



Molecular structure elucidation and hydrogen bonding analysis of a pyrazolone derivative

Rajnikant^{†#}, Sarita Parihar[†], Sabeta Kohli[†], Sakshi Sharma[†], B. Narayana^{*} and S. Samshuddin^{*}

[†]Laboratory for X-ray Crystallography, Post- Graduate Department of Physics, University of Jammu, Jammu Tawi - 180 006, INDIA

^{*}Department of Studies in Chemistry, University of Mangalore, Mangalagangothri, Mangalore- 574 199, INDIA

[#]Corresponding author . E-mail: rk_paper@rediffmail.com

Abstract: The title compound crystallizes in the monoclinic crystal system with space group $P2_1/c$ having unit cell parameters: $a=7.6329(4)$, $b=7.8137(4)$, $c=28.0651(14)$ Å, $\beta=95.995^\circ$. The structure converges to a final R-value of 0.0563. The two C-N bonds in Ring B are puckered as the torsion around these bonds is $29.67(2)^\circ$ and $-18.49(2)^\circ$, respectively. The two methyl carbons as well as the oxygen atom of the central N-containing five-membered ring (B) are significantly deviated from their mean positions. The magnitude of dihedral angle between the phenyl ring A and B is $133.09(1)^\circ$ while it is $170.43(1)^\circ$ between ring B and the phenyl ring C. This indicates that the molecule adopts a non-planar configuration. The crystal structure is stabilized by few C-H...O and C-H...N inter and intramolecular hydrogen interactions.

Keywords: Crystal structure, Pyrazolone, Dihedral angle, Hydrogen bonding

INTRODUCTION

Pyrazolones are well known elicitors of hypersensitivity and also exhibit broad spectrum of biological activities such as *analgesic*, *antipyretic* and *anti-inflammatory* therapeutical drugs (Al-Haiza *et al.*, 2001; Himly *et al.*, 2003). In view of the biological importance of these derivatives, we report X-ray structure of the title compound with particular emphasis on hydrogen bonding analysis.

MATERIALS AND METHODS

4-Amino-1,5-dimethyl-2-phenyl-1,2-dihydro-3H-pyrazol-3-one [2.03g, 0.01mol and 3-nitrobenzaldehyde(1.51g, 0.01mol)] was refluxed in 30 ml ethanol with two drops of dilute HCl for 6 hours. The crude product obtained was filtered and recrystallized from ethanol. Good quality crystals were obtained by evaporation of the solution in ethyl methyl ketone. (m.p. 491-493K). Composition for $C_{18}H_{16}N_4O_3$: C: 64.22(64.28); H: 4.76(4.79); N: 16.61(16.66). The compound has a molecular formula $C_{18}H_{16}N_4O_3$ and its molecular weight is 336.35. The chemical structure of the title compound as established on the basis of chemical studies is shown in Fig. 1.

A single crystal having well-defined morphology was selected for three-dimensional crystal intensity data collection on a computer-controlled single crystal X-ray diffractometer having CCD camera (*X'calibur system – Oxford diffraction-make*) by using $MoK\alpha$ radiation ($\lambda = 0.71073\text{Å}$). CrysAlis^{Pro} (2007) software was used for data

collection and CrysAlis^{RED} (2007) software was used for data reduction. A total number of 9491 reflections were recorded of which 5319 reflections were found unique having index range: $-11 \leq h \leq 10$, $-11 \leq k \leq 11$, $-37 \leq l \leq 40$.

The structure of the title compound was obtained by employing direct methods using SHELXS86 (1986) software. All non-hydrogen atoms of the molecule were located from the E-map (electron density map). Refinement was carried out by full-matrix least-squares method on F^2 using SHELXL97 (1997) software. The anisotropic refinements with thermal parameters for non-hydrogen atoms and subsequent refinement cycles converged the R-factor to 0.0563. The maximum and minimum residual electron density is 0.302 and -0.226 $e.\text{Å}^{-3}$, respectively. The crystallographic data are listed in Table 1.

