

КРАТКИЕ СООБЩЕНИЯ

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CHARACTERIZATION AND CRYSTAL STRUCTURES OF SOLVATED
N'-(4-HYDROXY-3-NITROBENZYLIDENE)-3-METHYLBENZOHYDRAZIDE AND
N'-(4-DIMETHYLAMINO BENZYLIDENE)-3-METHYLBENZOHYDRAZIDE

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Two new solvated benzohydrazone derivatives *N'*-(4-hydroxy-3-nitrobenzylidene)-3-methylbenzohydrazide—methanol—water (2/1/1) $2(\text{C}_{15}\text{H}_{13}\text{N}_3\text{O}_4) \cdot \text{CH}_3\text{OH} \cdot \text{H}_2\text{O}$ (**1**) and *N'*-(4-dimethylaminobenzylidene)-3-methylbenzohydrazide methanol monosolvate $\text{C}_{17}\text{H}_{19}\text{N}_3\text{O} \cdot \text{CH}_3\text{OH}$ (**2**) are prepared and characterized by elemental analysis, ^1H and ^{13}C NMR, and single crystal X-ray diffraction. Compound **1** crystallizes in the monoclinic space group $P2_1/c$ with unit cell dimensions $a = 17.084(2) \text{ \AA}$, $b = 12.706(1) \text{ \AA}$, $c = 15.412(1) \text{ \AA}$, $\beta = 113.207(1)^\circ$, $V = 3074.1(4) \text{ \AA}^3$, $Z = 4$, $R_1 = 0.0567$, and $wR_2 = 0.1209$. Compound **2** crystallizes in the monoclinic space group $P2_1/n$ with unit cell dimensions $a = 15.058(1) \text{ \AA}$, $b = 6.658(1) \text{ \AA}$, $c = 17.211(2) \text{ \AA}$, $\beta = 94.189(2)^\circ$, $V = 1720.8(3) \text{ \AA}^3$, $Z = 4$, $R_1 = 0.0611$, and $wR_2 = 0.1594$. X-ray diffraction indicates that the asymmetric unit of **1** contains two independent benzohydrazone molecules, one methanol and one water molecules. The asymmetric unit of **2** contains one benzohydrazone molecule and one methanol molecule. Benzohydrazone molecules of the compounds display *trans* configurations with respect to the C=N double bonds. The crystal structures of the compounds are stabilized by hydrogen bonds and weak $\pi \cdots \pi$ interactions.

Key words: benzohydrazone, Schiff base, hydrogen bonding, $\pi \cdots \pi$ interaction.

Introduction. Benzohydrazone derivatives containing $-\text{CH}=\text{N}-\text{NH}-\text{C}(\text{O})-$ functional groups are quite important compounds in biological and medical chemistry [1–3]. The compounds are readily prepared by the condensation reaction between benzohydrazides and carbonyl-containing compounds. In the past decade, a number of benzohydrazone derivatives have been prepared and investigated for their structure-activity relationships [4–6]. A detailed study on the crystal structures seems to be essential for the understanding of the activities and applications of the compounds. However, to the best of our knowledge, benzohydrazone compounds derived from 3-methylbenzohydrazide have seldom been reported. In this paper, the author reports the synthesis, characterization, and crystal structures of two new solvated benzohydrazone compounds: *N'*-(4-hydroxy-3-nitrobenzylidene)-3-methylbenzohydrazide—methanol—water (2/1/1) $2(\text{C}_{15}\text{H}_{13}\text{N}_3\text{O}_4) \cdot \text{CH}_3\text{OH} \cdot \text{H}_2\text{O}$ **1** and *N'*-(4-dimethylaminobenzylidene)-3-methylbenzohydrazide methanol monosolvate $\text{C}_{17}\text{H}_{19}\text{N}_3\text{O} \cdot \text{CH}_3\text{OH}$ (**2**), derived from the reaction of 3-methylbenzohydrazide with 4-hydroxy-3-nitrobenzaldehyde and 4-dimethylaminobenzaldehyde respectively.

Experimental. Materials and measurements. 3-Methylbenzohydrazide, 4-hydroxy-3-nitrobenzaldehyde, and 4-dimethylaminobenzaldehyde were purchased from Aldrich. Methanol was commercially available and used without further purification. Elemental analyses (C, H, and N) were performed on a Perkin-Elmer 2400 CHN Elemental Analyzer. ^1H and ^{13}C NMR spectra were obtained

from solution in DMSO- d_6 with Me₄Si as the internal standard using a Bruker AVANCE 500 MHz analyzer.

