

Short Note

1,3-Bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol

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Received: 26 November 2017; Accepted: 15 December 2017; Published: 19 December 2017

Abstract: 1,3-Bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol Schiff base was synthesized in an acceptable yield by condensation of 3-bromobenzaldehyde with 1,3-diaminopropan-2-ol in methanol. The structure of the desired Schiff base compound was spectroscopically analyzed by EI-MS, CHN-elemental analysis, FT-IR, UV-visible, and ¹H and ¹³C-NMR. The structure was also computed by DFT-optimization, MEP, Mulliken, NPA, IR- B3LYP/6-311++G(d), and SCF-TD-DFT.

Keywords: Schiff base; DFT; NMR; FT-IR; condensation

1. Introduction

Schiff bases as azomethine compounds are well-known versatile molecules that have recently received great attention in different fields [1–3]. Such compounds have been used as dyes and pigments, corrosion inhibitors, thermo-stable materials, and catalysts [3–6] and in medical applications as antifungal, anticancer, and antibacterial agents [7–12].

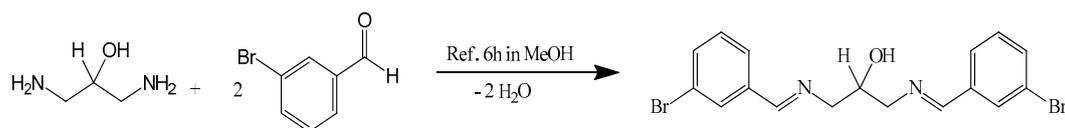
The presence of the unsaturated nitrogen atom (>C=N) together with its lone pair of electrons makes the Schiff base an attractive e-donor ligand [11–14]. Such donation ability plays a critical role in the complexation with several metal ions centers [10–17].

Metal-Schiff based drugs are highly promising and of great interest in biology and chemistry. Biologically active nitrogen of (>C=N-) upon coordination with a transition metal center lead to complexes with improved pharmacological and physicochemical properties [7–15]. Despite the large number of the prepared Schiff base ligands together with their complexes, there remains an urgent need for novel ligands with new applications and properties.

In connection with previous work [12–18], we report the preparation of 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol, its spectroscopic characterization, and computational studies using DFT techniques.

2. Results

1,3-Bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol was synthesized by condensing 2.1 equiv of 3-bromobenzaldehyde with 1 equiv 1,3-diaminopropan-2-ol in absolute methanol under reflux conditions, as shown in Scheme 1. The compound was a white powder with m.p. = 145.2 °C as a final product. The product was soluble in chloroform at RT, soluble in EtOH at 50 °C, and insoluble in *n*-hexane (non-polar) or water even at high temperature.



Scheme 1. Synthesis of the 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol ligand.

The elemental analysis of the 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol is consistent with its proposed molecular formula (Calcd. for $C_{17}H_{16}Br_2N_2O$: C, 48.14; H, 3.80 and N, 6.60. Found: C, 48.02; H, 3.71 and N, 6.53). EI-MS reflected an excellent agreement with the expected structure, the experimental molecular ion $[M^+]$ $m/z = 424.1$ (424.9 theoretical).

2.1. Optimization, MEP, Mulliken, and NPA Analysis

The B3LYP/6-311++G(d)-optimized molecular structure (bonds and angles lengths) of 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol ligand is shown in Figure 1a and Table 1. The compound exists as *E,E*-conformation with respect to the imine functions. The bond lengths of $N2=C$ and $N5=C$ are found to be 1.2733 and 1.2739 Å, respectively, which is clearly consistent with $C=N$. The $C-N=C$ bond angle of 117.82 and 118.87 ($^\circ$) confirms the sp^2 hybridization character of both N atoms, as seen in Table 1. The calculation indicated a short intramolecular hydrogen bond of the type $O-H \cdots N$ (2.233 Å) with a pseudo S_5 -heterocyclic formation (in Figure 1a). Moreover, the phenyl rings are oriented in perpendicular planes, which minimized the internal repulsion energy in the desired molecule.

Table 1. Structure parameters (bond length and bond angle) of the compound.

