Tsuji, K.; Fujii, Y.; Sasaki, S.; Yoshifuji, M. *Chem. Lett.* **1997**, 855



Sekuguchi, A.; Inoue, S.; Ichinohe, M.; Arai, Y. *J. Am. Chem. Soc.* **2004**, 126, 9626

### Radical cations



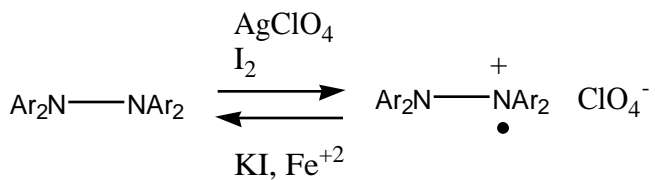
Wurster, C. *Chem. Ber.* **1879**, 12, 522

Wurster, C.; Sendtner, R. *Chem. Ber.* **1879**, 12, 1803

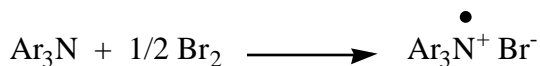
Wurster, C.; Schobig, E. *Chem. Ber.* **1879**, 12, 1807

Wurster, C. *Chem. Ber.* **1879**, 12, 2071

Wurster, C. *Chem. Ber.* **1886**, 19, 3195



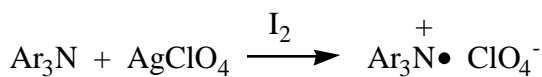
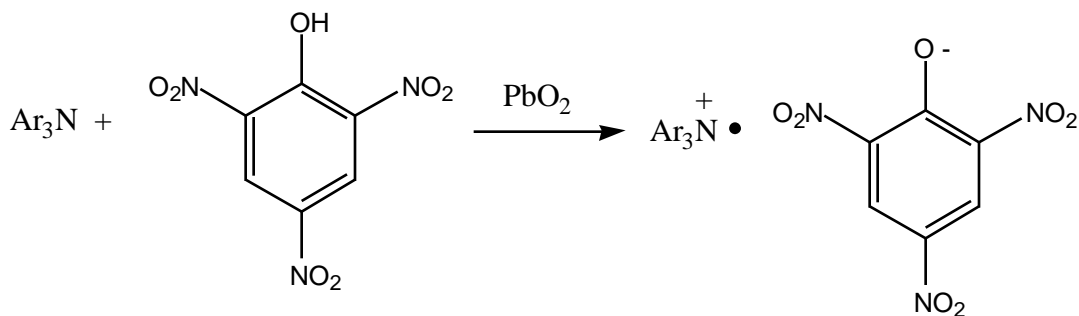
Wieland, H.; Gambajarin, S. *Chem. Ber.* **1906**, 39, 1499



Wieland, H. *Chem. Ber.* **1907**, 40, 4260

Wieland, H. *Chem. Ber.* **1908**, 41, 3478

Wieland, H.; Wecker, E. *Chem. Ber.* **1910**, 43, 699



Weitz, E. *Angew. Chem.* **1922**, 39, 1193

Weitz, E.; Schwechten, H.W. *Chem. Ber.* **1926**, 59, 2307

Weitz, E.; Schwechten, H.W. *Chem. Ber.* **1927**, 60, 545

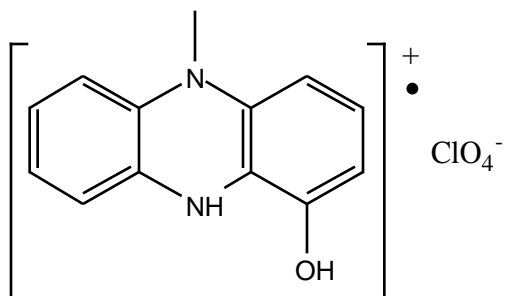


Weitz, E.; Schwechten, H.W. *Chem. Ber.* **1926**, 59, 2307

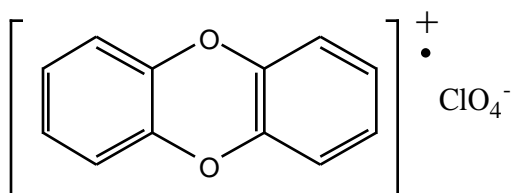
Weitz, E.; Müller, E. *Chem. Ber.* **1935**, 68, 2306

Müller, E.; Wiesemann, W. *Chem. Ber.* **1936**, 69, 2157

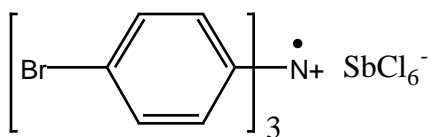
Hoskins, R. *J. Chem. Phys.* **1956**, 25, 788



Kuhn, R.; Schon, K. *Chem. Ber.* **1935**, 68, 1537

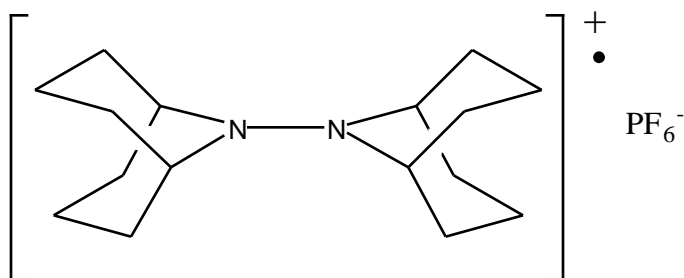


Cauquis, G.; Maurey, M. *Compt. Rend. Ser. C. Chim.* **1968**, 266, 1021

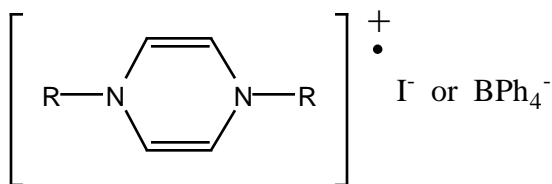


Bell, F.A.; Ledwith, A.; Sherrington, D.C. *J. Chem. Soc. C* **1969**, 2719

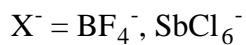
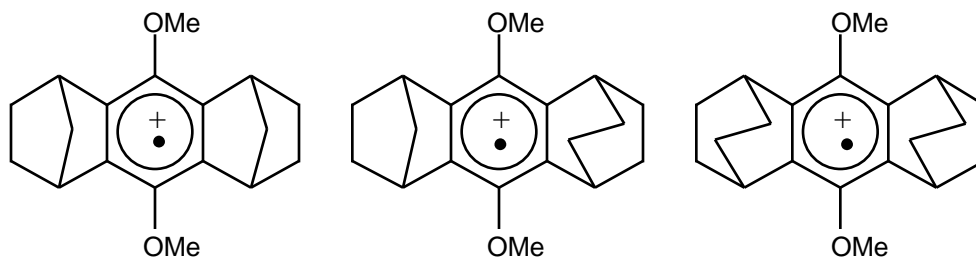
Bell, F.A.; Ledwith, A.; Sherrington, D.C. *J. Org. Chem.* **1976**, 13, 155



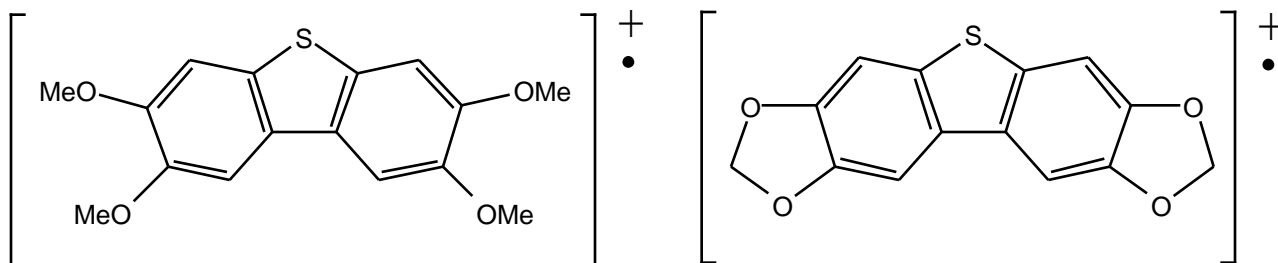
Nelson, S.F.; Kessel, C.R. *J. Am. Chem. Soc.* **1977**, 99, 2392



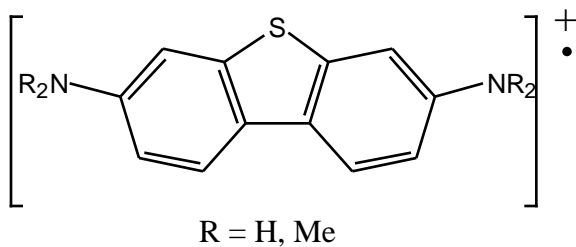
Schulz, A.; Kaim, W.; Hausen, H.D. *J. Chem. Soc. Faraday Trans. 1* **1988**, 84, 3207



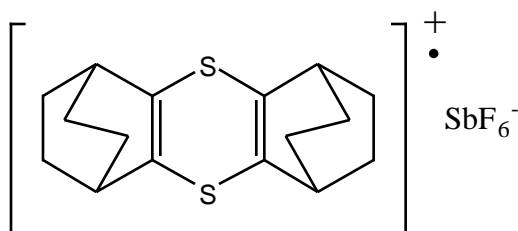
Rathore, R.; Kochi, J.K. *J. Org. Chem.* **1995**, 60, 4399



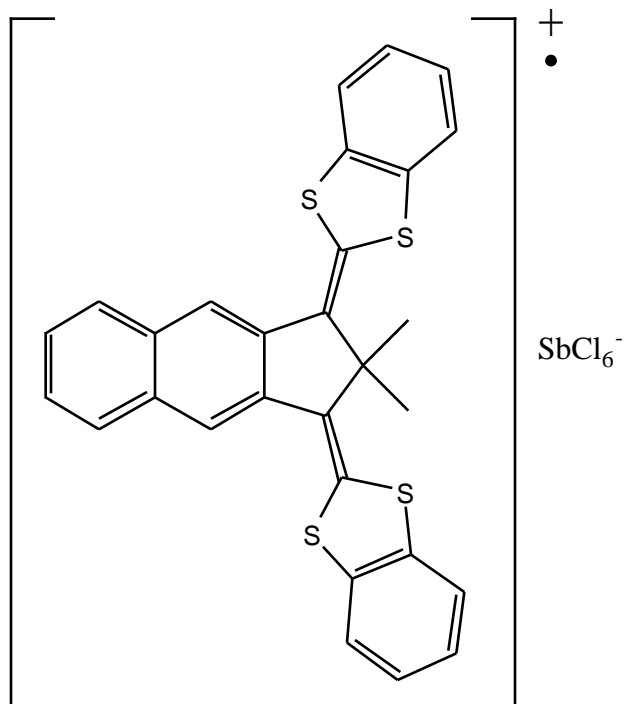
Cariou, M.; Douadi, T.; Simonet, J. *New J. Chem.* **1995**, 19, 65



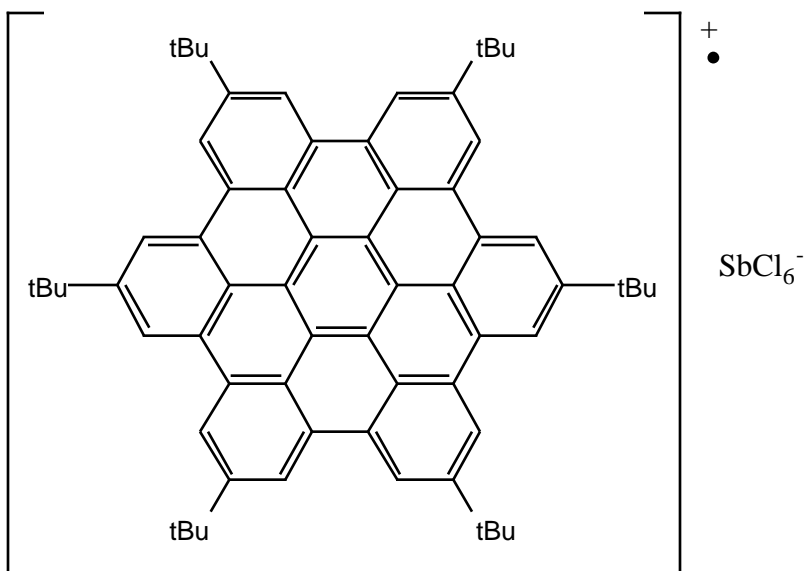
Cariou, M.; Douadi, T.; Simonet, J. *Bull. Soc. Chim. Fr.* **1996**, 133, 597



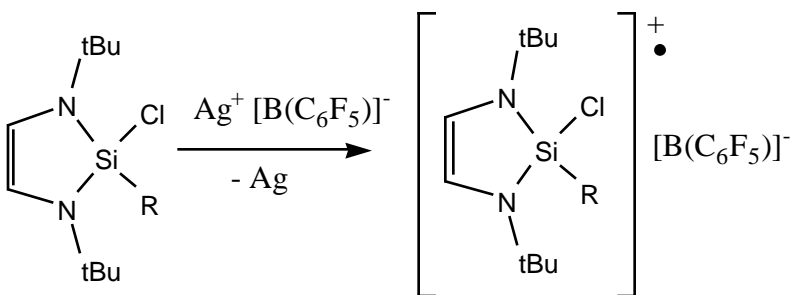
Nishinaga, T.; Wakamiya, A.; Komatsu, K. *Tetrahedron Lett.* **1999**, 40, 4375



Suzuki, T.; Yoshino, T.; Ohkita, M.; Tsuji, T. *J. Chem. Soc. Perkin Trans. 1* **2000**, 3417



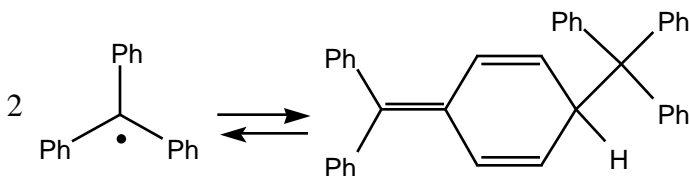
Rathore, R.; Burns, C.L. *J. Org. Chem.* **2003**, 68, 4071



Ishida, S.; Nishinaga, T.; Komatsu, K. *Chem.* **2005**, 34, 486

### Radicals (Group IV centred - carbon, silicon, germanium, tin)

#### (i) Radicals (carbon centred)



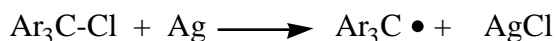
Gomberg, M., *J. Am. Chem. Soc.* **1900**, 22, 757

Gomberg, M. *Chem. Ber.* **1900**, 33, 3150

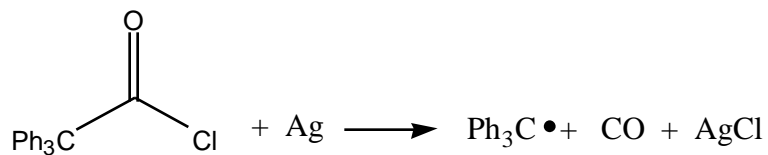
Gomberg, M. *Chem. Ber.* **1901**, 34, 2726

Gomberg, M.; Bachmann, W.E. *J. Am. Chem. Soc.* **1924**, 46, 2339

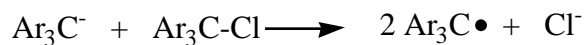
Lankamp, H.; Nauta, W.T.; MacLean, C. *Tetrahedron Lett.* **1968**, 249



Gomberg, M.; Cone, L.H. *Chem. Ber.* **1906**, 39, 3286

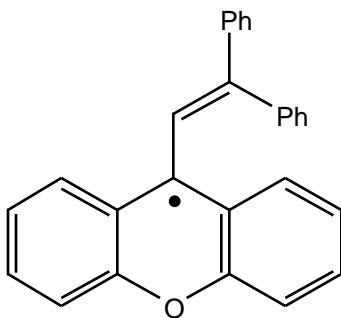


Schmidlin, J. *Chem. Ber.* **1910**, 43, 1140

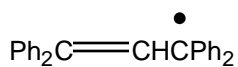


Schlenk, W.; Marcus, E. *Chem. Ber.* **1914**, 47, 1664

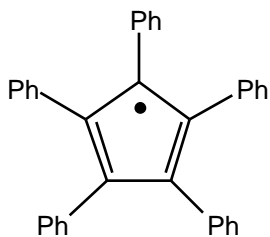
Ziegler, K.; Boye, E. *Ann. Chem.* **1927**, 458, 248



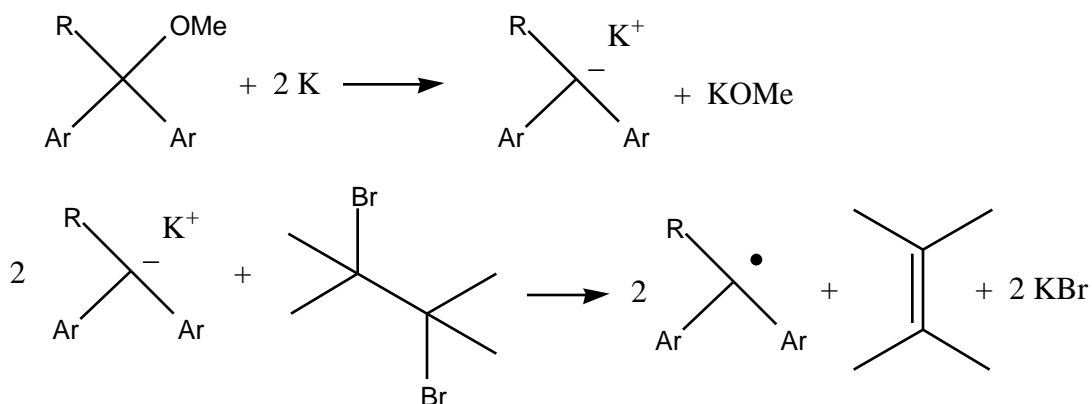
Ziegler, K.; Ochs, C. *Chem. Ber.* **1922**, 55, 2257



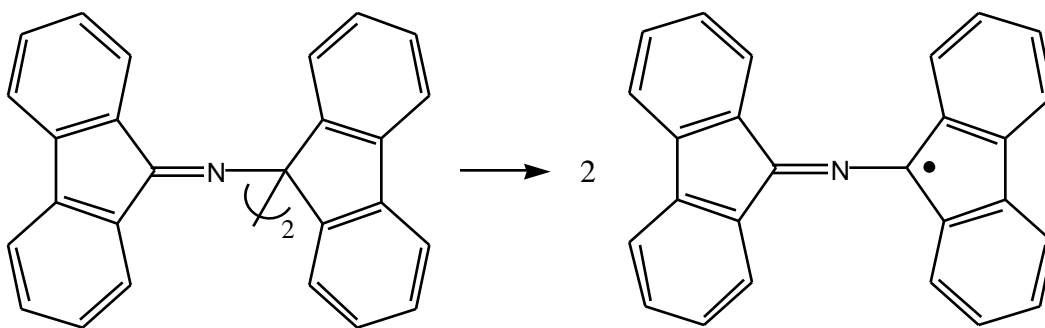
Ziegler, K.; Bremer, G.; Thiel, F.; Thielmann, F. *Ann. Chem.* **1923**, 434, 34



Ziegler, K.; Schnell, B. *Ann. Chem.* **1925**, 445, 266



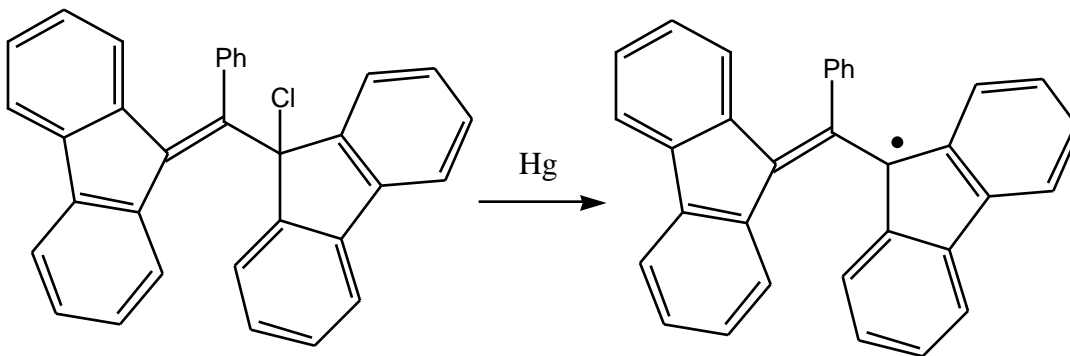
Ziegler, K.; Schnell, B. *Ann. Chem.* **1924**, 437, 227



