ЖУРНАЛ СТРУКТУРНОЙ ХИМИИ

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КРАТКИЕ СООБЩЕНИЯ

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CRYSTAL STRUCTURE OF 1,9-DIMETHYL-4,5-DIHYDRO-6*H*-PYRIDO[3′,2′:4,5]THIENO[2,3-*f*′]PYRROLO[1,2-*a*][1,4]DIAZEPIN-6-ONE

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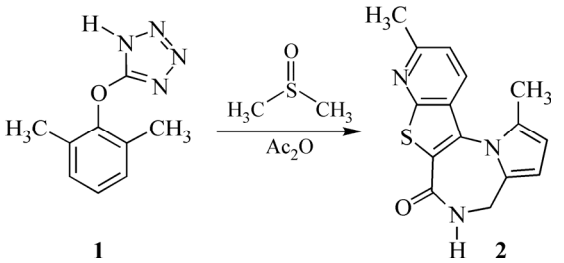
A new tetracyclic compound, 1,9-dimethyl-4,5-dihydro-6*H*-pyrido[3′,2′:4,5]thieno[2,3-*f*′]pyrrolo[1,2-*a*][1,4]diazepin-6-one (**2**) was isolated and studied by X-ray crystallography. Compound **2** crystallizes in the orthorhombic system, space group $Pna2_1$, $a = 11.1098(8)$, $b = 8.4815(6)$, $c = 28.367(2)$ Å, $V = 2673.0(3)$ Å^3, $Z = 8$. The crystal structure comprises two crystallographically independent molecules of the compound. They relate as stereoisomers; in each the diazepine ring exhibits a boat conformation. The crystal packing reveals zig-zag H-bonded chains with two distinct hydrogen bonds. The H…O distances and N—H…O angles for N3—H3…O1′ are 2.012 Å and 174°, and for N3′—H3′…O1 are 1.974 Å and 154°, respectively.

K e y w o r d s: hydrogen bond, independent molecules, torsion helicoid, diazepinones.

Several kinds of diazepinones and especially their fused benzo and/or pyrido derivatives are well known as pharmaceutical compounds [1—8]. A structure combining two enantiomers of a compound with diazepine ring has been reported [9]. This paper reports the crystal structure of a new, the title, compound **2** that was unexpectedly synthesized from the reaction of 5-(2,6-dimethyl-phenoxy)-1*H*-tetrazole (**1**) with dimethyl sulfoxide in acetic anhydride *via* a complex route (Scheme 1).



1 **2**

Scheme 1

Experimental. Dry DMSO (10 ml) was added dropwise over a period of 30 min to a solution of compound **1** (0.19 g) in acetic anhydride (4 ml). The mixture was stirred for 40 h at 45—50 °C; then the excess of DMSO and acetic anhydride was removed under reduced pressure and the residue was washed with several portions (2—3 ml each) of water. The precipitate was dissolved in methylene chloride (20 ml); the solution was dried over calcium chloride and evaporated. The residue was separated by column chromatography on silica gel to isolate compound **2** (20 %). The crystals of the new tetracyclic compound **2** were prepared by crystallization from cyclohexane:ethyl acetate (80:20/v:v) at room temperature. The crystals grew as colorless plates. ^{1}H NMR (300 MHz, DMSO-d_6, δ, ppm): 2.23 (s, 3H), 2.66 (s, 3H), 3.55 (dd, 1H, $J_1 = 6$ Hz, $J_2 = 6$ Hz) 3.99 (dd, 1H, $J_1 = 15$ Hz, $J_2 = 6$ Hz), 6.02 (d, 1H, $J = 3$ Hz), 6.25 (d, 1H, $J = 3$ Hz) 7.12 (d, 1H, $J = 9$ Hz), 7.88 (d, 1H, $J = 9$ Hz), 8.29 (bs, 1H). ^{13}C

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Table 1

Crystal Data and Experimental Details for **2**

Empirical formula	$C_{15}H_{13}N_3OS$	Index ranges	$-14 \le h \le 14$, $-11 \le k \le 11$, $-37 \le l \le 37$
Formula weight	283.34		
Temperature, *T*, K	120(2)	Measured reflections	24132
Crystal system	Orthorhombic	Independent reflections	6433
Space group, *Z*	$Pna2_1$, 8	R_{int}	0.0516
a, *b*, *c*, Å	11.1098(8), 8.4815(6), 28.367(2)	Reflections with $I > 2\sigma(I)$	4549
		Refined parameters	365
V, Å^3	2673.0(3)	GOOF	1.00
d_x, g/cm^3	1.408	*R* factors ($I > 2\sigma(I)$)	$R_1 = 0.0588$, $wR_2 = 0.1140$
$\mu(MoK_\alpha)$, cm^{-1}	2.41	*R* factors (all data)	$R_1 = 0.0832$, $wR_2 = 0.1229$
Crystal shape, color	Plate, colorless	Residual min/max, e/Å^3	–0.35/1.31
Crystal sizes, mm	0.30×0.20×0.10	CCDC deposition No	697473
θ range, deg.	2.51—28.00		

