

Crystal Structures of Synthetic Analgetics. VI. Normethadone Hydrochloride

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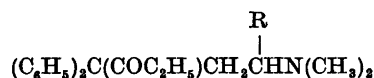
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The weak analgetic normethadone crystallizes as a hydrochloride in the triclinic space group $P\bar{1}$, with unit cell dimensions $a=9.142(2)$ Å; $b=9.438(2)$ Å; $c=13.318(3)$ Å; $\alpha=69.31(2)^\circ$; $\beta=87.82(2)^\circ$; $\gamma=62.27(2)^\circ$ and two independent molecules in the asymmetric unit. The structure was determined by a combination of the heavy atom techniques and direct methods and was refined to $R=0.039$ for 2424 observed reflections. The mean e.s.d.'s in bond lengths and angles are 0.006 Å and 0.4° , respectively.

The two molecules A and B are practically identical. The propylamino chain is nearly fully extended, the pertinent dihedral angle C4—C5—C6—N being -165.3 and -167.1° for molecule A and B, respectively. Comparatively strong N—H...Cl hydrogen bonds of 2.93 and 2.97 Å link the organic cations to the chloride ions.

A relation between the interplanar angle and the bond angle at the bridging carbon atom is discussed for bridged diphenyl and triphenyl compounds.

Normethadone (*1a*) is a weak narcotic analgetic¹ closely related to methadone (*1b*)



1a, R=H; *1b*, R=CH₃.

The present X-ray analysis was undertaken as a part of a structure research program on analgetics in progress in this laboratory. Conformational investigations on biologically active compounds have to include studies with the molecules in different environments. So far, however, there has been no success in preparing single crystals of the free base of normethadone.

EXPERIMENTAL

Commercial normethadone hydrochloride was recrystallized from a solution of the compound in acetone/diethyl ether. A colourless single crystal with dimensions 0.2 mm × 0.4 mm × 0.4 mm was used for the experiments.

The crystals are triclinic and a uniform intensity distribution combined with acentric $N(Z)$ -values as calculated during the structure determination, indicated space group $P\bar{1}$, rather than $P\bar{1}$.

Unit cell dimensions were determined on a Syntex P1 diffractometer with graphite crystal monochromated MoK α radiation ($\lambda=0.71069$ Å).

Three-dimensional intensity data were collected utilizing the $2\theta-\theta$ autocollection program with variable scan rate ($4-8^\circ \text{ min}^{-1}$) and a cut off for low intensities. The scan range was from 0.6° below $2\theta(\alpha_1)$ to 0.7° above $2\theta(\alpha_2)$ and the background was counted for 0.35 times the scan time at each end of the scan range. The intensities of three periodically measured reflections did not show any systematic variation. E.s.d.'s in the intensities were taken as the square root of the total counts with a 2 % addition for instrumental instability.

A total of 2872 independent reflections with $\sin \theta/\lambda \leq 0.60$ were recorded; 2424 had a net count larger than $3\sigma_I$.

Corrections for Lorentz and polarization effects were carried out by ordinary methods.

All calculations were performed in a CYBER-74 computer using the programs in Ref. 2, except for the phase determination by direct methods.³ Atomic form factors were those of Hanson *et al.*⁴ for Cl, O, N, and C and of Stewart *et al.*⁵ for H.

CRYSTAL DATA

Normethadone hydrochloride, C₂₀H₂₅NO·HCl, triclinic.

Table 1. Positional and thermal parameters with their e.s.d.'s for molecule A. The anisotropic temperature factors are given by $\exp[-2\pi^2(U11h^2a^{*2} + U22k^2b^{*2} + U33l^2c^{*2} + U12hka^*b^* + U13hla^*c^* + U23klb^*c^*)]$.

