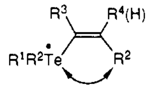
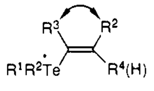
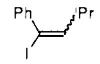
isomerization,[3] the stereoselectivity should be determined by the relative stabilities of the transition states of the S_H2 reactions on tellurium (**7a** and **7b**). These, in turn, would be affected mainly by the steric repulsion between R^2 and R^1R^2Te (**7a**) or R^3 (**7b**) in the cases of terminal alkynes (R^4 = H). Bond fission of tellurides takes place exclusively on $^{sp^3}$C–Te bonds rather than $^{sp^2}$C–Te bonds (runs 1–5), on ^{tertiary}C–Te bonds rather than ^{primary}C–Te bonds (runs 6–9), and on the Bn–Te bond rather than the ^{n}Bu–Te bond (run 10). This could indicate that the more stable carbon radical is liberated from tellurium via **7**.



7a



7b



8

Recently, Curran and co-workers established a very useful synthetic method for the preparation of iodomethylene-substituted cycloalkanes by the photoinitiated radical cyclization of iodoalkylacetylenes.[2c,4] This also involves a similar S_H2 process on iodine. A competitive reaction of PhTe^{i}Pr and ^{i}PrI with phenylacetylene afforded **3b** and **8** in 26% and 2.5% yields, respectively, indicating that the addition of PhTe^{i}Pr proceeds about *10 times faster* than that of ^{i}PrI. Actually, the intermolecular reaction of ^{i}PrI with a stoichiometric amount of phenylacetylene affords only a 13% (*E*/*Z* = 53/47) yield of **8** under conditions identical to run 2.

A variety of heteroatom-containing compounds having an H–Z bond (where Z = heteroatom (group)) easily add to carbon–carbon unsaturated bonds. Although this transformation has been widely used in organic synthesis, as exemplified by hydrosilation and hydrostannation, the similar addition of C–Z compounds hardly proceeds and often affords unsatisfactory results, except the reactions of some alkyl halides.[2,4] The carbotelluration described herein appears to be the first example of this type of reaction that is quite efficient and very general.[5,6]

Alkenyl tellurides as well as other diorganyl tellurides undergo facile transmetalation with organolithiums[7] and transition metal complexes[8] and have great potential in organic synthesis. The application of this carbotelluration to a variety of unsaturated compounds and further manipulation of the products are now in progress.

Acknowledgment. This work was supported by a Grant in Aid for Scientific Research on Priority Areas (No. 04217101) from the Ministry of Education, Science, and Culture, Japan. Thanks are due to the Instrumental Analysis Center, Faculty of Engineering, Osaka University, for assistance in obtaining MS, NMR, and elemental analyses.

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(3) Giese, B. *Angew. Chem., Int. Ed. Engl.* **1989**, *28*, 969.

(4) (a) Curran, D. P.; Chen, M.-H.; Kim, D. *J. Am. Chem. Soc.* **1986**, *108*, 2489. (b) Curran, D. P.; Kim, D. *Tetrahedron Lett.* **1986**, *27*, 5821. (c) Curran, D. P.; Chang, C.-T. *Tetrahedron Lett.* **1987**, *28*, 2477. (d) Curran, D. P.; Chen, M.-H. *J. Am. Chem. Soc.* **1987**, *109*, 6558. (e) Curran, D. P.; Chang, C.-T. *J. Org. Chem.* **1989**, *54*, 3140. (f) Curran, D. P.; Chen, M.-H.; Spletzer, E.; Seong, C. M.; Chen, C.-T. *J. Am. Chem. Soc.* **1989**, *111*, 8872. (g) Curran, D. P.; Chen, M.-H.; Kim, D. *J. Am. Chem. Soc.* **1989**, *111*, 6265.

(5) Recently, the following two types of reactions were reported. Addition of 2-(phenylseleno)propanedioates and related compounds to alkenes: (a) Byers, J. H.; Lane, G. C. *Tetrahedron Lett.* **1990**, *31*, 5697. (b) Byers, J. H.; Gleason, T. G.; Knight, K. S. *J. Chem. Soc., Chem. Commun.* **1991**, 354. (c) Curran, D. P.; Thoma, G. *J. Am. Chem. Soc.* **1992**, *114*, 4436. Photoinitiated intramolecular cyclization of acylgermanes: (d) Kiyooka, S-i.; Kaneko, Y.; Matsue, H.; Hamada, M.; Fujiyama, R. *J. Org. Chem.* **1990**, *55*, 5562. (e) Curran, D. P.; Liu, H. *J. Org. Chem.* **1991**, *56*, 3463. It is also reported that carbotelluration products are obtained by the reaction of phenyltellurolate with perfluoroalkyl halides and olefins via an electron-transfer mechanism: (f) Uneyama, K.; Kitagawa, K. *Tetrahedron Lett.* **1991**, *32*, 7425.

