Nitrosochlorination of acyclic monoterpenoids

Yana V. Markova[a] and Alexey V. Tkachev*[b]

[a] *Department of Natural Sciences, Novosibirsk State University, 630090 Novosibirsk, Russian Federation*
[b] *N. N. Vorozhtsov Novosibirsk Institute of Organic Chemistry, Siberian Branch of the Russian Academy of Sciences, 630090 Novosibirsk, Russian Federation. Fax: +7 3832 34 4752; e-mail: atkachev@nioch.nsc.ru*

10.1070/MC2000v010n04ABEH001266

Reactions of linalyl acetate, dehydrolinalool and geranyl acetate with NOCl result in selective addition to the $\Delta^{6,7}$ double bond.

Nitroso chlorides of unsaturated terpenic compounds are of great interest as starting compounds for the synthesis of chiral organic molecules.[1] Although the chemistry of nitroso chlorides derived from cyclic hydrocarbons has been studied intensively, there are no data on the addition of NOCl to acyclic terpenoids. This work demonstrates the use of unstable nitroso chlorides from acyclic monoterpenoids (linalool, dehydrolinalool, linalyl acetate, geranyl acetate and citronellyl acetate) for preparing nitrogen-containing derivatives (Scheme 1).

Reactions of the terpenoids with NOCl were performed as described below. Gaseous NOCl diluted with dry nitrogen was slowly passed over a solution of a terpenoid (10.2 mmol) in CH_2Cl_2 with stirring for 1.5 h at –15 to –5 °C. After the starting compound disappeared (TLC), the solvent was removed by passing an air flow over the reaction mixture at –5 to 0 °C to afford a crude nitroso chloride as emerald-green oil.† Only in case of linalyl acetate **1**, the addition of several drops of methanol followed by keeping the solution at –12 °C for several days resulted in a crystalline nitroso chloride as a mixture (~1:1) of diastereomers.‡ According to NMR spectroscopy, the other terpenoids produced oily nitroso chlorides as mixtures of several diastereomeric forms. For example, there are at least eight sets of signals in the ^{13}C NMR spectrum of the crude dehydrolinalool nitroso chloride due to (i) the presence of two asymmetric C^3 and C^6 atoms, (ii) the formation of (*Z*)- and (*E*)-dimers[2] and (iii) the absence of free rotation at the C^6–C^7 and C^6–N bonds. The formation of diastereomeric forms of nitroso chlorides was supported by transforming the mixtures to amino oximes by treatment with primary or secondary amines.[1]

Thus, the nitrosochlorination of **1** {$[\alpha]_{580}^{15}$ +7.7 (*c* 1.83, $CHCl_3$)} followed by the treatment with corresponding amines resulted in amino oxime **3a**, hydroxylamino oxime **3b**, ethanolamine derivative **3c** or morpholino derivative **3e**.§ Racemic dehydrolinalool **4** was transformed to hydroxylamino, benzylamino and morpholino derivatives **6b**, **6d** and **6e**, respectively.¶ Only a carbon–carbon double bond was involved in the reaction. Nitrosochlorination of geranyl acetate proceeds regioselectively at the 6,7-double bond to form crystalline amino oximes such as benzylamino **9d** and morpholino **9e** derivatives.††

The formation of crystalline amino oximes can be used for preparing pure compounds from natural mixtures of geranyl and citronellyl acetates. Thus, the treatment of a nitroso chloride prepared from a 3:2 mixture of geranyl acetate **7** and citronellyl acetate **10** (0.50 g, isolated by distillation from geranium oil) with morpholine in MeOH resulted in a yellow solid (0.42 g), which was crystallised from MeOH to give compound **9e** (31% yield on the basis of geranyl acetate). Purification of the mother liquor by column chromatography (SiO_2, toluene–*tert*-butyl methyl ether) afforded citronellyl derivative **12e**‡‡ (0.19 g, 60% yield on the basis of citronellyl acetate). At the same time, the

† A red or brown colour of the reaction mixture is a result of decomposition of nitroso chlorides.

