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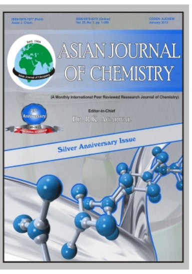

Synthesis and Structural Characterization of *N*-propyl-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide

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The compound *N*-propyl-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide ($C_{11}H_{13}NO_3$, $M_r = 207.22$) was synthesized and characterized by elemental analysis, ^{1}H NMR spectra, IR spectra and single crystal X-ray diffraction. The crystal belongs to monoclinic, space group P21/c, with a = 9.7040(10), b = 8.9501(8), c = 15.4719(16) Å, β = 128.845 (2)°, V = 1046.58(18) Å^3, Z = 4, D_c = 1.315 g/cm^3, λ = 0.71073 Å, μ(MoK_α) = 0.096 mm^{-1}, F(000) = 736. The final refinement gave R = 0.0434, wR(F^2) = 0.0998 for 5.254 observed reflections with I > 2σ(I). The structure of this compound comprises a racemic mixture of chiral molecules containing four stereogenic centres. X-ray diffraction analysis reveals that the cyclohexene ring tends towards a boat conformation, the tetrahydrofuran ring and the dihydrofuran ring adopt envelope conformation. The plan C3/C4/C5/C8 and the plan C5/C6/C7/C8 form dihedral angles of 69.1 (2)° and 64.2 (2)°, respectively with the pyrrole ring. The crystal structure is stabilized by C-H...O hydrogen bonds.

Key Words: *N*-propyl-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide, Synthesis, Structure characterization.

INTRODUCTION

The imide moiety is an integral structural part of various important bioactive molecules such as fumaramidmycin, granulatimide, isogranulatimide and rebeccamycin. These molecules are reported to exhibit antitumor, antiinflammatory and antimicrobial activities[1-3]. 7-Oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride has been widely employed in clinical practice, as it is less toxic and much easier to be synthesized[4,5]. Its derivatives are also pharmacologically active[6]. Furthermore, exo-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide and its *N*-substituent compounds have recently become an intense research topic in heterocyclic chemistry because of their antitumor, antivirus, analgesic, sedative and fungicidal activities[7]. In this paper, *N*-propyl-7-oxa-bicyclo-[2,2,1]hept-5-ene-2,3-dicarboximide was synthesized and its molecular structure was investigated by elemental analysis, FT-IR, ^{1}H NMR and X-ray crystallographic techniques.

EXPERIMENTAL

All the reagents were of AR grade and used without further purification. IR spectra (4000-400 cm^{-1}), as KBr pellets, were recorded on a Nicolet FT-IR 510P spectrometer. ^{1}H NMR spectra were measured with a Bruker ALP 80 nuclear magnetic resonance spectrometer (CD_3COCD_3 as solvent, TMS as internal standard).

Synthesis of *N*-propyl-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide: Exo-7-oxa-bicyclo [2,2,1]hept-5-ene-2,3-dicarboxylic anhydride was synthesised according to the literature[8]. A mixture of exo-7-oxa- bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride (0.332 g, 2 mmol) and 4-amino-1,2-dihydro-2,3-dimethyl-1-phenylpyrazol-5-one (0.406 g, 2 mmol) in methanol (5 mL) was stirred for 1 h at room temperature and then refluxed for 1 h. After cooling, the precipitate was filtered and dried, the title compound was obtained. Yield: 82 %. The crude product of 20 mg was dissolved in methanol of 10 mL. The solution was filtered to remove impurities and then the filtrate was left for crystallization at room temperature. The single crystal suitable for X-ray determination was obtained by evaporation from the methanol solution after 6 d.

Anal. calcd. (%) for $C_{11}H_{13}NO_3$: C 63.77, H 6.28, N 6.76. Found (%): C 63.72, H 6.32, N 6.74. Selected IR (KBr, ν_{max}, cm^{-1}) data: 2935 (-C-H), 1695 (C=O), 1600 (C=C), 1191 (C-O-C), 718 (=C-H). ^{1}H NMR (DMSO-d_6, ppm) δ: 5.80 (d, 2H, C_6H, C_7H), 4.67 (m, 2H, C_5H, C_8H), 3.51 (m, 2H, C_9H), 3.09 (d, 2H, C_3H, C_4H), 1.60 (m, 2H, $C_{10}H$), 0.97 (m, 3H, $C_{11}H$).

