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3-Butyl-1-(5-nitrobenzo[*c*][1,2]-thiazol-3-yl)-3-phenyltriazene

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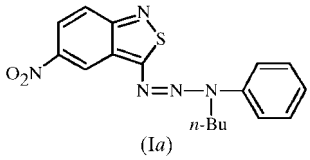
The molecule of the title compound, $C_{17}H_{17}N_5O_2S$, consists of three π systems, *viz*. two aromatic rings and the triazene moiety, which are mutually deconjugated although coplanar. The *n*-butyl chain is roughly perpendicular to the molecular plane, with the terminal methylene and methyl groups disordered between two equally populated positions. The molecules in the crystal associate in an antiparallel fashion, forming dimers across the centre of symmetry, the principal intradimer interaction being stacking of the π-electron portions of the molecules.

Comment

1,3-Diaryltriazenes, Ar–N═N—N(*R*)–Ar, are a well known class of antitumour agents, which act by non-covalent interaction with B-DNA, *viz*. either by intercalation between the base pairs of the DNA duplex or by binding to the DNA minor groove (Vaughan, 1990; Kimball & Haley, 2002). The third type of drug in this class exhibits the so-called 'mixed binding' mode, in which a planar part of the drug molecule is involved in the intercalative interaction, whereas a non-planar portion(s) protrudes out of the helix interior, where it interacts with minor-groove functionalities. Thus, as a part of our program aimed at developing novel anticancer drugs, we have prepared a series of derivatives, (I), in which *R* is an alkyl, alkoxy or hydroxyalkyl group. As detailed knowledge of the molecular structure is of central value in drug design, it is of



(I*a*)

interest to examine the extent of conjugation (*i.e.* planarity) in these molecules by a combined use of theoretical and experimental methods. In this communication, we report on the crystal structure of the *n*-butyl derivative, (I*a*).

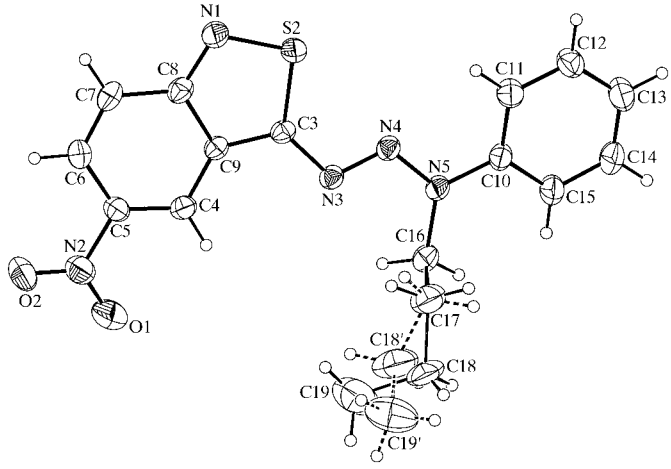


Figure 1
Displacement ellipsoid plot of (I*a*), with the labelling scheme for the non-H atoms, which are drawn as 35% probability ellipsoids. Both rotamers of the disordered butyl chain are shown.

The molecular structure along with the atom-numbering scheme is shown in Fig. 1. The terminal atoms, C18 and C19, of the *n*-butyl chain are disordered between two positions (C18/C18′ and C19/C19′) with approximately equal occupancies; the disorder results from concerted rotations about the C16—C17 and C17—C18 bonds (Table 1), and gives rise to two conformers, differing mainly in the orientation (*gauche* and *trans*, respectively) of the C19 and C19′ sites (Fig. 1).

As noted above, the main purpose of this work was to establish the extent of π-electron delocalization and hence the overall planarity of the molecule. As shown in Table 1, the sum of the valence angles around atom N5 is close to 120°, *i.e.* the formally amine N atom is sp^2-hybridized, with the lone-pair electrons available for π bonding. Furthermore, the N3═N4 and N4—N5 bonds, although non-equivalent, are both intermediate between a double and a single bond, assuming bond lengths of 1.23 and 1.41 Å for pure N═N double and N—N single bonds, respectively (Burke-Laing & Laing, 1976). These data indicate the π-electron delocalization within the triazene linkage. That the N3═N4 double bond is delocalized through conjugation with the lone-pair electrons on atom N5 rather than the adjacent heterocyclic ring is also evidenced by (i) the C3—N3 bond distance [1.390 (4) Å], which is only slightly, though significantly, shortened relative to the value [1.425 (3) Å] found for a pure Csp^2—Nsp^2 single bond (Adler *et al.*, 1976), and (ii) the pattern of bond lengths and angles within the heterocyclic ring, which is almost identical to other benzo[*c*]-1,2-thiazole derivatives containing substituents not involved in conjugation with the aromatic system, as revealed by a search of the Cambridge Structural Database (Allen *et al.*, 1983). Similarly, the N5—C10 distance [1.426 (4) Å] is even identical, within experimental error, to the above value of 1.425 (3) Å and is comparable to the N5—C16 bond length [1.459 (4) Å], which is definitely deconjugated with the triazene moiety. Even though the conjugation of the triazene π