ATOM	X	Y	Z	U11	U22	U33	U12	U13	U23
CL	0.0000(8)	1.2000(8)	0.0000(8)	.1290(14)	.0653(9)	.0502(8)	-.0564(9)	-.0266(4)	.0128(4)
N	.4595(4)	.2566(4)	.3269(3)	.0594(21)	.0676(23)	.0754(24)	-.0419(24)	.0192(14)	-.0171(18)
O	.1374(5)	.7527(4)	.2240(3)	.0559(24)	.0365(20)	.0460(21)	-.0219(18)	.0021(17)	-.0092(17)
C1	.6727(7)	-.0824(8)	.3443(5)	.0710(40)	.0771(39)	.0862(42)	.0275(33)	.0140(33)	-.0342(33)
C2	.4339(6)	-.0007(6)	.4015(4)	.0526(31)	.0482(29)	.0757(34)	.0208(25)	.0129(26)	.0247(26)
C3	.3700(6)	.1898(6)	.3732(4)	.0507(28)	.0536(28)	.0381(24)	.0302(25)	-.0012(21)	.0107(21)
C4	.2030(5)	.2981(5)	.4098(3)	.0500(27)	.0406(25)	.0339(22)	.0252(22)	.0043(19)	-.0003(19)
C5	.1766(6)	.4826(6)	.3796(3)	.0586(29)	.0410(26)	.0347(23)	.0205(23)	.0043(21)	-.0106(19)
C6	.1213(6)	.5936(6)	.2574(3)	.0669(31)	.0441(28)	.0412(25)	.0324(24)	-.0014(22)	.0056(20)
C7	.3144(7)	.7144(8)	.2275(4)	.0851(40)	.1046(46)	.0614(33)	.0600(36)	-.0077(28)	.0078(31)
C8	.0522(9)	.8588(7)	.2891(5)	.1554(54)	.0534(34)	.0630(41)	-.0340(35)	.0141(30)	-.0210(31)
C9	.2238(5)	.2078(5)	.5344(4)	.0398(25)	.0369(24)	.0427(25)	.0188(21)	.0036(19)	.0055(20)
C10	.2690(5)	.2534(6)	.6857(3)	.0465(27)	.0480(27)	.0401(26)	-.0221(21)	.0026(21)	-.0100(22)
C11	.2933(6)	.1767(6)	.7174(4)	.0541(29)	.0580(30)	.0377(26)	.0241(25)	.0039(21)	-.0122(24)
C12	.2684(6)	-.0319(7)	.7606(4)	.0513(32)	.0716(36)	.0391(27)	.0200(28)	.0027(22)	-.0012(25)
C13	.2243(6)	-.0241(6)	.6984(4)	.0627(32)	.0515(29)	.0500(30)	.0311(26)	.0033(24)	-.0001(24)
C14	.2015(6)	.0626(6)	.5783(4)	.0553(29)	.0444(26)	.0463(27)	.0272(24)	.0013(22)	.0050(21)
C15	.0525(6)	.3111(5)	.3525(3)	.0488(28)	.0294(23)	.0374(23)	.0273(21)	.0035(17)	.0061(18)
C16	.0665(6)	.2853(6)	.2566(4)	.0526(28)	.0477(27)	.0512(27)	.0259(22)	.0001(22)	.0200(22)
C17	-.0001(7)	.3121(6)	.2020(4)	.0658(34)	.0479(30)	.0500(31)	.0431(27)	-.0064(24)	.0145(24)
C18	-.2350(7)	.3645(7)	.2444(5)	.0537(37)	.0591(33)	.0747(38)	.0274(28)	-.0157(24)	.0050(27)
C19	-.2406(6)	.3932(6)	.3395(5)	.0444(33)	.0602(33)	.0608(35)	.0100(26)	.0021(25)	.0004(27)
C20	-.0007(6)	.3667(6)	.3918(4)	.0500(32)	.0558(29)	.0431(26)	.0206(25)	.0062(24)	-.0003(22)

ATOM	X	Y	Z	B	ATOM	X	Y	Z	B
H1C1	.616	-.215	.366	8.0	H2C1	.679	-.067	.360	8.0
H3C1	.535	-.321	.258	8.0	H1C2	.477	-.064	.487	6.5
H2C2	.333	-.018	.385	6.5	H1C5	.290	.474	.402	3.2
H2C5	.085	.545	.420	3.2	H1C6	-.004	.629	.237	4.2
H2C6	.195	.518	.214	4.2	H1H	.048	.874	.224	4.0
H1C7	.319	.830	.203	6.0	H2C7	.370	.651	.175	6.0
H3C7	.377	.635	.307	6.0	H1C8	-.073	.889	.282	6.0
H2C8	.056	.970	.250	6.0	H3C8	.110	.797	.365	6.0
H1C10	.206	.372	.674	4.0	H1C11	.323	.222	.769	4.5
H1C12	.282	-.031	.845	5.2	H1C13	.207	-.133	.721	4.5
H1C14	.167	.017	.526	4.0	H1C16	.169	.245	.224	4.0
H1C17	-.084	.292	.128	4.5	H1C18	-.343	.300	.275	5.2
H1C19	-.352	.435	.371	4.5	H2C0	-.103	.389	.463	4.0