RESULTS AND DISCUSSION

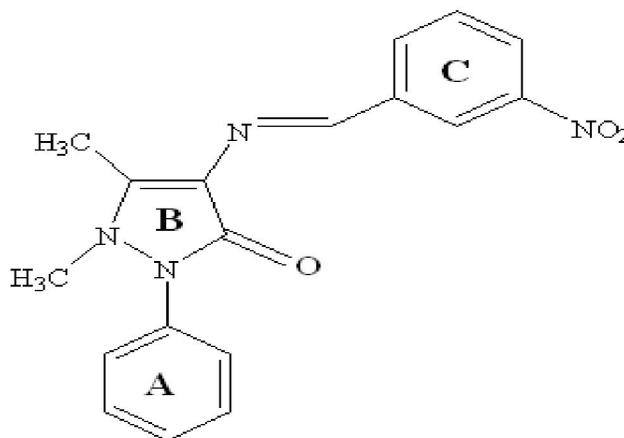
The final atomic coordinates and equivalent isotropic thermal factors for all the non-hydrogen atoms are listed in Table 2. Bond distances and bond angles for non-hydrogen atoms are listed in Table 3. Torsion angles for non-hydrogen atoms are listed in Table 4. An ORTEP view of the molecule indicating atomic numbering scheme (thermal ellipsoids drawn at 50% probability level) is shown in Fig. 2 (Farrugia, 1997). The geometrical calculations have been performed using PARST (Nardelli, 1995) program.

The molecule comprises of two six-membered rings and

Table 1. Crystal data and structure refinement details.

Empirical formula	C ₁₈ H ₁₆ N ₄ O ₃
Formula weight	336.35
Temperature	293(2) K
Wavelength (MoK λ)	0.71073 Å
Crystal System, Space group	Monoclinic, P2 ₁ /c
Unit cell dimensions	a= 7.6329(4), b= 7.8137(4), c= 28.0651(14) Å, β = 95.995°
Volume	1664.68(15) Å ³
No. of molecules per unit cell (Z)	4
Calculated density	1.342 Mg/m ³
Absorption coefficient	0.094 mm ⁻¹
F(000)	704
Crystal size	0.20 x 0.25 x 0.30 mm
range for data collection	3.19 to 32.38°
Limiting indices	-11 ≤ h ≤ 10, -11 ≤ k ≤ 11, -37 ≤ l ≤ 40
Reflections collected/unique	9491/5319 [R(int) = 0.0195]
Refinement method	Full-matrix least-squares on F ²
Data/ restraints/ parameters	5319/ 0 / 226
Goodness-of-fit on F ²	1.098
Final R indices [I > 2σ(I)]	R1 = 0.0563, wR2 = 0.1612
R indices (all data)	R1 = 0.0897, wR2 = 0.1720
Largest diff. peak and hole	0.302 and -0.226 eÅ ⁻³

one five-membered ring. The two six-membered rings are labelled as Ring-A and Ring-C and five membered ring as Ring-B. The bond lengths and bond angles for Ring-A and Ring-C are in good agreement with the standard values. The bond lengths such as C9-O3

**Fig. 1.** 1, 5-Dimethyl-4-[(E)-(3-nitrophenyl)methylidene]amino}phenyl-1,2-dihydro-3H-Pyrazol-3-one

(1.233(2) Å), N1-N2 (1.406(2) Å), C13-N1 (1.423(2) Å), C8-N3 (1.389(2) Å) and C10-C11 (1.490(2) Å), are comparable with some analogous structures (Liu *et al.*, 2002, Rajnikant *et al.*, 2006).

The bond N2-C10 is puckered as the torsion around it is 29.67(2)°, while it is -18.49(2)° around the C9-N1 bond. The position of two methyl carbon atoms C11 and C12 is deviated from the mean position of the five membered ring -B and it may be due to the torsion present along N2-C10 bond. The dihedral angle between the plane of phenyl ring -A and ring- B is 133.09(1)° while it is 170.43(1)° between the ring- B and C. The two exocyclic bond angles

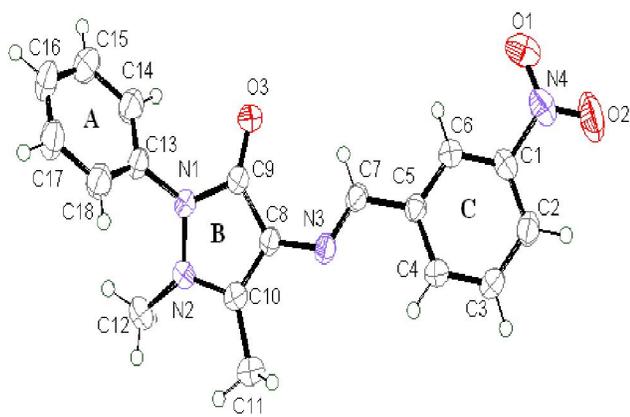
Table 2. Atomic coordinates and equivalent isotropic temperature factors (Å²)(with e.s.d's in parentheses) for non-hydrogen atoms