‡ *1-(4-Chloro-4-methyl-3-nitrosopentyl)-1-methylallyl acetate*, *dimer* **2**: yield 55%, white crystals, mp 89–92.5 °C (CH_2Cl_2–MeOH), $[\alpha]_{580}^{15}$ +1.2 (*c* 1.72, $CHCl_3$). ^1H NMR (400 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v) δ: 5.88 and 5.84 (2dd, *J* 17.0 and 11.0 Hz), 5.727 and 5.721 (2dd, *J* 10.5 and 2.5 Hz), 5.10 (dd, *J* 17.0 and 1 Hz), 5.08 and 5.07 (2dd, *J* 11.0 and 1.0 Hz), 1.954 and 1.948 (s, AcO), 1.65 and 1.60 (s, Me–C=C), 1.48 and 1.46 (s, 3H^9). ^{13}C NMR (100 MHz, CCl_4–[$^2H_6$]acetone, 4:1, v/v) δ: 168.34 and 168.30 (C=O), 141.40 and 141.20 (C^2), 113.76 and 113.67 (C^1), 81.80 and 81.65 (C^3), 72.56 (C^6), 69.48 and 69.46 (C^7), 36.52 and 36.47 (C^4), 30.26 and 30.16, 29.16 and 29.12 (C^{10}, C^8), 23.92 (C^9), 23.31 (C^5), 21.89 (*Me*COO). IR (0.25% in KBr, ν/cm^{-1}): 1725 (C=O), 1360 (N=O), 1170 (N=O), 1250 (C–O–C), 1055 and 915 (CH=CH_2). MS, *m*/*z* (%): 195 (19), 126 (9), 115 (12), 107 (14), 105 (6), 103 (13), 95 (7), 93 (34), 82 (8), 81 (84), 79 (17), 77 (13), 71 (33), 69 (23), 68 (8), 67 (18), 55 (27), 53 (11), 43.1 (17), 43.0 (100), 41 (34), 39 (7), 28 (7). Found (%): C, 54.9; H, 7.8; N, 5.4; Cl, 13.8. Calc. for $[C_{12}H_{20}ClNO_3]_2$ (%): C, 55.17; H, 7.70; N, 5.35; Cl, 13.54.

§ *1-(4-Amino-3-hydroxyimino-4-methylpentyl)-1-methylallyl acetate* **3a**: yield 42%, white crystals, mp 100–104 °C (CH_2Cl_2–light petroleum, 1:1 v/v), $[\alpha]_{580}^{22}$ +13.6 (*c* 0.88, $CHCl_3$). ^1H NMR (400 MHz, [$^2H_5$]pyridine) δ: 12.3 (br. s, =NOH), 6.12 (dd, 1H, *J* 17.0 and 11.0 Hz), 5.25 (d, 1H, *J* 17.0 Hz), 5.07 (d, 1H, *J* 11.0 Hz), 3.1 (br. s, NH_2), 2.7–2.3 (m, 4H), 1.92 (s, AcO), 1.61 (s, 3H^9), 1.36 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_5$]pyridine) δ: 169.66 (C=O), 164.53 (C^6), 142.33 (C^2), 113.44 (C^1), 83.27 (C^3), 54.44 (C^7), 36.27 (C^4), 29.32 (C^8 and C^{10}), 23.82 (C^9), 22.03 (*Me*COO), 20.58 (C^5). IR (3% in $CHCl_3$, ν/cm^{-1}): 3590 (=NO–H), 1730 (C=O), 1360 (O–H), 1250 (C–O–C), 920 (N–O). MS, *m*/*z* (%): 242.1621 (M^+, 1), 227 (M^+ – Me, 1), 182 (M^+ – AcOH, 1), 167 (8), 150 (3), 81 (3), 69 (3), 59 (4), 58 (100), 57 (3), 55 (3), 43 (13), 42 (8), 41 (7), 28 (7). Found (%): C, 59.1; H, 9.0; N, 11.4. Calc. for $C_{12}H_{22}N_2O_3$ (%): C, 59.48; H, 9.15; N, 11.56.