NMR (75 MHz, DMSO-d_6, δ, ppm): δ 159.8 (C), 157.5 (C), 155.0 (C), 140.6 (C), 136.5 (C), 134.2 (C), 132.1 (C), 124.8 (CH), 124.2 (CH), 117.5 (C), 113.5 (CH), 107.5 (CH), 38.2 (CH_2), 22.3 (CH_3), 14.5 (CH_3).

The X-ray diffraction analysis of a single crystal of **2** was performed on a Bruker SMART 1000 diffractometer with a MoK_α radiation source (λ = 0.71073 Å) and CCD area detector at 120(2) K. Data collection, unit cell refinement and data reduction were performed with the SMART [10] and SAINTPlus [11] programs. Data were corrected for absorption using the multi-scan technique (SADABS) [12], with the minimum and maximum transmission coefficients of 0.940 and 0.976, respectively. Programs used to solve and refine the structure, create molecular graphics and prepare material for publication were included in SHELXTL, version 5.1 [13]. The least-square refinement was conducted on F^2. The positions of H atoms were found from the difference Fourier map. All H atoms were refined in isotropic approximation in riding model with the U_{iso} equal to $1.5U_{eq}$ and $1.2U_{eq}$ of adjacent C atoms for methyl and other groups, respectively. The crystallographic data, experimental details and parameters of the structure solution and refinement for **2** are summarized in Table 1.

The crystallographic data for **2** were deposited with the Cambridge Crystallographic Data Centre (no. 697473) and copies of these data can be requested free of charge on application to the CCDC: http://www.ccdc.cam.ac.uk/data_request/cif; 12 Union Road, Cambridge, UK, fax: +44-1223-336033, e-mail: deposit@ccdc.cam.ac.uk.

Results and discussion. Two crystallographically independent molecules that form the asymmetric unit of the structure are shown in Fig. 1. The X-ray crystallographic analysis proves the molecular structure of the compound **2** and reveals an interesting fact that this structure features two stereochemically different molecules (**2A** and **2B**) that can be understood as different torsion helicoids (Fig. 1). The compound has two stereoisomers (R and S conformers). In each the seven-membered diazepinone ring exhibits a boat conformation. The fused pyrido[3′,2′:4,5]thieno ring moiety has planar geometry. The C3—H3 bond is slightly off the fused pyrido[3′,2′:4,5]thieno ring plane. The hindrance repulsion between the hydrogen atom at C3 on pyridine ring and methyl group on pyrrole ring makes the molecule of **2** essentially non-planar (repulsion of C3—H3A with C15 and C3′—H3′B with C15′ of methyl groups) (Scheme 2). The torsion angles between the pyrrole and thiophene rings in **2A** and **2B** are 45.7(6)° and –49.3(6)°, respectively.

Selected bond lengths, angles and torsion angles are summarized in Table 2. There are no significant differences between the bonds and angles of the two independent molecules; however, there are significant differences in the magnitudes of some of the corresponding torsion angles.

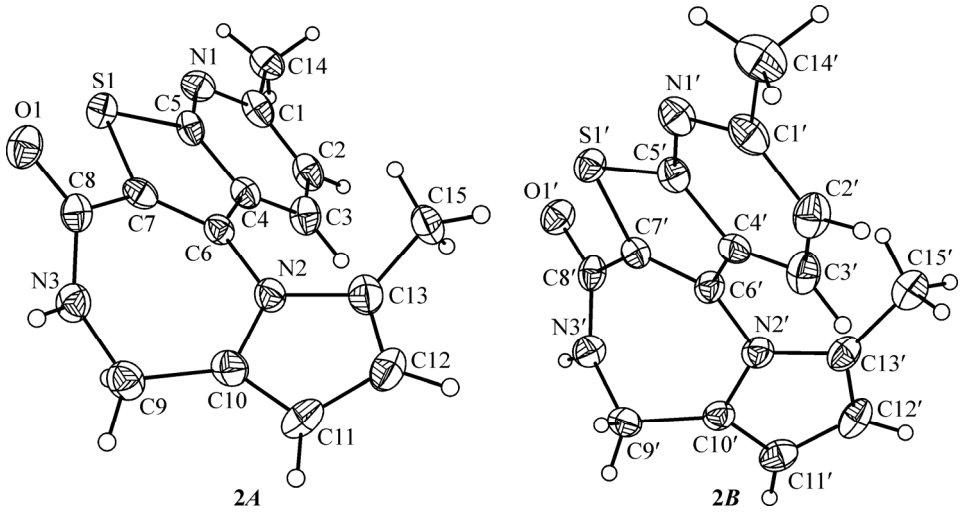
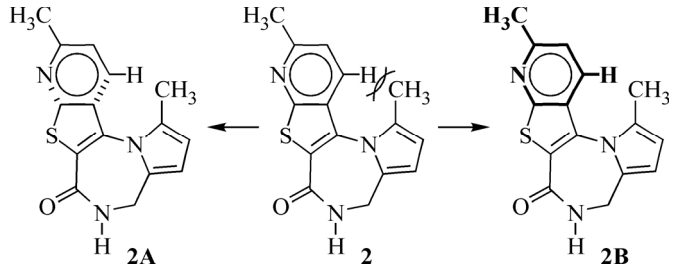


