A Close Insight into the Nature of Intermolecular Interactions in Dihydropyrimidine-2(*1H*)-thione Derivatives

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Electronic Supporting Information (ESI)

Table S8. Molecular dipole moments and electrostatic potentials for **1**-**4** and related compounds.

Figure S1. Overlay diagram of the first independent molecule A (shown in red) and the second independent molecule B (shown in blue) for compound **1**.

Figure S2. Packing diagram of **1** showing alternated $R_2^2(8)$ and $R_2^2(12)$ motifs motifs *via* intermolecular N–H···S and C–H···S hydrogen bonds, respectively, as well as intermolecular energies for the respective molecular pairs.

Figure S3. Packing diagram of **2** showing $R_2^2(10)$ motifs through intermolecular N–H···S and C–H···S hydrogen bonds, as well as C–H···Cl hydrogen bonds. Intermolecular energies are given for the respective molecular pairs.

Figure S4. Packing diagram of **3** displaying intermolecular N–H···S hydrogen bonds forming $R_2^2(8)$ dimers interconnected by C–H···S hydrogen bonds. Intermolecular energies are showed for the respective molecular pairs.

Figure S5. Packing diagram of **4** showing $R_2^2(8)$, $R_2^2(14)$ and $R_2^2(6)$ motifs *via* intermolecular N–H···S, C–H···S and C–H···O hydrogen bonds, respectively. Intermolecular energies are given for the respective molecular pairs.

Figure S6. Hirshfeld surfaces for compound **1,** mapped over: (a) shape index and (b) curvedness, the former highlighting the touching red and blue triangles involved in π-stacking interactions.

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Figure S9. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing the charge depleted (CD) region (in red) and charge concentrated (CC) region (in blue) for compound **1**. Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^3.

Figure S10. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing the CD region (in red) and CC region (in blue) for compound **2**.Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^3.

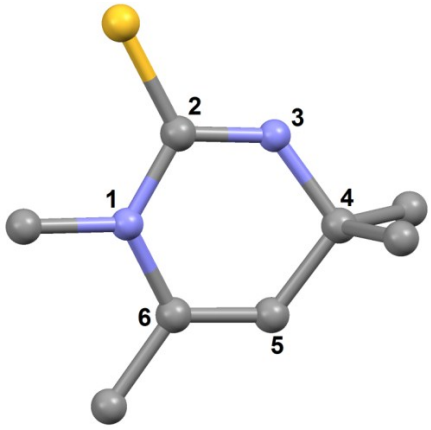
Figure S11. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing CD region (in red) and CC region (in blue) for compound **3**.Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^3.

Figure S12. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing the CD region (in red) and CC region (in blue) for compound **4**. Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^3.

Table S1. Ring puckering parameters for compounds **1**-**4** (Å, º).

	Q	**θ**	**ϕ**
Compound **1A**	0.3023	110.10	231.80
Compound **1B**	0.1860	70.03	46.54
Compound **2**	0.2244	61.65	62.91
Compound **3**	0.1480	108.77	147.72
Compound **4**	0.1089	71.92	185.82

Table S2. Endocyclic torsion angles in the pyrimidine ring for compounds **1**-**4** (°).



Atoms	**1A**	**1B**	**2**	**3**	**4**
6-1-2-3	9	-4	-1	4	-4
1-2-3-4	17	-12	-13	12	-6
2-3-4-5	34	22	18	-26	12
3-4-5-6	28	-17	-10	26	-10
4-5-6-1	-8	4	-1	-14	3
5-6-1-2	-13	9	8	-3	5

Table S3. Topological parameters (atomic units) of the close shell intermolecular (3,-1) critical points (electron density (ρ), Laplacian ($\nabla^2\rho$) and positive curvature (λ_3)) and geometrical parameters (Å and °) of the interactions used in the structure description of compound **1**.

INTERACTION[a,b]		ρ	$\nabla^2\rho$	λ_3	$d_{H\cdots S/Cl}$	$\theta_{D-H\cdots S/Cl}$
I	NH(A)···S(B) (i)	0.0194	0.0433	0.0829	2.425	161.5
II	S(A)···HN(B) (ii)	0.0138	0.0365	0.0617	2.605	146.1
III	S(A)···H_R(B) (iii)	0.0104	0.0296	0.0464	2.758	150.2
IV	H_R(A)···S(A) (iv)	0.0101	0.0279	0.0446	2.772	166.8
V	Cl(A)···H_{me}(B) (v)	0.0099	0.0329	0.0508	2.689	171.7
VI	S(B)···H_R(B) (vi)	0.0096	0.0262	0.0414	2.817	163.0
VII	H_{me}(A)···S(B) (ii)	0.0090	0.0319	0.0449	2.744	133.8
VIII	S(B)···H_R(A) (vii)	0.0084	0.0238	0.0366	2.870	162.2

[a]: atom or group belonging to the reference molecule on the left of the interaction symbol. A and B between parentheses stand for identifying the molecule within asymmetric unit. [b]: between parentheses at the line end symmetry operation generating the neighbor molecule (i: x,1/2-y,-1/2+z; ii: x,1/2-y,-1/2+z; iii: 1-x,1/2+y,1.5-z; iv: -x,1-y,1-z; v: x,1+y,z; vi: 1-x,-y,2-z; vii: -x,-1/2+y,1.5-z).

Table S4. Topological parameters (atomic units) of the close shell intermolecular (3,-1) critical points (electron density (ρ), Laplacian ($\nabla^2\rho$) and positive curvature (λ_3)) and geometrical parameters (Å and °) of the interactions used in the structure description of compound **2**.

