Crystal structure of 4-[(4,5-dihydro-1,3-thiazol-2-ylthio)methyl] - 6- methyl- 2Hchromen-2-one

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ABSTRACT

In the title compound, C_{14} H_{13} N O_2 S_2 the chemicals used as molecular precursors for the design of new functionalized materials [3,4]. Currently, the synthesis of thioethers through the construction of such carbon–sulphur bond is an important area of research due to their wide spectrum of biological activity and pharmaceutical applications The 2 H-chromene ring systems is nearly planar, with a maximum deviation of 0.0234(17) Å for atom C9 and the thiazole ring adopts a twist boat chair conformation. The dihedral angle between the 2H-chromene ring (O3 C6 C7 C8 C9 C10 C11 C12 C13 C14) and the thiazole ring (N5 S1 C17 C18 C19) is 82.71(11)°. Bond lengths and angles are within the normal ranges [6]. The crystal structure contains only weak intermolecular C16---H16B...N5 and C7---H7...S2 hydrogen bonds. The packing of the crystal structure is stabilized by C19—H19A…π Cg(3) (C9 C10 C11 C12 C13 C14) interactions as well as π–π [Cg(2): O3 C6 C7 C8 C9 C10) – Cg(3) (C9 C10 C11 C12 C13 C14)] interactions between fused benzene rings of chromene and oxygen contain benzene ring [shortest centroid–centroid distance = 3.6368 (10) Å] . The crystal structure is further stabilized by other intermolecular C15—H15C…S2 hydrogen bonds, that generate inversion dimers with $R_2^2(16)$ ring motifs.

Synthesis

A series of novel thioether derivatives called as substituted thiazolyl coumarins **(2a-2j)** were synthesized by stirring the reaction mixture of 4,5-dihydrothiazole-2-thiol **(1)** (0.01mol) and powdered anhydrous K_2CO_3 (0.03mol) with various 4-bromomethyl coumarins **(1a-1j)** (0.01mol) in absolute ethanol(10ml) at room temperature. After completion of reaction, the reaction mixture was quenched in crushed ice; the solid product was filtered and given water wash. Lastly the product was recrystallized from ethanol. For the synthesis of target compounds, the reaction sequence outline in **Scheme-1**. Synthesis of various 4-bromomethyl coumarins **(1a-1j)** was brought about by the Pechman cyclization of phenols with 4-bromoethylacetoacetate. A series of novel thiazolyl coumarin derivatives **(2a-2b)** were synthesized by stirring the reaction mixture of 4,5-dihydrothiazole-2-thiol **(1)** and anhydrous K_2CO_3 with various 4-bromomethyl coumarins **(1a-1j)** in absolute ethanol at room temperature . All the products gave satisfactory analytical and spectroscopic data, which are in accordance with their assigned structures. The ORTEP diagram of compound

4-[(4,5-dihydro-1,3-thiazol-2-ylthio)methyl]-6-methyl-2H-chromen-2-one is given in **Fig- 1**

The various new compounds synthesized during the present investigation and the time taken for the completion of reaction, yields and melting points are given in.The structures of newly synthesized compounds were confirmed by their spectral analysis and the structures of compounds **2a** and **2b** were determined by X-ray crystal structural analysis. Colourless crystals; IR (KBr) (v_{max}/cm^{-1}): 1732(C=O of coumarin), 1611(C=N of thiazole) cm^{-1}; ^{1}H NMR (300 MHz, DMSO-d_6, δ ppm) δ
2.12 (t, 2H, Ar-CH_2), 2.37 (s, 3H, CH_3), 2.9 (t, 2H, Ar-CH_2), 3.54 (s, 2H, CH_2), 6.11 (s, 1H, Ar-H), 6.85 (d, 1H, Ar-H), 6.92(d, 1H, Ar-H), 7.13(s, 1H, Ar-H) ; ^{13}C NMR (75MHz δ ppm, DMSO): 24.3, 32.5, 35.4, 55.7, 112.3, 121.3, 122.5, 127.2, 128.5, 135.4, 147.8, 155.3, 160.7, 162.3; ESI-MS: 291 $[M]^+$; Anal. calcd for $C_{14}H_{13}NO_2S_2$: C, 57.71; H, 4.50; N, 4.81%. Found: C, 57.68; H, 4.54; N, 4.85%

