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Crystal Structure Analysis of N,N′-bis(3-chloro-2-methylsalicylidene)-1,4-butanediamine

P. Sharmila[1], R. Rajesh[2], R. Venkatesan[2], Jagadeesan Ganapathy,[1†] and S. Aravindhan[1]

Abstract

The crystal structure of the saliciline derivatives N,N′-bis(3-chloro-2-methylsalicylidene)-1,4-butanediamine ($C_{20}H_{22}Cl_2N_2O_2$) has been determined from single crystal X-ray diffraction data. In the title compound crystallizes in the triclinic space group Pī with unit cell dimension a= 4.6085(3) Å, b=5.9747(3) Å and c= 5.9747(3) Å [α=83.889 (4)°, β= 86.744(5)° and γ= 82.085(5)°]. The title compound is essentially planar conformation. The compound lies across a crystallographic inversion centre and adopts E configurations with respect to the C-N bonds. The crystal packing of the molecules of compound is stabilized through weak O-H...N intra molecular interactions

Keywords: Chromene; Schiff Base Ligand; Single Crystal Structure; X-ray Diffraction

1. Introduction

Salicylidene is a Schiff base ligand. A Schiff base named after Hugo Schiff, is a compound with a functional group that contains a carbon-nitrogen double bond with the nitrogen atom connected to an aryl or alkyl group . Schiff bases in a broad sense have the general formula $R^1R^2C=NR^3$, where R is an organic side chain. The chain on the nitrogen makes the Schiff base a stable imine.

The electrophilic carbon atoms of aldehydes and ketones can be targets of nucleophilic attack by amines. The end result of this reaction is a compound in which the C=O double bond is replaced by a C=N double bond. This type of compound is known as an Imine or Schiff base. Schiff bases are some of the most widely used organic compounds. They are used as pigments and dyes, catalysts, intermediates in organic synthesis, and as polymer stabilizers.

Schiff bases have also been shown to exhibit a broad range of biological activities, including antifungal, antibacterial, antimalarial, antiproliferative, anti-inflammatory, antiviral, and antipyretic properties[1,2]. Imine or azomethine groups are present in various natural (Ancistrocladidine), natural-derived (Chitosan), and non-natural (N-Salicylidene-2-hydroxyaniline) compounds. The imine group present in such compounds has been shown to be critical to their biological activities like anti malarial, antifungal and anti bacterial[3,4].

Salicylidene acylhydrazides are promising compounds for the treatment of infections caused by Gram-negative pathogens. They are inhibitors of bacterial type III secretion (T3S) in Yersinia, Salmonella, Shigella and enterohemorrhagic Escherichia coli. Salicylideneamino-2-thiophenol (SAL-2) can be a potent anti-inflammatory agent for treatment of inflammatory-related diseases[5].

Chloro-salicylidene aniline with Co(II) and Cu(II) were screened for antibacterial activity against several bacterial strains, namely Escherichia coli, Staphylococcus aureus and Pseudomonas aeruginosa[6]. Salicylaldehyde Schiff bases of 1-amino-3-hydroxyguanidine tosylate are a good platform for the design of new antiviral agents[7].

In view of these biological and medicinal importance of the Salicylidene derivatives, X-ray crystallographic studies of the following one compound have been carried out to obtain detailed information on the molecular conformation in the solid state. The IUPAC name and chemical diagram of the compounds are given in Fig. 1.

IUPAC name of the compound: **N,N′-bis(3-chloro-2-methylsalicylidene)-1,4-butanediamine**

[1]Department of Physics, Presidency College, Chennai 600005, India
[2]Department of Chemistry, Pondicherry University, Pondicherry-605014, India

†Corresponding author : jaganbiophysics@gmail.com
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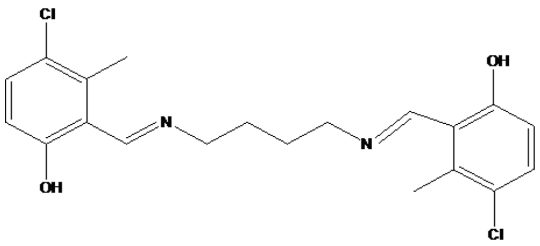

Fig. 1. shows schematic diagram.