Table 2. Positional and thermal parameters with their e.s.d.'s for molecule B. The anisotropic temperature factors are given by $\exp[-2\pi^2(U11h^2a^{*2} + U22k^2b^{*2} + U33l^2c^{*2} + U12hka^*b^* + U13hla^*c^* + U23klb^*c^*)]$.

ATOM	X	Y	Z	U11	U22	U33	U12	U13	U23
CL	.4330(2)	.5027(2)	.5228(1)	.0723(9)	.0727(9)	.0504(8)	-.0337(8)	-.0159(7)	-.0006(7)
N	.6507(5)	.6173(5)	.9368(3)	.0659(25)	.0942(29)	.0780(27)	-.0508(24)	.0270(21)	-.0444(23)
O	.0761(6)	.4070(5)	.7246(3)	.0484(23)	.0492(23)	.0426(21)	.0266(20)	.0010(17)	-.0152(18)
C1	.6374(12)	.8444(12)	1.0299(8)	1.1308(73)	1.165(74)	1.1430(79)	.0307(59)	.0786(66)	-.0973(66)
C2	.7725(8)	.7742(9)	.9692(5)	1.119(51)	1.075(48)	1.075(48)	.0700(45)	.0541(40)	-.0807(44)
C3	.7608(6)	.6590(6)	.9191(4)	.0516(31)	.0530(31)	.0475(28)	.0262(27)	.0103(23)	-.0200(24)
C4	.8965(6)	.5078(6)	.8492(4)	.0471(28)	.0394(25)	.0394(25)	.0262(23)	.0039(21)	-.0160(21)
C5	.8720(6)	.4525(6)	.8212(3)	.0463(27)	.0463(25)	.0419(25)	.0186(22)	.0010(20)	-.0165(20)
C6	.7221(6)	.5341(6)	.7338(4)	.0570(31)	.0452(27)	.0478(27)	.0279(24)	.0061(23)	-.0113(22)
C7	.5954(8)	.3441(7)	.6153(5)	.0774(43)	1.157(38)	.0560(36)	.0683(35)	.0100(31)	-.0164(30)
C8	.8214(8)	.2571(9)	.7093(5)	.0913(42)	.0620(34)	.0631(36)	.0359(31)	.0046(31)	-.0349(35)
C9	1.0604(6)	.5001(6)	.9175(4)	.0451(28)	.0539(27)	.0359(26)	.0237(24)	.0065(23)	-.0173(22)
C10	1.1551(6)	.3225(7)	.9762(4)	.0537(32)	.0639(31)	.0458(33)	.0260(28)	.0062(23)	-.0213(22)
C11	1.3098(7)	.2483(7)	1.0378(5)	.0606(36)	.0772(31)	.0467(30)	.0247(28)	.0002(23)	-.0211(29)
C12	1.3793(9)	.3474(7)	1.0434(4)	.0548(47)	1.183(37)	.0474(32)	.0351(37)	-.0024(32)	-.0244(27)
C13	1.2956(7)	.5221(8)	.9856(4)	.0653(41)	1.016(38)	.0504(31)	.0050(35)	.0138(28)	-.0305(29)
C14	1.1408(6)	.5990(6)	.9229(4)	.0601(33)	.0666(31)	.0463(27)	.0230(27)	.0048(24)	-.0201(24)
C15	.8786(6)	.7306(6)	.7419(4)	.0448(28)	.0423(31)	.0453(25)	.0218(25)	.0048(21)	-.0193(23)
C16	.7350(6)	.6868(7)	.6969(4)	.0524(32)	.0485(36)	.0627(28)	.0219(28)	.0026(25)	-.0217(24)
C17	.7100(7)	1.0067(8)	.5938(4)	.0643(37)	.0407(40)	.0600(32)	.0264(32)	-.0104(27)	-.0112(29)
C18	.8473(7)	.9604(10)	.5355(5)	.0806(37)	.0630(57)	.0476(33)	.0472(40)	-.0133(28)	-.0015(30)
C19	.901(7)	.8105(8)	.5781(5)	.0703(38)	.0725(40)	.0491(35)	.0457(37)	.0120(34)	-.0223(36)
C20	1.0092(7)	.6956(7)	.6613(4)	.0579(34)	.0542(33)	.0386(28)	-.0305(29)	.0011(25)	-.0138(24)

