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2-(2,1-Benzoxazol-3-yl)-3,5-dimethoxyphenol and 3-phenyl-2,1-benzoxazole

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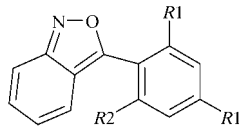
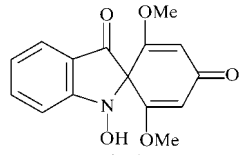
The title compounds, $C_{15}H_{13}NO_4$, (I), and $C_{13}H_9NO$, (II), are produced, along with the corresponding anilines, by the reduction of the appropriate *o*-nitrobenzophenones. In (I), the planar benzisoxazole and phenol fragments are tilted relative to one another by a rotation of 53.02 (14)° about the bond joining them, and the molecules are linked into chains by phenol O—H···N and phenyl C—H···$O_{oxazole}$ hydrogen bonds. The cell of (II) (space group *I*2/*c*) contains eight molecules in general positions, four more in the 2*b* sites, with twofold axial symmetry that induces a degree of disorder, and a further four as centrosymmetric pairs of complete molecules, each with an occupancy of one-half. The relative tilt of the planar fragments varies slightly from one molecule to another but is much less than that in (I), ranging from 8.8 (8) to 12.58 (15)°.

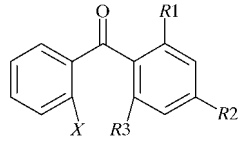
Comment

The title compounds, (I) and (II), are products, along with the corresponding anilines, (I*b*) and (II*b*), of the zinc-dust reduction of a mixture of aqueous ammonium chloride and an ethanol solution of the appropriate 2′-nitrobenzophenone, (I*a*) or (II*a*). Forrester *et al.* (1992) have already shown that a similar reduction of the 2′-nitrobenzophenone (III*a*) results in the formation of the hydroxylamine spirodienone (III) [Cambridge Structural Database (CSD; Allen, 2002) refcode KUJHUS] rather than a benzisoxazole and point out that compounds such as (I), (II) and (III) can be regarded as intermediates in the reduction of the nitro compound to the corresponding aniline.

In the structure of (I), the asymmetric unit consists of a single complete molecule (Fig. 1). In (II) (space group *I*2/*c*), the situation is more complex. The asymmetric unit now comprises three distinct molecules, which are, as far as possible, labelled in the same manner as the molecule of (I) but are distinguished from one another by the suffixes *A*, *B* and *C*. The 'normal' molecules *A* of (II) (Fig. 2) are found in


(I) *R*1 = MeO, *R*2 = OH
(II) *R*1 = *R*2 = H


(III)


(I*a*,*b*) *R*1 = *R*2 = MeO, *R*3 = OH
(II*a*,*b*) *R*1 = *R*2 = *R*3 = H
(III*a*,*b*) *R*1 = *R*3 = MeO, *R*2 = OH
a: *X* = NO_2; *b*: *X* = NH_2

the 8*c* general positions. Precisely the same numbering scheme with a change of suffix applies to molecules *C*, which occur in pairs that are centrosymmetrically related about the 4*a* sites, each member of the pair being a complete molecule with an occupancy of 0.5. Atom C7 of molecule *B* (found in the 2*b*

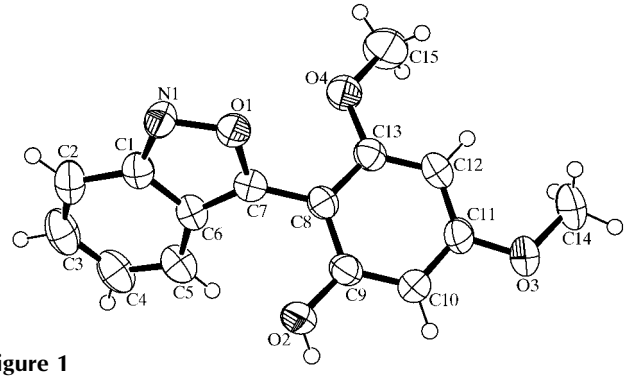


Figure 1
A view of the molecule of (I), showing the atomic labelling scheme. Non-H atoms are shown as 50% probability displacement ellipsoids and H atoms are shown as small circles of arbitrary radii.

