Available online at www.derpharmachemica.com

ISSN 0975-413X
CODEN (USA): PCHHAX

Der Pharma Chemica, 2016, 8(19):328-333
(http://derpharmachemica.com/archive.html)

Crystal structure and Hirshfeld surface analysis of (*E*)-2-(1-(2-(4-chlorophenyl) hydrozono)ethyl) naphtolen-1-ol

A. L. Amrutha Kala[a], Karthik Kumara[a], G. Pavithra[b], M. Prabhuswamy[c], K. Ajay Kumar[b] and N. K. Lokanath*[a]

[a]*Department of Physics, University of Mysore, Mysuru, India*
[b]*Department of Chemistry, Yuvaraja College, University of Mysore, India*
[c]*Department of Physical Science Education, JSS Institute of Education, Sakaleshpur, India*

ABSTRACT

Schiff base of 2-acetyl-1-hydroxynaphthol and 4-chlorophenylhydrazine hydrochloride was synthesized by condensation reaction in the presence of sodium acetate in ethyl alcohol under reflux conditions. The crystal structure of the title compound was determined and analyzed by single crystal X-ray diffraction studies. The compound crystallizes in the Orthorhombic crystal system with space group P_{212121} and unit cell parameters, a = 7.215 (11) Å, b = 7.208 (10) Å, c = 29.10(4) Å and Z = 4. The crystal and molecular structure of the title compound is stabilized by the C—H···Cl, C—H···O and O—H···N and C—H···π interactions.

Keywords: Schiff base, condensation, X-ray diffraction, crystal structure, interactions.

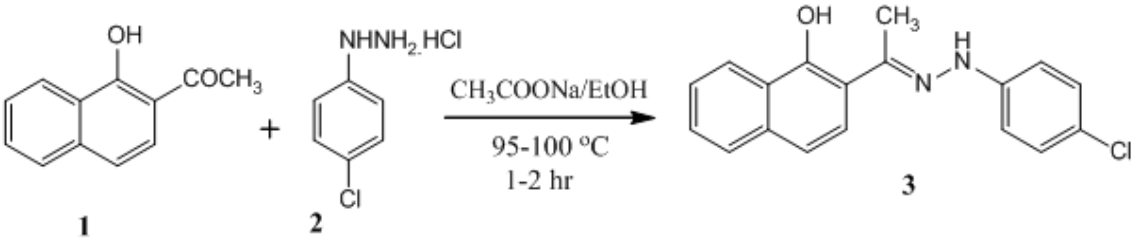
INTRODUCTION

In recent times, interest in the study of Schiff base hydrazones has been increasing due to their biological importance in medicinal chemistry. The hydrazones were proved to be versatile intermediates in synthetic organic and inorganic chemistry. They have been used for the preparation of stable coordination complexes with most transition metal ions [1]. In organic synthesis, hydrazones were extensively used as precursors for the construction of bioactive molecules such as pyrazolines [2-4], formyl pyrazoles [5,6], oxadiazoles [7-9] and thiazolidinones [10]. Hydrazones constitute an essential class of compounds for the development of new chemical entities to treat various diseases of clinical importance. Hydrazones were known to exhibit wide spectrum of biological effects including antifungal [11], anti-inflammatory [12], anticonvulsant [13] and analgesic [14]. In view of the synthetic utility and pharmaceutical applications associated with hydrazones, herein we report the synthesis, crystal growth, spectral and X-ray diffraction studies of new hydrazone (*E*)-2-(1-(2-(4-chlorophenyl) hydrazono) ethyl) naphtholen-1-ol.

MATERIALS AND METHODS

Procedure for the synthesis of (E)-2-(1-(4 chlorophenyl) hydrazono) ethyl) naphtholen-1-ol
In this present study, we synthesized (*E*)-2-(1-(2-(4-chlorophenyl) hydrazono) ethyl) naphtholen-1-ol (3) by the reaction of 2-acetyl-1-hydroxynaphthol (1) and 4-chlorophenylhydrazine hydrochloride (2) in the presence of

sodium acetate in ethyl alcohol under reflux conditions on water bath. The reaction pathway is illustrated in Scheme 1.