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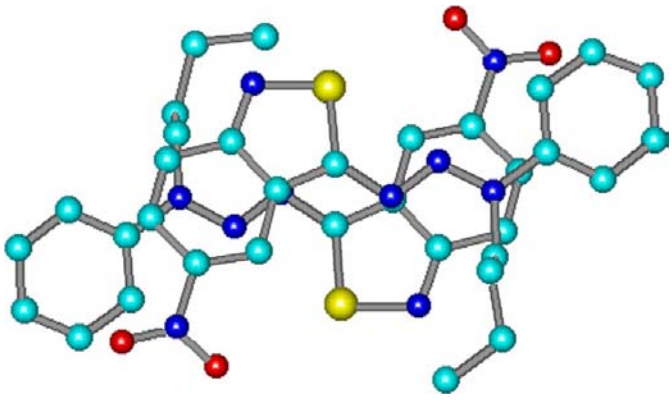

Figure 2
A view of the dimer along the stacking axis.

system with the aromatic rings is very small, if it occurs at all, both rings are approximately coplanar with the plane of the triazene group; the dihedral angle between the mean planes through the 5-nitrobenzo[*c*][1,2]thiazole and triazene groups is 4.0 (3)°, and the corresponding dihedral angle for the phenyl ring/triazene group is 11.9 (3)°. Thus, on the basis of the present crystallographic data, molecule (I*a*) is approximately planar as a whole, except for the *n*-butyl group, which is approximately perpendicular to the rest of the molecule (Table 1). However, a rather low barrier to rotation around the C—N bond linking the heterocyclic ring and the triazene group is predicted, while almost free rotation of the phenyl ring around the triazene is expected.

The crystal packing is dominated by a π–π stacking interaction between the centrosymmetrically related molecules, which leads to the formation of dimers across the centre of symmetry. The mean interplanar separation of the planar portion of the molecules within the dimer is 3.47 Å. The stacking geometry (Fig. 2) is such that the triazene linkage of one molecule is superimposed on the benzene ring of the heterocyclic moiety in the other molecule. The *n*-butyl chains are loosely packed by van der Waals interactions, as reflected by the U_{eq} values of the C atoms, which increase on approaching the methyl termini.

Experimental

Compound (I*a*) was synthesized by a two-step procedure, as described elsewhere (Přikryl *et al.*, 2003). Briefly, in the first step, cooling and stirring of 96% sulfuric acid (25 ml, 0.45 mol) was followed by addition of $NaNO_2$ in small portions, so as to avoid evolution of nitrous gases. After continuous stirring and slow heating (to 343 K), the resulting solution of nitrosyl sulfuric acid was cooled to 300 K. 3-Amino-5-nitrobenzo[*c*][1,2]thiazole was added and the reaction mixture was stirred for 3 h. In the next step, a solution of *N*-butylaniline (7.82 g, 52.5 mmol) in 1 *M* aqueous HCl (60 ml) was treated with charcoal and kieselguhr (0.25 g each), and after 10 min of stirring, the solution was filtered. The filtrate, a solution of *N*-butylanilinium chloride, was treated with an emulsifier and sodium acetate trihydrate (68 g, 0.5 mol) with stirring. The obtained emulsion of *N*-butylaniline was mixed with finely crushed ice, and then the solution of the diazonium salt obtained in the previous step was added with stirring. The reaction mixture was stirred for 3 h, whereupon the separated orange–brown precipitate of the triazene was collected by suction. The raw product (12.6 g, 71% yield) was purified by repeated crystallization from acetone (m.p. 398–400 K).

Crystal data

$C_{17}H_{17}N_5O_2S$
M_r = 355.42
Triclinic, $P\overline{1}$
a = 9.702 (5) Å
b = 9.750 (5) Å
c = 10.106 (6) Å
α = 83.24 (5)°
β = 79.72 (4)°
γ = 72.92 (4)°
V = 897.0 (9) Å^3
Z = 2
D_x = 1.316 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 20 reflections
θ = 7–20°
μ = 0.20 mm^{-1}
T = 293 (2) K
Needle, orange
0.08 × 0.02 × 0.02 mm

Data collection

Oxford Diffraction Xcalibur CCD diffractometer
ω and φ scans
6600 measured reflections
3993 independent reflections
2017 reflections with $I > 2\sigma(I)$
R_{int} = 0.019
θ_{max} = 27.6°
$h = -12 \rightarrow 12$
$k = -11 \rightarrow 12$
$l = -11 \rightarrow 13$

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.067
$wR(F^2)$ = 0.163
S = 1.03
3993 reflections
249 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0613P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 0.16 e Å^{-3}
$\Delta\rho_{min}$ = −0.22 e Å^{-3}

Table 1
Selected geometric parameters (Å, °).

