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The first conglomerate in the series of 2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-diones

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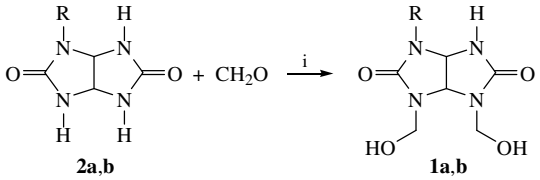
The condensation of 2-alkyl-4,6-di(hydroxymethyl)glycoluriles with aliphatic amines has been studied for the first time, and chiral derivatives of 2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-diones have been synthesised. The first example of conglomerates in the series of such structures, 2-*tert*-butyl-8-(2-hydroxyethyl)-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione, has been found.

We have been interested in the chemistry and stereochemistry of 2,4,6,8-tetraazabicyclo[3.3.0]octane-3,7-diones (glycoluriles), which are a new class of neurotropically active compounds and possess neurotropic activity of a wide range: tranquilizer, sedative, antihypoxic and neuroprotective actions.[1–5] It is known that all of asymmetrically substituted glycoluriles are chiral and in this series several compounds were found, which could crystallise as conglomerates.[6–8]

Recently, we synthesised *N*-(hydroxymethyl)glycoluriles, including chiral 2-*tert*-butyl(cyclohexyl)-4,6-di(hydroxymethyl)-glycoluriles **1a**,**b**, by the condensation of 2-*tert*-butyl(cyclohexyl)glycoluriles **2a**,**b** with formaldehyde under alkaline catalysis conditions.[9] Hydroxymethyl groups were introduced to this reaction regiospecifically only in the 4- and 6-positions. The hydrogen atom at N(8) was not substituted by the hydroxymethyl group regardless of the reagent ratio. This result is probably connected with steric hindrances created by 2-*tert*-butyl or cyclohexyl substituents (Scheme 1).



Scheme 1 *Reagents and conditions*: i, Pr^{i}OH–H_2O (1:1), pH 8–9, 85 °C, 1 h.

In this work, the possibility of preparing chiral derivatives of 2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-diones **3a**–**n** by the condensation of glycoluriles **1a**,**b** with primary aliphatic amines **4a**–**g** was studied and a search of conglomerates among the synthesised chiral tricyclic compounds **3** was undertaken. Only achiral 2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]-undecane-1,5-diones, which have no substituents at N(2) and N(8), were reported; however, they were described as Markush structures.[10,‡]

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Methods for the synthesis of target tricyclic compounds **3a**–**n** were developed using the interaction of 2-*tert*-butyl-4,6-di-(hydroxymethyl)glycolurile **2a** with amine **4e** at refluxing for 2 h. The reaction was performed in a mixture of H_2O–Pr^{i}OH (1:1) due to a limited solubility of Bu^{t}NH$_2$ in water. The reaction results were monitored by NMR spectroscopy every 15 min at the disappearance of signals due to the OH groups of initial glycolurile **2a** in dry evaporated equal parts of the reaction mixture. It was found that the optimal duration of this reaction was 1 h. The condensation of 2-*tert*-butyl(cyclohexyl)-4,6-di(hydroxymethyl)glycoluriles **2a**,**b** with amines **4a**–**g** under the found conditions resulted in chiral tricyclic compounds **3a**–**n** in 70–84% yields (Scheme 2). The structure of the obtained compounds was confirmed by ^{1}H and ^{13}C NMR spectroscopy and mass spectrometry.§

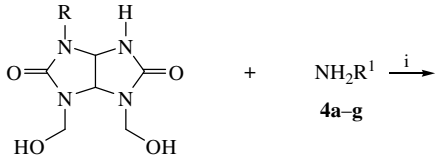
‡ The structures of Markush do not correspond to particular compounds; they are a convenient method for the representation of chemical structures in a generalised form.

§ All new compounds gave satisfactory elemental analysis data. Their structures were confirmed by ^{1}H and ^{13}C NMR spectroscopy and mass spectrometry. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AM-300 spectrometer (300.13 MHz for ^{1}H and 75.47 MHz for ^{13}C). Chemical shifts were measured with reference to residual protons of a [$^2H_6$]DMSO solvent (δ 2.50 ppm). Mass spectra were measured on an MS 30 spectrometer.