Goldschmidt, S.; Reickel, L. *Ann. Chem.* **1927**, 456, 152

Kuhn, R. *Angew. Chem. Int. Ed.* **1962**, 1, 602

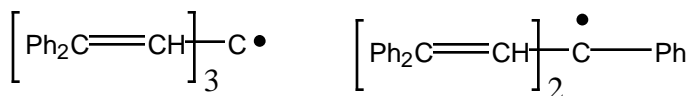
Kuhn, R.; Neugebauer, F.A. *Monatsh. Chem.* **1963**, 94, 16



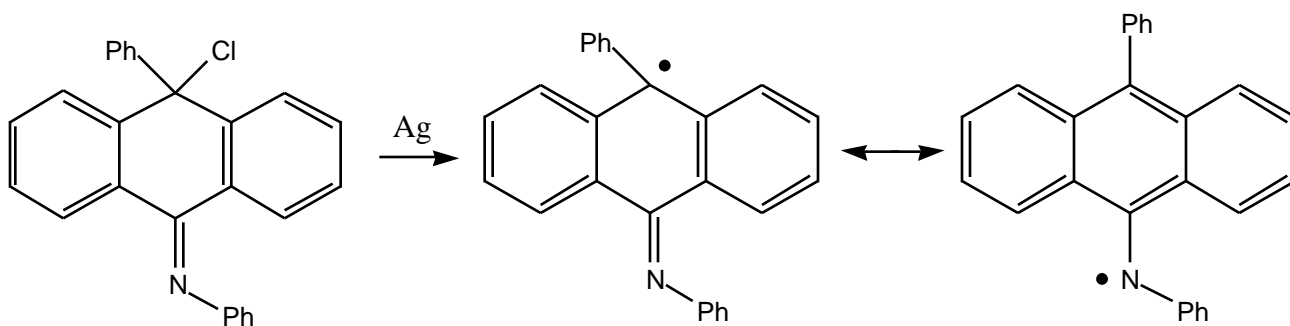
Koelsch, C.F. *J. Am. Chem. Soc.* **1932**, 54, 4744

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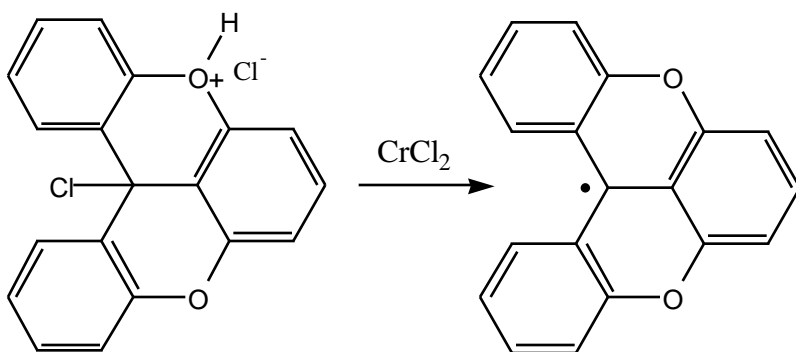
Kuhn, R.; Neugebauer, F.A. *Monatsh. Chem.* **1964**, 95, 3



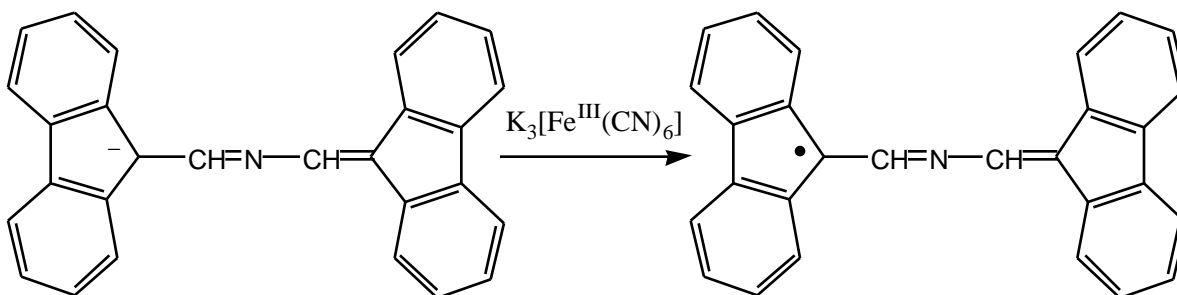
Wittig, G.; Obermann, B. *Chem. Ber.* **1935**, 68, 2214



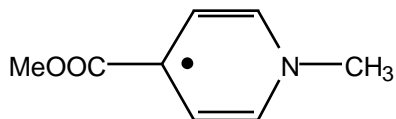
Julian, P.L.; Cole, W.; Schroeder, R. *J. Am. Chem. Soc.* **1949**, 71, 2368



Neuhoeffer, O.; Haase, H. *Chem. Ber.* **1958**, 91, 1801



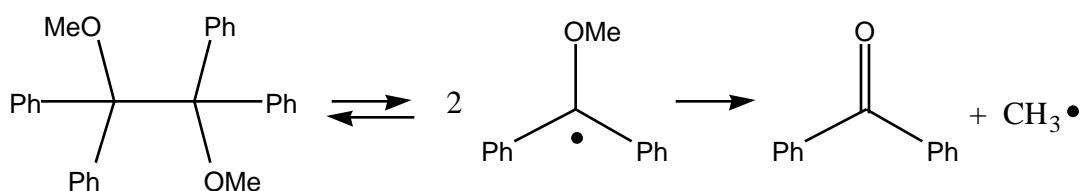
Kuhn, R.; Neugebauer, F.A. *Monatsh. Chem.* **1963**, 94, 1



Kosower, E.M.; Poziomek, E.J. *J. Am. Chem. Soc.* **1963**, 85, 2035

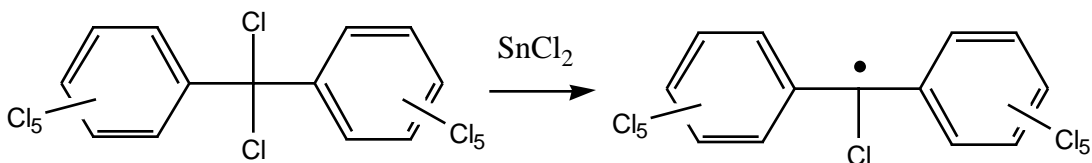
Kosower, E.M.; Poziomek, E.J. *J. Am. Chem. Soc.* **1964**, 86, 5515

Kosower, E.M.; Lindqvist, L. *Tetrahedron Lett.* **1965**, 4481



Hartzell, G.E.; Huyser, E.S. *J. Org. Chem.* **1964**, 29, 3341

Hartzell, G.E.; Bredeweg, C.J.; Loy, B. *J. Org. Chem.* **1965**, 30, 3119

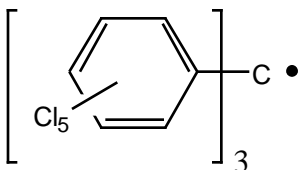


Ballester, M.; Riera, J. *J. Am. Chem. Soc.* **1964**, 86, 4505

Ballester, M.; Boise, M.; Castaner Gargallo, J.; Riera, F.J. ES 311,620, ES 311,621

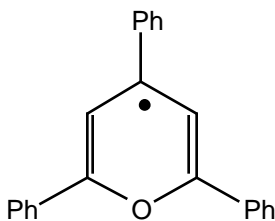
(*Chem. Abs.* **1966**, 64, 3414; **1965**, 63, 17965)

Ballester, M.; Riera, J.; Castaner, J.; Badia, C.; Monso, J.M. *J. Am. Chem. Soc.* **1971**, 93, 2215

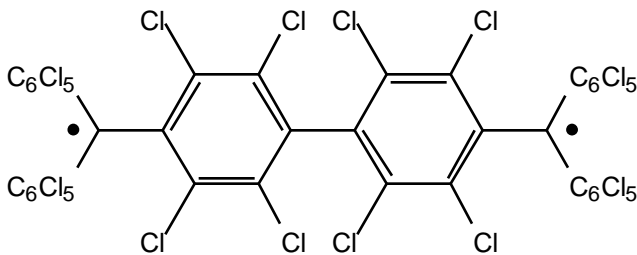


Ballester, M. *Bull. Soc. Chim. Fr.* **1966**, 7

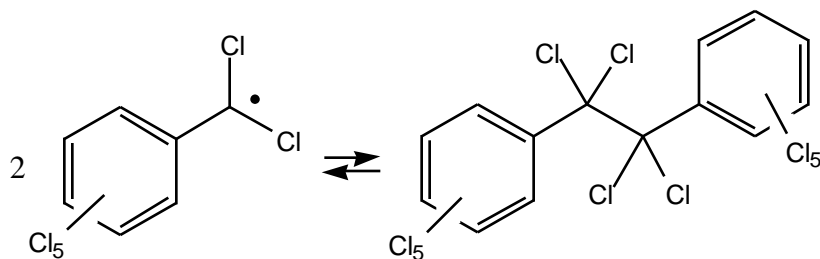
Ballester, M. *Pure Appl. Chem.* **1967**, 15, 123



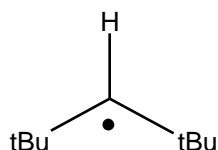
Palchkov, V.A.; Zhdanov, Yu.A.; Dorofeenko, G.N. *Zh. Org. Khim.* **1965**, 1, 1171



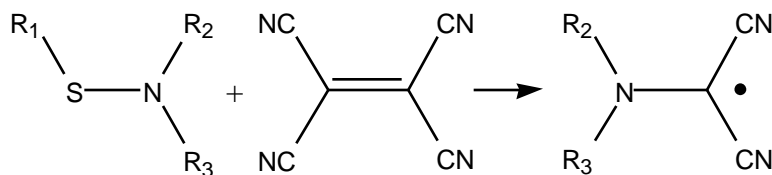
Ballester, M.; Riera, J.; Castaner, J.; Badia, C.; Monso, J.M. *J. Am. Chem. Soc.* **1971**, 93, 2215



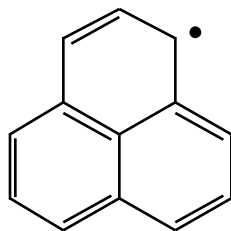
Olivella, S.; Ballester, M.; Castaner, J. *Tetrahedron Lett.* **1974**, 587



Mendenhall, G.D.; Griller, D.; Lindsay, D.; Tidwell, T.T.; Ingold, K.U. *J. Am. Chem. Soc.* **1974**, 96, 2441

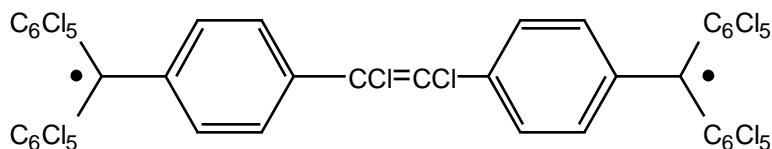


Heimer, N.E. *J. Org. Chem.* **1977**, 42, 3767

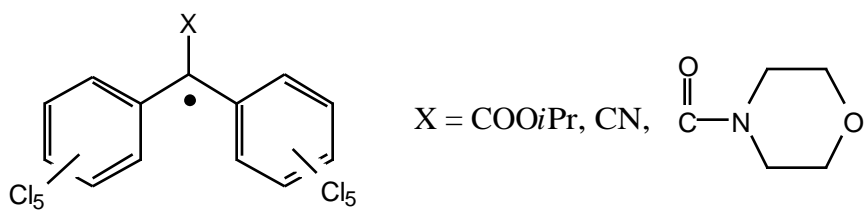


Haddon, R.C.; Wudl, F.; Kaplan, M.L.; Marshall, J.H.; Bramwell, F.B. *Chem. Commun.* **1978**, 429

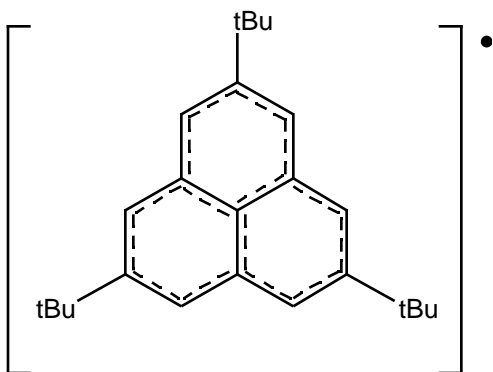
Goto, K.; Kubo, T.; Yamamoto, K.; Nakasuji, K.; Sato, K.; Shiomi, D.; Takui, T.; Kubota, M.; Kobayashi, T.; Katsui, K.; Ouyang, J. *J. Am. Chem. Soc.* **1999**, 121, 1619  
Zheng, S.J.; Lan, J.; Khan, S.I.; Rubin, Y. *J. Am. Chem. Soc.* **2003**, 125, 5786



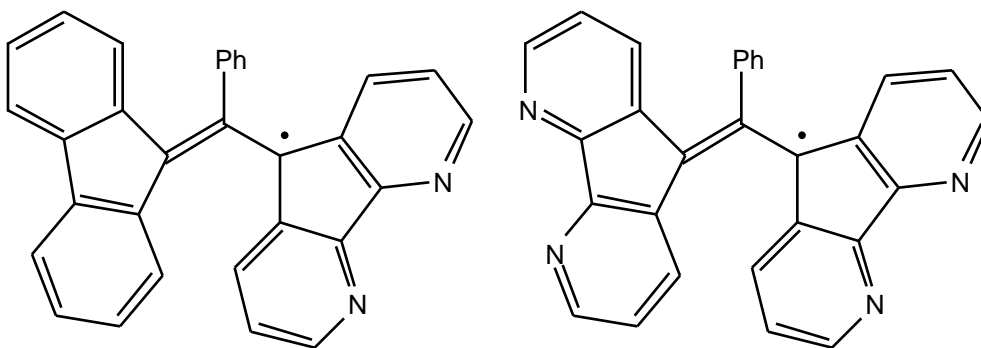
Ballester, M.; Castaner, J.; Riera, J.; Ibanez, A. *Tetrahedron Lett.* **1980**, 21, 2435



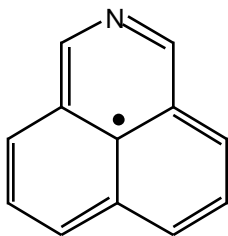
Hegarty, A.F.; O'Neill, P. *Tetrahedron Lett.* **1987**, 28, 901



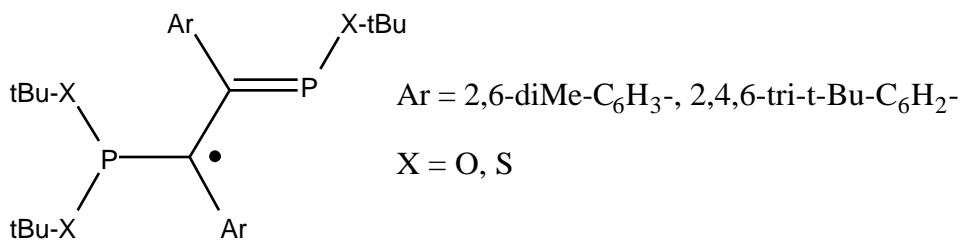
Goto, K.; Kubo, T.; Yamamoto, K.; Nakasuji, K.; Sato, K.; Shiomi, D.; Takui, T.; Kubota, M.; Kobayashi, T.; Yakusi, K.; Ouyang, J. *J. Am. Chem. Soc.* **1999**, 121, 1619



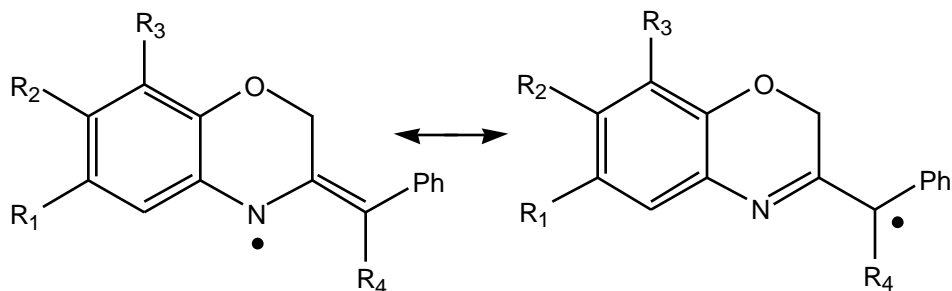
Plater, M.J.; Kemp, S.; Lattmann, E. *J. Chem. Soc. Perkin Trans. 1* **2000**, 971



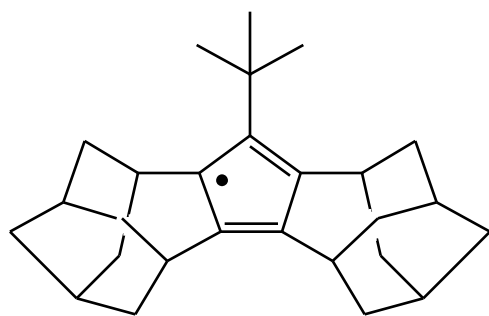
Zheng, S.; Lan, J.; Khan, S.I.; Rubin, Y. *J. Am. Chem. Soc.* **2003**, 125, 5786



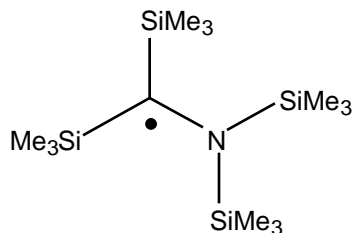
Gigmes, D.; Berchadsky, Y.; Finet, J.P.; Siri, D.; Tordo, P. *J. Phys. Chem. A* **2003**, 107, 9652



Alajarin, M.; Vidal, A.; Ortin, M.M.; Bautista, D. *Synlett* **2004**, 991



Kitagawa, T.; Ogawa, K.; Komatsu, K. *J. Am. Chem. Soc.* **2004**, 126, 9930

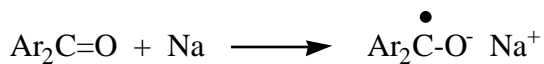


 Brunton, G.; Taylor, J.F.; Ingold, K.U. *J. Am. Chem. Soc.* **1976**, 98, 4879

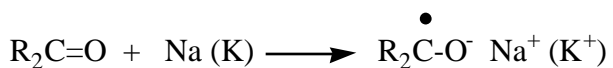
**(ii) Radicals (aryl)**

No stable analogues observed to date.

