N'-(α-ACETOXIMINOALKYL)DIAZENE-N-OXIDES AND SOME OF THEIR TRANSFORMATIONS

O. A. Luk'yanov, Yu. B. Salamonov, A. G. Bass, and Yu. A. Strelenko

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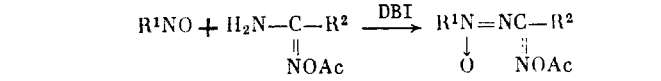
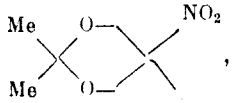
Nitroso compounds of the aromatic and aliphatic series react with O-acetylalkanoylamidoximes in the presence of dibromoisocyanurate, forming the previously unknown N'-(α-acetoximinoalkyl)diazene-N-oxides, which under gaseous NH_3 or oxalic acid in methanol lose the acetyl group and as a result are transformed into the previously unknown N'-(α-hydroximinoalkyl)diazene-N-oxides.

Synthesis of α-hydroximinoalkyl derivatives of diazene oxides is mentioned in the literature with a single example [1] which indicates that nitrosation of the diazene 4-$ClC_6H_4N{=}NC(=NOH)Me$, unlike its other analogs, leads to formation of 4-$ClC_6H_4N{=}\overset{+}{N}{=}NC(=NOH)Me$. Our attempts to reproduce these data were unsuccessful. Invariably a compound was obtained which had a melting point lower by ~20°C, the ^{14}N NMR spectrum of which did not contain a narrow signal characteristic of the N-oxide N atom.

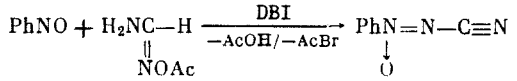
We also did not obtain α-hydroximinoalkyldiazene oxides by nitrosation of N'-alkoxycarbonylmethyldiazene-N-oxides [2] in acidic or basic media or by condensation of nitro compounds with alkanoylamidoximes in the presence of dibromoisocyanurate (DBI). It was found, however, that if these nitroso compounds are reacted with amidoximes protected at the O atom, particularly their O-acetyl derivatives, then reaction proceeds in the desired direction, thus affording a fairly general method for synthesis of the previously unknown N'-(α-acetoximinoalkyl)diazene-N-oxides (III)



(IIa-c) (Ia-h) (IIIa-k)

R^1 = Ph, R^2 = Me (a), CH_2Cl (b), CH_2N_3 (c), $CH_2NMe(NO_2)$ (d), CO_2Et (e), 3-$O_2NC_6H_4$ (g); R^1 =  , R^2 = CO_2Et (f), Me (k); $R^1 = R^2$ = Ph (h); R^1 = 2,4-$(O_2N)_2C_6H_3$, R^2 = Me (i).

Aliphatic and aromatic nitroso compounds and O-acetylamidoximes enter into this reaction with a wide set of substituents. It should be noted, however, that with O-acetylformamidoxime (Ii, R^2 = H), instead of the corresponding (III), the known [3] cyanodiazene oxide (IV)* is formed, which can be explained by transformation at any reaction step of the acetoximine group into a nitrile group.



(IIa) (Ii) (IV)

*Compound (IV) was identified by data of IR and mass spectra and by mp (see [3]).

N. D. Zelinskii Institute of Organic Chemistry, Academy of Sciences of the USSR, Moscow.
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TABLE 1. Analytical and IR Characteristics of the Synthesized Compounds