INTERACTION[a]		ρ	$\nabla^2\rho$	λ_3	$d_{H/Cl\cdots S/Cl}$	$\theta_{D-H\cdots S/Cl}$
I	NH···S(i)	0.0146	0.0373	0.0649	2.531	161.8
II	H_R···S(ii)	0.0115	0.0325	0.0522	2.684	157.7
III	H_R···S(iii)	0.0098	0.0267	0.0427	2.806	160.4
IV	H_{me}···S(iv)	0.0083	0.0288	0.0411	2.782	141.4
V	Cl2···Cl2(v)	0.0070	0.0291	0.0379	3.378	
VI	H_{me}···S(vi)	0.0055	0.0180	0.0256	3.026	144.5

[a]: atom or group belonging to the reference molecule on the left of the interaction symbol. Between parentheses at the line end symmetry operation generating the neighbor molecule (i: -x,-1/2+y,1/2-z; ii: ;iii: -x,1/2+y,1/2-z; iv: -x,-1/2 +y,1/2 -z; v: 1-x,1-y,-z; vi: -x,-1/2 +y,1/2-z).

Table S5. Topological parameters (atomic units) of the close shell intermolecular (3,-1) critical points (electron density (ρ), Laplacian ($\nabla^2\rho$) and positive curvature (λ_3)) and geometrical parameters (Å and °) of the interactions used in the structure description of compound **3**.

INTERACTION[a,b]		ρ	$\nabla^2\rho$	λ_3	$d_{H\cdots S}$	$\theta_{D-H\cdots S}$
I	NH···S(i)	0.0215	0.0465	0.0918	2.367	163.6
II	S···H_R(ii)	0.0077	0.0250	0.0361	2.910	125.5
III	S···H_R(iii)	0.0061	0.0184	0.0269	3.053	130.7
IV	S···H_{me}(iv)	0.0058	0.0203	0.0272	2.972	137.6

[a]: atom or group belonging to the reference molecule on the left of the interaction symbol. Between parentheses symmetry operation generating the neighbor molecule (i: 1-x,2-y,2-z; ii: 1/2+x,1.5-y,1/2+z; iii: 1-x,1-y,2-z; iv: 1-x,2-y,2-z)

Table S6. Topological parameters (atomic units) of the close shell intermolecular (3,-1) critical points (electron density (ρ), Laplacian ($\nabla^2\rho$) and positive curvature (λ_3)) and geometrical parameters (Å and °) of the interactions used in the structure description.

INTERACTION[a]		ρ	$\nabla^2\rho$	λ_3	$d_{H\cdots S/O}$	$\theta_{D-H\cdots S/O}$
I	S··· HN(i)	0.0198	0.0440	0.0846	2.416	159.2
II	$H_{me}\cdots O$(ii)	0.0105	0.0341	0.0557	2.446	143.2
III	$H_R\cdots S$(iii)	0.0094	0.0264	0.0414	2.813	148.8
IV	$O\cdots H_{me}$(iv)	0.0074	0.0273	0.0413	2.604	128.7

[a]: atom or group belonging to the reference molecule on the left of the interaction symbol. Between parentheses symmetry operation generating the neighbor molecule (i:-x,2-y,-z; ii: -1+x,y,z,1/2+z; iii: 1-x,1-y,-z; iv: 2-x,-y,1-z).

Table S7. Interaction energies (E_{TOT}) partitioned into coulombic, polarization, dispersion and repulsion contributions (kJ mol^{-1}) for various molecular pairs involving H···H contacts in **1**–**4** and related compounds (RefcodeCSD).

Compound	Symmetry	Involved Interactions	Centroid distance	E_{coul}	E_{pol}	E_{disp}	E_{rep}	E_{TOT}
1	-x,½+y,1.5-z	H11A···H20F	7.187	-10.6	-6.7	-32.4	24.8	-24.9
	-1+x,1.5-y,-½+z	H11C···H21B	11.757	0.5	-1.1	-8.0	3.6	-5.0
2	1-x,1-y,1-z	H6A···H6A	9.109	0.5	-1.2	-7.4	3.6	-4.5
3	½+x,1.5-y,½+z	H15B···H3B	7.606	-14.1	-8.0	-28.4	22.4	-28.2
4	-x,1-y,-z	H2A···H13B	7.450	-3.4	-3.1	-22.4	14.7	-14.2
DUNZIW	1-x,2-y,1-z	H15···H9A	5.779	-15.3	-7.5	-45.7	27.3	-41.1
EVEWIM	2-x,1-y,1-z	H11A···H11A	11.048	-5.3	-1.7	-11.3	7.2	-11.1
	1+x,½-y,-½+z	H15···H6C	10.618	-2.2	-1.0	-7.4	3.8	-6.7
VAGSUR	1-x,1-y,-z	H12···H12	9.377	-4.8	-1.2	-9.1	3.1	-12.0
IMARIY	1.5-x,-½+y,½-z	H13B···H14B	8.492	-3.5	-1.8	-17.9	9.6	-13.5
PUJYID	1.5-x,-y,-½+z	H14A···H21C	9.534	-3.7	-2.9	-13.9	15.0	-5.5
FAXVOQ-I	-½+x,½-y,1-z	H20A···H18A	7.684	-2.9	-1.9	-17.4	11.2	-11.0
FAXVOQ-II	-1+x,y,z	H4A···H2A	8.486	-2.0	-3.4	-13.9	6.8	-12.4
	-1-x,1-y,1-z	H3A···H3A	12.105	-0.6	-0.9	-7.7	4.3	-4.9
	-x,-y,1-z	H11B···H13D	5.547	-8.6	-4.5	-42.9	23.2	-32.8

Table S8. Theoretical and experimental molecular dipole moments and electrostatic potentials[a] for **1**-**4** and related compounds.

