J. prakt. Chem. 339 (1997) 656–659

Journal für praktische Chemie
Chemiker-Zeitung

A Synthesis of Substituted Tetrahydro-2-pyranols

Klaus Peseke, Lutz Götze, and Helmut Reinke

Rostock, Fachbereich Chemie der Universität

Quirino Arias Cedeño, José Quincoces Suarez, and Mario Gomez Andreu

Santa Clara (Cuba), Centro de Bioactivos Químicos, Facultad de Química y Farmacia Universidad Central de Las Villas

Hermán Vélez Castro

La Habana (Cuba), Centro Nacional de Investigaciones Cientificas

Received April 24th, 1997 respectively June 18th, 1997

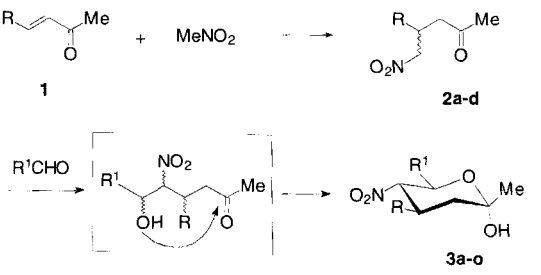
γ-Nitro ketones [1] derived from vinyl ketones **1** and nitromethane have been previously studied as synthetic intermediates by several authors. Walker [2] isolated 5-aryl-4-nitrocyclohexanones in the reaction of γ-nitro ketones with various alkyl carboxylates. Mack [3] investigated the addition of *N*-nucleophiles to γ-nitro ketones. Reichert and Posemann [4] tried to react some aromatic aldehydes with several γ-nitro ketones but they have not been successful.

We wish to report an improved synthetic route to nitro substituted tetrahydropyranols by nitroaldol reaction of γ-nitro ketones with various aromatic aldehydes and subsequent cyclisation. Although there exists a lot of conditions to carry out a nitroaldol addition [5] (Henry reaction) we found the best results with sodium ethoxide as a quite classic base. The resulting products should be of great interest because of their structural similarity to the pyranose moiety.

γ-Nitro ketone **2a** was first published by Kohler *et al.* [6] and **2b** by Koslow *et al.* [7] and **2d** by Walker [2]. They used diethylamine or sodium methanolate and got moderate yields with partly long reaction times. We inform about a more convenient method for the synthesis of these γ-nitro ketones **2**. By refluxing a mixture of vinyl ketone **1** with an excess of nitromethane and a catalytic amount potassium carbonate in dry ethanol for 8 hours and extraction with chloroform we isolated pure compounds **2** with 60–95% yield either by crystallisation or by distillation under reduced pressure.

Kaji *et al.* [8], Zen *et al.* [9] and Sohar *et al.* [10] synthesized nitrotetrahydropyranoles and their derivatives by Michael reaction [11] of nitroalkoholes with unsaturated aldehydes. It was also possible to synthesize nitropyranols by addition of nitronium iodide to unsaturated pyranols [12].

A new way to compounds **3** is shown in Scheme 1. We carried out this nitroaldol reaction with sodium ethoxide in dry ethanol at room temperature. This reaction is marked by short reaction times and good yields of pure products. Aliphatic aldehydes do not undergo reaction under above described conditions. We succeeded to react acetaldehyde with several γ-nitro ketones



1,2	R
a	Ph
b	Fur-2-yl
c	5-Me-fur-2-yl
d	4-$MeOC_6H_4$

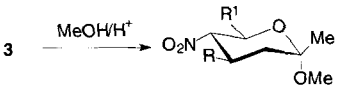
3	R	R^1
a	Ph	Fur-2-yl
b	Ph	2-$NO_2C_6H_4$
c	Ph	2-ClC_6H_4
d	Ph	4-ClC_6H_4
e	Ph	3-$MeOC_6H_4$
f	Ph	3,4,5-$(MeO)_3C_6H_2$
g	Fur-2-yl	2-$NO_2C_6H_4$
h	Fur-2-yl	4-$NO_2C_6H_4$
i	Fur-2-yl	2-ClC_6H_4
j	Fur-2-yl	3,4,5-$(MeO)_3C_6H_2$
k	5-Me-fur-2-yl	2-$NO_2C_6H_4$
l	4-$MeOC_6H_4$	2-$NO_2C_6H_4$
m	Ph	Me
n	Fur-2-yl	Me
o	5-Me-fur-2-yl	Me

Scheme 1

in the presence of an equimolar amount of tetrabutylammonium fluoride in tetrahydrofuran at 4 °C.

