X-ray powder diffraction data for 1-methylhydantoin, an antiasthmatic and antidepressive hydantoin compound

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X-ray powder diffraction data, unit cell parameters, and space group for 1-methylhydantoin, C4H6N2O2, are reported [$a = 5.6070(9)$ Å, $b = 12.170(1)$ Å, $c = 8.097(1)$ Å, $\beta = 105.41(1)$, $Z = 4$, unit cell volume $V = 532.66(9)$ Å^3, with M20 = 50.2 and F30 = 62.2 (0.0082, 59)]. All measured lines were indexed and are consistent with the monoclinic $P21/c$ space group.
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Key words: X-ray powder diffraction, 1-methylhydantoin, antiasthmatic, antidepressive

I. INTRODUCTION

The imidazolidine-2,4-dione, or hydantoin, is a common 5-member ring containing a reactive cyclic urea core (López and Trigo, 1985; Meusel and Gütschow, 2004). This heterocycle represents a significant molecular template in combinatorial chemistry libraries (Park *et al.*, 2001), due principally to the four possible points of substitutions. The biological activities of hydantoin derivatives have been recognized for a long time, and are responsible for a wide variety of biological behavior due principally to its wide range of therapeutic properties (Mutschler and Derendorf, 1995). The best known hydantoin, 5,5-diphenylhydantoin or phenytoin, has been the most widely used antiepileptic drug since the experimental determination of its anticonvulsant properties (Merrit and Putnam, 1938).

Particularly, 1-methylhydantoin (Figure 1) is a hydantoin produced by bacterial creatinine deaminase in the intestinal tract of uremic patients (Yang *et al.*, 2007), and was found as a metabolite of the intelligence affecting substance dupracetam, a nootropic drug from the racetam family (Baune and Renger, 2014). Recently, for this molecule has been found to have excellent antiasthmatic and antitussive effects (Han *et al.*, 2014) and antidepressant properties (You *et al.*, 2013).

For this compound, experimental and theoretical vibrational study using DFT calculation was performed (Nogueira *et al.*, 2014), and the crystal structure of 1-methylhydantoin was reported (Puszynska-Tuszkanow *et al.*, 2011), CSD-database refcode EWUVEY (Allen, 2002; CSD, 2014), crystallizing in the monoclinic space group $P2_1/c$ (No. 15). However, the only experimental pattern in the ICDD Powder Diffraction File (00-013-0685) (ICDD, 2011) no precise unit cell data, and only *d*-spacings were reported.

In continuation of our previous investigation on hydantoin derivative compounds (Delgado *et al.*, 2007, 2012, Seijas *et al.*, 2010), the present work is focused on report the spectroscopic characterization [Fourier-transform infrared (FTIR), nuclear magnetic resonance (NMR)], thermal analysis (TGA-DSC), and X-ray powder diffraction data for 1-methylhydantoin.

II. EXPERIMENTAL

1-methylhydantoin 99% was a commercial material, purchased from Aldrich Co. (M49887), and was used as-received (m.p. 156–157 °C).

A. FTIR and NMR spectroscopy

The FTIR absorption spectrum was obtained as KBr pellet using a Perkin-Elmer 1600 spectrometer. ^{1}H-NMR and ^{13}C-NMR spectra were recorded on a Bruker Avance 400 model spectrometer in DMSO-d_6 solution. Infrared spectrometry showed stretching vibrations; 3439.0 cm^{-1} [t, N-H], 3428.5 cm^{-1} [t, N-H], 1768.6 cm^{-1} [t, C = O], 1707.9 cm^{-1} [t, C = O], 1500.1 cm^{-1} [t, N-H], 1454.4 [t, C-N], and NMR; ^{1}H NMR (400 MHz, DMSO-d_6) $\delta = 10.69$

