C(7)—O—C(8)	101.8 (2)	C(1)—C(6)—C(5)	119.2 (2)
C(4)—N(1)—C(7)	125.7 (3)	O—C(7)—N(1)	115.7 (2)
N(3)—N(2)—C(7)	105.0 (2)	O—C(7)—N(2)	113.6 (3)
N(2)—N(3)—C(8)	107.9 (2)	N(1)—C(7)—N(2)	130.8 (2)
C(11)—N(4)—C(12)	116.3 (3)	O—C(8)—N(3)	111.8 (3)
Cl—C(1)—C(2)	119.7 (2)	O—C(8)—C(9)	120.6 (2)
Cl—C(1)—C(6)	119.3 (2)	N(3)—C(8)—C(9)	127.6 (2)
C(2)—C(1)—C(6)	121.0 (2)	C(8)—C(9)—C(10)	123.6 (2)
C(1)—C(2)—C(3)	119.6 (2)	C(8)—C(9)—C(13)	118.7 (3)
C(2)—C(3)—C(4)	120.5 (2)	C(10)—C(9)—C(13)	117.8 (2)
N(1)—C(4)—C(3)	116.9 (3)	C(9)—C(10)—C(11)	119.6 (2)
N(1)—C(4)—C(5)	124.3 (2)	N(4)—C(11)—C(10)	123.6 (2)
C(3)—C(4)—C(5)	118.9 (2)	N(4)—C(12)—C(13)	124.0 (2)
C(4)—C(5)—C(6)	120.8 (2)	C(9)—C(13)—C(12)	118.7 (2)

Data collection was performed using *CAD*-4 diffractometer software (Enraf–Nonius, 1977). The structure was solved by direct methods with the *MULTAN*11/82 programs (Main *et al.*, 1982). The structure was refined by full-matrix least-squares methods using the *SDP* programs (Frenz, 1978).

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates, bond distances and angles involving H atoms, least-squares-planes data and torsion angles have been deposited with the IUCr (Reference: AB1133). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

References

Enraf–Nonius (1977). *CAD-4 Operations Manual.* Enraf–Nonius, Delft, The Netherlands.

Frenz, B. A. (1978). *The Enraf–Nonius CAD-4 SDP – a Real-Time System for Concurrent X-ray Data Collection and Crystal Structure Solution. Computing in Crystallography*, edited by H. Schenk, R. Olthof-Hazekamp, H. van Koningsveld & G. C. Bassi, pp. 64–71. Delft Univ. Press.

Giordano, F. (1992). *Acta Cryst.* C**48**, 2172–2174.

Main, P., Fiske, S. J., Hull, S. E., Lessinger, L., Germain, G., Declerq, J.-P. & Woolfson, M. M. (1982). *MULTAN*11/82. *A System of Computer Programs for the Automatic Solution of Crystal Structures from X-ray Diffraction Data.* Univs. of York, England, and Louvain, Belgium.

Rodier, N., Robert, J.-M. & Le Baut, G. (1993). *Acta Cryst.* C**49**, 161–163.

Vansdadia, R. N., Vikani, H. J. & Hansa Rarekh (1988). *J. Indian Chem. Soc.* **65**, 782–783.

Zhang, Z.-Y., Yang, K.-X. & Zeng, F.-L. (1988). *Chem. J. Chin. Univ.* **9**, 239–245.

Acta Cryst. (1995). C**51**, 1587–1590

Depogen, a Haemorheological Agent

Zsolt Böcskei and Kálmán Simon

Department of Chemical Research, Chinoin Pharmaceuticals, PO Box 110, 1325 Budapest, Hungary

Antal Friesz

Laboratory of Chemical Technology, Chinoin Pharmaceuticals, PO Box 110, 1325 Budapest, Hungary

István Hermecz

Department of Chemical Research, Chinoin Pharmaceuticals, PO Box 110, 1325 Budapest, Hungary

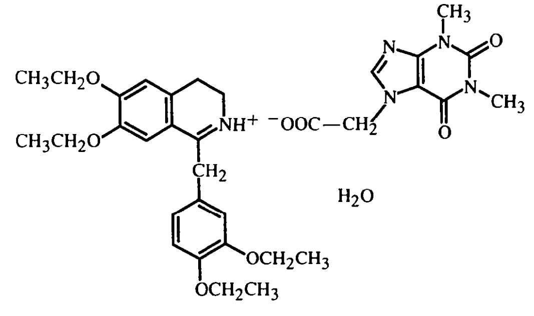
(*Received* 28 *November* 1994; *accepted* 13 *January* 1995)