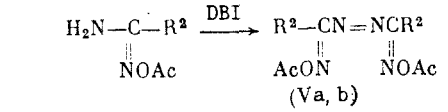
Compound	Yield, %	Mp, °C (solvent)	Found/calculated, % C	H	N	IR spectrum ν, cm^{-1}
(Ib)*	95	87 (benzene)	32,44 / 31,89	4,77 / 4,65	18,78 / 18,60	3435, 3350, 3250, 3220, 1645, 1620, 1445, 1375, 1250, 1055, 1020, 980, 935, 885, 760
(Ic)	85	71,5–72,5 (benzene)	–	–	–	3420, 3330, 2120, 1730, 1600, 1420, 1355, 1300, 1260, 1200, 995, 970, 880, 870
(Id)	92	112,5 (MeOH)	31,54 / 31,58	5,20 / 5,26	29,29 / 29,47	3475, 3330, 3200, 3000, 1740, 1645, 1620, 1500–1440, 1410, 1375, 1325, 1280–1220, 1000, 945, 900, 840
(If)	82	166,5–167,5 (alcohol)	41,33 / 41,38	5,79 / 5,79	16,01 / 16,09	3440, 3330, 1780, 1650, 1230, 1105, 1030, 980, 935, 910
(Ih)	77	121–123 (MeOH)	48,09 / 48,43	4,02 / 4,04	19,36 / 18,83	3480, 3370, 1755, 1645, 1610, 1535, 1400, 1370, 1350, 1240, 1150, 1080, 1020, 960, 910
(IIb)	33,5	84–86 (decomp.)	37,56 / 37,89	5,43 / 5,26	14,16 / 14,74	–
(IIIa)	42	49,5–50,5 (hexane : CCl_4, 4 : 1)	54,30 / 54,30	5,02 / 5,00	18,93 / 19,00	1765, 1630, 1475, 1430, 1365, 1320, 1245, 1200, 995, 935, 905
(IIIb)	65	Oil	–	–	–	3080, 1780, 1675, 1625, 1490, 1445, 1430, 1360, 1330, 1315, 1250, 1200, 1020, 1000, 975, 930, 875
(IIIc)	35	»	–	–	–	2120, 1790, 1635, 1500, 1450, 1380, 1340, 1320, 1260, 1200, 1080, 1030, 1010, 945, 900, 785
(IIId)	48	»	–	–	–	3070, 3000, 2940, 1760, 1700, 1620, 1500, 1475, 1430, 1320, 1280, 1180, 1100, 960, 930, 760
(IIIf)	50	76–79 (hexane – CCl_4, 2 : 1)	39,88 / 39,78	4,80 / 4,97	–	3000, 2940, 1800, 1745, 1580, 1500, 1440, 1380, 1370, 1300, 1270, 1190, 1100, 1050, 1000, 950, 855, 820
(IIIg)	34	149–150 (hexane : CCl_4, 3 : 1)	62,74 / 63,60	4,41 / 4,59	–	1760, 1580, 1460, 1425, 1340, 1315, 1210, 1165, 1160, 1000, 980, 975, 920, 900, 870, 780, 755
(IIIh)	45	Oil	–	–	–	3100, 1785, 1625, 1535, 1485, 1440, 1360–1330, 1260, 1210–1170, 1105, 1075, 1005, 960–930, 885, 815, 785, 760, 710
(IIIi)	14	99,5–100,5 (hexane : $CHCl_3$, 3 : 1)	38,11 / 38,60	2,91 / 2,89	22,40 / 22,50	3115, 3095, 1775, 1635, 1620, 1570, 1550, 1505, 1375, 1350, 1320, 1255, 1200, 1065, 955
(IIIk)	18	107,5–108,5 (hexane)	–	–	–	3030, 3010, 2960, 1785, 1650, 1580, 1500, 1445, 1385, 1375, 1345, 1315, 1300, 1265, 1245, 1210, 1195, 1155, 1145, 1100, 1060, 1005, 945, 915, 850, 830
(Va)	60	164–166 (decomp. MeOH)	41,76 / 42,11	5,44 / 5,26	–	1780, 1605, 1420, 1360, 1260, 1170, 1015, 985, 950, 915, 835
(Vb)	32	126,5–129,5 (alcohol)	41,93 / 41,86	4,77 / 4,65	16,10 / 16,27	3000, 2930, 1785, 1735, 1580, 1420, 1350, 1275, 1180, 1140, 990, 970, 875, 835, 825
(VIa)	93	116–119 (CCl_4)	52,45 / 52,63	5,22 / 5,03	23,76 / 23,46	3330–3100, 1645, 1570, 1460, 1420, 1280, 1230, 1030, 970, 755, 670
(VIb)	98	Oil	–	–	–	3600–3100, 2950–2800, 1500, 1450, 1330, 1200, 1180 1075, 1000, 975, 790, 760, 700
(VIc)	86	61,5–62,5 (hexane: CCl_4, 3 : 1)	43,48 / 43,64	3,93 / 3,64	39,01 / 38,18	3500–3050, 2120, 1495, 1445, 1370, 1330, 1120, 1080, 1035, 1015, 960, 875, 785, 730
(VId)	95	154–156 (hexane: $CHCl_3$, 1 : 5)	–	–	–	3700–3200, 1600, 1475, 1440, 1330, 1300–1250, 1100, 1025, 1000, 775, 765, 680, 600
(VIe)	–	88,5–90 (hexane: CCl_4, 1 : 1)	50,17 / 50,63	4,65 / 4,64	17,77 / 17,72	3500–3100, 2980, 2900, 1725, 1475, 1430, 1330, 1300, 1175, 1145, 1100, 1015, 870, 790