Fig. 1. Two independent molecules of **2** in the crystal studied



Scheme 2

The —NH— group of each molecule (*e.g.* molecule **2A**) makes an intermolecular hydrogen bond to the C = O functional group of the molecule of another kind (molecule **2B**), and *vice versa*. For example, the intermolecular hydrogen bond N3—H3…O1′ involves the N3 atom from molecule **2A** and O1′ atom from the carbonyl group of molecule **2B**, and *vice versa* for N3′—H3′…O1 (Fig. 2). The crystal packing reveals zig-zag H-bonded chains along the crystallographic axes with two distinct hydrogen bonds (Fig. 2 and Table 3). The intermolecular hydrogen bonds play a principal role in the crystal packing. As shown in Table 3, there are also short intermolecular contacts of the C—H…O type.

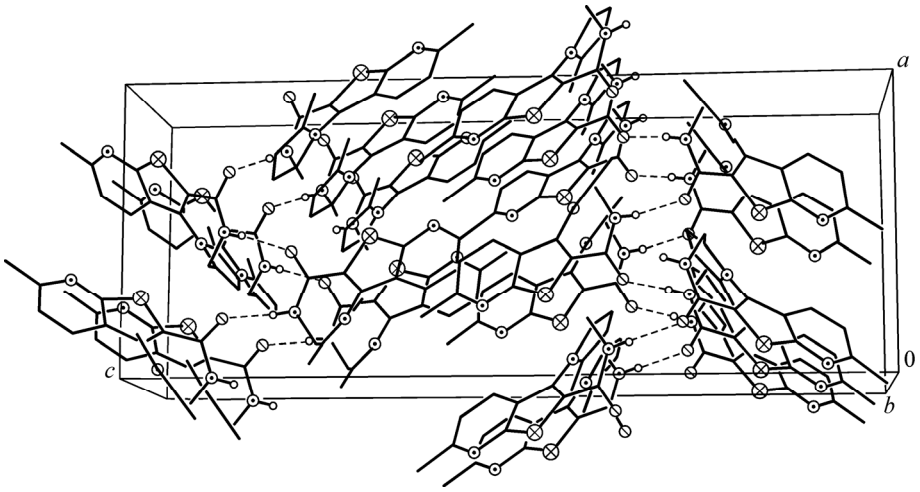


Fig. 2. Fragment of the crystal packing showing zig-zag H-bonds (shown by dash lines)

Table 2

Selected bond lengths (*d*, Å) *and bond and torsion angles* (ω *and* φ, deg.) *for* **2**

Molecule **2A**				Molecule **2B**			
Bond	*d*	Bond	*d*	Bond	*d*	Bond	*d*
S(1)—C(5)	1.737(4)	C(6)—N(2)	1.407(5)	S(1′)—C(5′)	1.739(4)	C(6′)—N(2′)	1.413(5)
S(1)—C(7)	1.740(4)	C(6)—C(4)	1.435(5)	S(1′)—C(7′)	1.739(4)	C(6′)—C(4′)	1.442(6)
O(1)—C(8)	1.233(5)	N(2)—C(10)	1.386(5)	O(1′)—C(8′)	1.254(5)	N(2′)—C(13′)	1.389(6)
N(1)—C(5)	1.332(5)	N(2)—C(13)	1.396(5)	N(1′)—C(5′)	1.327(5)	N(2′)—C(10′)	1.391(6)
N(1)—C(1)	1.339(5)	N(3)—C(8)	1.328(5)	N(1′)—C(1′)	1.346(5)	N(3′)—C(8′)	1.312(5)
C(6)—C(7)	1.364(6)	N(3)—C(9)	1.468(5)	C(6′)—C(7′)	1.370(5)	N(3′)—C(9′)	1.468(5)