2. Material and Methods

The title compound is crystallized by simple solvent slow evaporation method. Three round of crystallization trials, diffraction crystals.

The diffraction quality crystals after screening its size and stability, X-ray diffraction data collection was done at Department of chemistry- Pondicherry University. The data was reduced with appropriate corrections at the facility and the error free data was taken for structure determination.

Using WinGx suite, structure determination was done using SHELXS97 with Direct Methods protocols. After manual inspections and corrections, Isotropic refinements followed by anisotropic refinements were carried out. With the satisfied model (agreeable R factor, Goodness of Fit and other) hydrogen atoms were geometrically fixed and after the final refinement the R factor is 4.0%.

3. Experimental Section

3.1. Synthesis of the Title Compound

A solution of 1, 4 -butanediamine (0.5818 g, 0.0066 mol) in EtOH as solvent was refluxed with 3-chloro-6-hydroxy-2-methylbenzaldehyde (2.2304 g, 0.013 mol) for 12 hrs. The yellow precipitate was filtered off and recrystallized twice from EtOH. The purity of the product was checked by thinlayer chromatography [Yield: 1.95 g (87%)]. The compound has been recrystallized with ethyl acetate by slow evaporation method to get better quality single crystals.

3.2. X-Ray Crystallography

For the crystal structure determination, the single crystal of the compound $C_{18}H_{15}NO_4$ was used for data collection on a Oxford diffractometer[8]. The MoKα radiation of wavelength, (# = 0.71073 Å) and multi-scan technique for absorption correction were used for data collection. The lattice parameters were determined by the least-squares methods on the basis of all reflections with F2>2$ (F2). The structures were solved by direct methods using SHELXS-97 and refined by a full-matrix least-squares procedure using the program SHELXL-97[9,10]. H atoms were positioned geometrically and refined using a riding model, fixing the aromatic C-H distances at 0.93 Å [Uiso(H) = 1.2 Ueq (C)].

Table 1. Crystal data and structure refinement

Parameters	Compound
Empirical formula	$C_{20}H_{22}Cl_2N_2O_2$
Formula weight	393.3
Temperature	293(2) K
Wavelength	0.71073 Å
Crystal system	Triclinic
Space group	P$\bar{1}$
Unit cell dimensions	a = 4.6085(3) Å
	b = 5.9747(3) Å
	c = 17.0454(9) Å
	α = 83.889(4)°
	β = 86.744(5) °
	γ = 82.085(5)°
Volume	470.82 (5) Å^3
Z, Calculated density	2, 1.387 Mg/m^3
Absorption coefficient	0.724 mm^{-1}
F(000)	214
Crystal size(mm)	0.25×0.22×0.20
θ range	3.5 to 25.5°
Limiting indices	-5 ≤ h ≤ 5
	-7 ≤ k ≤ 5
	-18 ≤ l ≤ 20
Reflections collected /	3039/ 1757
unique	[R(int)= 0.017]
Completeness to theta	99.90%
Refinement method	Full-matrix
	least-squares on F^2
Data / restraints / parameters	1757 / 0 / 119
Goodness-of-fit on F^2	1.059
Final R indices [I>2σ(I)]	R1 = 0.0437
R indices (all data)	wR2 = 0.0989
	R1 = 0.0665
	wR2 = 0.1100
Largest diff. peak and hole	0.19 and -0.17 e.Å^{-3}

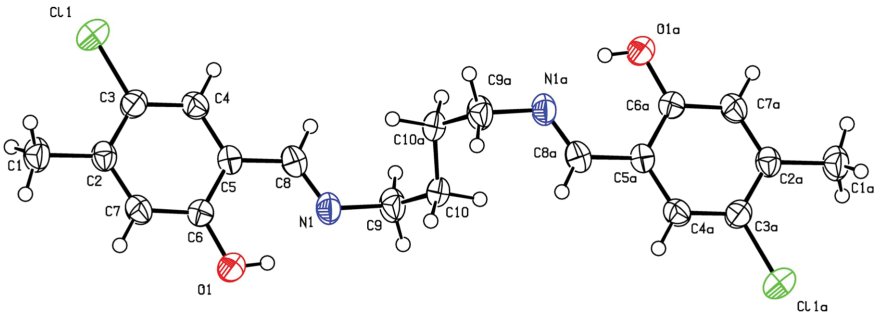

Fig. 2. Displacement ellipsoids are drawn at the 30% probability level.