**(iii) Radicals (ketyl)**



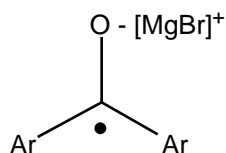
Beckmann, E.; Paul, T. *Ann. Chem.* **1891**, 266, 1



R = Ph, Ar

Schlenk, W.; Weichel, T. *Chem. Ber.* **1911**, 44, 1182

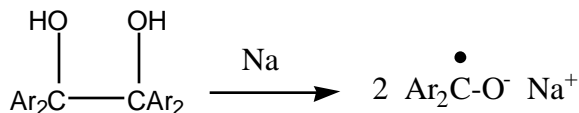
Schlenk, W.; Thal, A. *Chem. Ber.* **1913**, 46, 2840



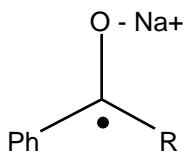
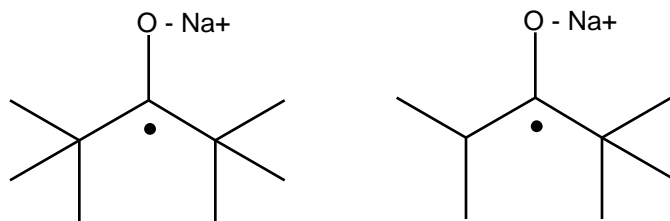
Gomberg, M.; Bachmann, W.E. *J. Am. Chem. Soc.* **1927**, 49, 236

Bachmann, W.E. *J. Am. Chem. Soc.* **1931**, 53, 2758

Bachmann, W.E. *J. Am. Chem. Soc.* **1933**, 55, 770

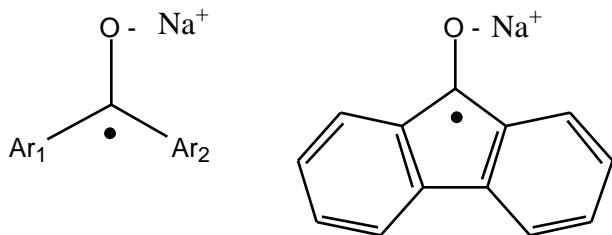


Bachmann, W.E. *J. Am. Chem. Soc.* **1933**, 55, 355



R = Me, Et, Pr, iPr, Et<sub>2</sub>CH, tBu, Me<sub>2</sub>EtC, MeEt<sub>2</sub>C

Nazarov, N. *Compt. Rend. Acad. Sci. URSS* **1934**, 1, 325

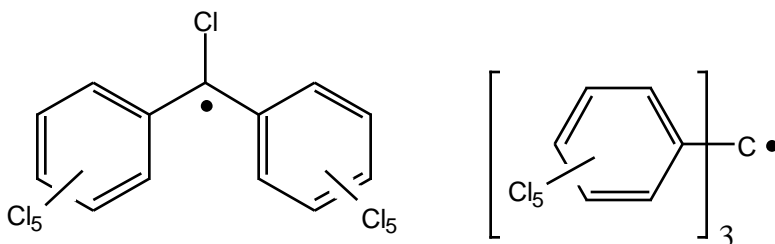


Mathias, A.; Warhurst, E. *Trans. Faraday Soc.* **1962**, 58, 948

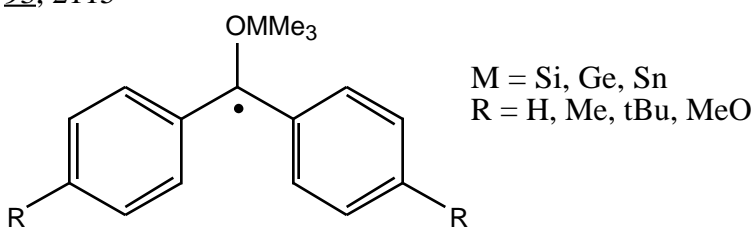
Hirota, N.; Weissman, S.I. *J. Am. Chem. Soc.* **1964**, 86, 2538

Hirota, N. *J. Am. Chem. Soc.* **1967**, 89, 32

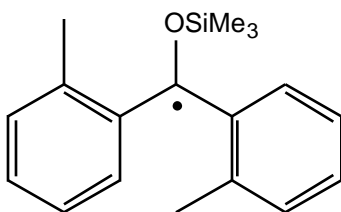
Carter, H.V.; McClelland, B.J.; Warhurst, E. *Trans. Faraday Soc.* **1960**, 56, 455



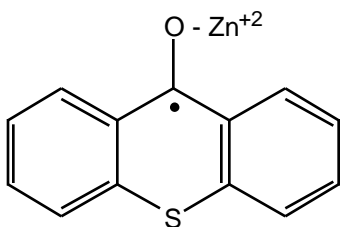
Ballester, M.; Riera, J.; Castafier, J.; Badfa, C.; Monso, J.M. *J. Am. Chem. Soc.* **1971**, 93, 2115



Neumann, W.P.; Schroeder, B.; Ziebarth, M. *Ann. Chem.* **1975**, 2279

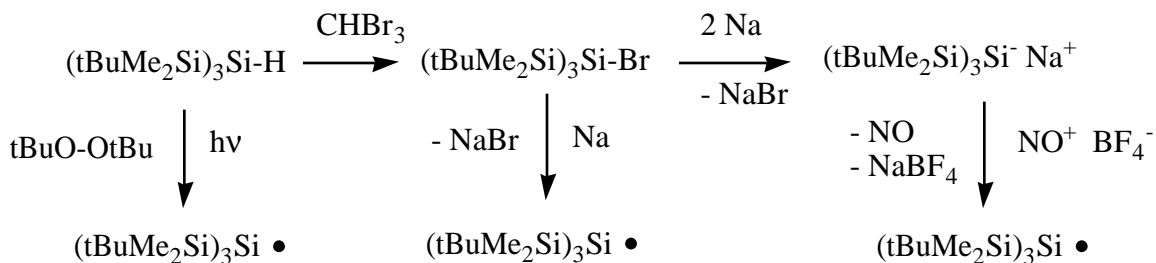


Ziebarth, M.; Neumann, W.P. *Ann. Chem.* **1978**, 1765

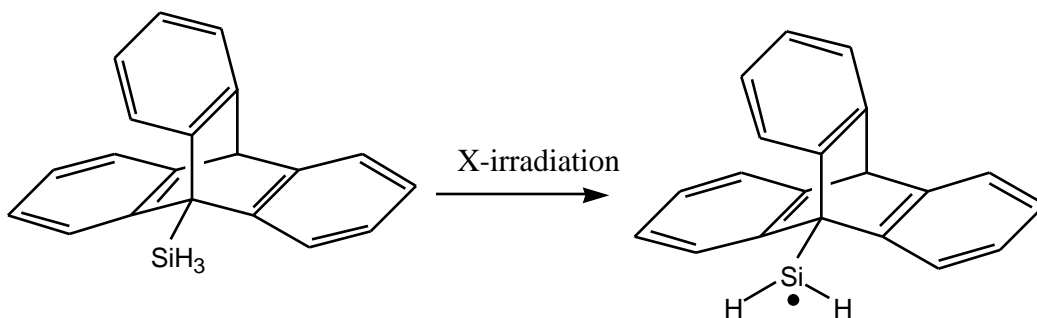


Castrillon, J. *J. Chem. Educ.* **1987**, 64, 352

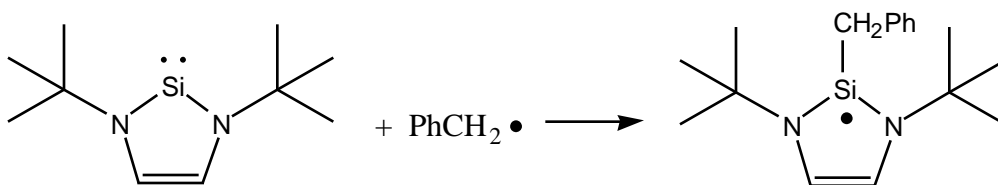
#### (iv) Radicals (silyl)



Kira, M.; Obata, T.; Kon, I.; Hashimoto, H.; Ichinohe, M.; Sakurai, H.; Kyushin, S.; Matsumoto, H. *Chem. Lett.* **1998**, 1097

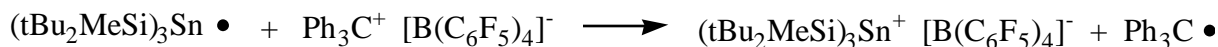


Brynda, M.; Bernardinelli, G.; Dutan, C.; Geoffroy, M. *Inorg. Chem.* **2003**, 42, 6586



Tumanskii, B.; Pine, P.; Apeloig, Y.; Hill, N.J.; West, R. *J. Am. Chem. Soc.* **2004**, 126, 7786

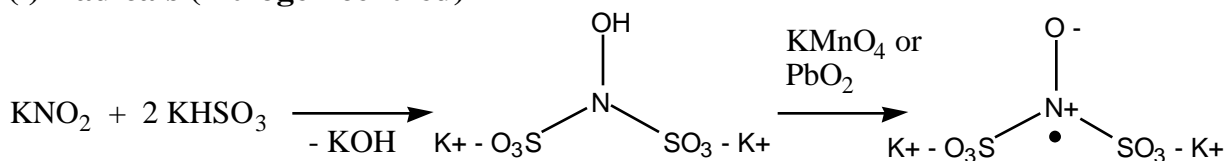
### (v) Radicals (stannyl)



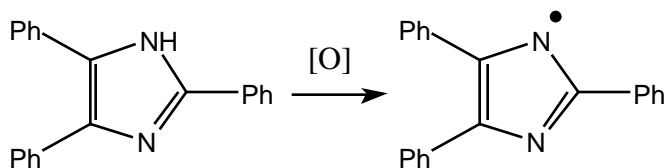
Sekiguchi, A.; Fukawa, T.; Lee, V.Y.; Nakamoto, M. *J. Am. Chem. Soc.* **2003**, 125, 9250

### Radicals (Group V centred - nitrogen and phosphorus)

#### (i) Radicals (nitrogen centred)

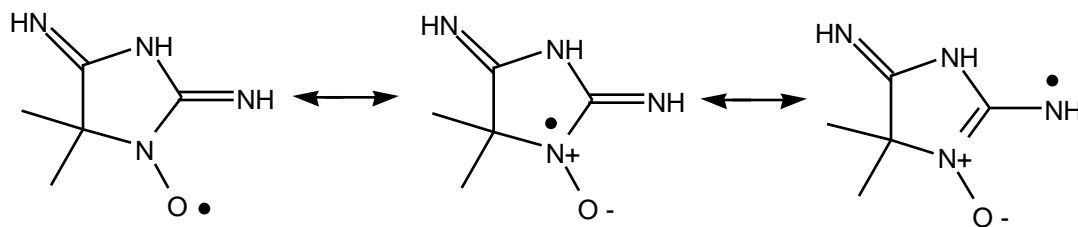


Fremy, E. *Ann. Chim. Phys.* **1845**, 15[3], 408

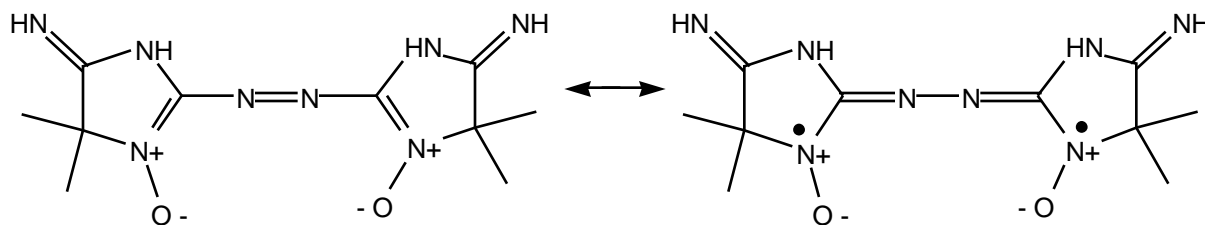


Radziszewski, B. *Chem. Ber.* **1877**, 10, 70; 321

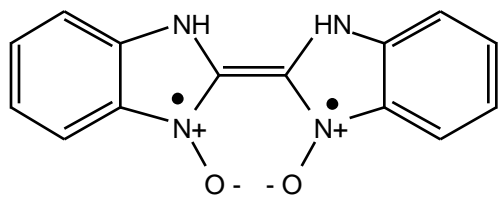
Kautsky, H.; Kaiser, K.H. *Naturwiss.* **1943**, 31, 505



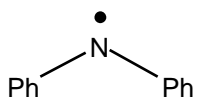
Piloty, O.; Schwerin, B.G. *Chem. Ber.* **1901**, 34, 1870; 2354



Piloty, O.; Vogel, W. *Chem. Ber.* **1907**, 36, 1283



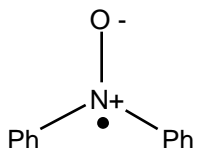
Niementowski, S. *Chem. Ber.* **1910**, 43, 3012



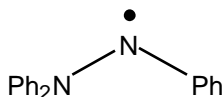
Wieland, H. *Ann. Chem.* **1911**, 381, 200

Wieland, H.; Lecher, H. *Ann. Chem.* **1911**, 381, 206

Wieland, H. *Chem. Ber.* **1915**, 48, 1078

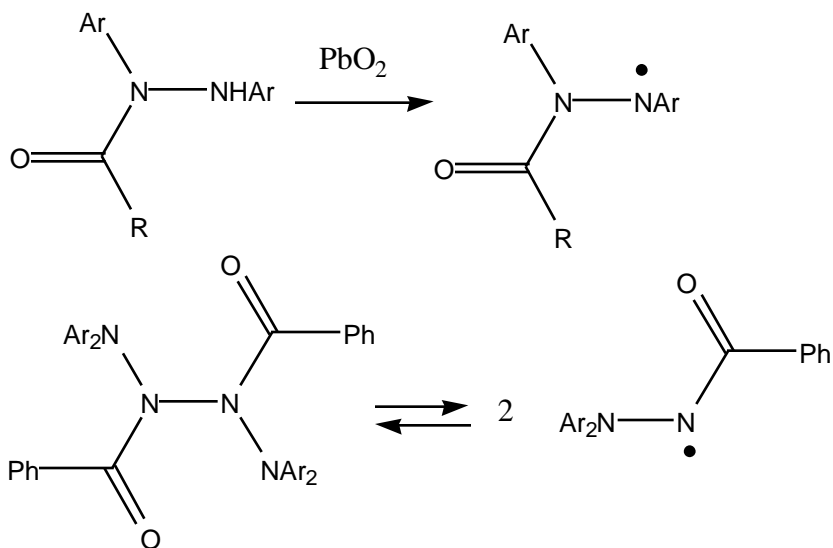


Wieland, H.; Offenbächer, M. *Chem. Ber.* **1914**, 47, 2111



Goldschmidt, S. *Chem. Ber.* **1920**, 53, 44

Goldschmidt, S.; Bader, J. *Ann. Chem.* **1929**, 473, 137

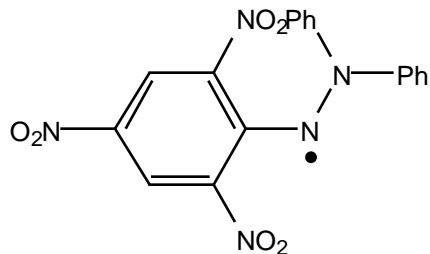


Goldschmidt, S.; Euler, K. *Chem. Ber.* **1922**, 55, 616

Goldschmidt, S.; Wolf, A.; Wolffhardt, E.; Drimmer, I.; Nathan, S. *Ann. Chem.* **1924**, 437, 194

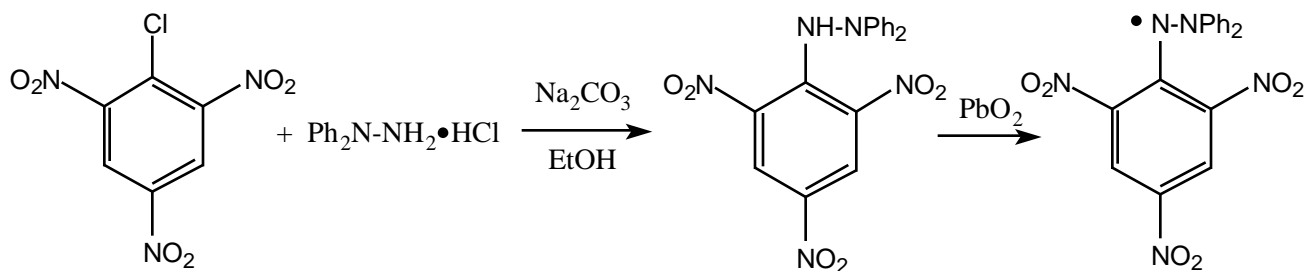
Goldschmidt, S.; Bader, J. *Ann. Chem.* **1929**, 473, 137

Wilmarth, W.K.; Schwartz, N. *J. Am. Chem. Soc.* **1955**, 77, 4543; 4551

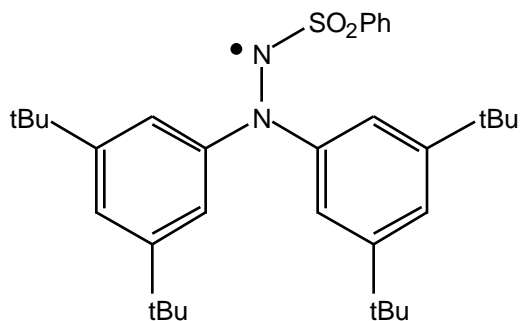


Goldschmidt, S.; Renn, K. *Chem. Ber.* **1922**, 55, 628

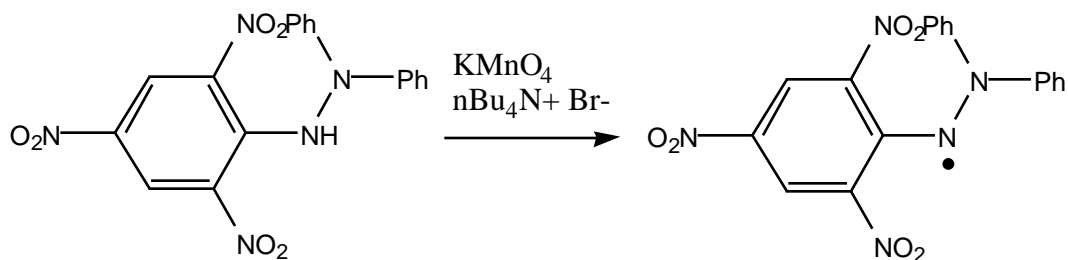
Goldschmidt, S.; Graef, F. *Chem. Ber.* **1928**, 61, 1858



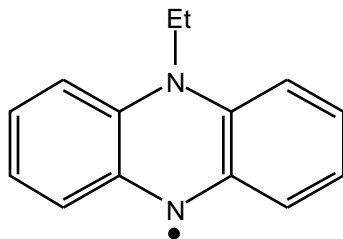
Poirier, R.H.; Kahler, E.J.; Benington, F. *J. Org. Chem.* **1952**, 17, 1437



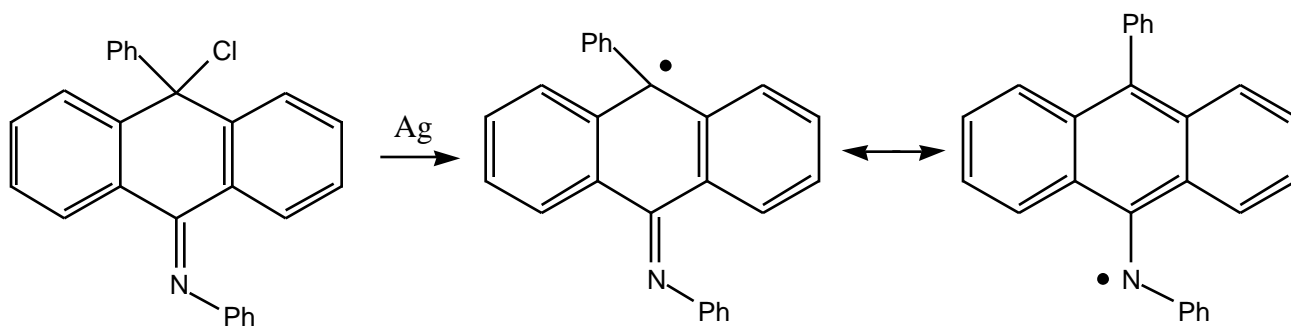
Balaban, A.T.; Caproiu, M.T.; Negoita, N.; Baicau, R. *Tetrahedron* **1977**, 33, 2249



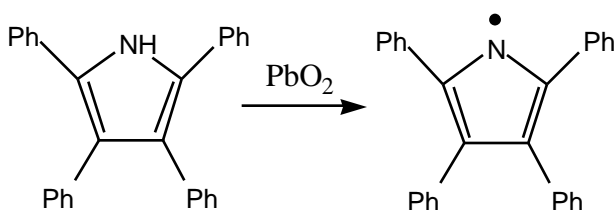
🇨🇦 Brown, K.C.; Weil, J.A. *Can. J. Chem.* **1986**, 64, 1836



McIlwain, H. *J. Chem. Soc.* **1937**, 1704



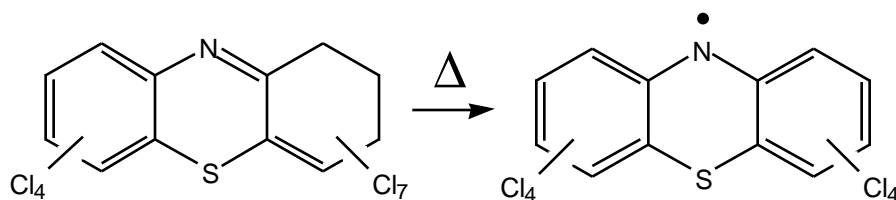
Julian, P.L.; Cole, W.; Schroeder, R. *J. Am. Chem. Soc.* **1949**, 71, 2368



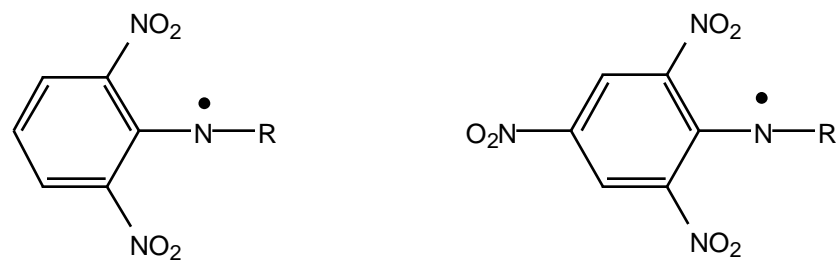
Kuhn, R.; Kainer, H. *Biochim. Biophys. Acta* **1953**, 12, 325

Zimmermann, H.; Baumgärtel, H.; Bakke, F. *Angew. Chem.* **1961**, 72, 808

Schliffarth, K.; Zimmermann, H. *Chem. Ber.* **1965**, 98, 3124



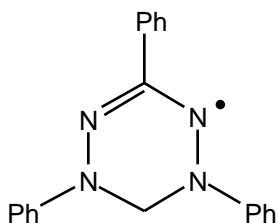
Bodea, C.; Silberg, I. *Nature* **1963**, 198, 883