TABLE 1 (continued)

Compound	Yield, %	Mp, °C (solvent)	Found/Calculated, % C	H	N	IR spectrum ν, cm^{-1}
(VIf)	90	87.5–88.5 (hexane: CCl_4, 1 : 1)	37.89 / 37.50	5.10 / 5.00	17.34 / 17.50	3600–3100, 2990, 2950, 1740, 1720, 1630, 1580, 1520, 1460, 1390, 1330, 1230, 1180, 1160, 1115, 1050, 845
(VIg)	95	127–128 (*i*-PrOH)	–	–	–	3600–3200, 1460, 1410, 1260, 1230, 1130, 1030, 1020, 995, 980, 955, 880, 860, 755, 730
(VIh)	90	172–174 (CCl_4–ethyl acetate)	54.25 / 54.55	3.54 / 3.50	19.09 / 19.58	3600–3400, 3400–3150, 1630–1600, 1540, 1490, 1435, 1400, 1355, 1330–1280, 1180, 1100, 1065, 1045, 990, 915, 785, 780, 745, 730, 690

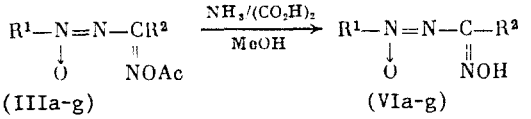
*Analysis for Cl: found, %: 23.73; calculated, %: 23.59.

In some cases together with (III) dimerization products of (I) are also isolated under the action of DBI–(V), which are formed also upon treatment with DBI of solutions of (Ia, d) containing no nitroso compound.



$R^2 = Me(a), CO_2Et(b)$.

The obtained compounds (III) are liquid or crystalline substances, generally quite stable upon storage. Chromatography on silica gel of (IIIe) converts it into a compound with no oxime group. It was established that the acetyl group on the acetoximinodiazene oxides is easily removed by bases (gaseous NH_3 in MeOH) or acids (oxalic acid in MeOH), which gives a simple method for synthesis of the previously unknown α-hydroximinoalkyldiazene oxides (VI)



(IIIa-g) (VIa-g)

The latter compounds are usually crystalline stable substances. Their structure was established by elemental analysis, IR, and ^1H, ^{13}C, and ^{14}N spectra. The fact that the chemical shifts of the phenyl carbon atoms in the acetoximino- and hydroximinoalkyldiazene oxides depend little on the substituents on the other side of the diazene oxide group suggests that (III) and (IV) are the trans isomers.

EXPERIMENTAL

PMR spectra were taken on Tesla BS-467, Bruker WM-250, and Bruker AM-300 instruments with working frequencies of respectively 60, 250, and 300 MHz in $CDCl_3$ (δ = 77.0 ppm), $(CD_3)_2CO$ (δ = 30.0 ppm) or $(CD_3)_2SO$ with HMDS as internal standard. ^{13}C (75.5 MHz) and ^{14}N (21.7 MHz) NMR spectra were taken on a Bruker AM-300 instrument. Chemical shifts in the ^{14}N NMR spectra are given relative to external standard $MeNO_2$ (δ = 0.0 ppm) without correction for diamagnetic susceptibility. IR spectra were obtained on UR-20 and Specord IR instruments using KBr pellets for solid samples and neat films for liquid ones. Mass spectra were taken on a MS-30 instrument.