For further experiments we protected the anomeric OH group of compounds **3** in good yields by refluxing in methanol under Fischer-glycosidation condition with a catalytic amount of concentrated hydrochloric acid. The resulting acetals **4** form stable crystals by standing some hours at room temperature or at 0 °C (Scheme 2).

Although all compounds are racemic one isomer in Schemes 1 and 2 is only shown. Due to the 1,3 interaction of the bulky aryl groups **3** possesses a 1,4 chair conformation. The *J* values between the protons 3_{ax}-H, 4-H; 4-H, 5-H and 5H, 6-H are 10–12 Hz. Therefore, in all cases the NO_2 group,



4a-f

4	R	R^1
a	Ph	Fur-2-yl
b	Ph	2-$NO_2C_6H_4$
c	Ph	2-ClC_6H_4
d	C_4H_3O	2-$NO_2C_6H_4$
e	C_4H_3O	4-$NO_2C_6H_4$
f	C_4H_3O	2-ClC_6H_4

Scheme 2

R and R^1 are oriented in the preferred equatorial arrangement. Other diastereomers were not isolated. Any traces of another isomers could not be detected in the mother liquid. According to the anomeric effect and the small long range coupling of the OH group with an axial proton of the methylenegroup in ^{1}H NMR-spectra the OH group in **3** as well as the MeO group in **4** are in axial position.

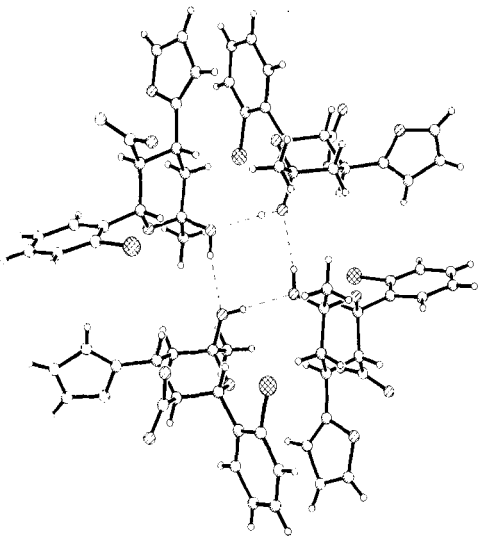


Fig. 1 Arrangement of four molecules [2*RS*-(2α, 4β, 5α, 6β]-(±)- 6-(2-chloro-phenyl)-4-(fur-2-yl)-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-ol (**3i**) in the crystal lattice (30% probability of the thermal ellipsoids)

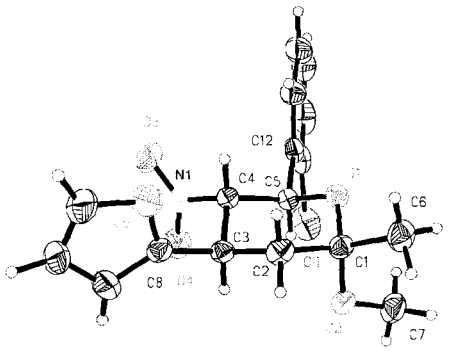


Fig. 2 Molecular structure of [2*RS*-(2α, 4β, 5α, 6β]-(±)- 6-(2-chloro-phenyl)-4-(fur-2-yl)-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-yl-methylether (**4f**) (ORTEP, 30% probability of the thermal ellipsoids).

