



Synthesis, Characterization and Crystal Structures of Hydrazone Compounds Derived from Cyanoacetohydrazide

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Received: 20 March 2014;

Accepted: 21 May 2014;

Published online: 6 November 2014;

AJC-16217

Two new hydrazone compounds, 2-cyano-*N'*-(3-ethoxy-2-hydroxybenzylidene)acetohydrazide (**1**) and 2-cyano-*N'*-(2-methoxybenzylidene)acetohydrazide (**2**), were prepared and structurally characterized by elemental analysis, IR and UV-visible spectra and single crystal X-ray determination. Compound **1** crystallizes as monoclinic space group $P2_1/c$, with unit cell dimensions $a = 19.573(7) \text{ \AA}$, $b = 9.620(4) \text{ \AA}$, $c = 13.731(5) \text{ \AA}$, $\beta = 110.372(4)^\circ$, $V = 2423.8(15) \text{ \AA}^3$, $Z = 8$, $R_1 = 0.1047$ and $wR_2 = 0.2767$. Compound **2** crystallizes as monoclinic space group $P2_1/c$, with unit cell dimensions $a = 4.503(2) \text{ \AA}$, $b = 10.066(3) \text{ \AA}$, $c = 24.435(3) \text{ \AA}$, $\beta = 95.29(2)^\circ$, $V = 1103.0(5) \text{ \AA}^3$, $Z = 4$, $R_1 = 0.0430$ and $wR_2 = 0.0978$. Crystal of the compounds are stabilized by hydrogen bonds and $\pi \cdots \pi$ interactions.

Keywords: Hydrazone, Cyanoacetohydrazide, Crystal structure, Hydrogen bonding.

INTRODUCTION

Hydrazones are a kind of compounds bearing the typical -C(O)-NH-N=CH- groups, which can easily be prepared by the condensation reactions of carbonyl-containing compounds with hydrazines. The compounds have been attracted considerable attention for their wide range of biological activities, such as antibacterial^{1,2}, antifungi³, antitumor^{4,5}, antiinflammatory^{6,7}, and cytotoxic^{8,9}. In recent years, a large number of hydrazones derived from benzohydrazides with various aldehydes have been reported¹⁰⁻¹³. However, those derived from cyanoacetohydrazide are less reported^{14,15}. In the present paper, two new hydrazone compounds, 2-cyano-*N'*-(3-ethoxy-2-hydroxybenzylidene)acetohydrazide (**1**) and 2-cyano-*N'*-(2-methoxybenzylidene)acetohydrazide (**2**), are presented.

EXPERIMENTAL

Starting materials, reagents and solvents with AR grade were purchased from commercial suppliers and used without further purification. Elemental analyses were performed on a Perkin-Elmer 24 °C elemental analyzer. IR spectra were recorded on a Jasco FT/IR-4000 spectrometer as KBr pellets in the 4000-400 cm^{-1} region. UV-visible spectra were recorded on a Lambda 900 spectrometer with methanol as solvent.

Synthesis of 2-cyano-*N'*-(3-ethoxy-2-hydroxybenzylidene)acetohydrazide (1**):** 3-Ethoxysalicylaldehyde (1 mmol, 0.166 g) and cyanoacetohydrazide (1 mmol, 0.099 g) were

mixed in methanol and stirred at room temperature for 1 h. The solvent was evaporated to obtain colourless crystalline product of **1**, which was washed with methanol and dried in air. Yield: 87 %. Single crystals of **1** suitable for X-ray diffraction were obtained by recrystallization of the product in methanol. m.p. 183-185 °C. Anal. calcd. for $C_{12}H_{13}N_3O_3$: C, 58.3; H, 5.3; N, 17.0; Found: C, 58.2; H, 5.3; N, 16.8 %. IR data (KBr, ν_{max} , cm^{-1}): 3326 (w), 3163 (w), 1679 (s), 1619 (m), 1471 (w), 1413 (m), 1370 (w), 1312 (w), 1255 (m), 1170 (w), 1051 (w), 963 (w), 755 (m), 572 (w), 540 (w).