Compound	μ(D)		Interactions	Electrostatic potential (au)						
	Theor	Exp		H	S	F	Cl	Br[b]	C	O
1	5.15	5.82	N11-H1A···S2	0.112	-0.082	-	-	-	-	-
			N21-H2A···S1	0.084	-0.082	-	-	-	-	-
			C110-H11A···S1	0.040	-0.053	-	-	-	-	-
			C207-H20G···Cl1	0.043	-	-	-0.017	-	-	-
2	5.04	5.79	N1-H1A···S1	0.174	-0.027	-	-	-	-	-
			C9-H9A···S1	0.139	-0.022	-	-	-	-	-
			C6-H6C···Cl1	0.031	-	-	-0.018	-	-	-
			Cl1···C12	-	-	-	0.005	-	-0.018	-
			Cl2···Cl2	-	-	-	0.012	-	-	-
3	3.67	5.86	N1-H1A···S1	0.117	-0.086	-	-	-	-	-
			C5-H5A···S1	0.013	-0.076	-	-	-	-	-
4	4.30	5.45	N2-H2···S1	0.109	-0.087	-	-	-	-	-
			C3-H3A···S1	0.047	-0.078	-	-	-	-	-
			C12-H12A···O1	0.050	-	-	-	-	-	-0.063
			C7-H7B···O1	0.018	-	-	-	-	-	-0.062
IJUGEA	5.16	5.35	N1-H1A···S1	0.108	-0.078	-	-	-	-	-
			C9-H9···Cl1	0.040	-	-	-0.019	-	-	-
DUNZIW	5.59	5.62	N3-H1···S1	0.104	-0.074	-	-	-	-	-
			C15-H15···Cl1	0.032	-	-	-0.024	-	-	-
EVEWIM	5.19	5.61	N1-H1A···S1	0.111	-0.079	-	-	-	-	-
			C3-H3A···F1	0.038	-	-0.033	-	-	-	-
VAGSUR	3.29	4.87	N2-H1···S1	0.117	-0.080	-	-	-	-	-
			C5-H8···S1	0.024	-0.068	-	-	-	-	-
			C7-H11···Br1	0.019	-	-	-	-0.016	-	-
IMARIY	5.19	5.10	N2-H2···S1	0.116	-0.080	-	-	-	-	-
			C9-H9A···S1	0.037	-0.072	-	-	-	-	-
PUJYID	5.09	5.05	N1-H1N···S2,	0.089	-0.082	-	-	-	-	-
			N3-H3N···S1	0.103	-0.081	-	-	-	-	-
FAXVOQ-I	5.09	5.10	N2-H2A···S2,	0.096	-0.087	-	-	-	-	-
			N4-H4A···S1	0.098	-0.090	-	-	-	-	-
			C12-H12A···S1	0.037	-0.067	-	-	-	-	-
FAXVOQ-II	5.09	5.10	N2-H2A···S1	0.085	-0.086	-	-	-	-	-
			C13-H13A···S1	0.046	-0.059	-	-	-	-	-

(a) 6-31G** basis set; (*b*) cc-ρVDZ basis set

Figure S1. Overlay diagram of the first independent molecule A (shown in red) and the second independent molecule B (shown in blue) for compound **1**.

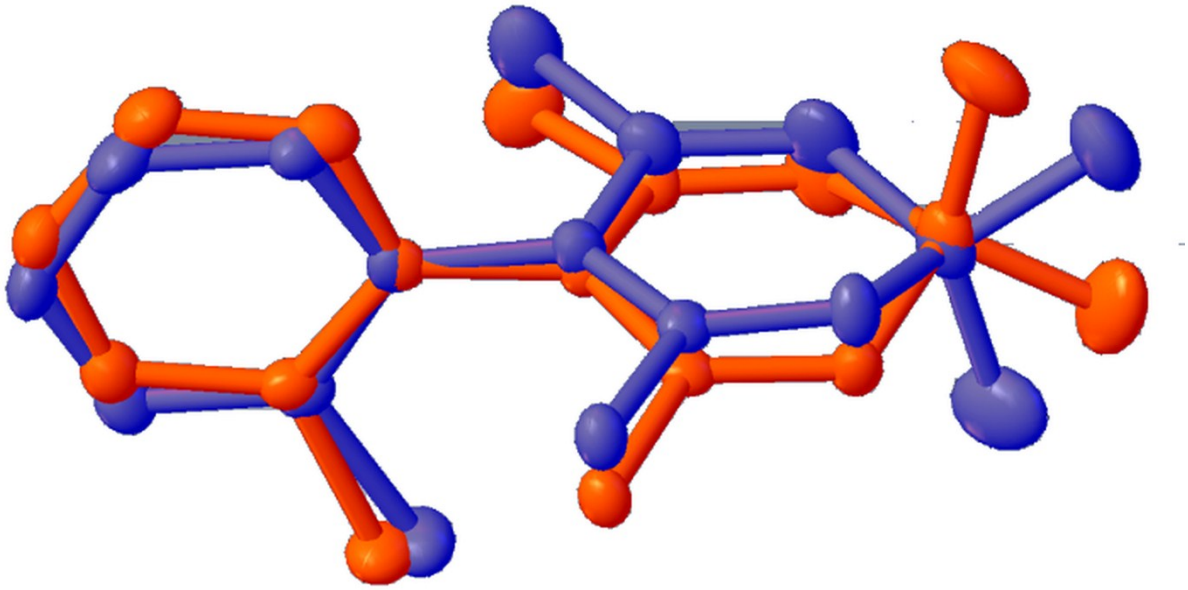
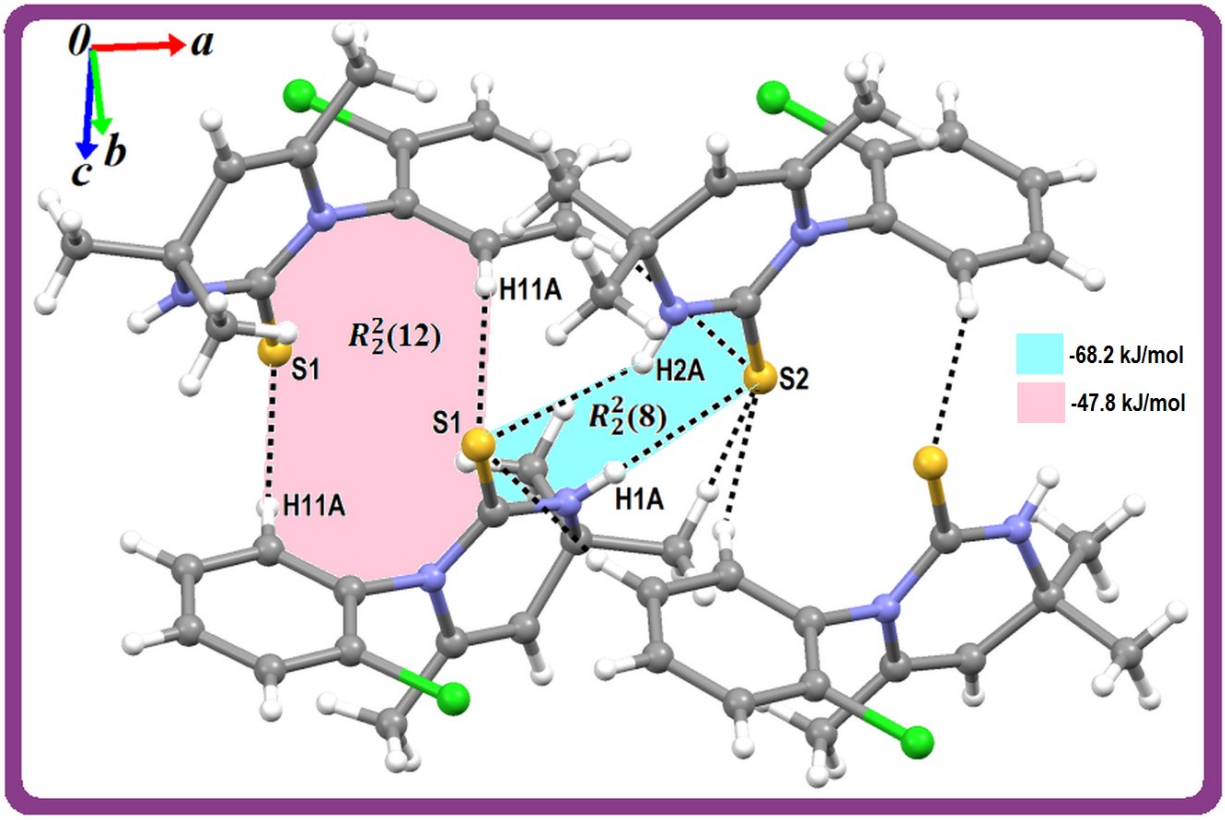


