



# The X-ray Structure of 4-Aminobenzyl alcohol (4-Aminophenylmethanol)

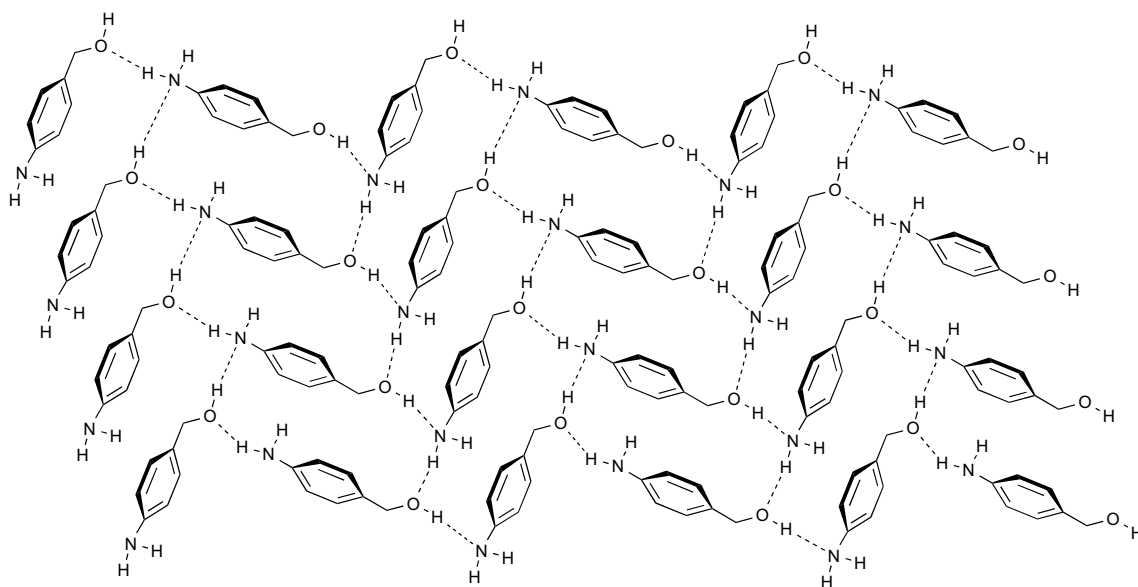
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## Abstract

A second polymorph of 4-aminobenzyl alcohol [orthorhombic,  $a = 8.95051(15)$ ,  $b = 5.8248(1)$ ,  $c = 12.1645(2)$  Å, space group  $Pna2_1$ ] shows a “herringbone” structure with stacks of hydrogen-bonded molecules when viewed down the  $b$ -axis.

## Graphical Abstract



A new polymorph of 4-aminobenzyl alcohol adopts a “herringbone” structure with stacks of hydrogen bonded molecules viewed down the  $b$ -axis.

**Keywords** 4-Aminobenzyl alcohol · Hydrogen bonding · Herringbone structure

## Introduction

In connection with current studies on functionalised analogues of azophenine, we recently prepared 4-aminobenzyl alcohol **1**. Although this compound was first reported in 1895 [1], we initially believed that its X-ray structure had not hitherto been determined. The combination of amino and hydroxyl groups with a benzene ring gives interesting opportunities for the formation of hydrogen-bonded networks and

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such features have already been noted for both the *meta*-isomer **2** [2] and the *ortho*-isomer **3** [3]. In addition, hydrogen-bonding patterns in structures of the closely related *ortho*-, *meta*- and *para*-hydroxybenzyl alcohols **4–6** have been examined in detail [4, 5] (Scheme 1). We determined the X-ray structure and, at that stage, found a previously published structure [6] but the two were markedly different. In this paper, we describe the crystal and molecular structure of the new polymorph of **1** and compare the observed hydrogen-bonding patterns with those for the originally reported polymorph and related compounds.