The structures of **3i** and **4f** were further verified by single crystal x-ray diffraction. All atoms (hydrogens introduced at theoretical positions) were refined. ORTEP plots of **3i** and **4f** are shown in Figure 1 and 2, which gives for **4f** the numbering scheme of the atoms. The crystallographic data were in agreement with a 1,4 chair conformation and the axial position of OH and MeO group, respectively.

We thank the Deutsche Forschungsgemeinschaft and the Fonds der Chemischen Industrie for financial support. Mario Gómez Andreu is grateful to Deutscher Akademischer Austauschdienst for providing a scholarship.

Experimental

Melting points were obtained on a Boëtius melting point apparatus. The ^{1}H and ^{1}C NMR spectra were taken on a Bruker AC 250 and a Bruker ARX 300 spectrometer, respectively. The calibration of spectra was carried out by means of solvent peaks [D_6]DMSO: δ^1H = 2.50; δ^{13}C = 39.7 ppm; *J* values in Hz. The ^{13}C NMR spectra were determined by DEPT and/or ^{1}H, ^{13}C COSY experiments. Mass spectra were recorded on a AMD 402/3 spectrometer (AMD Intectra GmbH). TLC was performed by Silica gel foils 60 F_{254} (Merck) with detecting by charring with sulphuric acid. For column chromatography silica gel 60 (230–400 mm) (Merck) was used.– Elemental analyses were carried out with a Leco CHNS-932 apparatus.

(RS)-(±)-4-(Aryl- and fur-2-yl, resp.)-5-nitro-2-pentanones (**2a,b,d**)

A mixture of **1** (0.1 mol), 27 ml (0.5 mol) nitromethane, 40 ml absolute ethanol and 0.14 g (0.001 mol) potassium carbonate was refluxed for 4 hours. It was allowed to cool and 50 ml of water were added. The mixture was kept for 12 hours at 5 °C. The solid product was filtered off and recrystallized from ethanol.

2a: Yield 1.95 g (95%), white crystals, *m.p.* 97–99 °C (Lit. 99–100 °C [6]).

2b: Yield 1.50 g (76%), white crystals, *m.p.* 44–46 °C (Lit. *b.p.* 162 °C/16 mbar [7]).

$C_9H_{11}NO_4$ (197.19) Calcd.: C 54.82 H 5.58 N 7.10 Found: C 54.56 H 5.55 N 7.23

2d: Yield 2.13 g (90%), white crystals, *m.p.* 78–79 °C (Lit. 86–87 °C [2]).

(RS)-(±)-4-(5-Methyl-fur-2-yl)-5-nitro-2-pentanone (**2c**)

A mixture of **1c** (0.1 mol), 54 ml (1.0 mol) nitromethane, 50 ml absolute ethanol and 0.14 g (0.001 mol) potassium carbonate was refluxed for 8 hours. It was allowed to cool and 50 ml of water were added. The aqueous solution was extracted with 4×50 ml chloroform. The combined organic extracts were washed with water, dried with sodium sulfate and refluxed with activated charcoal, filtered off and concentrated *in vacuo* and compound **2c** was isolated by distillation under reduced pressure.

Yield 1.33 g (63%), yellow *oil*, *b.p.* 74 °C/1.6 × 10^{-4} mbar. – ^{1}H NMR (250 MHz, $CDCl_3$): δ/ppm = 2.14 (s, 3H, CH_3), 2.21(d, 3H, C_4H_2O–$\underline{CH_3}$), 2.89 (m, 2H, J_{3a-3b}= 18.0 Hz, J_{3a-4}

= 6.4 Hz, 3_a-H, 3_b-H), 4.01 (m, 1H, 4-H), 4.63 (d, 2H, J_{4-5} = 6.4 Hz, 5_a-H, 5_b-H), 5.83 (dd, 1H, $J_{C4H2O4\text{-}CH3}$ = 0.9 Hz, C_4H_2O-4H), 5.97 (d, 1H, $J_{C4H2O\text{-}3\text{-}4}$ = 3.0 Hz, C_4H_2O-3H). – ^{13}C NMR (62.9 MHz, $CDCl_3$): δ/ppm = 13.3 (CH_3) 33.0, 30.1 (C-4, C-1), 43.6 (C-3), 77.2 (C-5), 107.6, 106.2 (C_4H_2O–C-3,4), 151.9, 149.7 (C_4H_2O–C-2,5), 205.0 (C-2).