Figure S2. Packing diagram of **1** showing alternated $R_2^2(8)$ and $R_2^2(12)$ motifs *via* intermolecular N–H···S and C–H···S hydrogen bonds, respectively, as well as intermolecular energies for the respective molecular pairs.



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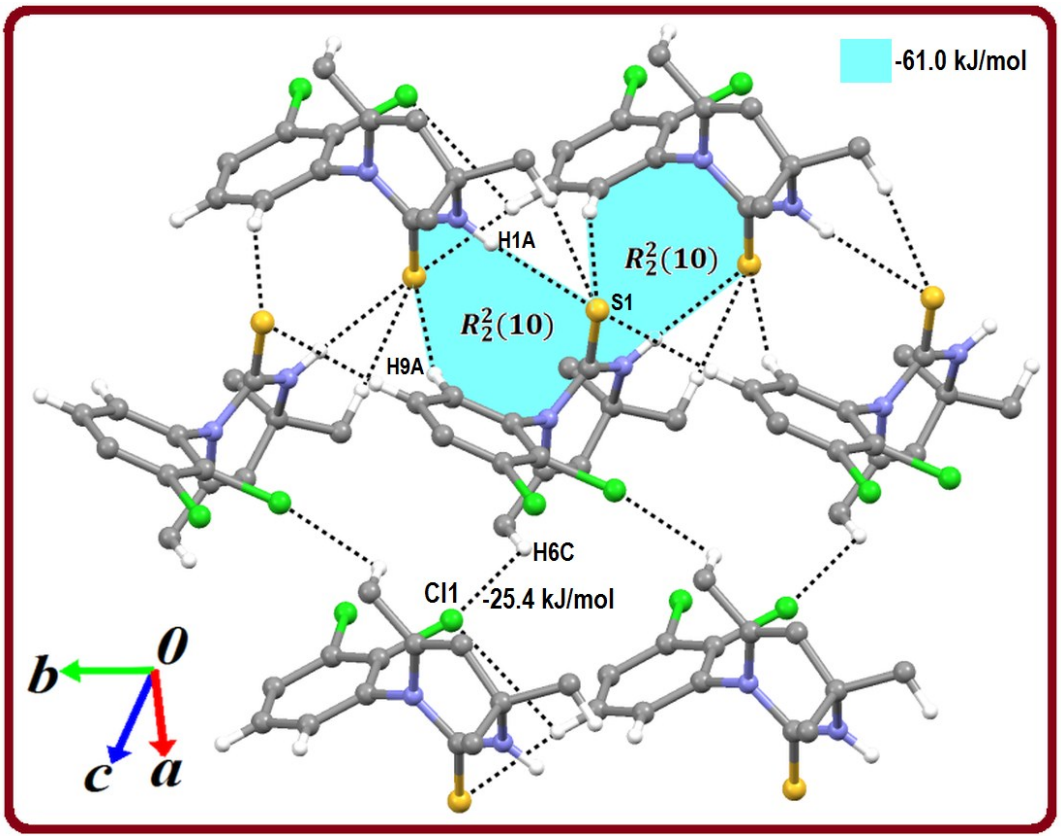