Synthesis of 1. 3-Methylbenzohydrazide (1.0 mmol, 0.15 g) and 4-hydroxy-3-nitrobenzaldehyde (1.0 mmol, 0.17 g) were dissolved in methanol (20 ml). The mixture was stirred at room temperature for 30 min to give a yellow solution. After keeping the solution containing a drop of water, in air for a few days, yellow block-shaped single crystals suitable for X-ray diffraction precipitated. The crystals were isolated by filtration, washed with methanol and dried in air. Yield 0.35 g (53%). Anal. Calcd for C₃₁H₃₂N₆O₁₀: C 57.4, H 5.0, N 13.0 %; found: C 57.6, H 5.1, N 12.9 %. ¹H NMR (ppm): δ: 2.35 (s, 3H), 6.95 (d, 1H), 7.3–7.8 (m, 4H), 8.12 (s, 1H), 8.38 (s, 1H), 10.87 (s, 1H), 12.11 (s, 1H). ¹³C NMR (ppm): δ: 20.7, 116.5, 124.1, 124.6, 125.5, 128.1, 128.6, 132.3, 133.7, 135.3, 136.2, 137.5, 154.6, 167.7.

Synthesis of 2. 3-Methylbenzohydrazide (1.0 mmol, 0.15 g) and 4-dimethylaminobenzaldehyde (1.0 mmol, 0.15 g) were dissolved in methanol (20 ml). The mixture was stirred at room temperature for 30 min to give a colorless solution. After keeping the solution in air for a few days, colorless block-shaped single crystals suitable for X-ray diffraction precipitated. The crystals were isolated by filtration, washed with methanol and dried in air. Yield 0.22 g (70 %). Anal. Calcd for C₁₈H₂₃N₃O₂: C 69.0, H 7.4, N 13.4 %; found: C 68.9, H 7.4, N 13.5 %. ¹H NMR (ppm): δ: 2.35 (s, 3H), 2.83 (s, 6H), 6.62 (d, 2H), 7.3–7.8 (m, 6H), 8.11 (s, 1H), 12.23 (s, 1H). ¹³C NMR (ppm): δ: 20.7, 43.2, 113.3, 120.5, 124.3, 128.1, 128.7, 129.6, 132.2, 133.3, 137.4, 146.9, 154.1, 167.9.

X-ray crystallography. Suitable single crystals were carefully selected under a microscope. Crystal data for the two compounds were collected on a Bruker SMART APEX II-CCD diffractometer at 298(2) K using graphite monochromated MoK_α radiation ($\lambda = 0.71073 \text{ \AA}$). Cell parameters were obtained by the global refinement of the positions of all collected reflections. An empirical absorption correction was applied. The structures were solved by a direct method and refined by full-matrix least-squares on F^2 using the SHELXL-97 software [7]. All the non-hydrogen atoms were refined anisotropically. The water and amino H atoms in the compounds were located from difference Fourier maps and refined isotropically, with O—H, H \cdots H, and N—H distances restrained to 0.85(1), 1.37(2), and 0.90(1) Å respectively. The remaining H atoms were added theoretically. Some relevant crystallographic data and structure determination parameters are summarized in Table 1. Selected bond lengths and angles for the compounds are given in Tables 2. Hydrogen bonding interactions are listed in Table 3.

Results and discussion. The compounds were readily prepared by the reaction of equimolar quantities of 3-methylbenzohydrazide with 4-hydroxy-3-nitrobenzaldehyde and 4-dimethylaminobenzaldehyde respectively in methanol. The elemental analyses are in agreement with the empirical formulae given by the single crystal X-ray determination. The single crystals of **1** can be formed only with a drop of water added to the methanol solution containing the compound. The single crystals of **2** can be formed by crystallization from the anhydrous methanol solution. The compounds are soluble in methanol, ethanol, acetonitrile, and chloroform.