R = pMe<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>, pMeOC<sub>6</sub>H<sub>4</sub>

R = Ph<sub>2</sub>NC<sub>6</sub>H<sub>4</sub>, 3,4-(MeO)<sub>2</sub>C<sub>6</sub>H<sub>3</sub>

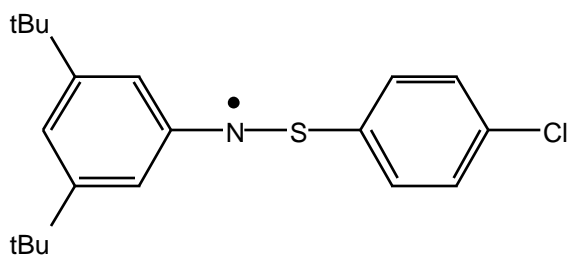
Balaban, A.T.; Frangapol, P.T.; Frangapol, N.; Negoits, N. *Tetrahedron* **1967**, 23, 1661



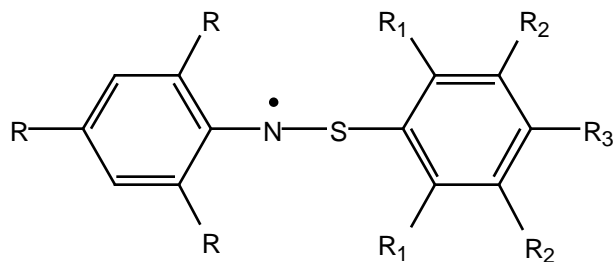
Miura, Y.; Morimoto, Y.; Kinoshita, M. *Bull. Chem. Soc. Jpn* **1975**, 48, 3765

Miura, Y.; Morimoto, Y.; Kinoshita, M. *Chem. Lett.* **1975**, 19

Miura, Y.; Morimoto, Y.; Kinoshita, M. *Bull. Chem. Soc. Jpn* **1976**, 49, 1715



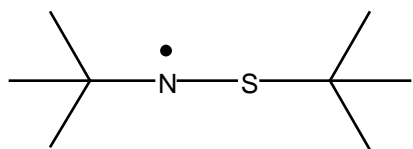
Miura, Y.; Katsura, Y.; Kinoshita, M. *Chem. Lett.* **1977**, 409



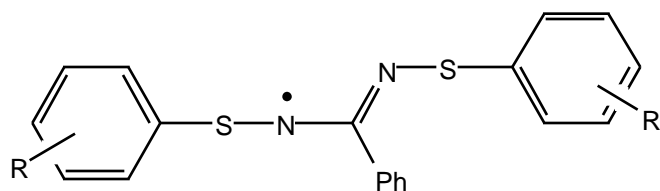
R = Me, OMe, iPr, tBu

R<sub>1</sub> = H, Me; R<sub>2</sub> = H, Cl; R<sub>3</sub> = H, Cl, Me, NO<sub>2</sub>

Miura, Y.; Katsura, Y.; Kinoshita, M. *Bull. Chem. Soc. Jpn* **1979**, 52, 1121

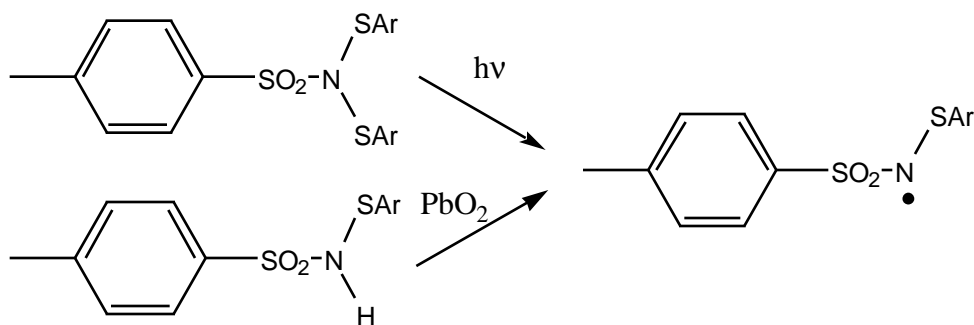


Miura, Y.; Asada, H.; Kinoshita, M.; Ohta, K. *J. Phys. Chem.* **1983**, 87, 3450



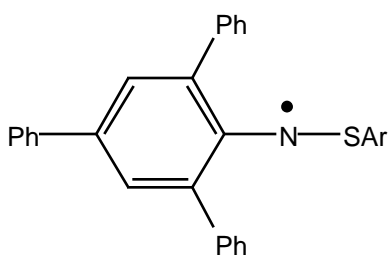
Miura, Y.; Kunishi, T.; Kinoshita, M. *Chem. Lett.* **1983**, 885

Miura, Y.; Kunishi, T.; Isogai, M.; Kinoshita, M. *J. Org. Chem.* **1985**, 50, 1627

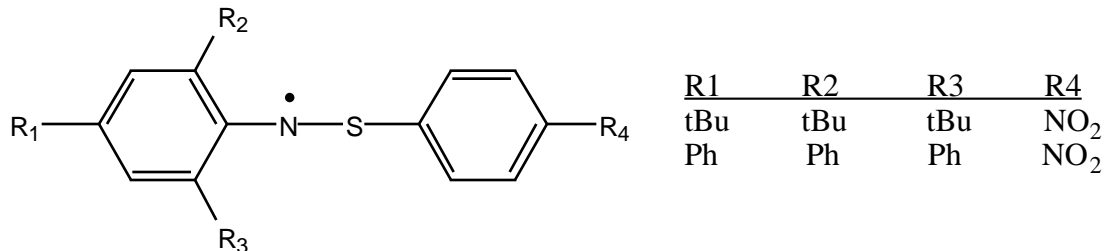


Miura, Y.; Kunishi, T.; Kinoshita, M. *J. Org. Chem.* **1985**, 50, 5862

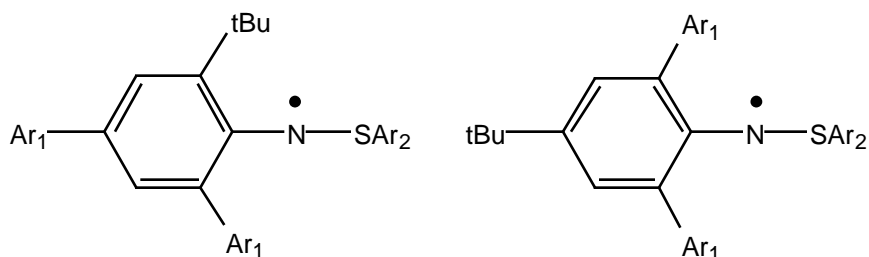
Miura, Y.; Kunishi, T.; Kinoshita, M. *Bull. Chem. Soc. Jpn.* **1985**, 58, 1696



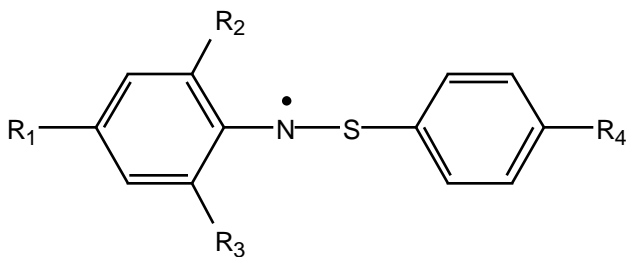
Miura, Y.; Tanaka, A.; Hirotsu, K. *J. Org. Chem.* **1991**, 56, 6638



Miura, Y.; Tanaka, A. *Electrochim. Acta* **1992**, 37, 2095

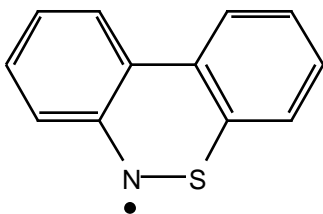


Miura, Y.; Momoki, M.; Fuchikami, T.; Teki, Y.; Itoh, K.; Mizutani, H. *J. Org. Chem.* **1996**, 61, 4300

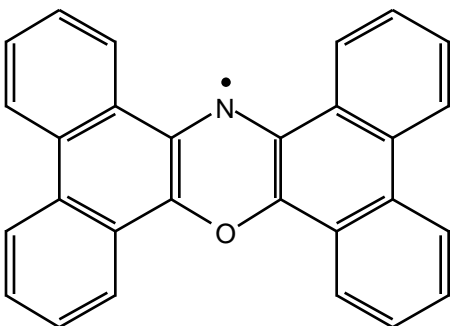


R1	R2	R3	R4
tBu	Ph	Ph	NO <sub>2</sub>
tBu	Ph	Ph	H
Ph	tBu	Ph	NO <sub>2</sub>
Ph	tBu	Ph	H
p-ClPh	tBu	p-ClPh	H
p-ClPh	tBu	p-ClPh	NO <sub>2</sub>
p-FPh	tBu	p-FPh	H
tBu	p-ClPh	p-ClPh	H
tBu	p-FPh	p-FPh	H
tBu	p-ClPh	p-ClPh	NO <sub>2</sub>
tBu	p-FPh	p-FPh	NO <sub>2</sub>

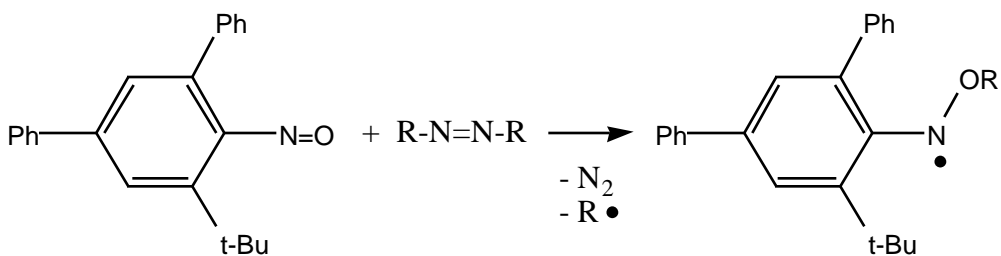
Miura, Y.; Momoki, M.; Fuchikami, T.; Mitzutani, H.; Teki, Y.; Itoh, K. *Molecular Crystals Liquid Crystals Sect. A* **1997**, 306, 271



Benin, V.; Kaszynski, P. *J. Org. Chem.* **2000**, 65, 8348

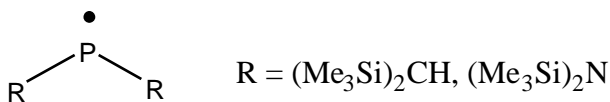


Jeromin, G.E. *Tetrahedron Lett.* **2001**, 42, 1863



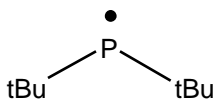
Miura, Y.; Muranaka, Y. *Chem. Lett.* **2005**, 34, 480

**(ii) Radicals (phosphorus centred)**

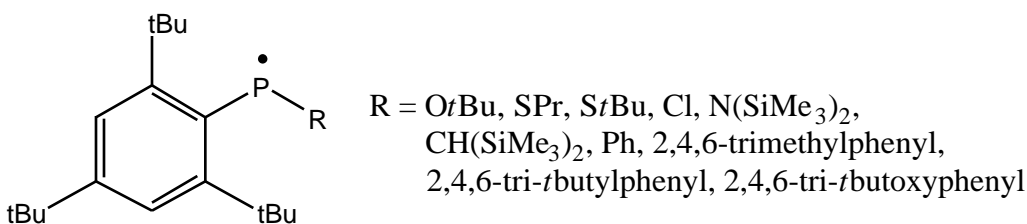


Gynane, M.J.S.; Hudson, A.; Lappert, M.F.; Power, P.P.; Goldwhite, H. *Chem. Commun.* **1976**, 623

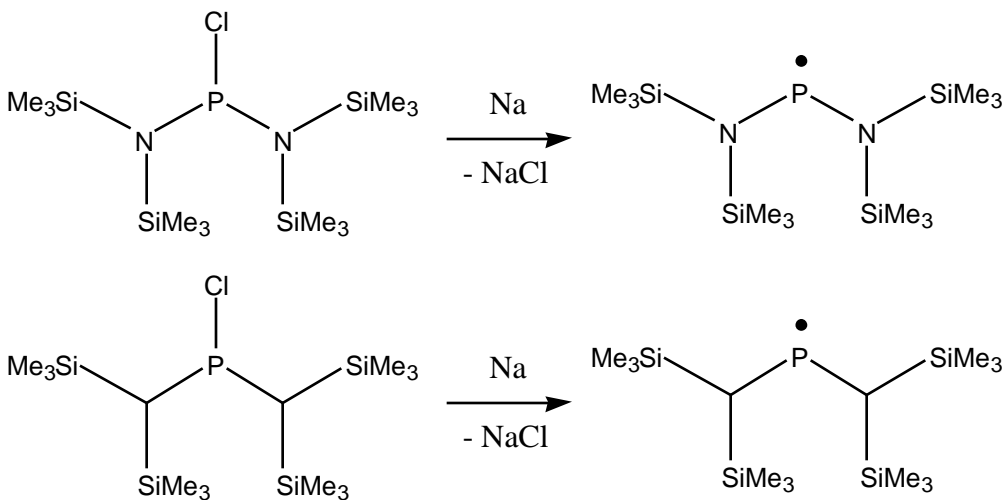
Gynane, M.J.S.; Hudson, A.; Lappert, M.F.; Power, P.P.; Goldwhite, H. *J. Chem. Soc. Dalton Trans.* **1980**, 2428



Dombek, B.D. *J. Org. Chem.* **1978**, 43, 3408



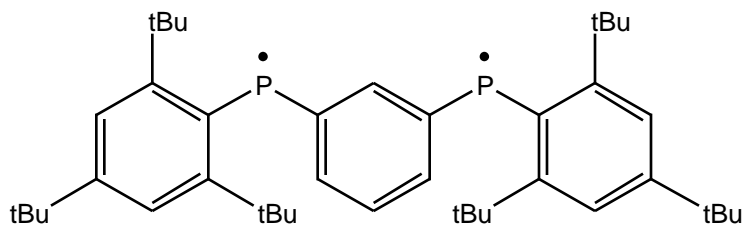
Cetinkaya, B.; Hudson, A.; Lappert, M.F.; Goldwhite, H. *Chem. Commun.* **1982**, 609



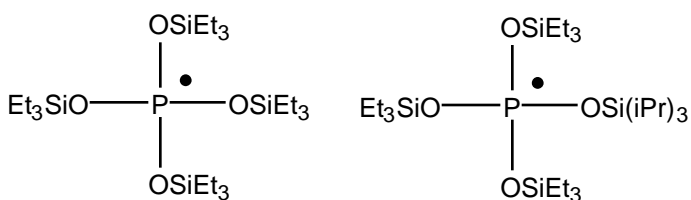
Gynane, M.J.S.; Hudson, A.; Lappert, M.F.; Power, P.P. *Chem. Commun.* **1976**, 623

Gynane, M.J.S.; Hudson, A.; Lappert, M.F.; Power, P.P.; Goldwhite, H. *J. Chem. Soc. Dalton Trans.* **1980**, 2428

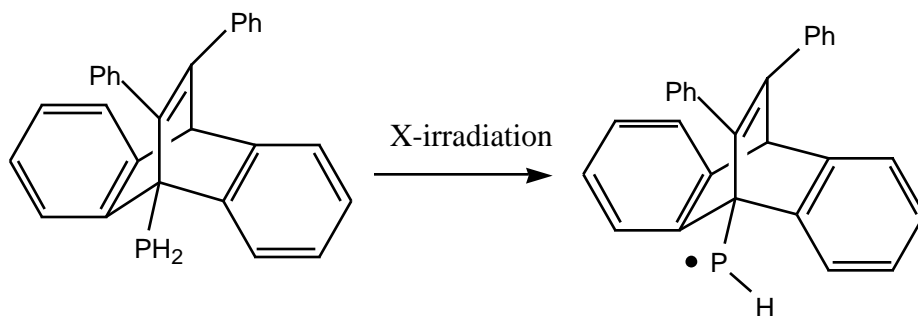
Cowley, A.H.; Kemp, R.A. *Inorg. Chem.* **1983**, 22, 547



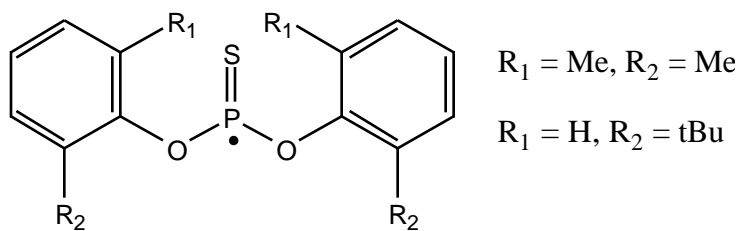
Wienk, M.M.; Janssen, R.A.J. *Chem. Commun.* **1996**, 1919 (triplet bisphosphinyl radical)



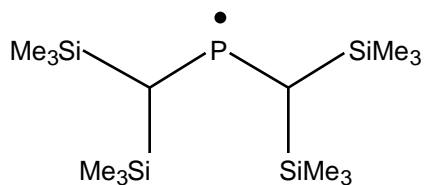
Marque, S.; Berchadsky, Y.; Bertrand, P.; Fournel, A.; Tordo, P.; Lang, K.; Moussavi, M.; Belorizky, E. *J. Phys. Chem. A* **1997**, 101, 5640



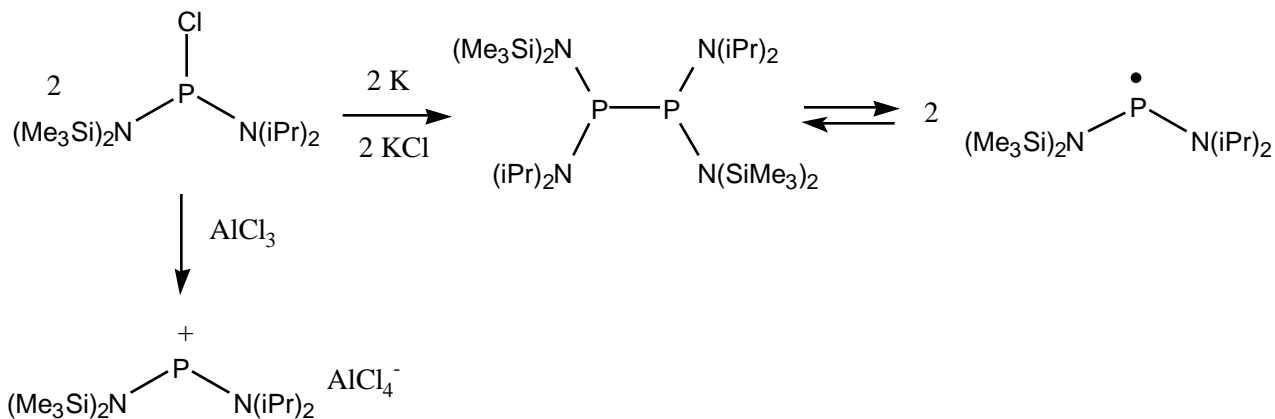
Brynda, M.; Berclaz, T.; Geoffroy, M.; Ramakrishnan, G. *J. Phys. Chem. A* **1998**, 102, 8245



Odabasoglu, M.; Tapramaz, R.; Gumrukcuoglu, I.E. *Phosphorus, Sulfur, Silicon, and Related Elements* **2000**, 158, 57



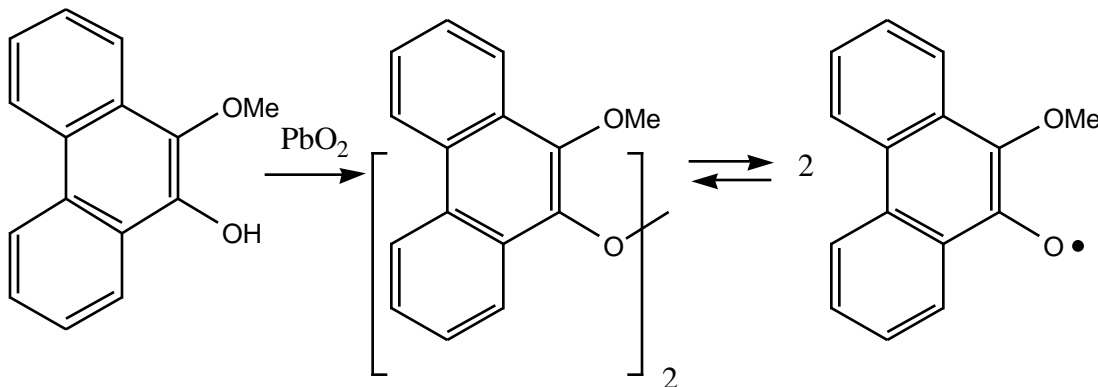
Hinchley, S.L.; Morrison, C.A.; Rankin, D.W.H.; Macdonald, C.L.B.; Wiacek, R.J.; Cowley, A.H.; Lappert, M.F.; Gundersen, G.; Clyburne, J.A.C.; Power, P.P. *Chem. Commun.* **2000**, 2045