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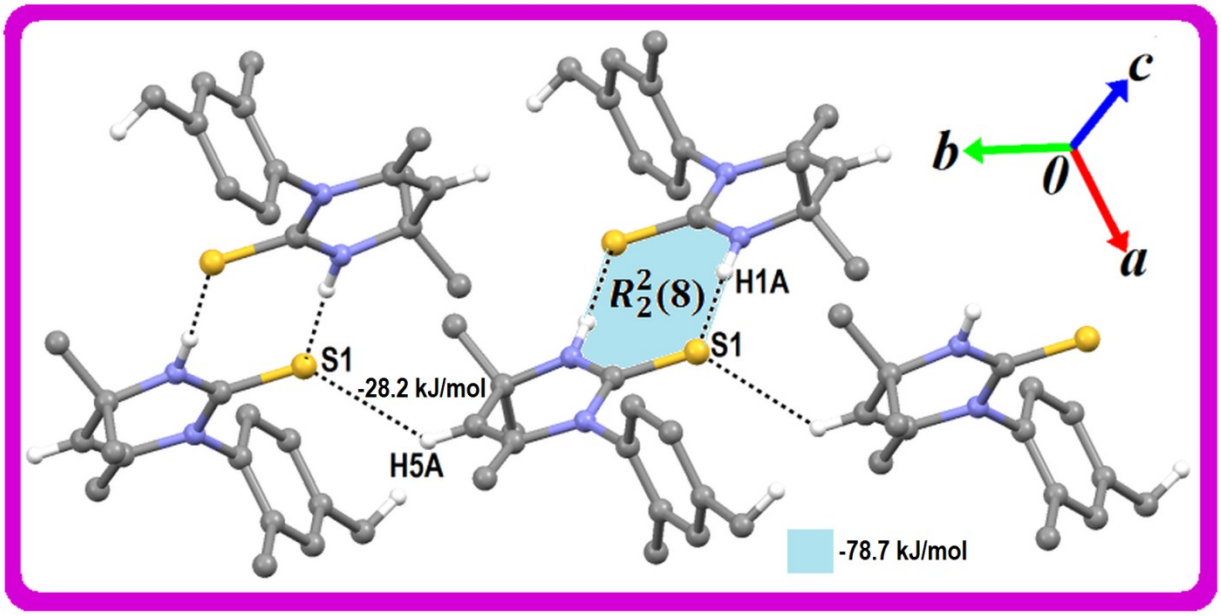

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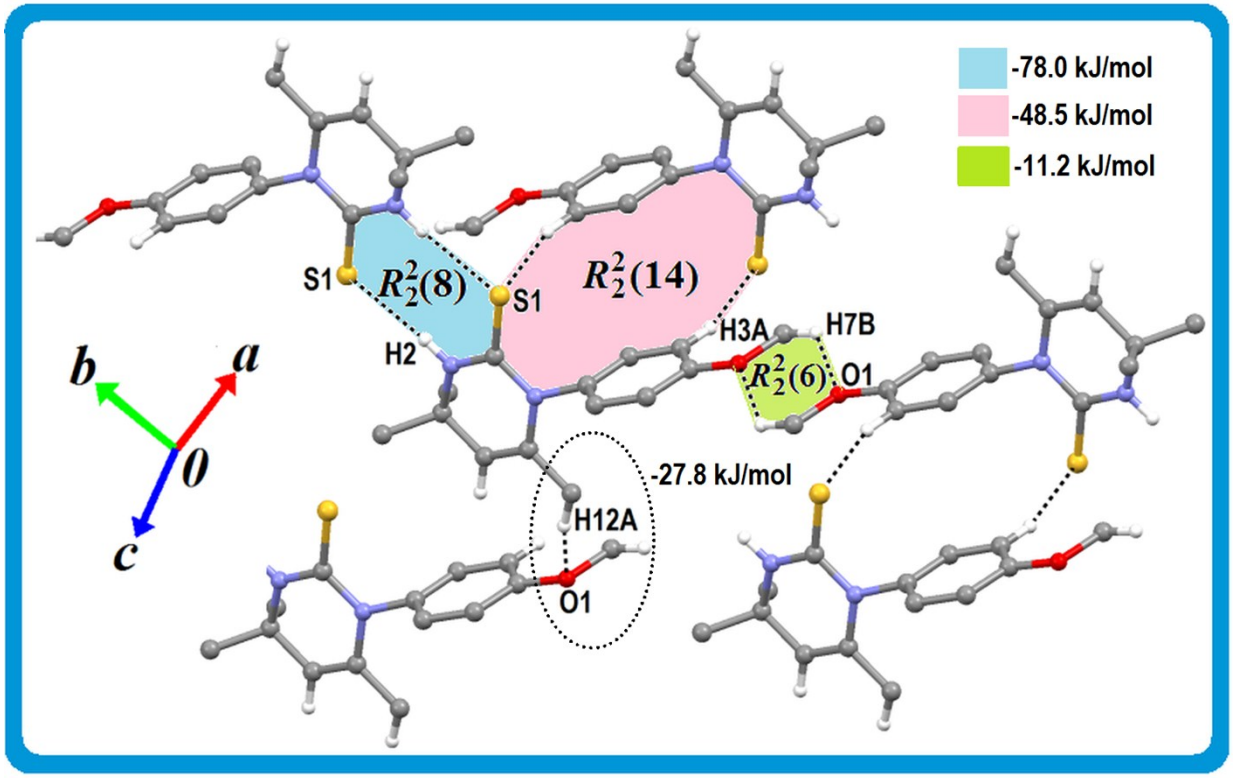

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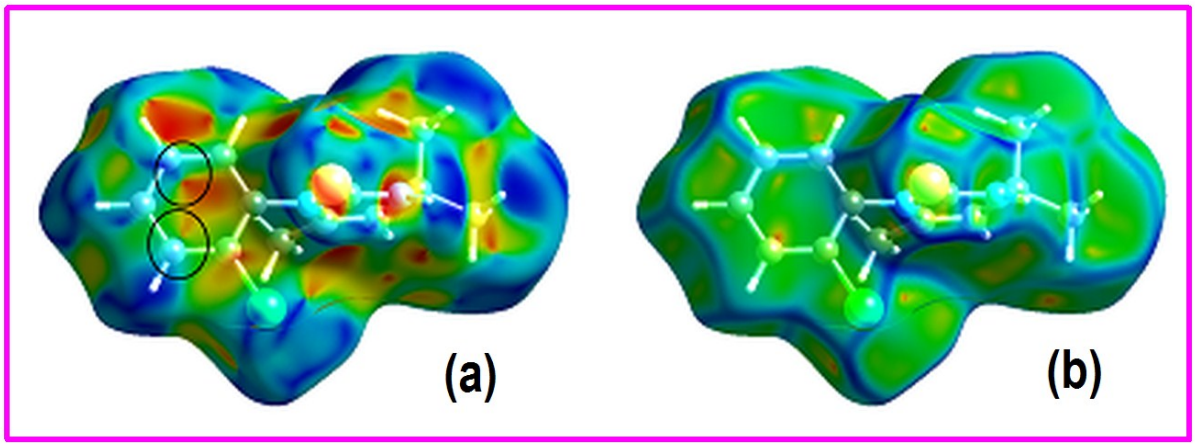

