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^{1}HNMR and X-Ray Crystallographic Structure Determination of $4_aR^*,5R^*,10_bR^*$-5-(7-Methylcoumarin- 4yl)-3,4,4_a,5,6,10_b-Hexahydro-2H-Pyrano[3,2-c]Quinoline

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Authors' contributions

Authors MK and GV involved in structure refinement and prepare the write up for the title compound, the authors SDS and KKS synthesized the title compound and helped for NMR studies.

Review Article

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ABSTRACT

The title compound, $C_{22}H_{21}NO_3$ belongs to the monoclinic system, space group P21/c with a = 9.3400 (3) Å, b = 22.1653 (8) Å, c = 8.7044 (3) Å, α = γ = 90˚ , β = 105.549 (1)˚, V = 1736.07 (10) Å^3, Z = 4, D_c = 1.3291(1) Mg /m^3, F(000) = 736, R = 0.0358 and wR = 0.0959, S= 1.082, T = 296 K. In the title compound, $C_{22}H_{21}NO_3$, the nitrogen- containing ring of the pyranoquinoline moiety adopts a slightly distorted half-chair conformation and the oxygen- containing ring adopts a slightly distorted chair conformation. The benzene rings make a dihedral angle of 48.07(9) ˚. In the crystal, weak C—H…O and π—π interactions link the molecules into chains extending along the a-axis direction. The crystal structure of the title compound was characterized by X-ray diffraction studies and spectroscopic ^{1}H NMR technique.

Keywords: *Pyranoquinoline; benzene ring; coumarin; methyl substituted derivative.*

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1. INTRODUCTION

Coumarin is the simplest member of the group of oxygen heterocyclics called benzo-2-pyrones. Coumarins are an important class of compound due to their presence in natural products as well as their medicinal applications such as anti-inflammatory, anti-viral, antioxidant, antibacterial, antifungal, anti-HIV and as anti-carcinogenic agents [1]. A review article dealing with the varied physiological activities of coumarin derivatives has been published, describing their anticoagulant, antibacterial, antihelminitic, hypothermal properties and vasodilatatory action. During the last twenty years, the study of the biological activities of coumarin derivatives has been the aim of many researchers [2]. Coumarin and several of its derivatives were investigated for their photosensitizing properties. With a few exceptions, the coumarins are potentially strong photocontact sensitizers but do not evoke phototoxic reactions [3]. Coumarin derivatives are used as fluorescent dyes for synthetic fibres and daylight fluorescent pigments [4]. The synthesis of pyranoquinoline derivatives has been the focus of great interest, because it was reported that these possess a broad spectrum of biological properties. Some of these activities include psychotropic activity, anti-allergenic activity, anti-inflammatory and estrogenic activities [5,6]. Compounds containing pyranoquinolone motifs exhibit antiproliferative and antitubulin activities and it includes antibacterial and antifungal activities. Some of the pyranoquinoline derivatives have been found to block acetylcholinesterase and cell calcium signals, and cause neuroprotection against calcium overload and free radicals [7]. In addition, the pyranoquinoline moiety is present in many alkaloids [8]. We report herein the crystal structure of the title compound, a pyranoquinoline-substituted methyl coumarin derivative.

2. MATERIALS AND METHODS

2.1 General

Proton (^{1}H) nuclear magnetic resonance (NMR) spectra was recorded at 500 MHz in $CDCl_3$ and coupling constants were measured in Hertz. For the crystal structure determination, the single-crystal of the compound $C_{22}H_{21}NO_3$ was used for data collection on a Bruker Kappa APEXII CCD diffractometer [7]. The MoKα radiation of wavelength, (λ = 0.71073 Å) and multi-scan technique for absorption were used for data collection. The lattice parameters were determined by the least-squares method on the basis of all reflections with $F^2>2\sigma$ (F^2).

2.2 Synthesis

2.2.1 Synthesis of 4_aR^*, $5R^*$, 10_bR^*-5-(7-methylcoumarin-4yl)-3,4,4_a,5,6,10_b-hexahydro-2H-pyrano[3,2-c] quinoline

7-Methylcoumarin-4-azadiene (0.263 g, 1 mmol) and $ZnCl_2$ (0.136 g, 1 mmol) were stirred in dichloroethane (5 ml) for 15 minutes and dihydropyran (0.252 g, 3 mmol) was added slowly at room temperature. The solution was heated till complete consumption of the 7-methylcoumarin-4-azadiene . The solution was cooled to room temperature, quenched with water and the product was extracted with chloroform. Organic layer was separated and dried over anhydrous Na_2SO_4 and the solvent was evaporated to obtain a sticky mass which was purified by column chromatography on silica gel using chloroform.