Bond No.	Bond Type		Å	Angle No.	Angle Type			($^\circ$)
1	C1	N2	1.47	1	N2	C1	C3	109.47
2	C1	C3	1.54	2	C1	N2	C6	120
3	N2	C6	1.2936	3	C1	C3	C4	87.9
4	C3	C4	1.54	4	C1	C3	O7	138.96
5	C3	O7	1.4299	5	C4	C3	O7	85.01
6	C4	N5	1.4699	6	C3	C4	N5	109.47
7	N5	C15	1.2936	7	C4	N5	C15	120
8	C6	C27	1.54	8	N2	C6	C27	120
9	C15	C21	1.54	9	N5	C15	C21	120
10	C16	C17	1.4014	10	C17	C16	C21	120
11	C16	C21	1.4014	11	C16	C17	C18	120
12	C17	C18	1.4014	12	C16	C17	Br37	120
13	C17	Br37	1.91	13	C18	C17	Br37	120
14	C18	C19	1.4015	14	C17	C18	C19	120
15	C19	C20	1.4014	15	C18	C19	C20	120
16	C20	C21	1.4015	16	C19	C20	C21	120
17	C27	C28	1.4014	17	C15	C21	C16	120
18	C27	C29	1.4014	18	C15	C21	C20	120
19	C28	C30	1.4014	19	C16	C21	C20	120
20	C29	C32	1.4014	20	C6	C27	C28	120
21	C30	C34	1.4014	21	C6	C27	C29	120
22	C30	Br38	1.91	22	C28	C27	C29	120
23	C32	C34	1.4014	23	C27	C28	C30	120
				24	C27	C29	C32	120
				25	C28	C30	C34	120
				26	C28	C30	Br38	120
				27	C34	C30	Br38	120
				28	C29	C32	C34	120
				29	C30	C34	C32	120

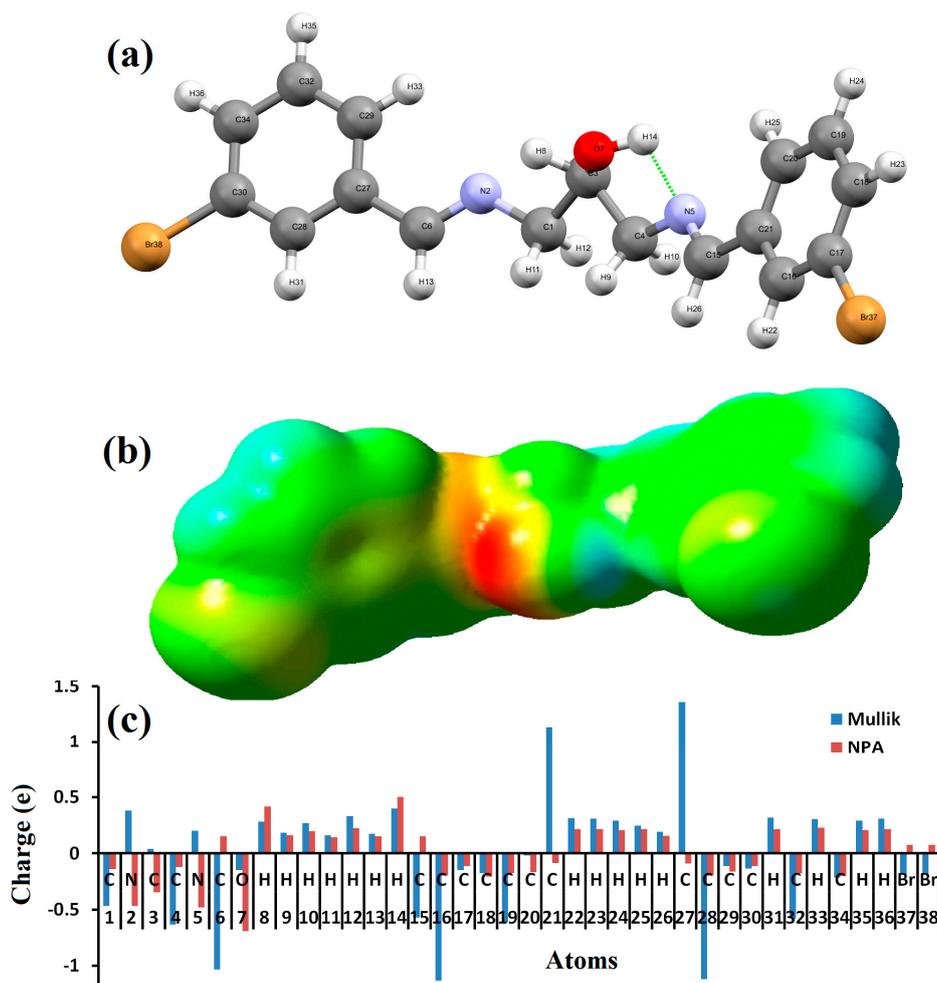


Figure 1. (a) DFT-optimized structure; (b) MEP; and (c) Mulliken and NPA analysis.