Atom	x	y	z	U(eq) [*]
N1	-0.1264(2)	0.2759(2)	0.3442(1)	0.040(1)
N2	-0.0889(2)	0.4476(2)	0.3560(1)	0.038(1)
N3	0.1427(2)	0.2493(2)	0.4577(1)	0.036(1)
N4	0.4772(2)	-0.2921(2)	0.5920(1)	0.054(1)
O1	0.4145(3)	-0.4100(2)	0.5681(1)	0.089(1)
O2	0.5705(2)	-0.3121(2)	0.6296(1)	0.080(1)
O3	-0.0305(2)	0.0116(1)	0.3750(1)	0.048(1)
C1	0.4387(2)	-0.1187(2)	0.5746(1)	0.036(1)
C2	0.5257(2)	0.0152(2)	0.5992(1)	0.041(1)
C3	0.4917(2)	0.1784(2)	0.5814(1)	0.044(1)
C4	0.3770(2)	0.2038(2)	0.5410(1)	0.039(1)
C5	0.2890(2)	0.0683(2)	0.5169(1)	0.031(1)
C6	0.3212(2)	-0.0963(2)	0.5344(1)	0.035(1)
C7	0.1701(2)	0.0971(2)	0.4730(1)	0.033(1)
C8	0.0385(2)	0.2844(2)	0.4153(1)	0.033(1)
C9	-0.0378(2)	0.1690(2)	0.3789(1)	0.035(1)
C10	0.0019(2)	0.4485(2)	0.4001(1)	0.036(1)
C11	0.0494(3)	0.6099(2)	0.4269(1)	0.051(1)
C12	-0.2176(3)	0.5779(2)	0.3387(1)	0.049(1)
C13	-0.1757(2)	0.2283(2)	0.2956(1)	0.038(1)
C14	-0.2898(3)	0.0911(2)	0.2870(1)	0.049(1)
C15	-0.3363(3)	0.0406(3)	0.2400(1)	0.059(1)
C16	-0.2748(3)	0.1276(3)	0.2025(1)	0.061(1)
C17	-0.1653(3)	0.2656(3)	0.2117(1)	0.055(1)
C18	-0.1127(2)	0.3157(2)	0.2582(1)	0.047(1)

$$U_{eq}^* = (1/3) \sum_i \sum_j U_{ij} a_i^* a_j^* (a_i a_j)$$

Table 3. Selected Bond distances (Å) and angles (°) with e.s.d's in parentheses for non-hydrogen atoms.

Bond lengths (Å)			
N3-C7	1.2740(19)	N3-C8	1.3880(18)
C10-N2	1.354(2)	C10-C8	1.371(2)
C10-C11	1.494(2)	C5-C7	1.471(2)
N1-C9	1.402(2)	N1-C13	1.4243(19)
N2-C12	1.462(2)	O3-C9	1.2366(18)
C8-C9	1.439(2)	C1-N4	1.460(2)
N4-O1	1.208(2)	N1-N2	1.4039(18)
N4-O2	1.219(2)		
Bond angles (°)			
C7-N3-C8	122.16(13)	N2-C10-C8	110.33(13)
C6-C5-C7	120.53(13)	C4-C5-C7	121.02(14)
N3-C7-C5	119.39(13)	C9-N1-N2	109.52(12)
C9-N1-C13	124.64(13)	N2-N1-C13	120.14(12)
C10-C8-N3	122.07(13)	C10-C8-C9	108.11(13)
N3-C8-C9	129.68(13)	C6-C1-N4	118.86(15)
C2-C1-N4	117.78(15)	O3-C9-N1	123.68(13)
O3-C9-C8	131.82(14)	C10-N2-N1	107.03(12)
O1-N4-C1	117.95(17)	O2-N4-C1	119.12(17)
N1-C9-C8	104.47(13)	C18-C13-C14	120.72(15)
N2-C10-C11	122.64(15)	C8-C10-C11	127.02(15)
C10-N2-C12	124.14(14)	N1-N2-C12	118.32(14)
C18-C13-N1	121.37(15)	C14-C13-N1	117.91(15)
O1-N4-O2	122.93(17)		

**Fig. 2.** ORTEP view of the molecule (thermal ellipsoids drawn at 50% probability level).**Table 4.** Selected torsion angles (°) for non-hydrogen atoms (e.s.d's given in parentheses).