N

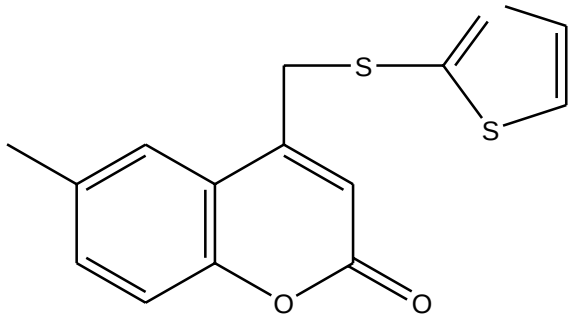

Figure: 1 Schematic diagram for $C_{14}H_{13}NO_2S_2$

Crystal and molecular structure

The experimental procedure for data collection and data reduction are explained in the section 3.2 of chapter 3. The crystal data and structure refinement details are given in table 4.2.1. The value of R_{int} and R_{sigma} for the data set is 0.0200 and 0.0183 respectively. The structure was solved using SHELXS-97[50]. All the frames could be indexed using primitive monoclinic lattice. 2000 phase sets were refined with the best phase set having a combined figure of merit (CFOM) of 0.1060 using the normalized structure factor with these phase a total of 256 phases were generated. The final RE value equals 24%. The non hydrogen atoms were refined an-isotropically before hydrogen atoms were fixed. The hydrogen atoms were fixed at chemically suitable positions and allowed to ride on the parent atoms. The final residual value is
0.038. The largest peak and hole is 0.36 e.$Å^{-3}$ and -0.24 e.$Å^{-3}$ The 172 parameters were refined with 2376 unique reflections using SHELXL-97[51]. ORTEP [52] of the molecule is shown in fig (7.2.1).

Details of the data collection condition and parameters of refinement process are given in the table 7.2.1. The

final position coordinates with equivalents isotropic temperature factors for the non-hydrogen atoms and hydrogen atoms are listed in tables 7.2.2, 7.2.3 respectively. Anisotropic thermal parameters (U_{ij}**)** of the non-hydrogen atoms are listed in the table 4.2.4.The bond length C9-C10 is 1.396(2) and C10-C14,C11-C12 are 1.378(3), 1.376(3)respectively. The bond length C6-C7, C8-C9 and C8-C16 are 1.439(3), 1.448(3) and 1.509(2) respectively. The torsion angle is
-178.07(12) about C9-C18-C16-S2 indicates *–anti-periplanar* conformation. The torsion angle -20.9(3) about N5-C18-C19-S1 indicates *+Syn-periplanar* conformation. Bond lengths, bond angles and torsion angles are listed in the table 7.2.4, 7.2.5, 7.2.6. An ORTEP (3) view of the compound with the atom number scheme is shown in the figure 7.2.2. Figure 7.2.3 represents the packing of the molecules in the unit cell, figure 7.2.4, 7.2.5, 7.2.6 shows packing of the molecules which are projected down *a*, *b*, and *c*-axis respectively.

Crystallographic data and X-ray structure of compound $C_{14}H_{13}NO_2S_2$,. Measurements were made using Bruker SMART CCD [53] area-detector diffractometer with monochromatic Mo *K*α radiation at room temperature. The crystalline state of a crystal is characterized by a long range, well defined three dimensional orders. Crystals was crystallized using dry ethanol (solvent) by slow evaporation at room temperature and crystalline state is characterized by a long range, well defined three dimensional orders.

Result and discussion

The asymmetric unit contains only on independent molecule is depicted . The 2 H-chromene ring systems is nearly planar, with a maximum deviation of 0.0234(17) Å for atom C9 and the thiazole ring adopts a twist boat chair conformation. The dihedral angle between the 2H-chromene ring (O3 C6 C7 C8 C9 C10 C11 C12 C13 C14) and the thiazole ring (N5 S1 C17 C18 C19) is 82.71(11)°. Bond lengths and angles are within the normal ranges [6]. The crystal structure contains only weak intermolecular C16---H16B...N5 and C7---H7...S2 hydrogen bonds. The packing of the crystal structure is stabilized by C19—H19A…π Cg(3) (C9 C10 C11 C12 C13 C14) interactions as well as π–π [Cg(2): O3 C6 C7 C8 C9 C10) – Cg(3) (C9 C10 C11 C12 C13 C14)] interactions between fused benzene rings of chromene and oxygen contain benzene ring [shortest centroid–centroid distance = 3.6368 (10) Å] . The crystal structure is further stabilized by other intermolecular C15—H15C…S2 hydrogen bonds, that generate inversion dimers with $R_2^2(16)$ ring motifs.