Scheme 1: Schematic diagram for the synthesis of (*E*)-2-(1-(2-(4-chlorophenyl)hydrazono) ethyl) naphtholen-1-ol

To the solution of 2-acetyl-1-hydroxynaphthol, **1** (0.01 mol) in ethyl alcohol (20 mL), a solution of 4-chlorophenylhydrazine hydrochloride, **2** (0.01 mol) and sodium acetate (0.01 mol) in water : ethyl alcohol was added. Then the mixture was refluxed on a water bath for 1-2 h. The progress of the reaction was monitored by TLC. After completion of the reaction, the mixture was poured into ice cold water. The solid separated was filtered, washed with ice cold water and dried to obtain target molecule (*E*)-2-(1-(2-(4-chlorophenyl) hydrazono) ethyl) naphtholen-1-ol, **3** in 90% yield. In order to obtain the single crystals of the product, the solid obtained was dissolved in a minimum quantity of methyl alcohol at its boiling conditions, and the solution was kept aside undisturbed for slow evaporation of solvent for three days. Colorless sharp needle shaped single crystals formed were carefully separated from the solvent and dried.

The ^{1}H NMR spectra was recorded on Agilent-NMR 400 MHz spectrophotometer in $CDCl_3$ with TMS as an internal standard. The Chemical shifts are expressed in δ ppm. Mass spectra were obtained on Mass Lynx SCN781 spectrophotometer, TOF mode.

Physical and Spectral data

M.P. 174-175 °C; ^{1}HNMR ($CDCl_3$, δ ppm): 2.23 (s, 3H, CH_3), 6.07 (s, 1H, NH), 7.01-8.09 (m, 10H, Ar-H), 8.68 (s, 1H, OH). MS (m/z) for $C_{18}H_{15}ClN_2O$: 312 (M+2, ^{37}Cl, 33%), 310 (M+, ^{35}Cl, 100%).

RESULTS AND DISCUSSION

Single crystal X-Ray diffraction studies

Data collections were carried out by choosing a single crystal of dimension 0.30X0.35X0.40 mm of the title compound and X-ray intensity were collected with χ fixed at 54° and φ, from 0° to 360°, scan width at 0.5°, exposure time of 3s, the sample to detector distance of 50.0 mm at a temperature 293 K on Rigaku XtaLAB Mini X-ray diffractometer operating at 50 kV and 12 mA with MoKα radiation of wavelength λ= 0.71073 Å. A complete data set was processed by CRYSTAL CLEAR [15]. The structure was solved by direct methods and refined by full-matrix least squares method on F^2 using SHELX [16]. After several cycles of refinement, the final difference Fourier map showed peaks of no chemical significance and the residual is saturated to 0.0606. The crystal data and the structure refinement details are given in **Table 1.** The bond lengths and bond angles are given in **Table 2,** the torsion angles are listed in **Table 3.** The geometrical calculations were carried out using PLATON [17]. The molecular and packing diagrams were generated using MERCURY [18]. The *ORTEP* of the molecule with displacement ellipsoids drawn at 50 % probability level is shown in **Figure 1**. The packing of molecules when viewed down along *a* axis is shown in **Figure 2,** which indicates that the molecules form an infinite one dimensional ripple like chains along *a*-*c* plane.