(6) Proceedings of the 6th International Conference on the Chemistry of Selenium and Tellurium, 1991, Osaka, Japan, Han, L.-B.; Ishihara, K.-I.; Kambe, N.; Ogawa, A.; Sonoda, N. *Phosphorus, Sulfur, Silicon* **1992**, *67*, 243.

(7) (a) Reich, H. J.; Phillips, N. H.; Reich, I. L. *J. Am. Chem. Soc.* **1985**, *107*, 4101. (b) Hiiro, T.; Kambe, N.; Ogawa, A.; Miyoshi, N.; Murai, S.; Sonoda, N. *Angew. Chem., Int. Ed. Engl.* **1987**, *26*, 1187. (c) Barros, S. M.; Comasseto, J. V.; Berriel, J. *Tetrahedron Lett.* **1989**, *30*, 7353. (d) Hiiro, T.; Mogami, T.; Kambe, N.; Fujiwara, S.; Sonoda, N. *Synth. Commun.* **1990**, *20*, 703. (e) Hiiro, T.; Morita, Y.; Inoue, T.; Kambe, N.; Ogawa, A.; Ryu, I.; Sonoda, N. *J. Am. Chem. Soc.* **1990**, *112*, 455. (f) Hiiro, T.; Atarashi, Y.; Kambe, N.; Fujiwara, S.; Ogawa, A.; Ryu, I.; Sonoda, N. *Organometallics* **1990**, *9*, 1356. (g) Reich, H. J.; Green, D. P.; Phillips, N. H. *J. Am. Chem. Soc.* **1991**, *113*, 1414.

(8) (a) Uemura, S.; Ohe, K.; Kim, J.-R.; Kudo, K.; Sugita, N. *J. Chem. Soc., Chem. Commun.* **1985**, 271. (b) Ohe, K.; Takahashi, H.; Uemura, S.; Sugita, N. *J. Organomet. Chem.* **1987**, *326*, 35. (c) Ohe, K.; Takahashi, H.; Uemura, S.; Sugita, N. *J. Org. Chem.* **1987**, *52*, 4859. (d) Comasseto, J. V.; Berriel, J. N. *Synth. Commun.* **1990**, *20*, 1681.

Dicyclopropylcarbene: Direct Characterization of a Singlet Dialkylcarbene[†]

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Analogy to methylene might suggest that unconstrained dialkylcarbenes have triplet ground states.[1] Supporting experimental or theoretical[2] evidence is scarce, however. Rapid intramolecular reactions in the singlet states usually preclude intermolecular trapping or direct spectroscopic characterization.[3–6] The only dialkylcarbenes previously instrumentally observed were triplets by EPR.[7] As in carbocations, a cyclopropyl group can significantly stabilize a singlet carbene via homoconjugative interactions.[8–11] In this vein, we now report the first spectroscopic characterization of a singlet dialkylcarbene, dicyclopropylcarbene (**1**).

In contrast to earlier reports,[12] we have found that dicyclopropyldiazirine (**2**) can be synthesized from the cyclohexylimine of the corresponding ketone.[13] Irradiation of **2**, matrix isolated in N_2 (1:700, 6 K, 334 nm, 28 h), produced two major products whose IR spectra exhibited differential photochemical behavior.[14]

[†] Dedicated to Professor Orville L. Chapman, on the occasion of his 60th birthday.

(1) Kirmse, W. *Carbene Chemistry*; Academic Press: New York, NY, 1971. Baron, W. J.; DeCamp, M. R.; Hendrick, M. E.; Jones, M., Jr.; Levin, R. H.; Sohn, M. B. In *Carbenes*; Moss, R. A., Jones, M., Jr., Eds.; Wiley: New York, NY, 1973; Vol. 1, p 1 and references therein.

(2) Gallo, M. M.; Schaefer, H. F., III. *J. Phys. Chem.* **1992**, *96*, 1515 and references therein.