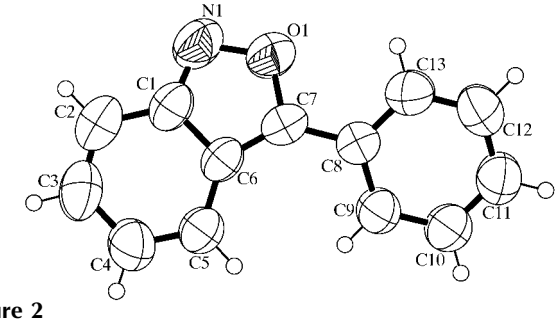


Figure 2
A view of molecule *A* of (II). The representation is the same as in Fig. 1. The atom labels, from which the suffixes have been omitted, are equally applicable to molecule *C*.

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sites; Fig. 3) coincides with a crystallographic twofold axis. Consequently, the six-membered C1–C6 and C18–C13 rings of the other molecules are now related by symmetry, as shown in Fig. 3, and atoms N1, O1 and H1 are distributed over pairs of sites, all of occupancy 0.5 (only one member of each pair is shown). For convenience, the individual molecules are denoted (I), (II*A*), (II*B*) and (II*C*).

Bond lengths and angles for the benzisoxazole residue comprising atoms O1, N1 and C1–C7 and the torsion angles involving the C7—C8 bonds of all four molecules are given in Table 2. Ignoring for the moment the torsion angles, which are discussed later, the bond lengths and angles are similar in all four molecules and are entirely consistent with the distribution of single and double bonds indicated in the chemical structural drawings of (I) and (II). Agreement is particularly good for molecules (I) and (II*A*), but less so for (II*C*) and especially (II*B*), in which the crystallographically induced pseudosymmetry and disorder noted above are seen to have a deleterious effect.

All of the molecules consist of two essentially planar fragments, namely the benzisoxazole residue discussed above and the substituent phenyl ring [C8–C13 or its equivalent in molecule (II*B*)]. In all four cases, these fragments are related by rotation about the C7—C8 bond joining them [or its equivalent in molecule (II*B*)] by angles (computed from the relevant torsion angles; Table 2) of 53.02 (14), 12.58 (15), 12.3 (2) and 8.4 (8)° for molecules (I), (II*A*), (II*B*) and (II*C*), respectively. These rotations can occur in either a clockwise or an anticlockwise sense and consequently render the molecules handed. In the non-centrosymmetric structure of (I), where the twist is greatest, probably because of the steric requirement of the *o*-methoxy substituents, all of the molecules in a given crystal are of the same hand, while crystals of opposite hand are presumably present in the bulk sample. In the absence of atoms of atomic number higher than that of oxygen, the absolute structure is, however, indeterminate. The centrosymmetric structure of (II), in which the twist is much smaller, is of course racemic.

The phenol residue of (I) merits further comment. The substituent atoms O2–O4 are not significantly displaced from the plane defined by the C8–C13 ring nucleus, and neither is atom C7. The displacement of the methyl C14 group is only 0.027 (6) Å, while that of atom C15 is much greater at 0.327 (5) Å.

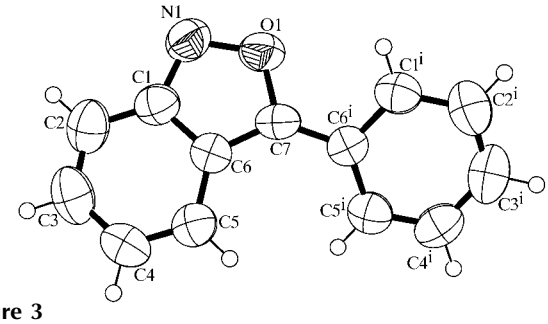

Figure 3
A view of molecule *B* of (II). The representation is the same as in Fig. 1. [Symmetry code: (i) $-x, y, \frac{3}{2} - z$.]