Special Details

All compounds were routinely checked by thin-layer chromatography (TLC) on aluminum-backed silica gel plates. Melting points were determined with open capillary method and are uncorrected. IR spectra were recorded on a *Nicolet 5700 FT-IR* instrument (*Nicolet, Madison, WI, USA*) as KBr discs. The ^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker AC-300F 300 MHz spectrometer in DMSO using TMSi as an

internal standard with ^{1}H resonant frequency of 300 MHz and ^{13}C resonant frequency of 75 MHz. All chemical shifts were reported as δ values (ppm). Mass spectra were recorded on an Autospec EI-MS and elemental analysis was carried out using Heraus CHN rapid analyzer. All the compounds gave C, H and N analysis within ± 0.4% of the theoretical values. The X-ray single-crystal structure of compound recorded using Bruker Smart Apex-2 and refined using the SHELXL Software Package.

Computing Details:

SMART (Bruker, 2001) ; cell refinement: SAINT (Bruker, 2001) [1]; data reduction: SAINT ; program(s) used to solve structure: SHELXS97 ; molecular graphics: ORTEP-3 ; software used to prepare material for publication: SHELXL97 E-map provided positions for all non H-atoms. The full-matrix least-squares refinement was carried out on F^2 using anisotropic temperature factors for all non H-atoms. The H-atoms were located from DF-maps, and then their positions were refined using a riding model with isotropic thermal parameters taken as 1.2 times temperature factors for their parent-atoms. The ORTEPs of these isomers were obtained by the PLATON program. Coordinates were deposited in the Cambridge Crystallographic Data Centre vide no. CCDC 897299

Refinement.

Refinement of *F*2 against ALL reflections. The weighted *R*-factor *wR* and goodness of fit *S* are based on *F*2, conventional *R*-factors *R* are based on *F*, with *F* set to zero for negative *F*2. The threshold expression of $F2 > 2\sigma(F2)$ is used only for calculating *R*-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. *R*-factors based on *F*2 are statistically about twice as large as those based on *F*, and *R*-factors based on ALL data will be even larger.

Table 1: Crystal data, Data collection and Structure refinement ($C_{14}\ H_{13}\ N\ O_2\ S_2$)

Empirical formula	$C_{14}\ H_{13}\ N\ O_2\ S_2$
Formula weight	291.37
Temperature	293(2) K
Wavelength	0.71073 Å
Crystal system, space group	Triclinic P-1
Unit cell dimensions	a = 7.93370(10)Å
	b = 8.09230(10)Å
	c = 10.7299(2)Å
	α = 99.1900(10)°, β= 92.5250(10)°
	γ = 96.4970(10)°
Volume	674.313(17)Å ^{3}
Z	2
Calculated density	1.435mg/m^3
Crystal size	0.22 × 0.15 × 0.12 mm

Absorption coefficient	0.391mm^{-1}
F(000)	304
Crystal form	Prism, colourless
Radiation source	fine-focus sealed tube
Radiation type	Mo *Kα*
Radiation monochromator	graphite
Criterion for observed reflection	I > 2σ(I)
Data collection	
Diffractometer	Bruker SMART CCD area-detector
Data collection method	ω- χ scans
Absorption correction	multi-scan
Theta range for data collection	1.93 to 24.99°
Limiting indices	$-9 \le h \le 9$, $-9 \le k \le 9$, $-12 \le l \le 12$
Reflections collected / unique	10734 / 2376 [R(int) = 0.0200]
Completeness to theta	99.6 %
Max. and min. transmission	T_{max} = 1.000, T_{min} = 0.790
Refinement	
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	2376 / 0 / 172
Goodness-of-fit on F^2	1.059
Final R indices [I>2σ(I)]	R1 = 0.0379, wR2 = 0.1108
R indices (all data)	R1 = 0.0414, wR2 = 0.1141
Weighting scheme	$\omega = 1/[\sigma^2(F^2) + (0.0692P)^2 + 0.2281P]$ Where $P = (F^2 + 2F^2)/3$
(Δ/σ)max	< 0.001
Largest diff. peak and hole	0.356 and -0.237e.Å^{-3}