N1—C8	1.337 (4)	C5—N2	1.457 (5)
N1—S2	1.653 (3)	C6—C7	1.335 (5)
S2—C3	1.705 (3)	C7—C8	1.443 (5)
C3—N3	1.390 (4)	C8—C9	1.436 (4)
C3—C9	1.394 (4)	N3—N4	1.293 (3)
C4—C5	1.363 (4)	N4—N5	1.325 (3)
C4—C9	1.400 (4)	N5—C10	1.426 (4)
C5—C6	1.415 (5)	N5—C16	1.459 (4)
N1—S2—C3	96.41 (16)	N3—N4—N5	114.3 (3)
N3—C3—C9	123.7 (3)	N4—N5—C10	115.1 (3)
N3—C3—S2	127.3 (2)	N4—N5—C16	120.6 (3)
C9—C3—S2	108.9 (2)	C10—N5—C16	124.2 (3)
N4—N3—C3	110.3 (3)		
C4—C5—N2—O1	10.0 (5)	N4—N5—C16—C17	85.5 (4)
S2—C3—N3—N4	4.3 (4)	N5—C16—C17—C18	172.3 (5)
C3—N3—N4—N5	179.7 (2)	N5—C16—C17—C18′	−163.2 (8)
N3—N4—N5—C10	−179.9 (3)	C16—C17—C18—C19	80.5 (13)
N3—N4—N5—C16	0.1 (4)	C16—C17—C18′—C19′	−179.1 (13)
N4—N5—C10—C11	−10.8 (5)		

The disorder in the *n*-butyl chain was modelled by resolving the positions of atoms C18 and C19 into two components (C18/C18′ and C19/C19′) and using a total of 21 restraints on corresponding bond distances and anisotropic displacement parameters [a combination of DFIX and SIMU options in *SHELXL*97 (Sheldrick, 1997)]. The refined occupancy factors for the unprimed and primed sites were 0.53 (1) and 0.47 (1), respectively. H atoms were refined with fixed geometry, riding on their carrier atoms, with U_{iso} values set at 1.2 (1.5 for the methyl H atoms) times U_{eq} of the parent atom.

Data collection: *CrysAlis CCD* (Oxford Diffraction, 2001); cell refinement: *CrysAlis RED* (Oxford Diffraction, 2003); data reduction: *CrysAlis RED*; program(s) used to solve structure: *SHELXS*97 (Sheldrick, 1997); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *ORTEP*II (Johnson, 1976); software used to prepare material for publication: *SHELXL*97.

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Supplementary data for this paper are available from the IUCr electronic archives (Reference: SK1691). Services for accessing these data are described at the back of the journal.

References

Adler, R. W., Goode, N. C., King, T. S., Mellor, J. M. & Miller, B. W. (1976). *J. Chem. Soc. Chem. Commun.* pp. 173–174.
Allen, F. H., Kennard, O. & Taylor, R. (1983). *Acc. Chem. Res.* **16**, 146–153.
Burke-Laing, M. & Laing, M. (1976). *Acta Cryst.* B**32**, 3216–3224.
Johnson, C. K. (1976). *ORTEP*II. Report ORNL-3794. Oak Ridge National Laboratory, Tennessee, USA.
Kimball, D. B. & Haley, M. M. (2002). *Angew. Chem. Int. Ed.* **41**, 3338–3351.
Oxford Diffraction (2001). *CrysAlis CCD*. Version 169.3. Oxford Diffraction Ltd, Abingdon, Oxfordshire, England.
Oxford Diffraction (2003). *CrysAlis RED*. Version 170.17. Oxford Diffraction Ltd, Abingdon, Oxfordshire, England.
Přikryl, J., Lyčka, A., Bertolasi, V. & Macháček, V. (2003). *Eur. J. Org. Chem.* pp. 4413–4421.
Sheldrick, G. M. (1997). *SHELXS*97 and *SHELXL*97. University of Göttingen, Germany.
Vaughan, K. (1990). *The Chemistry of Antitumour Agents*, edited by D. E. V. Wilman, pp. 159–186. New York: Blackie/Chapman and Hall.