C6-C1-N4-O1	5.57(3)	C6-C5-C7-N3	179.94(1)
C2-C1-N4-O1	-173.15(2)	N2-N1-C9-C8	6.61(2)
C6-C1-N4-O2	174.49(2)	C8-C10-N2-C12	149.31(2)
C2-C1-N4-O2	6.80(3)	C9-N1-N2-C12	153.91(1)
C7-N3-C8-C9	-8.17(2)	C13-N1-C9-C8	159.79(1)
C8-C10-N2-N1	5.51(2)	N2-C10-C8-N3	174.68(1)
C9-N1-N2-C10	-7.64(2)	N2-C10-C8-C9	-1.42(2)
C13-N1-C9-O3	-18.46(3)	C10-C8-C9-O3	174.82(2)
C13-N1-N2-C10	-162.23(1)	C13-N1-N2-C12	51.50(2)
C11-C10-N2-N1	-173.62(2)	C11-C10-N2-C12	29.82(3)
C11-C10-C8-N3	-6.23(3)	N2-N1-C13-C14	148.79(2)
N2-N1-C13-C18	31.04(2)	C9-N1-C13-C14	60.65(2)
C9-N1-C13-C18	-119.51(2)		

Table 5. Geometry of intra and intermolecular hydrogen bond interactions (e.s.d's in parentheses).

[X-H...A]	D[X...A(Å)]	d[H...A(Å)]	[X-H...A(°)]
C7-H7...O3	3.078(2)	2.438(1)	126.01(9)
C4-H4...N3	2.814(2)	2.513(1)	99.10(1)
C6-H6...O1	2.697(2)	2.416(2)	97.32(10)
C2-H2...O2	2.706(2)	2.426(2)	97.30(11)
C18-H18...N2	2.920(2)	2.668(1)	96.27(11)
C14-H14...O3	3.063(2)	2.767(1)	99.60(12)
C11-H11B...N3	3.010(2)	2.965(1)	83.42(11)
C3-H3...O1 ⁽ⁱ⁾	3.284(2)	2.773(2)	115.60(11)
C12-H12B...O3 ⁽ⁱ⁾	3.775(2)	2.863(1)	159.11(11)
C11-H11A...O3 ⁽ⁱ⁾	3.487(2)	2.562(1)	161.93(11)
C4-H4...O1 ⁽ⁱ⁾	3.118(2)	2.430(2)	130.75(10)
C12-H12C...O1 ⁽ⁱⁱ⁾	3.411(3)	2.628(2)	138.96(13)
C12-H12C...N4 ⁽ⁱⁱ⁾	3.674(3)	2.989(2)	129.38(12)
C12-H12C...O2 ⁽ⁱⁱ⁾	3.586(3)	2.925(2)	127.08(12)
C16-H16...O2 ⁽ⁱⁱⁱ⁾	3.341(3)	2.613(2)	135.56(13)
C11-H11C...N3 ^(iv)	3.853(2)	2.946(1)	158.07(12)
C17-H17...O3 ^(v)	3.551(2)	2.631(1)	170.29(12)

Symmetry code:

(i) x,+y+1,+z **(ii)**-x,-y,-z+1 **(iii)** x-1,-y-1/2,+z-1/2**(iv)** -x,-y+1,-z+1 **(v)** -x,+y+1/2,-z+1/2

at N2 are significantly deviated from the normal values. The atoms N4 and C7 lie above the plane of Ring-C (deviation being 0.051 and 0.045 Å, respectively). The exocyclic bond angles with respect to the oxygen of the nitro group have normal values.

The unit cell packing of molecules depicting partial hydrogen bonding network along *a*-axis is shown in Fig. 3. There exists few intra- and intermolecular hydrogen

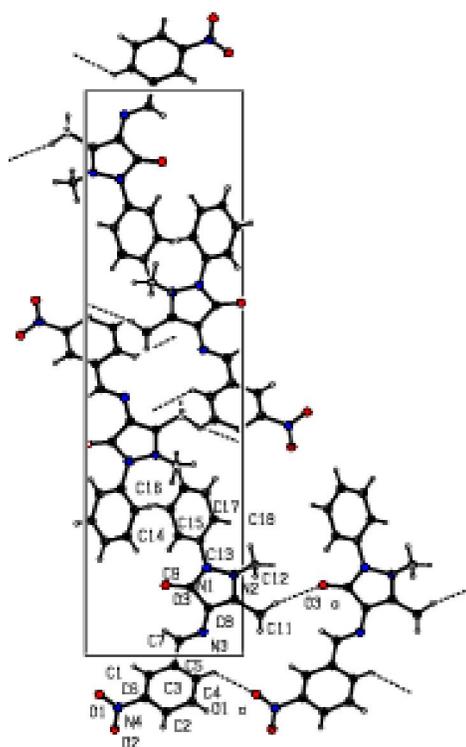
**Fig. 3.** Unit cell packing and hydrogen bonding network of the molecules along *a*-axis.