Bezombes, J.P.; Borisenko, K.B.; Hitchcock, P.B.; Lappert, M.F.; Nycz, J.E.; Rankin, D.W.H.; Robertson, H.E. *J. Chem. Soc. Dalton Trans.* **2004**, 1980

## Radicals (Group VI centred - oxygen, sulfur, selenium)

### (i) Radicals (oxygen centred)

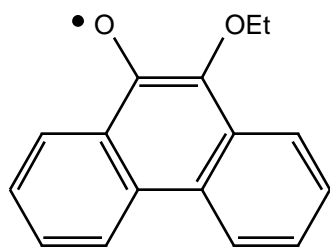


Pummerer, R.; Frankfurter, F. *Chem. Ber.* **1914**, 47, 1472

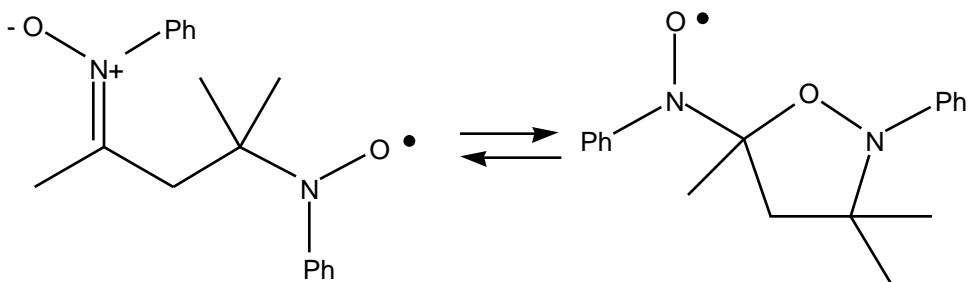
Pummerer, R.; Cherbuliez, E. *Chem. Ber.* **1914**, 47, 2957

Pummerer, R.; Frankfurter, F. *Chem. Ber.* **1919**, 52, 1416

Goldschmidt, S.; Schmidt, W. *Chem. Ber.* **1922**, 55, 3197

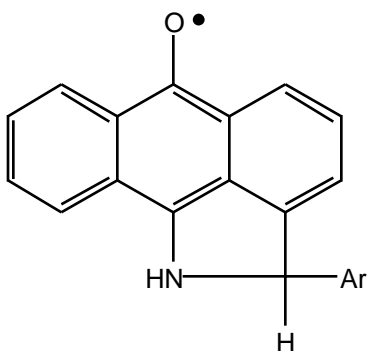


Goldschmidt, S.; Vogt, A.; Bredig, M.A. *Ann. Chem.* **1925**, 445, 123

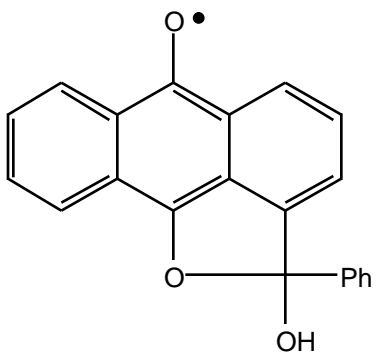


Banfield, F.H.; Kenyon, J. *J. Chem. Soc.* **1926**, 1612

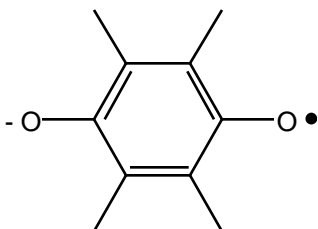
Baldry, P.J.; Forrester, A.R.; Thomson, R.H. *J. Chem. Soc. Perkin Trans. 2* **1976**, 76



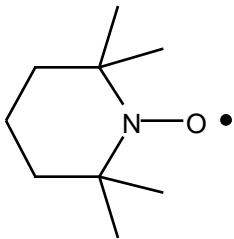
Scholl, R.; Böttger, O. *Chem. Ber.* **1931**, 64, 1878



Fieser, L.F.; Young, W.Y. *J. Am. Chem. Soc.* **1932**, 54, 4095



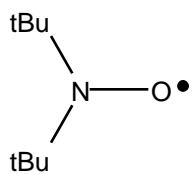
Michaelis, L.; Schubert, M.P.; Reber, R.K.; Kuck, J.A.; Granick, S. *J. Am. Chem. Soc.* **1938**, 60, 1678



Lebedev, O.L.; Kazarnovskii, S.N. *Papers on Chemistry and Chemical Technology*, Gorky, 1959, p. 649

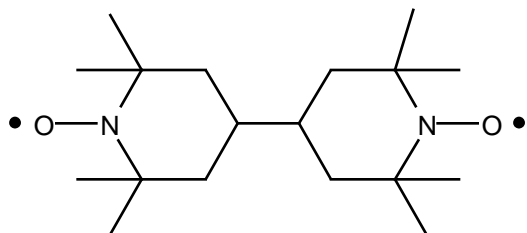
Il'yasov, A.V. *Zh. Strukt. Khim.* **1962**, 3, 95

Garif'yasov, I.S.; Il'yasov, A.V.; Yablokov, Yu. V. *Dokl. Akad. Nauk SSSR* **1963**, 149, 876

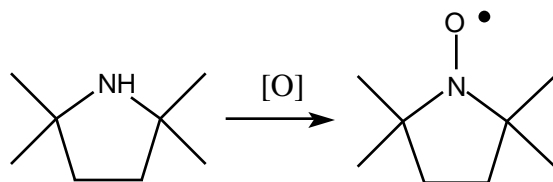


Hoffmann, A.K.; Henderson, A.T. *J. Am. Chem. Soc.* **1961**, 83, 4671

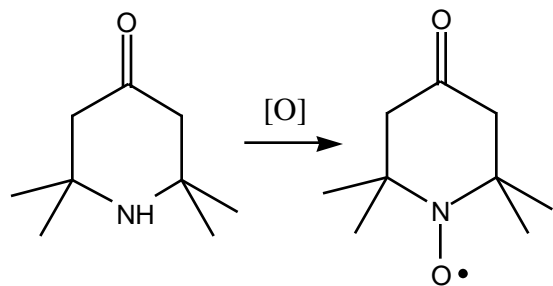
Hoffmann, A.K.; Hodgson, W. *J. Am. Chem. Soc.* **1961**, 83, 4675



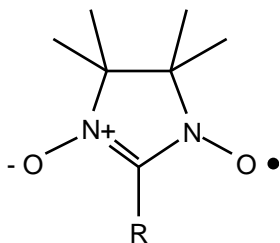
Rozantsev, E.G.; Golubev, V.A.; Neiman, M.B. *Izv. Akad. Nauk SSSR, Ser. Khim.* **1965**, 393



Rozantsev, E.G. *Usp. Khim.* **1966**, 35, 1549

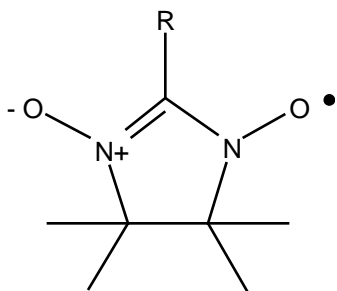


Rozantsev, E.G. *Izv. Akad. Nauk SSSR, Ser. Khim.* **1966**, 770

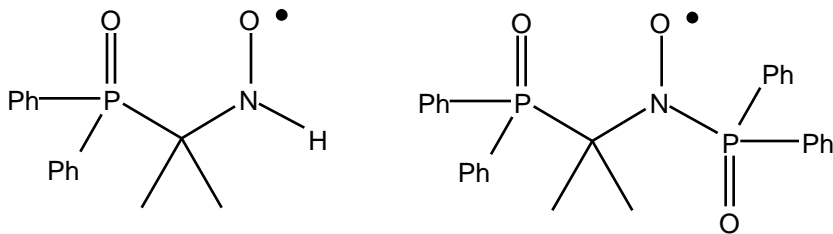


Rozantsev, E.G.; Sholle, V.D. *Synthesis* **1971**, 190

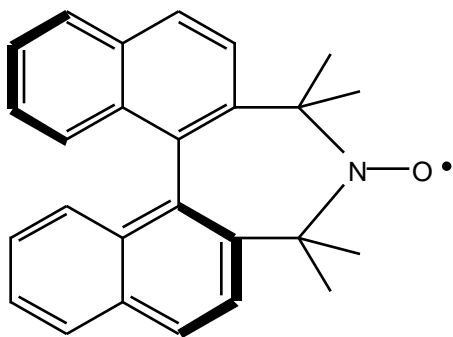
Rozantsev, E.G.; Sholle, V.D. *Synthesis* **1971**, 401



Ullman, E.F.; Osiecki, J.H.; Boocock, D.G.B.; Darcy, R. *J. Am. Chem. Soc.* **1972**, 94, 7049

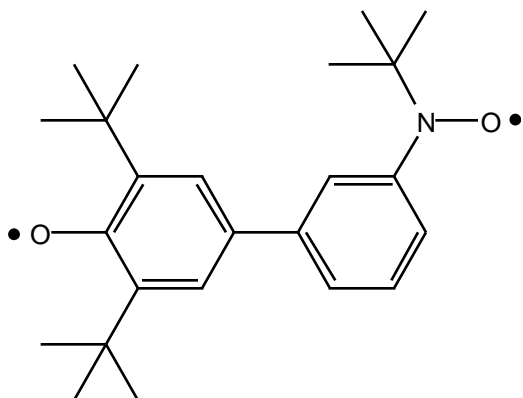


Alberti, A.; Hudson, A. *J. Chem. Soc. Faraday Trans.* **1990**, 86, 3207

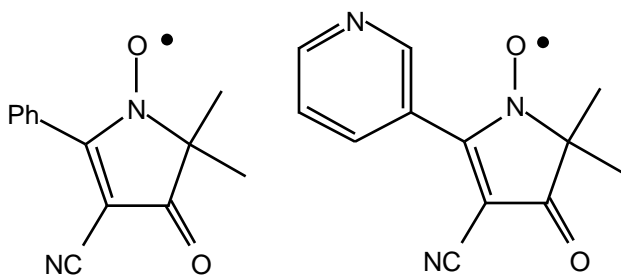


Rychnovsky, S.D.; McLernon, T.L.; Rajapakse, H. *J. Org. Chem.* **1996**, 61, 1194  
(Rychnovsky TEMPO catalyst)

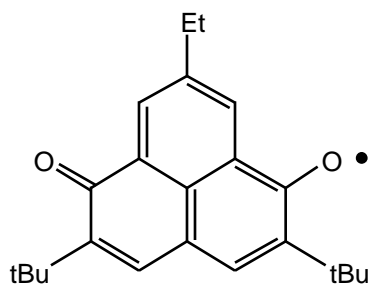
Rychnovsky, S.D.; Vaidyanathan, R. *J. Org. Chem.* **1999**, 64, 310



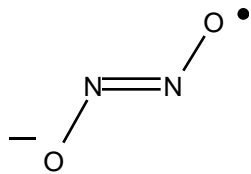
Liao, Y.; Xie, C.; Lahti, P.M.; Weber, R.T.; Jiang, J.; Barr, D.P. *J. Org. Chem.* **1999**, 64, 5176



Reznikov, V.A.; Ovcharenko, I.V.; Pervukhina, N.V.; Ikorskii, V.N.; Grand, A.; Ovcharenko, V.I. *Chem. Commun.* **1999**, 539



Morita, Y.; Ohba, T.; Haneda, N.; Maki, S.; Kawai, J.; Hatanaka, K.; Sato, K.; Shiomi, D.; Takui, T.; Nakasuji, K. *J. Am. Chem. Soc.* **2000**, 122, 4825

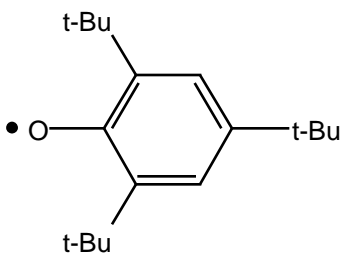


Poskrebyshv, G.A.; Shafirovich, V.; Lyman, S.V. *J. Am. Chem. Soc.* **2004**, 126, 891 (hyponitrite radical)

### (ii) Radicals (acetoxy)

No stable analogues observed to date.

### (iii) Radicals (phenoxy)



Müller, E.; Ley, K. *Z. Naturforsch.* **1953**, 8B, 694

Müller, E.; Ley, K. *Chem. Ber.* **1954**, 87, 922

Müller, E.; Ley, K.; Kiedaisch, W. *Chem. Ber.* **1954**, 87, 1605

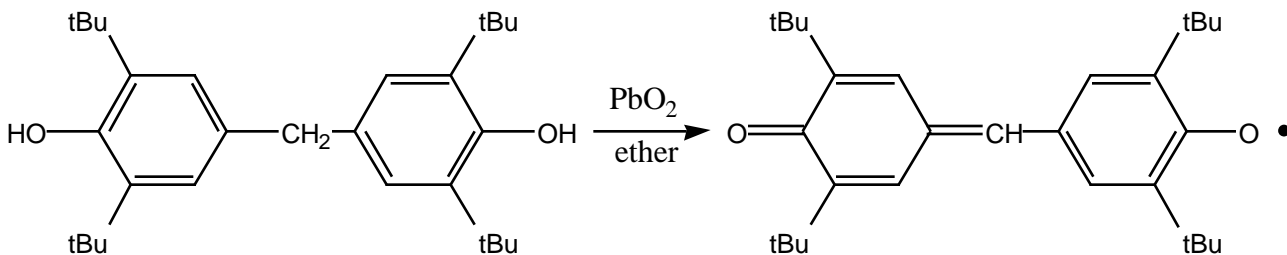
Müller, E.; Ley, K. *Chem. Ber.* **1955**, 88, 601

Cook, C.D. *J. Am. Chem. Soc.* **1953**, 18, 261

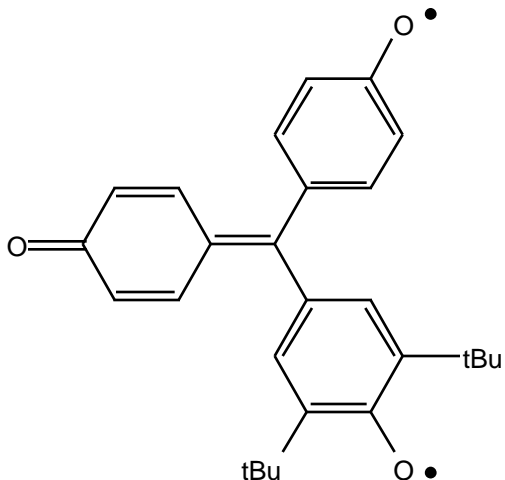
Cook, C.D.; Kuhn, D.A.; Fianu, P. *J. Am. Chem. Soc.* **1956**, 78, 2002

Blanchard, H.S. *J. Org. Chem.* **1960**, 25, 264

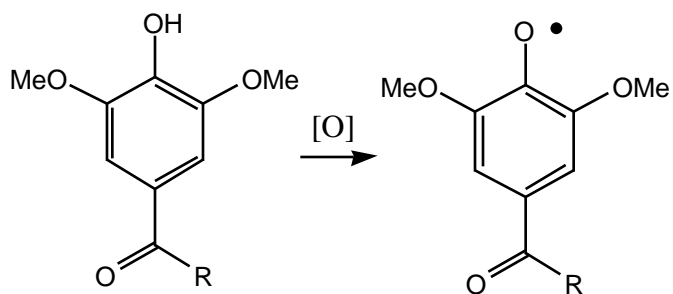
Altwicker, E.R. *Chem. Rev.* **1967**, 67, 475



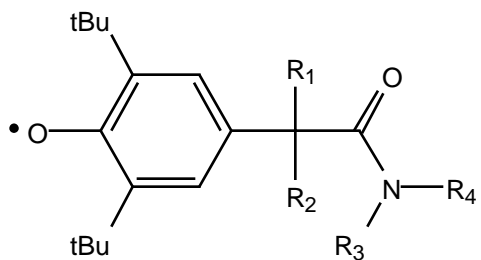
Coppinger, G.M. *J. Am. Chem. Soc.* **1957**, 79, 501



Yang, N.; Kastro, A. *J. Am. Chem. Soc.* **1960**, 82, 6208



Steelink, C. *J. Am. Chem. Soc.* **1965**, 87, 2056 (stable phenoxy radicals in lignin)

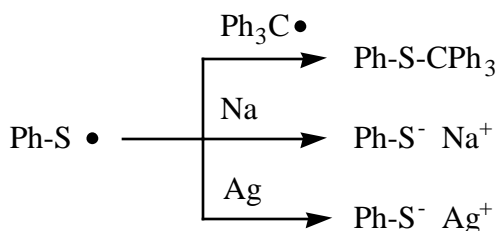


Lai, J.T. *Tetrahedron Lett.* **2001**, 42, 557

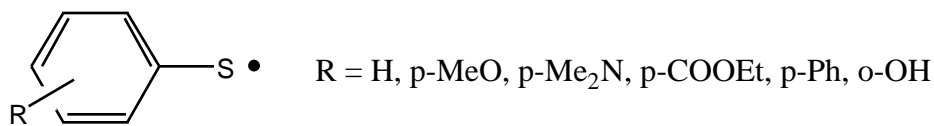
**(iv) Radicals (peroxy)**

No stable analogues observed to date.

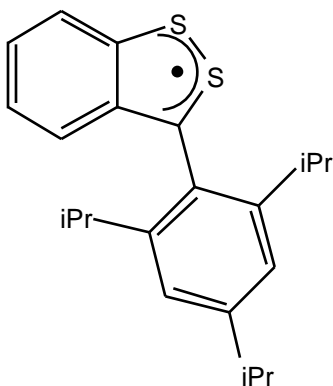
**(v) Radicals (sulfur centred)**



Schönberg, A. *Trans. Faraday Soc.* **1934**, 30, 17

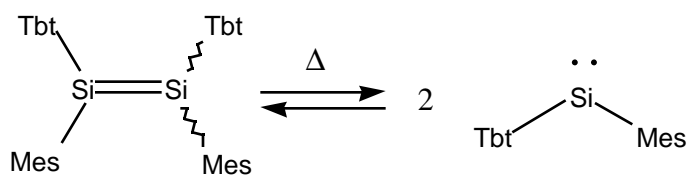


Schmidt, U.; Müller, A.; Markau, K. *Tetrahedron Lett.* **1963**, 1091



Ogawa, S.; Kikuchi, M.; Kawai, Y.; Niizuma, S.; Sato, R. *Chem. Commun.* **1999**, 1891

### Silylenes

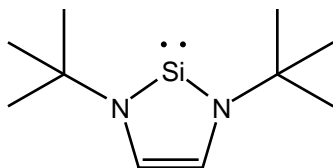


Tokitoh, N.; Suzuki, H.; Okazaki, R.; Ogawa, K. *J. Am. Chem. Soc.* **1993**, 115, 10428

Suzuki, H.; Tokitoh, N.; Okazaki, R.; Harada, J.; Ogawa, K.; Tomoda, S.; Goto, M.

