

The ribose appears in the C(3')-endo mode of puckering (Table 4) and is in the asymmetrical 3T_2 twist conformation having a phase angle of pseudorotation $P = 12.4^\circ$ (Sundaralingam, 1975). The staggered conformation about the exocyclic C(4')-C(5') is *trans* ($\psi = 176.1^\circ$).

The ribose moiety in the analogous nucleotide fragment in vitamin B₁₂ exhibits a C(2')-exo, $_2E$ envelope conformation (Tables 4 and 5). The phase angle of pseudorotation P of 343.3° also confirms this type of conformation. The conformation about C(4')-C(5') is *gauche*⁺ (Table 5).

The orientation of the base relative to the sugar ring, described in terms of rotation about C(1')-N(7) for the sequence O(1')-C(1')-N(7)-C(8), is 142.7° (Sundaralingam, 1975) and the molecule is *syn*. The α -D-5,6-dimethylbenzimidazole ribonucleotide moiety (in vitamin B₁₂) with $\chi_{CN} -46^\circ$ (Table 5) occurs in the *anti* conformation.

The molecules are connected by hydrogen bonds O(2')-H(O2')...N(9), 2.701 (6) Å, acting between sugar and base moieties. The pronounced base stacking appears in the lattice along **b** with an interplanar separation of 5.460 (3) Å.

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2-Ethoxy-1,7,9-triethyl-7,9-dihydro-1H-purine-6,8-dione; a Tetraethyl Derivative of Uric Acid

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Abstract. C₁₃H₂₀N₄O₃, $M_r = 280.33$; monoclinic, $P2_1/n$; $a = 15.491$ (6), $b = 4.794$ (2), $c = 19.597$ (5) Å, $\gamma = 95.26$ (3)°, $Z = 4$, $D_c = 1.285$, $D_m = 1.28$ Mg m⁻³ (floatation); final $R = 0.048$ (852 reflections). Uric acid was ethylated and four isomers of tetraethyluric acid were isolated. One isomer, m.p. 387.2-387.7 K, was analyzed.

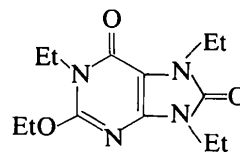
Introduction. For a quantitative measurement of uric acid in sera by isotope-dilution mass spectrometry, a stable derivative of uric acid was required. The title compound (I) was prepared by ethylating uric acid with

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triethylphenylammonium carbonate and purified by preparative thin-layer chromatography. As the structure of the title compound could not be determined with certainty by standard chemical techniques, it was solved by single-crystal X-ray diffraction.



(I) m.p. 387.2-387.7 K

Colorless transparent needles were obtained by recrystallization from acetone and pentane. A crystal of (I) (0.04 × 0.05 × 0.3 mm) was mounted on a four-circle diffractometer for data collection. Systematic extinctions observed with the diffractometer established the space group as $P2_1/n$ (c unique). The radiation used was graphite-monochromated $\text{Cu } K\alpha$ ($\lambda = 1.5418 \text{ \AA}$). 4662 reflections were collected to $2\theta = 115^\circ$. Equivalent reflections were averaged to a unique set of 1975 reflections of which 852 had an intensity of $I > 3\sigma(I)$. The data were corrected for Lorentz and polarization effects but not for extinction. The structure was solved by using the program *MULTAN* (Germain, Main & Woolfson, 1971), and was refined with full-matrix least-squares calculations. After the first isotropic refinements, the approximate positions of the H atoms were determined from a difference Fourier synthesis. However, in the final mixed anisotropic refinement, the ideal calculated positions were used for all H atoms. The weighting scheme used and the final R values are

Table 1. *Chemical and refinement data for*
 $\text{C}_{13}\text{H}_{20}\text{N}_4\text{O}_3$