ATOM	X	Y	Z	B	ATOM	X	Y	Z	B
H1C1	.616	-.215	.366	8.0	H2C1	.679	-.067	.360	8.0
H3C1	.535	-.321	.258	8.0	H1C2	.477	-.064	.487	6.5
H2C2	.333	-.018	.385	6.5	H1C5	.290	.474	.402	3.2
H2C5	.085	.545	.420	3.2	H1C6	-.004	.629	.237	4.2
H2C6	.195	.518	.214	4.2	H1H	.048	.874	.224	4.0
H1C7	.319	.830	.203	6.0	H2C7	.370	.651	.175	6.0
H3C7	.377	.635	.307	6.0	H1C8	-.073	.889	.282	6.0
H2C8	.056	.970	.250	6.0	H3C8	.110	.797	.365	6.0
H1C10	.206	.372	.674	4.0	H1C11	.323	.222	.769	4.5
H1C12	.282	-.031	.845	5.2	H1C13	.207	-.133	.721	4.5
H1C14	.167	.017	.526	4.0	H1C16	.169	.245	.224	4.0
H1C17	-.084	.292	.128	4.5	H1C18	-.343	.300	.275	5.2
H1C19	-.352	.435	.371	4.5	H2C0	-.103	.389	.463	4.0

$a = 9.142(2) \text{ \AA}$, $b = 9.438(2) \text{ \AA}$, $c = 13.318(3) \text{ \AA}$,
 $\alpha = 69.31(2)^\circ$, $\beta = 87.82(2)^\circ$, $\gamma = 62.27(2)^\circ$. $V = 940.4 \text{ \AA}^3$, $M = 331.9$, $Z = 2$.

$D_{\text{obs}} = 1.16 \text{ g cm}^{-3}$ (floatation), $D_{\text{calc}} = 1.17 \text{ g cm}^{-3}$.
 Space group $P1$.

STRUCTURE DETERMINATION AND REFINEMENT

The structure was determined by a combination of the heavy atom techniques and direct methods. The coordinates of the two chloride ions were established from a sharpened Patterson map. A false symmetry of the Fourier synthesis and as much as 46 non-hydrogen atoms in the asymmetric unit made the chloride ions unsuitable as a phasing model in Fourier synthesis. Application of MULTAN^s in the ordinary way did not lead to a structure solution. However, success was achieved with the chloride ions as the fragment in a tangent-formulae refinement utilizing the 490 highest E -values (≥ 1.30). Only 17 peaks (in-

clusive the chloride positions) could be associated with reasonable atomic sites, but three successive fragment refinement cycles including an increasing number of atoms eventually gave an E -map which revealed all the non-hydrogen atoms. Anisotropic full-matrix least-squares refinements gave an R -factor of 0.09. Approximate positional parameters of all the 52 hydrogen atoms were calculated from stereochemical considerations. They were ascribed the isotropic temperature factors of the atoms to which they are bonded and included in the structure factor calculations. Convergence was attained at $R = 0.039$ ($R_w = 0.043$).

The final parameters are listed in Tables 1 and 2. In these tables and the subsequent discussion the two non-equivalent molecules of the asymmetric unit are labelled A and B. A complete list of the observed and calculated structure factors may be obtained from the author upon request.