Crystal structure description of 1. Fig. 1 gives the perspective view of **1** with the atomic labeling system. All the bond lengths in the compound are within normal ranges [8], and are compara-

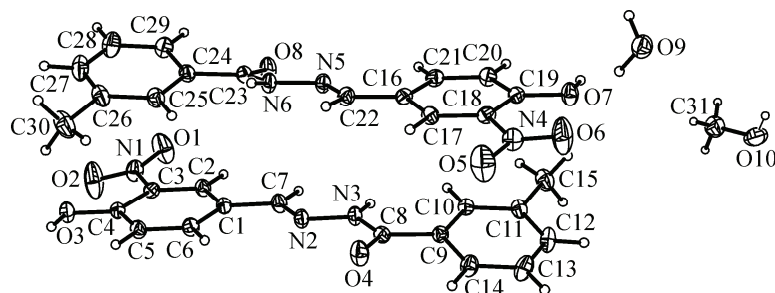


Fig. 1. Molecular structure of **1** showing 30 % probability displacement ellipsoids

ble to those of similar benzohydrazone compounds [9—12]. The C7—N2 and C22—N5 bond lengths confirm them as double bonds. The C8—N3, N3—N2, C23—N6, and N6—N5 bond lengths are relatively short, suggesting some degree of delocalization in each of the acetohydrazone systems. The dihedral angles between the two benzene rings are 14.9(3)° in one molecule and 11.8(3)° in another. The molecules exist in *trans* configuration with respect to the C=N double bonds of the central

Table 1

Crystal data for **1** and **2**

Compounds	1	2
Color / shape	Yellow / block	Colorless / block
Empirical formula	2(C ₁₅ H ₁₃ N ₃ O ₄)·CH ₃ OH·H ₂ O	C ₁₇ H ₁₉ N ₃ O·CH ₃ OH
Formula weight	648.63	313.39
Temperature, K	298(2)	298(2)
Crystal system	Monoclinic	Monoclinic
Space group	<i>P</i> 2 ₁ / <i>c</i>	<i>P</i> 2 ₁ / <i>n</i>
Unit cell dimensions <i>a</i> , <i>b</i> , <i>c</i> , Å; β, deg.	17.080(2), 12.706(1), 15.412(1); 113.207(1)	15.058(2), 6.658(1), 17.211(2); 94.189(2)
Volume, Å ³	3074.1(4)	1720.8(3)
<i>Z</i>	4	4
Density (calculated), g/cm ³	1.401	1.210
Absorption coefficient, mm ⁻¹	0.107	0.080
<i>F</i> (000)	1360	672
Crystal size, mm	0.17×0.15×0.15	0.17×0.13×0.12
θ range for data collection, deg.	2.15—27.00	2.37—24.47
Limiting indices	-19 ≤ <i>h</i> ≤ 21, -16 ≤ <i>k</i> ≤ 16, -17 ≤ <i>l</i> ≤ 19	-17 ≤ <i>h</i> ≤ 17, -7 ≤ <i>k</i> ≤ 7, -20 ≤ <i>l</i> ≤ 19
Reflections collected	17841	14219
Observed reflections [<i>I</i> ≥ 2σ(<i>I</i>)]	3480	2052
Data / restraints / parameters	6600 / 5 / 442	2835 / 1 / 216
<i>R</i> _{int}	0.0489	0.0499
Goodness-of-fit on <i>F</i> ²	1.025	1.022
Final <i>R</i> indices [<i>I</i> ≥ 2σ(<i>I</i>)]	<i>R</i> ₁ = 0.0567, <i>wR</i> ₂ = 0.1209	<i>R</i> ₁ = 0.0611, <i>wR</i> ₂ = 0.1594
<i>R</i> indices (all data)	<i>R</i> ₁ = 0.1257, <i>wR</i> ₂ = 0.1626	<i>R</i> ₁ = 0.0841, <i>wR</i> ₂ = 0.1866
Largest diff. peak and hole	0.395, -0.308	0.264, -0.182

Table 2

Selected bond lengths (Å) and angles (deg.) for **1** and **2**

Bond distances				Bond angles			
1							
C7—N2	1.268(3)	N2—N3	1.384(3)	C7—N2—N3	116.4(2)	N2—N3—C8	118.5(2)
N3—C8	1.341(3)	C8—O4	1.238(3)	N3—C8—O4	121.7(2)	N3—C8—C9	117.5(2)
C22—N5	1.272(3)	N5—N6	1.385(3)	C22—N5—N6	116.1(2)	N5—N6—C23	118.2(2)
N6—C23	1.353(3)	C23—O8	1.230(3)	N6—C23—O8	121.9(2)	N6—C23—C24	116.7(2)
2							
C9—N1	1.276(3)	N1—N2	1.382(3)	C9—N1—N2	115.5(2)	N1—N2—C10	118.5(2)
N2—C10	1.349(3)	C10—O1	1.220(3)	N2—C10—O1	121.9(2)	N2—C10—C11	116.8(2)