## Experimental

4-Nitrobenzyl alcohol (20 g, 0.12 mol) was added to a boiling suspension of zinc dust (80 g, 1.22 mol) and calcium chloride (8 g, 0.07 mol) in water (400 mL). The resulting solution was boiled for 30 min and then filtered hot. On cooling the filtrate, a reddish solid appeared and this was filtered off and discarded. Sodium carbonate was then added to the filtrate to precipitate the calcium salts, which were then filtered off. The filtrate was evaporated down to dryness. The resulting oil was then recrystallized from toluene to afford a pale yellow solid (3.69 g, 23%) m.p. 60–61 °C, (lit. [7] 58–61 °C).

$\delta_{\text{H}}$  (Bruker AV400, 400 MHz,  $\text{CDCl}_3$ ) 7.18 (2H, d,  $J=8.5$  Hz, ArH) 6.69 (2H, d,  $J=8.5$  Hz, ArH), 4.57 (2H, s,  $\text{CH}_2\text{OH}$ ) and 3.65 (2H, s,  $\text{NH}_2$ ) (agreement with lit. values [8]).

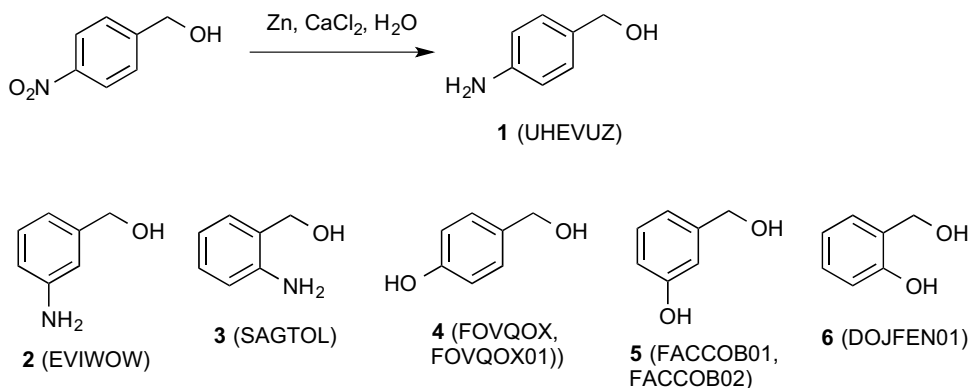
Data were collected using a Rigaku XtaLAB P200 and a Mercury CCD (confocal optics Cu-K $\alpha$  radiation) at 125 K. Intensity data were collected using  $\omega/\phi$  steps accumulating area detector frames spanning at least a hemisphere of reciprocal space (data were integrated using CrystalClear). All data were corrected for Lorentz, polarisation and long-term intensity fluctuations. Absorption effects were corrected on the basis of multiple equivalent reflections. The structure was solved by direct methods and refined by full-matrix

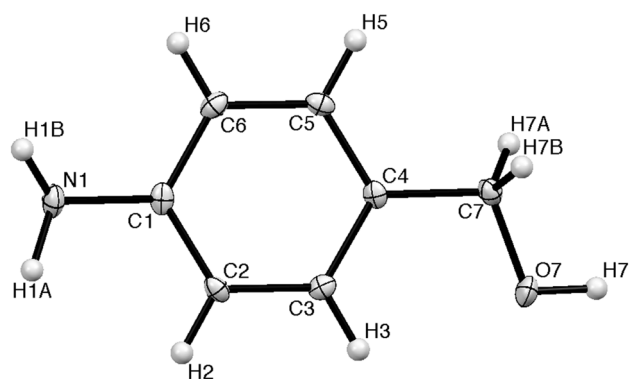
least-squares against  $F^2$  (SHELXTL [9]). Carbon-bound hydrogen atoms were assigned riding isotropic displacement parameters and constrained to idealised geometries while OH and NH hydrogen atoms were refined freely. Table 1 summarises the X-ray data.