(3) Platz and co-workers have recently reported interception of adamantylidene[4] and homocubanylidine[5] with pyridine. These carbenes are likely ground-state singlets by virtue of small carbenic bond angles. Dimethylcarbene,[6] suggested to be a ground-state triplet, has also recently been observed by this trapping technique.

(4) Morgan, S.; Jackson, J. E.; Platz, M. S. *J. Am. Chem. Soc.* **1991**, *113*, 2782.

(5) (a) Chen, N.; Jones, M., Jr.; White, W. R.; Platz, M. S. *J. Am. Chem. Soc.* **1991**, *113*, 4981. (b) Eaton, P. E.; Appell, R. B. *J. Am. Chem. Soc.* **1990**, *112*, 4055. (c) For a theoretical treatment, see also: Hvrovat, D. A.; Borden, W. T. *J. Am. Chem. Soc.* **1992**, *114*, 2719.

(6) Modarelli, D. A.; Platz, M. S. *J. Am. Chem. Soc.* **1991**, *113*, 8985.

(7) (a) Gano, J. E.; Wettach, R. H.; Platz, M. S.; Senthilnathan, V. P. *J. Am. Chem. Soc.* **1982**, *104*, 2326. (b) Myers, D. R.; Senthilnathan, V. P.; Platz, M. S.; Jones, M., Jr. *J. Am. Chem. Soc.* **1986**, *108*, 4232.

(8) (a) Hoffmann, R.; Zeiss, G. D.; Van Dine, G. W. *J. Am. Chem. Soc.* **1968**, *90*, 1485. (b) Schoeller, W. W. *J. Org. Chem.* **1980**, *45*, 2161. (c) Shevlin, P. B.; McKee, M. L. *J. Am. Chem. Soc.* **1989**, *111*, 519. (d) Wang, R.; Deng, C. *Tetrahedron* **1988**, *44*, 7355. (e) Chou, J.-H.; McKee, M. L.; De Felippis, J.; Squillacote, M.; Shevlin, P. B. *J. Org. Chem.* **1990**, *55*, 3291.

(9) Ho, G. J.; Krogh-Jespersen, K.; Moss, R. A.; Shen, S.; Sheridan, R. S.; Subramanian, R. *J. Am. Chem. Soc.* **1989**, *111*, 6875.

(10) Moss, R. A.; Ho, G.-J.; Shen, S.; Krogh-Jespersen, K. *J. Am. Chem. Soc.* **1990**, *112*, 1638.

(11) (a) Bonneau, R.; Liu, M. T. H.; Rayez, M. T. *J. Am. Chem. Soc.* **1989**, *111*, 5973. (b) Liu, M. T. H.; Bonneau, R. *J. Phys. Chem.* **1989**, *93*, 7298.

(12) Church, R. R. R.; Weiss, M. J. *J. Org. Chem.* **1970**, *35*, 2456.

(13) By a procedure similar to that reported by Liu and Jennings: Liu, M. T. H.; Jennings, B. M. *Can. J. Chem.* **1977**, *55*, 3596. Details are given in the supplementary material.

(14) The low temperature matrix isolation apparatus and irradiation setup have been previously described in the following: Kesselmayer, M. A.; Sheridan, R. S. *J. Am. Chem. Soc.* **1986**, *108*, 99. Hayes, J. C.; Sheridan, R. S. *J. Am. Chem. Soc.* **1990**, *112*, 5879.