2.3 NMR Spectra

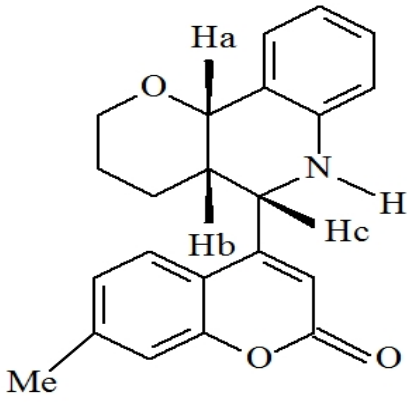
The ^{1}H NMR spectrum of title compound showed 1.41-1.61 (m, 4H, C_3H and C_4H), 2.47 (m, 1H, C_{4a}H), 2.53 (s, 3H, CH_3) 3.48 (td, 1H, C_{2a}H, *J* = 2.5 and 10.5 Hz), 3.66 (dd, 1H, C_{2b}H, *J* = 2.5 and 10.5 Hz), 3.82 (bs, 1H, NH), 5.10 (s, 1H, C_5H), 5.47 (d, 1H, C_{10b}H, *J* = 5 Hz), 6.74 (d, 1H, C_7H, *J* = 8 Hz), 6.77 (s, 1H, $C_{3'}$H), 6.93 (t, 1H, C_9H, *J* = 7.5 Hz), 7.18-7.21 (m, 2H, C_8H and $C_{6'}$H), 7.26 (s, 1H, $C_{8'}$H), 7.51 (d, 2H, C_{10}H and $C_{5'}$H, *J* = 8 Hz). The coupling constant between H_{10b} and H_{4a} is 5 Hz and there was no coupling observed between H_5 and H_{4a} this seems to be there is cis relation between H_{10b}, H_{4a} and H_5.

2.3.1 X- ray structure determination

A colourless crystal of the title compound 1 with dimensions 0.25 x 0.20 x 0.15 mm was chosen for the data collection. The data were collected with graphite- monochromated Mo Kα radiation (λ = 0.71073 Å). For the compound 1 data collection: APEX2 [9] ; cell refinement : APEX2/SAINT [9] ; data reduction : SAINT/XPREP [9] ; molecular graphics: ORTEP-3 [10] and publication software: PLATON [11] . The structure of compound 1 was solved by direct methods using SHELXS-97 [12] and refined using SHELXL- 97 [12]. All non-hydrogen atoms were assigned anisotropic displacement parameters in the refinement. All hydrogen atoms were positioned geometrically and treated as riding on their parent atoms, with C-H = 0.93 Å (aromatic) and 0.97Å (methylene), and refined using a riding model with U_{iso}(H) = 1.2 U_{eq} or 1.5 U_{eq} (parent atom). In the range of 1.8° – 23.2° , a total of 13468 reflections were collected, of which 2471 were independent (R_{int} = 0.029). The maximum and minimum peaks and holes are 0.14 and -0.17 e/Å^3, respectively. S= 1.082 and wR = 0.0959. Chemical structure of the title compound is shown in scheme 1**.** Molecular structure of the title compound showing the atomic numbering scheme is shown in Fig. 1. The crystallography details for the structures determination of the compound are displayed in Table 1 and Hydrogen bond geometry are shown in Table 2 respectively.

3. RESULTS AND DISCUSSION

The chemical structure of the title compound as shown in scheme- 1.