*Organometallics* **1995**, 14, 1016

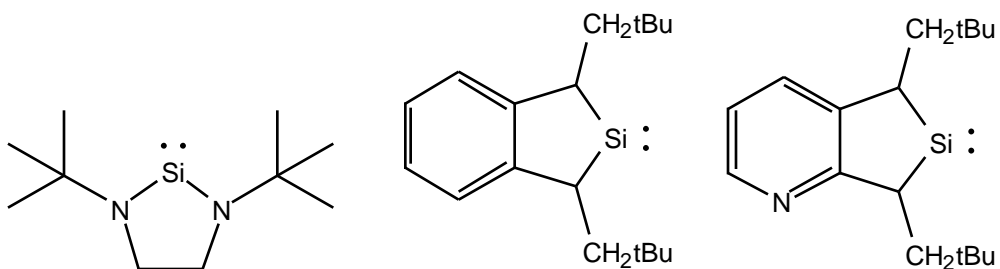
Suzuki, H.; Tokitoh, N.; Okazaki, R. *Bull. Chem. Soc. Jpn* **1995**, 68, 2471



Denk, M.; Lennon, R.; Hayashi, R.; West, R.; Belykov, A.V.; Verne, H.P.; Haaland, A.; Wagner, M.; Metzler, N. *J. Am. Chem. Soc.* **1994**, 116, 2691

Haaf, M.; Schmiedl, A.; Schmedake, T.A.; Powell, D.R.; Millevolte, A.J.; Denk, M.; West, R. *J. Am. Chem. Soc.* **1998**, 120, 12714

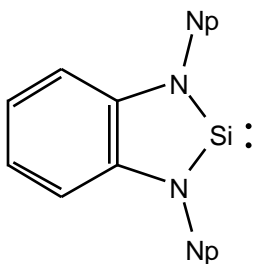
Tumanskii, B.; Pine, P.; Apeloig, Y.; Hill, N.J.; West, R. *J. Am. Chem. Soc.* **2004**, 126, 7786



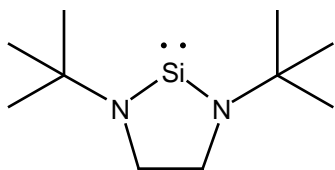
Denk, M.; Green, J.C.; Metzler, N.; Wagner, M. *J. Chem. Soc. Dalton Trans.* **1994**, 2405

Gehrus, B.; Lappert, M.F.; Heinicke, J.; Boese, R.; Blaser, D. *Chem. Commun.* **1995**, 1931

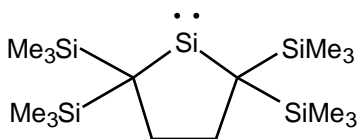
Heinicke, J.; Opera, A.; Kindermann, M.K.; Karbati, T.; Nyulaszi, L. *Chem. Eur. J.* **1998**, 541



Gehrus, B.; Hitchcock, P.B.; Lappert, M.F. *Angew. Chem. Int. Ed.* **1997**, 36, 2514

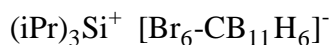


West, R.; Schmedake, T.A.; Haaf, M.; Becker, J.; Mueller, T. *Chem. Lett.* **2001**, 68

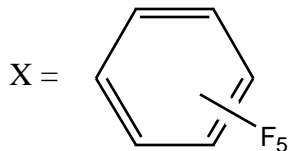
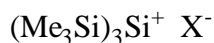
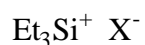
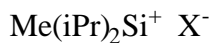


Kira, M.; Ishida, S.; Iwamoto, T.; de Meijere, A.; Fujitsuka, M.; Ito, O. *Angew. Chem. Int. Ed.* **2004**, 43, 4510

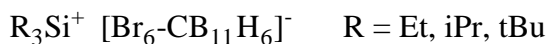
### Silylium ions



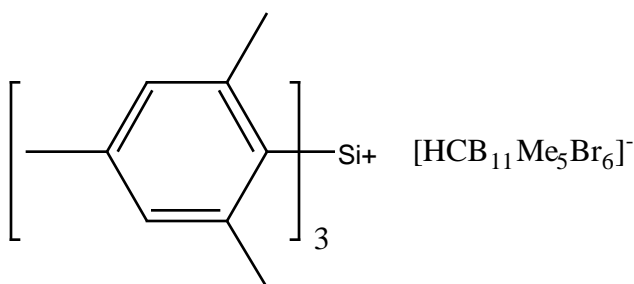
Reed, C.A.; Xie, Z.; Bau, R.; Benesi, A. *Science* **1993**, 262, 402



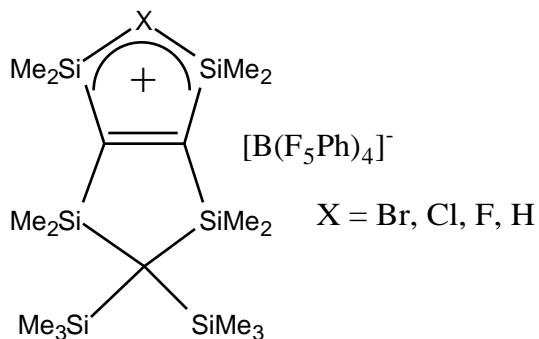
Lambert, J.B.; Zhang, S.; Ciro, S.M. *Organometallics* **1994**, 13, 2430



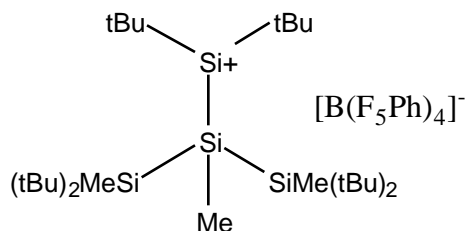
Xie, Z.; Bau, R.; Benesi, A.; Reed, C.A. *Organometallics* **1995**, 14, 3933



Kim, K.C.; Reed, C.A.; Elliott, D.W.; Mueller, L.J.; Tham, F.; Lin, L.; Lambert, J.B. *Science* **2002**, 297, 825

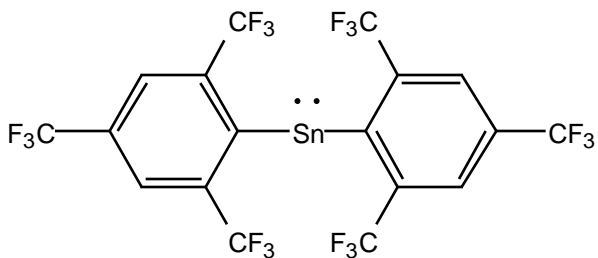


Sekiguchi, A.; Murakami, Y.; Fukaya, N.; Kabe, Y. *Chem. Lett.* **2004**, 33, 530



Nakamoto, M.; Fukawa, T.; Sekiguchi, A. *Chem. Lett.* **2004**, 33, 38

## Stannylenes

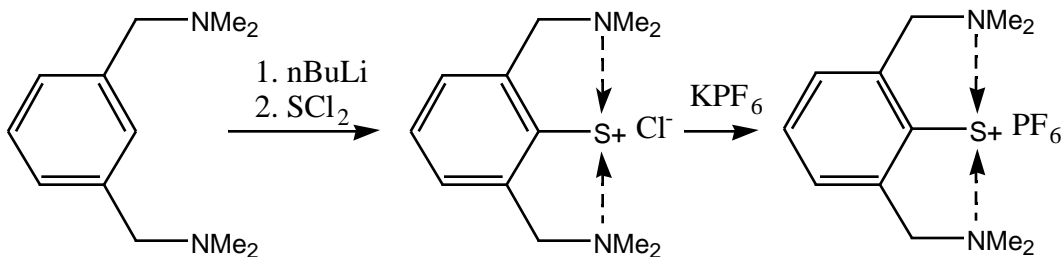


Edelman; Belay *J. Fluorine Chem.* **1997**, 84, 29

### Sulfenium ions

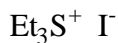


Nabi, S.N.; Khaleque, M.A. *J. Chem. Soc.* **1965**, 3626

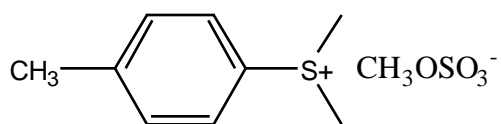


Kobayashi, K.; Sato, S.; Horn, E.; Furukawa, N. *Tetrahedron Lett.* **1998**, 39, 2593

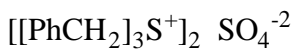
### Sulfonium ions



Oefele, *Ann. Chem.* **1864**, 132, 82



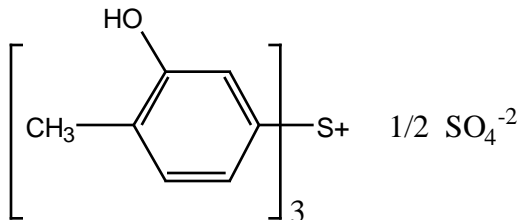
Auwers, K. von; Arndt, F. *Chem. Ber.* **1909**, 42, 2713



Fichter; Sjöstedt *Chem. Ber.* **1910**, 43, 3422

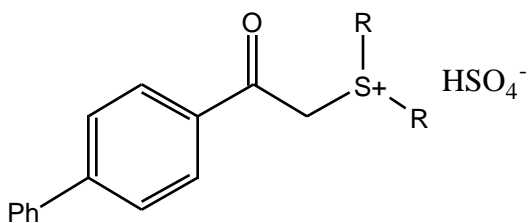


Vanino, ; Mussnug, *Chem. Ber.* **1917**, 50, 23

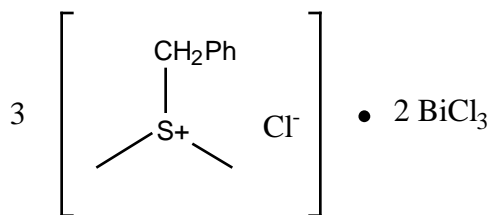


Richter, *Ann. Chem.* **1918**, 416, 291

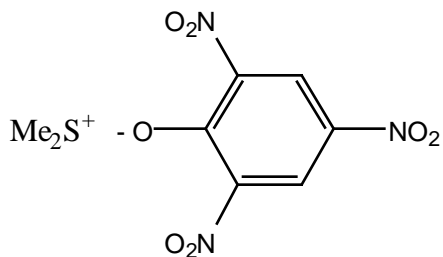
Libermann, *Compt. Rend.* **1934**, 198, 1421



Bost; Schultze, *J. Am. Chem. Soc.* **1942**, 64, 1165

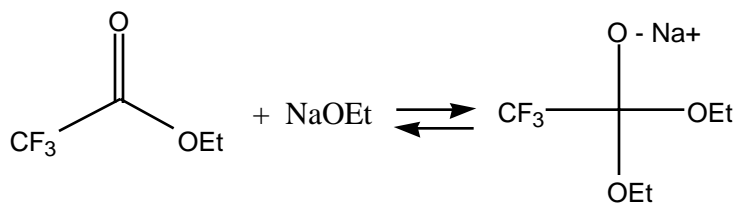


Ray, F.E.; Farmer, J.L. *J. Org. Chem.* **1943**, 8, 391

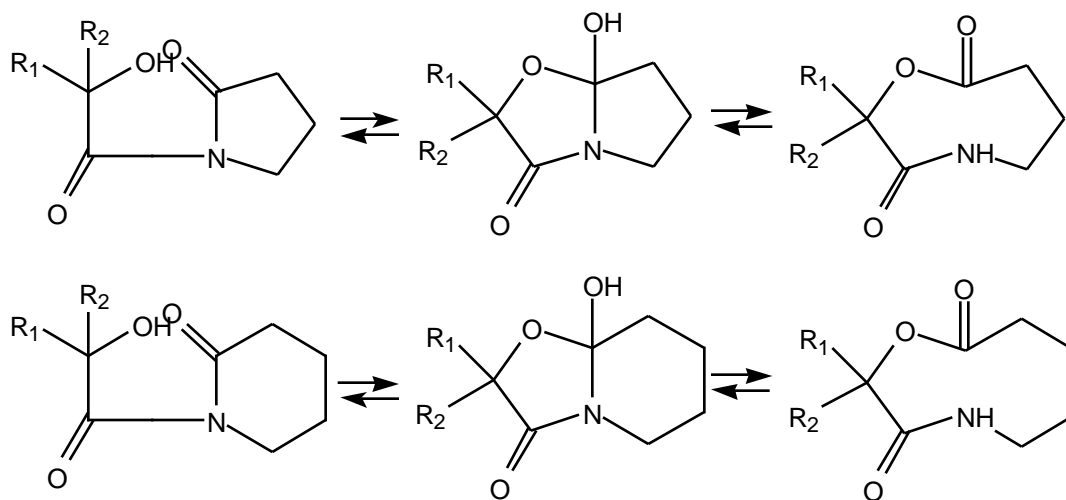


Ray, F.E.; Szasz, G.J. *J. Org. Chem.* **1943**, 8, 121

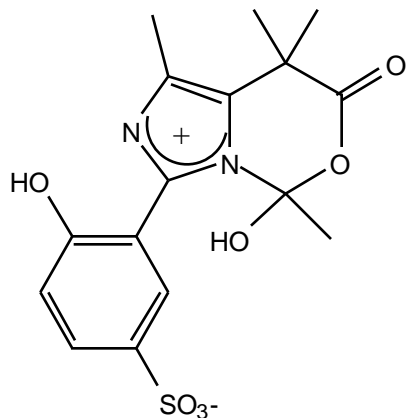
### Tetrahedral intermediates



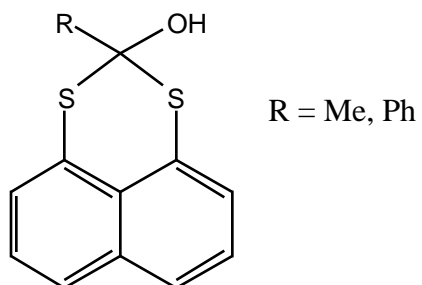
Swarts, F. *Bull. Soc. Chim. Belg.* **1926**, 35, 414



Griot, R.G.; Frey, A.J. *Tetrahedron* **1963**, 19, 1661

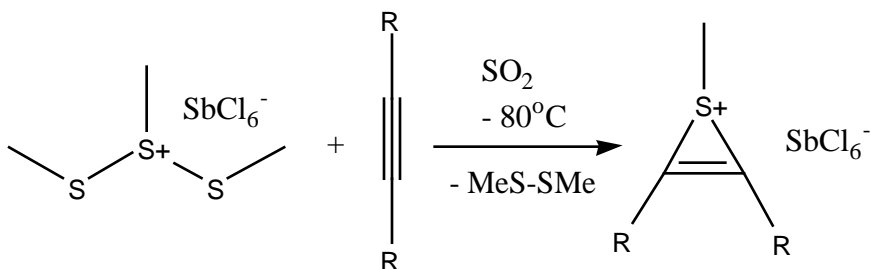


Rogers, G.A.; Bruice, T.C. *J. Am. Chem. Soc.* **1973**, 95, 4452

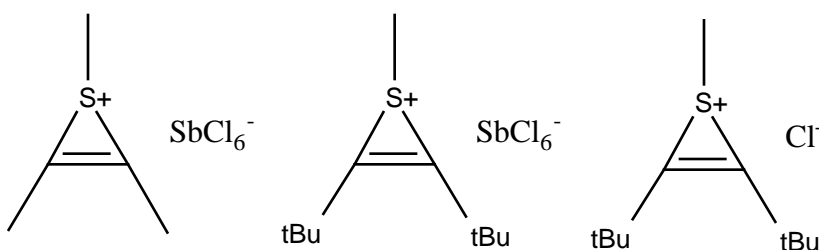


Takagi, M.; Ishihara, R.; Matsuda, T. *Bull. Chem. Soc. Jpn* **1977**, 50, 2193

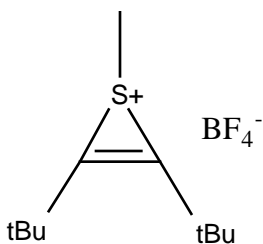
### Thiirenium ions



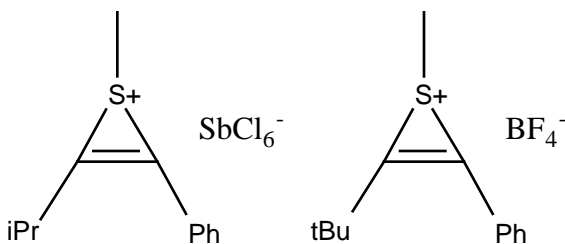
Capozzi, G.; De Lucchi, O.; Lucchini, V.; Modena, G. *Chem. Commun.* **1975**, 248



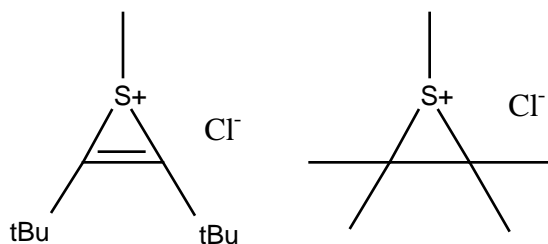
Capozzi, G.; Lucchini, V.; Modena, G.; Scrimin, P. *Tetrahedron Lett.* **1977**, 911



Destro, R.; Pilati, T.; Simonetta, M. *Chem. Commun.* **1977**, 576

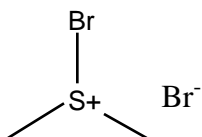


Lucchini, V.; Modena, G.; Valle, G.; Capozzi, G. *J. Org. Chem.* **1981**, 46, 4720



Lucchini, V.; Modena, G.; Zaupa, T.; Capozzi, G. *J. Org. Chem.* **1982**, 47, 590

### Thiooxonium ions



Furukang, N.; Inoue, T.; Aida, T.; Oae, S. *Chem. Commun.* **1973**, 212

### Transition metal carbene complexes

See carbenoids (metallocarbenes).

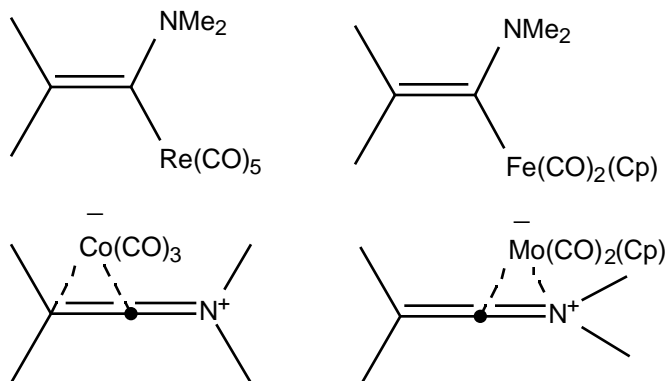
### Transition metal carbyne complexes

See carbynes.

### Transition metal ketenyl complexes

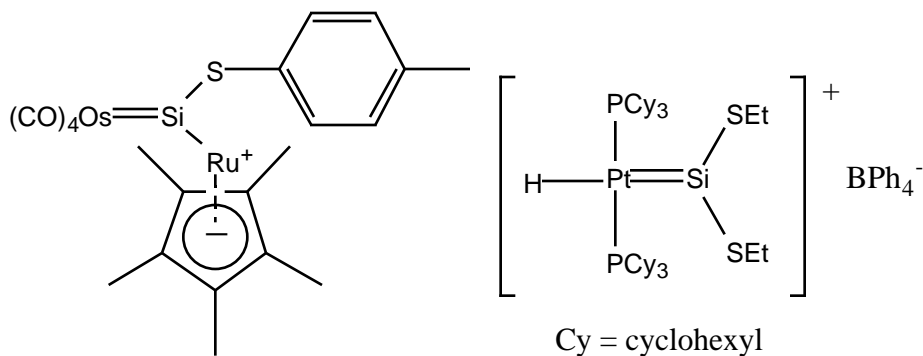
See ketenyl transition metal complexes.

