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Different classical hydrogen –bonding patterns in two imidazole derivatives (N-(tert-butyl)-2-(4-nitrophenyl)imidazo[1,2-a]pyrazin-3-amine and N-(tert-butyl)-2-(2-nitrophenyl)imidazo[1,2-a]pyridin-3-amine)

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Abstract : The title compounds, $C_{16}H_{17}N_5O_2$ in (I) and $C_{17}H_{18}N_4O_4$ in (II), are imidazole derivatives in which the imidazole moiety is fused with a piperdine ring system in (I), and with an benzene ring system in (II). The compound I, crystallized in the triclinic space group p1- with two molecules in a unit cell and compound II, crystallizes in a monoclinic in a C-centered lattice with eight molecules in the unit cell. According to single-crystal x-ray data, intra (C-H…N 3.397(3)) Å and intermolecular hydrogen bonds C-H…O 3.397(3)Å are formed between C-H groups of the imidazole cycle and O atoms of the paramagnetic moieties. The intermolecular H-bonds connect the molecules forming chains along the c-axis. Moreover, there are short intermolecular contacts between the O atoms (3.97)Å and between the O and C atoms (3.98)Å of the nitrophonyl moiety within the chain. Anti-bacterial study reveals that complexes are better anti-microbial agents than three Schiff base due to bacterial cell penetration by chelation.
Keywords : imidazole, pyridine, Crystal Structure, hydrogen bonding.

I. Introduction

Imidazoles are heterocyclic compounds which show important pharmacological and biochemical properties. They exhibit anti-fungal[1], anti-bacterial [2], anti-tumour [3,4], antiprotozoal [5], anti-herpes [6], anti-inflammatory [7], antiulcerative, anti-hypertensive, anti-histaminic and antihelminthic properties [8]. They also exhibit different therapeutic [8,9,10] and fluorescence properties [11,12]. Keeping in view of the biological importance, we have synthesized the title compound to study its crystal structure.

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2. Experimental procedure

2.1 X-ray Structure Determination

Single crystal of the compound suitable for x-ray diffraction was obtained by slow evaporation method. Three dimensional intensity data were collected on a Bruker6 SMART APEX CCD Diffractometer using graphite monochromatized Mo-Kα radiation (λ= 0.71073 Å) at Department of chemistry, IIT, Chennai, India. The structure was solved by direct methods and refined on F^2 by full-matrix least-squares procedures using the SHELXL programs [13]. All the non-hydrogen atoms were refined using isotropic and later anisotropic thermal parameters. The hydrogen atoms were included in the structure factor calculation at idealized positions by using a riding model, but not refined. Images were created with ORTEP-3 [14]. The crystallographic data for the compound are listed in Table 1.

2.2 Synthesis

The title compounds were prepared in a similar manner using a stirred solution of 4-Nitro benzaldehyde (1mmol), 2-Amino pyrazine (1mmol), tertiary Butyl isocyanide (1mmol) and Ethanol (8 ml) were added to 50 ml RB flask. The reaction mixture was stirred at room temperature with catalytic amount of Iodine for about 24 hours. An orange –yellow wish precipitate was formed. Check TLC in hexane: ethyl acetate (65: 35) percentage used as eluting solvents. The precipitate was filtered off, washed with excess ethanol and dried under vacuum for compound (I), and compound II, 2-Nitro benzaldehyde (1mmol), 2-Amino pyridine (1mmol), tertiary Butyl isocyanide (1mmol) and Ethanol (8 ml) were added to 50 ml RB flask. The reaction mixture was stirred at room temperature with catalytic amount of Iodine for about 24 hours. An orange -yellowish precipitate was formed. Check TLC in hexane: ethyl acetate (65: 35) percentage used as eluting solvents. The precipitate was filtered off, washed with excess ethanol and dried under vacuum. The resulting solution was subjected to crystallization by slow evaporation of the solvent for 48 hours resulting in the formation of single crystals. The overall yields 98% are shown in Fig. 1&2.

3. Results and discussion

3.1 Structure description

In (I), the mean plane of the imidazole ring system makes a dihedral angle of 3.30(2)° with the piperdine ring system, and a dihedral angle of 1.4(7)° with the benzene ring system in (II), showing that the fused units are essentially planar. The imidazole ring and benzene ring are nearly coplanar, making a dihedral angle of 17.11(2) and 54.5(7)° for compound I and II, respectively. The C atoms of the amine groups are slightly displaced from their attached imidazole ring as indicated by the C1-N4-C13-C15 in I and C5-N3-C8-C11in II, torsion angles of -172.7(3) and -80.8(2)°, respectively. The benzene ring is also conformation to the nitro group which is evident from the torsion angle C9-C10-N5-O1 of 13.1(5)°, indicating a (+) *Syn-Periplanar* conformation for compound I and C17-C16-N14-O1 of 53 (2)°, indicating a (+) *Syn-Clinal* conformation for compound II, respectively.