Scheme 1. Chemical structure of the title compound

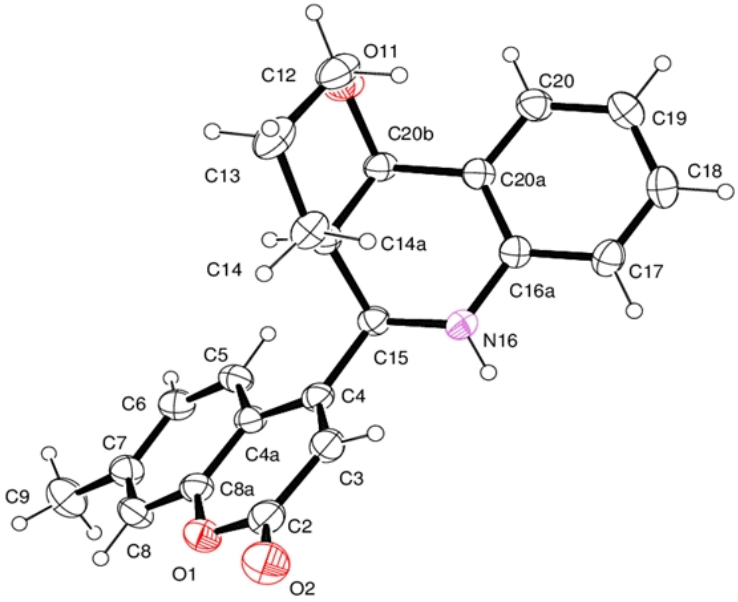


Fig. 1. The molecular structure of the title compound with displacement ellipsoids drawn at the 50% probability level

Table 1. Crystal data, data collection and structure refinement parameters

Formula weight	347.40
Crystal shape, colour	block, colorless
Temperature	296 K
Wavelength	0.71073 Å
Crystal system	monoclinic
Space group	P21/c
Unit cell dimensions	a = 9.3400(3) Å b =22.1653(8) Å c = 8.7044(3) Å
Volume	1736.07(10) $Å^3$
Z	4
Density (calculated)	1.329 Mg/m^3
Absorption coefficient	0.088 mm^{-1}
F(000)	736.0
Crystal size	0.25x0.20x0.15 mm
Theta range for data collection	1.8° to 23.2°
Index ranges	-10 ≤ h ≤ 10 -23 ≤ k ≤ 24 -7 ≤ l ≤ 9
Reflection collected	13468
Completeness to theta	23.2°
Max. and min transmission	0.987, 0.979
Refinement method	Full-matrix least-squares on F^2
Data/restraints/parameters	2471/0/252
Goodness-of-fit on F^2	1.082
R indices (all data)	R_1=0.0358, wR_2= 0.0959
Largest diff. peak and holes	0.14 e. $Å^{-3}$, and -0.17 e. $Å^{-3}$

Table 2. Hydrogen bonds geometry (Å, º)

D*—H···*A	***D*—H**	**H···*A***	***D*···*A***	***D*—H···*A***
C5—H5···o11^{i}	0.93	2.51	3.335(2)	149
C17—H17···O2^{ii}	0.93	2.58	3.412 (2)	149

Symmetry codes: (i) 1-x,-y,-z (ii) x,1/2-y,1/2+z.

The title compound, $C_{24}H_{22}ClNO_2$, crystalized in the monoclinic system, space group P21/c with a = 9.3400 (3) Å, b = 22.1653 (8) Å, c = 8.7044 (3) Å, α = γ = 90°, β = 105.549(1)°, V = 1736.07 (10) Å^3 , Z = 4, D_c = 1.3291(1) Mg /m^3, F(000) = 736, R = 0.0358 and wR = 0.0959, S = 1.082, T = 296K. The dihedral angle between the phenyl rings of the coumarin molecule and the pyranoquinoline moiety is 48.07(9)°. The C2 atom of the carbonyl group has a distorted trigonal geometry with O2—C2— O1 [116.90 (18)°] and O2—C2—C3 [125.67(21)°], deviating significantly from the ideal sp^2 value of 120°, which is consistent with the values observed in a related structure [1]. In the crystal, weak intermolecular C5—H5···O11 hydrogen bonds together with C17—H17···O2 hydrogen bonds between inversion-related molecules, give one-dimensional chain structures which extend along the *a*-axis. The substituent ring defined by (N16, C15, C14A, C20B, C20A, C16A) adopts a slightly distorted half-chair conformation with Q = 0.5226 (18) Å, θ = 48.1(2)° and φ = 93.7 (3)°while the ring defined by (O11, C12–C14, C14A, C20B) adopts a slightly distorted chair conformation with Q = 0.5495 (19) Å, θ = 4.3 (2)° and φ = 48 (2)° [13].

