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Synthesis, spectral studies and structure of 2-hydroxyacetophenone nicotinic acid hydrazone

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Abstract

2-Hydroxyacetophenone nicotinic acid hydrazone (H₂ApNH) was synthesized as a part of our work, in search for non-linear optical crystal based on hydrazones, and studied spectroscopically. Complete NMR assignments for the hydrazone was made using COSY homonuclear and HMQC heteronuclear correlation techniques. Solid state reflectance was also studied in order to understand the electronic structure of the synthesized compound. The crystal and molecular structures of H₂ApNH were determined. The compound crystallizes into an orthorhombic lattice with a non-centrosymmetric space group $Pca2_1$ with two crystallographically unique molecules of in an asymmetric unit. The geometry reveals quasi co planarity in the whole molecular skeleton with localization of the double bonds in the C=N-N-C=O with an E-configuration. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

Chemistry of Schiff bases has been intensively investigated in recent years, owing their coordination properties and diverse applications. Schiff base hydrazones are widely used in analytical chemistry as a selective metal extracting agent as well as in spectroscopic determination of certain transition

metals [1-4]. Copper(II) complex of salicylaldehyde benzoylhydrazone was shown to be a potent inhibitor of DNA synthesis and cell growth. This hydrazone also has mild bacteriostatic activity and a range of analogues has been investigated as potential oral iron chelating drugs for genetic disorders such as thalassemia [5-8]. There are also some reports on the catalytic activities of their nickel complexes [9-12]. Hydrazones have been the subject of extensive investigation due to their versatile chelating behavior in particular those derived from pyridoxal phosphate and isonicotinic acid [13,14], but those having the side chain at 2- position of the heteroaromatic ring have received much less attention. The corresponding nicotinic acid hydrazones have not been as much

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Fig. 1. Structure of H₂ApNH.

investigated and to the best of our knowledge and there are no reports on 2-hydroxyacetophenone nicotinic acid hydrazone (H₂ApNH) (Fig. 1). In this paper we discuss the structural and spectroscopic studies of H_2ApNH .

2. Experimental

2.1. Materials

2-Hydroxyacetophenone (CDH) and nicotinic acid hydrazide (Fluka) were used as received. 2-Hydroxyacetophenone nicotinic acid hydrazone (H₂ApNH) was prepared by refluxing 1:1 molar methanolic solution of 2-hydroxyacetophenone and nicotinic acid hydrazide for 6 h. On cooling the reactant medium, pale yellow needle like crystals were separated out, which were isolated by filtration and recrystallised from methanol. The melting point of the compound, H₂ApNH is found to be 180–182 °C. The empirical formula given for the compound C₁₄H₁₃N₃O₂ was confirmed by elemental analysis. Found C, 66.12; H, 5.20; N, 16.95%. Calculated C, 65. 87; H, 5.13; N, 16.46%. The ¹H NMR, ¹³C NMR, COSY and HMQC spectra were recorded by using Bruker DRX500, using DMSO-d₆ as solvent and TMS as standard. IR spectrum was recorded on ECO2000 FTIR NICO-LET, using KBr pellet. Solid state reflectance spectrum was recorded on Ocean Optics, Inc. SD2000 Fiber Optic Spectrometer.

2.2. X-ray data collection, structure solution and refinement

Single crystals of the H_2ApNH were obtained by slow evaporation of a methanolic solution of

Table 1
Summary of crystal data and structure refinement for H ₂ ApNH

Empirical formula	$C_{14}H_{14}N_3O_2$
Formula weight	256.28
Color; shape	Greenish brown; block
Measured temperature	213(2) K
Crystal system	Orthorhombic
Space group	$Pca2_1$
Unit cell dimensions	$a = 8.2221(1)(5)$ Å, $\alpha = 90^{\circ}$
	$b = 11.3743(1)$ Å, $\beta = 90^{\circ}$
	$c = 26.3962(4)$ Å, $\gamma = 90^{\circ}$
Volume $V(Å^3)$	2468.59(5)
Ζ	8
$D_x ({\rm g}{\rm cm}^{-3})$	1.379
$\mu (\mathrm{mm}^{-1})$	0.095
Absorption correction	Empirical
F(000)	1080
θ range (°)	3.06-28.27°
Completeness to θ	92.2%
h, k, l	-10/10, -15/12, -31/34
Reflections collected	14083
Reflections unique	5588
$T_{\rm max}/T_{\rm min}$	0.9831 and 0.9540
Number of parameters	345
GoF	1.004
Final <i>R</i> indices $[I \ge 2\sigma(I)]$	R1 = 0.0995, wR2 = 0.2415
Residual highest peak and deepest	$1.142 \text{ and } -0.746 \text{ e}\text{\AA}^{-3}$
hole	