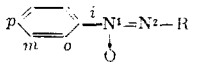
For chromatography on columns and TLC Silpearl silica gel was used (with Luminofor for TLC). Melting points were determined on a Koffler table. DBI was obtained by the method of [4], alkanoylamidoximes by the method of [5], and (IIa, c) in accordance with [6, 7]. Constants and IR spectral data for the obtained substances are shown in Table 1, and ^1H, ^{13}C, and ^{14}N NMR data in Tables 2 and 3.

Synthesis of Methylnitraminoacetamidoxime. To a solution of 0.04 mole of $MeN(NO)_2CH_2CN$ [8] and 0.06 mole of $HCl \cdot H_2NOH$ in 50 ml of water with vigorous stirring 0.06 mole of Na_2CO_3 was added at a temperature not higher than 35°C, and after 1.5 h the mixture was extracted

TABLE 2. PMR Spectral Data of the Synthesized Compounds

Compound	Solvent	δ, ppm, from HMDS						
		Ph		H_2N	$COCH_3$	CH_2R'	CH_3	others
		o-H, m	*m,p*-H, m					
(Ib)	Acetone-d_6	–	–	6,25 s	2,03	4,13 s	–	–
(Ic)	»	–	–	6,25 s	2,03	3,93 s	–	–
(Id)	»	–	–	6,08 s	2,00	4,56 s	3,40 s	–
(If)	DMSO-d_6	–	–	6,92 s	2,12	–	1,22 t	4,23 q ($\underline{OCH_2}Me$)
(Ih)	»	8,77–7,43		7,13 s	2,17	–	–	–
(IIIa)	Acetone-d_6	8,33–7,94	7,61–7,34	–	2,14	–	1,885	–
(IIIb)	»	8,37–8,02	7,77–7,35	–	2,03	4,58	–	–
(IIIc)	»	8,37–8,05	7,80–7,38	–	2,00	4,33	–	–
(IIId)	»	8,33–8,03	7,80–7,45	–	2,18	5,10	3,40	–
(IIIe)	$CDCl_3$	8,46–8,00	7,80–7,15	–	2,18	–	1,27 t 1,32 t	4,30 q ($\underline{OCH_2}Me$)
(IIIf)	»	–	–	–	2,20	4,70 s	1,40 s	4,34 q ($\underline{OCH_2}Me$); 1,3 t.($CH_2\underline{CH_3}$)
(IIIg)	Acetone-d_6	8,40–8,08 7,88–7,18		–	2,05	–	–	–
(IIIh)	»	8,60–7,43		–	2,13	–	–	–
(IIIi)	»	8,95 d (J=2 Hz), 8,88 dd		–	2,24/2,16	–	2,16/2,24	–
(IIIk)	»	8,45 d(J=8,5 Hz)						
		–	–	–	2,18/2,13	4,65 s	2,13/2,18 1,41	–
(Va)	$CDCl_3$	–	–	–	2,22/2,28	–	2,28/2,22	–
(Vb)	»	–	–	–	2,24 s	–	1,28 t	4,32 q (OCH_2)
(VIa)	Acetone-d_6	8,41–7,91	7,82–7,24	–	2,14 s	–	2,09 s 1,85 s	–
(VIb)	»	8,35–8,05	7,78–7,30	–	–	4,50 s	–	–
(VIc)	»	8,38–8,02	7,81–7,39	–	–	4,25 s	–	–
(VId)	DMSO-d_6	8,27–7,83	7,83–7,43	–	–	5,00	3,40	–
(VIe)	$CDCl_3$	8,44–8,03	7,68–7,20	–	–	4,29 q (OCH_2)	1,23 t	10,43 m (OH)
(VIf)	Acetone-d_6	–	–		–	4,80 s	1,42 s	1,23 t
(VIg)	»	8,41–8,00		–	–	4,32 q		11,00 (OH)
(VIh)	»	7,91–7,18		–	–	–	–	–
		8,70–7,03		–	–	–	–	

TABLE 3. ^{13}C and ^{14}N NMR Data for Compounds (III) and (VI) (solvent: acetone-d_6)