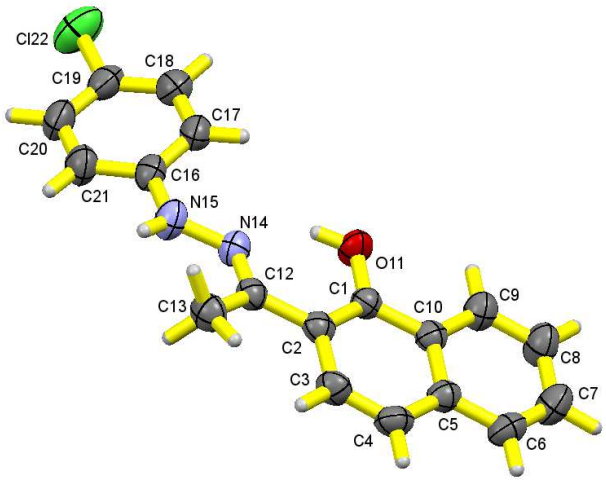


Figure 1. The *ORTEP* of the molecule with numbering scheme for non hydrogen atoms drawn at 50% probability level

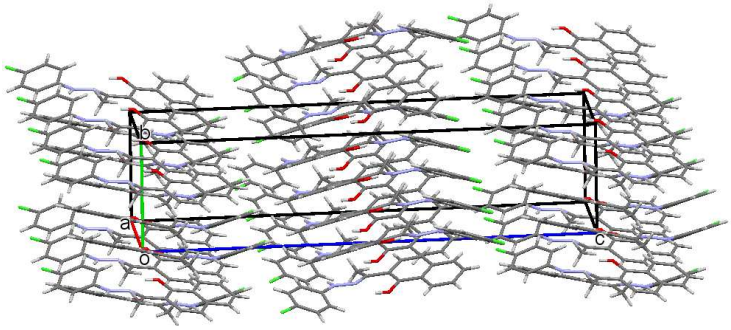


Figure 2. The packing of molecules when viewed down along *a* axis

Table 1. Crystallographic data and the details of structure refinement

CCDC No.	1511399
Empirical formula	$C_{18}H_{15}Cl_1N_2O_1$
Formula weight	310.77 g mol^{-1}
Temperature	293 K
Wavelength	0.71073 Å
Crystal system, space group	Orthorhombic, $P\ 2_12_12_1$
Unit cell dimensions	a = 7.215(11) Å
	b =7.208(10)Å
	c = 29.10(4) Å
Volume	11513(4)$Å^3$
Z, calculated density	4, 1.364 Mg/m^3
Absorption coefficient	0.255mm^{-1}
F_{000}	648
Crystal size	0.30×0.35×0.40 mm
Limiting indices	$-8 \le h \le 5$, $-8 \le k \le 3$, $-32 \le l \le 14$
Reflections collected / unique	2109/1775(R int = 0.0315)
Absorption correction	multi-scan, T_{min} = 0.9037 and T_{max} = 0.9265
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	1775 / 0 / 201
Goodness-of-fit on F^2	1.085
Final R indices [I>2sigma(I)]	R1 = 0.0606, wR2 = 0.1548
R indices (all data)	R1 = 0.0734, wR2 = 0.1693
Largest diff. peak and hole	0.176 and −0.207 e. $Å^{-3}$

Table 2. Bond lengths and bond angles (Å, °)

C1—O11	1.353(6)	C9—C10	1.389 (6)
C1—C2	1.396(7)	C12—N14	1.290(7)
C1—C10	1.437(7)	C12—C13	1.482 (5)
C2—C3	1.405(7)	N14—N15	1.383 (4)
C2—C12	1.484(6)	N15—C16	1.399(7)
C3—C4	1.363(7)	C16—C17	1.372 (6)
C4—C5	1.403(7)	C16—C21	1.386 (4)
C5—C10	1.414(7)	C17—C18	1.380(8)
C5—C6	1.415(7)	C18—C19	1.394(7)
C6—C7	1.363(9)	C19—C20	1.381(9)
C7—C8	1.401(8)	C19—Cl22	1.730(6)
C8—C9	1.379(7)	C20—C21	1.374(8)
O11—C1—C2	122.6(4)	C8—C9—C10	120.9(5)
O11—C1—C10	116.2(4)	C9—C10—C5	119.6(4)
C2—C1—C10	121.3(4)	C9—C10—C1	121.9(4)
C1—C2—C3	117.8(4)	C5—C10—C1	118.5(4)
C1—C2—C12	123.0 (3)	C17—C16—C21	118.9(5)
C3—C2—C12	120.2(4)	C17—C16—N15	122.9(4)
C4—C3—C2	122.2(5)	C21—C16—N15	118.2(5)
C3—C4—C5	121.2(4)	C16—C17—C18	120.1(4)
C10—C5—C6	118.0(5)	C17—C18—C19	119.3 (4)
C10—C5—C4	119.7 (3)	C20—C19—C18	121.1 (4)
C6—C5—C4	122.3 (3)	C20—C19—Cl22	119.7 (3)
C7—C6—C5	121.6(5)	C18—C19—Cl22	119.2 (4)
C6—C7—C8	120.0(5)	C19—C20—C21	119.8(5)
C9—C8—C7	119.9(5)	C16—C21—C20	121.0(5)