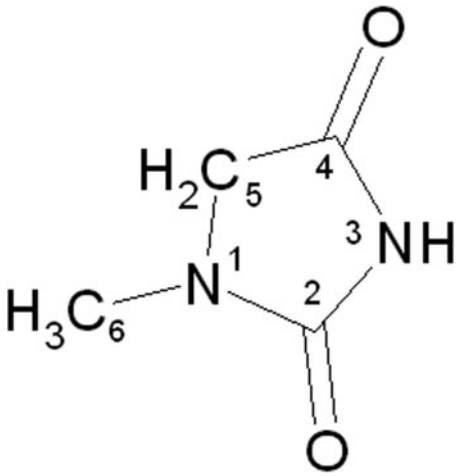

Figure 1. Structural formula of 1-methylhydantoin. Ring atoms are numbered 1-5.

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TABLE I. X-ray powder diffraction data of 1-methylhydantoin.

$2\theta_{obs}$ (°)	d_{obs} (Å)	$(I/I_o)_{obs}$	h	k	l	$2\theta_{cal}$ (°)	d_{cal} (Å)	$\Delta 2\theta$ (°)
13.460	6.5727	40.9	0	1	1	13.464	6.5706	0.004
14.541	6.0863	3.8	0	2	0	14.544	6.0850	0.003
16.386	5.4050	10.1	1	0	0	16.385	5.4054	−0.001
17.945	4.9387	5.4	−1	1	0	17.940	4.9400	−0.005
18.474	4.7985	29.2	0	2	1	18.472	4.7991	−0.003
22.662	3.9203	20.1	−1	2	1	22.659	3.9209	−0.003
23.499	3.7825	2.2	1	1	1	23.515	3.7801	0.015
24.295	3.6604	42.2	−1	0	2	24.302	3.6593	0.007
24.700	3.6013	3.5	0	3	1	24.712	3.5996	0.012
25.381	3.5062	100.0	−1	1	2	25.394	3.5043	0.013
27.109	3.2865	14.4	0	2	2	27.119	3.2853	0.010
27.454	3.2459	6.9	−1	3	0	27.466	3.2446	0.012
28.427	3.1371	74.0	−1	2	2	28.437	3.1360	0.010
29.314	3.0441	3.0	0	4	0	29.330	3.0425	0.015
32.474	2.7547	1.5	1	1	2	32.478	2.7544	0.004
32.934	2.7173	3.3	−1	3	2	32.935	2.7172	0.001
33.116	2.7027	4.3	2	0	0	33.117	2.7027	0.001
34.238	2.6167	2.9	−1	4	1	34.241	2.6165	0.003
34.813	2.5748	13.2	−1	1	3	34.819	2.5744	0.006
35.768	2.5082	8.1	−2	1	2	35.764	2.5085	−0.004
			−1	2	3	37.163	2.4172	−0.002
37.165	2.4171	4.8						
			1	4	1	37.176	2.4164	
37.558	2.3927	1.1	0	2	3	37.562	2.3925	0.004
38.463	2.3384	0.8	−1	4	2	38.445	2.3395	−0.018
			0	5	1	38.718	2.3236	0.015
38.703	2.3245	1.1						
			2	1	1	38.723	2.3233	
39.096	2.3020	1.0	−2	3	1	39.116	2.3009	0.020
40.626	2.2188	1.1	−1	5	0	40.615	2.2194	−0.011
40.884	2.2054	1.2	2	2	1	40.874	2.2059	−0.010
41.188	2.1898	1.0	0	3	3	41.180	2.1902	−0.008
41.941	2.1522	1.3	−2	1	3	41.930	2.1528	−0.011
43.572	2.0754	1.6	1	5	1	43.558	2.0760	−0.014
			−2	2	3	43.951	2.0583	−0.004
43.955	2.0582	1.4						
			−2	4	1	43.963	2.0578	
			0	6	0	44.636	2.0283	0.004
44.632	2.0285	3.0						
			−1	5	2	44.676	2.0266	
			−1	0	4	44.960	2.0145	−0.008
44.967	2.0141	1.6						
			1	2	3	44.988	2.0133	
			2	0	2	45.583	1.9884	0.017
45.565	1.9891	1.0						
			−1	1	4	45.606	1.9874	
45.868	1.9767	1.0	0	4	3	45.848	1.9775	−0.019
			0	1	4	47.123	1.9269	
47.174	1.9249	1.0						
			−2	3	3	47.167	1.9252	−0.008
			2	2	2	48.100	1.8900	0.000
48.100	1.8900	1.0						
			1	3	3	48.149	1.8882	
			−3	0	2	49.738	1.8316	−0.015
49.753	1.8310	0.7						
			−2	0	4	49.793	1.8297	
			2	5	0	50.412	1.8086	
50.451	1.8073	1.0						
			1	6	1	50.465	1.8069	0.013
51.459	1.7743	1.2	−1	6	2	51.466	1.7740	0.007
51.753	1.7649	1.9	−2	5	2	51.745	1.7651	−0.008
			−3	2	2	52.104	1.7538	
52.152	1.7523	2.2						
			−2	2	4	52.156	1.7522	0.005
			1	0	4	53.982	1.6971	
53.990	1.6969	0.9	0	7	1	53.988	1.6970	−0.002
			2	5	1	53.992	1.6969	
55.012	1.6678	4.9	−2	3	4	55.009	1.6679	−0.003
			0	4	4	55.927	1.6426	
55.959	1.6418	1.5						
			−2	6	1	55.975	1.6414	0.016
57.559	1.5999	1.3	0	6	3	57.566	1.5997	0.007
			−3	4	2	58.795	1.5692	
58.852	1.5678	0.9						
			−2	4	4	58.844	1.5680	−0.008