Table 2 : Atomic coordinates and is equivalent thermal parameters of the non-hydrogen atoms for ($C_{14}H_{13}NO_2S_2$)Å

Atom	X	Y	Z	U_{eq}
S1	0.26051(8)	0.54985(7)	1.06939(5)	0.0591(2)
S2	0.30427 (6)	0.58968 (6)	0.80172 (5)	0.04881 (19)
O3	−0.14765 (15)	0.20784 (17)	0.45602 (13)	0.0449 (3)
O4	−0.29455 (17)	0.3557 (2)	0.59227 (15)	0.0559 (4)
N5	0.2522 (2)	0.2937 (2)	0.88498 (16)	0.0493 (4)
C6	−0.1550 (2)	0.3230 (2)	0.56297 (18)	0.0426 (4)
C7	0.0036 (2)	0.3970 (2)	0.62975 (18)	0.0414 (4)

C8	0.1552 (2)	0.3592 (2)	0.59139 (17)	0.0365 (4)
C9	0.1604 (2)	0.2350 (2)	0.47888 (17)	0.0360 (4)
C10	0.0060 (2)	0.1618 (2)	0.41534 (18)	0.0390 (4)
C11	0.3096 (2)	0.1788 (2)	0.43036 (18)	0.0398 (4)
C12	0.3053 (2)	0.0559 (2)	0.32526 (19)	0.0438 (4)
C13	0.1465 (3)	−0.0138 (2)	0.26608 (19)	0.0485 (5)
C14	−0.0021 (2)	0.0385 (2)	0.30986 (19)	0.0467 (5)
C15	0.4663 (3)	−0.0044 (3)	0.2763 (2)	0.0585 (5)
C16	0.3211 (2)	0.4416 (3)	0.65983 (18)	0.0435 (4)
C17	0.2680 (2)	0.4518 (2)	0.91029 (18)	0.0424 (4)
C18	0.2395 (4)	0.2195 (3)	1.0004 (2)	0.0672 (6)
C19	0.1994 (4)	0.3456 (3)	1.1098 (2)	0.0681 (6)

$$U_{eq}^{*} = \frac{1}{3}\left[\sum_i \sum_j U_{ij}\,(a_i^{*} a_j^{*})(a_i . a_j)\right]$$

Table 3: Atomic coordinates and equivalent thermal parameters of hydrogen atoms for ($C_{14}H_{13}NO_2S_2$) **(** Å).

Atom	**X**	**Y**	**Z**	**U_{eq}**
H7	0.0009	0.4749	0.7032	0.050*
H11	0.4142	0.2261	0.4705	0.048*
H13	0.1416	−0.0976	0.1953	0.058*
H14	−0.1064	−0.0085	0.2690	0.056*
H15A	0.4390	−0.0898	0.2029	0.088*
H15B	0.5244	−0.0505	0.3407	0.088*
H15C	0.5383	0.0886	0.2541	0.088*
H16A	0.3863	0.4996	0.6019	0.052*
H16B	0.3849	0.3537	0.6816	0.052*

H18A	0.3462	0.1785	1.0201	0.081*
H18B	0.1512	0.1241	0.9866	0.081*
H19A	0.2625	0.3325	1.1864	0.082*
H19B	0.0790	0.3307	1.1233	0.082*

$$\frac{1}{3}[\underline{U}_{eq}^{*}(\ )\sum_{i}\sum_{j}U_{ij}\,(a_i a_j)^{*}(a_i.\,a_j)^{*}]$$

Table 4: Anisotropic thermal parameter of the non-hydrogen atoms for ($C_{14}H_{13}NO_2S_2$) Å.