Abstract

The crystal structure of the haemorheological agent depogen {1-[(3,4-diethoxyphenyl)methyl]-6,7-diethoxy-3,4-dihydro-2*H*$^+$-isoquinolinium 1,2,3,6-tetrahydro-7*H*-1,3-dimethyl-2,6-dioxopurine-7-acetate monohydrate, $C_{24}H_{32}NO_4^+.C_9H_9N_4O_4^-.H_2O$} reveals the role of a water molecule in building up a network of hydrogen bonds in its crystal lattice. Knowledge of the structure may help the elucidation of the differences in the pharmacological properties of the hydrated and the dehydrated compound.

Comment

The haemorheological agent depogen, (I) (Kapui *et al.*, 1992), has been produced in two crystal forms. While the cotton-like anhydrous form resisted attempts to produce single crystals of good quality (and indeed a substance suitable for drug formulation purposes), the monohydrate crystals were of sufficient quality to be subjected to X-ray diffractometry.



(I)

©1995 International Union of Crystallography
Printed in Great Britain – all rights reserved

The N-atom-containing ring of the isoquinoline moiety in the cation is in a screw boat conformation ($^2S_3$), as shown by the sign combination of the corresponding torsion angles (0, +, −, +, 0, −) (Table 2). Apart from the ethoxy group containing the disordered C29*B* atom, the remaining three are closely embedded in the plane of their corresponding benzene ring.

It is worth mentioning that the shape of the cation is characterized by the torsion angles N1—C2—C11—C12 and C2—C11—C12—C13. Accordingly, in other crystal structures containing the same cation but only a single chloride anion and different solvent molecules, these two torsion angles vary the most, while other structural parameters (such as the freely rotating torsion angles involving the atoms of the ethoxy groups) remain essentially the same in all the examined structures (Böcskei, Menyhárd, Simon, Friesz & Hermecz, 1994).

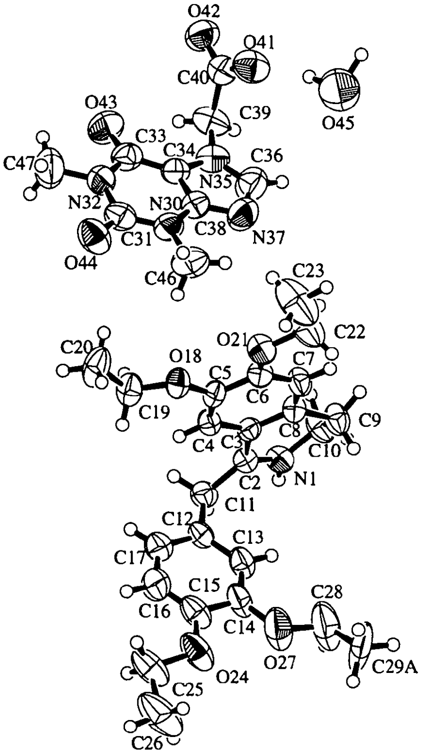


Fig. 1. Molecular structure and atomic numbering of the title compound.

As far as the intermolecular contacts are concerned, it can be seen (Fig. 2) that the water molecule plays an essential role in the construction of the crystal structure, since it bridges the O41 and O42 atoms of the carboxylate groups of two separate theophylline-7-acetate residues. Additionally, O41 is the acceptor atom in another hydrogen bond donated by N1 of the isoquinoline residue. The graph notation (Etter, 1990) for the hydrogen-bond chain consisting of the hydrogen bonds donated by the water molecules is $C^2_2(6)$, while the symbol for that donated by the N1 atom is *D*.

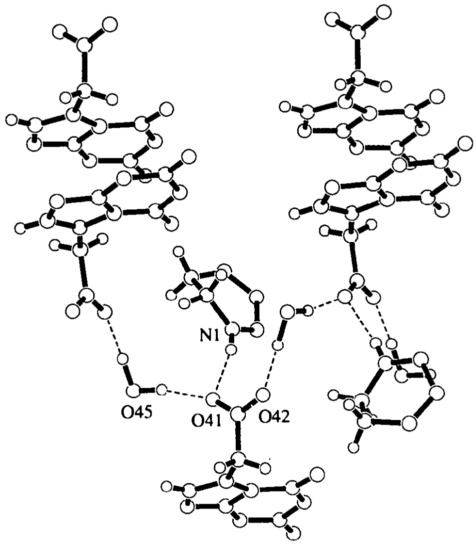


Fig. 2. Hydrogen-bonding interactions in the crystal structure of the title compound.