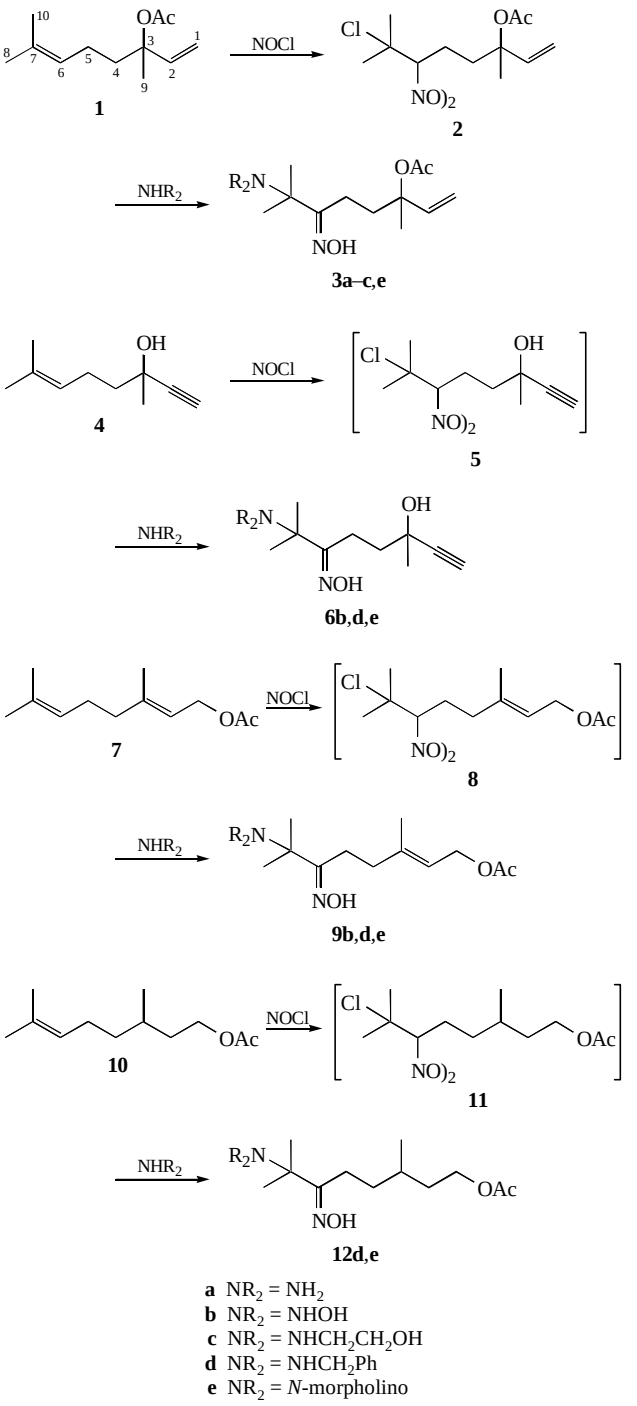
1-(4-Hydroxyamino-3-hydroxyimino-4-methylpentyl)-1-methylallyl acetate **3b**: yield 77%, yellowish oil, $[\alpha]_{580}^{22}$ +9.8 (*c* 1.22, $CHCl_3$). ^1H NMR (400 MHz, [$^2H_6$]acetone) δ: 9.8 (br. s, =NOH), 6.01 (dd, *J* 17.0 and 11.0 Hz), 5.13 (d, *J* 17.0 Hz), 5.06 (d, *J* 11.0 Hz), 2.4–1.9 (m, 4H), 1.96 (s, AcO), 1.52 (s, 3H^9), 1.17 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 170.08 (C=O), 163.29 (C^6), 142.69 (C^2), 113.36 (C^1), 83.41 (C^3), 62.18 (C^7), 35.33 (C^4), 24.00 (C^9), 23.52 (C^8 and C^{10}), 22.05 (*Me*COO), 20.07 (C^5). IR (3% in $CHCl_3$, ν/cm^{-1}): 3650 (=NO–H), 1725 (C=O), 1365 (O–H), 1250 (C–O–C), 925 (N–O). MS, *m*/*z* (%): 241.1556 (M^+ – OH, 1), 183 (43), 167 (32), 150 (22), 111 (30), 108 (15), 82 (14), 81 (34), 79 (12), 74 (87), 73 (100), 71 (17), 68 (13), 67 (19), 59 (14), 58 (28), 56 (25), 55 (24), 43 (78), 42 (27), 41 (35), 39 (13), 28 (27).