0002-7863/92/1514-7592$03.00/0

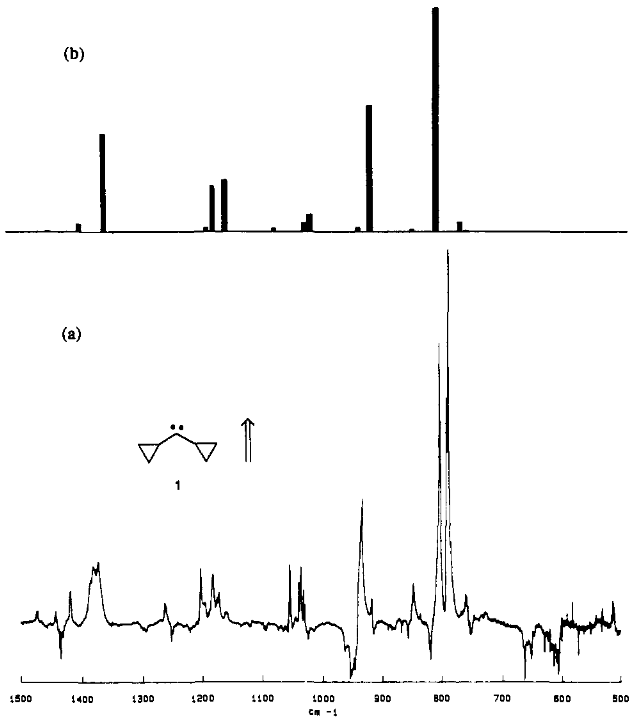
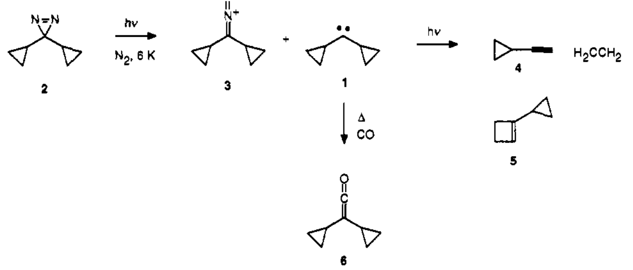


Figure 1. (a) Difference IR spectrum of carbene **1** (positive peaks, in absorbance). Spectrum generated by subtracting IR of N$_2$ matrix containing **1** (from 28-h 334-nm irradiation of **2**) before and after 1-h irradiation at 475 nm. Negative peaks are due to photoproducts of **1**. (b) Calculated (MP2/6-31G*) IR spectrum of carbene **1a** on same wavenumber scale. Frequencies have been multiplied by a factor of 0.93.

Scheme I



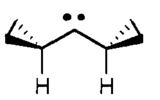
One set of bands included a strong absorption at 2053 cm^{-1}, consistent with dicyclopropyldiazomethane (**3**). The other set of bands, with strongest absorption at 802 cm^{-1}, we assign to carbene **1** (Figure 1). Subsequent irradiation of the matrix at 475 nm for 1 h destroyed the IR peaks of **1** and increased those of ethylene, cyclopropylacetylene (**4**),[15] and 1-cyclopropylcyclobutene (**5**),[16] which were initially present in minor amounts. The diazo compound **3** was stable at these wavelengths and only slowly produced the same photoproducts with broad-band irradiation >340 nm. These results are summarized in Scheme I.

Confirmation of the assignment of the IR spectrum of **1** came from trapping experiments. Irradiation of diazirine **2** in an Ar matrix doped with CO (50:1 Ar:CO, 20 K) produced carbene **1** in the IR. Warming the matrix to 38 K resulted in a decrease of the IR bands of **1** with concurrent growth of a strong absorbance at 2112 cm^{-1}, along with other new bands. This frequency matches that recently reported[17] for dicyclopropylketene (**6**).

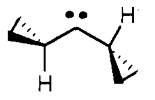
The UV/vis spectrum of the irradiated matrix of **2** showed a broad band at 400–600 nm (λ_{max} 490 nm), along with a stronger absorbance at λ_{max} 230 nm; both bands grew and disappeared simultaneously with the IR of **1**. The "action spectrum" of photodestruction of the IR peaks assigned to **1** roughly matched the UV/vis spectrum, substantiating that the same species was observed by both methods. Irradiation of matrices containing **1** at either end of the long- or short-wavelength UV/vis absorbances caused all of the IR bands of the carbene to disappear simultaneously (as well as the UV/vis spectra). This implies the presence of only one conformer of **1**.[18]

The above spectroscopic results suggest that **1** is a ground-state singlet. Triplet methylene absorbs well only below 200 nm in wavelength, whereas the singlet shows broad absorption from 550 to 950 nm.[19] Shevlin and McKee[8c] have estimated, on the basis of ab initio calculations, that triplet cyclopropylmethylene is ca. 1 kcal/mol lower than the singlet.[20] It is thus not unreasonable that two cyclopropylcarbinyl interactions as in **1** would favor a singlet ground state.