Compound	R	δ, ppm					R	
		p	*m*	*o*	*i*	N^1		
(IIIa)	$-C(=NOCOCH_3)-CH_3$	134,4	130,3	123,3	147,7	−42,5	$C-CH_3$ $C=CH_3$ O C=O C=N	13,6 19,6 168,2 162,3
(IIId)	$-CCH_2N(CH_3)(NO_2)=NOCOCH_3$	134,8	130,4	123,4	147,4	−40,3	C=N C=O CH_2 $N=CH_3$ $C-CH_3$ O NO_2	162,0 167,7 50,7 40,7 19,5 −28,0
(IIIf)	$-C(=NOCOCH_3)-C_6H_5$	134,6	130,4	123,4	147,5	−41,4	C=N C_p $C_{o,m}$ C=O CH_3	162,3 132,0 129,6; 129,4 168,2 19,6
(VIa)	$-C(=NOH)-CH_3$	133,6	130,1	123,1	148,0	−47,9	CH_3	12,1
(VIe)	$-C(=NOH)-COOCH_2CH_3$	134,1	129,3	122,9	145,2	−43,3	C=N C=O CH_2 CH_3	156,0 163,4 63,3 13,8
(VIf)	$-C(=NOH)-C_6H_5$	133,9	130,3	123,3	148,0	−44,5	C=N C_p $C_{o,m}$	155,3 130,6 129,5; 129,1

many times with ethyl acetate. The extract was dried above $MgSO_4$ and after solvent removal colorless crystals (VIId) were obtained with 75% yield, which decomposed upon attempts to purify by recrystallization.

General Method for Obtaining O-Acetylamidoximes (I). To a solution of a suspension of amidoxime* in a small amount of abs. dioxane at 8-10°C a solution of an equimolar amount of Ac_2O in dioxane was added dropwise. The mixture was stirred for 1 h and allowed to warm to ~20°C. If (I) did not precipitate as it formed, then hexane was added and the product was frozen out with solid CO_2. Precipitated (I) was separated by filtration, dried in air, and purified by recrystallization.

Synthesis of 2,2-Dimethyl-5-nitroso-1,3-dioxane (IIb). To a suspension of 1.5 g of sodium salt of 2,2-dimethyl-5-nitro-1,3-dioxane [9] in 200 ml of abs. CH_2Cl_2 at −35°C with vigorous stirring a solution of 7.54 g (5.06 ml) of N_2O_4 in CH_2Cl_2 was added dropwise. The mixture was stirred at this temperature another 30 min, allowed to warm to 0-5°C, and filtered. Then half of the mixture was evaporated, filtered through a layer of silica gel 40/100 (thickness 5 cm), and the residue of (IIb) was washed from the silica gel with CH_2Cl_2. This procedure was repeated 3-4 times with fresh silica gel. The residue after removal of CH_2Cl_2 was kept for 0.5-1 h in the cold. The solidified product was ground with 15-20 ml of ether and quickly filtered. After drying in air 4.5 g of (IIb) was obtained.

General Method for Obtaining N-substituted N'-(α-Acetoximinoalkyl)diazene-N-oxides (III). To a solution of equimolar amounts of (I) and (II) in abs. CH_2Cl_2 or $CHCl_3$ an equimolar [in the case of (Id) – 3 moles] amount of DBI was added, the mixture was stirred at ~20°C until disappearance of (I), and filtered from cyanuric acid and unreacted DBI. The filtrate was evaporated and by TLC or column chromatography compound (III) was isolated.

*The authors express gratitude to V. N. Yarovenko for a gift of amidoxime $H_2NC(=NOH)CH_2N_3$.

General Methods for Obtaining N-substituted N'-(Hydroximinoalkyl)diazene-N-oxides (VI). a. Under Basic Conditions. Into a solution of (III) in a small amount of MeOH an intense flow of NH_3 was passed for 5 min, the residue was extracted with $CHCl_3$, solvent removed, and from the residue compound (VI) was isolated by TLC or chromatography on silica.

b. Under Acidic Conditions. Compound (III) was boiled for 30 min in MeOH with a three- to fourfold excess of oxalic acid, evaporated, and by TLC of the residue compound (VI) was isolated.

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