The angle formed by the two hydrogen bonds connected to O41 is *ca* 90°, somewhat narrower than expected from the possible localization of the nonbonding electron pairs.

Experimental

Crystal data

$C_{24}H_{32}NO_4^+.C_9H_9N_4O_4^-.H_2O$
$M_r = 653.72$
Orthorhombic
*Fdd*2
$a = 24.612 (6)$ Å
$b = 60.310 (8)$ Å
$c = 9.131 (7)$ Å
$V = 13\,553 (7)$ Å^3
$Z = 16$
$D_x = 1.281$ Mg m^{-3}

Cu *Kα* radiation
$\lambda = 1.5418$ Å
Cell parameters from 20 reflections
$\theta = 20.93–57.85°$
$\mu = 0.779$ mm^{-1}
$T = 293 (2)$ K
Hexagonal
0.300 × 0.300 × 0.150 mm
Yellow

Data collection

AFC-6*S* diffractometer
$\omega/2\theta$ scans
Absorption correction: none
4311 measured reflections
3738 independent reflections
1925 observed reflections [$I > 2\sigma(I)$]

$\theta_{max} = 75.36°$
$h = -30 \rightarrow 29$
$k = -54 \rightarrow 75$
$l = -6 \rightarrow 11$
3 standard reflections monitored every 150 reflections intensity decay: 0.95%

Refinement

Refinement on F^2
$R(F) = 0.0581$
$wR(F^2) = 0.1556$

Extinction correction: *SHELXL*93 (Sheldrick, 1993)

$S = 1.126$
3733 reflections
439 parameters
Only H-atom U's refined
$w = 1/[\sigma^2(F_o^2) + (0.1162P)^2 + 6.9099P]$
where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{\text{max}} = -0.240$
$\Delta\rho_{\text{max}} = 0.341$ e Å^{-3}
$\Delta\rho_{\text{min}} = -0.297$ e Å^{-3}

Extinction coefficient: 0.00006 (2)
Atomic scattering factors from *International Tables for Crystallography* (1992, Vol. C, Tables 4.2.6.8 and 6.1.1.4)
Absolute configuration: Flack (1983)