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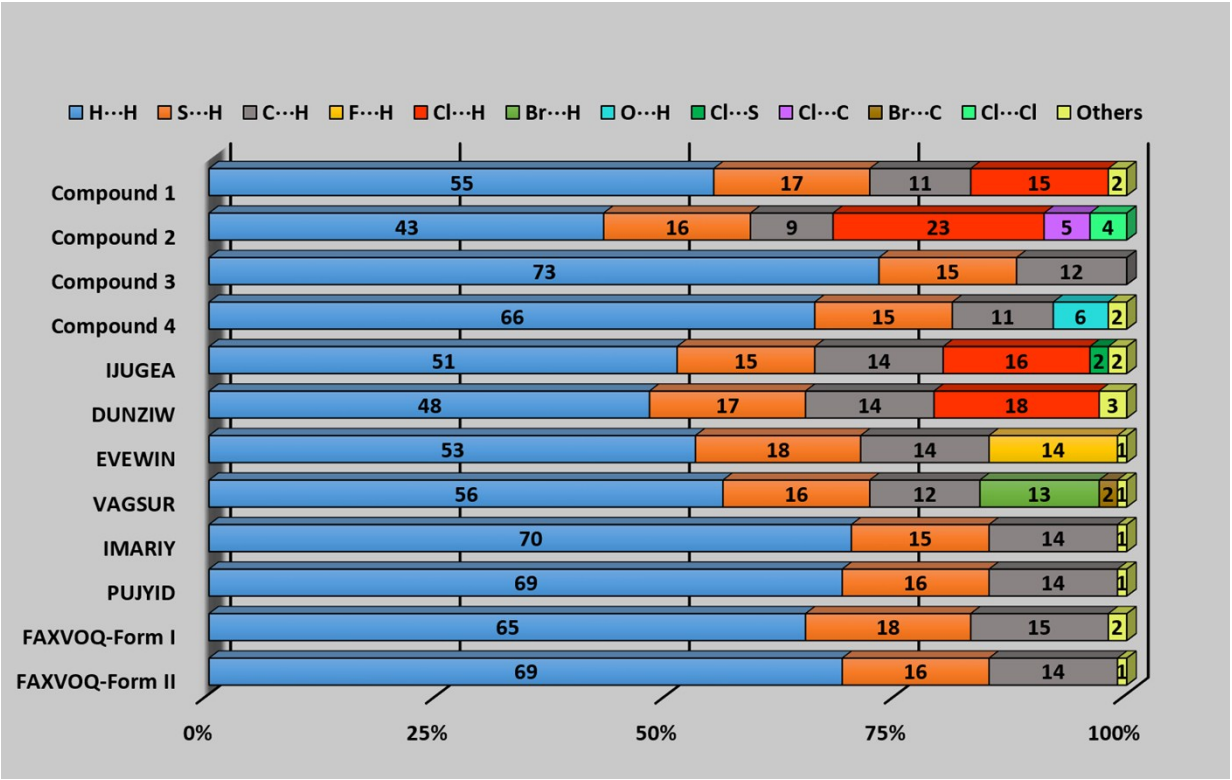

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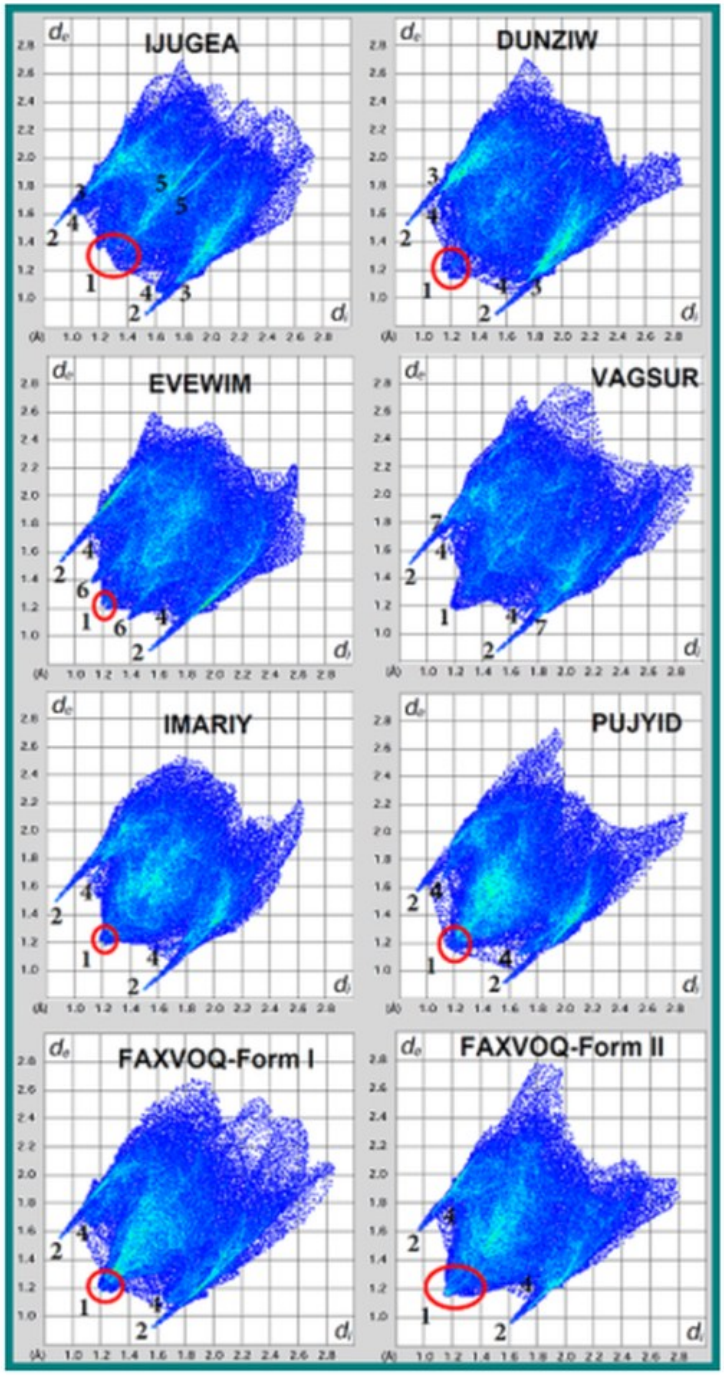

