Structure of an Indole Analogue: 3,5-Dichloro-3-methyl-2(3*H*)-indolone
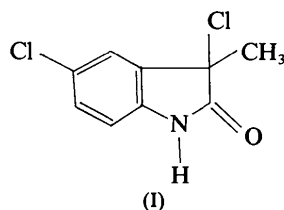
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Abstract. $C_9H_7Cl_2NO$, $M_r = 216.07$, monoclinic, $P2_1/n$, $a = 13.150$ (7), $b = 8.678$ (2), $c = 25.433$ (7) Å, $\beta = 92.65$ (3)°, $V = 2899$ (2) Å^3, $Z = 12$, $D_m = 1.482$, $D_x = 1.485$ Mg m^{-3}, λ(Mo $K\alpha$) = 0.7107 Å, $\mu = 0.63$ mm^{-1}, $F(000) = 1320$, $T = 298$ K, $R = 0.071$ for 2012 observed reflections. There are three crystallographically independent molecules in the asymmetric unit and the crystal structure shows disorder with respect to the Cl atoms and the methyl C atoms. The individual five- and six-membered rings are essentially planar for all three independent molecules and are inclined to one another at 3.4 (4), 0.8 (4) and 4.3 (3)°. The bond linking the C(=O) atom to the tetrahedral C atom is a single bond.

Introduction. Indole and its various analogues have long been known for their interesting chemical and biological activities. Electrophilic substitution of 3-methyl-1*H*-indole (skatole) with sulfuryl chloride in the presence of acetic acid produces the present compound (I). The study of this compound by ^{1}H NMR spectroscopy cannot conclusively prove the existence of the —NH group because its signals are absent due to the high rate of the proton-exchange reaction in deuterated solvents. The present X-ray investigation has been undertaken in order to establish the presence of such a group in the compound and to provide X-ray data on halogen-substituted oxoindole compounds rarely present in the literature. Moreover, X-ray analysis will help to explain the chemical and biological behaviour of the compound (Sundberg, 1970), which depends on the substituent groups and on the stereochemical arrangement.

(I)

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Experimental. Needle-shaped crystals from a solution of acetone by slow evaporation at room temperature, density by flotation (tribromoethane–bromoform); crystal size $0.30 \times 0.25 \times 0.175$ mm; cell parameters determined by least squares from the setting angles of 15 reflections ($20 < 2\theta < 25°$); intensity data measured on a Syntex $P2_1$ diffractometer using graphite-monochromatized Mo $K\alpha$ radiation; 3171 unique reflections collected ($h = -14$–14, $k = 0$–9, $l = 0$–27; $2 \leq 2\theta \leq 45°$); 2012 observed reflections with $I > 2\sigma(I)$. Data corrected for Lp factors but no absorption corrections were applied. Structure solved by *SHELXS*86 (Sheldrick, 1985).

Disorder. The positions of the non-H atoms were refined isotropically using full-matrix least squares (*SHELX*76; Sheldrick, 1976) to an R value of 0.18. Subsequent least-squares refinement proved disappointing and the R value could not be reduced below 0.18. Moreover, the refinement distorted the two bonds C(8)—Cl(2) and C(8)—C(9) for all three independent molecules to improbable values and the thermal parameters of atoms Cl(2) and C(9) became abnormal. This is attributed to the presence of disorder in the Cl and CH$_3$ groups. It was assumed that two alternative positions of atoms C(9) and Cl(2) exist for all three independent molecules and refinement became futile owing to the interaction of these overlapping atoms in spite of correct gross structure. Hanson (1964) has also observed the presence of disorder in the 1:1 complex of indole with 1,3,5-trinitrobenzene. No decisive information about the disorder could be inferred from the Fourier and difference syntheses. Initially, in the trial model the probable orientations and positions of the disordered atoms were obtained from geometrical considerations and the parameters of the methyl C and Cl atoms were refined alternately with equal occupancies.

After a few cycles of full-matrix least-squares refinement, first using isotropic and then anisotropic thermal parameters, the R value came down to 0.084. At this stage, the positions of all the H atoms except those belonging to the methyl groups were obtained from a difference Fourier synthesis. These atoms were assigned the equivalent isotropic thermal

parameters of the heavier atoms to which they were attached and refined isotropically. The refinement was terminated at $R = 0.071$ and $wR = 0.071$, $S = 1.39$. The function minimized was $\Sigma w(|F_o| - |F_c|)^2$ with $w = 1/\sigma^2|F_o|$. In the final cycle, maximum shift $/\sigma$ is 0.51, average shift$/\sigma < 0.06$; peak heights in final ΔF map from -0.23 to $+0.37$ e Å^{-3}. The geometrical parameters of the molecule were computed with the program *PARST* (Nardelli, 1983).

