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STABLE SELENOXANTHENIUM YLIDES : SYNTHESIS AND NEW REDUCTIVE CYCLIZATION OF SELENOXANTHEN-10-IO(ALKOXALYL ALKOXYCARBONYL)METHANIDES AND THEIR RELATED COMPOUNDS

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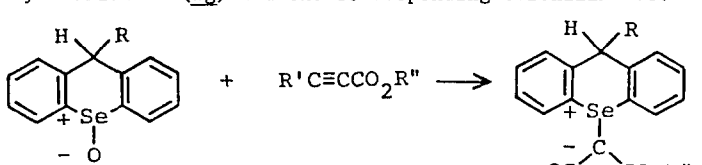
Summary: Stereoisomers of 9-substituted selenoxanthen-10-io(alkoxalyl alkoxycarbonyl)methanides were prepared from the corresponding selenoxides and activated acetylenes. In the reaction of 9-phenylselenoxanthene 10-oxide(1c) with methyl propiolate afforded an unexpected product, methyl 9-phenylselenoxanthen-9-ylpropiolate(5) together with ylide(2e). The selenonium ylides underwent new reductive cyclization with sodium borohydride to afford new cyclic selenonium ylides.

Recently some stable π-selenuranes were synthesized[1] and their interesting reactions were reported.[2] Concerning the stereoisomer of selenonium ylides, Oae et al. succeeded in the synthesis of optically active one by asymmetric induction,[3] but no report has been published on the isolation of the pure stereoisomers of selenonium ylides. Previously we reported the isolation of the stereoisomers of selenilimines having activated hydrogen on their γ-position and their stereospecific reactions.[4] We wish to report here the first isolated stereoisomers of selenonium ylides having activated γ-hydrogen and their new reductive cyclization with $NaBH_4$.

9-Phenylselenoxanthen-10-io(methoxalyl methoxycarbonyl)methanide(2e) was prepared from 9-phenylselenoxanthene 10-oxide and dimethyl acetylenedicarboxylate(DMAD) in acetonitrile at room temperature for 140 hr, and separated into two stereoisomers, cis-2e and trans-2e by preparative TLC or column chromatography. cis-9-Phenylselenoxanthen-10-io(methoxalyl methoxycarbonyl)methanide (cis-2e) as colorless prisms: mp 211-214°(dec.); ^{1}H-NMR ($CDCl_3$) δ 3.55(3H, s, CO_2CH_3), 3.90(3H, s, CO_2CH_3), 5.04(1H, s, C_9-H), 7.00-7.90(13H, m, ArH); MS m/e 480(M^+, Se=80). trans-9-Phenylselenoxanthen-10-io(methoxalyl methoxycarbonyl)methanide(trans-2e) as colorless prisms: mp 197-200° (dec.), ^{1}H-NMR ($CDCl_3$) δ 3.42(3H, s, CO_2CH_3), 3.86(3H, s, CO_2CH_3), 5.67(1H, s, C_9-H), 6.60-7.00 (2H, m, $C_{2',6'}$-H), 7.00-7.95(11H, m, ArH); MS m/e 480(M^+, Se=80).

The stereochemical relationship between the 9-R and Se^+-$\bar{C}$(COR' CO_2R") groups in the selenonium ylides(2) was determined by a comparison of the NMR spectra with those of the perdeuteriophenyl derivative(2g) and the corresponding selenilimines.[4,5]



1a:R=H
1b:R=iso-C_3H_7
1c:R=C_6H_5
1d:R=C_6D_5

MP:R'=H, R"=CH_3
DMAD:R'=CO_2CH_3, R"=CH_3
DEAD:R'=$CO_2C_2H_5$, R"=C_2H_5

2a:R=H, R'=CO_2CH_3, R"=CH_3
2b:R=H, R'=$CO_2C_2H_5$, R"=C_2H_5
2c:R=iso-C_3H_7, R'=CO_2CH_3, R"=CH_3
2d:R=C_6H_5, R'=H, R"=CH_3
2e:R=C_6H_5, R'=CO_2CH_3, R"=CH_3
2f:R=C_6H_5, R'=$CO_2C_2H_5$, R"=C_2H_5
2g:R=C_6D_5, R'=CO_2CH_3, R"=CH_3

Refluxing the trans-2e in toluene for 6 hr did not cause isomerization and rearrangement, but a little decomposition. Other stable selenonium ylides were prepared from the corresponding selenoxides[6] with activated acetylenes(MP, DMAD, and DEAD)(Table 1).

