Acta Cryst. (1996). C**52**, 486–489

Two Isoxazolidines

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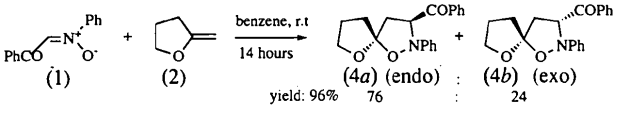
(Received 22 May 1995; accepted 5 October 1995)

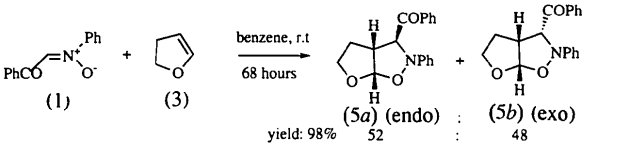
Abstract

The crystal structures of *trans*-phenyl 2-phenyl-1,6-dioxa-2-azaspiro[4.4]non-3-yl ketone, $C_{19}H_{19}NO_3$, and (3α,3aα,6aα)-hexahydro-2-phenylfuro[3,2-*d*]isoxazol-3-yl phenyl ketone, $C_{18}H_{17}NO_3$, are reported. In both compounds, the isoxazolidine rings adopt envelope conformations in which the O atom is bent out of the approximate plane of the other four ring atoms. Modest to negligible *endo* selectivities were confirmed in 1,3-dipolar cycloadditions of benzoylmethyleneaniline *N*-oxide with enol ethers.

Comment

The structures of the two title molecules, *trans*-phenyl(2-phenyl-1,6-dioxa-2-azaspiro[4.4]non-3-yl)methanone, (4*a*), and (3α,3aα,6aα)-(hexahydro-2-phenylfuro-[3,2-*d*]isoxazol-3-yl)phenylmethanone, (5*a*), are shown in Figs. 1 and 2, respectively. The isoxazolidine rings in





both molecules adopt envelope conformations in which the O atoms (O3) are bent out of plane. These structures confirm that both of the major cycloadducts, (4*a*) and (5*a*), are formed by *endo* cycloaddition during the 1,3-dipolar cycloaddition. The *endo* adducts have the O atom of compound (2) or the ring of compound (3) near the N atom of the planar nitrone in the transition state. The X-ray structures of other related isoxazolidines have been reported by Lizamma, Varghese & Sankararaman (1993) and Bravo, Bruche, Farina, Fronza, Meille & Merli (1993).

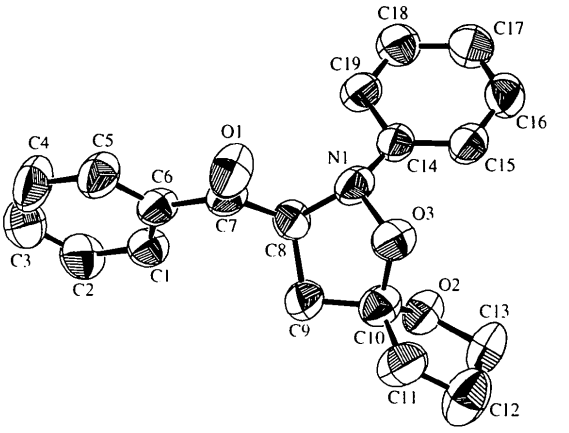


Fig. 1. An *ORTEP* (Johnson, 1965) view of compound (4*a*) with the atomic labeling scheme. Displacement ellipsoids are drawn at the 50% probability level. H atoms are omitted for clarity.

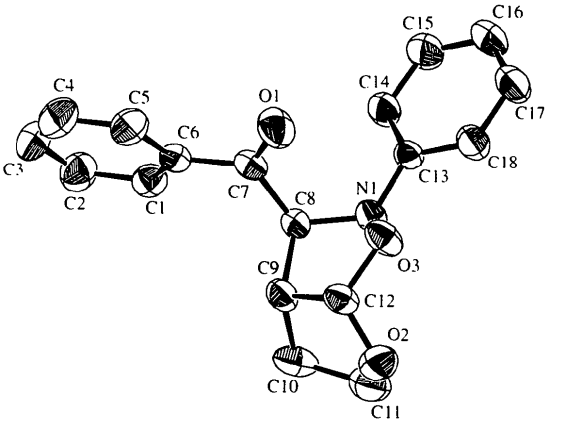


Fig. 2. An *ORTEP* (Johnson, 1965) view of compound (5*a*) with the atomic labeling scheme. Displacement ellipsoids are drawn at the 50% probability level. H atoms are omitted for clarity.

