Structure of 3β-Methoxy-22α-methyl-norserrat-14-en-21-one*

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Abstract. $C_{30}H_{48}O_2$, $P2_12_12_1$, $Z = 4$, $a = 9.598$ (1), $b = 10.559$ (1), $c = 25.150$ (2) Å, $D_o = 1.15$, $D_c = 1.148$ g cm^{-3}. The structure was solved by a combination of direct and Fourier methods, and refined to $R = 0.037$ using 2373 intensities. The A, B and E rings assume the chair conformation, the seven-membered C ring a twist-chair conformation, and the six-membered D ring a half-chair conformation.

Introduction. Serratenes are a novel group of naturally occurring pentacyclic triterpenes with a central seven-membered ring. The present structure, 3β-methoxy-22α-methyl-norserrat-14-en-21-one, differs from all previously known serratene compounds in that it lacks the 22α-methyl group thus having only five tertiary methyls instead of seven and having one secondary methyl group. A preliminary communication on the structure has been reported (Conner, Haromy & Sundaralingam, 1981).

Crystals of the compound were provided by A. Conner of the US Forest Products Laboratory, Madison, Wisconsin. Crystals with dimensions up to 2 mm on a side were obtained by slow evaporation of a methylene chloride solution over a period of several weeks. The crystal chosen for the analysis was approximately cylindrical, elongated along the b axis with an average radius of 0.3 mm and length of 0.9 mm ($\mu = 0.53$ mm^{-1}). Intensity data were collected on a Picker four-circle diffractometer using Ni-filtered Cu $K\alpha$ radiation ($\lambda = 1.5418$ Å). Unit-cell parameters were refined by a least-squares algorithm using 24 automatically centered reflections. Of a total of 2414 unique reflections measured up to a 2θ limit of 127.5°, 2373 had intensities greater than $1.5\sigma(I)$ and were used for the structure analysis. Both crystal decay and absorption effects were found to be insignificant. The data were corrected for Lorentz and polarization effects.

The structure was solved by application of the multisolution method using the computer program *MULTAN* (Main, Germain & Woolfson, 1970) coupled with numerous Fourier syntheses. The E values input to *MULTAN* were calculated using group

scattering factors (Main, 1975) based on a Δ^{14} serratene skeleton which was previously assumed for this structure (and later shown to be incorrect) based on chemical and spectral work (Conner *et al.*, 1981). A total of 347 reflections with E values greater than 1.4 were used for the structure determination. Of the 16 phase sets calculated, the E map of one of them contained density corresponding to the atoms of the A ring and O(1) of the actual structure. Several additional non-H atoms connected to ring A were determined by Fourier syntheses. The phases of 33 reflections whose F_c/F_o ratio exceeded 0.6 were used as the starting set of phases to determine the phases of the rest of the original set of E's by the cyclic tangent-refinement procedure (Karle, 1968). The resulting E map, although very noisy, revealed 25 of the 32 non-H atoms in the structure. The remaining non-H atoms were determined from a subsequent Fourier synthesis.

Block-diagonal least-squares refinement using isotropic temperature factors and weights proportional to $1/[\sigma^2(F) + (0.02F_o)^2]$ reduced R from 0.206 to 0.109. Refinement using anisotropic temperature factors further reduced R to 0.089. A difference Fourier synthesis revealed all the H atoms. Full-matrix least-squares refinement of the non-H atoms, keeping the H atoms fixed, lowered R to 0.039. When the H atoms were also refined, using isotropic temperature factors, R dropped to 0.037.

The average and maximum values of the shift/error ratios for the atomic parameters after refinement were 0.03 and 0.14 respectively. The scattering factors used for the O and C atoms were taken from Cromer & Waber (1965) and those for H were taken from Stewart, Davidson & Simpson (1965).