Three conformations of **1** (**1a**, **1b**, and **1c**) can maximally benefit from interaction between the empty carbenic p orbital and the Walsh orbitals of both cyclopropanes. Only **1a** and **1b**,[8c,d] however, would be expected to exhibit low barriers for ring expansion. We thus carried out ab initio calculations to address these conformational issues in more detail.[21] The geometries of **1a**, **1b**, and **1c** were optimized at the MP2/6-31G* level (relative energies: 0, 4.0, and 12.8 kcal/mol for **1a**, **1b**, and **1c**, respectively, uncorrected for zero point energy). Vibrational calculations indicated that a C_{2v} structure for **1c** was not an energy minimum (in contrast to **1a** and **1b**). Relaxation to a skewed C_2 geometry, however, produced a local minimum. The vibrational spectrum calculated for **1a**, scaled by a factor of 0.93,[22] is in excellent agreement with the observed IR (Figure 1b).[23] In contrast, calculated vibrations for **1b** or **1c** do not fit the experimental spectra. The calculated wavelengths for the lowest energy electronic transition from the CIS method[21] (configuration interaction with single excitations, 6-31G*) for **1a**, **1b**, and **1c**, respectively, are 475, 538, and 629 nm. The ab initio calculations thus support the contention that **1** is a ground-state singlet, and that only conformation **1a** is observed.[24,25]



1a



1b

1c

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[15] Cyclopropylacetylene, IR: Schrumpt, G.; Klein, A. W. *Spectrochim. Acta* **1985**, *41A*, 1251.

[16] Cyclopropylcyclobutene was independently synthesized as in the following: Nishida, S.; Moritani, I.; Tsuda, E.; Teraji, T. *J. Chem. Soc., Chem. Commun.* **1969**, 781.

[17] Allen, A. D.; Baigrie, L. M.; Gong, L.; Tidwell, T. T. *Can. J. Chem.* **1991**, *69*, 138.

[18] (a) Sheridan, R. S.; Kesselmayer, M. A. *J. Am. Chem. Soc.* **1984**, *106*, 436. (b) Kesselmayer, M. A.; Sheridan, R. S. *J. Am. Chem. Soc.* **1986**, *108*, 844. (c) Sheridan, R. S.; Moss, R. A.; Wilk, B. K.; Shen, S.; Wlostowski, M.; Kesselmayer, M. A.; Subramanian, R.; Kmiecik-Lawrynowicz, G.; Krogh-Jespersen, K. *J. Am. Chem. Soc.* **1988**, *110*, 7563. (d) Du, X.-M.; Fan, H.; Goodman, J. L.; Kesselmayer, M. A.; Krogh-Jespersen, K.; LaVilla, J. A.; Moss, R. A.; Shen, S.; Sheridan, R. S. *J. Am. Chem. Soc.* **1990**, *112*, 1920.

[19] (a) Herzberg, G. *Proc. R. Soc., London* **1961**, *A262*, 291. (b) Herzberg, G.; Johns, J. W. C. *Proc. R. Soc., London* **1964**, *295*, 107.

[20] Phenyl(1-benzylcyclopropyl)carbene exhibits a triplet EPR spectrum at low temperatures: Barcus, R. L.; Palik, E. C.; Platz, M. S. *Tetrahedron Lett.* **1982**, *23*, 1323.

[21] Ab initio calculations were carried out with Gaussian 90, Revision J: Frisch, M. J.; Head-Gordon, M.; Trucks, G. W.; Foresman, J. B.; Schlegel, H. B.; Raghavachari, K.; Robb, M.; Binkley, J. S.; Gonzalez, C.; Defrees, D. J.; Fox, D. J.; Whiteside, R. A.; Seeger, R.; Melius, C. F.; Baker, J.; Martin, R. L.; Kahn, L. R.; Stewart, J. J. P.; Topiol, S.; Pople, J. A. Gaussian, Inc., Pittsburgh, PA, 1990.

[22] (a) Wiberg, K. B.; Walters, V. A.; Dailey, W. P. *J. Am. Chem. Soc.* **1985**, *107*, 4860. (b) O'Gara, J. E.; Dailey, W. P. *J. Am. Chem. Soc.* **1992**, *114*, 3581.

[23] We do not know the origin of the splitting of the ca. 800 cm^{-1} IR absorption of **1** into two bands. The 14-cm^{-1} splitting is probably too large to be due to different matrix sites, is observed in both Ar and N$_2$, cannot be annealed out at 35 K, and is not predicted by the calculations. It is possible that the two bands arise from Fermi resonance with an overtone of a ca. 400 cm^{-1} band, of the same symmetry, predicted by the calculations.