1-[4-(2-Hydroxyethylamino)-3-hydroxyimino-4-methylpentyl]-1-methylallyl acetate **3c**: yield 55%, yellowish viscous oil, $[\alpha]_{580}^{15}$ –6.6 (*c* 3.04, $CHCl_3$). ^1H NMR (400 MHz, [$^2H_6$]acetone) δ: 6.03 (dd, *J* 17.0 and 11.0 Hz), 5.21 (d, *J* 17.0 Hz), 5.09 (d, *J* 11.0 Hz), 3.53 (t, NCH_2CH_2O, *J* 6.0 Hz), 2.84 (s, NH), 2.48 (t, NCH_2CH_2O, *J* 6.0 Hz), 1.97 (s, AcO), 1.55 (s, 3H^9), 1.21 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 169.88 (C=O), 163.55 (C^6), 142.76 (C^2), 113.43 (C^1), 83.39 (C^3), 62.46 (C^7), 57.89 (NCH_2CH_2O), 46.00 (NCH_2CH_2O), 35.87 (C^4), 26.33 (C^8, C^{10}), 23.97 (C^9), 22.02 (*Me*COO), 20.03 (C^5). IR (3% in $CHCl_3$, ν/cm^{-1}): 3590 (=NO–H, O–H), 1720 (C=O), 1250 (C–O–C), 920 (N–O). MS, *m*/*z* (%): 106 (27), 105 (15), 97 (22), 92 (17), 91 (64), 73 (100), 71 (19), 70 (16), 59 (17), 57 (82), 55 (25), 43 (65), 42 (15), 41 (47), 39 (18), 29 (21), 28 (46).

1-(3-Hydroxyimino-4-methyl-4-morpholin-4-ylpentyl)-1-methylallyl acetate **3e**: yield 50%, white crystals, mp 80–83 °C (toluene–light petroleum, 1:1 v/v), $[\alpha]_{580}^{22}$ +9.8 (*c* 1.22, $CHCl_3$). ^1H NMR (400 MHz, [$^2H_6$]acetone) δ: 9.63 (s, =NOH), 6.01 (dd, *J* 17.0 and 11.0 Hz), 5.20 (d, *J* 17.0 Hz), 5.08 (d, *J* 11.0 Hz), 3.57 (m, 4H, NCH_2CH_2O), 2.39 (m, 4H, NCH_2CH_2O), 1.97 (s, AcO), 1.53 (s, 3H^9), 1.10 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 169.68 (C=O), 163.97 (C^6), 142.78 (C^2), 113.33 (C^1), 83.36 (C^3), 68.04 (NCH_2CH_2O), 62.19 (C^7), 47.19 (NCH_2CH_2O), 35.48 (C^4), 22.02 (C^9), 21.01 (*Me*COO), 20.81 and 20.64 (C^8 and C^{10}), 20.12 (C^5). IR (3% in $CHCl_3$, ν/cm^{-1}): 3650 (=NO–H), 1730 (C=O), 1365 (O–H), 1250 (C–O–C), 1180 (C–N), 1115 (C–O), 925 (N–O). MS, *m*/*z* (%): 312.2057 (M^+, 3), 297 (M^+ – Me, 2), 295 (M^+ – OH, 5), 235 (9), 167 (15), 154 (8), 151 (6), 150 (5), 128 (100), 111 (12), 86 (13), 70 (3), 43 (10), 28 (5). Found (%): C, 62.1; H, 9.2; N, 9.1. Calc. for $C_{16}H_{28}N_2O_4$ (%): C, 61.51; H, 9.03; N, 8.97.

treatment of a nitroso chloride prepared from a 3:2 mixture of geranyl acetate **7** and citronellyl acetate **10** (0.65 g) with benzyl amine in MeOH resulted in a mixture of amino oximes **9d** and **12d** (1.01 g). The crystallization from MeOH gave a mixture (~2:1, NMR) of **9d** and **12d** (0.48 g).§§

The reaction of nitroso chloride of geranyl acetate **8** with NH_2OH resulted in piperidine derivative **13** instead of a simple acyclic α-hydroxyl amino oxime. Thus, the refluxing of nitroso chloride **8** (prepared from 0.55 g of geranyl acetate) in a methanolic solution of NH_2OH for 2 h resulted in yellowish oil



a $NR_2 = NH_2$
b $NR_2 = NHOH$
c $NR_2 = NHCH_2CH_2OH$
d $NR_2 = NHCH_2Ph$
e NR_2 = *N*-morpholino