Elemental analysis: Exp.	%C : H : N = 56.28 : 7.24 : 20.18
Calc.	55.70 : 7.19 : 19.99
IR (chloroform)	(5.85 μm) 170.9 mm^{-1} (C=O) (5.96 μm) 167.8 mm^{-1} (C=O)
Mass spectra	(E1) m/e 280 (M^+)
μ (Cu $K\alpha$)	0.78 mm^{-1}
Criterion for $\sigma(I)$	$\sigma(I)^2 = I + 0.00017I^2$
Criterion for $\sigma(F_o)$	$\sigma(F_o) = \{F_o^2 + \sigma(I)/Lp\}^{1/2} - F_o$
Weighting function	$w = \{\sigma(F_o)\}^{-2}$
Function minimized	$\sum w(F_o - F_c)^2$
$R = \sum F_o - F_c / \sum F_o$	0.048 [852 reflections with $I > 3\sigma(I)$]
$R_w = [\sum w(F_o - F_c)^2]^{1/2} / \sum wF_o^2$	0.040
Maximum and average shift/error	0.53, 0.08

given in Table 1. Analysis of the resulting difference synthesis revealed no peak higher than 0.3 e \AA^{-3} .

Table 2 lists the final atomic parameters.* The scattering factors used were those of Cromer & Mann (1968) for the heavy atoms, and those of Stewart, Davidson & Simpson (1965) for H. Corrections for anomalous dispersion were applied for C, N, O (*International Tables for X-ray Crystallography*, 1974). Calculations (except *MULTAN*) were performed using the XRAY system (1976).

Discussion. Bond distances and angles for the title compound are given in Fig. 1 and the packing in the unit cell is shown in Fig. 2. A least-squares-plane calculation through the ring atoms [C(1), C(2), C(3), C(4), C(5), N(1), N(2), N(3), N(4)] shows that they lie in essentially the same plane. The maximum deviation of the ring atoms from the plane is -0.026 \AA for C(2) and the average deviation is 0.010 \AA . The distances (in parentheses) from the plane for the atoms attached to the ring are: O(1) (0.02 \AA), O(2) (0.06 \AA), O(3) (0.05 \AA), C(6) (-0.13 \AA), C(8) (-0.02 \AA), C(12) (0.04 \AA).

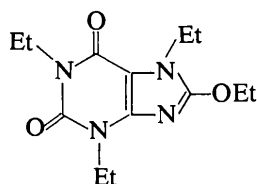
Twelve isomers of the tetraethyl derivative of uric acid are possible. In the preparation of the ethylated derivative, however, only (I) and three other isomers were obtained. The possible structures of the remaining three isomers and their melting points are:

* Lists of structure factors and anisotropic thermal parameters have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 34229 (17 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

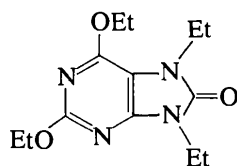
Table 2. *Positional parameters ($\times 10^4$) with estimated standard deviations in parentheses*

The positions of the hydrogen atoms were calculated assuming tetrahedral geometry with a bond distance of 1.0 \AA .

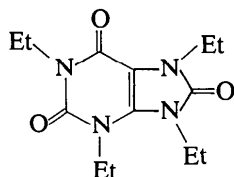
	x	y	z		x	y	z
O(1)	5754 (3)	9636 (10)	2636 (2)	H1(C6)	5266	11462	1456
O(2)	6614 (2)	7070 (8)	32 (2)	H2(C6)	5738	10858	734
O(3)	8532 (2)	1500 (8)	966 (2)	H1(C7)	4507	6794	1329
N(1)	6106 (3)	8476 (11)	1518 (3)	H2(C7)	4848	6916	545
N(2)	7544 (3)	4181 (10)	532 (2)	H3(C7)	4212	9177	806
N(3)	7722 (3)	3780 (10)	1736 (2)	H1(C8)	7928	1269	-139
N(4)	6789 (3)	6546 (10)	2367 (3)	H2(C8)	7340	3541	-489
C(1)	6164 (5)	8372 (15)	2224 (4)	H1(C9)	8523	6989	-407
C(2)	6681 (4)	6697 (14)	1242 (3)	H2(C9)	8784	4347	-857
C(3)	6906 (4)	6131 (13)	556 (3)	H3(C9)	9109	4689	-69
C(4)	7915 (4)	3167 (13)	1105 (3)	H1(C10)	9314	2324	1796
C(5)	7097 (4)	5546 (13)	1764 (3)	H2(C10)	8636	-466	1884
C(6)	5462 (4)	9941 (14)	1149 (3)	H1(C11)	9416	-3055	1104
C(7)	4686 (4)	8015 (16)	945 (4)	H2(C11)	9976	-182	864
C(8)	7816 (4)	3300 (12)	-151 (3)	H3(C11)	10127	-1488	1619
C(9)	8626 (4)	4953 (13)	-392 (3)	H1(C12)	6615	6451	3388
C(10)	9024 (4)	598 (14)	1546 (3)	H2(C12)	7104	3827	3093
C(11)	9708 (4)	-1108 (14)	1271 (3)	H1(C13)	7898	9432	3177
C(12)	7059 (5)	5915 (15)	3055 (3)	H2(C13)	8379	6680	2958
C(13)	7923 (5)	7372 (15)	3245 (3)	H3(C13)	8038	7014	3736