Angle	ω	Angle	ω
C(5)—S(1)—C(7)	90.6(2)	C(5′)—S(1′)—C(7′)	90.8(2)
C(5)—N(1)—C(1)	115.5(4)	C(5′)—N(1′)—C(1′)	115.6(4)
C(7)—C(6)—N(2)	122.6(4)	C(7′)—C(6′)—N(2′)	123.2(4)
N(2)—C(6)—C(4)	125.1(4)	N(2′)—C(6′)—C(4′)	124.6(4)
C(10)—N(2)—C(6)	123.0(4)	C(10′)—N(2′)—C(6′)	123.1(4)
C(8)—N(3)—C(9)	123.9(3)	C(8′)—N(3′)—C(9′)	124.4(3)
N(1)—C(5)—S(1)	121.2(3)	N(1′)—C(5′)—S(1′)	121.0(3)
C(6)—C(7)—C(8)	132.5(4)	C(6′)—C(7′)—C(8′)	130.8(4)
O(1)—C(8)—N(3)	123.1(4)	O(1′)—C(8′)—N(3′)	123.4(4)
O(1)—C(8)—C(7)	119.2(4)	O(1′)—C(8′)—C(7′)	119.4(4)
N(3)—C(8)—C(7)	117.6(4)	N(3′)—C(8′)—C(7′)	117.2(4)
N(3)—C(9)—C(10)	111.8(4)	N(3′)—C(9′)—C(10′)	111.3(3)
Torsion angle	φ	Torsion angle	φ
C(4)—C(6)—N(2)—C(13)	45.7(6)	C(4′)—C(6′)—N(2′)—C(13′)	–49.3(6)
N(2)—C(6)—C(4)—C(3)	13.8(7)	N(2′)—C(6′)—C(4′)—C(3′)	–10.3(7)
N(2)—C(6)—C(7)—C(8)	–6.1(7)	N(2′)—C(6′)—C(7′)—C(8′)	1.6(7)
C(6)—C(7)—C(8)—O(1)	151.6(4)	C(6′)—C(7′)—C(8′)—O(1′)	–145.5(4)
S(1)—C(7)—C(8)—O(1)	–28.4(5)	S(1′)—C(7′)—C(8′)—O(1′)	32.8(5)
C(8)—N(3)—C(9)—C(10)	66.0(5)	C(8′)—N(3′)—C(9′)—C(10′)	–65.8(5)
C(6)—N(2)—C(13)—C(12)	171.9(4)	C(6′)—N(2′)—C(13′)—C(12′)	–170.8(4)
C(2)—C(3)—C(4)—C(6)	178.0(4)	C(2′)—C(3′)—C(4′)—C(6′)	–178.5(4)
C(7)—S(1)—C(5)—N(1)	179.5(4)	C(7′)—S(1′)—C(5′)—N(1′)	–179.1(4)
C(5)—C(4)—C(3)—H(3A)	–175.35	C(5′)—C(4′)—C(3′)—H(3′B)	174.85
C(11)—C(12)—C(13)—C(15)	176.6(5)	C(11′)—C(12′)—C(13′)—C(15′)	–175.6(5)

Table 3

Intermolecular hydrogen bonds for **2** (Å *and* deg.)

D—H…A	*d*(D—H)	*d*(H…A)	*d*(D…A)	∠DHA
N(3)—H(3)…O(1′)^{i}	0.86	2.012	2.870(5)	174
N(3′)—H(3′)…O(1)^{ii}	0.86	1.974	2.774(5)	154
C(9′)—H(9′A)…O(1′)^{vii}	0.970	2.415	3.266	146.23
C(9)—H(9B)…O(1)^{vii}	0.970	2.390	3.189	139.38
C(15)—H(15A)…O(1)^{iv}	0.960	2.539	3.470	163.43

Symmetry codes: (i) *x*+1/2, –*y*+1/2, *z*; (ii) *x*, *y*, *z*; (iv) *x*, *y*+1, *z*; (vii) *x*+1/2, –*y*+1/2, *z*.

To summarize, the X-ray single crystal diffraction analysis showed that the structure of **2** consists of two independent molecules related as two opposite torsion helicoids. The seven membered diazepinone ring has a boat conformation. The compound studied shows two distinct intermolecular hydrogen bonds. The molecules in the crystal are connected *via* the bonds to form zig-zag chains.

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