Discussion. There are three crystallographically independent molecules in this structure. The arrangement of these molecules in the asymmetric unit (designated *A*, *B* and *C*) and the atom-labelling scheme are shown in Fig. 1. The final atomic parameters are listed in Table 1.* The bond lengths and bond angles are listed in Table 2.

In all three independent molecules the C(7)—C(8) bond distances have typical single-bond values. The C(7)=O(1) bond distances are lengthened while the C(7)—N(1) bond distances are shortened. The geometry around the N(1) atom for all three independent molecules is almost planar indicating that the N atom shows considerable sp^2 character, and the lone pair on the N atom and the π electrons of the carbonyl bond are delocalized over the three atoms [N(1)—C(7)=O(1)]. Similar effects have also been observed by James & Williams (1972).

The three independent molecules (*A*, *B* and *C*) have rather different surroundings in the crystal structure which influence the molecular conformations to a certain extent. Individual six-membered rings are planar for all the three independent molecules *A*, *B* and *C*. The five-membered ring of *B* is planar while the five-membered rings of *A* and *C* are slightly puckered. The N(1), C(4), C(5) and N(1),

* Lists of structure factors, anisotropic thermal parameters, least-squares planes and H-atom parameters have been deposited with the British Library Document Suppy Centre as Supplementary Publication No. SUP 52916 (19 pp.). Copies may be obtained through The Technical Editor, International Union of Crystallography, 5 Abbey Square, Chester CH1 2HU, England.
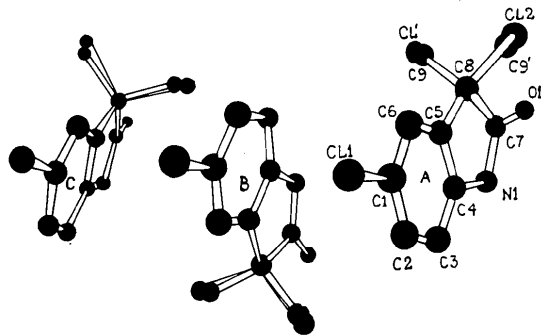
Table 1. *Fractional atomic coordinates and their equivalent isotropic temperature factors for the three independent molecules* (*A*, *B* and *C*) *with e.s.d.'s in parentheses*

$$B_{eq} = (4/3)\Sigma_i\Sigma_j\beta_{ij}\mathbf{a}_i.\mathbf{a}_j.$$

	x	y	z	B_{eq} (Å²)
A				
Cl(1)	0.1782 (2)	0.0266 (4)	0.5754 (1)	6.61
Cl(2)	−0.1588 (7)	0.4298 (10)	0.5039 (4)	10.78
Cl'	−0.1895 (4)	0.4199 (7)	0.6176 (2)	5.39
O(1)	−0.3637 (5)	0.2867 (8)	0.5392 (3)	5.80
N(1)	−0.2635 (6)	0.0767 (11)	0.5557 (4)	4.78
C(1)	0.0460 (7)	0.0370 (14)	0.5724 (4)	4.41
C(2)	−0.0074 (10)	−0.0978 (16)	0.5726 (5)	5.60
C(3)	−0.1135 (9)	−0.0990 (14)	0.5679 (5)	5.28
C(4)	−0.1592 (7)	0.0429 (13)	0.5632 (4)	4.42
C(5)	−0.1051 (8)	0.1784 (12)	0.5644 (4)	3.42
C(6)	−0.0007 (9)	0.1787 (13)	0.5683 (4)	4.11
C(7)	−0.2807 (8)	0.2280 (12)	0.5497 (5)	4.28
C(8)	−0.1787 (7)	0.3111 (11)	0.5582 (4)	3.78
C(9)	−0.1785 (12)	0.4098 (16)	0.6075 (6)	3.58
C(5')	−0.1594 (11)	0.4097 (17)	0.5113 (7)	3.79
B				
Cl(1)	0.2895 (2)	0.0505 (4)	0.7109 (1)	5.74
Cl(2)	−0.0927 (5)	−0.3207 (7)	0.7031 (3)	6.79
Cl'	−0.0615 (6)	−0.2356 (10)	0.8151 (3)	9.17
O(1)	−0.2606 (6)	−0.1205 (9)	0.7545 (3)	5.66
N(1)	−0.1496 (7)	0.0754 (11)	0.7357 (4)	4.84
C(1)	0.1586 (6)	0.0620 (13)	0.7188 (4)	4.17
C(2)	0.1142 (9)	0.2065 (13)	0.7122 (4)	4.69
C(3)	0.0094 (10)	0.2211 (13)	0.7178 (5)	4.89
C(4)	−0.0444 (8)	0.0917 (12)	0.7287 (4)	3.92
C(5)	0.0019 (7)	−0.0508 (11)	0.7364 (4)	3.44
C(6)	0.1044 (8)	−0.0676 (13)	0.7314 (4)	4.35
C(7)	−0.1758 (9)	−0.0706 (13)	0.7467 (4)	4.37
C(8)	−0.0762 (7)	−0.1691 (12)	0.7482 (4)	4.12
C(9)	−0.0574 (11)	−0.2399 (20)	0.8007 (8)	4.89
C(9')	−0.0837 (11)	−0.2973 (17)	0.7059 (7)	4.50
C				
Cl(1)	0.3601 (2)	0.0661 (4)	0.8560 (1)	6.74
Cl(2)	−0.0648 (5)	0.3501 (8)	0.8432 (2)	6.37
Cl'	0.0471 (5)	0.4746 (6)	0.9333 (3)	5.90
O(1)	−0.1463 (6)	0.2804 (9)	0.9555 (3)	6.27
N(1)	−0.0438 (7)	0.0724 (11)	0.9404 (4)	4.39
C(1)	0.2354 (8)	0.0574 (13)	0.8767 (4)	4.38
C(2)	0.2022 (9)	−0.0803 (15)	0.8969 (5)	5.00
C(3)	0.1085 (9)	−0.0867 (12)	0.9181 (5)	4.75
C(4)	0.0505 (7)	0.0455 (12)	0.9189 (4)	3.95
C(5)	0.0838 (8)	0.1820 (12)	0.8968 (4)	3.53
C(6)	0.1784 (9)	0.1887 (12)	0.8758 (4)	4.31
C(7)	−0.0718 (8)	0.2208 (12)	0.9365 (5)	4.40
C(8)	0.0051 (8)	0.3057 (12)	0.9039 (4)	4.30
C(9)	0.0482 (12)	0.4432 (18)	0.9316 (7)	4.08
C(9')	−0.0445 (12)	0.3507 (19)	0.8518 (6)	3.78