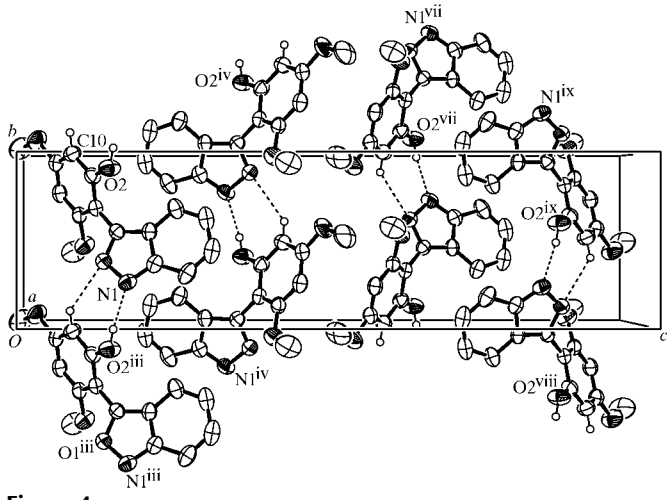

Figure 4
A view of the unit cell of (I), in the same representation as in Fig. 1 except that all H atoms other than those involved in hydrogen-bond (dashed lines) formation have been omitted and only selected atoms are labelled. The view is along *a*. [Symmetry codes: (iii) $x, y-1, z$; (iv) $-x, \frac{1}{2}+y, \frac{1}{2}-z$; (v) $-x, y-\frac{1}{2}, \frac{1}{2}-z$; (vi) $\frac{1}{2}-x, 1-y, \frac{1}{2}+z$; (vii) $\frac{1}{2}-x, 2-y, \frac{1}{2}+z$; (viii) $\frac{1}{2}+x, \frac{1}{2}-y, 1-z$; (ix) $\frac{1}{2}+x, \frac{3}{2}-y, 1-z$.]

A feature of the packing of the molecules in the cell of (I) (Fig. 4) is the presence of O2—H2···N1 and ancilliary C10—H10···O1 hydrogen bonds (Table 1). These connect the molecules into chains propagated in the *b* direction, in which adjacent molecules within the chain are related by cell translation. No equivalent intermolecular interaction is observed in (II).

Compounds (I) and (II) have also been characterized to some extent by spectroscopy (see below). Thus, while the ^{1}H NMR spectrum of (II) shows only multiple aryl H-atom chemical shifts, that of (I) can be analysed more specifically, with the alkoxy groups being seen to bring the resonances of the H atoms adjacent to them up-field (to $\delta = 6.19$ and 6.28 p.p.m.). Mass spectral fragmentation is also consistent with previous observations (Dyall & Karpa, 1989) that loss of CO and HCN is coupled to C_7H_4N, C_7H_5N and C_7H_4NO fragments, which are also found in the spectrum of (I). Fragmentation of (II) shows a pattern similar to that of (I).

Experimental

Crystals of (I) were obtained in a manner similar to that described for (III) by Forrester *et al.* (1992). Zinc dust (1.0 g) was added in portions over a period of 2 h to a stirred mixture of 2′-nitro-4,6-dimethoxy-2-hydroxybenzophenone, (I*a*) (1.0 g), in ethanol (200 ml) and NH_4Cl (1.0 g) in water (10 ml). After stirring overnight at room temperature, work-up in the usual manner yielded 813 mg of solid in the form of a mixture of products. The solid was dissolved in ethyl acetate and the components were separated by preparative thin-layer chromatography (TLC), with silica gel as the stationary phase and ethyl acetate/benzene as eluant. Two comparatively immobile phases (minor components) were not isolated. The most mobile phase, eluted with EtOAc/benzene in a 2:1 ratio, was the aniline (I*b*), resulting from complete reduction of the nitro group of the original benzophenone. The fraction containing (I), the major component, which constituted approximately 75% by weight of the total solids

recovered, was obtained by further elution with EtOAc/benzene in a 4:1 ratio. Recovery of the solid and recrystallization from $CHCl_3$ provided crystals of (I) (m.p. 431–434 K) suitable for analysis. ^{1}H NMR ($CDCl_3$): δ 7.67–6.90 (ArH), 6.28 and 6.19 (both *d*, *J* = 3 Hz, 3H or 5H), 3.85 (OMe), 3.83 (OMe), 7.11 (OH); *m*/*e*: 271 (100%), 256, 254, 242, 240, 212, 200, 196, 120. Reduction of *o*-nitrobenzophenone, (II*a*), in precisely the same manner afforded (II) in admixture with 2-aminobenzophenone, (II*b*). Compound (II) was isolated by preparative TLC as before and recrystallized from light petroleum (boiling range 333–353 K), yielding orange–yellow prisms (m.p. 323–326 K; literature value 326 K; Smith *et al.*, 1953). The melting point of (II) demanded low-temperature (< 323 K) manipulation for its recovery and recrystallization. ^{1}H NMR ($CDCl_3$): δ 6.45–8.00 (ArH); *m*/*e*: 195 (100%), 188, 167, 139, 118, 105, 92, 77, 63, 51, 39.