$C_{10}H_{13}NO_4$ (211.21) calcd.: C 56.87 H 6.20 N 6.63
found: C 56.97 H 6.25 N 6.67.

[2RS-(2α, 4β, 5α, 6β]-(±)-4-(Aryl- and fur-2-yl, resp.)-6-(aryl- and fur-2-yl, resp.)-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-ols (**3a–l**)

To a mixture of the aldehyde (0.01 mol) and **2** (0.01 mol) in dry ethanol (10 ml) a solution of 20 drops of 10% sodium ethoxide was dropwise added under stirring. When the reaction was complete the solid product was filtered off or isolated by column chromatography and recrystallized from ethanol.

[2RS-(2α, 4β, 5α, 6β]-(±)- 4-(Aryl- and fur-2-yl, resp.)-3,4,5,6-tetrahydro-2,6-dimethyl-5-nitro-2H-pyran-2-ols (**3m–o**)

To a chilled mixture of **2** (0.01 mol) in dry tetrahydrofuran (40 ml) an equimolar amount of tetrabutylammonium fluoride in tetrahydrofuran (1molar solution) and aliphatic aldehyde (0.01 mol) was added under stirring at 4 °C dropwise. The resulting mixture was kept for 24 hours at 4 °C. The solvent was removed under reduced pressure. The product was separated by column chromatography.

3a: white crystals.– ^{1}H NMR (250 MHz, [D_6]DMSO): δ/ppm = 1.42 (3H, s, CH_3), 1.94 (1H, dd, 3_{ax}-H), 2.07 (1H, dd, $J_{3ax-3eq}$ = 13.3 Hz, 3_{eq}-H), 3.83 (1H, ddd, J_{3ax-4} = 12.1 Hz, J_{3eq-4} = 4.5 Hz, 4-H), 5.22 (1H, dd, J_{4-5} = 10.2 Hz, J_{5-6} = 10 Hz, 5-H), 5.43 (1H, d, J_{5-6} = 10 Hz, 6-H), 6.43 (1H, m, C_4H_3O-4-H), 6.54 (1H, s, OH), 6.56 (1H, d, C_4H_3O-3-H), 7.32 (5H, m, C_6H_5), 7.67 (1H, d, $J_{4\text{-}C4H3O\text{-}5}$ = 1.6 Hz, C_4H_3O-5-H). – ^{13}C NMR (62.9 MHz, [D6]DMSO): δ/ppm = 28.3 (CH_3), 95.7 (C-2), 41.6 (C-3), 42.6 (C-4), 66.8 (C-6), 89.9 (C-5), 109.9 (C_4H_3O–C-3), 110.7 (C_4H_3O–C-4), 127.6 (C_6H_5–C-4), 127.8 (C_6H_5–C-2,6), 128.6 (C_6H_5–C-5), 128.9 (C_6H_5–C-3), 139.1 (C_6H_5–C-1), 143.9 (C_4H_3O–C-5), 149.8 (C_4H_3O–C-2).