[24] Dicyclopropylcarbene (**1**) has been trapped in solution. (a) Bekhazi, M.; Risbood, P. A.; Warkentin, J. *J. Am. Chem. Soc.* **1983**, *105*, 5675. (b) Freeman, P. K.; Wuerch, S. E.; Clapp, G. E. *J. Org. Chem.* **1990**, *55*, 2587.

[25] Preliminary experiments indicate that **1** does not react with O$_2$ in Ar matrices at 40 K, under conditions where triplet carbenes react spontaneously. This lends additional support to a singlet ground state for **1**. See, for example: Sander, W. *Angew. Chem., Int. Ed. Engl.* **1990**, *29*, 344.

Acknowledgment. We thank the donors of the Petroleum Research Fund, administered by the American Chemical Society, and the National Science Foundation (CHE-8903155) for generous support of this work. We also thank the National Science Foundation for partial funding for the purchase of the Convex C210 computer used in this work.

Supplementary Material Available: Synthetic details for **2**, experimental IR data for **1**, and ab initio calculated geometries and vibrational frequencies for **1a**, **1b**, and **1c** (14 pages). Ordering information is given on any current masthead page.

Intramolecular Carbon–Carbon Bond Formation by the Anodic Oxidation of Unsaturated α-Stannyl Heteroatom Compounds. Synthesis of Fluorine-Containing Heterocyclic Compounds

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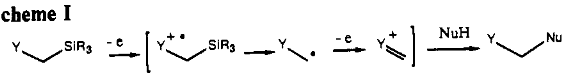
Although group 14 organometallic compounds are normally utilized as carbanion equivalents,[1,2] recent investigations reveal that they also serve as carbocation equivalents if one employs electrochemical oxidation.[3] For example, anodic oxidation of α-silyl ethers results in facile cleavage of the carbon–silicon bond and introduction of a nucleophile such as an alcohol onto the carbon (Scheme I). However, the introduction of carbon nucleophiles to form a new carbon–carbon bond by anodic oxidation of such compounds has remained an unexplored area of research.[4,5]

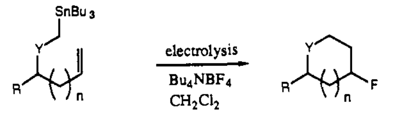
In this paper we wish to report that the anodic oxidation of α-stannyl ethers and carbamates containing carbon–carbon double bonds can lead to effective intramolecular carbon–carbon bond formation (Scheme II). A fluorine atom is introduced onto one of the original olefinic carbons in the cyclized product. The method outlined here is a new approach to both electrochemical carbon–carbon bond formation[6] and the synthesis of fluorine-containing compounds.[7,8]

Scheme I



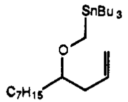
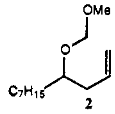
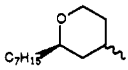
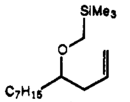
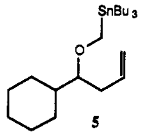
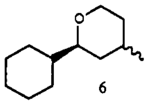
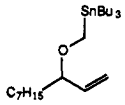
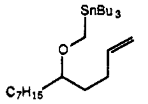
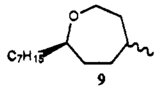
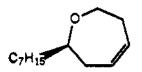
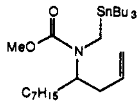
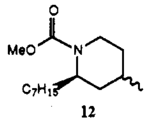
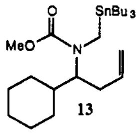
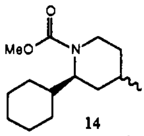
Y = R'O, R'S, R'NCO$_2$Me
NuH = R"OH, R"NHCO$_2$Me

Scheme II



Y = O, NCO$_2$Me
n = 1, 2

Table I. Intramolecular Carbon–Carbon Bond Formation by the Anodic Oxidation of Unsaturated α-Stannyl Ethers and Carbamates[a]

substrate	electrolyie	electricity (F/mol)	product	yield, %
 **1**	Bu$_4$NBF$_4$ [b]	2.3	 **2**	93
	Bu$_4$NBF$_4$	3.1	 **3** (cis / trans = 2.8 : 1)	83
	Bu$_4$NPF$_6$	2.5	**3** (cis / trans = 1.2 : 1)	98
 **4**	Bu$_4$NBF$_4$	4.6	**3** (cis / trans = 1.2 : 1)	68
 **5**	Bu$_4$NBF$_4$	3.2	 **6** (cis / trans = 3 : 1)	95
 **7**	Bu$_4$NBF$_4$	3.2	complex mixture	
 **8**	Bu$_4$NBF$_4$	3.1	 **9**	61 [c]
			 **10**	28
 **11**	Bu$_4$NBF$_4$	2.3	 **12** (cis / trans = 1.5 : 1)	70
 **13**	Bu$_4$NBF$_4$	2.0	 **14** (cis / trans = 3.1 : 1)	50