Atom	U^{11}	U^{22}	U^{33}	U^{12}	U^{13}	U^{23}
S1	0.0746 (4)	0.0539 (3)	0.0440 (3)	0.0071 (3)	−0.0002 (3)	−0.0047 (2)
S2	0.0525 (3)	0.0415 (3)	0.0482 (3)	−0.0034 (2)	−0.0061 (2)	0.0037 (2)
O3	0.0311 (6)	0.0511 (8)	0.0503 (8)	−0.0024 (5)	−0.0028 (5)	0.0084 (6)
O4	0.0333 (7)	0.0677 (10)	0.0675 (10)	0.0061 (6)	0.0060 (6)	0.0123 (8)
N5	0.0570 (10)	0.0448 (9)	0.0430 (9)	0.0008 (7)	−0.0017 (7)	0.0031 (7)
C6	0.0351 (9)	0.0461 (10)	0.0486 (11)	0.0010 (7)	0.0020 (8)	0.0167 (8)
C7	0.0371 (9)	0.0452 (10)	0.0412 (10)	0.0021 (7)	0.0004 (7)	0.0078 (8)
C8	0.0348 (9)	0.0378 (9)	0.0377 (9)	−0.0012 (7)	−0.0007 (7)	0.0135 (7)
C9	0.0345 (9)	0.0347 (9)	0.0392 (9)	−0.0014 (7)	−0.0012 (7)	0.0123 (7)
C10	0.0335 (9)	0.0404 (9)	0.0440 (10)	−0.0016 (7)	−0.0012 (7)	0.0145 (8)
C11	0.0352 (9)	0.0390 (9)	0.0453 (10)	−0.0004 (7)	0.0004 (7)	0.0120 (8)
C12	0.0468 (10)	0.0389 (9)	0.0475 (10)	0.0036 (8)	0.0053 (8)	0.0130 (8)
C13	0.0579 (12)	0.0392 (10)	0.0455 (11)	0.0001 (8)	0.0004 (9)	0.0032 (8)
C14	0.0447 (10)	0.0441 (10)	0.0473 (11)	−0.0064 (8)	−0.0077 (8)	0.0069 (8)
C15	0.0557 (12)	0.0528 (12)	0.0671 (14)	0.0101 (9)	0.0123 (10)	0.0055(10)
C16	0.0351 (9)	0.0516 (11)	0.0418 (10)	−0.0007 (8)	−0.0013 (7)	0.0071 (8)
C17	0.0341 (9)	0.0471 (11)	0.0418 (10)	0.0018 (7)	−0.0052 (7)	−0.0008(8)
C18	0.0948 (18)	0.0544 (13)	0.0516 (13)	0.0049 (12)	0.0008 (12)	0.0105(10)
C19	0.0813 (16)	0.0700 (15)	0.0529 (13)	0.0064 (12)	0.0098 (12)	0.0103(12)

Table 5: Bond lengths of ($C_{14}H_{13}NO_2S_2$) (A^0).

Atom	Atom	Bond
S1	C17	1.7705 (19)
S1	C19	1.795 (3)
S2	C17	1.749 (2)
S2	C16	1.801 (2)
O3	C6	1.366 (2)
O3	C10	1.383 (2)
O4	C6	1.210 (2)
N5	C17	1.255 (3)
N5	C18	1.462 (3)
C6	C7	1.439 (3)
C7	C8	1.340 (3)
C8	C9	1.448 (3)
C18	C19	1.498 (3)
C8	C16	1.509 (2)
C9	C10	1.396 (2)
C9	C11	1.407 (3)
C10	C14	1.378 (3)
C11	C12	1.376 (3)
C12	C13	1.401 (3)
C12	C15	1.505 (3
C13	C14	1.374(3)
C13	H13	0.9300
C14	H14	0.93
C15	H15A	0.96
C15	H15B	0.96
C15	H15C	0.96
C7	C8	1.340 (3)
C16	H16B	0.97
C18	C19	1.498 (3)
C18	H18A	0.97
C18	H18B	0.97
C19	H19A	0.97
C10	C14	1.378 (3)

Table 6: Bond lengths of ($C_{14}H_{13}NO_2S_2$) (Å).