Table 3. Torsion angles (°)

C12-N14-N15-C16	−177.8(4)	C4-C5-C6-C7	178.4(5)
N15-N14-C12-C2	175.6(4)	C10-C5-C6-C7	−0.5(7)
N15-N14-C12-C13	−5.2(6)	C4-C5-C10-C1	−0.6(6)
N14-N15-C16-C17	−27.8(7)	C4-C5-C10-C9	179.7(4)
N14-N15-C16-C21	153.2(5)	C6-C5-C10-C1	178.4(4)
O11-C1-C2-C3	176.8(4)	C6-C5-C10-C9	−1.3(7)
O11-C1-C2-C12	−0.7(7)	C5-C6-C7-C8	2.4(8)
C10-C1-C2-C3	−2.9(6)	C6-C7-C8-C9	−2.4(8)
C10-C1-C2-C12	179.6(4)	C7-C8-C9-C10	0.6(8)
O11-C1-C10-C5	−176.8(4)	C8-C9-C10-C1	−178.5(5)
O11-C1-C10-C9	3.0(6)	C8-C9-C10-C5	1.3(7)
C2-C1-C10-C5	2.9(6)	N15-C16-C17-C18	178.8(5)
C2-C1-C10-C9	−177.4(4)	C21-C16-C17-C18	−2.2(8)
C1-C2-C3-C4	0.6(7)	C16-C17-C18-C19	−0.9(8)
C12-C2-C3-C4	178.1(4)	C17-C18-C19-Cl22	−175.7(4)
C1-C2-C12-N14	11.9(6)	C17-C18-C19-C20	3.5(8)
C1-C2-C12-C13	−167.3(4)	Cl22-C19-C20-C21	176.3(5)
C3-C2-C12-N14	−165.6(4)	C18-C19-C20-C21	−2.9(9)
C3-C2-C12-C13	15.2(6)	C19-C20-C21-C16	−0.3(9)
C2-C3-C4-C5	1.8(7)	N15-C16-C21-C20	−178.1(5)
C3-C4-C5-C6	179.3(4)	C17-C16-C21-C20	2.8(9)
C3-C4-C5-C10	−1.7(7)		

In the title compound, (*E*)-2-(1-(2-(4-chlorophenyl)hydrazono)ethyl)naphtholen-1-ol, a torsion angle of 176.8 (4)° for the segment C1—O11 about O11— C1—C2—C3 confirm that the segment C1—O11 is an + *anti-periplanar* conformation with respect to the mean plane defined by the naphthalene ring C1→C10 reflecting the fact that the hydroxy group is slightly twisted about the mean plane of the naphthalene ring. X-ray diffraction studies of compound **3** shows *E* configuration around C12-N14 double bond. The segment C13—C12 is in a +s*yn-periplanar* conformation with the mean plane described by the naphthalene ring as confirmed by the torsion angle 15.2 (6)° about C13—C12— C2— C3. A dihedral angle of 29.52 (19)° formed by the mean plane of naphthalene ring with the mean plane of the chlorophenyl ring indicates that the naphthalene ring is in the axial position with the chlorophenyl ring.