Scheme 1

¶ *6-Hydroxy-2-hydroxyamino-2,6-dimethyloct-7-yn-3-one oxime* **6b**: yield 27%, white crystals, mp 107–110 °C (toluene). ^{1}H NMR (400 MHz, [$^2H_6$]acetone) δ: 9.7 (br. s, =NOH), 2.83 (s, C≡CH), 2.67–2.52 (m, 2H), 2.08–2.02 (m, 2H), 1.45 (s, 3H^9), 1.21 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 163.62 (C^6), 89.21 (C^2), 71.87 (C^1), 67.71 (C^3), 62.33 (C^7), 39.85 (C^4), 30.08 (C^9), 23.64 (C^8 and C^{10}), 21.07 (C^5). IR (3% in $CHCl_3$, ν/cm^{-1}): 3590 (=NO–H, N–O–H, O–H), 3310 (≡C–H), 925 (N–O). MS, *m*/*z* (%): 214.1317 (M$^+$, 1), 196 (M$^+$ – H_2O), 181 (7), 165 (7), 150 (14), 148 (36), 79 (23), 74 (100), 73 (74), 69 (18), 59 (15), 56 (28), 55 (16), 43 (33), 42 (34), 41 (33), 28 (20). Found (%): C, 55.8; H, 8.9; N, 12.7. Calc. for $C_{10}H_{18}N_2O_3$ (%): C, 56.06; H, 8.47; N, 13.07.

2-Benzylamino-6-hydroxy-2,6-dimethyloct-7-yn-3-one oxime **6d**: yield 82%, white crystals, mp 152–155 °C (MeOH). ^{1}H NMR (400 MHz, [$^2H_5$]pyridine) δ: 12.52 s (=NOH), 7.50–7.20 (m, Ph), 4.89 (s, NH), 3.81 (s, PhCH_2N), 3.23 (s, C≡CH), 3.32–3.19 (m, 2H), 2.58 (t, 2H, *J* 8.5 Hz), 1.82 (s, 3H^9), 1.52 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_5$]pyridine) δ: 162.98 (C^6), 90.18 (C^2), 71.85 (C^1), 67.28 (C^3), 58.36 (C^7), 40.50 (C^4), 30.49 (C^9), 26.53 and 26.48 (C^8 and C^{10}), 21.37 (C^5), benzyl group: 142.31 (s, 1C), 128.49 (d, 3C), 126.83 (d, 2C), 48.05 (t, NCH_2Ph). IR (0.25% in KBr, ν/cm^{-1}): 3205 (C≡C–H), 3250 (N–H), 940 (N–O), 740 and 690 (C–H$_{aryl}$). MS, *m*/*z* (%): 273.1513 (M$^+$ – Me, 3), 254.1648 (M$^+$ – 2OH, 22), 154 (18), 240 (3), 183 (4), 149 (9), 148 (58), 106 (45), 92 (9), 91 (100), 69 (10), 65 (9), 28 (38). Found (%): C, 70.7; H, 8.6; N, 9.6. Calc. for $C_{17}H_{24}N_2O_2$ (%): C, 70.80; H, 8.39; N, 9.71.

6-Hydroxy-2,6-dimethyl-2-morpholin-4-yloct-7-yn-3-one oxime **6e**: yield 60%, white crystals, mp 145–148 °C (MeOH). ^{1}H NMR (400 MHz, [$^2H_6$]acetone) δ: 9.52 (s, =NOH), 3.57 (m, 4H, NCH_2CH_2O), 2.78 (s, (C≡CH), 2.72–2.54 (m, 2H), 2.41 (m, 4H, NCH_2CH_2O), 1.94 (t, 2H, *J* 8.0 Hz), 1.44 (s, 3H^9), 1.13 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone): 164.17 (C^6), 89.31 (C^2), 71.79 (C^1), 68.10 (NCH_2CH_2O), 67.83 (C^3), 62.39 (C^7), 47.38 (NCH_2CH_2O), 40.31 (C^4), 30.12 (C^9), 21.24 (C^5), 20.84 and 20.73 (C^8 and C^{10}). IR (0.25% in KBr, ν/cm^{-1}): 3220 (≡C–H), 1175 (C–N), 1110 (C–O), 945 (N–O). MS, *m*/*z* (%): 268 (M$^+$, 0.5), 251.1768 (M$^+$ – OH, 17), 183 (7), 166 (5), 148 (6), 140 (3), 128 (100), 86 (19), 78 (61), 77 (14), 69 (8), 56 (6), 45 (25), 31 (39), 28 (34). Found (%): C, 62.5; H, 9.2; N, 10.3. Calc. for $C_{14}H_{24}N_2O_3$ (%): C, 62.66; H, 9.01; N, 10.44.