**Table 1** Crystal data and structure refinement details for **1**

|                                              |                                                                                                     |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------|
| CCDC deposit no.                             | 1566675                                                                                             |
| Empirical formula                            | $\text{C}_7\text{H}_9\text{NO}$                                                                     |
| Formula weight                               | 123.15                                                                                              |
| Crystal system                               | Orthorhombic                                                                                        |
| Space group                                  | $Pna2_1$                                                                                            |
| Temperature (K)                              | 125(1)                                                                                              |
| Crystal form                                 | Colourless plate                                                                                    |
| Unit cell dimensions                         | $0.15 \times 0.15 \times 0.02$ mm<br>$a = 8.95051(15)$ Å<br>$b = 5.8248(1)$ Å<br>$c = 12.1645(2)$ Å |
| Volume (Å <sup>3</sup> )                     | 634.19(2)                                                                                           |
| $Z$                                          | 4                                                                                                   |
| $D_c$ (g cm <sup>-3</sup> )                  | 1.290                                                                                               |
| Absorption coefficient                       | $0.703 \text{ mm}^{-1}$                                                                             |
| Radiation type, wavelength                   | Cu K $\alpha$ , 1.54187 Å                                                                           |
| $F_{(000)}$                                  | 264                                                                                                 |
| $\theta$ range                               | $7.28^\circ$ – $75.31^\circ$                                                                        |
| Limiting indices                             | $-11 \leq h \leq 11$ ,<br>$-6 \leq k \leq 7$ ,<br>$-15 \leq l \leq 14$                              |
| Reflections collected/unique                 | 6342/1280                                                                                           |
| $R_{\text{int}}$                             | 0.0188                                                                                              |
| Data/restraints/parameters                   | 1280/4/95                                                                                           |
| Data with $I > 2\sigma(I)$                   | 1279                                                                                                |
| Goodness of fit on $F^2$                     | 1.035                                                                                               |
| $R_1, wR_2$ [data with $I > 2\sigma(I)$ ]    | 0.0608, 0.1293                                                                                      |
| $R_1, wR_2$ (all data)                       | 0.0611, 0.1294                                                                                      |
| Largest diff. peak/hole (e Å <sup>-3</sup> ) | 0.39 and $-0.53$                                                                                    |
| Flack parameter                              | 0.03(9)                                                                                             |