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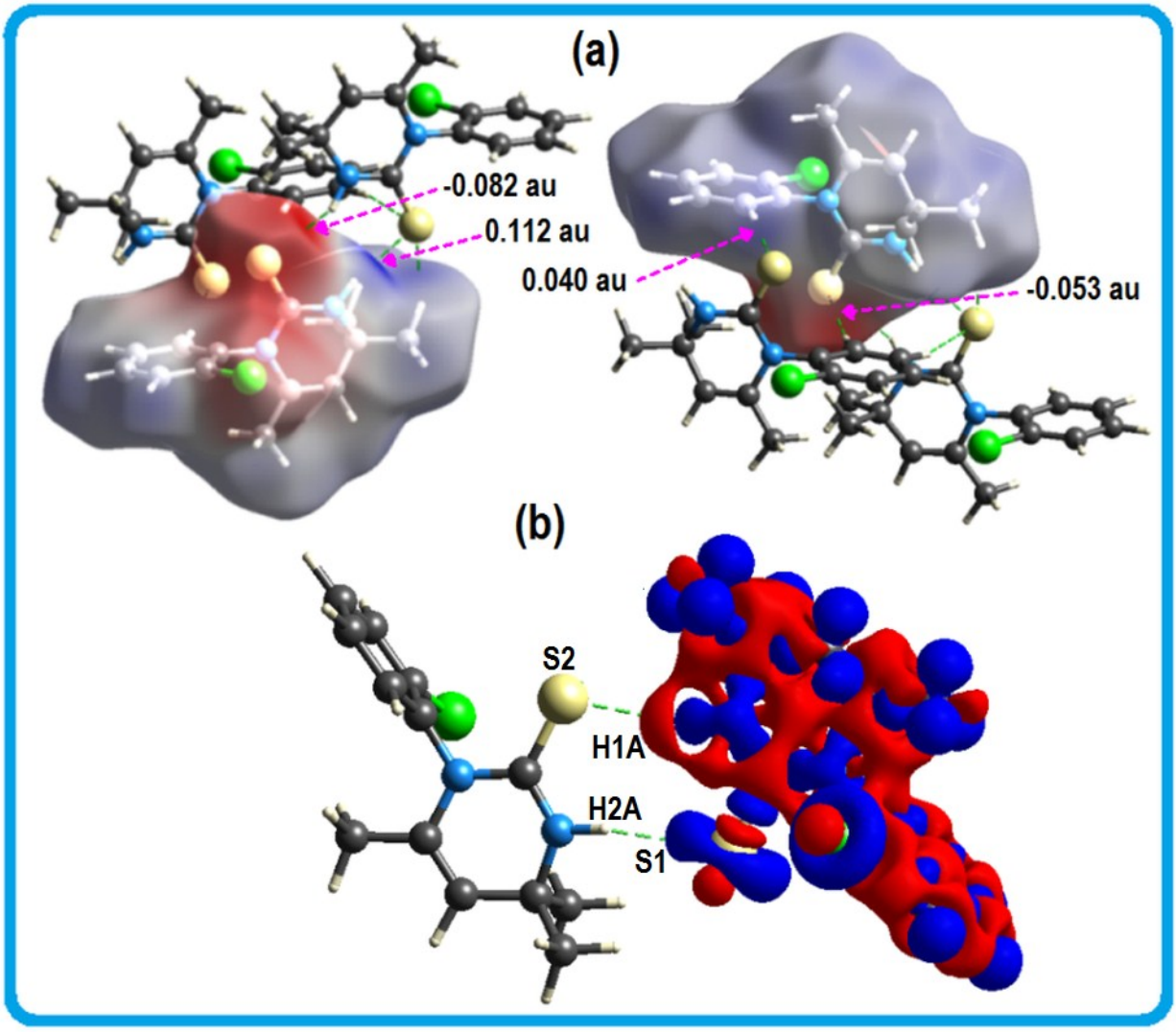
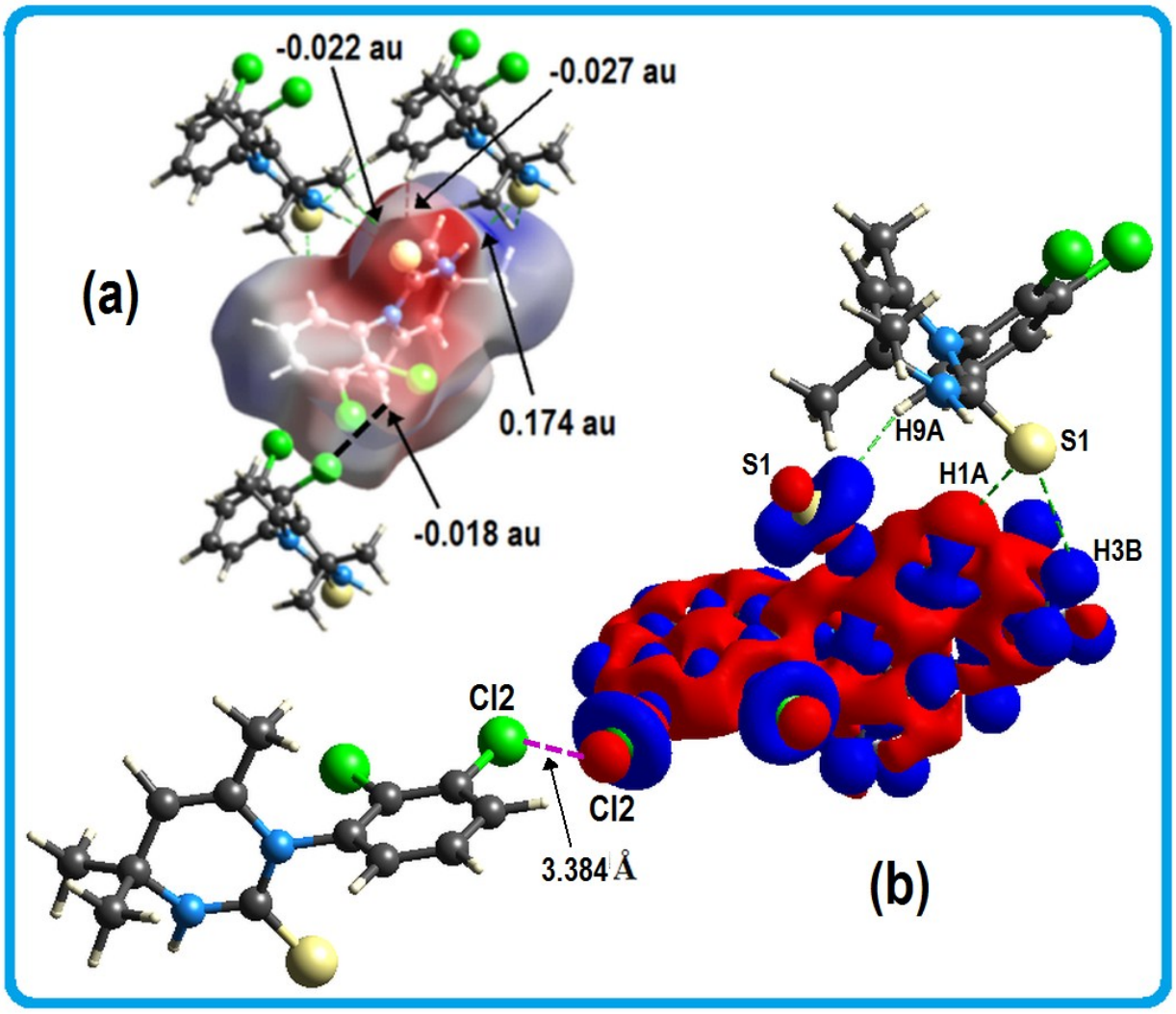