Glycoluriles **2a**,**b** were synthesised by the α-ureidoalkylation of 1-*tret*-butylcyclohexylureas (obtained by the interaction of corresponding amines with KOCN[11]) using 4,5-dihydroxyimidazolidin-2-one as an α-ureidoalkylating reagent under acidic catalysis.[12]

2-tert-Butyl-8-ethyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3a**: yield 76%, mp 185–187 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.0 (t, 3H, Me, ^3J 7.3 Hz), 1.3 (s, 9H, 3Me), 2.3 (q, 2H, CH_2, ^3J 7.3 Hz), 4.1, 4.5 (2m, 2×2H, 2NCH_2N), 5.25, 5.5 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 8.0 (s, 1H, NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 12.6 (Me), 28.0 (Me), 42.8 (CH_2), 52.4 (C), 58.3 (CH_2), 58.5 (CH_2), 63.4 (CH), 64.2 (CH), 157.2 (CO), 159.4 (CO).

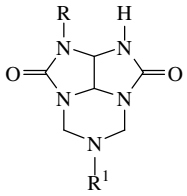
2-tert-Butyl-8-propyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3b**: yield 70%, mp 186–188 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.75 (t, 3H, Me, ^3J 7.3 Hz), 1.3 (s, 9H, 3Me), 1.35 (m, 2H, CCH_2C), 2.2 (dd, 2H, NCH_2C, ^3J 7.3 Hz), 4.1, 4.45 (2m, 2×2H, 2NCH_2N), 5.25–5.5 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 8.0 (s, 1H, NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 11.6 (Me), 20.0 (CH_2), 28.0 (Me), 50.5 (CH_2), 52.4 (C), 58.5 (CH_2), 59.1 (CH_2), 63.4 (CH), 64.3 (CH), 157.3 (CO), 159.5 (CO). MS, *m*/*z* (%): 252 (100), 224 (37), 167 (18), 152 (18), 124 (25), 112 (15), 84 (21), 70 (30), 56 (52), 43 (42).



1a,**b**

1a R = Bu^t
1b R = cyclohexyl

4a R^1 = Et
4b R^1 = Pr
4c R^1 = Bu
4d R^1 = Bu^s
4e R^1 = Bu^t
4f R^1 = cyclohexyl
4g R^1 = C_2H_4OH



3a–**n**

3a R = Bu^t, R^1 = Et
3b R = Bu^t, R^1 = Pr
3c R = Bu^t, R^1 = Bu
3d R = Bu^t, R^1 = Bu^s
3e R = Bu^t, R^1 = Bu^t
3f R = Bu^t, R^1 = cyclohexyl
3g R = Bu^t, R^1 = C_2H_4OH
3h R = cyclohexyl, R^1 = Et
3i R = cyclohexyl, R^1 = Pr
3j R = cyclohexyl, R^1 = Bu
3k R = cyclohexyl, R^1 = Bu^s
3l R = cyclohexyl, R^1 = Bu^t
3m R = cyclohexyl, R^1 = cyclohexyl
3n R = cyclohexyl, R^1 = C_2H_4OH

Scheme 2 *Reagents and conditions*: i, Pr^{i}OH–H_2O (1:1), 85 °C, 1 h.

2-tert-*Butyl-8-butyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3c**: yield 74%, mp 182–184 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.8 (t, 3H, Me, ^3J 7.33 Hz), 1.2 (m, 2H, CCH_2C), 1.32 (s, 9H, 3Me), 1.35 (m, 2H, CCH_2C), 2.3 (dd, 2H, NCH_2C, ^3J 7.3 Hz), 4.1, 4.45 (2m, 2×2H, $2NCH_2N$), 5.25, 5.5 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 8.0 (s, 1H, NH). MS, *m*/*z* (%): 266 (100), 211 (13), 155 (5), 124 (8), 112 (12), 84 (10), 70 (12), 56 (52), 43 (30).