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

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

	x	y	z	U_{eq}
N1	0.7246 (2)	0.02130 (10)	−0.1008 (8)	0.056 (2)
C2	0.7296 (3)	0.03492 (11)	0.0082 (9)	0.048 (2)
C3	0.6872 (3)	0.05122 (11)	0.0354 (8)	0.046 (2)
C4	0.6858 (3)	0.06326 (11)	0.1662 (8)	0.049 (2)
C5	0.6470 (3)	0.07943 (11)	0.1854 (8)	0.047 (2)
C6	0.6103 (3)	0.08436 (11)	0.0710 (9)	0.051 (2)
C7	0.6122 (3)	0.07243 (12)	−0.0581 (9)	0.056 (2)
C8	0.6502 (3)	0.05577 (11)	−0.0762 (9)	0.051 (2)
C9	0.6542 (3)	0.04326 (13)	−0.2175 (10)	0.063 (2)
C10	0.6763 (4)	0.02038 (14)	−0.1911 (11)	0.069 (2)
C11	0.7801 (3)	0.03327 (12)	0.0994 (10)	0.058 (2)
C12	0.8161 (3)	0.05343 (12)	0.0891 (9)	0.053 (2)
C13	0.8310 (3)	0.06161 (13)	−0.0471 (10)	0.066 (2)
C14	0.8649 (4)	0.07943 (14)	−0.0593 (12)	0.072 (3)
C15	0.8862 (4)	0.08926 (14)	0.0668 (12)	0.074 (3)
C16	0.8717 (4)	0.0812 (2)	0.1997 (12)	0.084 (3)
C17	0.8374 (4)	0.0631 (2)	0.2105 (12)	0.079 (3)
O18	0.6406 (2)	0.09182 (8)	0.3094 (6)	0.0575 (13)
C19	0.6651 (4)	0.08420 (13)	0.4400 (10)	0.066 (2)
C20	0.6437 (5)	0.0981 (2)	0.5642 (11)	0.093 (3)
O21	0.5753 (2)	0.10120 (9)	0.0993 (7)	0.0644 (14)
C22	0.5366 (4)	0.1071 (2)	−0.0117 (14)	0.092 (4)
C23	0.5034 (5)	0.1253 (2)	0.052 (2)	0.134 (6)
O24	0.9210 (3)	0.10661 (10)	0.0435 (9)	0.097 (2)
C25	0.9481 (4)	0.1154 (2)	0.1732 (13)	0.099 (4)
C26	0.9895 (5)	0.1322 (2)	0.1178 (17)	0.148 (7)
O27	0.8807 (4)	0.08854 (15)	−0.1880 (9)	0.123 (3)
C28	0.8674 (5)	0.0775 (2)	−0.3312 (11)	0.146 (7)
C29*A*	0.8724 (5)	0.0959 (2)	−0.4360 (11)	0.16 (2)
C29*B*	0.8150 (8)	0.0893 (4)	−0.3717 (25)	0.128 (12)
N30	0.4906 (3)	0.05157 (11)	0.4346 (10)	0.068 (2)
C31	0.4935 (3)	0.05137 (14)	0.5840 (12)	0.069 (2)
N32	0.4673 (3)	0.03396 (13)	0.6564 (9)	0.071 (2)
C33	0.4425 (3)	0.0155 (2)	0.5877 (12)	0.069 (2)
C34	0.4429 (3)	0.01724 (13)	0.4361 (10)	0.057 (2)
N35	0.4248 (3)	0.00283 (11)	0.3272 (10)	0.071 (2)
C36	0.4370 (5)	0.0128 (2)	0.2008 (14)	0.093 (3)
N37	0.4635 (4)	0.0326 (2)	0.2153 (10)	0.092 (3)
C38	0.4663 (3)	0.03480 (14)	0.3622 (10)	0.064 (2)
C39	0.3935 (3)	−0.01708 (13)	0.3485 (14)	0.078 (3)
C40	0.3329 (3)	−0.01352 (14)	0.3605 (11)	0.062 (2)
O41	0.3141 (2)	0.00163 (11)	0.2897 (10)	0.090 (2)
O42	0.3071 (3)	−0.02675 (12)	0.4371 (9)	0.090 (2)
O43	0.4232 (3)	0.00046 (12)	0.6625 (9)	0.100 (2)
O44	0.5167 (3)	0.06593 (11)	0.6534 (9)	0.092 (2)
O45	0.3015 (5)	0.0307 (2)	0.0355 (13)	0.165 (5)
C46	0.5146 (4)	0.0703 (2)	0.3559 (15)	0.101 (4)
C47	0.4695 (6)	0.0338 (2)	0.8164 (13)	0.110 (4)

Table 2. *Selected bond lengths* (Å) *and torsion angles* (°)

N1—C2	1.296 (9)	N1—C10	1.447 (10)
C10—N1—C2—C3	−4.9 (11)	C8—C9—C10—N1	−48.6 (10)
N1—C2—C3—C8	−16.9 (10)	N1—C2—C11—C12	114.3 (7)
C4—C3—C8—C9	177.4 (7)	C2—C11—C12—C13	−51.0 (10)
C3—C8—C9—C10	30.6 (10)	C34—N35—C39—C40	84.1 (12)
C2—N1—C10—C9	38.6 (11)	N35—C39—C40—O41	32.7 (14)

Table 3. *Hydrogen-bonding geometry* (Å, °)

D—H···*A*	*D*···*A*	*D*—H···*A*
O45—H45*A*···O41	2.924 (13)	168.1 (4)
O45′—H45*B*′···O42	2.828 (13)	174.9 (5)
N1″—H1···O41	2.695 (9)	158.9 (3)

Table 4. *Least-squares-planes data*

Equation of plane: 15.600 (35)x + 40.873 (65)y − 3.404 (16)z = 12.720 (22)
Deviation of atoms from the plane (Å):
(* indicates atom used to define plane)