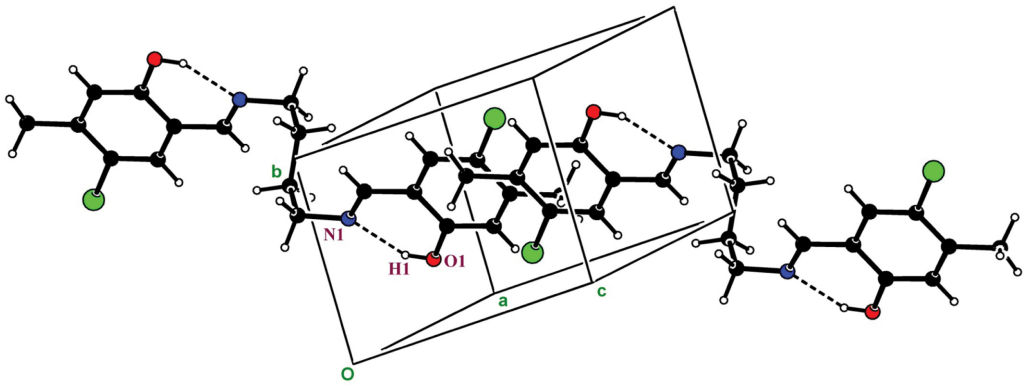

Fig. 3. Crystal packing of the title compound viewed down the *a*-axis, dashed line indicate the inter molecular interaction in the unit cell.

Table 2. Atomic coordinates ($\times 10^4$) and equivalent isotropic displacement parameters ($Å^2 \times 10^3$) for the non-hydrogen atoms of compound

Atom	x	y	z	*U(eq)
C1	-9380(5)	6590(4)	-4006(1)	49(1)
C2	-7214(4)	5528(4)	-3411(1)	36(1)
C3	-5696(5)	3385(4)	-3466(1)	38(1)
C4	-3695(5)	2428(4)	-2927(1)	39(1)
C5	-3118(4)	3585(4)	-2300(1)	33(1)
C6	-4649(4)	5751(4)	-2231(1)	36(1)
C7	-6648(5)	6662(4)	-2784(1)	41(1)
C8	-925(4)	2585(4)	-1750(1)	39(1)
C9	1825(5)	2365(4)	-632(1)	47(1)
C10	605(5)	1056(4)	91(1)	40(1)
N1	-440(4)	3509(3)	-1146(1)	41(1)
O1	-4193(4)	6969(3)	-1637(1)	57(1)
Cl1	-6246(2)	1861(1)	-4250(1)	65(1)

The softwares used for Molecular graphics are ORTEP-3 for Windows[11] and PLATON[12]. The software used to prepare material for publication is WinGX publication routines[13]. Experimental data are listed in Table 1. Fig. 1 shows schematic diagram of the molecule and molecular structure of the title compound along with the

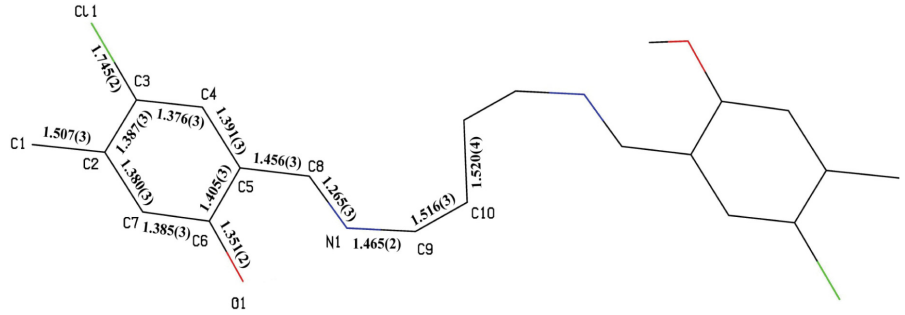

Fig. 4. Bond lengths [Å] of the compound.