2-tert-*Butyl-8*-sec-*butyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3d**: yield 75%, mp 185–187 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.7 (t, 3H, Me, ^3J 7.33 Hz), 1.0 (d, 3H, Me, ^3J 6.10 Hz), 1.3 (s, 9H, 3Me), 1.4 (m, 2H, CH_2), 2.4 (m, 1H, CH), 4.0, 4.7 (2m, 2×2H, $2NCH_2N$), 5.25, 5.5 (2d, 2×1H, CH–CH, ^3J 7.93 Hz), 7.9 (br. d, 1H, NH). ^{13}C NMR ([$^2H_6$]DMSO) δ: 9.08, 9.29 (Me), 16.87, 16.92 (Me), 25.98, 26.06 (CH_2), 27.97, 28.00 (2×3Me), 51.53, 51.68 (CH), 52.43 (C), 56.20, 56.37, 56.56 ($3CH_2$), 63.39 (CH), 64.35 (CH), 156.72, 157.02 (CO), 158.98, 159.28 (CO). MS, *m*/*z* (%): 266 (100), 211 (39), 167 (11), 155 (15), 124 (12), 112 (27), 84 (20), 70 (26), 56 (91), 43 (26).

2,8-Di(tert-*butyl*)*-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3e**: yield 70%, mp 234–236 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.05 (s, 9H, 3Me), 1.3 (s, 9H, 3Me), 3.85, 4.75 (2m, 2×2H, $2NCH_2N$), 5.2, 5.5 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 7.95 (br. s, 1H, NH).

2-tert-*Butyl-8-cyclohexyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3f**: yield 84%, mp 162–163 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.0, 1.48, 1.63 (3m, 10H, C_6H_{10}), 1.3 (s, 9H, 3Me), 4.15, 4.75 (2m, 2×2H, $2NCH_2N$), 5.25, 5.45 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 7.95 (br. s, 1H, NH).

2-tert-*Butyl-8-(2-hydroxyethyl)-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]-undecane-1,5-dione* **3g**: yield 80%, mp 255–256 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.3 (s, 9H, 3Me), 2.4 (dd, 2H, NCH_2C, ^3J 6.41 Hz), 3.4 (m, 2H, CCH_2O), 4.1, 4.45 (2m, 2×2H, $2NCH_2N$), 5.25, 5.5 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 8.0 (br. s, 1H, NH). MS, *m*/*z* (%): 252 (100), 167 (66), 152 (62), 124 (82), 112 (45), 84 (35), 70 (39), 56 (70), 43 (22).

2-Cyclohexyl-8-ethyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3h**: yield 76%, mp 220–221 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.95 (t, 3H, Me, ^3J 6.98 Hz), 1.2, 1.6, 1.75 (3m, 10H, C_6H_{10}), 2.3 (q, 2H, NCH_2C, ^3J 6.62 Hz), 3.4 (m, 1H, CH), 4.1, 4.5 (2m, 2×2H, $2NCH_2N$), 5.3, 5.4 (2m, 2×1H, CH–CH), 7.85 (br. s, 1H, NH). MS, *m*/*z* (%): 292 (293) ($M^+ - 1$, 33), 278 (100), 237 (87), 167 (36), 155 (43), 128 (93), 112 (80), 99 (47), 83 (86), 71 (58), 56 (90).

2-Cyclohexyl-8-propyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3i**: yield 72%, mp 218–220 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.8 (t, 3H, Me, ^3J 7.17 Hz), 1.2, 1.6, 1.8 (3m, 10H, C_6H_{10}), 1.4 (m, 2H, CCH_2C), 2.3 (m, 2H, NCH_2C), 3.4 (m, 1H, CH), 4.15, 4.5 (2m, 2×2H, $2NCH_2N$), 5.3, 5.4 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 7.85 (br. s, 1H, NH). MS, *m*/*z* (%): 278 (100), 237 (7), 206 (7), 167 (9), 124 (9), 83 (9), 57 (23), 43 (16).

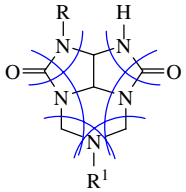


Figure 1 Schematic diagram of fragmentation directions for tricyclic compounds **3a**–**n** under electron impact.

A specific feature of the ^{1}H NMR spectra of compounds **3** are two multiplets at 3.8–4.8 ppm, which can be attributed to diastereotopic protons of CH_2 groups of the hexahydrotriazine ring, and two doublets of CH–CH groups at 5.2–5.5 ppm. The broad singlet of the NH group proton appears at 7.8–8.0 ppm. In the ^{13}C NMR spectra, the signals of CH_2 groups appear at 56–60 ppm; the signals of CH–CH groups, at 62–65 ppm and of the CO group, at 156–160 ppm. In the ^{13}C NMR spectra of compound **3k** containing a racemic Bu^s fragment, a doubling of carbon atoms was revealed, what gives evidence, as expected, of a diastereomeric composition of this compound.