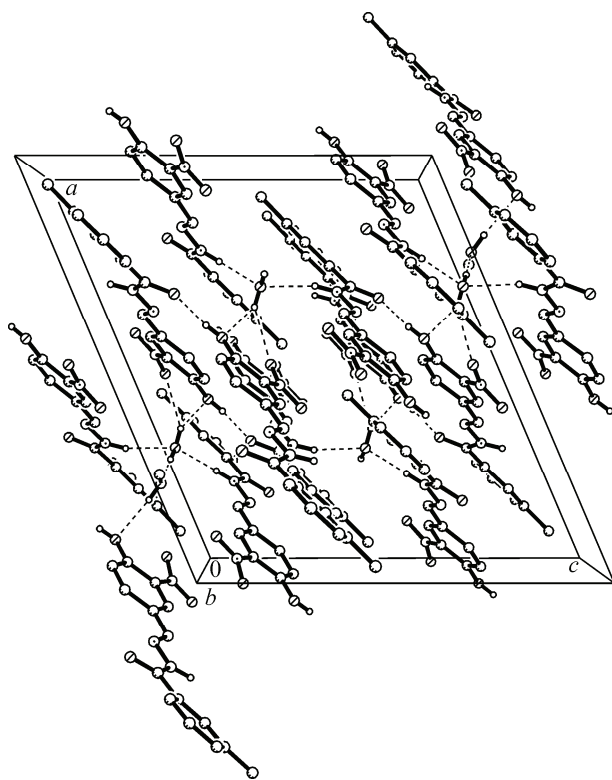
Table 3

Hydrogen-bond geometry (Å, deg.) of **1** and **2**

$D-H\cdots A$	$d(D-H)$ (Å)	$d(H\cdots A)$ (Å)	$d(D\cdots A)$ (Å)	Angle($D-H\cdots A$) (deg.)
1				
O9—H9B \cdots O7	0.85(1)	2.34(2)	3.068(3)	144(3)
O9—H9B \cdots O6	0.85(1)	2.29(2)	3.025(4)	145(3)
O9—H9A \cdots O10 ^a	0.85(1)	1.85(1)	2.700(3)	177(3)
N3—H3 \cdots O9 ^b	0.90(1)	2.207(12)	3.099(3)	170(3)
N6—H6 \cdots O9 ^c	0.90(1)	2.204(14)	3.081(3)	164(3)
O10—H10 \cdots O3 ^d	0.82	2.05	2.849(3)	166
O7—H7 \cdots N5 ^e	0.82	2.66	3.107(3)	115
O7—H7 \cdots O8 ^e	0.82	1.83	2.651(3)	173
O3—H3A \cdots N2 ^f	0.82	2.65	3.076(3)	114
O3—H3A \cdots O4 ^f	0.82	1.81	2.626(3)	172
2				
N2—H2 \cdots O2 ^g	0.90(1)	2.14(1)	3.029(3)	169(2)
O2—H2A \cdots N1	0.82	2.59	3.257(3)	140
O2—H2A \cdots O1	0.82	2.08	2.817(3)	150

Symmetry codes: ^a $x, y, -1+z$; ^b $1-x, 1/2+y, 1/2-z$; ^c $1-x, 1-y, -z$; ^d $-1+x, 3/2-y, 1/2+z$; ^e $1-x, -1/2+y, 1/2-z$; ^f $2-x, 1/2+y, 1/2-z$; ^g $x, -1+y, z$.

methylidene units. The C1—C6 benzene ring forms a dihedral angle of 13.0(3)° with the plane defined by the O1—N1—O2 nitro group. The C16—C21 benzene ring forms a dihedral angle of 8.0(3)° with



the plane defined by the O5—N4—O6 nitro group. Methanol and water molecules are linked to benzohydrazone molecules through intermolecular O—H \cdots O and N—H \cdots O hydrogen bonds.

In the crystal structure of **1**, benzohydrazone, methanol, and water molecules are linked through intermolecular O—H \cdots O, N—H \cdots O, and O—H \cdots N hydrogen bonds to form a 3D network (Fig. 2). Moreover, there are also π -electron ring— π -electron ring interactions in the structure that are specified in Table 4.