3b: white crystals. – IR (KBr): ν = 3543 cm^{-1} (OH), 2900 (CH_3), 1549, 1364 (NO_2, aliphat.), 1522, 1349 (NO_2, aromat.). – ^{1}H NMR (250 MHz, [D6]DMSO): δ/ppm = 1.4 (3H, s, CH_3), 1.97 (1H, dd, J_{3eq-4} = 4.6 Hz, $J_{3ax-3eq}$ = 13.4 Hz, 3_{eq}-H), 2.09 (1H, dd, J_{3ax-4} = 13.4 Hz, 3_{ax}-H), 3.88 (1H, ddd, 4-H), 5.38 (1H, dd, J_{4-5} = 11.3 Hz, J_{5-6} = 9.7 Hz, 5-H), 5.83 (1H, d, J_{5-6} = 9.7 Hz, 6-H), 6.50 (1H, s, OH), 7.20–7.45 (5H, m, C_6H_5), 8.00–7.50, (4H, m, $C_6H_4NO_2$). – ^{13}C NMR (62.9 MHz, [D6]DMSO): δ/ppm = 28.2 (CH_3), 41.7 (C-3), 42.2 (C-4), 68.7 (C-6), 91.6 (C-5), 96.0 (C-2), 123.7 ($C_6H_4NO_2$–C-3), 127.3 (C_6H_5–C-4), 127.5 (C_6H_5–C-2,6), 128.6 ($C_6H_4NO_2$– C-4), 129.8 ($C_6H_4NO_2$–C-6), 130.3 (C_6H_5–C-3,5), 132.7 ($C_6H_4NO_2$–C-5), 139.0 (C_6H_5–C-1), 142.9 ($C_6H_4NO_2$–C-1), 149.3 ($C_6H_4NO_2$–C-2). – MS (10 eV, FAB): *m/z* (%) 359 (80, $[M+H]^+$).

3g: white crystals. – IR (KBr): ν = 3307 cm^{-1} (OH), 2900, 2850 (CH_3), 1548, 1365 (NO_2). – ^{1}H NMR (250 MHz, [D6]DMSO): δ/ppm = 1.39 (3H, s, CH_3), 2.00 (1H, dd, J_{3ax-4} = 12.6 Hz, 3_{ax}-H), 2.09 (1H, dd, J_{3eq-4} = 4.7 Hz, $J_{3ax-3eq}$ = 13.3 Hz, 3_{eq}-H), 4.04 (1H, ddd, 4-H), 5.20 (1H, dd, J_{4-5} = 11.1 Hz, J_{5-6} = 9.9 Hz, 5-H), 5.73 (1H, d, 6-H), 6.30 (1H, m, J_{3-4} = 3.0 Hz, C_4H_3O-3-H), 6.39 (1H, m, C_4H_3O-4-H), 6.61 (1H, s, OH), 7.59 (1H, m, J_{4-5} = 1.5 Hz, C_4H_3O-5-H), 7.78, (4H, m, $C_6H_4NO_2$). – ^{13}C NMR (62.9 MHz, [D6]DMSO): δ/ppm = 27.7 (CH_3), 35.4 (C-4), 39.6 (C-3), 68.8 (C-6), 90.1 (C-5), 95.6 (C-2), 106.8 (C_4H_3O–C-3), 110.6 (C_4H_3O–C-4), 123.8 ($C_6H_4NO_2$–C-3), 129.3 ($C_6H_4NO_2$–C-1), 130.2 ($C_6H_4NO_2$–C-4), 130.3 ($C_6H_4NO_2$–C-6), 132.6 ($C_6H_4NO_2$–C-5), 142.9 (C_4H_3O–C-5), 149.3 ($C_6H_4NO_2$–C-2), 152.4 (C_4H_3O–C-2). – MS (70 eV, EI): *m/z* (%) 330 (11, M-18).

3m: white crystals. – IR (KBr): ν = 3443 cm^{-1} (OH), 1547, 1396, 1384 (NO_2). – ^{1}H NMR (250 MHz, [D_6]DMSO): δ/ppm = 1.20 (3H, d, J = 6.1 Hz, CH_3), 1.45 (3H, s, CH_3) 1.80 (1H, ddd, $J_{3ax\text{-}OH}$ = 2.1 Hz, J_{3ax-4} = 13.4 Hz, 3_{ax}-H), 2.08 (1H, dd, $J_{3ax-3eq}$ = 13.7 Hz, J_{3eq-4} 4.3 Hz, 3_{eq}-H), 2.33 (1H, d, J = 2.1 Hz, OH), 3.81 (1H, ddd, 4-H), 4.39 (1H, dd, J_{4-5} = 11.3 Hz, 5-H), 4.44–4.64 (m, 1H, H-6), 7.13–7.31 (m, 5H, Ph). – ^{13}C NMR (62.9 MHz, $CDCl_3$): δ/ppm = 18.07 (CH_3), 29.54 (CH_3), 41.18 (C-3), 41.79 (C-4), 43.6 (C-3), 67.43 (C-6), 93.45 (C-5), 95.52 (C-2, quart.), 127.17–128.93, 138.69 (C_6H_5, C-1). – MS (70 eV, EI): *m/z* (%) 251 (2.8, M^+).