The mass-spectrometric data showed that the observed fragmentation of tricyclic compounds **3a**–**n** under electron impact had the regularity indicated by curves in Figure 1.

To study the capacity of the synthesised compounds to crystallise as conglomerates, the crystallization of compounds **3a**–**n** from H_2O and an H_2O–Pr^{i}OH mixture (1:1) was investigated. We managed to grow (from water) monocrystals of **3g** with a hydroxyethyl substituent, suitable for an X-ray diffraction study.¶ This investigation showed that compound **3g** crystallised in the non-center symmetric space group C_2 as a conglomerate. This fact is another confirmation of the conglomerate formation ability of glycolurile derivatives containing functional groups. Since small sizes of crystals did not allow us to measure the

2-Cyclohexyl-8-butyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3j**: yield 75%, mp 209–211 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.8 (t, 3H, Me, ^3J 7.35 Hz), 1.2, 1.6, 1.8 (3m, 10H, C_6H_{10}), 1.2 (m, 2H, CH_2), 1.4 (m, 2H, CH_2), 2.3 (dd, 2H, NCH_2C, ^3J 7.3 Hz), 3.4 (m, 1H, CH), 4.15, 4.5 (2m, 2×2H, NCH_2N), 5.3, 5.4 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 7.85 (br. s, 1H, NH). MS, *m*/*z* (%): 321 (M^+, 7), 278 (100), 237 (20), 206 (18), 195 (11), 167 (18), 156 (17), 138 (13), 124 (36), 112 (35), 83 (64), 70 (26), 55 (80), 43 (22).

2-Cyclohexyl-8-sec-*butyl-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3k**: yield 78%, mp 211–213 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 0.75 (t, 3H, Me, ^3J 7.35 Hz), 1.0 (d, 3H, Me, ^3J 5.89 Hz), 1.2, 1.6, 1.8 (3m, 10H, C_6H_{10}), 1.45 (m, 2H, CH_2), 2.4 (m, 1H, CH), 3.4 (m, 1H, CH), 4.1, 4.7 (2m, 2×2H, NCH_2N), 5.3 (2d, 2×1H, CH–CH, ^3J 7.94 Hz), 7.8 (br. s, 1H, NH). MS, *m*/*z* (%): 292 (100), 237 (55), 220 (12), 194 (11), 167 (3), 155 (4), 138 (3), 101 (6), 83 (7), 56 (15), 43 (13).

2-Cyclohexyl-8-tert-*butyl-2,4,6,8,10-pentaazabicyclo[5.3.1.0^{3,11}]undecane-1,5-dione* **3l**: yield 70%, mp 243–245 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.15, 1.55, 1.7 (3m, 10H, C_5H_{10}), 1.1 (s, 9H, 3Me), 3.4 (m, 1H, CH), 3.9, 4.8 (2m, 2×2H, $2NCH_2N$), 5.3 (2d, 2×1H, CH–CH, ^3J 7.0 Hz), 7.85 (br. s, 1H, NH).

2,8-Di(cyclohexyl)-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-dione **3m**: yield 81%, mp 207–209 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.1, 1.6, 2.0, 2.2 (4m, 20H, $2C_5H_{10}$), 3.3 (m, 1H, CH), 3.6 (m, 1H, CH), 4.1, 4.75 (2m, 2×2H, $2NCH_2N$), 5.3 (2d, 2×1H, CH–CH, ^3J 7.93 Hz), 7.9 (br. s, 1H, NH). MS, *m*/*z* (%): 347 (M^+, 65), 304 (83), 252 (30), 237 (23), 124 (35), 112 (65), 83 (50), 69 (100), 56 (55), 43 (42).