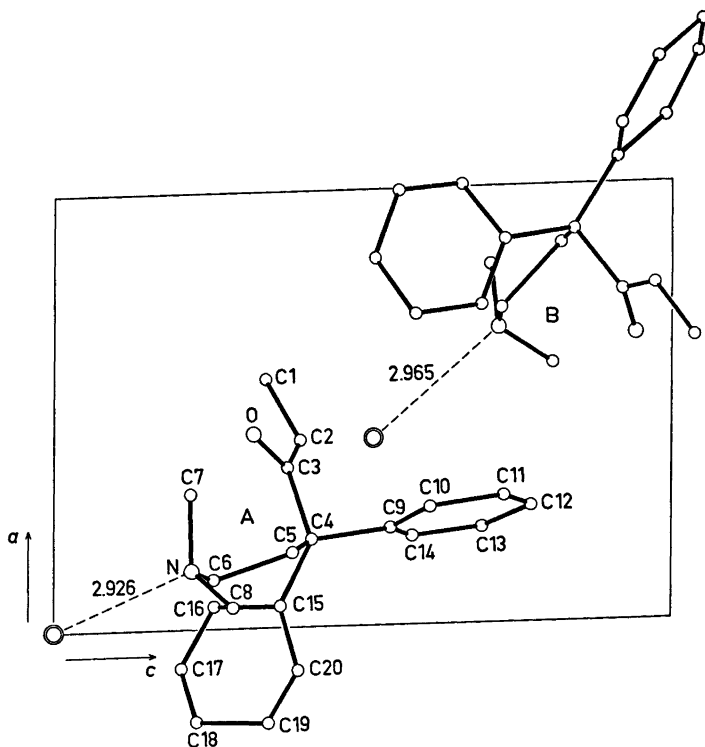


Fig. 1. The crystal structure of normethadone hydrochloride as seen when projected along the b -axis, on the ac -plane.

Table 3. Bond lengths (Å) with e.s.d.'s in parentheses for molecule A and B.

Molecule A		Molecule B	
DISTANCE	(Å)	DISTANCE	(Å)
C1 - C2	1,487 (7)	C1 - C2	1,468 (9)
C2 - C3	1,509 (6)	C2 - C3	1,584 (7)
C3 - C4	1,568 (6)	C3 - C4	1,561 (7)
C4 - C5	1,541 (6)	C4 - C5	1,559 (6)
C4 - C9	1,545 (6)	C4 - C9	1,532 (6)
C4 - C15	1,532 (6)	C4 - C15	1,529 (6)
C5 - C6	1,538 (6)	C5 - C6	1,527 (6)
N - C6	1,484 (5)	N - C6	1,485 (5)
N - C7	1,463 (8)	N - C7	1,479 (7)
N - C8	1,483 (7)	N - C8	1,497 (8)
C9 - C10	1,398 (6)	C9 - C10	1,391 (6)
C10 - C11	1,391 (6)	C10 - C11	1,397 (7)
C11 - C12	1,389 (7)	C11 - C12	1,376 (7)
C12 - C13	1,375 (7)	C12 - C13	1,368 (7)
C13 - C14	1,394 (6)	C13 - C14	1,389 (7)
C14 - C9	1,395 (6)	C14 - C9	1,408 (6)
C15 - C16	1,378 (6)	C15 - C16	1,375 (6)
C16 - C17	1,404 (6)	C16 - C17	1,394 (7)
C17 - C18	1,374 (7)	C17 - C18	1,365 (8)
C18 - C19	1,386 (7)	C18 - C19	1,403 (8)
C19 - C20	1,369 (7)	C19 - C20	1,385 (8)
C20 - C15	1,386 (6)	C20 - C15	1,391 (7)

DISCUSSION

Tables 3-5 give the bond lengths, bond angles and torsional angles with e.s.d.'s as calculated from the correlation matrix. The normethadone molecule with the numbering system of the atoms is shown in Fig. 1.

Inspection of Tables 3-5 reveals that the molecular structure of A and B are almost completely identical. Apart from the molecular distortions at the quaternary carbon atom C4, bond distances and interbond angles do not deviate significantly from their expected values and corresponding bond lengths and angles in the two molecules do not differ by more than 0.02 Å and 2°, respectively.

Four large groups are connected by C4; C-C single bonds involving this atom are increased by 0.03 Å as compared to their normal values.⁶ The corresponding C-C4-C bond angles are in the range 107-112°. This lengthening of interatomic distances and large variation of "tetrahedral" bond angles are in agreement with recent structure reports on diphenylpropylamine analgetics.⁷ As a result of the crowded situation around C4 this atom is displaced by 0.05 and 0.04 Å from one of the phenyl ring planes in molecule A and B, respectively.