Discussion. The final positional parameters are given in Table 1.† An *ORTEP* drawing (Johnson, 1976) of the title compound is given in Conner *et al.* (1981). The

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† Lists of structure factors and anisotropic thermal parameters and a packing diagram of the title compound have been deposited with the British Library Lending Division as Supplementary Publication No. SUP 36542 (10 pp.). Copies may be obtained through The Executive Secretary, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.

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* Also called 3β-methoxy-30-norserrat-14-en-21-one.

Table 1. Fractional positional coordinates (×10⁵, for H ×10⁴) and isotropic thermal parameters for all atoms of 3β-methoxy-22α-methyl-norserrat-14-en-21-one

$$B_{eq} = \tfrac{4}{3}\textstyle\sum_i \sum_j \beta_{ij}\, \mathbf{a}_i \cdot \mathbf{a}_j.$$

	x	y	z	B_{eq} or B (Å^2)
C(1)	42282 (21)	46939 (20)	30131 (7)	3·33 (4)
C(2)	33595 (23)	43798 (22)	35058 (8)	3·67 (5)
C(3)	21899 (22)	53249 (20)	35806 (7)	3·32 (4)
O(1)	13568 (16)	50414 (17)	40373 (5)	4·24 (3)
C(O1)	20377 (26)	52054 (26)	45272 (8)	4·53 (5)
C(4)	12100 (20)	53999 (18)	30988 (7)	2·98 (4)
C(4M1)	2828 (24)	42216 (23)	30656 (9)	4·11 (5)
C(4M2)	2495 (25)	65520 (23)	31779 (9)	4·12 (5)
C(5)	21298 (19)	56412 (17)	25956 (7)	2·68 (4)
C(6)	12971 (20)	58593 (21)	20883 (7)	3·32 (4)
C(7)	22209 (22)	64849 (21)	16728 (7)	3·38 (4)
C(8)	35128 (19)	57080 (17)	15220 (7)	2·67 (4)
C(8M)	30618 (23)	46013 (22)	11637 (8)	3·70 (4)
C(9)	43021 (18)	53253 (16)	20412 (6)	2·48 (3)
C(10)	33763 (18)	47264 (17)	24936 (7)	2·62 (4)
C(10M)	29394 (24)	33605 (19)	23509 (9)	3·71 (5)
C(11)	56445 (21)	45640 (20)	19394 (7)	3·26 (4)
C(12)	67738 (19)	51713 (21)	15946 (7)	3·09 (4)
C(13)	65041 (19)	50862 (17)	9894 (7)	2·63 (4)
C(14)	54934 (20)	60982 (18)	8046 (7)	2·80 (4)
C(15)	55296 (23)	65507 (21)	3131 (7)	3·51 (4)
C(16)	65397 (23)	61445 (24)	−1073 (7)	3·85 (5)
C(17)	73679 (20)	49696 (20)	554 (7)	2·97 (4)
C(18)	78557 (19)	50691 (17)	6418 (7)	2·70 (4)
C(18M)	87393 (22)	62476 (21)	7485 (8)	3·48 (4)
C(19)	86923 (23)	38742 (22)	7765 (8)	3·75 (5)
C(20)	98936 (25)	36018 (26)	3955 (9)	4·48 (5)
C(21)	94246 (23)	35851 (22)	−1735 (8)	3·92 (5)
O(2)	97782 (25)	27422 (20)	−4695 (8)	6·79 (5)
C(22)	85493 (22)	46964 (22)	−3492 (7)	3·50 (4)
C(22M)	80043 (28)	45233 (30)	−9115 (9)	5·11 (6)
C(23)	44321 (22)	66232 (18)	11902 (7)	3·02 (4)
H(1A)	5003 (23)	4165 (22)	3005 (8)	3·4 (5)
H(1B)	4649 (21)	5510 (21)	3060 (7)	3·2 (4)
H(2A)	3966 (25)	4371 (22)	3829 (8)	3·7 (5)
H(2B)	2916 (27)	3563 (26)	3480 (9)	4·8 (6)
H(3)	2631 (25)	6232 (24)	3631 (8)	3·8 (5)
H(CO1A)	2605 (26)	5887 (25)	4516 (9)	4·7 (6)
H(CO1B)	2772 (34)	4487 (31)	4563 (12)	8·0 (9)
H(CO1C)	1369 (26)	5248 (26)	4780 (9)	4·9 (6)
H(4M1A)	−412 (25)	4230 (25)	3360 (9)	4·5 (6)
H(4M1B)	−277 (23)	4181 (23)	2742 (8)	3·9 (5)
H(4M1C)	810 (34)	3457 (32)	3087 (10)	7·1 (8)
H(4M2A)	851 (25)	7361 (24)	3129 (8)	4·3 (5)
H(4M2B)	−196 (28)	6533 (27)	3539 (9)	5·2 (6)
H(4M2C)	−560 (28)	6516 (29)	2899 (9)	5·9 (7)
H(5)	2650 (24)	6460 (23)	2676 (8)	3·6 (5)
H(6A)	962 (22)	5079 (22)	1960 (7)	3·3 (4)
H(6B)	580 (23)	6316 (24)	2137 (8)	4·2 (5)
H(7A)	1714 (23)	6663 (23)	1349 (8)	3·8 (5)
H(7B)	2623 (30)	7352 (29)	1825 (10)	6·0 (7)
H(8MA)	2951 (25)	4960 (25)	798 (9)	4·3 (5)
H(8MB)	2229 (33)	4207 (30)	1306 (11)	6·8 (8)
H(8MC)	3749 (33)	4028 (32)	1130 (10)	6·5 (7)
H(9)	4595 (19)	6130 (19)	2196 (7)	2·2 (4)
H(10MA)	2190 (25)	3346 (24)	2098 (9)	4·2 (5)
H(10MB)	2669 (25)	2867 (23)	2663 (9)	4·0 (5)
H(10MC)	3736 (30)	2936 (27)	2237 (10)	5·7 (6)
H(11A)	6061 (22)	4464 (20)	2263 (8)	3·3 (4)
H(11B)	5300 (27)	3777 (27)	1744 (9)	5·0 (6)
H(12A)	7598 (21)	4835 (20)	1671 (7)	2·5 (4)
H(12B)	6958 (26)	6020 (26)	1727 (9)	4·7 (6)
H(13)	6051 (21)	4263 (19)	912 (7)	2·4 (4)
H(15)	4834 (28)	7146 (26)	204 (9)	4·9 (6)
H(16A)	7245 (27)	6809 (24)	−197 (9)	4·7 (6)
H(16B)	6060 (26)	5983 (25)	−425 (9)	4·5 (5)
H(17)	6705 (21)	4222 (21)	33 (8)	3·5 (5)