The nucleophilic and electrophilic positions of one molecule are represented here by an MEP map (Figure 1b). The O and one of the N atoms are indicated as nucleophilic centers, since it appears in red (electron-rich). The H of hydroxyl group together with its phenyl rings, indicated by the blue color, exhibit electrophilic behavior. The second N atom was not red since it was bonded to the H of the hydroxyl through the intramolecular hydrogen bond. The other functional groups in green were found to lack a nucleophilic or electrophilic character.

The Mulliken and neutral population charge analysis (NPA) of the compound along with the MPE result are shown in Figure 1c. The analysis revealed the presence of a negative charge on the donor atoms (nucleophilic positions) such as O, 2N, 2Br, and most of the C atoms. The hydrogen atoms together with the other C atoms reflected a positive character as electrophilic positions (acceptor atoms).

The condensation reaction was monitored by FT-IR, by measuring the IR of the starting materials before and after dehydration, as seen in Figure 2. The formation of the product mainly can be confirmed by the N–H amine disappearing at 3245 cm^{-1} (Figure 2a) and aldehyde C=O at 1685 cm^{-1} (Figure 2b) shifting to C=N at 1625 cm^{-1} (Figure 2c).

Theoretical-DFT-IR calculation was performed at the B3LYP/6-311++G(d) level of theory, as shown in Figure 2d. Experimental and theoretical FT-IR spectra showed acceptable agreement. There was a small expected discrepancy: DFT-calculation reflected higher functional-group frequencies compared to the experimental one [16].

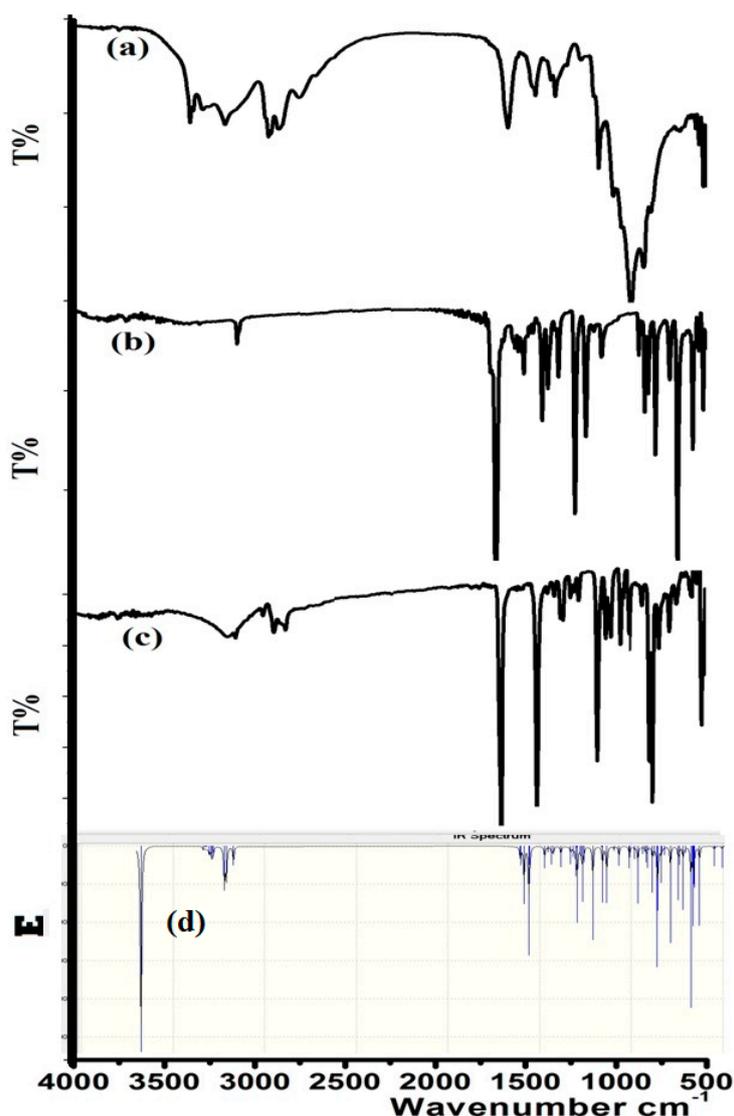


Figure 2. IR spectra of (a) 1,3-diaminopropan-2-ol; (b) 3-bromobenzaldehyde; (c) 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol; and (d) the B3LYP/6-311++G(d)-IR of the product.