2-Cyclohexyl-8-(2-hydroxyethyl)-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]-undecane-1,5-dione **3n**: yield 74%, mp 207–209 °C. ^{1}H NMR ([$^2H_6$]DMSO) δ: 1.2, 1.6, 1.7 (3m, 10H, C_5H_{10}), 2.4 (dd, 2H, NCH_2C, ^3J 5.88 Hz), 3.4 (m, 1H, CH), 3.4 (m, 2H, CH_2), 4.15, 4.5 (2m, 2×2H, NCH_2N), 4.4 (m, 1H, OH), 5.3, 5.4 (2d, 2×1H, CH–CH, ^3J 7.36 Hz), 7.9 (br. s, 1H, NH). MS, *m*/*z* (%): 291 (5), 278 (100), 249 (13), 235 (12), 220 (13), 206 (22), 196 (13), 167 (19), 152 (22), 138 (15), 124 (54), 112 (32), 98 (23), 83 (44), 69 (36), 56 (97), 43 (19).

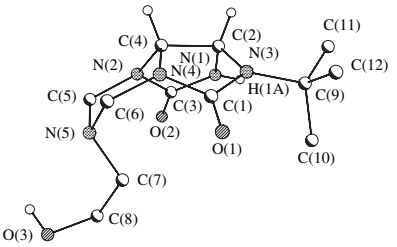


Figure 2 Molecular structure of **3g**.

optical activity of individual crystal, we used a microscope to find large crystals (~21 mg) and found that the angle of optical rotation of their aqueous solution was (–) 34.29°. This result supported the conglomerate formation in the crystallization of compound **3g**.

The molecule of **3g** is tricyclic with annelated imidazolidine and hexahydrotriazine rings (Figure 2). The imidazolidine rings N(1)C(2)C(4)N(2)C(3) and C(1)N(4)N(3)C(4)C(2) are characterised by the envelope conformation with the deviation of atoms C(3) (0.09 Å) and C(1) (0.18 Å), respectively. The hexahydrotriazine ring is characterised by a chair conformation with the equatorial position of the 2-hydroxyethyl fragment. Nitrogen atoms of the hexahydrotriazine ring are pyramidal, while all the others are characterised by a flattened configuration that is the consequence of conjugation with the C=O group. The *N*-(2-hydroxyethyl) fragment is characterised by a sinperiplanar conformation with the torsion angle N(5)–C(7)–C(8)–O(3) equal to 57.6°.

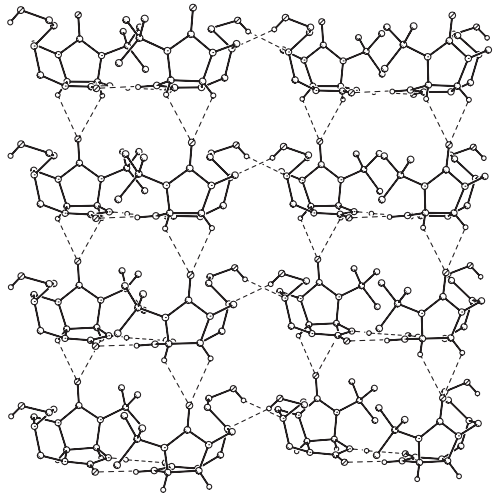


Figure 3 Fragment of H-bonded layers in a crystal of **3g**.

¶ *X-ray analysis.* Crystals of **3g** ($C_{12}H_{21}N_5O_3$, M = 283.34) are monoclinic, space group C_2, at 120(2) K: a = 19.7952(1), b = 6.2220(3) and c = 12.6706(7) Å, β = 119.601(3)°, V = 1356.91(12) Å^3, Z = 4, d_{calc} = = 1.441 g cm^{-3}, μ(MoKα) = 0.294 cm^{-1}, F(000) = 472. Intensities of 3887 reflections were measured with a Bruker AXS Smart 1000 CCD diffractometer (MoKα-radiation, ω-scan) and 1732 independent reflections (R_{int} = 0.0131) were used in a further refinement. The hydrogen atoms were located from the Fourier electron density synthesis and refined in the isotropic approximation. The refinement converged to wR_2 = 0.0867 and GOF = 1.068 for all independent reflections [R_1 = 0.0317 was calculated against F for 1672 observed reflections with $I > 2\sigma(I)$]. All calculations were performed using SHELXTL PLUS 5.0.

Atomic coordinates, bond lengths, bond angles and thermal parameters have been deposited at the Cambridge Crystallographic Data Centre (CCDC). These data can be obtained free of charge *via* www.ccdc.cam.uk/conts/retrieving.html (or from the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44 1223 336 033; or deposit@ccdc.cam.ac.uk). Any request to the CCDC for data should quote the full literature citation and CCDC reference number 637868. For details, see 'Notice to Authors', *Mendeleev Commun.*, Issue 1, 2007.