(s, CH_3), $\delta = 3.91$ (s, CH_2), $\delta = 2.79$ (s, NH). ^{13}C NMR (100.6 MHz, DMSO-d_6) $\delta = 171.67$ (**C**2), 157.00 (**C**4), $\delta = 52.41$ (**C**5), 28.65 (**C**6).

B. Thermal analysis

Thermal analysis of 1-methylhydantoin was performed in a thermal analyzer SDT Q600. Sample, 7.56 mg, was heated from 25 to 600 °C at a rate of 10 °C min^{-1}, under a nitrogen flux of 100 ml min^{-1}. A sharp endothermic peak observed at 156.6 °C corresponds to melting of the compound. The hydantoin compound decomposed completely at 242.7 °C.

C. X-ray powder diffraction data

For the X-ray analysis, a small quantity of the sample was ground mechanically in an agate mortar and pestle. The resulting fine powder, sieved to 106 μm, was mounted on a flat zero-background holder covered with a thin layer of petroleum jelly. The X-ray powder diffraction data was collected at room temperature 293(1) K, in θ/θ reflection mode using a Philips diffractometer with PW-1150/25 goniometer and monocromatized Cu$K\alpha$ radiation ($\lambda = 1.5418$ Å). The diffractometer was operated at 40 kV and 25 mA. The specimen was scanned from 5° to 60°2θ, with a step size of 0.02° and counting time of 10 s per step. Silicon (SRM 640) was used as an external standard. The software package HIGHSCORE PLUS V2.0 (PANalytical, Almelo, Netherlands) was used to

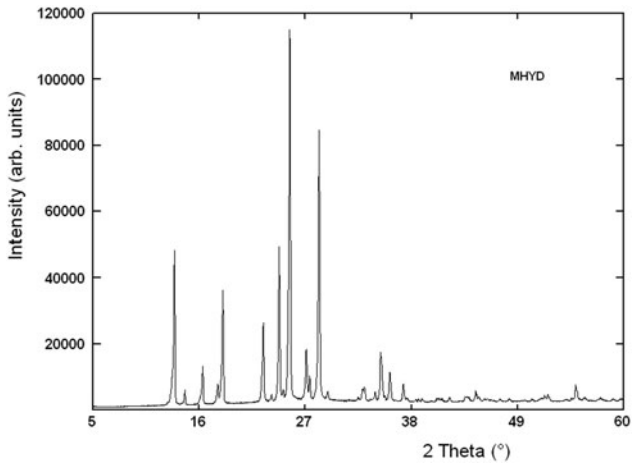

Figure 2. X-ray powder diffraction pattern of 1-methylhydantoin.