2.2. Electronic Transfer and TD-SCF Analysis

TD-SCF theoretical and experimental electron transfer spectral analysis was performed in a MeOH solvent. The experimental and TD-SCF/DFT analysis revealed no bands in the visible area. The $\lambda_{\max} = 260$ nm ($\pi \rightarrow \pi^*$) and 295 nm ($n \rightarrow \pi^*$) electronic transition were detected experimentally (Figure 3a). In the DFT calculation, a broad peak mainly at $\lambda_{\max} = 270$ nm was predicted (Figure 3b).

$^1\text{H-NMR}$ spectrum of the 1,3-bis[(*E*)-(3-bromobenzylidene)amino]propan-2-ol is simple and appeared in good agreement with its assigned structure: five aliphatic protons (δ_{H} 3.4, 3.5 and 4.2 ppm), one alcohol (δ_{H} 4.6 ppm), eight aromatic protons (δ_{H} 7.1–7.8 ppm), and two aldimine protons (δ_{H} 8.3 ppm) were observed as shown in Figure 4a.

$^{13}\text{C-NMR}$ spectrum revealed nine carbon signals. Two of them arose from aliphatic carbons at 50–70 ppm, six were aromatic carbons at 120–142 ppm, and aldimine carbons were noted at 165.5 ppm, as seen in Figure 4a.

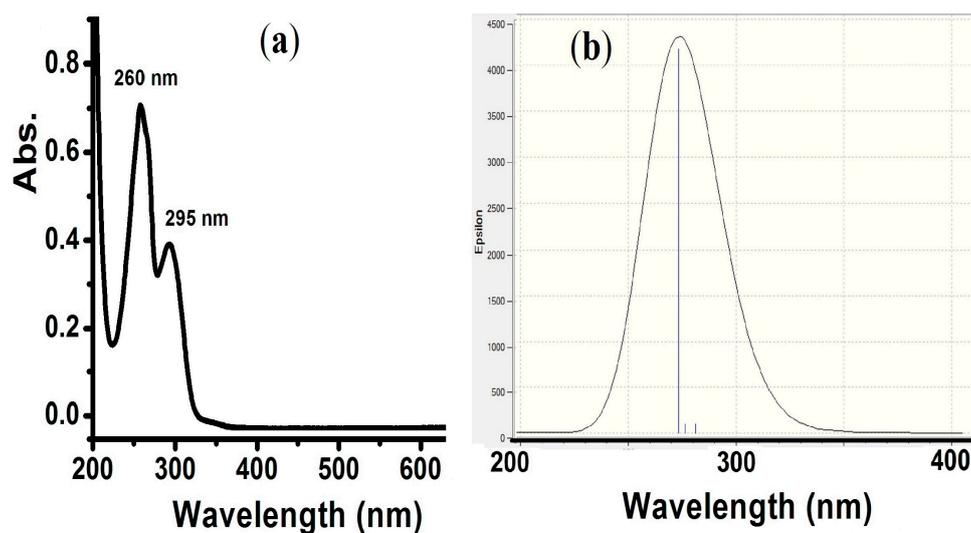


Figure 3. (a) UV-Visible spectrum and (b) TD-SCF-DFT of the compound in MeOH at RT.