**Scheme 1** Synthetic route used to compound **1**, and structures of related compounds **2–6** with CCDC Ref Codes





**Fig. 1** The molecular structure of the new polymorph of **1** showing numbering system used

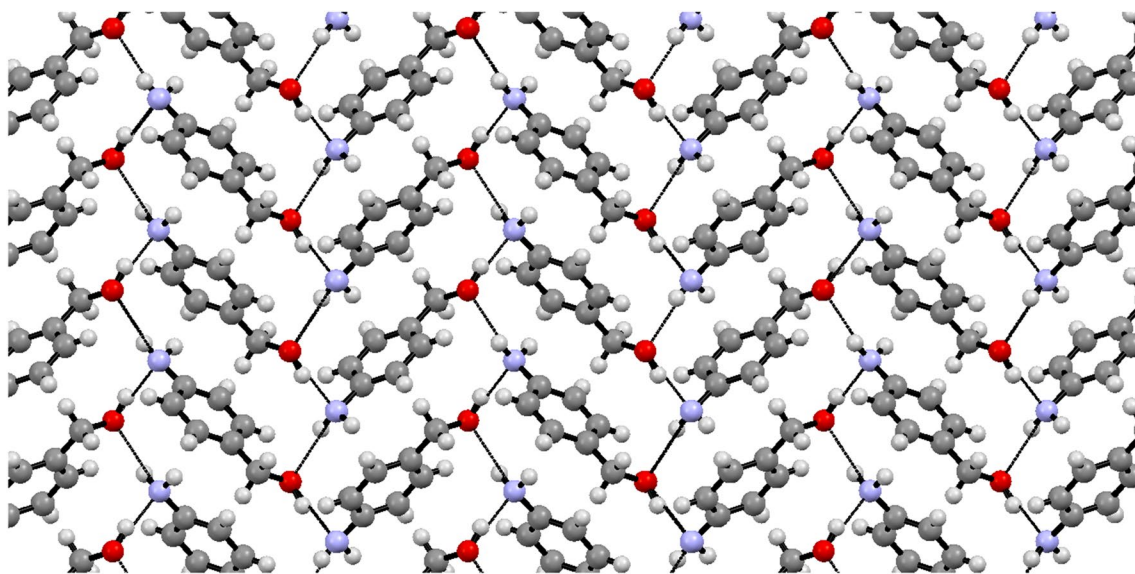
**Table 2** Bond lengths for **1**

| Bond       | Length (Å) |
|------------|------------|
| C(7)–O(7)  | 1.421(4)   |
| O(7)–H(7)  | 0.980(7)   |
| C(1)–N(1)  | 1.417(2)   |
| N(1)–H(1A) | 0.976(7)   |
| N(1)–H(1B) | 0.976(7)   |
| C(1)–C(2)  | 1.394(3)   |
| C(1)–C(6)  | 1.400(2)   |
| C(2)–C(3)  | 1.390(3)   |
| C(3)–C(4)  | 1.396(2)   |
| C(4)–C(5)  | 1.398(3)   |
| C(4)–C(7)  | 1.510(2)   |
| C(5)–C(6)  | 1.395(3)   |