Atom	Atom	Atom	Angle
C17	S1	C19	88.60 (10)
C 17	S2	C16	100.45 (9)
C6	O3	C10	121.25 (14)
C17	N5	C18	110.88 (18)
O4	C6	O3	117.07 (17)
O4	C6	C7	125.67 (19)
O3	C6	C7	117.25 (16)
C8	C7	C6	123.26 (18)
C9	C8	C16	118.48 (15)
C8	C16	S2	115.89 (13)
C7	C8	C9	118.68 (16)
C7	C8	C16	122.83 (17)
C10	C9	C8	117.85 (16)
C10	C9	C11	117.30 (17)
C11	C9	C8	124.83(16)
C14	C10	O3	116.31 (15)
C14	C10	C9	122.02 (17)
O3	C10	C9	121.66 (17)
C12	C11	C9	121.94 (17)
C11	C12	C13	118.16 (17)
C11	C12	C15	121.04 (18)
C13	C12	C15	120.79 (19)
C14	C13	C12	121.72 (18)
C13	C14	C10	118.86 (17)
N5	C17	S1	118.99 (16)
S2	C17	S1	115.23 (11)
N5	C17	S2	125.75 (16)
N5	C18	C19	111.30 (19)
C18	C19	S1	106.35 (17)

Table 7: Torsion angles of **(**$C_{14}H_{13}NO_2S_2$**)** [A°].

Atom	Atom	Atom	Atom	Angle	Atom	Atom	Atom	Atom	Angle
C10	O3	C6	O4	-179.68 (16)	C9	C11	C12	C15	178.95 (17)
C10	O3	C6	C7	1.4 (2)	C11	C12	C13	C14	0.5 (3)
O4	C6	C7	C8	−178.30 (18)	C15	C12	C13	C14	179.47 (19)
O3	C6	C7	C8	0.5 (3)	C12	C13	C14	C10	−0.5 (3)
C6	C7	C8	C9	−1.5 (3)	O3	C10	C14	C13	−179.20 (16)
C6	C7	C8	C16	178.01 (16)	C9	C10	C14	C13	0.0 (3)
C7	C8	C9	C10	0.6 (2)	C7	C8	C16	S2	2.4 (2)
C16	C8	C9	C10	−178.96 (15)	C9	C8	C16	S2	−178.07 (12)
C7	C8	C9	C11	−177.64 (16)	C17	S2	C16	C8	81.62 (15)
C16	C8	C9	C11	2.8 (2)	C18	N5	C17	S2	174.54 (16)
C6	O3	C10	C14	176.89 (16)	C18	N5	C17	S1	−3.3 (2)
C6	O3	C10	C9	−2.3 (2)	C16	S2	C17	N5	−2.84 (19)
C11	C9	C10	C14	0.5 (3)	C16	S2	C17	S1	175.08 (10)

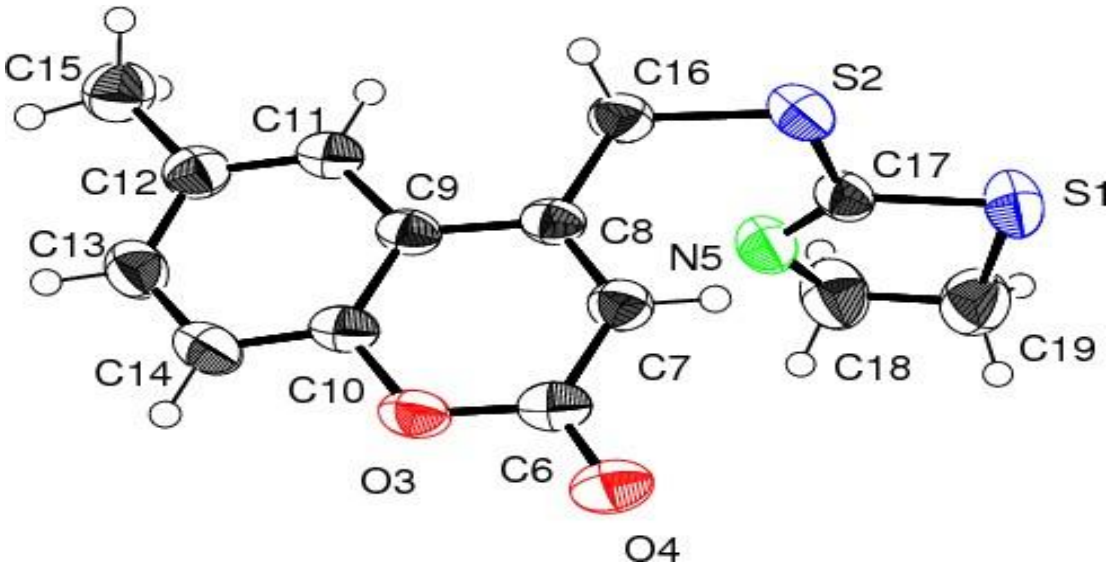

Figure 1 ORTEP diagram of the molecule $C_{14}H_{13}NO_2S_2$ at 50% probability.