In the crystal packing as shown in Fig. 2, viewed along the a-axis. In the crystal packing C5-H5…O11 and C17-H17…O2 hydrogen bonds along b-axis as shown in Fig. 3 and Table 2.

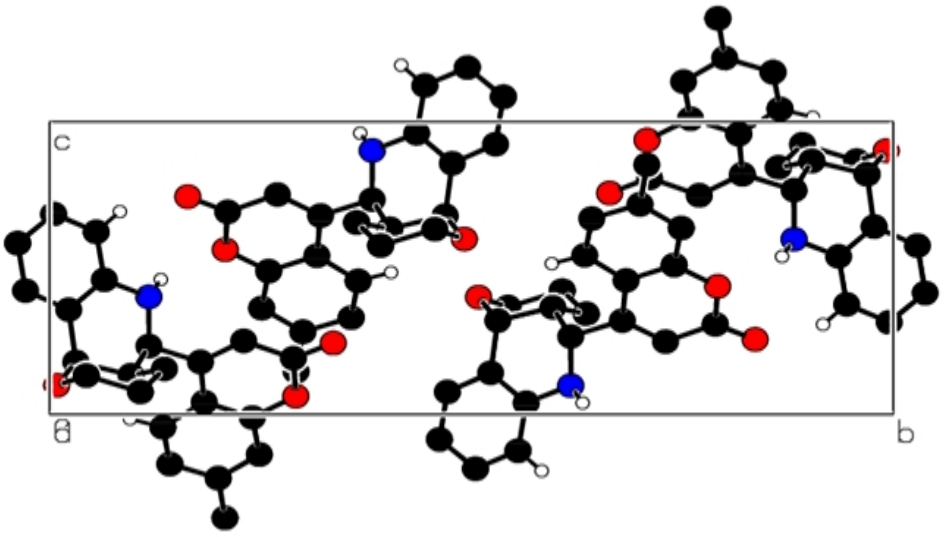


Fig. 2. Crystal packing of the title compound viewed down the a-axis

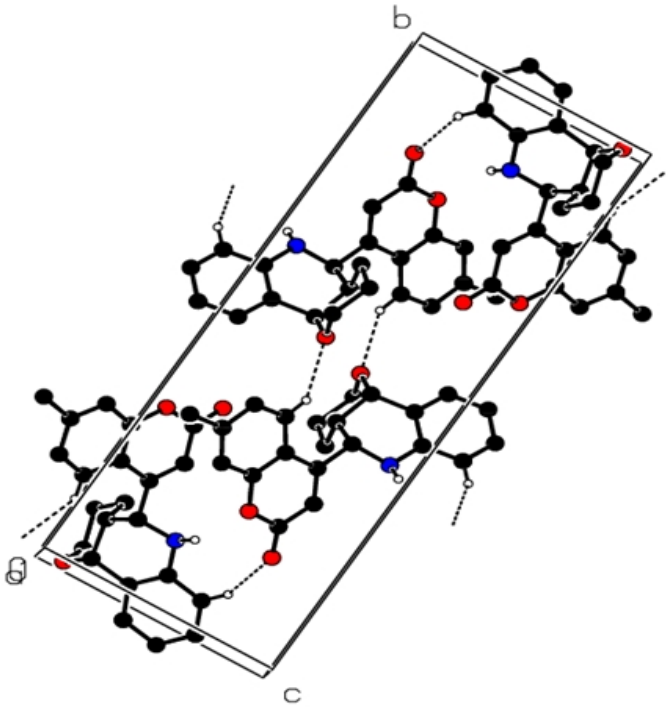


Fig. 3. Crystal packing of the title compound viewed down the a-axis showing C—H…O interactions with dashed lines

The structure is further stabilized by π…π [3.8575 Å] hydrogen bonding interactions, as shown in Fig. 4.