3n: yellow precipitate. – IR (KBr): ν = 1545.9 cm^{-1}, 1348.1 (NO_2), 1401.8, 1378.9 (CH_3), 3453.9 (OH). – ^{1}H NMR (250 MHz, $CDCl_3$): δ/ppm = 1.23 (3H, d, $J_{6\text{-}CH3}$ = 5.8 Hz, CH_3), 1.49 (3H, s, CH_3), 1.90 (1H, ddd, 3_{ax}-H), 2.16 (1H, dd, $J_{3ax-3eq}$ = 13.7 Hz, J_{3eq-4} = 4.3 Hz, 3_{eq}-H), 2.27 (1H, J = 2 Hz, OH), 4.00 (1H, ddd, 4-H), 4.38 (1H, t, J_{4-5} = 9.7 Hz, J_{5-6} = 9.7 Hz, 5-H), 4.48 (1H, m, 6-H), 5.08 (1H, d, C_4H_3O-3-H),

Tab. 1 Data of [2*RS*-(2α,4β,5α,6β)]-(±)-4-Aryl, (fur-2-yl)-6-aryl, (fur-2-yl), methyl-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-ols (**3a–o**)

3	yield (%)	*m.p.* (°C)	Molecular formula (Molecular mass)	Elemental analytical data found/calculated C	H	N
a	50	114–115	$C_{16}H_{17}NO_5$	63.36	5.61	4.62
			(303.31)	62.52	5.57	4.50
b	85	140–142	$C_{18}H_{18}N_2O_6$	60.33	5.03	7.82
			(358.35)	60.25	4.90	7.82
c	80	138–140	$C_{18}H_{18}ClNO_4$	62.24	5.18	4.03
			(347.79)	61.76	5.38	4.25
d	55	110–113	$C_{18}H_{18}ClNO_4$	62.24	5.18	4.03
			(347.79)	62.00	5.18	4.08
e	42	95–96	$C_{19}H_{21}NO_5$	66.47	6.12	4.08
			(343.37)	66.48	6.06	4.13
f	36	97–100	$C_{21}H_{25}NO_7$	62.53	6.20	3.47
			(403.43)	62.60	6.37	3.58
g	79	130–132	$C_{16}H_{16}N_2O_7$	55.17	4.60	8.05
			(348.31)	55.04	4.63	8.09
h	98	60–61	$C_{16}H_{16}N_2O_7$	55.17	4.60	8.05
			(348.31)	55.28	4.57	8.06
i	79	113–115	$C_{16}H_{16}ClNO_5$	56.97	4.73	4.41
			(337.75)	56.98	4.71	4.19
j	84	90–92	$C_{19}H_{23}NO_8$	57.98	5.84	3.56
			(393.39)	58.11	5.77	3.60
k	63	113–115	$C_{17}H_{18}N_2O_7$	56.35	4.97	7.73
			(362.33)	56.41	4.93	7.69
l	80	167–169	$C_{19}H_{20}N_2O_7$	58.76	5.15	7.21
			(388.37)	58.80	5.46	7.21
m	75	118–119	$C_{13}H_{17}NO_4$	62.15	6.82	5.57
			(251.28)	62.32	6.57	5.73
n	71	77–79	$C_{11}H_{15}NO_5$	54.77	6.27	5.81
			(241.24)	54.61	6.46	5.93
o	73	113–115	$C_{12}H_{17}NO_5$	56.46	6.71	5.49
			(255.27)	56.32	6.51	5.24

6.25 (1H, dd, $J_{C4H3O-3-4}$ = 3.3 Hz, C_4H_3O-4-H), 7.31 (1H, d, $J_{C4H3O-4-5}$ = 1.8 Hz, C_4H_3O-5-H). – ^{13}C NMR (62.9 MHz, [D6]DMSO): δ/ppm = 18.0 (CH_3), 29.4 (CH_3), 35.5 (C-4), 38.1 (C-3), 67.1 (C-6), 91.6 (C-5), 95.2 (C-2), 106.7 (C_4H_3O–C-3), 110.2 (C_4H_3O–C-4), 142.3 (C_6H_5–C-5), 152.1 (C_4H_3O–C-2). – MS (70 eV, EI): *m/z* (%) 241 (5.7, M^+).