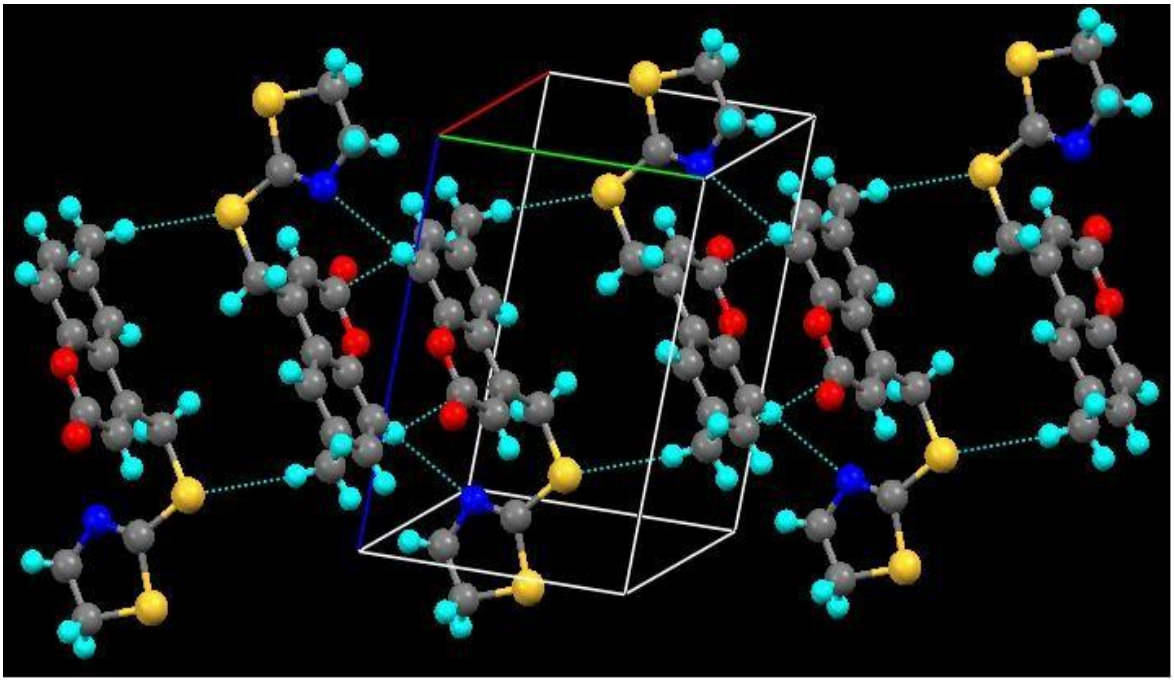

Figure 2: Packing of the molecule $C_{14}H_{13}NO_2S_2$ in the unit cell.

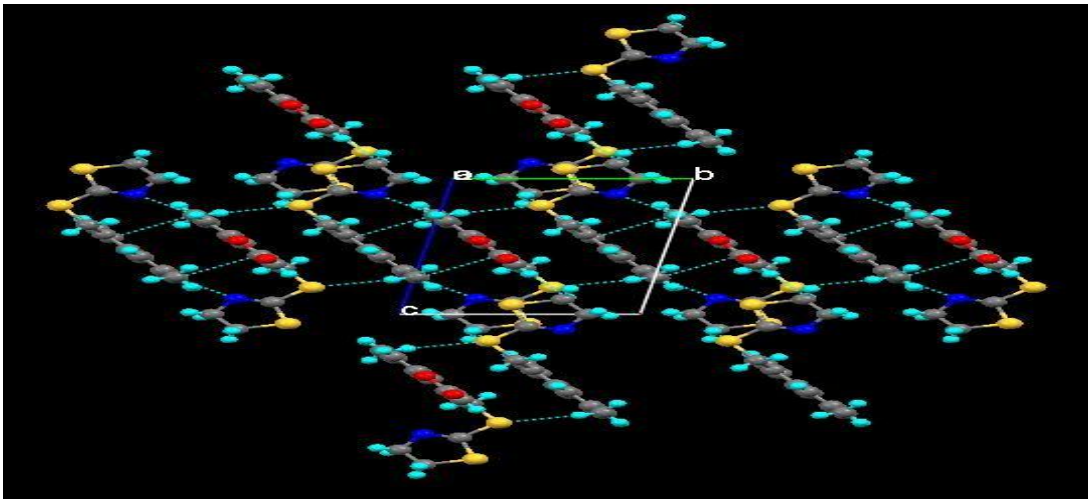

Figure 3: Packing of the molecule $C_{14}H_{13}NO_2S_2$ down *a*-axis.