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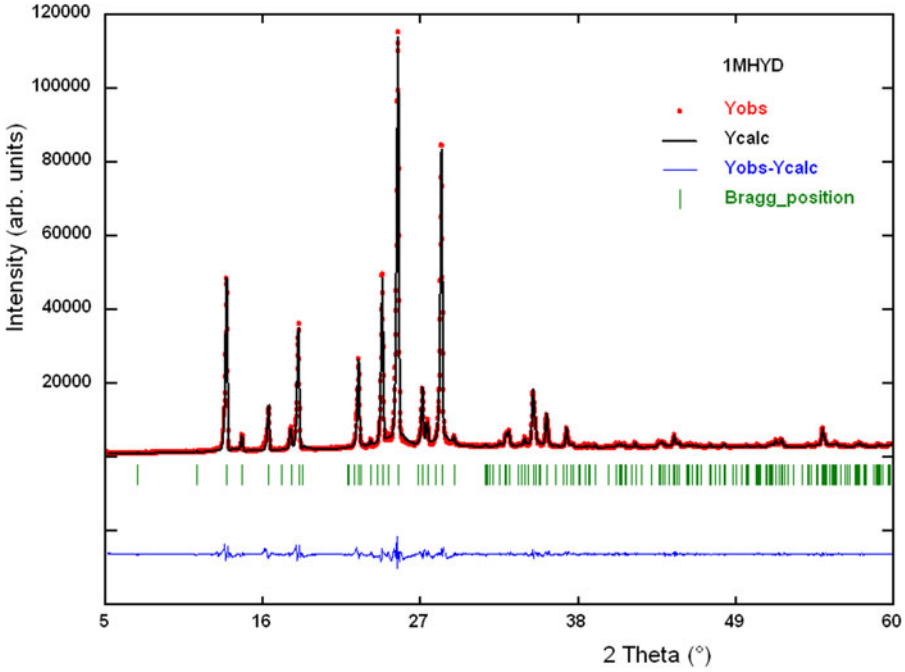

Figure 3. (Color online) Le Bail refinement of 1-methylhydantoin.

eliminate the $K\alpha_2$ component, establish the positions of the peaks and to determine the peak intensities of the diffraction peaks.

III. RESULTS AND DISCUSSION

The X-ray powder pattern of 1-methylhydantoin is shown in Figure 2. The 20 first peak positions were indexed using the program DICVOL06 (Boultif and Louër, 2004), which gave a unique solution in a monoclinic cell. This result confirms the crystal structure reported (Puszynska-Tuszkanow *et al.*, 2011). The complete powder diffraction dataset was reviewed in the monoclinic space group $P2_1/c$ (No. 15), using the program NBS*AIDS83 (Mighell *et al.*, 1981). All measured lines were indexed and were consistent with the mentioned space group. From this analysis, the refined unit cell parameters obtained were: $a = 5.6070(9)$ Å, $b = 12.170(1)$ Å, $c = 8.097(1)$ Å, $\beta = 105.41(1)$, $V = 532.66(9)$ Å^3, $Z = 4$, with figures of merit $M_{20} = 50.2$ (de Wolff, 1968) and $F_{30} = 62.2$ (0.0082, 59) (Smith and Snyder, 1979). The resulting X-ray powder diffraction data for 1-methylhydantoin, together with the observed and calculated 2θ, the d-spacing's as well as the relative intensities of the reflections, are given in Table I. In order to confirm the unit cell parameters, a Le Bail refinement (Le Bail, 2005) was carried out using the FULLPROF program (Rodríguez-Carvajal, 2014). Figure 3 shows the very good fit between the observed and calculated patterns.

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SUPPLEMENTARY MATERIALS AND METHODS

The supplementary material for this article can be found at http://www.journals.cambridge.org/PDJ.

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