Compound (I)

Crystal data

$C_{15}H_{13}NO_4$
M_r = 271.26
Orthorhombic, $P2_12_12_1$
a = 6.941 (3) Å
b = 7.277 (3) Å
c = 26.418 (10) Å
V = 1334.4 (9) Å^3
Z = 4
D_x = 1.350 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 15 reflections
θ = 9.0–12.4°
μ = 0.10 mm^{-1}
T = 298 (2) K
Block, orange–yellow
0.70 × 0.60 × 0.60 mm

Data collection

Nicolet *P*3 diffractometer
θ–2θ scans
1403 measured reflections
1402 independent reflections
1251 reflections with $I > 2\sigma(I)$
R_{int} = 0.002
θ_{max} = 25.0°
$h = 0 \rightarrow 8$
$k = 0 \rightarrow 8$
$l = 0 \rightarrow 31$
2 standard reflections
every 50 reflections
intensity decay: none

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.032
$wR(F^2)$ = 0.082
S = 1.09
1402 reflections
184 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.046P)^2 + 0.1144P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max} < 0.001$
$\Delta\rho_{max}$ = 0.11 e Å^{-3}
$\Delta\rho_{min}$ = −0.14 e Å^{-3}

Table 1
Hydrogen-bonding geometry (Å,°) in (I).

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
O2—H2···N1^{ii}	0.82	1.97	2.782 (3)	172
C10—H10···O1^{ii}	0.93	2.56	3.337 (3)	142

Symmetry code: (ii) *x*, 1 + *y*, *z*.

Compound (II)

Crystal data

$C_{13}H_9NO$
M_r = 195.21
Monoclinic, *I*2/*c*
a = 12.027 (13) Å
b = 10.706 (14) Å
c = 31.76 (3) Å
β = 102.11 (8)°
V = 3998 (8) Å^3
Z = 16
D_x = 1.297 Mg m^{-3}
Mo $K\alpha$ radiation
Cell parameters from 14 reflections
θ = 7.7–11.6°
μ = 0.08 mm^{-1}
T = 298 (2) K
Block, pale brown
0.70 × 0.50 × 0.50 mm

Table 2
Selected geometric parameters (Å, °) for (I) and (II).

	(I)	(II*A*)	(II*B*)†	(II*C*)
O1—N1	1.408 (2)	1.415 (3)	1.432 (12)	1.415 (8)
N1—C1	1.328 (3)	1.314 (4)	1.369 (5)	1.305 (12)
C1—C6	1.417 (3)	1.415 (4)	1.403 (4)	1.425 (14)
C1—C2	1.432 (3)	1.422 (4)	1.390 (4)	1.426 (14)
C2—C3	1.345 (4)	1.343 (5)	1.351 (4)	1.352 (15)
C3—C4	1.417 (4)	1.422 (4)	1.398 (4)	1.433 (16)
C4—C5	1.355 (3)	1.359 (4)	1.359 (4)	1.347 (14)
C5—C6	1.419 (3)	1.413 (4)	1.405 (4)	1.408 (13)
C6—C7	1.375 (3)	1.369 (4)	1.409 (3)	1.376 (12)
C7—O1	1.348 (3)	1.357 (3)	1.383 (5)	1.340 (9)
C7—C8	1.458 (3)	1.453 (4)	1.409 (3)	1.468 (10)
C7—O1—N1	110.34 (16)	110.4 (2)	112.3 (6)	112.3 (6)
O1—N1—C1	104.47 (17)	103.7 (3)	106.4 (4)	102.9 (8)
N1—C1—C2	127.6 (2)	125.8 (3)	133.1 (4)	127.3 (12)
N1—C1—C6	112.03 (18)	113.2 (3)	106.2 (3)	113.2 (10)
C2—C1—C6	120.3 (2)	121.0 (4)	120.7 (3)	119.4 (10)
C1—C2—C3	117.0 (2)	117.6 (3)	118.7 (3)	119.7 (14)
C2—C3—C4	122.7 (2)	121.9 (4)	121.4 (3)	119.4 (11)
C3—C4—C5	121.1 (2)	121.8 (4)	120.9 (3)	122.9 (12)
C4—C5—C6	117.3 (2)	118.0 (3)	118.9 (3)	118.5 (12)
C5—C6—C7	134.7 (2)	135.8 (3)	127.5 (3)	135.6 (12)
C5—C6—C1	120.66 (19)	119.7 (3)	119.3 (3)	119.9 (9)
C1—C6—C7	104.57 (19)	104.5 (3)	113.1 (3)	104.5 (10)
C6—C7—C8	134.4 (2)	136.2 (3)	135.7 (4)	136.4 (11)
C6—C7—O1	108.58 (19)	108.2 (3)	101.8 (5)	107.1 (9)
O1—C7—C8	117.03 (17)	115.6 (3)	121.4 (5)	116.5 (8)
C6—C7—C8—C9	−51.9 (3)	12.8 (5)	13.4 (2)	−10 (2)
C6—C7—C8—C13	125.8 (3)	−168.0 (3)	−168.7 (2)	172.6 (16)
O1—C7—C8—C9‡	128.2 (2)	−166.6 (3)	−152.3 (5)	170.1 (9)
O1—C7—C8—C13‡	−54.2 (3)	12.5 (4)	25.7 (5)	−7.8 (18)