Synthesis of 2-cyano-*N'*-(2-methoxybenzylidene)acetohydrazide (2**):** 2-Methoxybenzaldehyde (1 mmol, 0.136 g) and cyanoacetohydrazide (1 mmol, 0.099 g) were mixed in methanol and stirred at room temperature for 1 h. The solvent was evaporated to obtain colourless crystalline product of **2**, which was washed with methanol and dried in air. Yield: 79 %. Single crystals of **2** suitable for X-ray diffraction were obtained by recrystallization of the product in methanol. m.p. 149-151 °C. Anal. calcd. for $C_{11}H_{11}N_3O_2$: C, 60.8; H, 5.1; N, 19.3; Found: C, 61.0; H, 5.0; N, 19.4 %. IR data (KBr, ν_{max} , cm^{-1}): 3197 (w), 1678 (s), 1623 (m), 1475 (w), 1419 (m), 1301 (w), 1257 (m), 1034 (w), 966 (w), 755 (m), 558 (w).

Data collection, structural determination and refinement: Diffraction intensities for the compounds were collected at 298(2) K using a Bruker D8 VENTURE PHOTON diffractometer with MoK_α radiation ($\lambda = 0.71073 \text{ \AA}$). The collected

data were reduced using the SAINT program¹⁶, and multi-scan absorption corrections were performed using the SADABS program¹⁷. The structures were solved by direct methods and refined against F^2 by full-matrix least-squares methods using the SHELXTL¹⁸. All of the non-hydrogen atoms were refined anisotropically. The amino H atoms were located in difference Fourier maps and refined isotropically, with N-H distances restrained to 0.90(1) Å. All other H atoms were placed in idealized positions and constrained to ride on their parent atoms. The crystallographic data for the compounds are summarized in Table-1. Selected bond values are listed in Table-2. Hydrogen bonding information is given in Table-3.

TABLE-1
CRYSTALLOGRAPHIC AND EXPERIMENTAL
DATA FOR THE COMPOUNDS

Compound	1	2
m.f.	C ₁₂ H ₁₃ N ₃ O ₃	C ₁₁ H ₁₁ N ₃ O ₂
m.w.	247.2	217.2
T (K)	298(2)	298(2)
Crystal shape/colour	block/colourless	block/colourless
Crystal size (mm ³)	0.13 × 0.07 × 0.07	0.12 × 5.010 × 0.08
Crystal system	Monoclinic	Monoclinic
Space group	P2 ₁ /c	P2 ₁ /c
a (Å)	19.573(7)	4.503(2)
b (Å)	9.620(4)	10.066(3)
c (Å)	13.731(5)	24.435(3)
β (°)	110.372(4)	95.29(2)
V (Å ³)	2423.8(15)	1103.0(5)
Z	8	4
D _c (g cm ⁻³)	1.355	1.308
μ(MoK _α) (mm ⁻¹)	0.100	0.093
F(000)	1040	456
Reflections collected	12033	4101
Unique reflections	4261	1660
Observed reflections (I ≥ 2σ(I))	2619	1002
Parameters	335	149
Restraints	2	1
Min. and max. transmission	0.9871, 0.9930	0.9889, 0.9926
Goodness-of-fit on F ²	1.022	0.862
R ₁ , wR ₂ [I ≥ 2σ(I)] ^a	0.1047, 0.2767	0.0430, 0.0978
R ₁ , wR ₂ (all data) ^a	0.1483, 0.3143	0.0685, 0.1056
Large diff. peak and hole (eÅ ⁻³)	0.489, -0.338	0.096, -0.136

$$^a R_1 = F_o - F_c / F_o, wR_2 = [\sum w(F_o^2 - F_c^2) / \sum w(F_o^2)^2]^{1/2}$$