Fig. 1. A perspective view of the molecule (down **b**), showing the numbering of atoms.
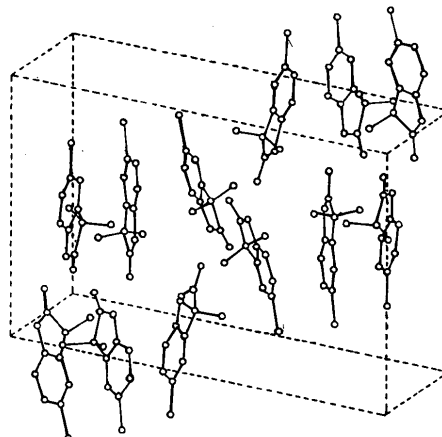

Fig. 2. Packing of the molecules viewed down the *b* axis.

Table 2. *Intramolecular bond distances (Å) and angles (°) for the three independent molecules (A, B and C) with e.s.d.'s in parentheses*

	A	B	C
Cl(1)—C(1)	1·739 (9)	1·745 (10)	1·747 (11)
Cl(2)—C(8)	1·752 (13)	1·752 (12)	1·801 (11)
Cl'—C(8)	1·792 (11)	1·798 (12)	1·724 (11)
O(1)—C(7)	1·223 (12)	1·221 (14)	1·226 (13)
N(1)—C(4)	1·407 (12)	1·410 (14)	1·398 (13)
N(1)—C(7)	1·339 (14)	1·345 (14)	1·341 (14)
C(1)—C(2)	1·364 (17)	1·390 (15)	1·379 (17)
C(1)—C(6)	1·376 (16)	1·377 (15)	1·363 (15)
C(2)—C(3)	1·395 (17)	1·398 (17)	1·369 (17)
C(3)—C(4)	1·372 (16)	1·362 (15)	1·378 (14)
C(4)—C(5)	1·373 (15)	1·388 (14)	1·390 (14)
C(5)—C(6)	1·372 (15)	1·367 (14)	1·377 (15)
C(5)—C(8)	1·507 (14)	1·492 (13)	1·507 (14)
C(7)—C(8)	1·529 (14)	1·563 (15)	1·526 (15)
C(8)—C(9)	1·518 (17)	1·480 (19)	1·484 (19)
C(8)—C(9')	1·499 (18)	1·547 (19)	1·501 (18)
C(4)—N(1)—C(7)	112·2 (8)	112·5 (9)	112·1 (9)
Cl(1)—C(1)—C(6)	119·4 (8)	120·2 (8)	118·8 (8)
Cl(1)—C(1)—C(2)	117·9 (8)	116·6 (8)	117·8 (8)
C(2)—C(1)—C(6)	122·5 (10)	123·0 (10)	123·1 (10)
C(1)—C(2)—C(3)	121·2 (12)	118·7 (10)	119·2 (11)
C(2)—C(3)—C(4)	115·6 (11)	118·0 (11)	118·7 (10)
N(1)—C(4)—C(3)	128·2 (9)	129·0 (10)	130·2 (9)
C(3)—C(4)—C(5)	122·7 (9)	122·2 (10)	121·1 (9)
N(1)—C(4)—C(5)	108·9 (8)	108·6 (9)	108·5 (8)
C(4)—C(5)—C(8)	108·7 (8)	109·8 (8)	109·0 (8)
C(4)—C(5)—C(6)	121·2 (9)	120·6 (9)	119·9 (9)
C(6)—C(5)—C(8)	129·9 (9)	129·4 (9)	130·8 (9)
C(1)—C(6)—C(5)	116·4 (10)	117·2 (10)	117·6 (9)
O(1)—C(7)—N(1)	125·2 (9)	127·7 (11)	126·6 (10)
N(1)—C(7)—C(8)	107·6 (8)	107·3 (9)	108·4 (8)
O(1)—C(7)—C(8)	127·0 (9)	124·9 (10)	124·8 (9)
C(5)—C(8)—C(7)	102·1 (7)	101·7 (8)	101·3 (8)
Cl'—C(8)—C(7)	105·3 (7)	104·5 (7)	112·4 (7)
Cl'—C(8)—C(5)	112·9 (7)	111·4 (7)	116·6 (7)
Cl(2)—C(8)—C(7)	109·1 (7)	108·4 (7)	104·1 (7)
Cl(2)—C(8)—C(5)	114·3 (7)	116·7 (7)	112·0 (7)
Cl(2)—C(8)—Cl'	112·0 (6)	112·5 (6)	109·3 (6)