C2*	0.061 (5)	O18*	−0.027 (5)
C3*	−0.026 (6)	O21*	0.053 (5)
C4*	−0.001 (6)	C19	−0.401 (10)
C5*	−0.011 (6)	C20	−0.590 (13)
C6*	0.007 (6)	C22	0.068 (15)
C7*	−0.011 (7)	C23	0.076 (19)
C8*	−0.038 (7)	N1	−0.203 (8)
C9*	−0.006 (6)	C10	−0.685 (12)

R.m.s. deviation of fitted atoms: 0.031 Å

Equation of plane: 19.316 (30)x − 37.331 (84)y − 0.277 (34)z = 13.767 (31)
Angle to previous plane (with approximate e.s.d.): 84.88 (13)°
Deviation of atoms from the plane (Å):
(* indicates atom used to define plane)

C11*	0.033 (5)	O24*	0.032 (6)
C12*	−0.022 (6)	O27*	−0.008 (7)
C13*	−0.001 (8)	C25	0.190 (15)
C14*	−0.009 (9)	C26	0.379 (19)
C15*	0.000 (9)	C28	0.189 (19)
C16*	−0.017 (8)	C29*A*	−0.375 (21)
C17*	−0.007 (8)	C29*B*	−1.253 (23)

R.m.s. deviation of fitted atoms: 0.018 Å

Equation of plane: 21.396 (23)x − 29.779 (77)y − 0.200 (18)z = 8.893 (13)
Angle to previous plane (with approximate e.s.d.): 8.7 (2)°
Deviation of atoms from the plane (Å):
(* indicates atom used to define plane)

N30*	−0.018 (7)	C38*	−0.025 (8)
C31*	0.020 (8)	C39*	−0.034 (6)
N32*	−0.036 (8)	O43*	0.017 (8)
C33*	−0.005 (8)	O44*	0.069 (7)
C34*	−0.018 (8)	C46*	−0.047 (9)
N35*	0.047 (7)	C47*	−0.016 (10)
C36*	0.035 (10)	C40	−1.439 (10)
N37*	0.011 (9)		

R.m.s. deviation of fitted atoms: 0.033 Å

Data collection: *MSC/AFC Diffractometer Control Software* (Molecular Structure Corporation, 1988). Cell refinement: *MSC/AFC Diffractometer Control Software*. Data reduction: *TEXSAN* (Molecular Structure Corporation, 1985). Program(s) used to solve structure: *SHELXS*86 (Sheldrick, 1985). Program(s) used to refine structure: *SHELXL*93 (Sheldrick, 1993). Software used to prepare material for publication: *TEXSAN*.

Lists of structure factors, anisotropic displacement parameters, H-atom coordinates and complete geometry have been deposited with the IUCr (Reference: KA1104). Copies may be obtained through The Managing Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

References

Böcskei, Z., Menyhárd, D., Simon, K., Friesz, A. & Hermecz, I. (1994). *J. Am. Chem. Soc.* Submitted.

Etter, M. C. (1990). *Acc. Chem. Res.* **23**, 120–126.

Flack, H. D. (1983). *Acta Cryst.* **A39**, 876–881.

Kapui, Z., Hermecz, I., Sarkadi, B., Szentmiklósi, P., Tardos, L. & Blaskó, Gy. (1992). *Thromb. Res.* **66**, 693–706.
Molecular Structure Corporation (1985). *TEXSAN. TEXRAY Structure Analysis Package.* MSC, 3200 Research Forest Drive, The Woodlands, TX 77381, USA.
Molecular Structure Corporation (1988). *MSC/AFC Diffractometer Control Software.* MSC, 3200 Research Forest Drive, The Woodlands, TX 77381, USA.
Sheldrick, G. M. (1985). *SHELXS86. Program for the Solution of Crystal Structures.* Univ. of Göttingen, Germany.
Sheldrick, G. M. (1993). *SHELXL93. Program for the Refinement of Crystal Structures.* Univ. of Göttingen, Germany.