TABLE-2
SELECTED BOND DISTANCES (Å) AND BOND
ANGLES (°) FOR THE COMPOUNDS

Compound 1			
N1-C7	1.293(6)	N1-N2	1.379(5)
N2-C8	1.354(6)	N4-C19	1.283(6)
N4-N5	1.372(5)	N5-C20	1.339(6)
C7-N1-N2	115.5(4)	C8-N2-N1	117.4(4)
C19-N4-N5	117.1(4)	C20-N5-N4	118.6(4)
Compound 2			
N1-C8	1.275(2)	N1-N2	1.371(2)
N2-C9	1.326(2)	-	-
C8-N1-N2	113.04(17)	C9-N2-N1	122.07(16)

RESULTS AND DISCUSSION

Compounds **1** and **2** were readily synthesized by reaction of 1:1 molar ratio of cyanoacetohydrazide with 3-ethoxysalicylaldehyde and 2-methoxybenzaldehyde, respectively, in methanol at room temperature. Single crystals of the compounds, suitable for X-ray diffraction, were obtained by slow evaporation of the solutions containing the compounds in air. The compounds have been characterized by elemental analyses and IR and UV-visible spectra. Structures of the compounds were further confirmed by single crystal X-ray crystallography.

Structure description of the compounds: Figs. 1 and 2 give perspective views of compounds **1** and **2** with atomic labeling systems. X-ray crystallography reveals that the compounds are similar hydrazone species. In compound **1**, the asymmetric unit contains two independent molecules. All the hydrazone molecules of the compounds adopt E configuration with respect to the methylidene units. The distances of the methylidene bonds, ranging from 1.27 Å to 1.30 Å, confirm them as typical double bonds. The shorter distances of the C-N bonds and the longer distances of the C=O bonds for the -C(O)-NH- units than usual, suggests the presence of conjugation effects in the molecules. The remaining bond lengths in the compounds are comparable to each other and are within normal values^{14,15}.

In the crystal structure of **1**, molecules are linked through N-H...O, O-H...N, C-H...O and C-H...N hydrogen bonds, to form layers parallel to the *bc* plane (Fig. 3). In the crystal structure of **2**, molecules are linked through N-H...O and C-H...O hydrogen bonds, to form chains running along the *a*

TABLE-3
HYDROGEN BOND DISTANCES (Å) AND BOND ANGLES (°) FOR THE COMPOUNDS

D-H...A	d(D-H)	d(H...A)	d(D...A)	Angle (D-H...A)
Compound 1				
N5-H5...O6 ⁱ	0.90	2.04(3)	2.892(6)	157(6)
N2-H2...O3 ⁱⁱ	0.90	1.98(2)	2.863(5)	169(6)
O4-H4...N4	0.82	1.88	2.598(5)	145
O1-H1...N1	0.82	1.87	2.585(5)	146
C7-H7...N3 ⁱⁱ	0.93	2.57	3.430	154
C9-H9A...O3 ⁱⁱ	0.97	2.56	3.278	131
C19-H19...N6 ⁱ	0.93	2.51	3.403	160
C21-H21B...O6 ⁱ	0.97	2.56	3.212	125
Compound 2				
N2-H2...O2 ⁱⁱⁱ	0.90	1.97(1)	2.861(2)	174(2)
C10-H10B...O2 ^{iv}	0.97	2.47	3.341	150

Symmetry codes: i) 2-x, -1-y, 2-z; ii) 1-x, -1-y, -z; iii) 2-x, 3/2+y, 3/2-z; iv) -1+x, y, z

TABLE-4
PARAMETERS BETWEEN THE PLANES OF THE COMPLEX

Cg	Distance between ring centroids (Å)	Dihedral angle (°)	Perpendicular distance of Cg(I) on Cg(J) (Å)	Perpendicular distance of Cg(J) on Cg(I) (Å)
Compound 1				
Cg1-Cg2 ^v	4.912	66	-1.254	4.806
Compound 2				
Cg3-Cg3 ^{vi}	4.503	0	3.394	-3.394