Crystal structure description of 2. Fig. 3 gives the perspective view of **2** with the atomic labeling system. All the bond lengths in the compound are within normal ranges [8], and are comparable to those of **1** and similar benzohydrazone compounds [9–12]. The C9—N1 bond length confirms it as a double bond. The

Fig. 2. Molecular packing of **1**, viewed along the b axis. Intermolecular hydrogen bonds are shown as dashed lines

Table 4

 π - π Interactions (\AA) of **1** and **2**

1				2	
$Cg1 \cdots Cg4$	3.807(2)	$Cg2 \cdots Cg3$	3.811(2)	$Cg5 \cdots Cg5^j$	3.941(2)
$Cg2 \cdots Cg4^h$	3.704(2)	$Cg3 \cdots Cg3^i$	4.829(2)	$Cg6 \cdots Cg6^k$	3.846(2)

$Cg1$, $Cg2$, $Cg3$, and $Cg4$ are the centroids of C1—C6, C9—C14, C16—C21, and C24—C29 rings, respectively, in (1). $Cg5$ and $Cg6$ are the centroids of C1—C6 and C11—C16 rings, respectively, in (2).

Symmetry codes: ^h $x, 1/2-y, -1/2+z$; ⁱ $1-x, -y, 1-z$; ^j $1-x, -y, -z$; ^k $1-x, -y, 1-z$.

C10—N2 and N2—N1 bond lengths are relatively short, suggesting some degree of delocalization in the acetohydrazide system. The dihedral angle between the two benzene rings is $10.8(3)^\circ$. The molecule exists in *trans* configuration with respect to the C=N double bond of the central methylene unit. The methanol molecule is linked to the benzohydrazone molecule through intermolecular O—H \cdots O and O—H \cdots N hydrogen bonds.

In the crystal structure of **2**, benzohydrazone molecules are linked by methanol molecules through intermolecular O—H \cdots O, N—H \cdots O, and O—H \cdots N hydrogen bonds to form chains running along the *b* axis (Fig. 4). Moreover, there are also π -electron ring— π -electron ring interactions in the structure that are specified in Table 4.

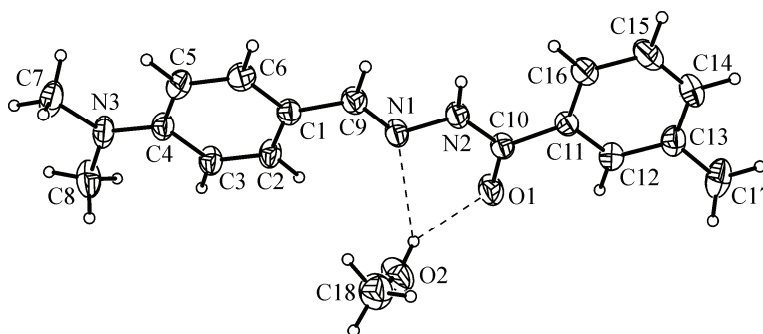


Fig. 3. Molecular structure of **2** showing 30 % probability displacement ellipsoids

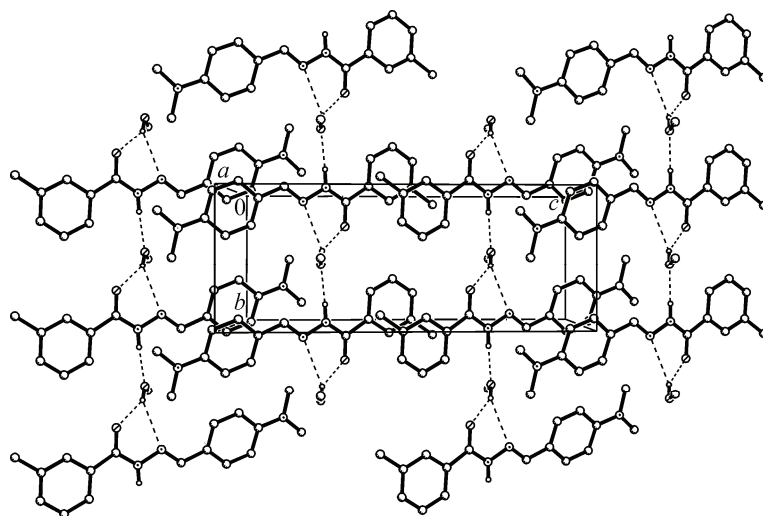


Fig. 4. Molecular packing of **2**. Intermolecular hydrogen bonds are shown as dashed lines

Supplementary material. Crystallographic data for the structures reported in this paper have been deposited with the Cambridge Crystallographic Data Centre as supplementary publication no. 874925 (1) and 874926 (2). Copies of available material can be obtained, free of charge, on application to the Director, 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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