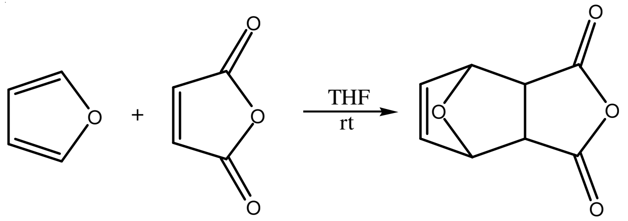
Data collection and structure determination: A selected crystal of the title compound was mounted on a SMART CCD diffractometer. The reflection data were measured at 298 K, using a graphite monochromator MoK_α (λ = 0.71073 Å) radiation with an ω-2θ scan mode. The total reflections were

5.254 with 1.853 independent ones ($R_{int} = 0.0434$), of which 138 were observed with $I > 2\sigma(I)$. Intensities were corrected for Lorentz and polarization effects and empirical absorption and all data were corrected using SADABB[9] program.

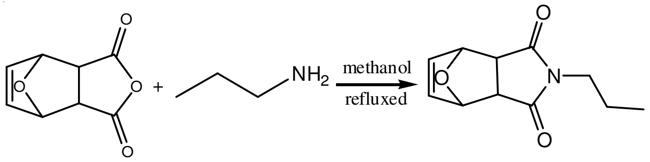
The structure was solved by direct methods using SHELXS-97[10] program. All the non-hydrogen atoms were refined on F^2 anisotropically by full-matrix least squares method. All hydrogen atoms were placed in the geometrically calculated positions. The contributions of these hydrogen atoms were included in the structure factor calculations. The atomic scattering factors and anomalous dispersion corrections were taken from international table for X-ray crystallography[11]. The final least-square cycle gave $R = 0.0672$ and $\omega R = 0.1169$ ($w = 1/[\sigma^2(Fo^2) + 0.0386P^2 + 0.3785P]$, where, $P = (Fo^2 + 2Fc^2)/3$). $S = 1.066$, $(\Delta\rho)_{min} = -0.164$ and $(\Delta\rho)_{max} = 0.177$ e/Å^3. CIF file containing complete information on the studied structure was deposited with CCDC, deposition number 825618 and is freely available upon request from the following web site: www.ccdc.cam.ac.uk/data_request/cif.

RESULTS AND DISCUSSION

Furan reacts in a Diels-Alder reaction with maleic anhydride in tetrahydrofuran at room temperature to give exo-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride, as shown in **Scheme-I**. The condensation reaction between exo-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride and 1-propanamine proceeded smoothly in methanol at room temperature for 5 h and refluxed temperature for 1 h, respectively, leading to the title compound in high yield, as shown in **Scheme-II**. The elemental analysis, IR spectra and ^{1}H NMR data clearly indicated the condensation reaction of exo-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride with 1-propanamine in a ratio of 1:1.



Scheme-I: Synthesis of exo-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboxylic anhydride



Scheme-II: Synthesis of the *N*-propyl-7-oxa-bicyclo[2,2,1]hept-5-ene-2,3-dicarboximide

The selected bond distances and bond angles are listed in Table-1. A displacement ellipsoid plot with atomic numbering scheme is shown in Fig. 1 and a perspective view of the crystal packing in the unit cell is shown in Fig. 2. Hydrogen bond schemes (Å, °) are listed in Table-2.