Symmetry codes: (v): $x, \frac{1}{2}-y, -1/2+z$; (vi): $-1+x, y, z$. Cg1 and Cg2 are the centroids of C13-C18 and C1-C6 benzene rings of **1**. Cg3 is the centroid of C1-C6 benzene ring of **2**

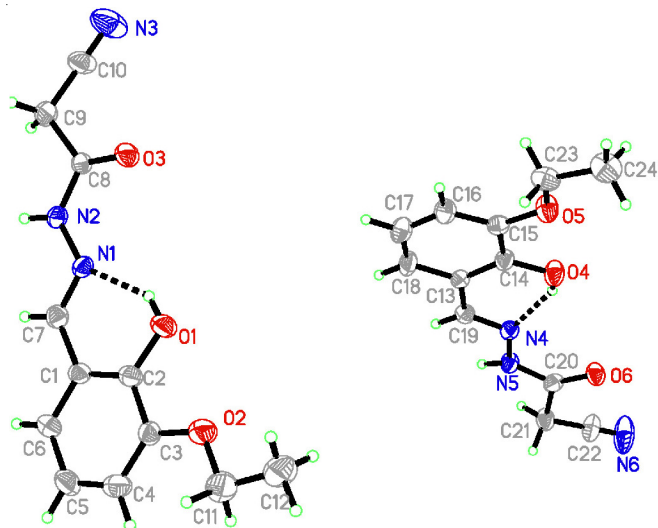


Fig. 1. A perspective view of the molecular structure of **1** with the atom labeling scheme. Thermal ellipsoids are drawn at the 30 % probability level. Hydrogen bonds are shown as dashed lines

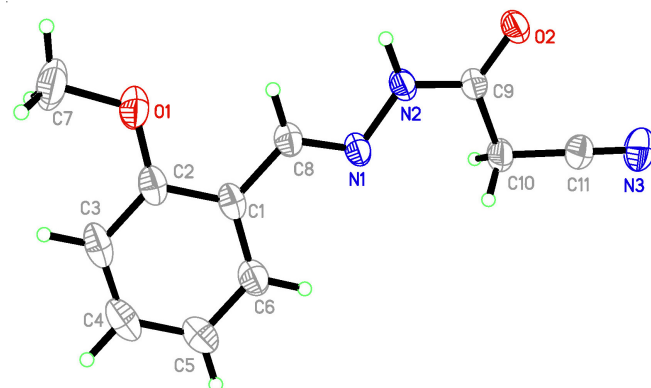


Fig. 2. A perspective view of the molecular structure of **2** with the atom labeling scheme. Thermal ellipsoids are drawn at the 30 % probability level

axis direction (Fig. 4). In addition, in both compounds, there exist $\pi\cdots\pi$ interactions (Table-4).

IR and UV-visible spectra: The characteristic intense bands at about 1678 cm^{-1} are generated by the $\nu(\text{C}=\text{O})$ vibrations, whereas the bands at about 1620 cm^{-1} are assigned to the $\nu(\text{C}=\text{N})$ vibrations. In the spectrum of **1**, there is a broad absorption centered at 3326 cm^{-1} , which can be attributed to the hydrogen-bonded phenol group. The sharp bands in the range $3200\text{--}3160\text{ cm}^{-1}$ are assigned to the $\nu(\text{N-H})$ vibrations. The methanolic solutions of the compounds with concentration of $10^{-5}\text{ mol L}^{-1}$ have been used to record the electronic spectra (Fig. 5). There are two major absorptions with the maximum