An interesting feature of the acyclic diphenyl-analgetics investigated so far is the correlation between the interplanar angle of the two phenyl rings, τ , and the bond angle θ or C9-C4-C15 using the present numbering. Corresponding dihedral and bond angle values of

Table 4. Bond angles (°) with e.s.d.'s in parentheses for molecule A and B.

Molecule A		Molecule B	
ANGLE	(°)	ANGLE	(°)
C1 - C2 - C3	115,1 (4)	C1 - C2 - C3	116,0 (6)
C2 - C3 - C4	119,0 (4)	C2 - C3 - C4	118,3 (4)
C2 - C3 - C	120,1 (4)	C2 - C3 - C	120,5 (5)
C3 - C4 - C5	108,6 (3)	C3 - C4 - C5	108,2 (4)
C3 - C4 - C9	106,9 (3)	C3 - C4 - C9	107,9 (4)
C3 - C4 - C15	111,4 (3)	C3 - C4 - C15	111,8 (4)
C5 - C4 - C9	110,3 (3)	C5 - C4 - C9	109,9 (4)
C5 - C4 - C15	108,1 (3)	C5 - C4 - C15	107,4 (3)
C9 - C4 - C15	111,8 (3)	C9 - C4 - C15	111,6 (3)
C5 - C6 - N	113,6 (3)	C5 - C6 - N	113,6 (3)
C6 - N - C7	112,3 (4)	C6 - N - C7	114,2 (3)
C6 - N - C8	112,6 (4)	C6 - N - C8	112,3 (4)
C7 - N - C8	109,6 (4)	C7 - N - C8	110,1 (4)
C4 - C9 - C10	122,2 (4)	C4 - C9 - C10	121,7 (4)
C4 - C9 - C14	119,0 (4)	C4 - C9 - C14	119,9 (4)
C9 - C10 - C11	120,7 (4)	C9 - C10 - C11	120,0 (4)
C10 - C11 - C12	121,0 (4)	C10 - C11 - C12	121,2 (5)
C11 - C12 - C13	118,6 (4)	C11 - C12 - C13	119,3 (5)
C12 - C13 - C14	120,9 (4)	C12 - C13 - C14	120,6 (5)
C13 - C14 - C9	120,9 (4)	C13 - C14 - C9	120,4 (4)
C14 - C9 - C10	118,0 (4)	C14 - C9 - C10	118,4 (4)
C4 - C15 - C16	122,4 (4)	C4 - C15 - C16	123,0 (4)
C4 - C15 - C20	115,8 (4)	C4 - C15 - C20	118,3 (4)
C15 - C16 - C17	120,6 (4)	C15 - C16 - C17	122,0 (5)
C16 - C17 - C18	119,0 (5)	C16 - C17 - C18	119,2 (5)
C17 - C18 - C19	119,0 (5)	C17 - C18 - C19	120,0 (6)
C18 - C19 - C20	119,6 (5)	C18 - C19 - C20	118,3 (5)
C20 - C15 - C16	117,9 (4)	C20 - C15 - C16	117,7 (4)

these compounds together with the values of a triphenyl derivative (DTM)⁸ are given in Table 6. From this table it is obvious that the bond angle θ increases as the interplanar angle decreases.

The opening of θ is effecting a separation of the two rings to reduce non-bonded interactions between the *ortho* hydrogen atoms. Fig. 2 shows a plot of $\ln \tau$ against θ and the experimental points lie fairly well on a straight line. The best line as determined by the method

Table 5. Torsional angles ($^{\circ}$) with e.s.d.'s in parentheses for molecule A and B.

Molecule A				
DIDEDRAL ANGLE ()				
C1 = C2 = C3 = 0	-15,0(6)			
0 = C3 = C4 = C5	-1,9(5)			
0 = C3 = C4 = C9	-120,9(4)			
0 = C3 = C4 = C15	117,1(4)			
C5 = C4 = C9 = C10	-20,0(6)			
C5 = C4 = C9 = C14	161,7(4)			
C3 = C4 = C9 = C19	97,9(5)			
C3 = C4 = C9 = C14	-89,3(5)			
C3 = C4 = C5 = C6	74,3(4)			
C9 = C4 = C5 = C8	-168,9(4)			
C15 = C4 = C5 = C6	-46,7(5)			
C3 = C4 = C15 = C16	-28,9(5)			
C3 = C4 = C15 = C20	165,3(4)			
C9 = C4 = C15 = C16	-140,2(4)			
C5 = C4 = C15 = C16	98,4(4)			
C4 = C5 = C6 = N	-165,3(4)			
C5 = C6 = N = C7	71,2(5)			
C5 = C6 = N = C8	-53,1(5)			