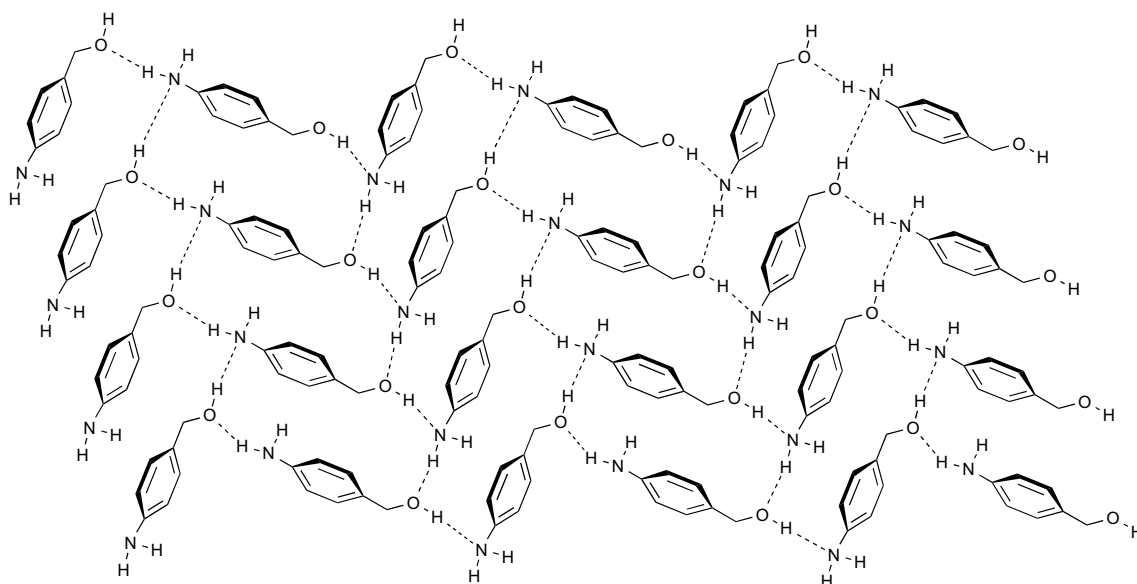
## Results and Discussion

We first attempted to prepare **1** by reduction of the readily available ethyl 4-aminobenzoate (benzocaine) using lithium aluminium hydride. Although this reaction does not appear to have been reported, the closely related reduction of methyl 4-aminotetradecuteriobenzoate with  $\text{LiAlD}_4$  is reported to afford the hexadeuteriated 4-aminobenzyl alcohol in 47% yield [10]. However in our hands the ethyl ester was recovered completely unchanged after prolonged boiling with a large excess of  $\text{LiAlH}_4$  in either diethyl ether or THF. We deduce that binding of the amino group to aluminium occurs and inhibits reduction. We therefore reverted to the original 1895 synthesis [1], and found that treatment of 4-nitrobenzyl alcohol with zinc dust in the presence of calcium chloride in boiling water gave the product in acceptable yield and in good purity after recrystallization from toluene. The crystals obtained were directly suitable for X-ray diffraction and the molecular structure of **1** is shown in Fig. 1.

The molecular structure has bond lengths (Table 2) and angles that are unremarkable but the crystal structure is much more interesting with a regular “herringbone” pattern featuring stacks of hydrogen-bonded molecules. A section of the structure viewed along the *b*-axis is shown in Fig. 2 and the equivalent schematic representation is in Fig. 3. Each OH and  $\text{NH}_2$  group is involved in one donor and one acceptor interaction, with the oxygen lone pair interacting with an NH and the nitrogen lone pair interacting with an OH. One NH in each molecule is not involved in hydrogen bonding but appears to interact with the  $\pi$ -electrons of a



**Fig. 2** Hydrogen bonding pattern in the crystal structure of **1** viewed along the *b*-axis



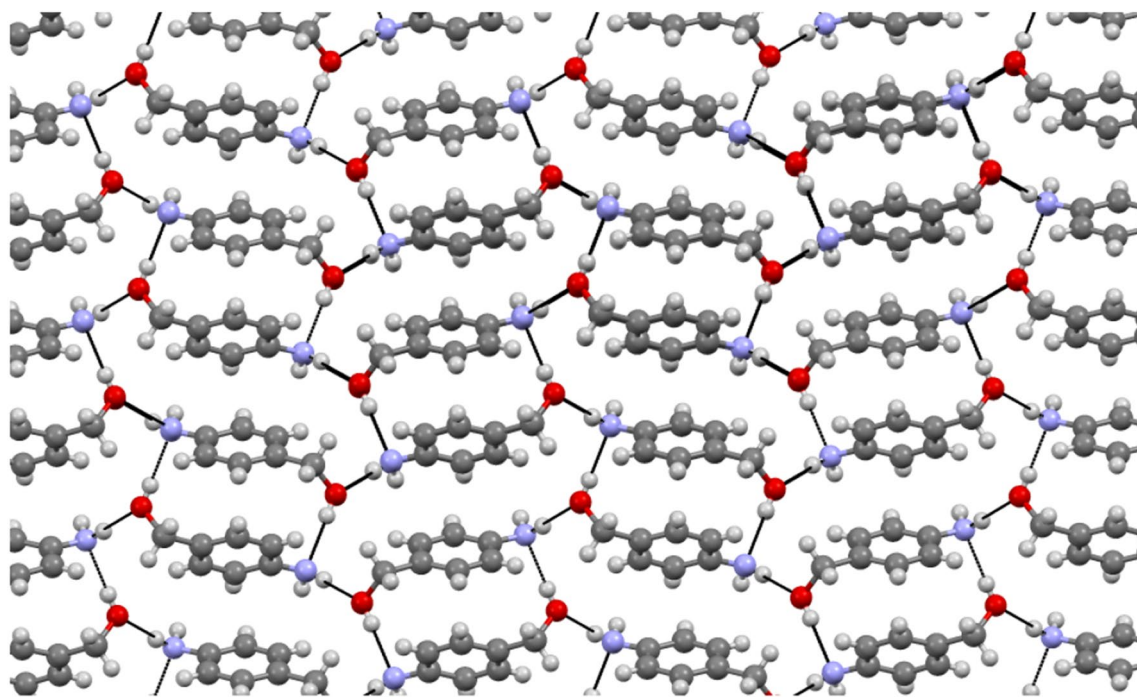
**Fig. 3** Schematic hydrogen bonding pattern in the crystal structure of **1**

