Diastereoselective Oxyselenylation of 1,n-Diolefins Utilizing PET Generated [PhSeSePh]$^{+\cdot}$ as an Electrophilic Species: An Efficient and General Strategy for the Synthesis of α,α′-*trans*-Dialkyl Cyclic Ethers

Ganesh Pandey*, R. Sochanchingwung, Shashi Kant Tiwari

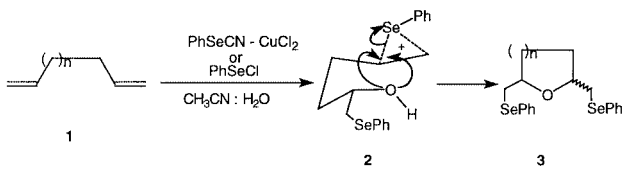
Division of Organic Chemistry (Synthesis), National Chemical Laboratory, Pune - 411008, INDIA.
Fax 91-(020)-393153; Email : pandey@ems.ncl.res.in

Received 26 May 1999

Abstract: PET generated electrophilic species [PhSeSePh]$^{+\cdot}$ is found to effect stereoselective oxyselenylation of 1,n-diolefins (**1**) leading to a novel strategy for the synthesis of α,α′-*trans*-dialkyl cyclic ethers (**5**) in good yields.

Key Words: photosensitized electron transfer (PET), episelenonium radical cation, oxyselenylation, α,α′-dialkyl cyclic ethers.

Stereoselective synthesis of α,α′-dialkyl cyclic ethers have attracted considerable attention, recently, owing to their unique structural features and presence in the large number of polyether antibiotics and other biologically active natural products[1]. In majority of these natural products, cyclic ether units display α,α′-*trans*-dialkyl substituents. For example, majority of *Annonaceous* acetogenins possess *trans*-2,5-dialkyl tetrahydrofurans[2] while swinholides,[3] potent cytotoxic agents[4], and laurapinnacins[5] display *trans*-2,6-dialkyl tetrahydropyran and *trans*-2,7-dialkyl oxepans moieties, respectively. Among the various strategies reported[6] for the synthesis of these structural units, bis addition of an oxygen nucleophile across the 1,n-diolefins (dienes) moiety represents an attractive approach,[7] however, these strategies afforded mixture of diastereomers. Oxyselenylation of diolefins **1**, reported[8] by using PhSeCN-$CuCl_2$ or PhSeCl as reagents in aqueous acetonitrile, though, is known to produce α,α′-dialkyl cyclic ethers, however, this strategy apart from utilising very toxic and unstable reagents is also not stereoselective. The non-stereoselectivity of these reagents may be understood by considering the possible lack of steric restriction for the face selection from the transition



Scheme 1

state structure **2** during the intramolecular selenoetherification step.

Few years back, we had reported[9, 10] a photosensitized electron transfer (PET) strategy of activating PhSeSePh for *in situ* generation of electrophilic selenium species

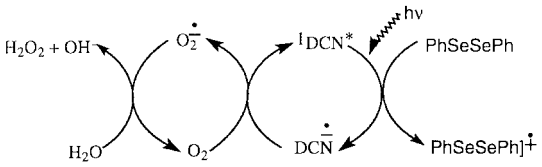
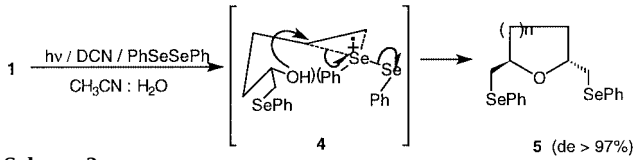


Figure 1

[PhSeSePh]$^{+\cdot}$ employing 1,4- dicyanonaphthalene (DCN) as light-harvesting electron acceptor

through the photosystem as shown in **fig.1** and the utility of this transient species was suggested for the efficient selenoetherification[9] and enyne cyclisation[10] reactions. Intrigued by the possible utilisation of [PhSeSePh]$^{+\cdot}$ for *trans*-selective oxyselenylation of **1**, owing to the envisaged *syn*-addition[11] of the hydroxyl group to the episelenonium radical cation[12] moiety from the expected transition state structure **4**, we initiated our study and are pleased to disclose herein the success and application of our concept for the synthesis of various α,α′-*trans*-dialkyl substituted tetrahydrofurans, tetrahydropyrans and oxepanes.