### Transition metal keteniminium complexes



King, R.B.; Hodges, K.C. *J. Am. Chem. Soc.* **1974**, 96, 1263

### Transition metal silylene complexes

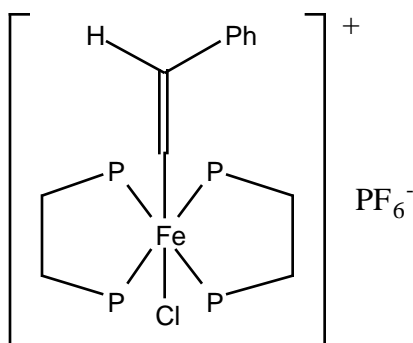


Grubbine, S.D.; Tilley, T.D.; Rheingold, A.L. *J. Am. Chem. Soc.* **1993**, 115, 358

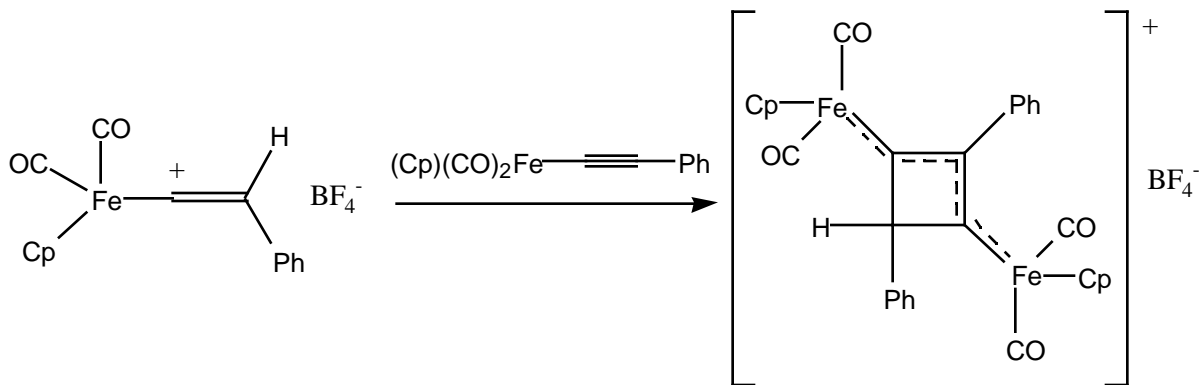
Grubbine, S.D.; Tilley, T.D.; Arnold, E.P.; Rheingold, A.L. *J. Am. Chem. Soc.* **1993**, 115, 7884

Grubbine, S.D.; Tilley, T.D.; Arnold, E.P.; Rheingold, A.L. *J. Am. Chem. Soc.* **1994**, 116, 5495

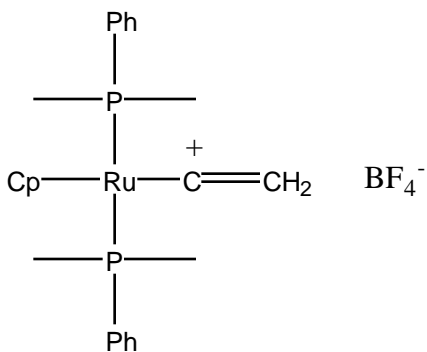
### Transition metal cationic vinylidene complexes



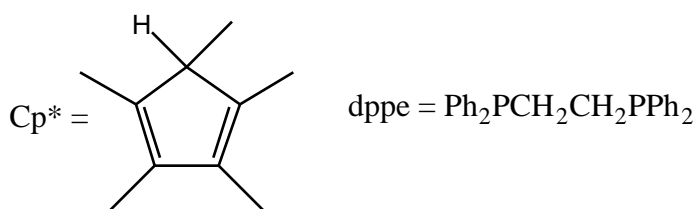
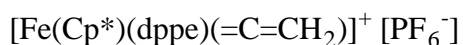
Bellerby, J.M.; Mays, M.J. *J. Organometallic Chem.* **1976**, 117, C21



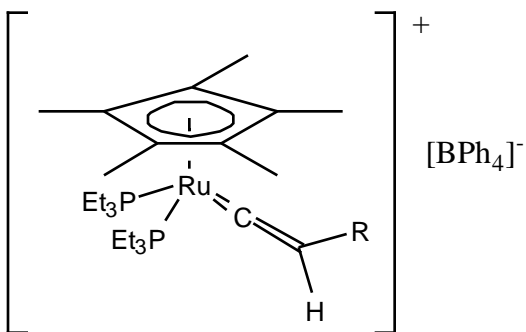
Davison, A.; Solar, J.P. *J. Organometallic Chem.* **1978**, 155, C8



Lompfrey, J.R.; Selegue, J.P. *J. Am. Chem. Soc.* **1992**, 114, 5518



Le Narvor, N.; Toupet, L.; Lapinte, C. *J. Am. Chem. Soc.* **1995**, 117, 7129



R = H, Ph, COOMe, tBu

Bustelo, E.; Carbo, J.J.; Lidos, A.; Mereiter, K.; Puerta, M.C.; Valerga, P. *J. Am. Chem. Soc.* **2003**, 125, 3311

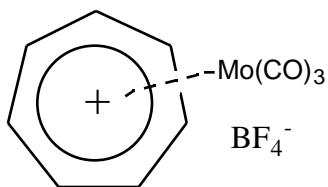
### Transition metal vinylidene complexes

See vinylidenes (alkylidenes).

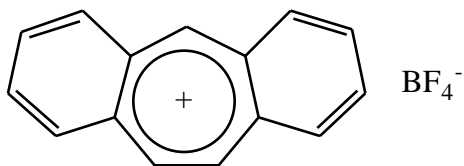
### Transition metal vinylidenecarbene complexes

See vinylidenecarbenes (alkenylidenes).

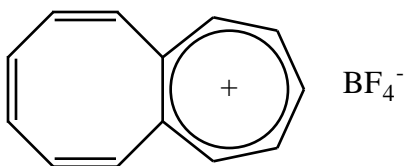
### Tropylium ions



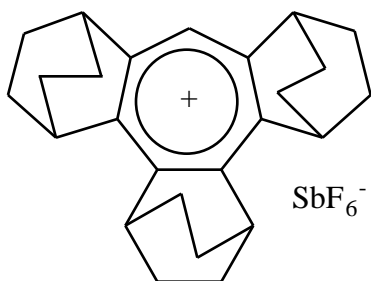
Dauben, H.J. Jr.; Honnen, L.R. *J. Am. Chem. Soc.* **1958**, 80, 5570



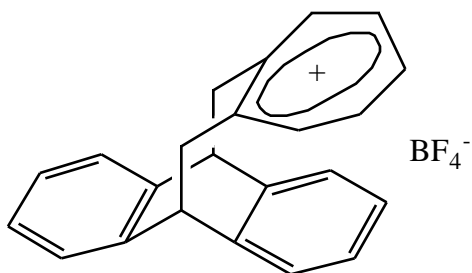
Feldman, M.; Jackson, J.A. *Tetrahedron Lett.* **1966**, 797



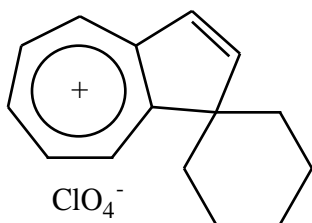
Breslow, R.; Horspool, W.; Sugiyama, H.; Vitale, W. *J. Am. Chem. Soc.* **1966**, 88, 3677



Komatsu, K.; Akamatsu, H.; Jinbu, Y.; Okamoto, K. *J. Am. Chem. Soc.* **1988**, 110, 633  
 Komatsu, K.; Akamatsu, H.; Aonuma, S.; Jinbu, Y.; Maekawa, N.; Takeuchi, K.  
*Tetrahedron* **1991**, 47, 6951

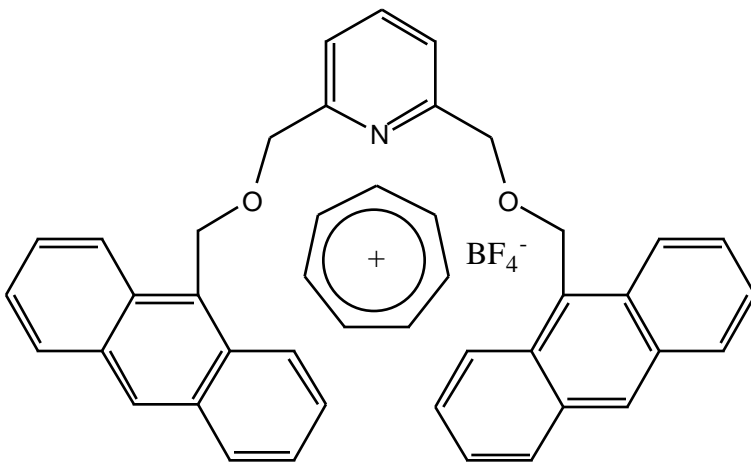


Fukazawa, Y.; Harada, S.; Inai, A.; Okajima, T. *Tetrahedron Lett.* **1993**, 52, 8493

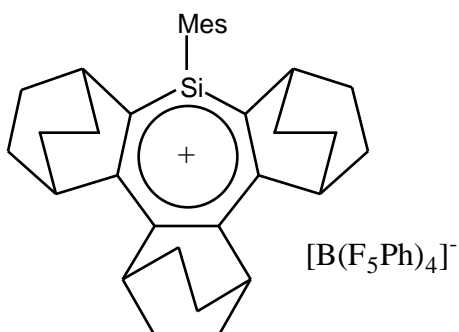


Oda, M.; Sakamoto, A.; Uchiyama, T.; Kajioka, T.; Miyatake, R.; Kuroda, S.  
*Tetrahedron Lett.* **1999**, 40, 3595

Oda, M.; Fukuta, A.; Kajioka, T.; Uchiyama, T.; Kainuma, H.; Miyatake, R.; Kuroda, S.  
*Tetrahedron* **2000**, 56, 9917

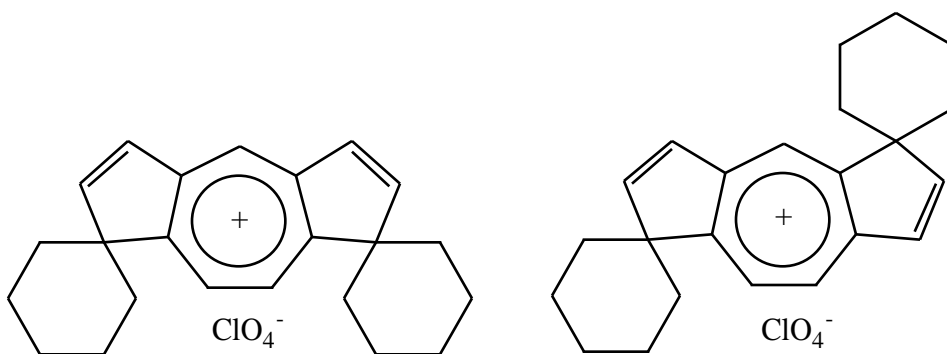


Lämsä, M.; Kiviniemi, S.; Kettukangas, E.R.; Nissinen, M.; Rissanen, J.P.K. *J. Phys. Org. Chem.* **2001**, 14, 551



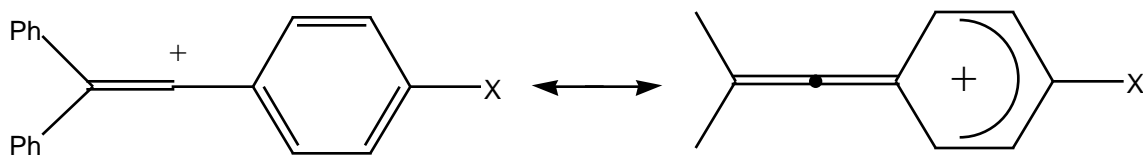
Nishinaga, T.; Izukawa, Y.; Komatsu, K. *Tetrahedron* **2001**, 57, 3645

Nishinaga, T.; Isukawa, Y.; Komatsu, K. *J. Am. Chem. Soc.* **2000**, 122, 9312

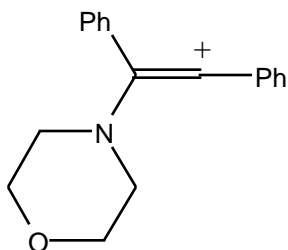


Oda, M.; Kainuma, H.; Uchiyama, T.; Miyatake, R.; Kuroda, S. *Tetrahedron* **2003**, 59, 2831

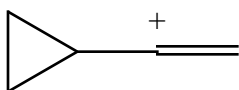
### Vinyl cations



Miller, L.L.; Kaufman, D.A. *J. Am. Chem. Soc.* **1968**, 90, 7282

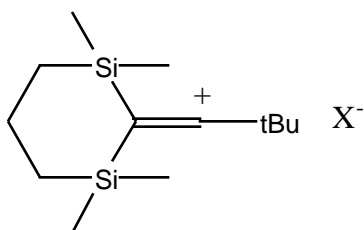


Huang, S.J.; Lessard, M.V. *J. Am. Chem. Soc.* **1968**, 90, 2432



Sherrod, S.A.; Bergman, R.G. *J. Am. Chem. Soc.* **1969**, 91, 2115

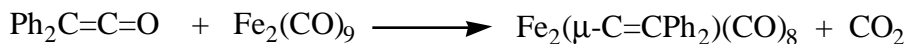
Hanack, M.; Bässler, T. *J. Am. Chem. Soc.* **1969**, 91, 2117



X = [B(F<sub>5</sub>Ph)<sub>4</sub>], [CB<sub>11</sub>H<sub>6</sub>Br<sub>6</sub>]

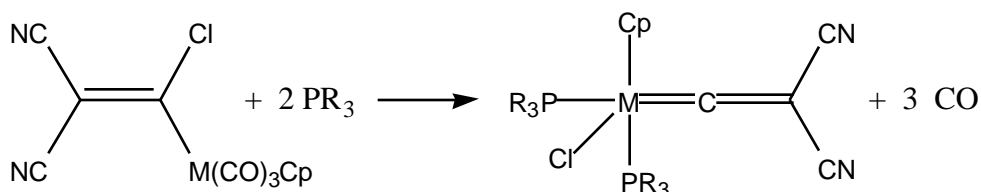
Müller, T.; Meyer, R.; Lennartz, D.; Siehl, H.U. *Angew. Chem. Int. Ed.* **2000**, 39, 3074  
 Müller, T.; Juhasz, M.; Reed, C.A. *Angew. Chem. Int. Ed.* **2004**, 43, 1543

### Vinylidenes (alkylidenes)



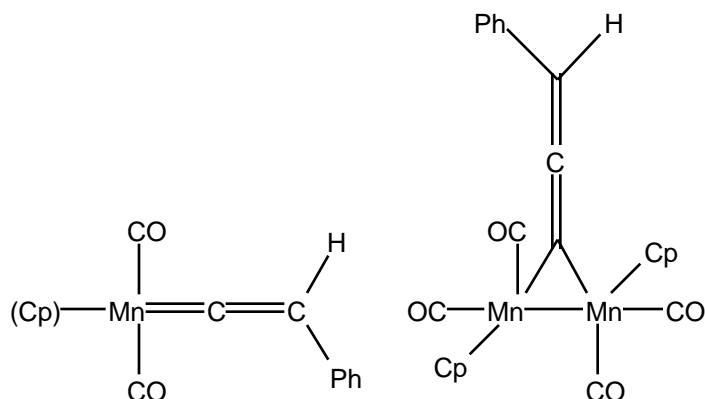
Mills, O.S.; Redhouse, A.D. *Chem. Commun.* **1966**, 444

Mills, O.S.; Redhouse, A.D. *J. Chem. Soc. A* **1968**, 1282

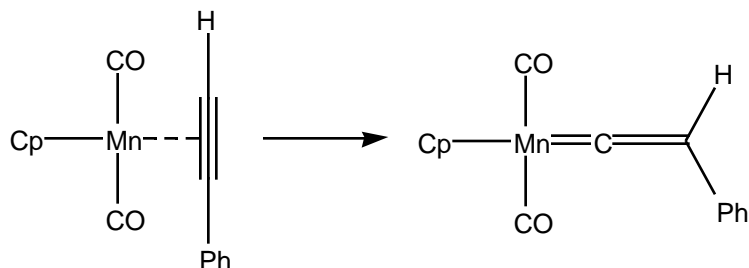


M = W, Mo; R = PPh<sub>3</sub>, P(OMe)<sub>3</sub>, P(OPh)<sub>3</sub>, P(OEt)<sub>3</sub>, AsPh<sub>3</sub>, SbPh<sub>3</sub>

King, R.B.; Saran, M.S. *Chem. Commun.* **1972**, 1053

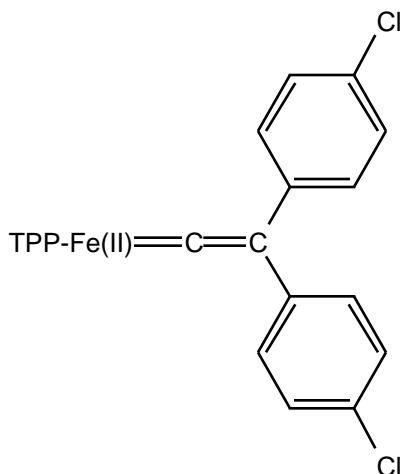


Nesmeyanov, A.N.; Aleksandrov, G.G.; Antonova, A.B.; Anisimov, K.N.; Kolobova, N.E.; Struchkov, Yu.T. *J. Organometallic Chem.* **1976**, 110, C36



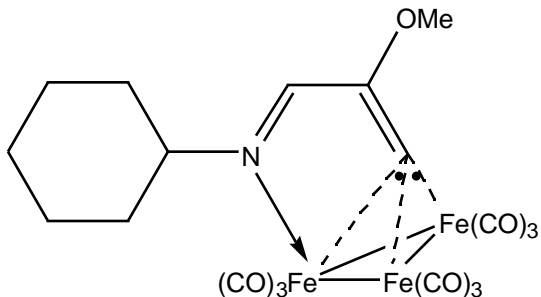
Antonova, A.B.; Kolobova, N.E.; Petrovsky, P.V.; Lokshin, B.V.; Obezyuk, N.S. *J. Organometallic Chem.* **1977**, 137, 55

Kolobova, N.E.; Antonova, A.B.; Khitrova, O.M.; Antipin, M.Yu. Struchkov, Yu.T. *J. Organometallic Chem.* **1977**, 137, 69



TPP = tetraphenylporphyrin

Mansuy, D.; Lange, M.; Chottard, J.C. *J. Am. Chem. Soc.* **1978**, 100, 3213



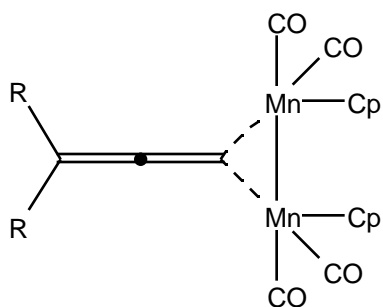
Aumann, R.; Heinen, H.; Krueger, C.; Goddard, R. *Chem. Ber.* **1986**, 119, 401

### Vinylidenecarbenes (alkenylidene, allenylidene)



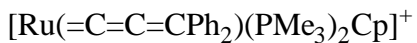
Berke, H. *Angew. Chem. Int. Ed. Engl.* **1976**, 15, 624

Fischer, E.O.; Kalder, H.J.; Frank, A.; Köhler, F.H.; Huttner, G. *Angew. Chem. Int. Ed.* **1976**, 15, 623



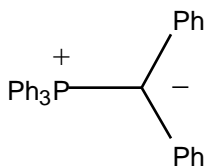
R = *t*Bu, CH<sub>2</sub>Ph, Ph, Cy

Berke, H. *J. Organometallic Chem.* **1980**, 185, 75



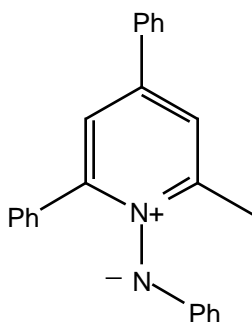
Selengue, J.P. *Organometallics* **1982**, 1, 217

### Ylides



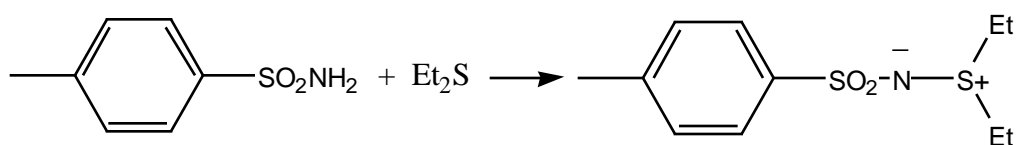
Staudinger, H.; Meyer, J. *Helv. Chim. Acta* **1919**, 2, 635

Coffmann, D.D.; Marvel, C.S. *J. Am. Chem. Soc.* **1929**, 51, 3496

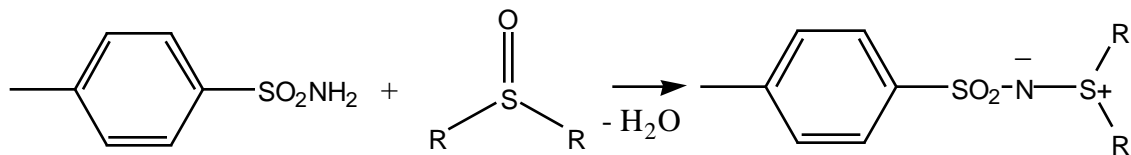


Scheider, W.; Seebach, F. *Chem. Ber.* **1921**, 54, 2285

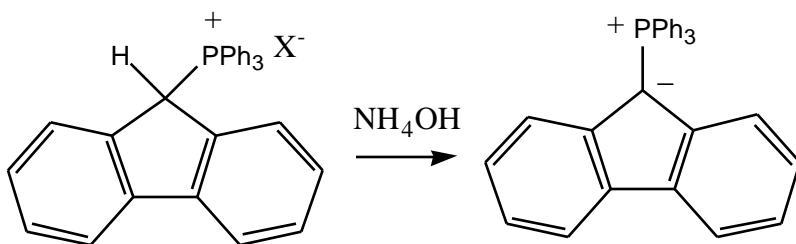
Scheider, W. *Ann. Chem.* **1924**, 438, 115



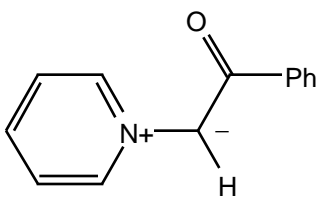
Mann, F.; Pope, W.J. *J. Chem. Soc.* **1922**, 121, 1052