**Table 3** Geometric parameters for intermolecular hydrogen bonding in **1**

| D–H···A           | d(D···A) | d(D–H)  | d(H···A) | <(D–H···A) |
|-------------------|----------|---------|----------|------------|
| O(7)–H(7)···N(1)  | 2.845(2) | 0.98(3) | 1.89(4)  | 165(3)     |
| N(1)–H(1B)···O(7) | 3.040(2) | 0.98(2) | 2.14(2)  | 153(2)     |

benzene ring. The geometric parameters for this pattern are given in Table 3.

The hydrogen-bonding pattern is remarkably different from those involved for the previously reported structure of **1** [6], and the other isomers **2** and **3**. We attribute the isolation of a second form of **1** to recrystallization of our sample



**Fig. 4** Hydrogen bonding pattern in the previously reported polymorph of **1** viewed along the *c* axis [6]

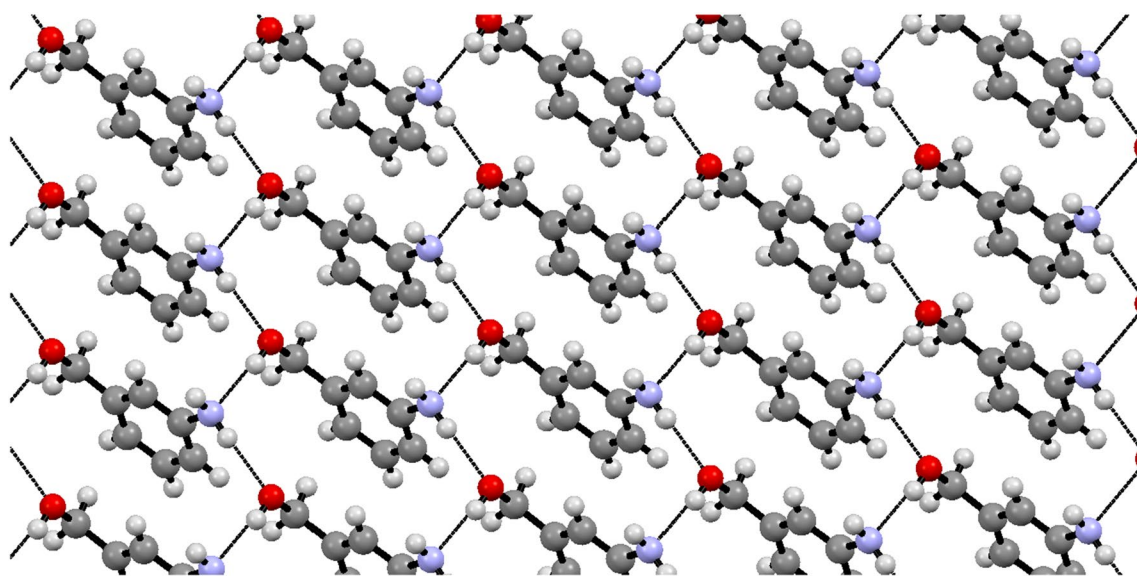


Fig. 5 Hydrogen bonding pattern in the crystal structure of **2** [2]