3.2 Packing details

In the crystal of (I), molecules are linked by N-H…O hydrogen bonds, forming chains propagating along the [001] direction. The chains are linked by C-H…π interactions, forming layers parallel to the (010) plane. In (II), the crystal packing also features N-H…N hydrogen bonds, which together with N-H…N hydrogen bonds link molecules to form chains propagating along the c-axis direction. The chains are linked by C-H…π interactions to form layers parallel to the (100) plane. Inversion-related layers are linked by offset π…π interactions. The intermolecular interactions of both compounds were analyzed using Hirshfeld surface analysis and two-dimensional fingerprint plots.

4. Conclusion

We succeeded to synthesize and isolate for the first time, stable spin-labeled imidazole in neutral form N-(tert-butyl)-2-(4-nitrophenyl)imidazo[1,2-a]pyrazin-3-amine and N-(tert-butyl)-2-(2-nitrophenyl)imidazo

[1,2-a]pyridin-3-amine. It was demonstrated that in the crystal state, the piperdine substituted amine group formed intermolecular hydrogen bonds C-H…O connecting the radicals into infinite chains. In addition, the result of anti-bacterial studies confirmed that ligand and complexes are bioactive showing good antimicrobial property. It has also been proposed that concentration plays a vital role in increasing the degree of inhibition, as the concentration increase, the activity increase.

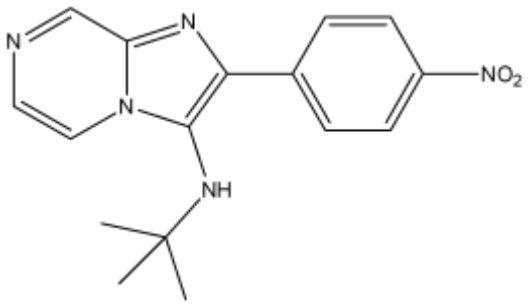

Fig.1 Scheme diagram compound I

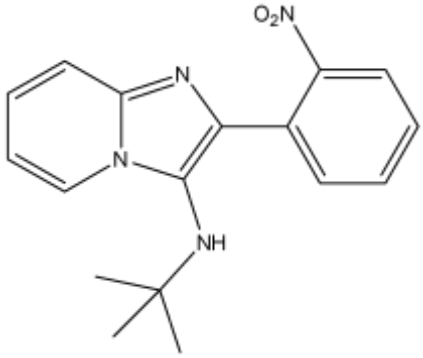

Fig.2 Scheme diagram compound II

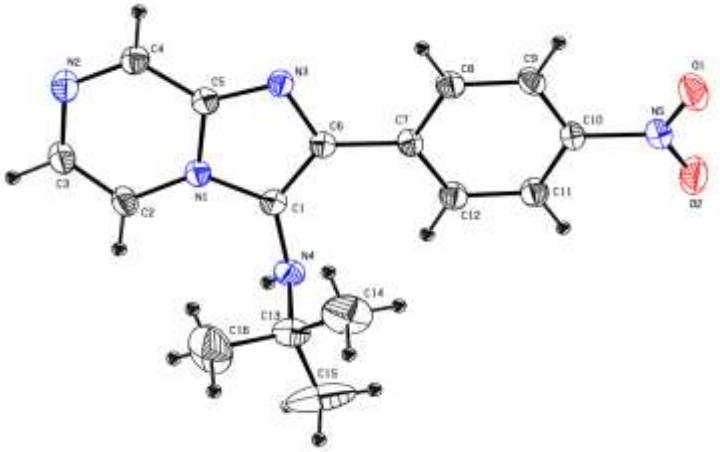

Fig.3 The molecular structure of compound (I), with the atom labeling. Displacement ellipsoids are drawn at the 50% probability level. H atoms are shown as small spheres of arbitrary radius.

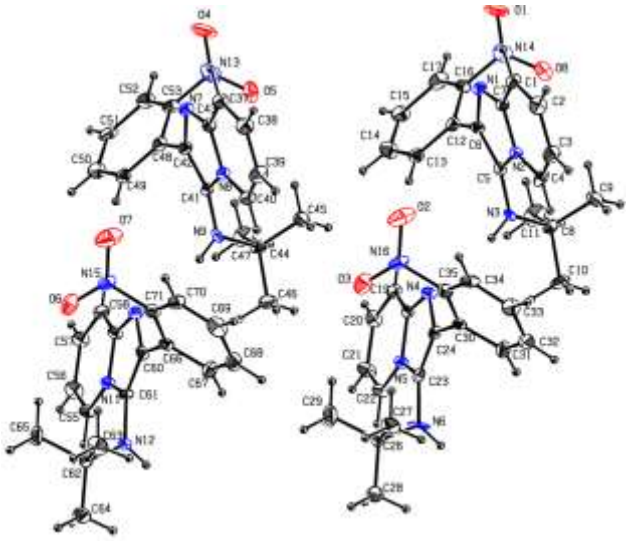

Fig.4 The molecular structure of compound (II), with the atom labeling. Displacement ellipsoids are drawn at the 25% probability level. H atoms are shown as small spheres of arbitrary radius.