the compound. А crystal, of size $0.18 \times 0.42 \times 0.52$ mm³, was mounted on glass fiber with epoxy cement for the X-ray crystallographic study. A summary of the crystallographic data for the title complex at 213 K is gathered in Table 1. The data was collected with a 1-K SMART CCD diffractometer using graphite-monochromated Mo Ka radiation with a detector distance of 4 cm and swing angle of -35° . A hemisphere of the reciprocal space was covered by combination of three sets of exposures; each set had a different of angle (0, 88, 180°) and each exposure of 30 s covered 0.3° in ω . The structures were solved by direct methods and refined by least-square on F_0^2 using the SHELXTL [15] software package. The selected bond lengths and bond angles of H₂ApNH are listed in Table 2.

3. Results and discussion

Solid state reflectance spectral data shows the π - π^* transition is at 31950 cm⁻¹, n- π^* of

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Table 2 Selected bond lengths (Å) and bond angles (deg) of H_2ApNH

O(1)-C(8) 1.242(6)	C(7)-N(1)-N(2) 117.7(4)
O(2)-C(5) 1.355(6)	C(8)-N(2)-N(1) 120.8(4)
N(1)-C(7) 1.284(6)	C(13)-N(3)-C(9) 122.7(5)
N(1)-N(2) 1.382(5)	O(2)-C(5)-C(6) 124.1(4)
N(2)-C(8) 1.339(6)	O(2)-C(5)-C(4) 115.8(4)
N(3)-C(13) 1.362(7)	N(1)-C(7)-C(6) 116.3(4)
N(3)-C(9) 1.374(7)	N(1)-C(7)-C(14) 123.6(5)
C(1)–C(6) 1.387(6)	O(1)-C(8)-N(2) 123.9(5)
	N(2)-C(8)-C(9) 114.7(5)
	C(10)-C(9)-N(3) 119.8(6)
	N(3)-C(9)-C(8) 120.5(5)
	C(9)-C(8)-O(1) 121.4(6)

the azomethine is found at 29590 cm⁻¹ and $n-\pi^*$ of carbonyl is at 26110 cm⁻¹ [16]. Significant IR bands of the compound and their tentative assignments are discussed here. A broad band obtained at 3432 cm⁻¹ is assigned to be due to the OH stretching. Other major bands are at 3238, 1672 and 1603 cm⁻¹ which are attributed to ν (NH), ν (C=O) and ν (C=N), respectively, [7,8].

The complete assignment of the ¹H NMR spectra is given here. The spectrum was recorded at 500 MHz. The assignment is done on the basis of chemical shifts, multiplicities and coupling constants. The signals at $\delta = 13.28$ ppm and $\delta = 11.56$ ppm represent OH and NH, respectively. Upon addition of D₂O the intensities of both OH and NH protons significantly decrease, confirming the assignment. We got one more singlet at $\delta = 9.1$, which is found to be coupled with a proton of H(12) ($\delta = 8.3$) from the 1 H/ 1 H correlation spectra. Hence it is assigned to be of H(13), for which a doublet is expected. A singlet of three protons at $\delta = 2.5$ was attributed to the methyl group protons which are chemically and magnetically equivalent. At $\delta = 6.9$ we got a quartet which is assigned to be a merged form of one triplet and a doublet corresponding to H(4) and H(2). OH $\delta = 13.28(s)$, NH $\delta = 11.56(s)$, H(13) $\delta = 9.1(s)$, H(11) $\delta = 8.8$ (d) J = 3.5 Hz, H (12) $d\delta = 8.3$ (d) J = 8 Hz, H(10) $\delta = 7.6$ (dd) J = 5 Hz, J = 7.5 Hz, H(1) $\delta = 7.7$ (d) J = 8 Hz, H(3) $\delta = 7.3$ (t) J = 8 Hz, J = 7.5 Hz, H(2) $\delta = 6.95$ (d) J = 8.5 Hz, H(4) $\delta = 6.90(d) J = 7.5 Hz, H(14) \delta = 2.5(s).$

Coupling between different protons are shown in Fig. 2.