Table 1 (cont.)

	x	y	z	B (Å^2)
H(18MA)	9121 (26)	6264 (25)	1125 (8)	4·1 (5)
H(18MB)	9565 (24)	6264 (26)	518 (9)	4·3 (5)
H(18MC)	8154 (30)	6937 (31)	678 (10)	6·7 (8)
H(19A)	8026 (26)	3199 (25)	774 (9)	4·4 (6)
H(19B)	9049 (27)	3911 (25)	1143 (8)	4·2 (5)
H(20A)	10534 (25)	4265 (24)	431 (9)	4·6 (5)
H(20B)	10404 (28)	2791 (28)	505 (10)	5·8 (7)
H(22)	9234 (23)	5404 (21)	−344 (8)	3·5 (5)
H(22MA)	8758 (32)	4277 (30)	−1119 (10)	6·3 (7)
H(22MB)	7162 (37)	4002 (34)	−944 (12)	7·7 (8)
H(22MC)	7731 (36)	5321 (35)	−1046 (12)	7·6 (9)
H(23A)	3831 (25)	7100 (23)	982 (8)	3·7 (5)
H(23B)	4902 (24)	7165 (22)	1426 (8)	3·5 (5)

absolute configuration of the structure (I) was derived by analogy with that obtained by the anomalous-dispersion technique for the bromoindole derivative of the related serratene structure: 3β-methoxyserrat-13-en-21-one (II) (Allen & Trotter, 1970). The published coordinates for the other previously reported serratene crystal structure, 21α-methoxyserrat-13-en-3β-ol (III) (Allen, Kennard & Sheldrick, 1977), correspond to the incorrect configuration, although the diagram presented in the paper has the correct stereochemistry.