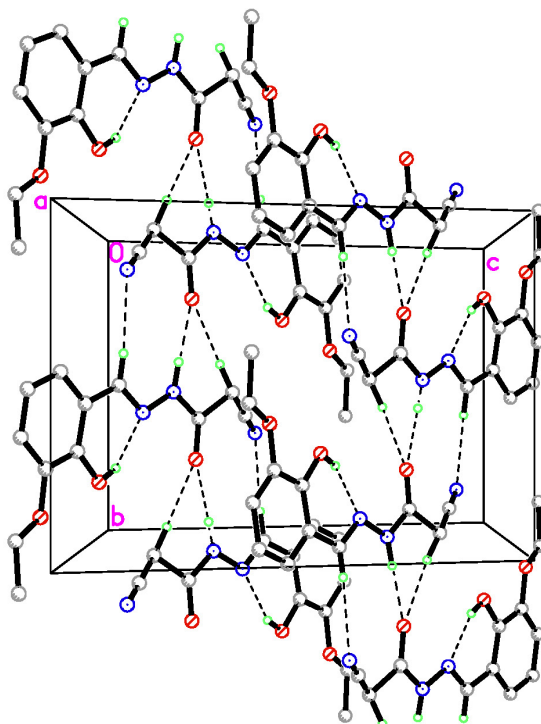


Fig. 3. Molecular packing structure of **1**, viewed along the a-axis direction. Hydrogen bonds are shown as dashed lines

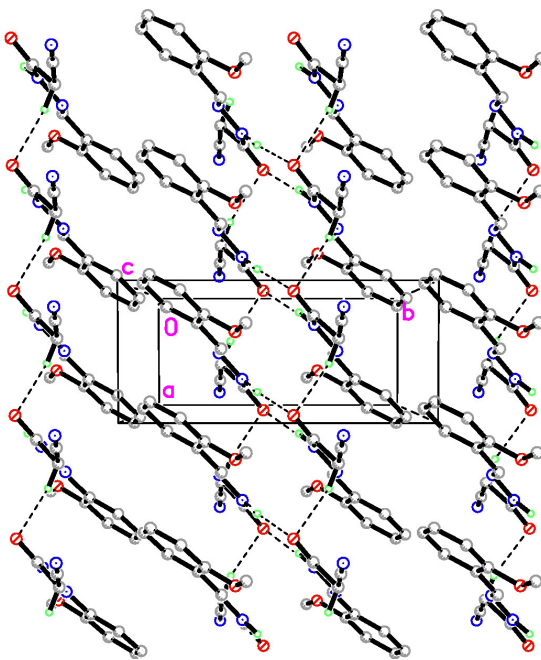


Fig. 4. Molecular packing structure of **2**, viewed along the c-axis direction. Hydrogen bonds are shown as dashed lines

absorptions at 225 and 288 nm for **1** and three major absorptions with the maximum absorptions at 213, 277 and 317 nm for **2**. The first absorption in each spectrum can be assigned to π - π^* transition and the other absorptions can be assigned to n - π^* transition.

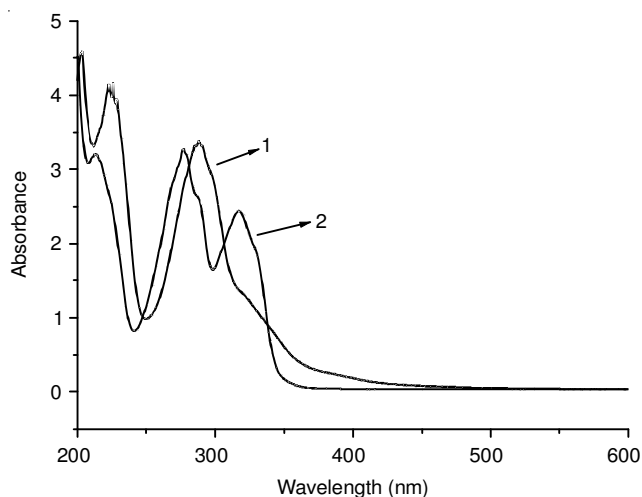


Fig. 5. UV-visible spectra of the compounds

Supplementary information: CCDC-992539 for **1** and 992540 for **2** contain the supplementary crystallographic data for this paper. These data can be obtained free of charge at <http://www.ccdc.cam.ac.uk/const/retrieving.html> or from the

Cambridge Crystallographic Data Centre (CCDC), 12 Union Road, Cambridge CB2 1EZ, UK; fax: +44(0)1223-336033 or e-mail: deposit@ccdc.cam.ac.uk.

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