Complete assignment of ${}^{13}C-{}^{1}H$ NMR spectra, recorded at 125.76 MHz is given below. Assignment of protonated carbons were made by two dimensional heteronuclear-correlated experiment using delay values which corresponds to ${}^{1}J(C,H)$. The HMQC experiment provides correlation between protons and their attached heteronuclei through the heteronuclear scalar coupling. This sequence is very sensitive (compare to the older HETCOR) as it is based on proton detection (instead of the detection of the least sensitive low gamma heteronuclei). From (Fig. 3) HMQC it is evident that C(5), C(6), C(7), C(8) and C(9) are nonprotonated carbons. C(5) $\delta = 159.6$, C(4) $\delta = 119$, C(3) $\delta = 133$, C(2) $\delta = 119$, C(1) $\delta = 129$, C(6) $\delta = 118$, C(7) $\delta = 159.4$, C(14) $\delta = 15$, C(8) $\delta = 164$, C(9) $\delta = 120$, C(10) $\delta = 129$, C(11) $\delta = 153$, C(12) $\delta = 137$, C(13) $\delta = 150$.

3.1. Crystal structure of the compound H₂ApNH

The molecule of H_2ApNH crystallizes into an orthorhombic lattice with a non-centrosymmetric space group $Pca2_1$. There are two crystallographically unique molecules of H_2ApNH in the asymmetric unit. The molecular structure showing 30% displacement ellipsoids with atomic-numbering scheme is shown in Fig. 4. The molecular packing of the molecule in a unit cell is shown in Fig. 5.

The C8-O1 bond, which averages 1.242(6) Å in H₂ApNH is longer than the C=O bond 1.236(4) in 3formylpyridine semicarbazone [16] indicating considerable amount of the bond delocalisation with the pyridyl ring. As expected the C7-N1 bond length is 1.284(6) Å is comparable to the corresponding bond length of 1.291 Å reported for 2-hydroxyacetophenone thiosemicarbazone [17]. The O atom and the hydrazinic N1 atom are trans with respect to C8-N2 bond. Structure of the compound reveals quasi coplanarity of the whole molecular skeleton with localization of the double bonds in the central -C=N-N-C=O which has an E-configuration with respect to the double bond of the hydrazone bridge. A trans s-cis configuration is fixed around the N2-N1 (1.382 Å) single bond [18]. The phenolic ring maintains coplanarity with the central chain. The angle N2-C8-O1 (123.9°) is significantly greater than C9–C8–O1 (121.4°) possibly in order to relive repulsion between lone pairs of electrons on atoms N1

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Fig. 2. ¹H/¹H coupling observed in COSY of H₂ApNH.

and O1. The central part of the molecule C7–N1–N2–C8–C9, adopts a completely extended conformation. The bond lengths C7–N1 (1.284 Å) and C8–O1 (1.242 Å) are typical of double bonds. So that the chain is likely correspond to C7=N1–N2–C8=O1. A similar observation was reported for a related molecule, pyridoxal isonicotinoyl hydrazone [19].

4. Supplementary data

Crystallographic data for the structural analysis has been deposited with the Cambridge Crystallographic Data Center, CCDC 190821 for compound H_2ApNH . Copies of this information maybe obtained free of charge from The Director, CCDC, 12 Union Road, P.B. Sreeja et al. / Journal of Molecular Structure 645 (2003) 221-226



Fig. 3. $^{13}C^{-1}H$ HMQC spectrum of the H₂ApNH.



Fig. 4. Perspective view of the two crystallographically unique molecules H_2ApNH with atom numbering scheme with atom numbering schemes and displacement ellipsoids at 50% probability level. Hydrogen atoms are shown as small spheres of arbitrary radii.

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Fig. 5. Packing diagram of the compound H₂ApNH.

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