(II) m.p. 366.2–367.2 K



(III) m.p. 352.2–353.9 K



(IV) m.p. 374.2–375.2 K

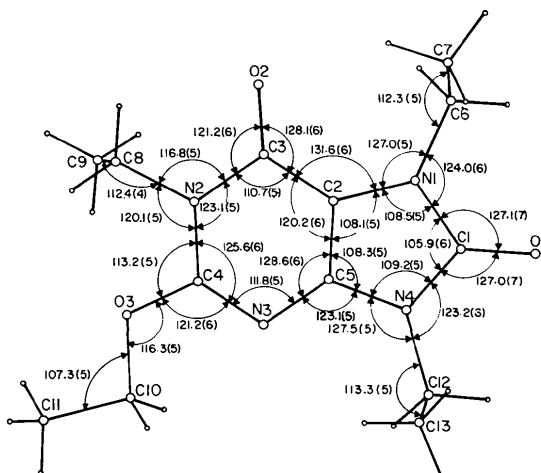
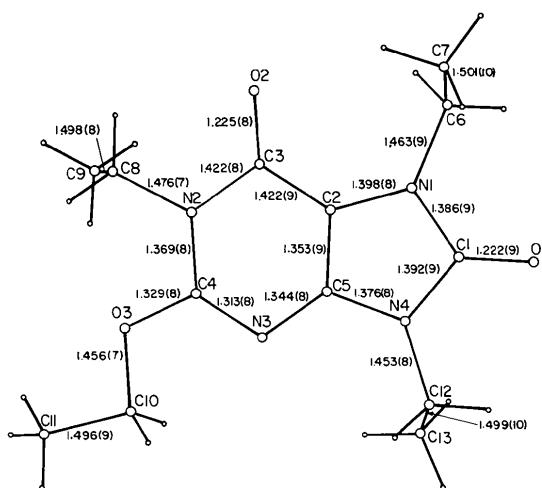


Fig. 1. Bond distances (Å) and angles (°). Estimated standard deviations are given in parentheses.

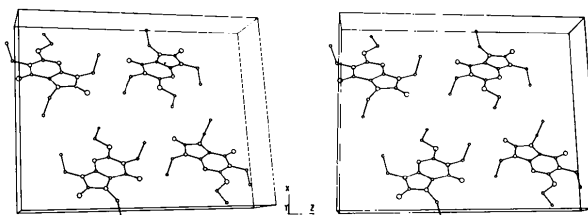


Fig. 2. Molecular packing in the unit cell.

Isomers (I) and (II) are used in a standard reference procedure for the quantitative determination of natural uric acid in sera. The chemical structures of isomers (II), (III) and (IV) are tentatively assigned on the basis of spectroscopic techniques (proton magnetic resonance, infrared, and ultraviolet) with the aid of caffeine and tetramethyluric acid as reference compounds. To verify the position of the ring functional groups (*N*-ethyl, *O*-ethyl, carbonyl) further X-ray work is planned on these isomers.

From the X-ray determination, the chemical structure of (I) was found to be identical to that assigned to the compound (m.p. 387.2 K) prepared by Birkofer, Ritter & Kuehlthau (1964) by treating tetrakis(triethylsilyl)uric acid with diethyl sulfate. Birkofer *et al.* predicted the chemical structure on the basis of the similarity of the ultraviolet and infrared spectra to those of the methyl analogue. A complete description of the synthesis of the products, including infrared and nuclear magnetic resonance analyses, will appear in a future paper by one of the authors (AC).

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