Experimental

Nitrone (1) (benzoylmethyleneaniline *N*-oxide) was reacted with olefins (2) (tetrahydro-2-methylenefuran) and (3) (2,3-dihydrofuran) as shown in the scheme above. Nitrone (1) was prepared according to the literature method of Averas, Cum, Strgno d'Alcontres & Uccella (1972). The products were separated by chromatography on silica gel. Compound (4*a*) was recrystallized from acetonitrile several times to afford single crystals (m.p. 372–373 K) suitable for X-ray diffraction analysis. Compound (5*a*) was recrystallized from a mixture of hexane and ethyl acetate. Compounds (4*a*) and (5*a*) have been reported previously in the literature (Fisera, Dandarova, Kovac, Gaplovsk'y, Patus & Goljer, 1982), but their stereochemistries were assigned based on the coupling constants of ^{1}H NMR spectra. The major products from both reactions [*i.e.* compounds (4*a*) and (5*a*)] were examined crystallographically to confirm the assigned stereochemistries.

Compound (4a)

Crystal data

$C_{19}H_{19}NO_3$
M_r = 309.36
Monoclinic
$P2_1/n$
a = 8.678 (7) Å
b = 16.19 (1) Å
c = 11.53 (1) Å
β = 99.00 (1)°
V = 1599 (2) Å^3
Z = 4
D_x = 1.285 Mg m^{-3}
D_m not measured

Cu $K\alpha$ radiation
λ = 1.5418 Å
Cell parameters from 22 reflections
θ = 8.2–13.2°
μ = 0.664 mm^{-1}
T = 298 K
Irregular
0.25 × 0.20 × 0.20 mm
Colorless

Data collection

Syntex (Crystal Logic) diffractometer
$\theta/2\theta$ scans
Absorption correction: none
2452 measured reflections
2140 independent reflections
1016 observed reflections [$I > 3\sigma(I)$]

R_{int} = 0.02
θ_{max} = 57.5°
$h = 0 \rightarrow 9$
$k = 0 \rightarrow 17$
$l = -12 \rightarrow 12$
3 standard reflections monitored every 97 reflections
intensity decay: 0.1%

Refinement

Refinement on F
R = 0.046
wR = 0.051
S = 1.457
1016 reflections
209 parameters
H atoms were placed in calculated positions
$w = 1/\sigma^2(F_o)$
$(\Delta/\sigma)_{max}$ = 0.002

$\Delta\rho_{max}$ = 0.28 e Å^{-3}
$\Delta\rho_{min}$ = −0.36 e Å^{-3}
Extinction correction: Larson (1967) isotropic
Extinction coefficient: 2468 (340)
Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV, Tables 2.2B and 2.3.1)

Table 1. *Fractional atomic coordinates and equivalent isotropic displacement parameters (Å^2) for (4a)*

$U_{eq} = (1/3)\sum_i\sum_j U_{ij}a_i^*a_j^*\mathbf{a}_i.\mathbf{a}_j$.

	x	y	z	U_{eq}
N1	0.0877 (6)	0.3450 (2)	−0.0940 (3)	0.063 (3)
O1	0.2585 (5)	0.3493 (2)	−0.2700 (3)	0.091 (3)
O2	0.1376 (4)	0.4269 (2)	0.1370 (3)	0.067 (3)
O3	0.1923 (4)	0.3218 (2)	0.0110 (3)	0.069 (3)
C1	0.2090 (5)	0.5703 (3)	−0.2737 (4)	0.062 (4)
C2	0.2278 (6)	0.6383 (3)	−0.3428 (5)	0.075 (4)
C3	0.2665 (7)	0.6267 (4)	−0.4527 (5)	0.089 (5)
C4	0.2900 (8)	0.5483 (4)	−0.4930 (5)	0.101 (5)
C5	0.2727 (7)	0.4803 (3)	−0.4236 (4)	0.083 (5)
C6	0.2307 (6)	0.4906 (3)	−0.3129 (4)	0.061 (4)
C7	0.2144 (6)	0.4162 (3)	−0.2414 (4)	0.062 (4)
C8	0.1410 (6)	0.4260 (3)	−0.1307 (4)	0.060 (4)
C9	0.2649 (6)	0.4552 (3)	−0.0281 (4)	0.077 (4)
C10	0.2478 (6)	0.3965 (3)	0.0701 (4)	0.066 (4)
C11	0.3919 (6)	0.3732 (4)	0.1565 (5)	0.089 (5)
C12	0.3452 (8)	0.3806 (4)	0.2742 (5)	0.103 (5)
C13	0.1730 (7)	0.3917 (3)	0.2523 (4)	0.083 (5)
C14	−0.0706 (7)	0.3344 (3)	−0.0858 (4)	0.057 (4)
C15	−0.1228 (8)	0.2927 (3)	0.0061 (4)	0.066 (4)
C16	−0.2806 (8)	0.2793 (3)	0.0026 (5)	0.073 (5)
C17	−0.3892 (7)	0.3075 (3)	−0.0891 (5)	0.076 (5)
C18	−0.3357 (7)	0.3478 (3)	−0.1807 (5)	0.076 (5)
C19	−0.1795 (7)	0.3611 (3)	−0.1799 (4)	0.070 (4)