†† *7-Benzylamino-6-hydroxyimino-3,7-dimethyloct-2-enyl acetate* **9d**: yield 60%, white crystals, mp 93–96 °C (toluene). ^{1}H NMR (400 MHz, [$^2H_6$]acetone) δ: 9.71 (s, =NOH), 7.37–7.15 (m, Ph), 5.36 (t, *J* 7.0 Hz), 4.54 (d, *J* 7.0 Hz), 3.56 (s, PhCH_2N), 2.8 (br. s, PhCH$_2$N*H*), 2.57–2.49 (m, 2H), 2.37–2.29 (m, 2H), 1.96 (s, AcO), 1.75 (s, 3H^9), 1.29 (s, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 170.88 (Me*C*OO), 163.67 (C^6), 142.71 (s, C^3), 119.52 (C^2), 61.47 (C^1), 58.41 (C^7), 48.11 (N*C*H$_2$Ph), 36.42 (C^4), 26.41 (C^8 and C^{10}), 24.34 (C^5), 20.80 (*Me*COO), 16.37 (C^9); phenyl group: 142.57 (s, 1C), 128.85 (d, 3C) and 127.24 (d, 2C). IR (0.25% in KBr, ν/cm^{-1}): 3290 (N–H), 1730 (C=O), 1235 (C–O–C), 940 (N–O), 830 (=C–H), 755, 695 (C–H$_{aryl}$). MS, *m*/*z* (%): 332.2106 (M$^+$, 1), 315 (11), 273 (5), 257 (4), 255 (3), 227 (6), 167 (10), 148 (66), 106 (44), 92 (10), 91 (100), 65 (5), 43 (15), 28 (16). Found (%): C, 68.6; H, 8.4; N, 8.0. Calc. for $C_{19}H_{28}N_2O_3$ (%): C, 68.65; H, 8.49; N, 8.43.

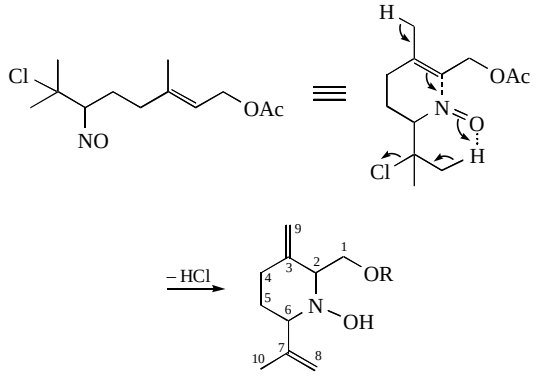
6-Hydroxyimino-3,7-dimethyl-7-morpholin-4-yloct-2-enyl acetate **9e**: yield 54%, white crystals, mp 81–84 °C (MeOH). ^{1}H NMR (400 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v, due to exchange processes at room temperature, some signals are broad) δ: 8.9 (br. s, =NOH), 5.33 (tq, *J* 7.0 and 1.0 Hz), 4.51 (d, *J* 7.0 Hz), 3.59 (br. s, $W_{1/2}$ 22 Hz, 4H, NCH_2CH_2O), 2.44 (br. s, $W_{1/2}$ 27 Hz, 6H), 2.29–2.22 (m, 2H), 1.96 (s, AcO), 1.67 (s, (3H^9), 1.20 (br. s, $W_{1/2}$ 21 Hz, 3H^8 and 3H^{10}). ^{13}C NMR (100 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v, due to exchange processes at room temperature, some signals are broad or undetectable) δ: 119.29 (C^2), 61.07 (C^1), 47.05 (N*C*H$_2$CH$_2$O), 36.11 (C^4), 20.84 (*Me*COO), 16.54 (C^9). IR (3% in $CHCl_3$, ν/cm^{-1}): 3580 (O–H), 1725 (C=O), 1235 (C–O–C), 1180 (C–N), 1110 (C–O), 960 (N–O). MS, *m*/*z* (%): 312.2072 (M$^+$, 3), 295 (10), 253 (16), 235 (2), 227 (6), 167 (12), 129 (9), 128 (100), 111 (6), 88 (11), 86 (14), 84 (8), 43 (10), 28 (15). Found (%): C, 61.4; H, 8.0; N, 9.0. Calc. for $C_{16}H_{28}N_2O_4$ (%): C, 61.51; H, 9.03; N, 8.97.