Table 1: Synthesis of Selenoxanthenium Ylides

Selenoxide	$R'C{\equiv}CCO_2R''$(molar ratio)	Solvent	Time(hr)	Temperature	Yield(%)[a]	Product(cis:trans)[b]
1a	DMAD (5)	CH_2Cl_2	4	r.t.	56.2	2a
1a	DEAD (2)	CH_2Cl_2	16 2	r.t. and then reflux	72.8	2b
1b[c]	DMAD (2)	$CHCl_3$	17	reflux	55.7	trans-2c[d]
1c[c]	MP (2)	CH_3CN	12	reflux	13.1	2d(1:6)
1c[c]	MP (10)	CH_2Cl_2	72	reflux	26.9	2d(1:9.3)
1c[c]	DMAD (1)	CH_3CN	140	r.t.	57.7	2e(1:3.7)
1c[c]	DEAD (1)	CH_3CN	312	r.t.	71.3	trans-2f[d]
1d[c]	DMAD (1)	CH_3CN	156	r.t.	77.7	2g(1:6.6)

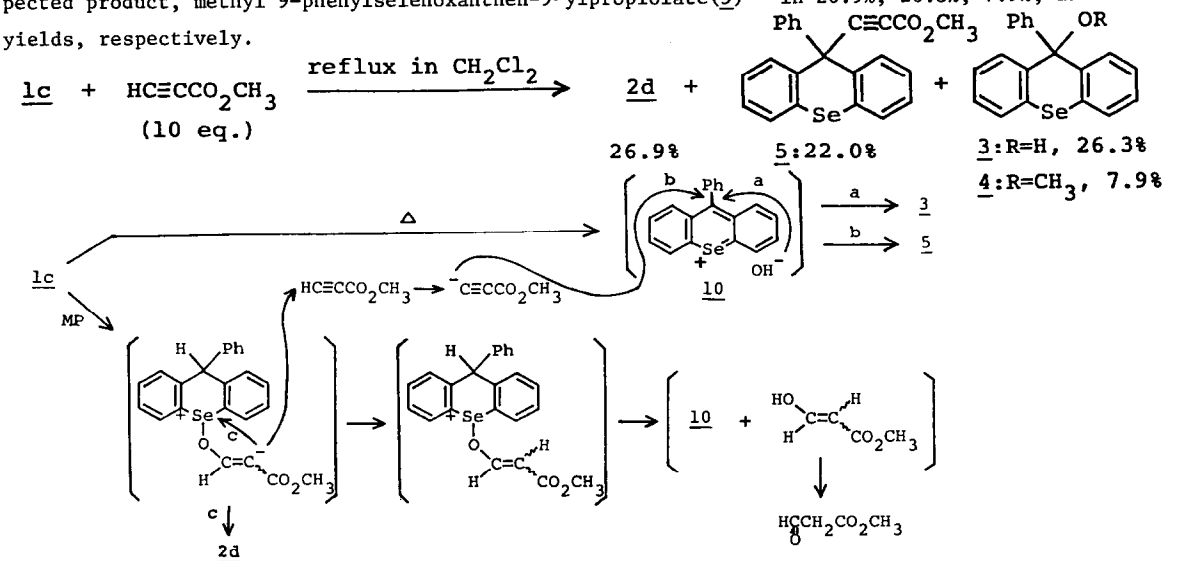
a) Isolated yield.

b) Isomer ratio was determined in comparison with the C_9-H intensities of their NMR spectra.

c) This selenoxide was only trans-isomer.