Table 2. *Selected geometric parameters (Å, °) for (4a)*

N1—C14	1.402 (6)	C6—C7	1.479 (6)
N1—O3	1.444 (4)	C7—C8	1.521 (6)
N1—C8	1.474 (5)	C8—C9	1.543 (6)
O1—C7	1.211 (5)	C9—C10	1.503 (6)
O2—C10	1.408 (5)	C10—C11	1.519 (6)
O2—C13	1.434 (5)	C11—C12	1.480 (7)
O3—C10	1.434 (5)	C12—C13	1.487 (7)
C1—C2	1.383 (6)	C14—C15	1.390 (6)
C1—C6	1.390 (6)	C14—C19	1.391 (6)
C2—C3	1.373 (7)	C15—C16	1.381 (7)
C3—C4	1.378 (7)	C16—C17	1.379 (6)
C4—C5	1.383 (6)	C17—C18	1.382 (7)
C5—C6	1.391 (6)	C18—C19	1.371 (7)
C14—N1—O3	113.9 (4)	C10—C9—C8	104.1 (4)
C14—N1—C8	118.9 (4)	O2—C10—O3	110.4 (4)
O3—N1—C8	106.7 (4)	O2—C10—C9	110.3 (4)
C10—O2—C13	107.7 (4)	O2—C10—C11	106.7 (4)
C10—O3—N1	107.4 (3)	O3—C10—C9	103.9 (4)
C2—C1—C6	121.2 (5)	O3—C10—C11	106.4 (4)
C3—C2—C1	119.4 (5)	C9—C10—C11	118.8 (5)
C2—C3—C4	120.5 (5)	C12—C11—C10	105.4 (5)
C3—C4—C5	120.2 (5)	C11—C12—C13	105.4 (5)
C4—C5—C6	120.2 (5)	O2—C13—C12	105.6 (4)
C1—C6—C5	118.6 (4)	C15—C14—C19	118.8 (5)
C1—C6—C7	123.1 (4)	C15—C14—N1	123.4 (5)
C5—C6—C7	118.4 (4)	C19—C14—N1	117.6 (5)
O1—C7—C6	121.0 (5)	C16—C15—C14	119.6 (5)
O1—C7—C8	120.9 (4)	C17—C16—C15	121.7 (5)
C6—C7—C8	118.1 (4)	C16—C17—C18	118.1 (5)
N1—C8—C7	109.8 (4)	C19—C18—C17	121.3 (5)
N1—C8—C9	105.4 (4)	C18—C19—C14	120.4 (5)
C7—C8—C9	110.0 (4)		
O3—N1—C8—C7	108.6 (4)	C8—C9—C10—O2	−89.4 (5)
O3—N1—C8—C9	−9.8 (5)	C8—C9—C10—O3	28.9 (5)
O3—N1—C14—C15	−10.3 (7)	C8—C9—C10—C11	147.0 (5)
O3—N1—C14—C19	175.2 (4)	C13—O2—C10—O3	90.4 (5)
C8—N1—C14—C15	−137.4 (5)	C13—O2—C10—C9	−155.3 (4)
C8—N1—C14—C19	48.1 (6)	C13—O2—C10—C11	−24.8 (5)
C10—O2—C13—C12	31.6 (5)	O2—C10—C11—C12	8.4 (6)
C8—N1—O3—C10	29.3 (5)	O3—C10—C11—C12	−109.5 (5)
C14—N1—O3—C10	−103.9 (5)	C9—C10—C11—C12	133.8 (5)
N1—O3—C10—O2	81.8 (4)	C10—C11—C12—C13	10.3 (6)
N1—O3—C10—C9	−36.5 (5)	C11—C12—C13—O2	−25.3 (6)
N1—O3—C10—C11	−162.8 (4)	N1—C14—C15—C16	−174.9 (5)