[a] The reactions were normally carried out with 0.25 mmol of the substrate. [b] Methanol was used as solvent. [c] A mixture of two stereoisomers (1.8:1).

We initially examined the anodic oxidation of α-stannyl ether **1** (Scheme III) because in the case of α-silyl ethers the radical intermediate generated by the first one-electron oxidation would be oxidized spontaneously on the surface of the anode (Scheme I). The oxidation potentials of carbon radicals are generally much

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(1) For example, (a) Colvin, E. W. *Silicon in Organic Synthesis*; Butterworths: London, 1981. (b) Weber, W. P. *Silicon Reagents for Organic Synthesis*; Springer-Verlag: West Berlin, 1983.

(2) Organostannanes are also used as carbon radical equivalents. For example: Pereyre, M.; Quintard, J.-P.; Rahm, A. *Tin in Organic Synthesis*; Butterworths: London, 1987.

(3) For example, (a) Yoshida, J.; Matsunaga, S.; Murata, T.; Isoe, S. *Tetrahedron* **1991**, *47*, 615–624. (b) Koizumi, T.; Fuchigami, T.; Nonaka, T. *Chem. Express* **1986**, *1*, 355–358. (c) Schaefer, H. J.; Hermeling, D.; Lange, K.-H. *Extended Abstracts*, Spring Meeting of the Electrochemical Society, May 6–11, 1984, Cincinnati, OH; p 441 and references cited therein.

(4) Carbon–carbon bond formation by the anodic oxidation of silyl enol ethers has been achieved: Schäfer, H. J. *Angew. Chem., Int. Ed. Engl.* **1981**, *20*, 911–934.

(5) Carbon–carbon bond formation has been achieved by photoelectron-transfer reactions of organometallic compounds. See, for example: (a) Cho, I.-S.; Tu, C.-L.; Mariano, P. S. *J. Am. Chem. Soc.* **1990**, *112*, 3594–3607. (b) Mizuno, K.; Nakanishi, K.; Otsuji, Y. *Chem. Lett.* **1988**, 1833–1836 and references cited therein. Oxidative carbon–carbon bond formation using thallium(III) trifluoroacetate has been reported: (c) Ochiai, M.; Arimoto, M.; Fujita, E. *Tetrahedron Lett.* **1981**, *22*, 4491–4494.

(6) Anodic oxidation: (a) Moeller, K. D.; Tinao, L. V. *J. Am. Chem. Soc.* **1992**, *114*, 1033–1041. (b) Hudson, C. M.; Marzabadi, M. R.; Moeller, K. D.; New, D. G. *J. Am. Chem. Soc.* **1991**, *113*, 7372–7385 and references cited therein. Cathodic reduction: (c) Amputch, M. A.; Little, R. D. *Tetrahedron* **1991**, *47*, 383–402. Lombardo, F.; Newmark, R. A.; Kariv-Miller, E. *J. Org. Chem.* **1991**, *56*, 2422–2427. Shono, T.; Kise, N.; Uematsu, N.; Morimoto, S.; Okazaki, E. *J. Org. Chem.* **1990**, *55*, 5037–5041 and references cited therein.

(7) Reviews, for example: (a) Welch, J. T. *Tetrahedron* **1987**, *43*, 3123–3197. (b) Gerstenberger, M. R. C.; Haas, A. *Angew. Chem., Int. Ed. Engl.* **1981**, *20*, 647–667. (c) Schlosser, M. *Tetrahedron* **1978**, *34*, 3–17.

(8) Electrochemical fluorination, for example: (a) Fuchigami, T.; Shimojo, M.; Konno, A.; Nakagawa, K. *J. Org. Chem.* **1990**, *55*, 6074–6075. (b) Brigaud, T.; Laurent, E. *Tetrahedron Lett.* **1990**, *31*, 2287–2290 and references cited therein.

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