Acta Cryst. (1995). C**51**, 1590–1593

2-(2-Methoxyphenyl)pyridine 1-Oxide and its 3-Methyl Derivative

IRENA WOLSKA, MACIEJ KUBICKI, MARIAN GAWRON, TERESA BOROWIAK AND WIESŁAW Z. ANTKOWIAK

Department of Chemistry, Adam Mickiewicz University, Grunwaldzka 6, 60-780 Poznań, Poland

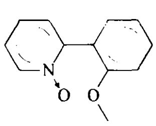
(*Received* 13 *December* 1994; *accepted* 13 *February* 1995)

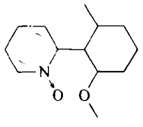
Abstract

The crystal structures of 2-(2-methoxyphenyl)pyridine 1-oxide, $C_{12}H_{11}NO_2$ (1), and 2-(2-methoxyphenyl)-3-methylpyridine 1-oxide, $C_{13}H_{13}NO_2$ (2), have been determined. The dihedral angle between the least-squares planes of the aromatic rings is 66.6 (1) for (1) and 74.70 (6)° for (2). Weak C—H···O hydrogen bonds govern the crystal packing.

Comment

Orellanine (3,3′,4,4′-tetrahydroxy-2,2′-bipyridine 1,1′-dioxide) was shown to lose both *N*-oxide groups at a surprisingly low temperature (Antkowiak & Gessner, 1979) compared with other bipyridine *N,N*′-dioxides (Wenkert & Woodward, 1983). As part of our studies on the mechanism of this deoxygenation reaction, we reported the structure of a model compound, 2-(2-hydroxyphenyl)pyridine 1-oxide (Kubicki, Borowiak, Antkowiak & Antkowiak, 1990), which has all the structural features necessary for the proposed mechanism of this deoxygenation process (Antkowiak & Gessner, 1984). In this structure, we found a strong intramolecular O—H···O—N hydrogen bond and the dihedral angle between the two aromatic rings was 38.2 (1)°. Since decrease of the twist angle is supposed to play a crucial role in the transition state of the deoxygenation process, we decided to check the influence of intramolecular hydrogen bonding on the molecular conformation by studying related compounds having no possibility of forming such a bond. In this paper, we present the structure determinations of two compounds, 2-(2-methoxyphenyl)pyridine 1-oxide, (1), and its 3-methyl derivative, (2).


(1)


(2)

The twist angle between the two almost perfectly planar aromatic rings is 66.6 (1) in (1) and 74.70 (6)° in (2). This seems to prove the role of intramolecular hydrogen bonding in stabilizing the conformation, reflected in a smaller dihedral angle, for this class of compounds. Comparing the conformations of (1) and (2), it was found that the rings were twisted in opposite directions; the absolute values of the torsion angles N1—C2—C1′—C2′ are 69.2 (3) and 106.8 (2)° in compounds (1) and (2), respectively. Thus, if one imagines a plane perpendicular to the pyridine ring and containing the central C2—C1′ bond, in (1) both O atoms will be on the same side of this plane, while in (2) they will lie on opposite sides. In the case of (1), even despite the lack of steric hindrance at positions 3 and 6′, a relatively short non-bonded O1···O2′ distance of 3.032 (3) Å is found. A similar situation is observed in 2,2′-bipyridine 1,1′-dioxide, where the absolute value of the torsion angle N1—C2—C2′—N1′ is 70.9 (2)° and the O1···O1′ distance is 3.040 (2) Å (Dutkiewicz, 1995). It is also noteworthy that the crystal structure of (2) contains both conformational enantiomers, while in (1) there are only homochiral molecules. The disposition of the methoxy group with respect to the phenyl ring is also slightly different in both compounds. In (1), the methoxy group is almost coplanar with the phenyl ring, while in (2) it is significantly tilted out of the plane; the torsion angles C3′—C2′—O2′—C2′1 are −3.3 (5) and −15.9 (3)° for compounds (1) and (2), respectively. This is accompanied by a statistically significant difference in the values of the C—O—C bond angles: 118.1 (3) for (1) and 116.5 (2)° for (2). The introduction of the methyl substituent in the 3-position changes the bond-angle pattern in the pyridine ring.

The differences between (2) and (1) are in agreement with the observations of Domenicano & Murray-Rust (1979) on mono- and disubstituted benzene derivatives. The N—O bond lengths of 1.307 (4) for (1) and 1.309 (2) Å for (2) are close to the typical values for N—O groups not involved in hydrogen bonding (Eichhorn, 1987).

In both structures, the molecular packing is determined by C—H···O hydrogen bonds. Compound (1) has a two-dimensional structure with chains of molecules along the [100] and [010] directions, interconnected with the rings of four other molecules. In (2),

©1995 International Union of Crystallography
Printed in Great Britain – all rights reserved