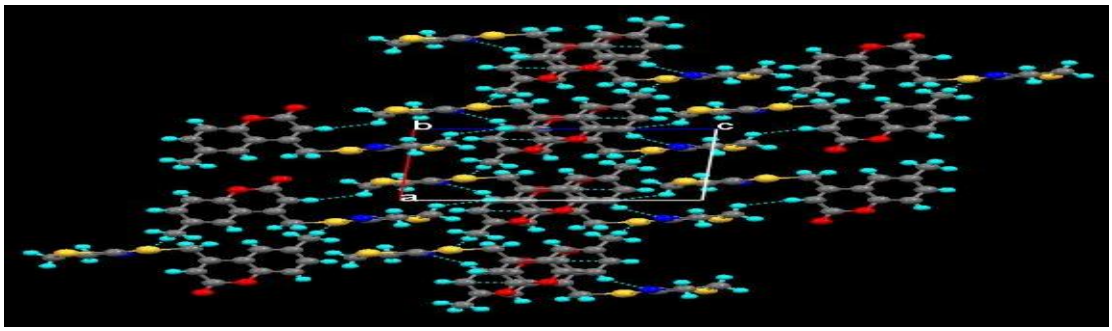

Figure 4: Packing of the molecule $C_{14}H_{13}NO_2S_2$ down b-axis

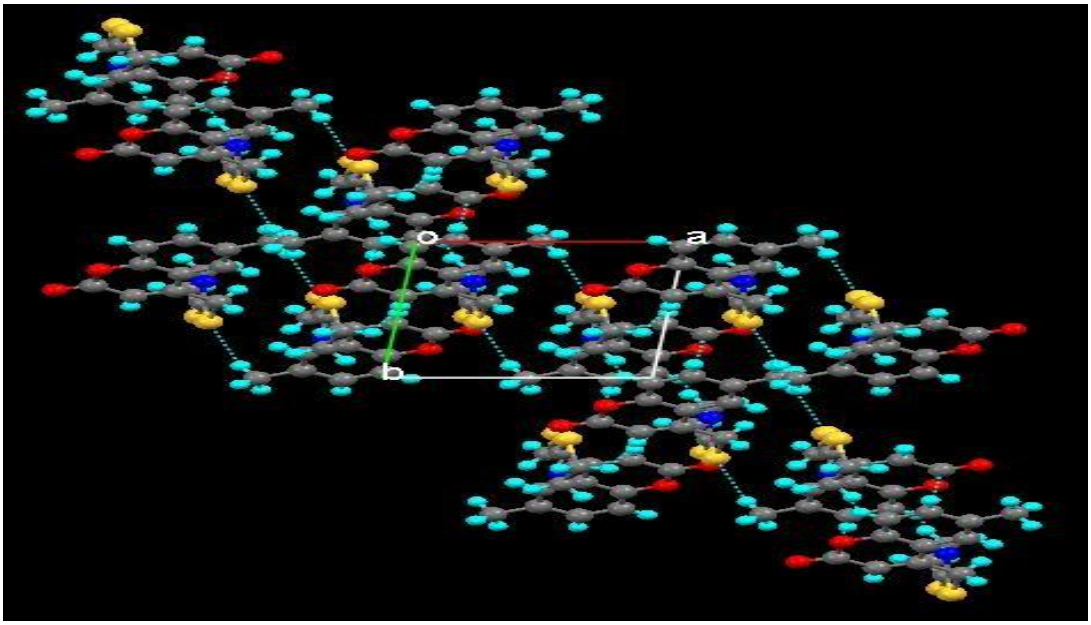

Figure 5: Packing of the molecule **(**$C_{14}H_{13}NO_2S_2$**)** down c-axis.

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