(I)   (II)   (III)
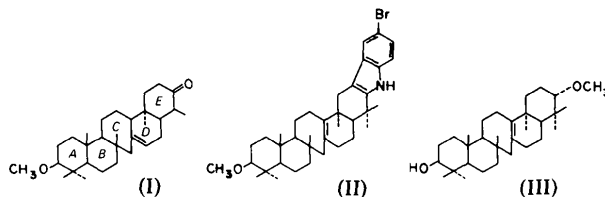
The main differences in bond lengths and angles (Fig. 1) between this structure and the two previous structures arise from the differing position of the double bond. The C—C single-bond distances vary from 1·521 (3) to 1·576 (2) Å with the bonds involving the more substituted C atoms having the greater lengths. Similarly, the differing location of the double bond causes substantial changes in the bond angles for the affected atoms.

The A, B and E rings are all in the chair conformation. The saturated seven-membered C ring assumes the twist-chair conformation while the unsaturated six-membered D ring is in the half-chair conformation with the ring buckling opposite to the double bond. The Cremer & Pople (1975) ring-puckering parameters for all five rings are given in Table 2. For comparison, these parameters are also tabulated for the previously reported serratene crystal structures where the double bond is internal to the seven-membered ring, thus constraining the ring to the chair conformation (Hendrickson, 1961) (see also Fig. 2). The amplitude of ring puckering is measured by the Q, q_2, and q_3 parameters: all three structures are comparable except with respect to q_2 which is signifi-

cantly greater in the current structure due to the twist-chair conformation of ring C. The θ parameter is a measure of the degree of chair (0 or 180°) vs boat (90°) character of a six-membered ring. The pseudo-rotation phase angle, φ, is seen to shift approximately 60° commensurate with the 60° movement of the double bond in ring D.
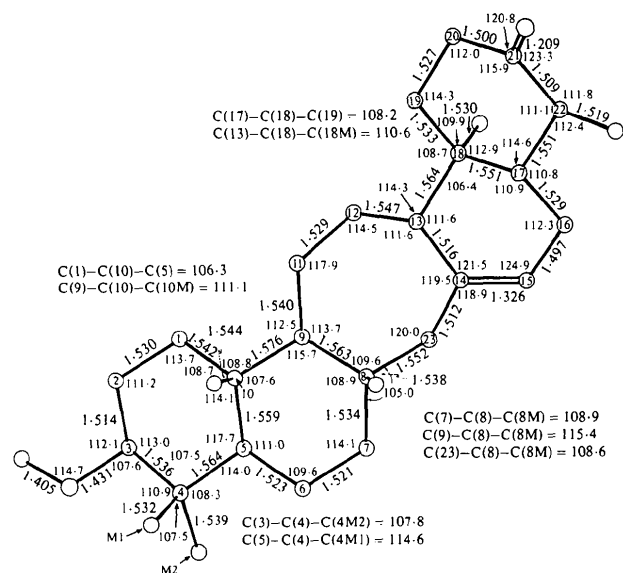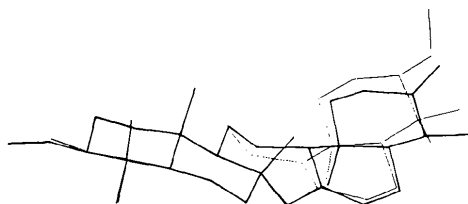

Fig. 2. An overlay of the title compound (darker lines) and the previously reported non-indole serratene crystal structure (21α-methoxyserrat-13-en-3β-ol) with the atoms of rings A and B superimposed. The r.m.s. differences for the atoms of rings A and B are 0·025 Å while those for rings C, D and E are 0·40 Å.