The molecules exhibit C—H···*Cg* interaction; C13—H13C···*Cg1* (*Cg1* is the centroid of the ring C1/C2/C3/C4/C5/C10) with a C—*Cg* distance of 3.597(7) Å, H···*Cg* distance of 2.730 Å, C—H···*Cg* angle of

150°, the angle of C—H bond with the π-plane being 78° and C13—H13C···*Cg2* (*Cg2* is the centroid of the ring C5/C6/C7/C8/C9/C10) with a C—*Cg* distance of 3.874(8) Å, H···*Cg* distance of 2.970 Å, C—H···*Cg* angle of 158°, the angle of C—H bond with the π-plane being 79°. The molecules are linked together with C—H···π interactions to form 3-dimensional supramolecular framework. The molecules also exhibit intermolecular hydrogen bond interactions, C—H···O and C—H···Cl, and intra molecular hydrogen bond interaction, O—H···N as listed in **Table 4**.

Table 4. Inter molecular and intra molecular hydrogen bond geometry (Å, °)

D—H···*A*	*D*—H	H···*A*	*D*···*A*	*D*—H···*A*
C7—H7···Cl22$^{(i)}$	0.93	2.930	3.630	133
O11—H11···N14*	0.82	1.870	2.590	145
N15—H15···C13*	0.86	2.398	2.740	104
C9—H9...O11*	0.93	2.460	2.773	100

*Symmetry codes: (i) 3/2−x, 1−y, ½+z; *Intra molecular hydrogen bond interactions.*

Hirshfeld surface analysis

The inter contact in the molecular structure is visualized by carrying out the Hirshfeld surface analysis by the computational methods implemented in *CRYSTAL EXPLORER* [19]. The Hirshfeld surface and the fingerprint plot are shown in **Figure 3** and **Figure 4** respectively.

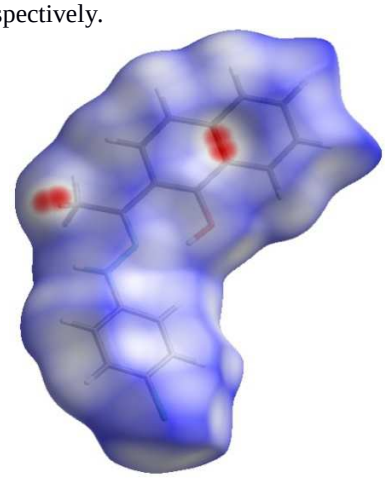


Figure 3. The Hirshfeld surface for visualizing the inter contacts of the molecule. Color scale between −0.050 au (blue) and 1.100 au (red)

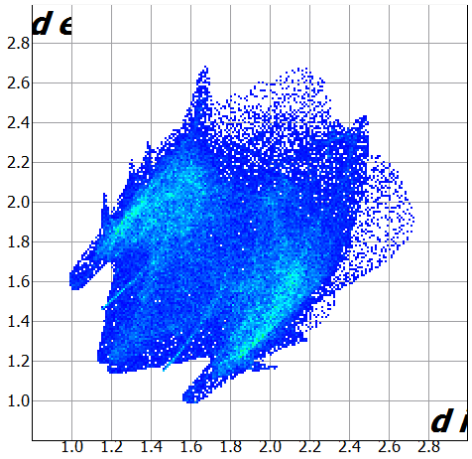


Figure 4. Finger print plot considering all atoms of the molecule

The inter contacts C···H show up as dark red spotsthat occur due to C—H···π interactions. The inter contacts that contribute for the Hirshfeld surface of the molecule are H···H (37%), C···H (37%), Cl···H (15%), N···H (5%), O···H (4%), C···C (1%), and O···C (1%) which play a vital role in the stabilization of the crystal structure of the molecules.