‡‡ *6-Hydroxyimino-3,7-dimethyl-7-morpholin-4-yloctyl acetate* **12e**: yellowish viscous oil. ^{1}H NMR (400 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v) δ: 8.91 (s, =NOH), 4.05 (m, 2H^1), 3.57 (m, 4H, NCH_2CH_2O), 2.42 (m, 4H, NCH_2CH$_2$O), 1.97 (s, AcO), 1.14 (br. s, $W_{1/2}$ 23 Hz, 3H^8 and 3H^{10}), 0.98 (d, 3H^9, *J* 6.0 Hz). ^{13}C NMR (100 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v) δ: 169.42 (C=O), 164.72 (C^6), 67.45 (NCH$_2$*C*H$_2$O), 62.54 (C^1), 60.88 (C^7), 46.80 (N*C*H$_2$CH$_2$O), 35.38 (C^4), 32.91 (C^5), 31.13 (C^3), 20.85 (*Me*COO), 20.67 (C^8 and C^{10}), 19.73 (C^9). IR (3% in $CHCl_3$, ν/cm^{-1}): 3590 (=NO–H), 1725 (C=O), 1245 (C–O–C), 960 (N–O). MS, *m*/*z* (%): 297 (0.5, M$^+$ – OH), 184 (8), 153 (11), 152 (100), 142 (20), 119 (11), 107 (12), 93 (10), 55 (8), 43 (27), 41 (14), 32 (10), 28 (47).

§§ ^{1}H NMR (400 MHz, CCl_4–[$^2H_6$]acetone, 4:1 v/v) for a mixture of **9d** and **12d**. Signals due to **9d**, δ: 9.52 (s, =NOH), 7.32–8.16 (m, Ph), 5.31 (t, H^3, *J* 7 Hz), 4.48 (d, 2H^2, *J* 7 Hz), 1.95 (s, AcO), 1.74 (s, 3H^9), 1.27 (s, 3H^8 and 3H^{10}). Signals due to 7-benzylamino-6-hydroxyimino-3,7-dimethyloctyl acetate **12d**, δ: 9.41 (=NOH), 7.32–8.16 (m, Ph), 1.94 (s, (AcO), 1.26 (s, 3H^8 and 3H^{10}), 0.95 (d, 3H^9, *J* 6 Hz).

(0.29 g), which was separated by column chromatography (SiO_2, toluene–*tert*-butyl methyl ether) to give piperidine derivative **13a** and acetoxy group hydrolysis product **13b**.¶¶ The formation of a cyclization product can be explained in terms of electrophilic addition of a nitroso group to the carbon–carbon double bond according to Scheme 2.

In all cases, the addition of NOCl proceeds only at the $\Delta^{6,7}$ double bond and is not hindered by a hydroxyl group or/and a carbon–carbon triple bond. Unusual cyclization was found in the reaction of geraniol-type nitroso chlorides, which leads to piperidine derivatives.



13: **a** R = Ac
b R = H

Scheme 2 The numbering of atoms is indicated for NMR interpretation.

This work was supported by the Russian Foundation for Basic Research (grant no. 96-15-97017), the Ministry of Higher Education of the Russian Federation (grant no. 98-8-3.1-68) and INTAS (grant no. 97-0217).

References

1 A. V. Tkachev, *Ross. Khim. Zh.*, 1998, **42**, 42 (in Russian).
2 S. A. Bakunov, A. Yu. Denisov and A. V. Tkachev, *Tetrahedron*, 1995, **51**, 8565.