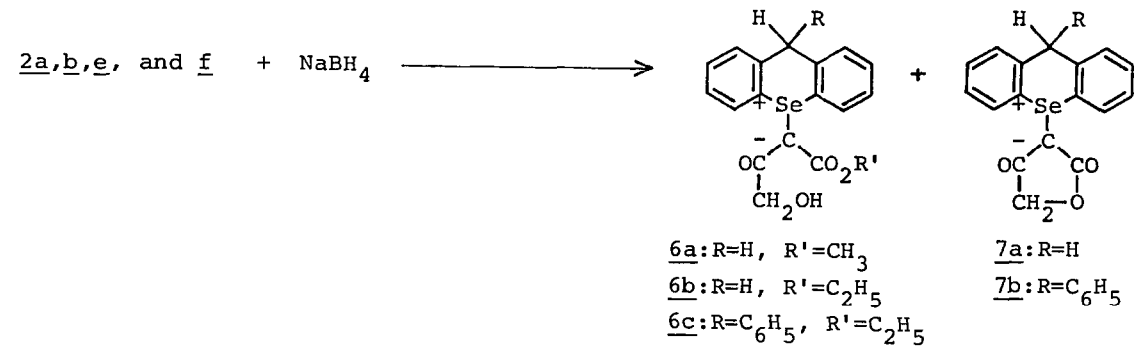
d) cis-Isomer could not be isolated.

In these reactions yield was largely affected by thermal stability of the selenoxides(1a-d)[7] and reactivity of activated acetylenes. Refluxing selenoxide(1c) in acetonitrile with 2 eq. of MP afforded 9-phenylselenoxanthenol(3) and selenonium ylide(2d) in 75.2% and 13.1% yields, respectively. The more the activated acetylene, the less the reaction time. However refluxing 1c in CH_2Cl_2 with 10 eq. of MP afforded 2d, 3, 9-methoxy-9-phenylselenoxanthene(4),[8] and an unexpected product, methyl 9-phenylselenoxanthen-9-ylpropiolate(5)[9] in 26.9%, 26.3%, 7.9%, and 22.0% yields, respectively.



The formation mechanism of 5 would be explained in the following way. Methyl propiolate is attacked by selenynyl oxygen to form the betaine intermediate, whose carbanion site would abstract acetylenic proton of methyl propiolate to form the acetylenic carbanion.[10] This carbanion would attack 9-phenylselenoxanthylium cation(10) to form 5. The cation(10) would be formed by thermal reaction of 1c by itself.

Treatment of selenonium ylide(2a) with 10 eq. of $NaBH_4$ in a mixture of EtOH and CH_2Cl_2 afforded new ylides, selenoxanthen-10-io(hydroxylacetyl methoxycarbonyl)methanide(6a) as colorless prisms: mp 177-180°(dec.); ^{1}H-NMR ($CDCl_3$) δ 3.44(3H, s, CO_2CH_3), 3.93(1H, d, J=16.8Hz, C_9-H), 3.94(1H, broad t, J=3.6Hz, CH_2OH), 4.36(1H, d, J=16.8Hz, C_9-H), 4.72(2H, d, J=3.6Hz, CH_2OH), 7.20-7.75(8H, m, ArH); IR (KBr) ν max cm^{-1} 3360(OH), 1665, 1595(CO); MS m/e 376(M^+, Se=80) and selenoxanthen-10-io-2,4-dioxooxolan-3-ide(7a) as colorless prisms: mp 196-199°(dec.); ^{1}H-NMR ($CDCl_3$) δ 3.97(1H, d, J=16.8Hz, C_9-H), 4.54(2H, s, $COCH_2O$), 4.55(1H, d, J=16.8Hz, C_9-H), 7.20-7.80(8H, m, ArH); IR (KBr) ν max cm^{-1} 1725, 1635(CO); MS m/e 344(M^+, Se=80). Interestingly, the product ratio was changed greatly with changing the solvent(Table 2). Using EtOH-CH_2Cl_2(10:1) the lactone was a main product, but using EtOH-CH_2Cl_2(1:10) the alcohol was a main product. The alcohol(6b) was converted to the lactone(7a) with K_2CO_3 in CH_3COCH_3 or $NaBH_4$ in EtOH in good yield. trans-Selenonium ylides(2e and 2f) were also reduced by $NaBH_4$ without stereo-isomerization.