Molecule B				
DIDEDRAL ANGLE ()				
C1 = C2 = C3 = 0	-6,3(9)			
0 = C3 = C4 = C5	-4,6(6)			
0 = C3 = C4 = C9	-123,4(5)			
0 = C3 = C4 = C15	113,5(5)			
C5 = C4 = C9 = C19	-21,6(6)			
C5 = C4 = C9 = C14	189,3(4)			
C3 = C4 = C9 = C19	96,2(5)			
C3 = C4 = C9 = C14	-82,9(5)			
C3 = C4 = C5 = C6	74,9(5)			
C9 = C4 = C5 = C6	-167,5(4)			
C15 = C4 = C5 = C6	-45,9(5)			
C3 = C4 = C15 = C16	-19,1(6)			
C3 = C4 = C15 = C20	167,0(4)			
C9 = C4 = C15 = C16	-140,0(4)			
C5 = C4 = C15 = C16	99,5(5)			
C4 = C5 = C6 = N	-167,1(4)			
C5 = C6 = N = C7	72,8(5)			
C5 = C6 = N = C8	-53,5(5)			

of least-squares is given by

$$\ln \tau = -0.078\theta + 12.9$$

(the r.m.s. error of the slope is 0.005). The small scattering of the experimental points in the

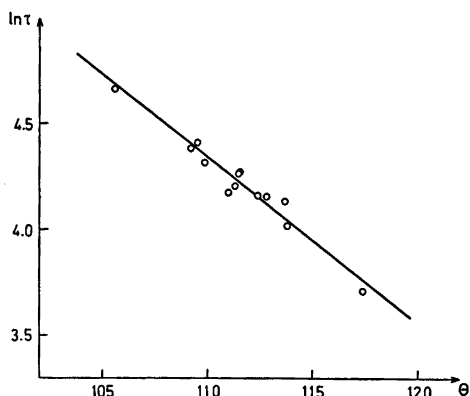

 Fig. 2. A plot $\ln \tau$ against θ for some diphenyl and triphenyl derivatives.

figure may partly be due to molecular distortions as caused by crystal packing. Additionally, the non-planarity of the central carbon atom (C4) with respect to the phenyl ring planes may also affect the values.

The propylamine chain has the *extended* form with the torsional angle C4–C5–C6–N of -165.3 and -167.1° , respectively. This conformation is similar to that reported for normethadone in solution¹⁴ and corresponds closely to that usually found for the salts of analgetics.^{7,11,13}

The crystal structure is shown in Fig. 2. Each normethadone molecule is connected to a chloride ion by a comparatively strong

 Table 6. Interplanar (τ) and bond angles (θ) of some compounds having two or three phenyl groups at a tetrahedral carbon atom.

No.	Compound	$\tau(^{\circ})$	$\theta(^{\circ})$	Ref.
1	DTM ^a	106.2	105.6	8
2	Methadone	80.7	109.5	9
3	Methadone	80.6	109.2	10
4	DTM ^a	75.3	109.9	8
5	Normethadone ^b	71.1	111.6	This work
6	Normethadone ^b	70.9	111.5	This work
7	Acetylmethadol ^b	67.2	111.3	11
8	Methadol ^b	65.0	111.0	11
9	DTM ^a	64.3	112.4	8
10	Methadone ^c	63.7	112.8	12
11	Isomethadone ^b	62.5	113.7	11
12	Dextromoramide ^d	55.2	113.8	13
13	Dextromoramide	40.6	117.4	7

^a Diphenylaminotriphenylmethane. ^b Crystal structure of the hydrochloride. ^c Crystal structure of the hydrobromide. ^d Crystal structure of the bitartrate.

N-H...Cl hydrogen bond. The present values 2.926 and 2.965 Å are far below the average value, 3.21 Å, quoted by Pimentel *et al.*¹⁵ In spite of the two normethadone molecules A and B being nearly identical, the chloride ions have different environments. There are no other particularly short intermolecular contacts.

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