C(7)—C(8)—C(9)	110·5 (9)	110·7 (9)	112·2 (9)
C(7)—C(8)—C(9')	109·6 (9)	110·3 (9)	109·4 (9)
C(5)—C(8)—C(9)	112·8 (9)	112·2 (9)	110·6 (9)
C(5)—C(8)—C(9')	111·6 (9)	112·2 (9)	112·3 (9)
Cl'—C(8)—C(9')	113·2 (8)	115·3 (8)	106·2 (8)
Cl(2)—C(8)—C(9)	109·0 (8)	106·8 (9)	113·8 (9)
C(9)—C(8)—C(9')	110·0 (9)	109·4 (9)	110·5 (10)

C(7), C(8) least-squares planes make a dihedral angle of 4·6 (9)° in A and 6·0 (9)° in C respectively. The angles between plane normals of the six- and five-membered rings are 3·4 (4) for A, 0·8 (4) for B and 4·3 (3)° for C.

The corresponding bond lengths and angles for the three independent molecules are similar. The molecular parameters for the six- and five-membered rings agree well with those of other structures (Codding, Lee & Richardson, 1984; Vega, Jimenez-Garay, Lopez-Castro & Marquez, 1980).

The packing of the molecule in the unit cell is shown in Fig. 2. The molecules are held together by normal van der Waals forces.

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Structure of Ranitidine Hydrochloride

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Abstract. N-(2-{[5-(Dimethylaminomethyl)-2-furanyl]methylthio}ethyl)-N'-methyl-2-nitro-1,1-ethenediamine hydrochloride, $C_{13}H_{23}N_4O_3S^+.Cl^-$, $M_r = 350·86$, monoclinic, $P2_1/n$, $a = 18·798$ (3), $b = 12·980$ (3), $c = 7·204$ (1) Å, $\beta = 95·09$ (1)°, $V = 1750·9$ (5) Å^3, $Z = 4$, $D_m = 1·330$ (2), $D_x = 1·331$ g cm^{-3}, λ(Cu $K\alpha$) = 1·5418 Å, $\mu = 32·00$ cm^{-1}, $F(000) = 744$, $T = 293$ K, final $R = 0·047$ for 2599 observed independent reflections. The N atom of the dimethylamino group is protonated and is hydrogen bonded to the Cl$^-$ ion. The structure of the N-ethyl-N'-methyl-2-nitro-1,1-ethenediamine moiety takes conformations, where amine NH, ethene CH and nitro O atoms are disordered. The ranitidine molecule, as a whole, takes an open conformation, where the side chain is folded in a spiral-shaped fashion.

Introduction. H$_2$-receptor antagonists could become excellent drugs for the treatment of peptic ulcers and