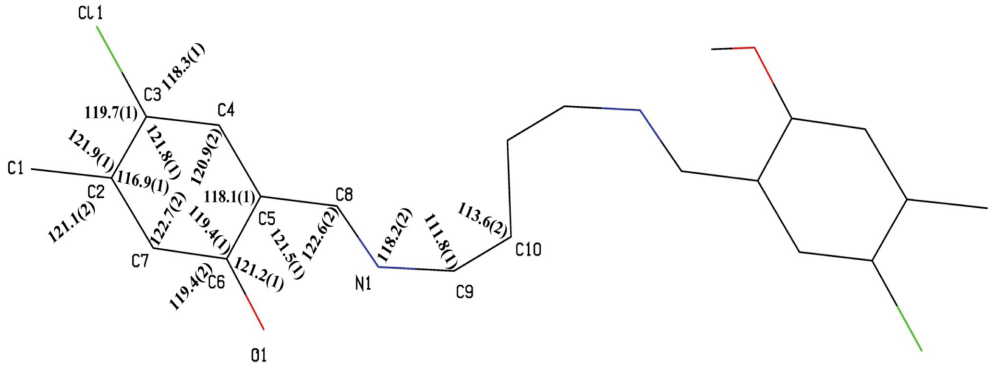

Fig. 5. Bond Angles [°] of the compound.

Table 3. Anisotropic displacement parameters (Å^2)

Atom	U11	U22	U33	U23	U13	U12
C1	44(2)	54(2)	48(1)	4(1)	-16(1)	-4(1)
C2	33(1)	39(1)	35(1)	4(1)	-3(1)	-8(1)
C3	42(1)	41(1)	34(1)	-3(1)	-4(1)	-11(1)
C4	42(1)	33(1)	39(1)	-4(1)	-3(1)	2(1)
C5	31(1)	36(1)	32(1)	2(1)	-2(1)	-4(1)
C6	39(1)	35(1)	33(1)	-3(1)	-3(1)	-4(1)
C7	40(1)	36(1)	44(1)	-2(1)	-6(1)	5(1)
C8	34(1)	40(1)	39(1)	4(1)	-1(1)	0(1)
C9	39(1)	50(2)	51(1)	7(1)	-17(1)	-8(1)
C10	43(1)	41(1)	36(1)	-1(1)	-15(1)	-2(1)
N1	40(1)	43(1)	40(1)	5(1)	-12(1)	-6(1)
O1	74(1)	46(1)	51(1)	-15(1)	-27(1)	11(1)
Cl1	89(1)	59(1)	50(1)	-17(1)	-23(1)	-7(1)

atom numbering scheme is depicted in Fig. 2 and a packing diagram is shown in Fig. 3. Table 1 shows the crystal data and crystal refinement statistics. Table 2 gives the atomic coordinates, Fig. 4 and Fig. 5 describes the bond lengths and angles respectively; Table 3 shows anisotropic displacement parameters, Table 4 shows the torsion angles, Table 5 shows Mean planes through various groups of atoms in the structure of Compound and

Table 4. Torsion angles [°]

