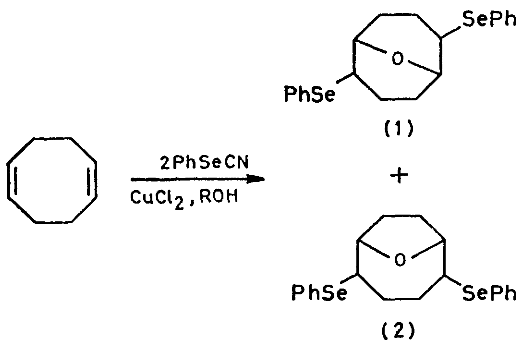
Oxyselenation of Cyclo-octa-1,5-diene. Solvent-controlled Formation of 9-Oxabicyclo-[3.3.1]- and -[4.2.1]-nonane Derivatives

By Sakae Uemura,* Akio Toshimitsu, Toshiaki Aoai, and Masaya Okano

(*Institute for Chemical Research, Kyoto University, Uji, Kyoto, Japan*)

Summary Reaction of cyclo-octa-1,5-diene with phenyl selenocyanate in alcohol or aqueous tetrahydrofuran in the presence of copper(II) chloride produces an isomeric mixture of 2,6-bis(phenylseleno)-9-oxabicyclo[3.3.1]-nonane and 2,5-bis(phenylseleno)-9-oxabicyclo[4.2.1]nonane in good yield, the isomer ratio being solvent dependent.

RECENTLY oxyselenation of olefins using aryl or alkyl selenocyanates with a copper or nickel halide has been reported to afford the corresponding β-oxyselenides in high yields.[1] We have now found that application of this reaction to cyclo-octa-1,5-diene (1,5-cod) gave the seleno-substituted isomeric oxabicyclononanes {[3.3.1] and [4.2.1]} in good yields and that a suitable choice of solvent resulted in the selective formation of each isomer.[2] This is the first example of a solvent-controlled preparation of these isomers and has not been achieved in reactions with other electrophiles such as mercury,[3,4] iodine,[3,5] or H^+,[6] and may be another characteristic feature of organoselenium chemistry in which we are currently interested.[1,7]

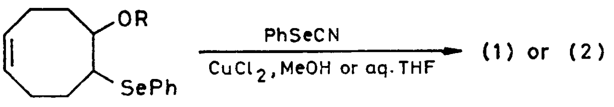


By heating an alcohol solution of 1,5-cod (1 mol. equiv.) and phenyl selenocyanate (2 mol. equiv.) in the presence of copper(II) chloride, an isomeric mixture of 2,6-bis(phenylseleno)-9-oxabicyclo[3.3.1]nonane (**1**) and 2,5-bis(phenylseleno)-9-oxabicyclo[4.2.1]nonane (**2**) was formed. The isomer ratio (**1**):(**2**) depended on the alcohol utilized; *i.e.*, (**1**) was the major product in methanol and (**2**) in t-butyl alcohol. When aqueous tetrahydrofuran (THF) was used as solvent, (**2**) became the sole product. Typical results are shown in the Table. If this reaction is comparable with the oxyselenation of other olefins by this method,[1] it should proceed through alkoxy- or hydroxyselenation of one double bond, followed by intramolecular attack of the alkoxy or hydroxy group upon the episelenonium ion formed at the other double bond by the attack of phenyl selenocyanate. In order to confirm this we have prepared 5-methoxy- and 5-hydroxy-6-phenylselenocyclooctene, (**3**) and (**4**) respectively, separately and treated both

TABLE. Oxyselenation of cyclo-octa-1,5-diene[a]

Solvent (10 ml)	% Yield of (**1**) + (**2**)[b]	Isomer ratio (**1**) : (**2**)[c]
MeOH	62	95:5
EtOH	62	90:10
$\mathrm{Pr^iOH}$	73	82:18
$\mathrm{Bu^tOH}$	44	38:62
$THF-H_2O$(9:1)	68	0:100

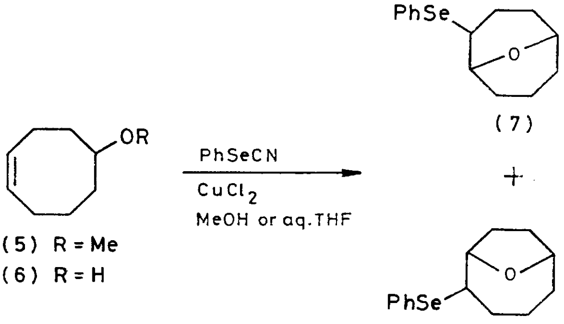
[a] Carried out using 1,5-cod (5 mmol), PhSeCN (10 mmol), and $CuCl_2$ (5 mmol) under reflux for 5 h. [b] Isolated yield. Both (**1**) and (**2**) gave satisfactory analytical and spectral data: m.p. of (**1**), 84—85 °C (n-hexane); m.p. of (**2**), 97·5—98·5 °C (n-hexane). [c] Determined by comparison of peak heights of the signals (^{13}C n.m.r. spectra) due to carbon atoms attached to oxygen or selenium: (**1**), δ 44·5 (d, *C*HSe) and 69·1 p.p.m. (d, *C*HO); (**2**), 40·1 (d, *C*HSe) and 81·0 p.p.m. (d, *C*HO).