6a: R=H, R'=CH_3
6b: R=H, R'=C_2H_5
6c: R=C_6H_5, R'=C_2H_5

7a: R=H
7b: R=C_6H_5

Table 2: Reaction of Selenonium Ylides with $NaBH_4$

Ylide	Molar Ratio of $NaBH_4$	Solvent EtOH:CH_2Cl_2	Time(hr)	Temperature	Product(% Yield)[a]
2a	2 mol	1 : 10	20	r.t.	6a(69.9), 7a(trace)
2a	2 mol	10 : 1	48	r.t.	7a(56.8)
2a	10 mol	10 : 1	8	r.t.	6a(trace), 7a(80.4)
2b	10 mol	1 : 10	7	r.t.	6b(75.2), 7a(trace)
2b	10 mol	EtOH	0.5	reflux	7a(67.3)
trans-2e	10 mol	2 : 1	9	r.t.	trans-7b(65.1)
trans-2f	2 mol	1 : 10	12	r.t.	trans-6c(72.8), trans-7b(4.8)
trans-2f	10 mol	2 : 1	24	r.t.	trans-7b(56.9)

a) Isolated yield.

Treatment of selenonium ylide(2a)with $KMnO_4$ in a mixture of CH_3COCH_3 and H_2O at room temperature afforded selenoxanthon-10-io(methoxalyl methoxycarbonyl)methanide(8) as colorless prisms: mp 190-191°; ^{1}H-NMR ($CDCl_3$) δ 3.46(3H, s, CO_2CH_3), 3.78(3H, s, CO_2CH_3), 7.55-7.90(6H, m, ArH), 8.35-8.65(2H, m, $C_{1,8}$-H); IR (KBr) ν max cm^{-1} 1745, 1672, 1650, 1545(CO); MS m/e 418(M^+, Se=80) in good yield. On the other hand trans-2e was not oxidized with $KMnO_4$. Selenonium ylide(8) was also prepared from selenoxanthone 10-oxide(9)[6] with 2 eq. DMAD in refluxing CH_2Cl_2 for 10 hr in 21.5% yield.

Further work on the selenoxanthenium ylides is now in progress.

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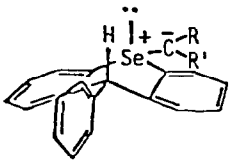
3) K.Sakaki and S.Oae, Tetrahedron lett., 3703 (1976).

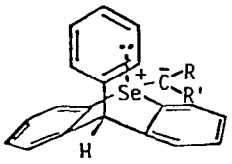
4) M.Hori, T.Kataoka, H.Shimizu, and K.Tomimatsu, Tetrahedron Lett., 23, 901 (1982).

5) The stereochemical structure of the selenonium ylide(2e) is shown below: cis-2e is A, and trans-2e is B.



A

$R=CO_2CH_3$
$R'=COCO_2CH_3$



B

6) Selenoxides(1a-d and 9) were prepared from the corresponding selenides with 1.1 eq. of m-chloroperbenzoic acid in high yield.

7) Refluxing 1c in CH_3CN for 10 hr afforded 3 almost quantitatively. Selenoxide(1a) was decomposed easily at room temperature to selenoxanthene and selenoxanthone. However trans-9-isopropylselenoxanthene 10-oxide (1b) was stable at room temperature.

8) 9-Methoxy-9-phenylselenoxanthene(4) was formed from 9-phenylselenoxanthylium cation and methanol being contained in CH_2Cl_2 as stabilizer.

9) Methyl 9-phenylselenoxanthen-9-ylpropiolate(5) as colorless prisms: mp 171-173°; ^{1}H-NMR ($CDCl_3$) δ 3.80(3H, s, CO_2CH_3), 6.60-6.95(2H, m, ArH), 6.95-7.70(9H, m, ArH), 8.15-8.37(2H, m, ArH); IR (KBr) ν max cm^{-1} 2235(C≡C), 1715(CO); MS m/e 404(M^+, Se=80).

10) Hydroxide anion might be abstract an acetylenic proton of methyl propiolate. We are now trying to detect the methyl formylacetate and the details will be discussed in the full paper.

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