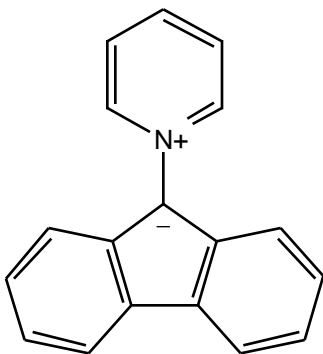
Tarbell, D.S.; Weaver, C. *J. Am. Chem. Soc.* **1941**, 63, 2939



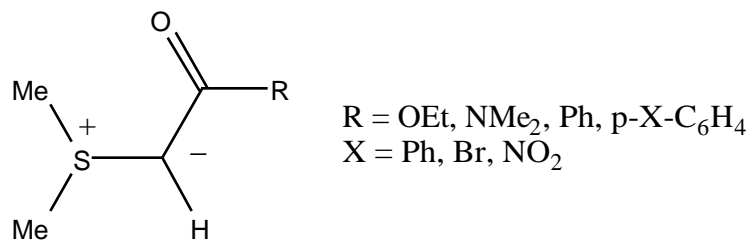
Pinck, L.A.; Hilbert, G.E. *J. Am. Chem. Soc.* **1947**, 69, 723



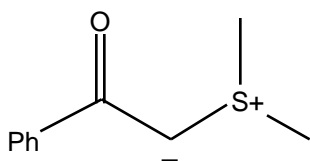
Kröhnke, F. *Chem. Ber.* **1935**, 68, 1177



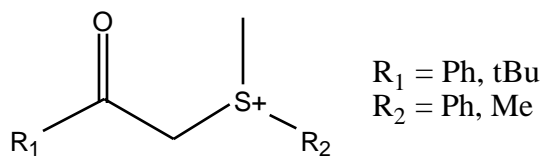
Pinck, L.A.; Hilbert, G.E. *J. Am. Chem. Soc.* **1946**, 68, 2011



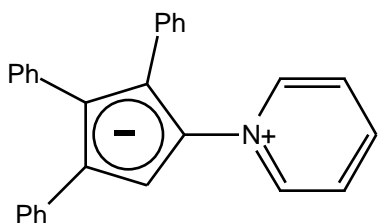
Ratts, K.W.; Yao, A.N. *J. Org. Chem.* **1966**, 31, 1185



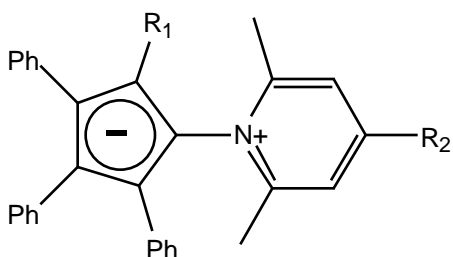
Trost, B.M. *J. Am. Chem. Soc.* **1966**, 88, 1587



Serratos, F.; Quintana, J. *Tetrahedron Lett.* **1967**, 2245

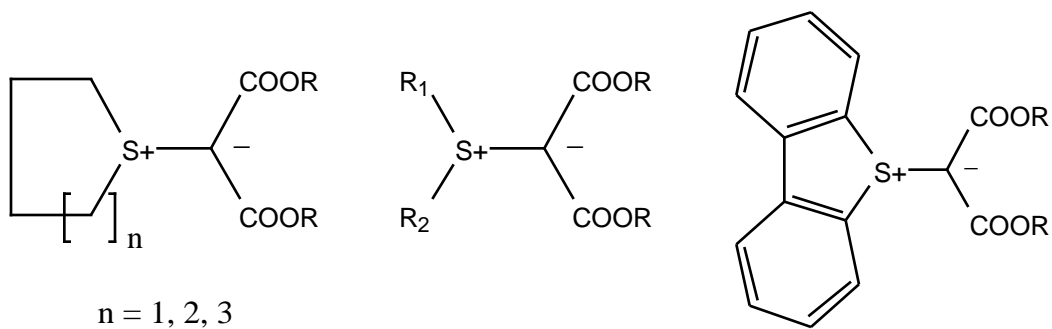


Lloyd, D.; Singer, M.I.C. *J. Chem. Soc. Sect. C* **1971**, 2941



$R_1 = \text{H, Ph}; R_2 = \text{H, Me}$

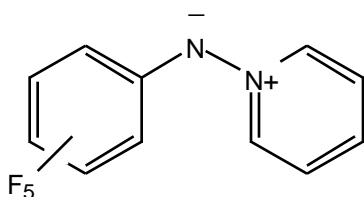
Duerr, H.; Heu, B.; Ruge, B.; Scheppers, G. *Chem. Commun.* **1972**, 1257



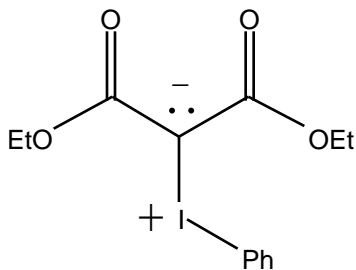
Ando, W.; Yagihara, T.; Migita, T. *Tetrahedron Lett.* **1969**, 1983

Ando, W.; Yagihara, T.; Tozune, S.; Imai, I.; Suzuki, J.; Toyama, T.; Nakaido, S.;

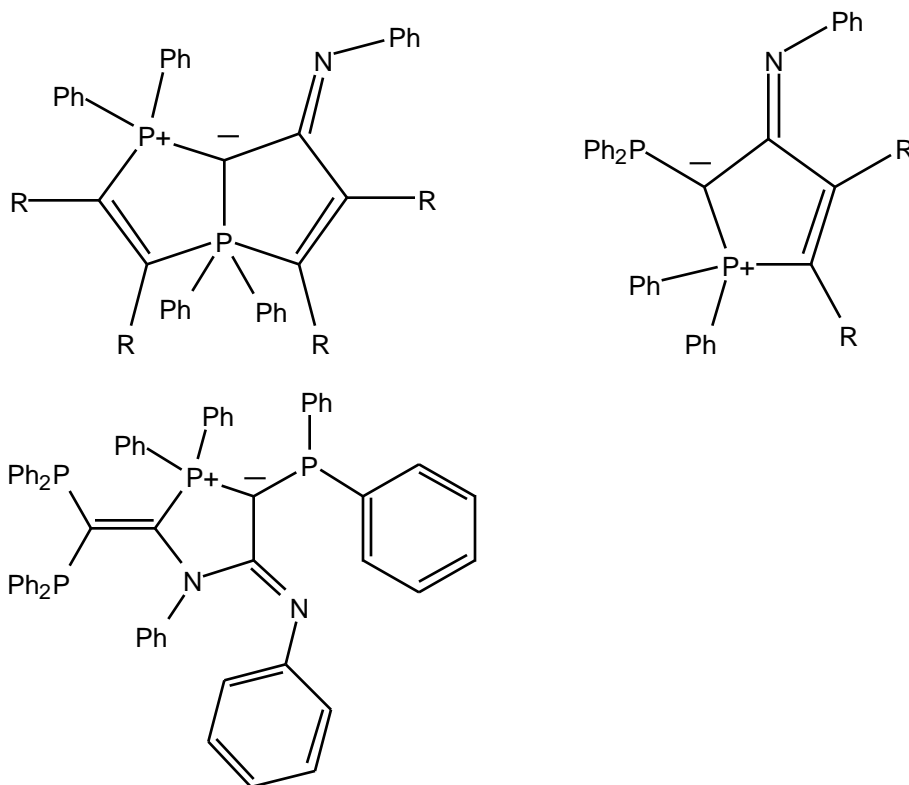
Migita, T. *J. Org. Chem.* **1972**, 37, 1721



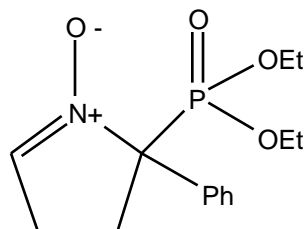
Poe, R.; Schnapp, K.; Young, M.J.T.; Grayzar, J.; Platz, M.S. *J. Am. Chem. Soc.* **1992**, 114, 5054



Camacho, M.B.; Clark, A.E.; Liebrecht, T.A.; De Luca, J.P. *J. Am. Chem. Soc.* **2000**, 122, 5210



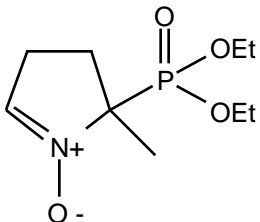
Ruiz, J.; Marquinez, F.; Riera, V.; Vivanco, M.; Garcia-Granda, S.; Diaz, M.R. *Angew. Chem. Int. Ed.* **2000**, 39, 1821



Karoui, H.; Nsanzumuhire, C.; Le Moigne, F.; Tordo, P. *J. Org. Chem.* **1999**, 64, 1471

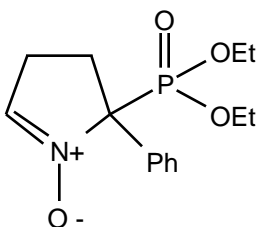
**Ynols**

No stable analogues observed to date.

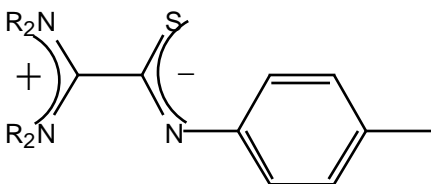
**Zwitterions**

Frejaville, C.; Karoui, H.; Le Moigne, F.; Culcasi, M.; Pietri, S.; Lauricella, R.; Tuccio, B.; Tordo, P. *Chem. Commun.* **1994**, 1793

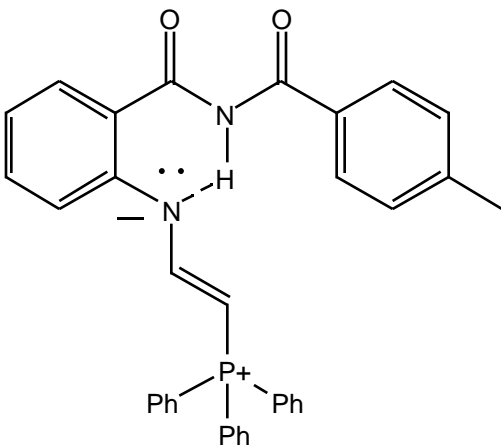
Frejaville, C.; Karoui, H.; Le Moigne, F.; Culcasi, M.; Pietri, S.; Lauricella, R.; Tuccio, B.; Tordo, P. *J. Med. Chem.* **1995**, 38, 258



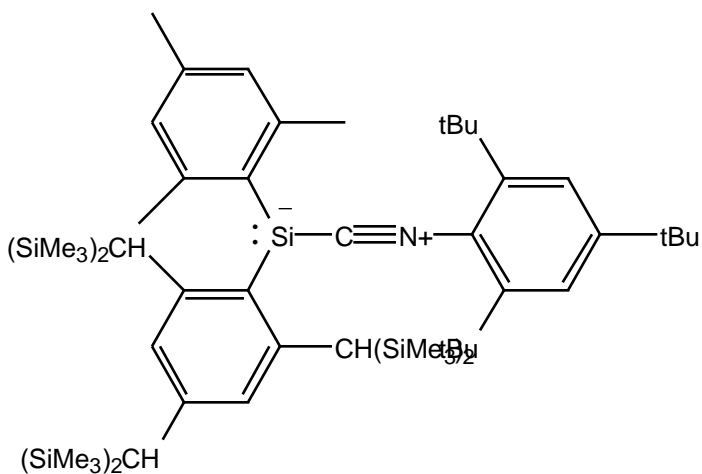
Karoui, H.; Nsanzumuhire, C.; Le Moigne, F.; Tordo, P. *J. Org. Chem.* **1999**, 64, 1471



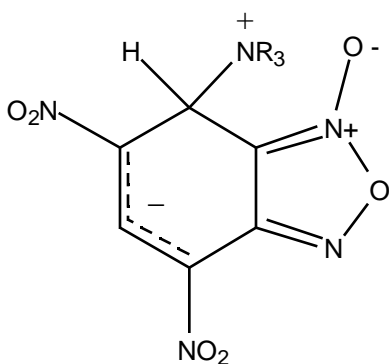
Nakayama, J.; Zhao, L.; Otani, T.; Sugihara, Y.; Ishii, A. *Chem. Lett.* **2000**, 1248



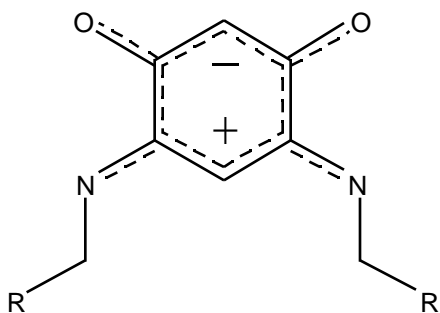
Velasco, M.D.; Molina, P.; Fresnada, P.M.; Sanz, M.A. *Tetrahedron* **2000**, 56, 4079



Takeda, N.; Tokitoh, N.; Okazaki, R. *Chem. Lett.* **2000**, 244



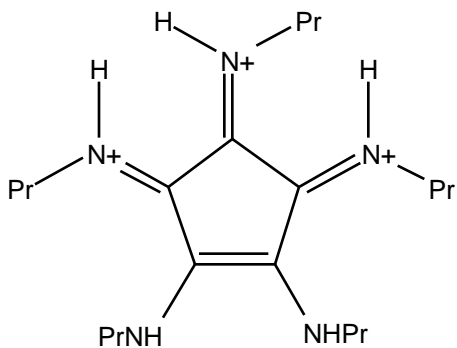
Boga, C.; Forlani, L. *J. Chem. Soc. Perkin Trans. 2* **2001**, 1408



Siri, O.; Braunstein, P. *Chem. Commun.* **2002**, 208

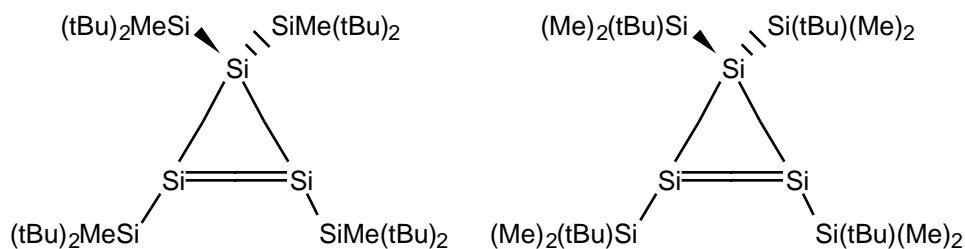
## Miscellaneous

### (i) Cyclopentenyl trication derivative



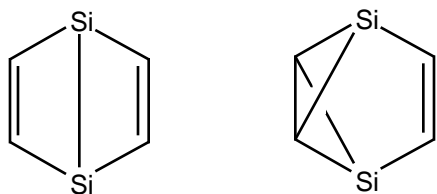
Breslow, R.; Werner *Tetrahedron Lett.* **1999**, 40, 2447

### (i) Cyclotrisilene



Ichinohe, M.; Matsuno, T.; Sekiguchi, A. *Angew. Chem. Int. Ed.* **1999**, 38, 2194  
(first stable cyclotrisilenes)

### (iii) 1,4-Disila(Dewar-benzene) and 1,4-Disilabenzene

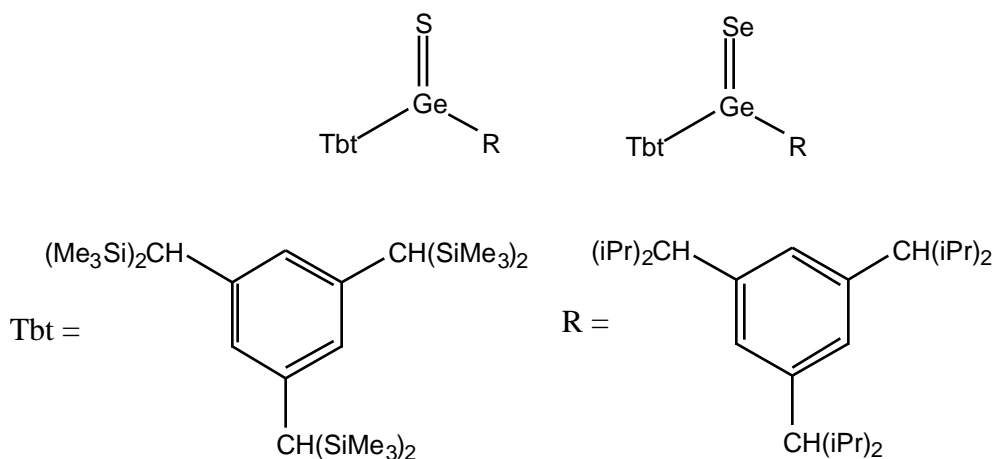


Ando, W. *Bull. Chem. Soc. Jpn.* **1996**, 69, 1

Sekiguchi, A.; Tanikawa, H.; Ando, W. *Organometallics* **1985**, 4, 584

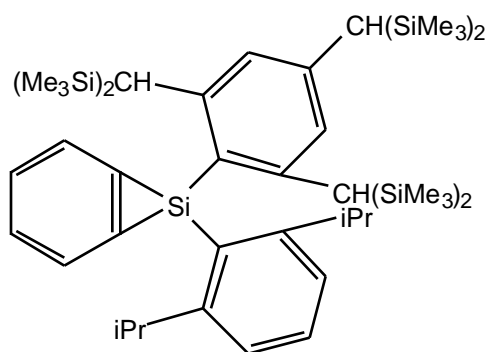
Ando, W.; Tanikawa, H.; Sekiguchi, A. *Tetrahedron Lett.* **1983**, 24, 4245

### (iv) Germanethiones and germaneselonones



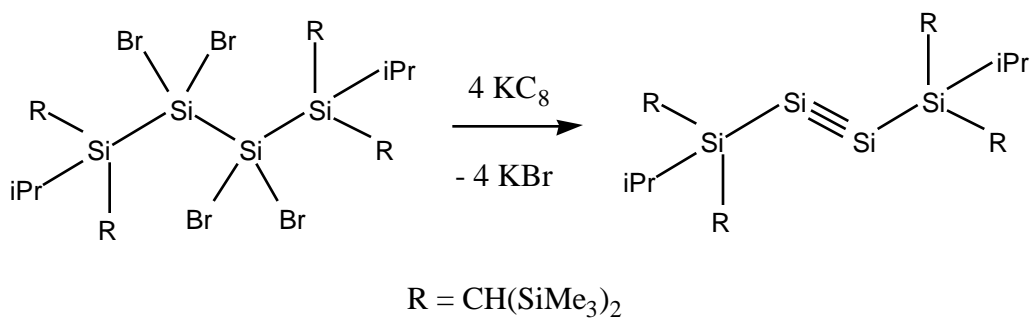
Matsumoto, T.; Tokitoh, N.; Okazaki, R. *J. Am. Chem. Soc.* **1999**, 121, 8811

**(v) Silacyclopropabenzene**

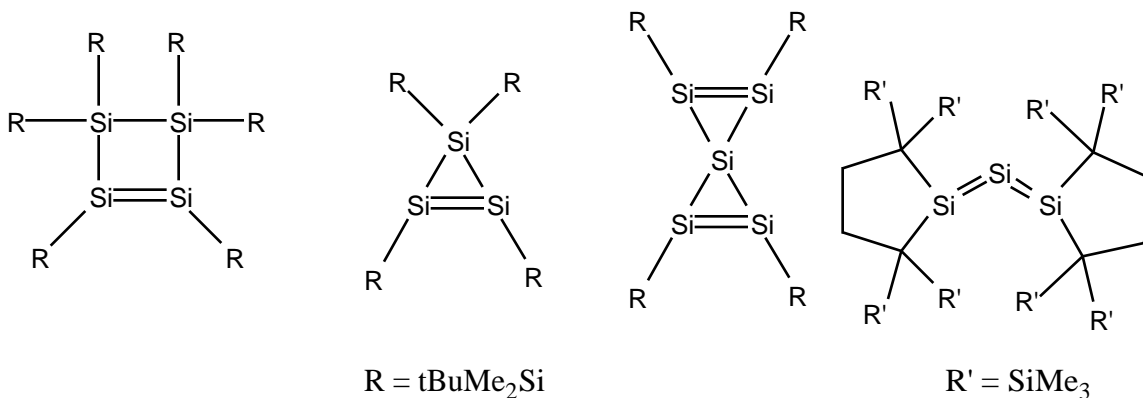


Hatano, K.; Tokitoh, N.; Takagi, N.; Nagase, S. *J. Am. Chem. Soc.* **2000**, 122, 4829

**(vi) Silicon based  $\pi$ -electron systems**



Sekuguchi, A.; Kinjo, R.; Ichinohe, M. *Science* **2004**, 305, 1755



Iwamoto, T. *Bull. Chem. Soc. Jpn.* **2005**, 78, 393

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