In a crystal, molecules are assembled into corrugated layers by N–H···O (2.93 Å) and O–H···N (3.0 Å) bonds of moderate strengths and weak C–H···O interactions (H···O 2.39–2.51 Å) with bridgehead hydrogen atoms (Figure 3).

Thus, a method for the synthesis of chiral 2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]undecane-1,5-diones has been developed. The first conglomerate in the series of these compounds, 2-*tert*-butyl-8-(2-hydroxyethyl)-2,4,6,8,10-pentaazatricyclo[5.3.1.0^{3,11}]-undecane-1,5-dione, has been revealed by X-ray diffraction analysis.

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References

1 M. D. Mashkovskii, *Lekarstvennye sredstva* (*Medicines*), Novaya Volna, Moscow, 2000, vol. 1, p. 86 (in Russian).
2 Yu. V. Vicharev, L. V. Anikina, I. E. Chikunov, A. S. Sigachev, A. N. Kravchenko, Yu. V. Shklyaev and N. N. Makhova, *Vopr. Biol. Med. Farm. Khim.*, 2006, 236 (in Russian).
3 I. E. Zimakova, R. A. Kamburg and S. V. Kirshin, *Farmakol. Toksikol.*, 1980, 368 (in Russian).
4 N. N. Makhova, A. N. Kravchenko, I. E. Chikunov, A. V. Shevtsov, V. Yu. Petukhova, A. S. Sigachev, O. V. Lebedev and G. A. Gazieva, *Book of Abstracts of the 7th International Seminar 'Scientific Advances in Chemistry: Heterocycles, Catalysis and Polymers as Driving Forces'*, Ekaterinburg, 2004, p. 48.
5 Yu. V. Vicharev, L. V. Anikina, I. E. Chikunov, Yu. V. Shklyaev and A. N. Kravchenko, *Book of Abstracts of the 7th International Seminar 'Scientific Advances in Chemistry: Heterocycles, Catalysis and Polymers as Driving Forces'*, Ekaterinburg, 2004, p. 129.
6 R. G. Kostyanovsky, K. A. Lyssenko, G. K. Kadorkina, O. V. Lebedev, A. N. Kravchenko, I. I. Chervin and V. R. Kostyanovsky, *Mendeleev Commun.*, 1998, 231.
7 R. G. Kostyanovsky, K. A. Lyssenko, A. N. Kravchenko, O. V. Lebedev, G. K. Kadorkina and V. R. Kostyanovsky, *Mendeleev Commun.*, 2001, 134.
8 K. A. Lyssenko, D. G. Golovanov, A. N. Kravchenko, I. E. Chikunov, O. V. Lebedev and N. N. Makhova, *Mendeleev Commun.*, 2004, 105.
9 A. N. Kravchenko, A. S. Sigachev, G. A. Gazieva, E. Yu. Maksareva, N. S. Trunova, K. Yu. Chegaev, K. A. Lyssenko, D. V. Lyubetsky, M. I. Struchkova, M. M. Il'in, V. A. Davankov, O. V. Lebedev, N. N. Makhova and V. A. Tartakovsky, *Khim Geterotsikl. Soedin.*, 2006, 411 [*Chem. Heterocycl. Compd.* (*Engl. Transl.*), 2006, **42**, 365].
10 A. Aumueller, P. Neumann and H. Trauth, *German Patent 3643887*, 1988 (*Chem. Abstr.*, 1988, **109**, 232138).
11 F. Arndt, *Organic Syntheses*, Wiley, New York, 1935, vol. XV, p. 48.
12 A. N. Kravchenko, A. S. Sigachev, E. Yu. Maksareva, G. A. Gazieva, N. S. Trunova, B. V. Lozhkin, T. S. Pivina, M. M. Il'in, K. F. Lyssenko, Yu. V. Nelyubina, V. A. Davankov, O. V. Lebedev, N. N. Makhova and V. A. Tartakovsky, *Izv. Akad. Nauk, Ser. Khim.*, 2005, 680 (*Russ. Chem. Bull., Int. Ed.*, 2005, **54**, 691).

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