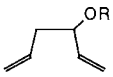
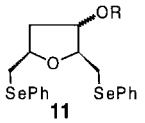
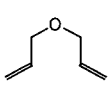
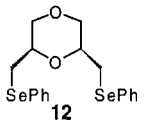
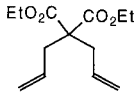
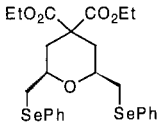
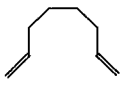
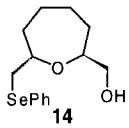
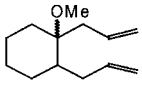
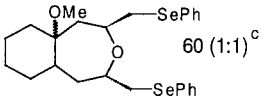


Scheme 2

The [PhSeSePh]$^{+\cdot}$ mediated oxyselenylation reaction was initially carried out by irradiating a mixture of 1,5-hexadiene (1, n=1) (6.0 mmol), PhSeSePh (6.0 mmol), and DCN (0.6 mmol) in CH_3CN:H_2O (4:1) solvent, utilizing 450-W Hanovia medium pressure lamp without removing dissolved oxygen from the solvent. The lamp was housed in a water cooled pyrex immersion vessel which allowed only >280 nm light to pass through. Under the irradiation condition mentioned, most of the light was absorbed by DCN only. After about 8 h of irradiation when **1** was substantially consumed (60%, monitored by GC) photolysis was discontinued. Removal of the solvent followed by column chromatographic purification of the crude photolysate gave **5** (n=1) in 80% yield. The yield of **5** was calculated based on the starting material utilized.

Diastereomeric purity of **5** in >97% was established by comparing the HPLC analysis (reverse phase, C_{18} Bonda pack 0.5 μm column) with the authentic mixture prepared by following the reported[8] procedure. The characterization and confirmation of the 2,5-*trans*-stereochemistry for **5** was established by detailed ^{1}H NMR, ^{13}C NMR and mass spectral analysis. DCN was recovered almost quantitatively (≈ 98 %) at the end of the reaction.

Table: trans-selective Oxyselenylation of 1,n-diolefins

Substrate	Irradiation time (h)	Products[a]	Yield[b] (%)	diastereomeric purity (%)[d]
 **6**	15	 **11**	60 (1:1)[c]	
 **7**	14	 **12**	80	98
 **8**	15	 **13**	65	98
 **9**	16	 **14**	50	97
 **10**	16	 **15**	60 (1:1)[c]	

a) Characterised by 1H NMR, 13C NMR and Mass spectral data. b) Isolated yields, calculated on the basis of strarting material utilised, longer irradiation leads to deselylation reaction [14]. c) ratio determined by HPLC analysis d) diastereomeric purity established by comparing the HPLC analysis with the authentic mixtures.

In order to establish the generality of this reaction, number of substrates (**6–10**) were studied and the results are summarized in the Table. The α,α′-*trans*-dialkyl stereochemistry in each product was established, beyond doubt, by detailed spectral analyses.[13] In each case, the products were isolated in the diselenylated form except for **9** where monodeselenylated product **14** was obtained, obviously, by the further oxidative PET cleavage of -C-Se- bond as reported by us earlier.[14]

In conclusion, a novel strategy involving atom economy concept[15] has been developed for the synthesis of α,α′-*trans* cyclic ethers by the oxyselenylation of dienes utilizing *in situ* generated electrophilic selenium species. Further, application of this strategy utilizing optically active diaryldiselenide is in progress .

Acknowledgement

One of us (RS) is thankful to CSIR, New Delhi for financial support.