Compound (5a)

Crystal data

$C_{18}H_{17}NO_3$
M_r = 295.34
Orthorhombic
Pbca
a = 10.181 (4) Å
b = 28.90 (1) Å
c = 10.071 (2) Å
V = 2963 (2) Å^3
Z = 8
D_x = 1.324 Mg m^{-3}
D_m not measured

Cu $K\alpha$ radiation
λ = 1.5418 Å
Cell parameters from 20 reflections
θ = 9.7–17.3°
μ = 0.694 mm^{-1}
T = 298 K
Needle
0.15 × 0.10 × 0.05 mm
Pale yellow

Data collection

Rigaku AFC-5*R* diffractometer	$\theta_{max} = 59.99°$
$\theta/2\theta$ scans	$h = 0 \rightarrow 11$
Absorption correction: none	$k = 0 \rightarrow 32$
2560 measured reflections	$l = 0 \rightarrow 11$
2560 independent reflections	3 standard reflections monitored every 150 reflections
1199 observed reflections $[I > 3\sigma(I)]$	intensity decay: 0.1%

Refinement

Refinement on F	$(\Delta/\sigma)_{max} = 0.010$
$R = 0.048$	$\Delta\rho_{max} = 0.42$ e Å^{-3}
$wR = 0.059$	$\Delta\rho_{min} = -0.56$ e Å^{-3}
$S = 1.337$	Extinction correction: none
1199 reflections	Atomic scattering factors from *International Tables for X-ray Crystallography* (1974, Vol. IV, Tables 2.2B and 2.3.1)
199 parameters	
H atoms placed in calculated positions	
$w = 1/\sigma^2(F_o)$	

Table 3. *Fractional atomic coordinates and equivalent isotropic displacement parameters (Å^2) for (5a)*

$$U_{eq} = (1/3)\Sigma_i\Sigma_j U_{ij} a_i^* a_j^* \mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	U_{eq}
O1	0.5295 (3)	0.3394 (1)	0.2706 (3)	0.060 (2)
O2	0.5307 (3)	0.5048 (1)	0.3408 (3)	0.057 (2)
O3	0.5079 (2)	0.4381 (1)	0.2114 (2)	0.048 (2)
N1	0.6422 (3)	0.4231 (1)	0.1841 (3)	0.037 (2)
C1	0.8181 (4)	0.3275 (1)	0.4736 (4)	0.045 (3)
C2	0.8690 (4)	0.2983 (2)	0.5710 (4)	0.057 (3)
C3	0.7916 (5)	0.2648 (1)	0.6273 (5)	0.065 (3)
C4	0.6627 (5)	0.2596 (1)	0.5887 (5)	0.066 (3)
C5	0.6110 (4)	0.2886 (1)	0.4926 (4)	0.055 (3)
C6	0.6881 (4)	0.3226 (1)	0.4347 (4)	0.039 (2)
C7	0.6271 (4)	0.3523 (1)	0.3309 (4)	0.039 (2)
C8	0.6849 (4)	0.4009 (1)	0.3058 (3)	0.036 (2)
C9	0.6319 (4)	0.4350 (1)	0.4109 (3)	0.041 (2)
C10	0.7228 (4)	0.4767 (1)	0.4369 (4)	0.054 (3)
C11	0.6683 (5)	0.5144 (2)	0.3490 (4)	0.060 (3)
C12	0.5118 (4)	0.4569 (1)	0.3419 (4)	0.043 (2)
C13	0.6483 (4)	0.4016 (1)	0.0588 (3)	0.034 (2)
C14	0.7464 (4)	0.3690 (1)	0.0336 (4)	0.045 (2)
C15	0.7614 (5)	0.3517 (1)	−0.0941 (4)	0.058 (3)
C16	0.6801 (5)	0.3661 (2)	−0.1958 (4)	0.061 (3)
C17	0.5836 (5)	0.3985 (2)	−0.1697 (4)	0.057 (3)
C18	0.5678 (4)	0.4164 (1)	−0.0432 (4)	0.046 (3)