Figure S10. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing the CD region (in red) and CC region (in blue) for compound **2**.Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^3.



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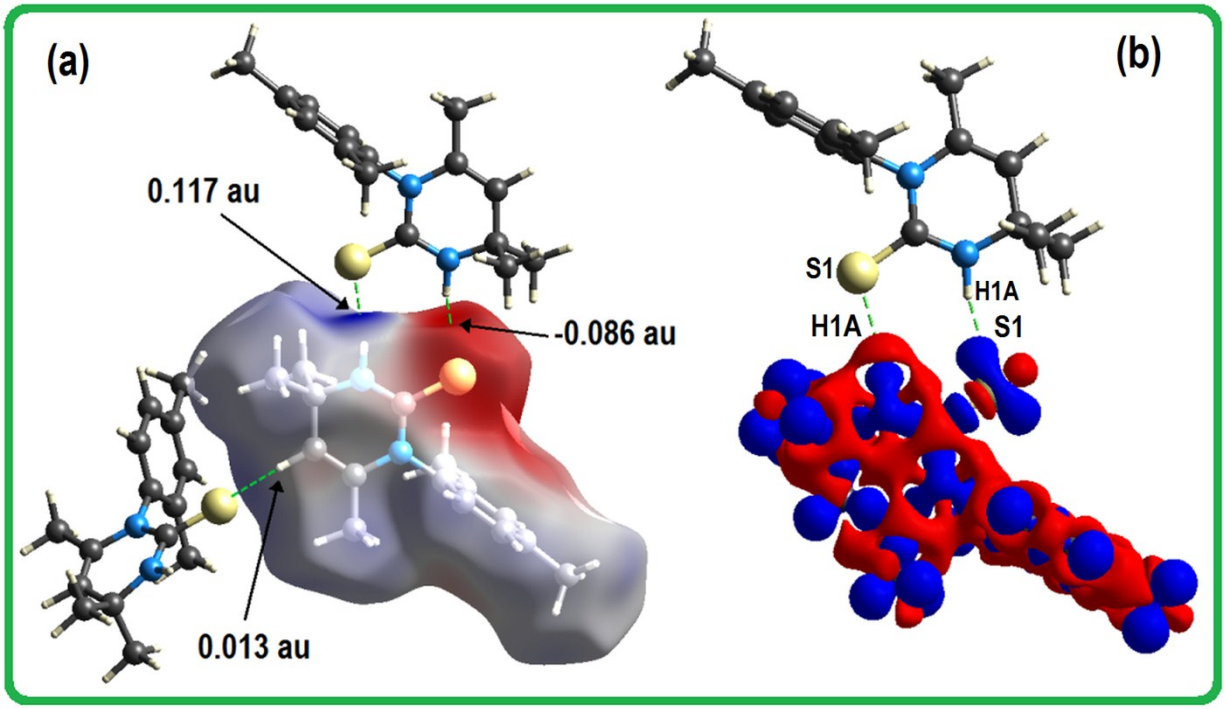

Figure S12. **(a)** Hirshfeld surface mapped with electrostatic potential (ESP) over the range ± 0.100 au, and **(b)** 3D-deformation density map showing the CD region (in red) and CC region (in blue) for compound **4**. Intermolecular contacts are shown in dashed lines. The isosurface is drawn at 0.008 e/au^{-3}.