Received: 20th January 2000; Com. 00/1592

¶¶ *1-Hydroxy-6-isopropenyl-3-methylene-2-piperidylmethyl acetate* **13a**: yield 33%, yellowish viscous oil. ^{1}H NMR (400 MHz, [$^2H_6$]acetone) δ: 4.87 (dq, H^{8a}, *J* 2 and 1.0 Hz), 4.84 (dd, H^{9a}, *J* 2 and 2 Hz), 4.81 (dd, H^{9b}, *J* 2 and 2 Hz), 4.79 (dq, H^{8b}, *J* 2 and 1.5 Hz), 4.53 (dd, H^{1a}, *J* 11 and 5 Hz), 4.39 (dd, H^{1b}, *J* 11 and 8 Hz), 3.83 (dd, H^2, *J* 8 and 5 Hz), 3.48 (dd, $W_{1/2}$ 2.5 Hz, H^6, *J* 7 and 7 Hz), 2.36 (ddddd, H^{4a}, *J* 14, 9, 9, 2 and 2 Hz), 2.21 (ddd, H^{4b}, *J* 14, 4 and 4 Hz), 1.97 (s, AcO), 1.73 (s, H^{10}, $W_{1/2}$ 3 Hz), 1.70 (m, 2H^5). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 170.36 (Me*C*OO), 147.51 (C^7), 145.35 (C^3), 111.93 (C^8 or C^9), 112.00 (C^9 or C^8), 69.05 (C^2), 65.78 (C^6), 61.06 (C^1), 29.65 (C^4), 29.03 (C^5), 20.82 (*Me*COO), 19.13 (C^{10}). IR (3% in $CHCl_3$, ν/cm^{-1}): 3590 (NO–H), 1745 (C=O), 1650 (C=CH_2), 1255 (C–O–C), 900 (=CH_2). MS, *m*/*z* (%): 225.1365 (M$^+$, 2), 194 (2), 184 (2), 165 (5), 153 (10), 152 (100), 135 (6), 134 (5), 120 (6), 119 (10), 110 (7), 107 (7), 94 (5), 93 (9), 91 (7), 81 (5), 79 (6), 67 (5), 55 (6), 43 (19), 41 (9), 28 (6).

2-Hydroxymethyl-6-isopropenyl-3-methylenepiperidin-1-ol **13b**: yield 12%, white crystals, mp 90–91 °C (benzene). ^{1}H NMR (400 MHz, [$^2H_6$]acetone) δ: 4.89 (ddq, H^{8a}, *J* 2.0, 0.9 and 1.0 Hz), 4.82 (m, 2H^9), 4.81 (ddq, H^{8b}, *J* 2.0, 0.4 and 1.5 Hz), 4.09 (dd, H^{1a}, *J* 10.9 and 6.9 Hz), 3.78 (dd, H^2, *J* 6.9 and 6.0 Hz), 3.62 (dd, H^{1b}, *J* 10.9 and 6.0 Hz), 3.53 (dd, $W_{1/2}$ 3 Hz, H^6, *J* 10.7 and 3.9 Hz), 2.31 (ddddd, H^{4a}, *J* 14.0, 12.0, 5.5, 1.9 and 1.9 Hz), 2.23 (ddd, H^{4b}, *J* 14.0, 4.7 and 3.7 Hz), 1.78 (m, H^{5a}), 1.77 (dd, 3H^{10}, *J* 1.0 and 1.5 Hz), 1.73 (m, H^{5b}). ^{13}C NMR (100 MHz, [$^2H_6$]acetone) δ: 147.58 (C^7), 146.16 (C^3), 111.97 (C^8), 111.30 (C^9), 72.55 (C^2), 65.39 (C^6), 61.43 (C^1), 30.39 (C^4), 28.76 (C^5), 19.68 (C^{10}). IR (0.25% in KBr, ν/cm^{-1}): 1650 (C=CH_2), 1030 (C–O), 890 (=CH_2). MS, *m*/*z* (%): 183.1234 (M$^+$, 1), 153 (10), 152 (100), 135 (7), 124 (5), 120 (11), 119 (14), 110 (9), 93 (13), 91 (10), 79 (7), 67 (6), 55 (6), 41 (14), 39 (9), 28 (12). Found (%): C, 65.3; H, 9.5; N 7.7. Calc. for $C_{10}H_{17}NO_2$ (%): C, 65.54; H, 9.35; N, 7.64.