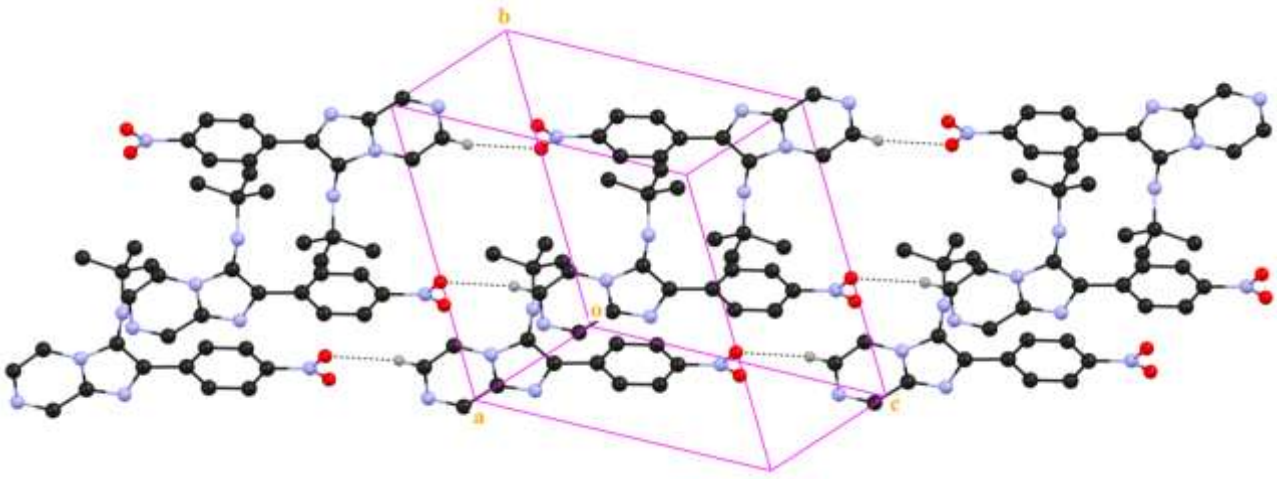

Fig.5 The packing of the title compound, viewed down an axis. Dashed lines indicate hydrogen bonds. H atoms not involved in hydrogen bonding have been omitted

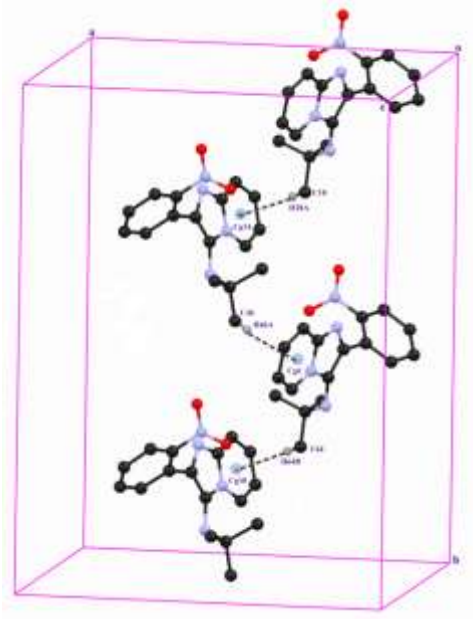

Fig.6 The crystal packing of compound (I) viewed along the c axis, showing the intermolecular C—H…π interactions as dashed lines.