Table 6. Comparative data on hydrogen bonding.

Properties	Very strong	Strong	Weak	Present work
D(X-H...A) range Å	2.2 – 2.5	2.5 – 3.2	3.0 – 4.0	2.697 – 3.853
d(H...A) range Å	1.2 – 1.5	1.5 – 2.2	2.0 – 3.0	2.416 – 2.989
(X-H...A) range (°)	175 – 180	130 – 180	90 – 180	83 – 170
Effect on crystal packing	strong	Distinctive	Variable	—
Utility in crystal engineering	Unknown	Useful	Partly useful	—
Electrostatics	Significant	Dominant	Moderate	—

bonds whose geometry is presented in Table 5. All the three oxygen atoms (O1, O2 and O3) are responsible for the occurrence of intra- and intermolecular interactions of the kind C-H...O and C-H...N (e.g., C7-H7...O3, C14-H14...O3, C4-H4...N3, C11-H11...N3, C2-H2...O2, C6-H6...O1 and C18-H18...N2). Based on the comparison of intra and intermolecular interactions with some standard data as given in Table 6 (Desiraju, 1999), it is observed that (i) the distance between the donor and acceptor [D(X-H...A)] falls in a range which is intermediate to *strong* and *weak* interactions and (ii) the hydrogen-acceptor (H-A) distance unequivocally makes the observed interactions fall them in the category of *weak* interactions.

Conclusions

Bond distances are comparable with some analogous structures.

Almost all the carbon-nitrogen bonds are puckered as the torsion is quite substantial.

All the three oxygen atoms are responsible for the occurrence of intra and intermolecular interactions in this system.

Comparison of interaction geometry with the literature makes these interactions to fall in the category of weak hydrogen bonds.

ACKNOWLEDGEMENTS

The corresponding author (Rajnikant) is thankful to the Ministry of Science and Technology, Govt. of India, New Delhi for the financial support (Research Project No. SR/S2/CMP-47/2003).

REFERENCES

- Al-Haiza, M.A., El-Assiery, S.A. and Sayed, G.H.(2001). Synthesis and potential antimicrobial activity of some new compounds containing the pyrazol-3-one moiety. *Acta Pharm*, 51: 251- 261
- CrysAlis^{Pro} (2007). *Softwares for Crystal Data Collection Software*, Oxford Diffraction Limited, Abingdon, Oxfordshire, England.
- CrysAlisRED (2007). *Softwares for Crystal Data Collection and Reduction software*, Oxford Diffraction Limited, Abingdon, Oxfordshire, England.
- Desiraju, G. J. and Steiner T. (1999). *The Weak Hydrogen Bond*, IUCr, New York.
- Farrugia, L.J. (1997). *ORTEP-3 for Windows - a version of ORTEP-III with a Graphical User Interface (GUI)*. *Journal of Applied Crystallography*, 30: 565
- Himly, M., Jahn-Schmid, B., Pittertschatscher, K., Bohle, B., Grubmayr, K., Ferreira, F., Ebner, H. and Ebner, C. (2003). IgE-mediated immediate-type hypersensitivity to the pyrazo-lone drug propyphenazone. *J Allergy Clin Immunol*; 111:882–888.
- Liu, L., Jia, D., Qiao, Y., Ji, Y., Yu, K. (2002). Synthesis and crystal structure of N-(1-phenyl-3-methyl-4-benzalpyrazolone-5)-N'-salicylidene hydrazine. *Journal of Chemical Crystallography*, 32 (8): 255-259.
- Nardelli, M.(1995). PARST95 - an update to PARST: a system of Fortran routines for Calculating molecular structure parameters from the results of crystal structure analyses. *J. Appl. Cryst.*, 28: 659.
- Rajnikant, Dinesh., Deshmukh, M.B. and Shawney, A. (2006). 2-[3-9- methylphenoxy methyl)-5-phenyl- 4H-1,2,4-triazol-4-yl] benzoic acid *Acta Cryst*, E62 o1373-1374.,
- Sheldrick, G.M.(1986). SHELXL86: *Program for Crystal Structure Determination*, University of Gottingen, Germany .
- Sheldrick, G.M.(1997). SHELXL97: *Program for the Refinement of Crystal Structures*, University of Gottingen, Germany.