Table 4. *Selected geometric parameters (Å, °) for (5a)*

O1—C7	1.223 (4)	C6—C7	1.488 (5)
O2—C12	1.397 (4)	C7—C8	1.543 (5)
O2—C11	1.431 (5)	C8—C9	1.543 (5)
O3—C12	1.423 (4)	C9—C10	1.542 (5)
O3—N1	1.460 (4)	C9—C12	1.542 (5)
N1—C13	1.408 (4)	C10—C11	1.509 (6)
N1—C8	1.450 (4)	C13—C18	1.382 (5)
C1—C6	1.388 (5)	C13—C14	1.396 (5)
C1—C2	1.394 (5)	C14—C15	1.388 (5)
C2—C3	1.371 (6)	C15—C16	1.381 (6)
C3—C4	1.377 (6)	C16—C17	1.382 (6)
C4—C5	1.384 (6)	C17—C18	1.384 (5)
C5—C6	1.386 (5)		

C12—O2—C11	109.1 (3)	C7—C8—C9	109.6 (3)
C12—O3—N1	105.1 (2)	C10—C9—C12	103.4 (3)
C13—N1—C8	123.3 (3)	C10—C9—C8	113.9 (3)
C13—N1—O3	109.9 (3)	C12—C9—C8	103.3 (3)
C8—N1—O3	104.6 (3)	C11—C10—C9	104.1 (3)
C6—C1—C2	119.4 (4)	O2—C11—C10	104.7 (3)
C3—C2—C1	120.3 (4)	O2—C12—O3	112.0 (3)
C2—C3—C4	120.5 (4)	O2—C12—C9	107.5 (3)
C3—C4—C5	119.6 (4)	O3—C12—C9	106.4 (3)
C4—C5—C6	120.5 (4)	C18—C13—C14	119.9 (3)
C5—C6—C1	119.6 (4)	C18—C13—N1	120.2 (3)
C5—C6—C7	117.9 (4)	C14—C13—N1	119.5 (3)
C1—C6—C7	122.5 (4)	C15—C14—C13	119.3 (4)
O1—C7—C6	120.8 (4)	C16—C15—C14	120.8 (4)
O1—C7—C8	120.4 (3)	C15—C16—C17	119.3 (4)
C6—C7—C8	118.7 (3)	C16—C17—C18	120.7 (4)
N1—C8—C7	115.3 (3)	C13—C18—C17	120.0 (4)
N1—C8—C9	101.1 (3)		

C11—O2—C12—O3	−92.1 (4)	N1—C8—C9—C10	−83.6 (4)
C11—O2—C12—C9	24.3 (4)	N1—C8—C9—C12	27.9 (3)
N1—O3—C12—O2	94.2 (3)	C7—C8—C9—C10	154.3 (3)
N1—O3—C12—C9	−22.9 (3)	C7—C8—C9—C12	−94.2 (4)
C12—O3—N1—C8	42.7 (3)	C8—C9—C10—C11	95.7 (4)
O3—N1—C8—C7	75.1 (3)	C8—C9—C12—O2	−123.3 (3)
O3—N1—C8—C9	−43.0 (3)	C8—C9—C12—O3	−3.2 (4)
C12—O3—N1—C13	177.1 (3)	C10—C9—C12—O2	−4.2 (4)
O3—N1—C13—C14	−154.0 (3)	C10—C9—C12—O3	115.8 (3)
O3—N1—C13—C18	33.2 (4)	C12—C9—C10—C11	−15.7 (4)
C8—N1—C13—C14	−29.9 (5)	C9—C10—C11—O2	30.2 (4)
C8—N1—C13—C18	157.3 (4)	C12—O2—C11—C10	−34.7 (4)
C13—N1—C8—C7	−51.4 (5)	N1—C13—C14—C15	−172.8 (4)
C13—N1—C8—C9	−169.5 (3)	N1—C13—C18—C17	173.4 (4)

Data collection: *COLLECT UCLA* (UCLA Crystallographic package, 1984) for (4*a*); *MSC/AFC Diffractometer Control Software* (Molecular Structure Corporation, 1988) for (5*a*). Cell refinement: *LEAST UCLA* for (4*a*); *LSQUARES MSC/AFC Diffractometer Control Software* for (5*a*). Data reduction: *REDUCE UCLA* for (4*a*); *PROCESS* in *TEXSAN* (Molecular Structure Corporation, 1989) for (5*a*). For both compounds, program(s) used to solve structures: *SHELXS*86 (Sheldrick, 1990); program(s) used to refine structures: *ORFLS UCLA*; molecular graphics: *ORTEP* (Johnson, 1965); software used to prepare material for publication: *ORFFE* (Busing, Martin & Levy, 1964), *UCLA*.

We are grateful to the National Institute of Health for financial support of this research.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: SX1007). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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