[2RS-(2α, 4β, 5α, 6β]-(±)- 4-(Aryl- and fur-2-yl, resp.)-6-(aryl- and fur-2-yl, resp.)-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-yl-methylethers (**4a–f**)

To a solution of **3** (0.01 mol) in absolute methanol (50 ml) was added concentrated hydrochloric acid (0.45 ml). The reaction mixture was refluxed for 8 h, then allowed to cool. The solid product was filtered off and recrystallized from methanol.

Tab. 2 Data of [2*RS*-(2α,4β,5α,6β)]-(±)-4-Aryl, (fur-2-yl)-6-aryl, (fur-2-yl)-3,4,5,6-tetrahydro-2-methyl-5-nitro-2H-pyran-2-yl-methylether (**4a–f**)

4	yield (%)	*m.p.* (°C)	Molecular formula (Molecular mass)	Elemental analytical data found/calculated C	H	N
a	45	120–121	$C_{17}H_{19}NO_5$	64.35	5.99	4.41
			(317.24)	64.02	6.17	4.42
b	90	148–149	$C_{19}H_{20}N_2O_6$	61.29	5.37	7.52
			(372.37)	61.34	5.51	7.55
c	85	156–157	$C_{19}H_{20}ClNO_4$	63.15	5.54	3.87
			(361.82)	63.09	5.80	3.87
d	90	110–111	$C_{17}H_{18}N_2O_7$	56.35	4.97	7.73
			(362.33)	56.14	5.13	7.76
e	66	105–106	$C_{17}H_{18}N_2O_7$	56.35	4.97	7.73
			(362.33)	56.41	5.16	7.74
f	95	123–124	$C_{17}H_{18}ClNO_5$	58.12	5.12	3.98
			(351.78)	58.15	5.26	3.98

4f : white crystals. – IR (KBr): ν = 1552 cm^{-1}, 1376 (NO_2). – ^1H NMR (250 MHz, $CDCl_3$): δ/ppm = 1.40 (3H, s, CH_3), 2.11 (1H, dd, J_{3ax-4} = 13.7 Hz, 3_{ax}-H), 2.25 (1H, dd, $J_{3ax-3eq}$ = 13.7 Hz, J_{3eq-4} = 4.6 Hz, 3_{eq}-H), 3.38 (3H, s, OCH_3), 4.20 (1H, ddd, 4-H), 4.95 (1H, dd, J_{4-5} = 11.3 Hz, 5-H), 5.68 (1H, dd, J_{5-6} = 10.1 Hz, 6-H), 6.13 (1H, d, C_4H_3O-3-H), 6.26 (1H, dd, $J_{C4H3O-3-4}$ = 3.3 Hz, C_4H_3O-4-H), 7.29 (1H, dd, $J_{C4H3O-4-5}$ = 1.8 Hz, C_4H_3O-5-H), 7.22–7.40 (4H, m, C_6H_4Cl). – ^{13}C NMR (62.9 MHz, $CDCl_3$): δ/ppm = 22.6 (CH_3), 35.8 (C-4), 39.3 (C-3), 48.6 (OCH_3), 69.8 (C-6), 89.4 (C-5), 98.8 (C-2), 107.1 (C_4H_3O–C-3), 110.3 (C_4H_3O–C-4), 127.4–130.4 (C_6H_4Cl–C-3,6), 134.2 (C_6H_4Cl–C-2), 135.5 (C_6H_4Cl–C-1), 142.4 (C_4H_3O–C-5), 151.8 (C_4H_3O-C-2).