TABLE-1
SELECTED BOND LENGTHS (Å) AND BOND ANGLES (°)

Bond	Length (Å)	Bond	Angle (°)
O(1)-C(1)	1.210(2)	C(5)-O(3)-C(8)	95.74(15)
O(2)-C(2)	1.203(2)	C(1)-N(1)-C(2)	112.31(17)
O(3)-C(5)	1.431(3)	C(1)-N(1)-C(9)	123.31(17)
O(3)-C(8)	1.436(3)	C(2)-N(1)-C(9)	124.32(17)
N(1)-C(1)	1.371(3)	O(1)-C(1)-N(1)	124.0(2)
N(1)-C(2)	1.378(3)	N(1)-C(1)-C(4)	109.33(17)
N(1)-C(9)	1.463(3)	O(2)-C(2)-N(1)	123.9(2)
C(6)-C(7)	1.305(3)	N(1)-C(2)-C(3)	109.41(17)

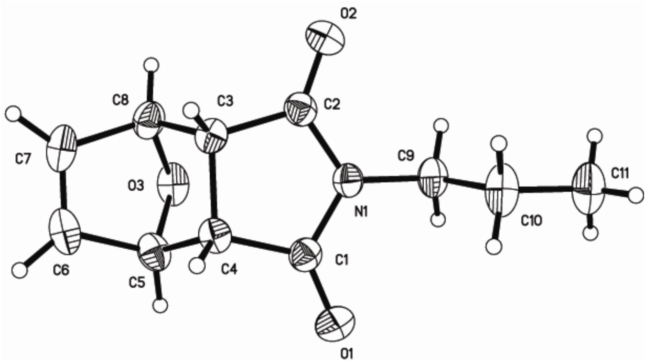


Fig. 1. Molecular structure with atomic numbering scheme

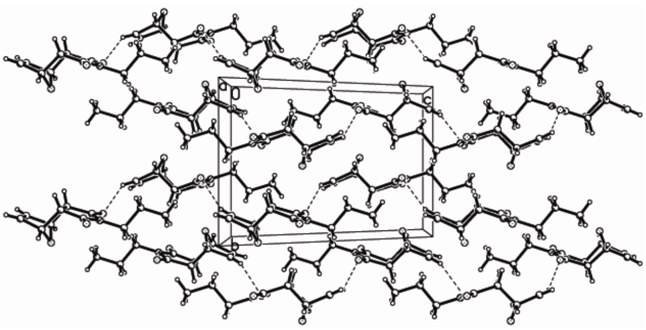


Fig. 2. View of crystal packing down the a-axis

TABLE-2
HYDROGEN BOND SCHEMES (Å°)

D-H…A	D-H	H…A	D-A	D-H…A
C6-H6…O2^i	0.93	2.560	3.429	156
C7-H7…O1^{ii}	0.93	2.510	3.327	147
C14-H14…N2^d	0.98	2.610	3.484	149

Symmetry codes: i) x, 1/2-y, ½ + z; ii) 1 + x, 1/2-y,1/2 + z

The title compound comprises a racemic mixture of chiral molecules containing four stereogenic centres. As seen from Fig. 1, the cyclohexene ring tends towards a boat conformation, the tetrahydrofuran ring and the dihydrofuran ring adopt envelope conformations. The plan C3/C4/C5/C8 and the plan C5/C6/C7/C8 form dihedral angles of 69.1 (2) ° and 64.2 (2) °, respectively with the essential planar pyrrole ring (maximum deviation = 0.010 (4) for atom N1). As seen from Table-1, the bond lengths are expected[12]. And they are comparable to those in the similar compounds[13,14]. In 7-oxabicyclo(2,2,1)hept-5-ene-2,3-dicarboximide group, the C-C bonds lengths [1.505 (3)-1.557 (3) Å], except C6-C7 double bond length [1.305(3) Å], are longer than the normal single bond length. The degree of lengthening of the C-C bonds in the title compound is in good agreement with that of corresponding C-C bonds in *N*-methyl-7-oxabicyclo(2,2,1)hept-5-ene-2,3-exo-dicarboximide[13], exo-4-[(4-bromophenyl)amino]-10-oxa-4-azatricyclo-(5,2,1,$0^{2,6}$)dec-8-ene-3,5-dine[14] and 4-(2-aminophenyl)-10-oxa-4-azatricyclo(5,2,1,$0^{2,6}$)dec-8-ene-3,5-dine[15]. The crystal structure is stabilized by C-H...O intermolecular hydrogen bonds (Fig. 2 and Table-2).

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