CONCLUSION

The title compound, (*E*)-2-(1-(2-(4-chlorophenyl)hydrazono) ethyl) naphtholen-1-ol was synthesized by the reaction of 2-acetyl-1-hydroxynaphthol and 4-chlorophenyl hydrazine hydrochloride in the presence of sodium acetate in ethyl alcohol under reflux conditions on water bath. The crystal structure of the title compound was determined and analyzed by single crystal X-ray diffraction studies. The compound crystallizes in the orthorhombic crystal system with space group P_{212121}. The dihedral angle between the mean plane of naphthalene ring and the mean plane of the chlorophenyl ring was 29.52(19)°. The crystal and molecular structure of the title compound is stabilized by the C—H···Cl, C—H···O and O—H···N and C—H·π·interactions. The Hirshfeld surface analysis was carried out to understand the contributions of various inter contacts in the stabilization of the molecular structure.

Acknowledgements
The authors thank the National Facility, Department of Studies in Physics, University of Mysore, Mysuru-570 006, India, for providing the X-ray intensity data.

REFERENCES

[1] N. Dharmaraj, P. Viswanathamurthi, K. Natarajan, *Transition Met.Chem.***2001,** 26, 105.
[2] K. Ajay Kumar, M. Govindaraju, *Int.J. ChemTech Res.***2015**,8(1), 313.
[3] G. Vasanth Kumar, M. Govindaraju, N. Renuka, Bi Bi Ahmadi Khatoon, B.N. Mylarappa, K. Ajay Kumar, K. *Rasayan J. Chem.*, **2012**, 5(3), 338.
[4] P. Jayaroopa, G. Vasanth Kumar, K. Ajay Kumar, *Turkish J. Chem.*, **2013**, 37, 853.
[5] R. Nagamallu,A. K. Kariyappa, *Bioorg. Med. Chem. Lett.***2013,** 23, 6406.
[6] P. Gurunanjappa, R. Nagamallu, A.K. Kariyappa, *Int. J. Pharm. Pharm. Sci.* **2015,** 7, 379.
[7] P. Jayaroopa, K. Ajay Kumar, G. Vasanth Kumar, *Int.J. Chem Tech Res.***2013,** 5(5), 2516.
[8] J. Prabhashankar, A.K. Kariyappa, D. Nagaraju, R.M. Puttaswamy, *Research & Reviews: J. Microbiol. Biotech.*, **2013,** 2(3), 55.
[9] H. N. Dogan, A. Duran, S. Rollas, G. Sener, Y. Armutak, M. Keyer-Uysal, *Med. Sci. Res.* **1998,** 26, 755.
[10] A. Kocatepe, E. De Clercq F. Sahin, M. Gulluce, *Eur. J. Med. Chem.***2006,** 41, 353.
[11] C. Loncle, J.M. Brunel, N. Vidal, M. Dherbomez, Y. Letourneux, *Eur. J. Med. Chem.* **2004,** 39, 1067.
[12] Z.A. Kaplancikli, M.D. Altintopa, A. Ozdemira, G. Turan-Zitounia, S.I. Khan, N. Tabanca. *Lett. Drug Des. Discov.* **2012,** 9, 310.
[13] J.R. Dimmock, S.C. Vashishtha, J.P. Stables, *Eur. J. Med. Chem.* **2000,** 35, 241.
[14] P.C. Lima, L.M. Lima, K.C.M. da Silva, P.H.O. Leda, A.L.P. de Miranda, C.A.M. Fraga, E.J. Barreiro, *Eur. J. Med. Chem.***2000,** 35, 187.
[15] Rigaku, *CRYSTAL CLEAR*, **2011** Rigaku Corporation, Tokyo, Japan.
[16] G.M. Sheldrick, *Acta. Cryst.*, **2008**, A64, 112.
[17] A.L. Spek, *Acta. Cryst.* **1990**, A46, C34.
[18] C.F. Macrae, I.J. Bruno, J A. Chisholm, P.R. Edgington, P. McCabe, E. Pidcock, L. Rodriguez-Monge, R. Taylor, J. van de Streek, P.A. Wood. *J. Appl. Cryst.*, **2008**, 41, 466.
[19] S.K. Wolff, D.J. Greenwood, J.J. McKinnon, M.J. Turner, D. Jayatilaka, M.A. Spackman, *CRYSTAL EXPLORER*, **2012**, Version 3.1.