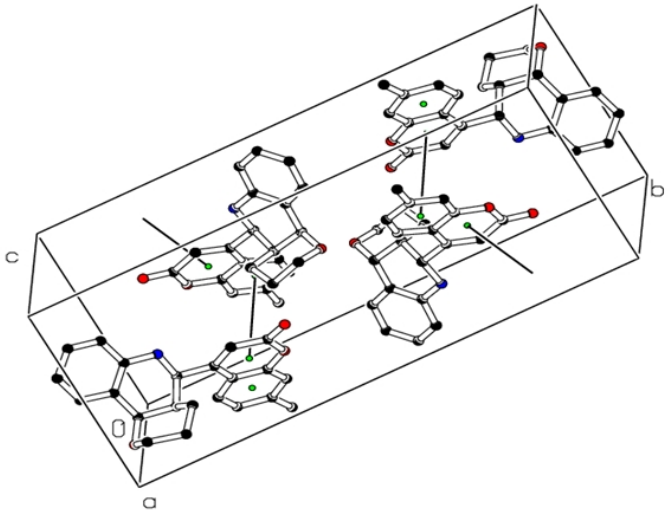


Fig. 4. The molecular interaction showing the weak π...π interactions and viewed along the a-axis. Cg is a centroid of C1-C4 ring

4. CONCLUSION

The crystal structure of the title compound has been characterized by single crystal X-ray diffraction method and spectroscopic ^{1}H NMR technique. The synthesized pyranoquinoline-substituted methyl coumarin derivative may be used in fluorescent dyes for synthetic fibres and daylight fluorescent pigments and possess a broad spectrum of biological activities such as anti-inflammatory, anti-viral, antioxidant, antibacterial, antifungal, anti-HIV, anti-carcinogenic agents, psychotropic activity, anti-allergenic activity and estrogenic activities.

SUPPLEMENTARY DATA

"CIF file containing complete information on the studied structure was deposited with CCDC, deposition number 901323, and is freely available upon request from the following web site: www.ccdc.cam.ac.uk/data_request/cif".

ACKNOWLEDGEMENTS

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Silva PSP, Parveen M, Khanam Z, Ali A, Silva MR. 6,8-Diiodo-5,7-dimethoxy-4-methylcoumarin. Acta Crystallographica. 2010;E66:o988.
2. Nofal Z M, El-Zahar M I, El-Karim SSA. Novel Coumarin Derivatives with Expected Biological Activity. Molecules. 2000;5:99-113.
3. Kaidbey KH, Kligman AM. Photosensitization by Coumarin Derivatives: Structure-Activity Relationships. Arch Dermatol. 1981;117:258-263.
4. Aazam ES, Fawazy A, Hitchcock PB. 4-Methyl-7-(salicylideneamino)coumarin. Acta Crystallographica. 2006;E62:o4285-o4287.
5. Du BX, Zhou J, Li YL,Wang XS. 5-Phenyl-3,4,4a,5,6,12c-hexahydro-2H-benzo[f]pyrano[3,2-c]quinoline. Acta Crystallographica. 2010;E66:1622.
6. Sabitha G, Reddy MSK, Arundhathi K, Yadav JS. VCl_3 –Catalyzed aza-Diels-Alder reaction: one-pot synthesis of pyrano[3,2-c]quinolines and furo[3,2-c]quinolines. ARKIVOC. 2006; (vi):153-160.
7. Chinnakali K, Sudha D, Jayagobi M, Raghunathan R, Fun HK. 1-Ethyl-2-tosyl-4,4,6-trimethyl-2,3,3a,4-tetrahydro-1H-pyrrolo[3,4-c]pyrano[6,5-b]quinoline-11 (6H)-one monohydrate. Acta *Crystallographica.* 2009;E65:2099-2100.
8. Ravikumar K, Sridhar B, Mahesh M, Reddy VVN. A diastereoisomer of pyrano[3,2-c]quinoline. Acta Crystallographica. 2005;E61:o461-o463.
9. Bruker, APEX2 and SAINT-plus, Bruker AXS Inc., Madison; 2004.
10. Farrugia LJ, ORTEP-3 for Windows- A version of ORTEP-III with a Graphical User Interrface (GUI), Journal of Applied Ctytallography. 1997;30:565.
11. Spek AL, Structure Validation in Chemical Crytallography, Acta Crystallography. 2009;D65:148-155.

12. Sheldrick GM. SHELXS-97 and SHELXL-97, Program for Crystal structure solution and refinement. University of Gottingen; 1997.
13. Cremer D, Pople JA. J. American. Chem, Soc. 1975;97:1354-1358.

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