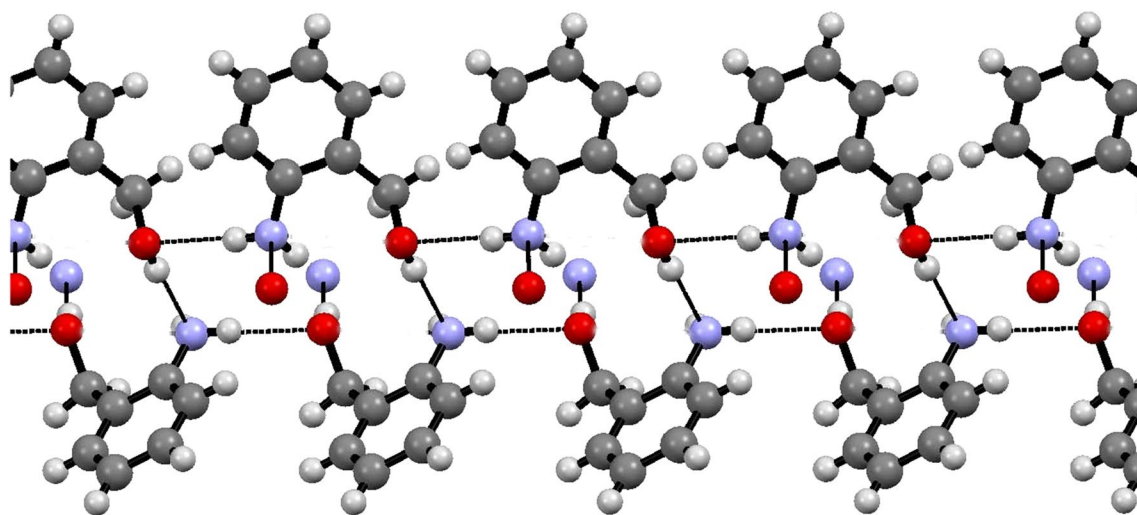


Fig. 6 Hydrogen bonding pattern in the crystal structure of **3** [3]

from toluene which apparently gives a new polymorph. The literature structure used commercially available material with no indication of the recrystallization solvent (if any) in its manufacture. The two polymorphs of **1** differ most obviously in that the previous structure is centrosymmetric with head-to-tail hydrogen bonded dimers which are then linked by further hydrogen bonding interactions in chains (Fig. 4). As is the case for our structure, each OH and NH is involved in one donor and one acceptor interaction with one NH not involved in hydrogen bonding. For the *meta*-isomer **2** [2], each OH and NH<sub>2</sub> group is again involved in one donor and one acceptor interaction, with the oxygen lone pair interacting with an NH and the nitrogen lone pair interacting with

an OH, but the molecules are all aligned in the same orientation (Fig. 5). In the *ortho*-isomer **3** [3], the molecules are arranged in antiparallel lines with an oxygen lone pair to NH interaction linking adjacent molecules within the line and one nitrogen lone pair to OH interaction per pair of molecules linking the two lines in centrosymmetric dimers (Fig. 6). The remaining nitrogen lone pair to OH interactions then link to further lines of molecules behind and in front of the plane giving an infinite layer with a hydrogen bonded interior and hydrophobic exterior.

Comparison with the structures adopted by the isomeric hydroxybenzyl alcohols **4–6** [4] is also interesting. The structures adopted by the two *ortho*-isomers **3** and **6** are

closely analogous with centro-symmetric dimers involved in further hydrogen bonding in each case, while for the two *meta*-isomers, **2** and **5**, there is again a good degree of similarity, with molecules all aligned in the same way and connected in a two-dimensional hydrogen bonded network. When we come to the *para*-isomers **1** and **4** however, the situation differs markedly. Although each hydrogen bonded group is involved in one acceptor and one donor interaction in both structures, the herringbone pattern of **1** is replaced in **4** by a three-dimensional hydrogen bonded network featuring spirals of molecules along the *c*-axis with a four molecule repeat unit.

## Conclusion

The crystal structure for this new polymorph of **1** is quite different from the previous polymorph and those previously reported for the isomers **2** and **3**. It also differs markedly from that of the closely similar hydroxy analogue **4**. Despite significant progress in being able to predict the X-ray structures of simple aromatic compounds containing OH and NH<sub>2</sub> groups [11], it is clear that further work is required to fully understand the forces that determine the structure adopted in a given case.

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