Crystal-Structure Determination

3i: Crystals were obtained by crystallisation from EtOH solution. The compound crystallises in $P2_1/c$ with two molecules within the asymmetric unit and a = 9.846(2), b = 14.034(3), c = 24.152(5) Å, b = 94.56 °, V = 3326.7 (12) $Å^3$, D_c = 1.349 gcm^{-3}, Z = 8.The data were collected at room temperature (25 °C) on a Siemens P4 four-circle diffractometer in routine w-scan. The structure was solved by direct methods and refined with 4279 reflections to R1 = 0.1097 and R1 = 0.0595 for the 2617 observed reflections, the observation criterion being I>2s(I). Since there is a hydroxyl group an attempt was made to calculate the position of lowest energy for the proton with SHELXL-93 (G.M. Sheldrick, Universität Göttingen, 1993). From the packing diagram the preferred position becomes clear, since four molecules of **3i** form a moiety as it is shown in Fig. 1. In addition to this hydrogen bonding phenomenon there is a short contact between chlorine atoms in different molecules of 3.331(2) Å.

4f: Crystals were obtained by crystallisation from EtOH solution. The compound crystallises in $P2_1/c$ with a = 6.018, b = 23.274(1), c = 12.732(1) Å, b = 103.49(1) °, V = 1734.1 (2) $Å^3$, D_c = 1.347 gcm^{-3}, Z = 4. The data were collected at room temperature (25 °C) on a Siemens P4 four-circle diffractometer in routine w-scan. The structure was solved by direct methods and refined with 2402 reflections to R1 = 0.0496 and R1 = 0.0432 for the 2096 observed reflections, the observation criterion being I>2s(I).

References

[1] H. G. Thomas in "Methoden der organischen Chemie (Houben–Weyl–Müller)", Vol. 7/2b, Thieme Verlag, Stuttgart 1976; p. 1581

[2] G. N. Walker, J. Org. Chem. **30** (1965) 1416

[3] W. Mack, Chem. Ber. **109** (1976) 3564

[4] B. Reichert, H. Posemann, Arch. Pharm. **275** (1937) 67

[5] a) H. H. Baer, L. Urbas, in „The Chemistry of the nitro and nitroso groups (S. Patai) „ J. Wiley, New York 1970, part 2; b) D. Seebach, E. W. Colvin, F. Lehr, T. Weller, Chimia **33** (1979) 1; c) G. Rosini, R. Ballini, Synthesis **1988**, 833; d) F. W. Lichtenthaler, Angew. Chem. **76** (1964) 84; e) H. G. Padeken, O. von Schick, in "Methoden der organischen Chemie (Houben–Weyl–Müller)", Vol. 10/1, Thieme Verlag, Stuttgart 1971; p. 182; f) H. Feuer, A. T. Nielsen, Nitro Compounds. Recent Advances in Synthesis and Chemistry, VCH Weinheim 1990; g) R. Ballini, G. Bosica, P. Forconi, Tetrahedron **52** (1996) 1677

[6] E. P. Kohler, N. L. J. Drake, Am. Chem. Soc. **45** (1923) 2144

[7] L. M. Koslow, E. F. Fink, Trudy Kazan. Khim. Tekhnol. Inst. im. S. M. Kirova, **1956**, 163, Chem. Abstr. **51** (1957) 11983;

[8] E. Kaji, H. Kohno, S. Zen, Bull. Chem. Soc. Jpn. **50** (1977) 928

[9] S. Zen, E. Kaji, H. Kohno, Chem. Lett. **1974**, 1029

[10] P. Sohar, G. Mikite, I. Pelczer, A. Kovacs, A. Kis–Tamas, Org. Magn. Reson. **22** (1984) 710

[11] E. D. Bergmann, D. Ginsburg, R. Pappo, Org. Reactions **10** (1959) 179

[12] W. A. Szarek, D. A. Lance, Carbohydr. Res. **13** (1970) 75

Address for correspondence:
Prof. Dr. K. Peseke
Fachbereich Chemie
Universität Rostock
Buchbinderstr. 9
D-18051 Rostock