Atoms	Angle
C(7)-C(2)-C(3)-C(4)	-0.5 (3)
C(1)-C(2)-C(3)-C(4)	179.2 (2)
C(7)-C(2)-C(3)-Cl(1)	-178.94 (16)
C(1)-C(2)-C(3)-C(l1)	0.8 (3)
C(2)-C(3)-C(4)-C(5)	0.0 (3)
Cl(1)-C(3)-C(4)-C(5)	178.51 (17)
C(3)-C(4)-C(5)-C(6)	0.4 (3)
C(3)-C(4)-C(5)-C(8)	-177.87 (19)
C(4)-C(5)-C(6)-O(1)	-179.9 (2)
C(8)-C(5)-C(6)-O(1)	-1.7 (3)
C(4)-C(5)-C(6)-C(7)	-0.4 (3)
C(8)-C(5)-C(6)-C(7)	177.8 (2)
C(3)-C(2)-C(7)-C(6)	0.5 (3)
C(1)-C(2)-C(7)-C(6)	-179.2 (2)
O1)-C(6)-C(7)-C(2)	179.5 (2)
C(5)-C(6)-C(7)-C(2)	0.0 (3)
C(4)-C(5)-C(8)-N(1)	-175.7 (2)
C(6)-C(5)-C(8)-N(1)	6.0 (3)
N(1)-C(9)-C(10)-C(10^{i})	70.9 (3)
C(5)-C(8)-N(1)-C(9)	-179.7 (1)
C(10)-C(9)-N(1)-C(8)	-99.9 (2)

Tables 6 shows Hydrogen-bond geometry.

4. Results and Discussion

Title compound crystallizes in the triclinic system with P$\bar{1}$ space group and total number molecule found in the unit cell is Z = 2. The title compound is essentially planar. The atoms O1, C1, C8 and Cl1 are deviated by 0.003(1) Å, 0.020(2) Å, 0.049(2) Å and 0.032(0) Å respectively from the least-squares plane of the chloro phenyl ring (C2-C7). The torsion angle C5-C8-N1-C9 is -179.7(1)º adopt anti-periplanar conformation. The compound lies across a crystallographic inversion centre and adopts E configurations with respect to the C-N bonds. The asymmetric unit of this compound is composed of one half-molecule. The imino group is coplanar with the benzene ring. Within the molecule, the planar units are parallel but extend in opposite directions from the methylene bridge. In the molecule, the O1-C6 (1.351(2) Å) bond has single-bond character, whereas the N1-C8 (1.265(3) Å) bond has a high degree of double-bond character as in related structure. The

Table 6. Atomic coordinates (x 10^4) and their isotropic displacement parameters (Å^2×10^3) for hydrogen atoms of compound

Atom	x	y	z	*Ueq
H1A	-10300	8016	-3847	73
H1B	-10799	5594	-4038	73
H1C	-8420	6837	-4514	73
H4	-2716	987	-2982	46
H7	-7649	8097	-2732	49
H8	163	1212	-1847	46
H9A	2912	3486	-466	56
H9B	3134	1328	-927	56
H10A	-908	2049	340	48
H10B	2109	611	465	48
H1	-2972	6238	-1352	85

Table 5. Mean planes through various groups of atoms in the structure of compound and deviations from the plane. The equation of the plane is of the form: m1x + m2y + m3z - D = 0. where m1, m2, m3 and D are constants

Plane	m1	m2	m3	D	Atom	Deviation(Å)
1	0.746(1)	0.356(1)	-0.561(1)	1.761(4)	C2*	0.003(2)
					C3*	-0.002(2)
					C4*	-0.001(2)
					C5*	0.003(2)
					C6*	-0.001(2)
					C7*	-0.001(2)
					O1	0.003(1)
					C1	0.020(2)
					C8	0.049(2)
					Cl1	0.032(0)

*Atoms are included in the plane calculations

packing of the molecules of compounds viewed down the *a*-axis is shown in Fig. 3. The O-H…N, N-H...O and O-H…O types of intra and inter molecular hydrogen bonds play vital role in crystal packing. The crystal packing of the molecules is stabilized by weak O-H...N intra molecular hydrogen bond.

5. Conclusion

Crystal structure of a novel saliciline schiff bases derivatives have also been exhibit a broad range of biological activities, including antifungal, antibacterial, antimalarial, antiproliferative, anti-inflammatory, antiviral, and antipyretic. The title compound is crystallized in ethyl acetate by slow evaporation techinique. The compound lies across a crystallographic inversion centre and adopts E configurations with respect to the C-N bonds. The asymmetric unit of this compound is composed of one half-molecule. title structure may be important from a medicinal point of view as well as their widespread biological significance. The structure may be useful for further investigation on the mechanism, potential activity, optimal reaction condition etc which will be further characterized as a future prospective of our project.

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