† The atom designations are correct and unambiguous for all except molecule (II*B*), where C8, C9 and C13 should be read as C6^i, C5^i and C1^i [symmetry code: (i) $-x$, y, $\frac{3}{2} - z$], respectively. ‡ These values are of dubious significance with regard to the twist about the C7—C8 bond for molecule (II*B*) as a result of the disorder of atom O1 in this molecule.

Data collection

Nicolet *P*3 diffractometer
θ–2θ scans
3726 measured reflections
3551 independent reflections
1555 reflections with $I > 2\sigma(I)$
R_{int} = 0.041
θ_{max} = 25.1°
$h = 0 \rightarrow 14$
$k = 0 \rightarrow 12$
$l = -37 \rightarrow 36$
2 standard reflections
every 50 reflections
intensity decay: none

Refinement

Refinement on F^2
$R[F^2 > 2\sigma(F^2)]$ = 0.054
$wR(F^2)$ = 0.123
S = 1.02
3551 reflections
348 parameters
H-atom parameters constrained
$w = 1/[\sigma^2(F_o^2) + (0.0333P)^2 + 0.6711P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 0.10 e Å^{-3}
$\Delta\rho_{min}$ = −0.12 e Å^{-3}

In the final stages of refinement of both structures, H atoms were placed in calculated positions and refined using a riding model, with *X*—H distances of 0.82, 0.93 and 0.96 Å, and U_{iso}(H) values equal to $1.5U_{eq}$, $1.2U_{eq}$ and $1.5U_{eq}$ of the parent atom for hydroxy, phenyl and methyl H atoms, respectively. In the case of (I), in the absence of species of atomic number higher than that of oxygen, no significant anomolous dispersion is observed. Therefore, Friedel pairs were merged; the Flack (1983) parameter is meaningless in this case and the absolute structure is indeterminate. At an appropriate point prior to the final refinement of (II), the essentially planar representation of molecule *C* as two superposed images was resolved by application of

the shape of molecule *A* (FRAG, FEND and AFIX instructions in *SHELXL*97; Sheldrick, 1997) to an appropriate selection of atoms from the compound image. Thereafter refinement was continued with the *SHELXL*97 SAME instruction in place, in order to constrain the bond lengths and angles of molecule *C*, but not the dihedral angle between the planar fragments, to be the same as those of molecule *A*.

For both compounds, data collection: *P*3 *Software* (Nicolet, 1980); cell refinement: *P*3 *Software*; data reduction: *RDNIC* (Howie, 1980); program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1990) for (I) and *SHELXS*97 (Sheldrick, 1997) for (II); program(s) used to refine structure: *SHELXL*97 (Sheldrick, 1997); molecular graphics: *ORTEP*-3 *for Windows* (Farrugia, 1997); 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: GD1263). Services for accessing these data are described at the back of the journal.

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