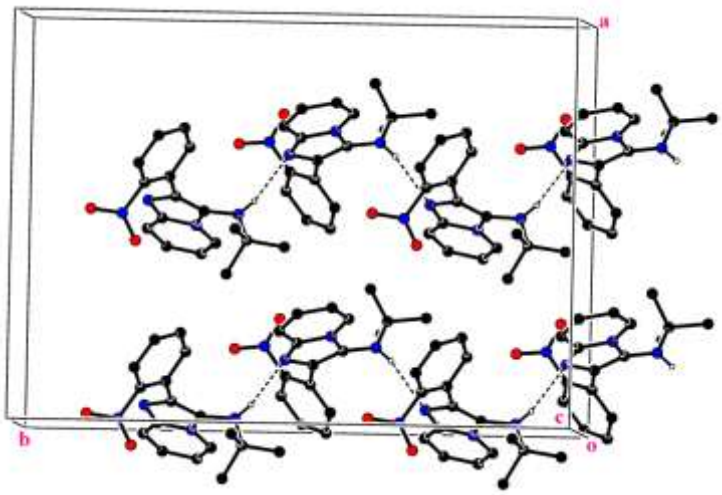

Fig.7 The crystal packing of compound (II) viewed along the b axis, showing the intermolecular N—H…N hydrogen bonds as dashed lines.

The crystallographic data for the compound are listed in **Table 1.**

Parameters	**I**	**II**
Empirical formula	C16 H17 N5 O2	C17 H18 N4 O2
Formula weight	311.34	310.35
Wavelength	0.71073 Å	0.71073 Å
Crystal system space group	Triclinic Pī	Monoclinic Cc
Unit cell dimensions	a = 7.1624(5) Å	a = 16.0877(10) Å
	b = 10.6301(9) Å	b = 22.0452(13) Å
	c = 11.2949(8) Å	c = 17.8670(11) Å
	α = 112.236(4)°	α = 90°
	β = 96.322(3)°	β = 93.213(4)°
	γ = 93.655(4)°	γ = 90°
Volume	785.96(10) $Å^3$	6326.7(7) $Å^3$
Z, Calculated density	2, 1.316 Mg/m^3	2, 1.303Mg/m^3
Absorption coefficient	0.091 mm^{-1}	0.089 mm^{-1}
F(000)	328	564
Crystal size	0.250 x 0.220 x 0.100 mm	0.250 x 0.220 x 0.100 mm
θ range	1.969 to 26.799°	1. .569 to 24.998°
Index ranges	$-7 \le h \le 9$ $-13 \le k \le 12$ $-14 \le l \le 14$	$-19 \le h \le 19$ $-26 \le k \le 24$ $-21 \le l \le 21$
Reflections collected / unique	7569 / 2757 [R(int) = 0.0345]	25500 / 9616 [R(int) = 0.0414]
Completeness to theta	100.0 %	99.90%
Refinement method	Full-matrix least-squares on F^2	Full-matrix least-squares on F^2
Data / restraints / parameters	2757 / 0 / 216	3762 / 0 / 325
Goodness-of-fit on F^2	0.964	0.973
Final R indices [I>2sigma(I)]	**R1 = 0.0515** wR2 = 0.1158	**R1 = 0.0446** wR2 = 0.1003
R indices (all data)	R1 = 0.1045 wR2 = 0.1386	R1 = 0.1336 wR2 = 0.1517
Largest diff. peak and hole	0.178 and -0.164 e.$Å^{-3}$	0.356 and -0.374 e.$Å^3$

Table 2. Selected bond lengths (A) and angles (˚) for compound I and II

C(9)-C(10)	1.383(3)	C(59)-N(10)	1.355(17)
C(10)-C(11)	1.370(3)	C(59)-N(11)	1.392(18)
C(10)-N(5)	1.459(3)	C(60)-C(61)	1.325(18)
C(11)-C(12)	1.373(3)	C(60)-N(10)	1.385(17)
C(13)-N(4)	1.475(4)	C(60)-C(66)	1.488(19)
C(13)-C(14)	1.504(4)	C(61)-N(11)	1.360(17)
C(13)-C(16)	1.515(4)	C(61)-N(12)	1.434(16)
C(13)-C(15)	1.515(5)	C(62)-C(64)	1.497(19)
N(5)-O(1)	1.222(2)	C(62)-N(12)	1.495(17)
N(5)-O(2)	1.223(3)	C(62)-C(63)	1.50(2)
N(4)-C(1)-N(1)	123.78(2)	C(62)-C(65)	1.59(2)
N(4)-C(1)-C(6)	132.2(2)	C(2)-C(1)-C(7)	119.2(14)
N(1)-C(1)-C(6)	104.0(2)	C(1)-C(2)-C(3)	121.2(14)
C(3)-C(2)-N(1)	118.3(2)	C(4)-C(3)-C(2)	122.1(15)
C(2)-C(3)-N(2)	124.7(2)	C(3)-C(4)-N(2)	117.3(15)
N(2)-C(4)-C(5)	123.5(2)	N(3)-C(5)-C(6)	135.6(12)

CCDC-1840412 and 1840413 contains supplementary crystallographic data for this paper. These data can be obtained free of charge via www.ccdc.cam.ac.uk/data_request/cif, by e-mailing data_request@ccdc.cam.ac.uk, or by contacting the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK.

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