References and Notes

(1) Westley, J. W. Ed., *Polyether Antibiotics*; *Naturally Occurring Acid Ionophores*. Marcell-Dekkar,New York, 1983, Vol. I & II.
(2) (a) Rupprecht, J.K.; Hui, Y.- H.; Mc Laughlin, J. L., *J. Natural Products*, **1990,** 53, 237. (b) Hoppe, R.; Scharf, H.-D. *Synthesis* **1995**, 1447. (c) Koert, U., *Synthesis*, **1995**, 115.
(3) Norcross, R. D.; Paterson, I. *Chem. Rev.* **1995**, 95, 2041.
(4) Doi, M.; Ishida, T.; Kobayashi, M.; Kitagawa, I., *J. Org. Chem.* **1991**, 56, 3629.
(5) Kotsuki, H.; Ushio, Y.; Kadota, I.; Ochi, M., *J. Org. Chem.* **1989**, 54, 5153. and references cited therein.
(6) (a) Elliott, M.C. *J. Chem. Soc. Perkin Trans.1* **1998**,4175. (b) Eluterio, A.; Candenas, M-L.; Perez, R.; Ravelo, J.L. and Martin, J. D. *Chem. Rev.* **1995**, 95, 1953. (c) Kotsuki, H., *Synlett*, **1992**, 97. (d) Taryn, L.B. Boivin, *Tetrahedron* **1987**, 43, 3309. (e) Moody, C.J.; Martin, J.D. *Studies in Natural Products: Atta-ur-Rehman* 1992, vol. 10, 201.
(7) (a) Kurth, M. J.; Rodriguez, M. J. *J. Am. Chem. Soc.* **1987**, 109, 7577 and references cited therein. (b) Kurth, M. J.; Rodriguez, M. J. *Tetrahedron* **1989,** 45, 6963.
(8) (a) Uemura, S.; Toshimitsu, A.; Aoai, T.; Okano, M. *Tetrahedron Lett*. **1980**, 21, 1533. (b) Uemura, S.; Toshimitsu, A.; Aoai, T.; Okano, M. *Chem. Lett.* **1979**, 1359. (c) Toshimitsu, A.; Uemura, S.; Okano, M., *J. Chem. Soc Chem. Commun*. **1982,** 87.
(9) (a) Pandey, G.; Rao, V. J.; Bhalerao, U. T. *J. Chem. Soc. Chem. Commun.* **1989**, 416.(b) Pandey, G.; Soma Shekhar, B.B.V., *J. Org. Chem.*, **1992,** 57, 4019.
(10) (a) Pandey, G.; Soma Sekhar, B.B.V. *J. Chem. Soc. Chem. Commun.* **1993**, 1636. (b) Pandey, G.; Soma Sekhar, B.B.V., *Tetrahedron*, **1995,** 51, 1483.
(11) For a recent *syn*-addition approach to trans-2,5-dialkyl tetrahydrofuran, see Towne, T.B.; McDonald, F.E. *J. Am. Chem. Soc.* **1997,** 119, 6022.
(12) For direct addition of a nucleophile to a radical-cation possessing stabilising functionalities, see Reitstoen, B.; Parker, V. D. *J. Am. Chem. Soc.* **1991**, 113, 6954.
(13) Representative ^{1}H NMR and ^{13}C NMR data of cyclic ethers: Compound **5;** ^{1}H NMR (200 MHz, $CDCl_3$): δ 7.53 (4H, m), 7.33 (6H, m), 4.31 (1H, m), 4.17 (1H, m), 3.16 (2H, m), 3.01 (2H, m), 2.15 (2H, m), 1.76 (2H, m). ^{13}C NMR (50 MHz, $CDCl_3$): δ 132.58, 132.49, 130.92, 129.43, 129.09, 126.65, 79.18, 78.70, 33.20, 32.13, 31.26. Compound **12**: ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.60 (4H, m), 7.25 (6H, m), 3.90 (1H, m), 3.75 (3H, m), 3.55 (1H, dd, J = 5.3, 11.2 Hz), 3.05 (4H, m), 2.73 (1H, dd, J = 5.3, 11.2 Hz). ^{13}C NMR (50 MHz, $CDCl_3$) δ 133.32, 133.15, 129.50, 127.48, 75.54, 70.61, 70.38, 69.50, 28.68, 28.32. Compound **14**: ^{1}H NMR (200 MHz, $CDCl_3$) δ 7.50 (2H, m), 7.24 (3H, m), 4.08 (1H, m), 3.88 (1H, m), 3.71 (1H, m), 3.08 (1H, dd, J = 7.2, 12.9 Hz), 2.95 (1H, dd, J = 7.2, 12.9 Hz), 2.05 (2H, m), 1.87 (2H, m), 1.59 (2H, m), 1.87 (3H, bs). ^{13}C NMR (50 MHz, $CDCl_3$) δ 132.77, 130.56, 129.24, 127.03, 78.55, 68.56, 33.26, 31.75, 26.17.
(14) (a) Pandey, G.; Soma Sekhar, B.B.V.; Bhalerao, U.T. *J.Am. Chem. Soc.* **1990,** 112, 5650. (b) Pandey. G.; Soma Sekhar, B.B. V. *J. Org. Chem.* **1994,** 59, 7367.
(15) (a) Trost, B.M., *Science*, **1991,** 254, 1471. (b) Trost, B. M. *Angew. Chem. Int. Ed. Eng.* **1995,** 34, 259.

Article Identifier:
1437-2096,E;1999,0,08,1257,1258,ftx,en;L06799ST.pdf