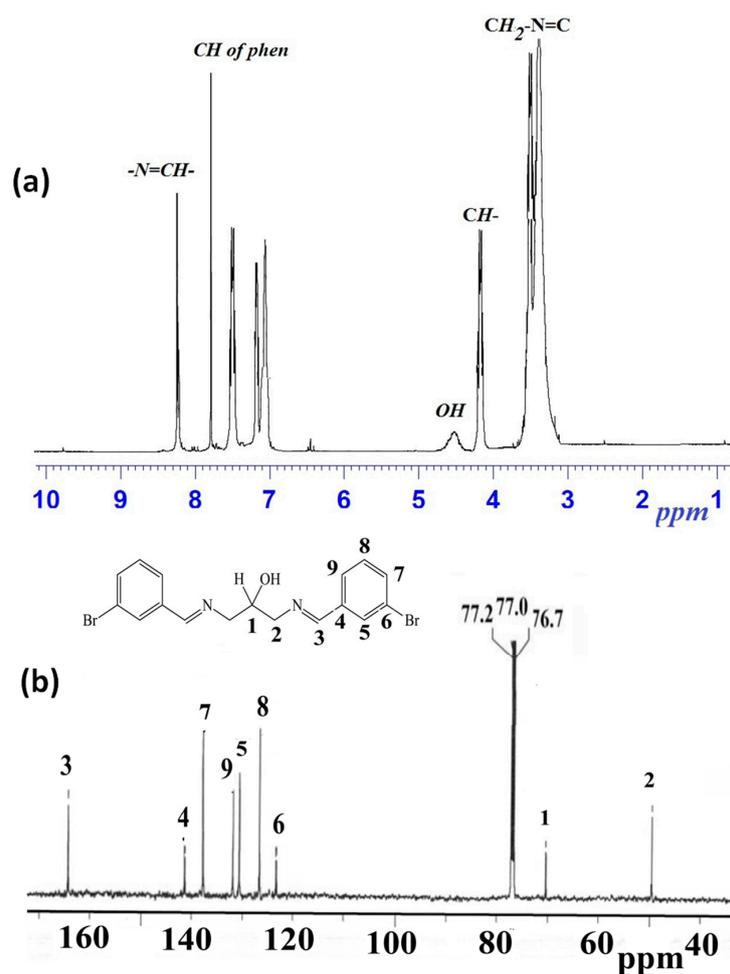


Figure 4. (a) 250 MHz ¹H-NMR and (b) 62.5 MHz ¹³C-NMR of 1,3-bis[(E)-(3-bromobenzylidene)amino]propan-2-ol in CDCl₃.

3. Materials and Methods

NMR was performed on a DRX 250 Bruker spectrometer (Bruker, Mainz, Germany). The UV-Visible spectrum was recorded on a double beam TU-1901 spectrophotometer (Purkinje General Instrument Co., Ltd., Beijing, China). The FT-IR spectra were measured with a PerkinElmer-1000 FT-IR Spectrometer (PerkinElmer Inc., Waltham, MA, USA). EI-MS were recorded on a Finnigan 711A (8 kV) (PerkinElmer Inc., Waltham, MA, USA).

A solution of 1,3-diaminopropan-2-ol (1 mmol) and 3-bromobenzaldehyde (2.1 mmol) in MeOH (20 mL) was subjected to reflux for 4 h. The mixture volume was reduced under vacuum (2 mL) until the white precipitate product appeared. The product was filtered, washed several times with distilled water and several times with *n*-hexane and ethers, and then dried.

Yield: 81% as a white powder, mp = 145.2 °C, was collected; molecular formula C₁₇H₁₆Br₂N₂O; ¹H-NMR (250 MHz, CDCl₃): (ppm) 3.4, 3.5 (2m, 4H, =NCH₂CH(OH)CH₂N=), 4.2 (m, 1H, =NCH₂CH(OH)CH₂N=), 4.6 (br, 1H, =NCH₂CH(OH)CH₂N=) 7.1–7.8 (8H, Ph), 8.3 (s, 2H, –HC=N-). ¹³C-NMR (62.5 MHz, CDCl₃): (ppm) 49.8 (2C, =NCH₂CH(OH)CH₂N=), 70.1 (C, =NCH₂CH(OH)CH₂N=), 124.8, 127.2, 130.4, 131.8, 138.1, 141.8 (12C, Ph), 165.5 (2C, –HC=N-). [M⁺] = 424.1 *m/z*. IR: 3240 cm⁻¹ (O–H), 3040 cm⁻¹ (ArC–H), 2985–2765 cm⁻¹ (Aliphatic C–H), 1625 cm⁻¹ (C=N).

Acknowledgments: The authors are thankful to DST-FIST for providing financial support under research grant scheme Project No. SR/FST/ETT-378/2014.

Author Contributions: H.A., N.A., and A.A.A. performed the experiments; N.A.-Z. measured and analyzed the NMR; N.S. measured and analyzed the MS; M.A.-N. and I.W. wrote the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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