The methyl substituents are splayed by 1,3 methyl–methyl interactions; the $C(4)-C(4M1)$ and $C(10)-C(10M)$ vectors are separated by 21·7° and the $C(10)-C(10M)$ and $C(8)-C(8M)$ vectors by 22·7°. The current structure has the axial methyl group at $C(22)$ replaced by $H(22)$ resulting in a smaller angle of 11·7° between the. $C(18)-C(18M)$ and $C(22)-H(22)$ vectors.

Fig. 1. A diagram of the title compound indicating atom numbering, bond lengths (Å) and bond angles (°) for all non-H atoms. The O(1) atom is bonded to C(3) and O(2) is bonded to C(21). The standard deviations for bond lengths are 0·003 Å while the standard deviations for bond angles are 0·02°.

Table 2. *Cremer–Pople ring-puckering parameters for the known serratene crystal structures*

		(I)	(II)	(III)
Ring A:	Q (Å)	0·558 (4)	0·567	0·546
	θ (°)	3·1 (3)	5·0	5·4
	φ (°)	57 (5)	69	46
Ring B:	Q (Å)	0·577 (3)	0·606	0·573
	θ (°)	7·7 (2)	15·3	8·9
	φ (°)	22 (2)	7·5	5
Ring C:	q_2 (Å)	0·467 (2)	0·350	0·356
	φ_2 (°)	267·2 (3)	260·9	260·4
	q_3 (Å)	0·665 (2)	0·689	0·666
	φ_3 (°)	36·4 (2)	28·7	26·4
Ring D:	Q (Å)	0·536 (3)	0·487	0·523
	θ (°)	130·0 (3)	125·0	129·4
	φ (°)	102·3 (4)	33·6	49·8
Ring E:	Q (Å)	0·519 (4)	0·511	0·547
	θ (°)	5·8 (3)	54·2	5·9
	φ (°)	69 (3)	50·8	151

(I) This work. (II) Bromoindole derivative of 3β-methoxyserrat-13-en-21-one (Allen & Trotter, 1970). (III) 21α-Methoxyserrat-13-en-3β-ol (Allen, Kennard & Sheldrick, 1977).

References

ALLEN, F. H., KENNARD, O. & SHELDRICK, G. M. (1977). *Acta Cryst.* B33, 1230–1235.

ALLEN, F. H. & TROTTER, J. (1970). *J. Chem. Soc. B*, pp. 721–727.

CONNER, A. H., HAROMY, T. P. & SUNDARALINGAM, M. (1981). *J. Org. Chem.* 46, 2987–2988.

CREMER, C. & POPLE, J. A. (1975). *J. Am. Chem. Soc.* 97, 1354–1358.

CROMER, D. T. & WABER, J. T. (1965). *Acta Cryst.* B24, 91–96.

HENDRICKSON, J. B. (1961). *J. Am. Chem. Soc.* 83, 4537–4546.

JOHNSON, C. K. (1976). *ORTEP* II. Report ORNL-5138. Oak Ridge National Laboratory, Tennessee.

KARLE, J. (1968). *Acta Cryst.* B24, 182–186.

MAIN, P. (1975). International Summer School on Crystallographic Computing, Prague, paper No. 48.

MAIN, P., GERMAIN, G. & WOOLFSON, M. M. (1970). *MULTAN. A System of Computer Programs for the Automatic Solution of Noncentrosymmetric Crystal Structures.* Univs. of York, England, and Louvain, Belgium.

STEWART, R. F., DAVIDSON, E. R. & SIMPSON, W. T. (1965). *J. Chem. Phys.* 42, 3175–3187.