(3) R = Me
(4) R = H

with phenyl selenocyanate and copper(II) chloride in methanol or aqueous THF under reflux for 5 h. Consistent with the results described above, (**1**) was the major product formed from (**3**) (R = Me) using methanol as solvent (62% isolated yield), while in aqueous THF (**2**) was the sole product (81% isolated yield).

A similar clear-cut difference of selectivity for the [3.3.1]- or [4.2.1]-ring framework was also observed when this oxyselenation was applied to 5-methoxy- and 5-hydroxy-cyclo-octene, (**5**) and (**6**) respectively. The product was a mixture of 2-phenylseleno-9-oxabicyclo[3.3.1]nonane (**7**) and 2-phenylseleno-9-oxabicyclo[4.2.1]nonane (**8**). Compound (**7**) was the main product formed when (**5**) was treated in methanol [80% yield, (**7**) : (**8**) = 89 : 11],† while (**8**) was the major product formed when (**6**) was treated in aqueous THF [99% yield, (**7**) : (**8**) = 19 : 81].† The slightly lower selectivity for (**8**) compared to that for (**2**) was attributed to isomerization between (**7**) and (**8**). In fact, a slow isomerization of (**8**) to (**7**) was observed under the conditions employed which was accelerated by the addition of hydrogen chloride; *i.e.*, almost pure (**8**) isomerized to a mixture of (**7**) and (**8**) [(**7**) : (**8**) = *ca.* 4 : 1] when heated in methanol containing HCl for 5 h. In contrast, no isomerization between (**1**) and (**2**) took place.



(5) R = Me
(6) R = H
(7)
(8)

The reason for this clear-cut difference of selectivity in these reactions is not yet clear, but the difference of stability in the intermediate oxonium ion which has hydrogen or an alkyl group as the leaving group seems to be the determining factor.

Application to other dienes such as diallyl ether and hexa-1,5-diene resulted in the formation of normal β-oxyselenides in most cases. However, when the reaction was carried out in t-butyl alcohol, 2,6-bis(phenylselenomethyl)-1,4-dioxan (25% isolated yield) and 2,5-bis(phenylselenomethyl)tetrahydrofuran (27% isolated yield) were selectively obtained from diallyl ether and hexa-1,5-diene, respectively.

Since arylseleno groups can be easily removed by oxidation or reduction,[8] this may be a useful method for producing a suitable cyclic ether or cyclic allylic ether.

(*Received*, 10*th April* 1979; *Com.* 391.)

---

† Yields were determined by g.l.c. analysis. Both (**7**) and (**8**), isolated by column chromatography (silica gel; eluant, n-hexane–ethyl acetate), gave satisfactory analytical and spectral data. The isomer ratio was determined as for (**1**) : (**2**) (see Table). ^{13}C N.m.r. data (δ): (**7**), 45·1 (d, CHSe), 66·3 (d, CHO), and 69·6 p.p.m. (d, CHO); (**8**), 48·6 (d, CHSe), 76·1 (d, CHO), and 81·1 p.p.m. (d, CHO).

[1] A. Toshimitsu, S. Uemura, and M. Okano, *J.C.S. Chem. Comm.*, 1977, 166.

[2] Presented at the 38th annual meeting of the Chemical Society of Japan, Nagoya, October 1978, Abstracts II, p. 407.

[3] A. C. Cope, M. A. McKervey, and N. M. Weinshenker, *J. Org. Chem.*, 1969, **34**, 2229.

[4] H. Stetter and H. J. Meissner, *Tetrahedron Letters*, 1966, 4599.

[5] J. N. Labows, Jr. and D. Swern, *J. Org. Chem.*, 1972, **37**, 3004.

[6] H. J. Franz, W. Höbold, R. Höhn, G. Müller-Hagen, R. Müller, W. Pritzkow, and H. Schmidt, *J. prakt. Chem.*, 1970, **312**, 622.

[7] S. Uemura, A. Toshimitsu, M. Okano, and K. Ichikawa, *Bull. Chem. Soc. Japan*, 1975, **48**, 1925; A. Toshimitsu, Y. Kozawa, S. Uemura, and M. Okano, *J.C.S. Perkin I*, 1978, 1273; A. Toshimitsu, S. Uemura, and M. Okano, *ibid.*, 1979, 1206.

[8] D. L. J. Clive, *Tetrahedron*, 1978, **34**, 1049 and references therein.