



Full wwPDB X-ray Structure Validation Report ⓘ

Jan 28, 2024 – 02:07 PM EST

PDB ID : 1DRF
Title : CRYSTAL STRUCTURE OF HUMAN DIHYDROFOLATE REDUCTASE
COMPLEXED WITH FOLATE
Authors : Oefner, C.; D'Arcy, A.; Winkler, F.K.
Deposited on : 1990-08-09
Resolution : 2.00 Å(reported)

This is a Full wwPDB X-ray Structure Validation Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtrriage (Phenix) : **NOT EXECUTED**
EDS : **NOT EXECUTED**
buster-report : 1.1.7 (2018)
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.36

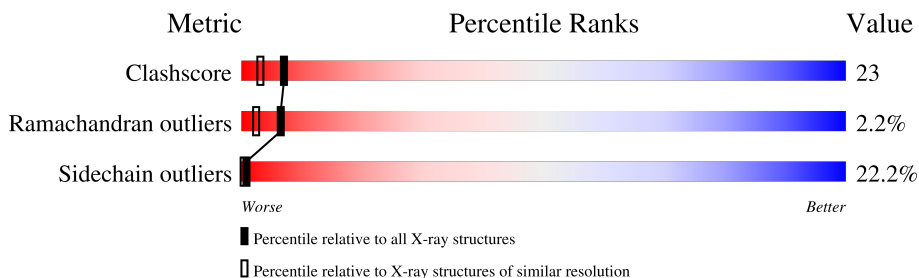
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.00 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
Clashscore	141614	9178 (2.00-2.00)
Ramachandran outliers	138981	9054 (2.00-2.00)
Sidechain outliers	138945	9053 (2.00-2.00)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	186	

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	FOL	A	187	-	X	-	-

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 1788 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called DIHYDROFOLATE REDUCTASE.

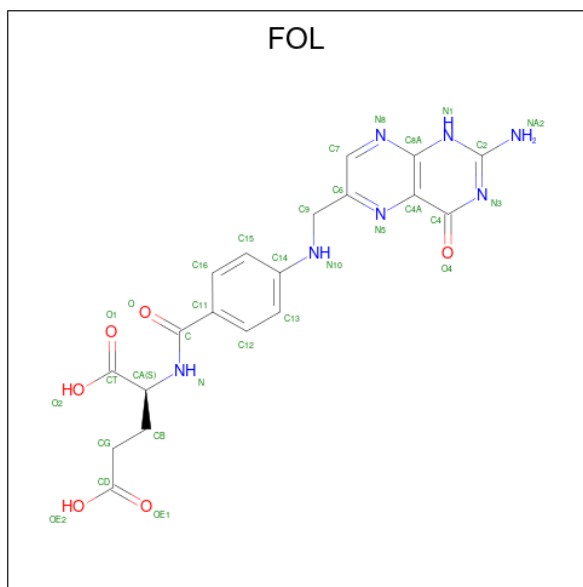
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	186	1497	960	252	278	7	0	0	0

- Molecule 2 is SULFATE ION (three-letter code: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	O	S		
2	A	1	5	4	1	0	0
2	A	1	5	4	1	0	0

- Molecule 3 is FOLIC ACID (three-letter code: FOL) (formula: C₁₉H₁₉N₇O₆).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	N	O		
3	A	1	32	19	7	6	0	0

- Molecule 4 is water.

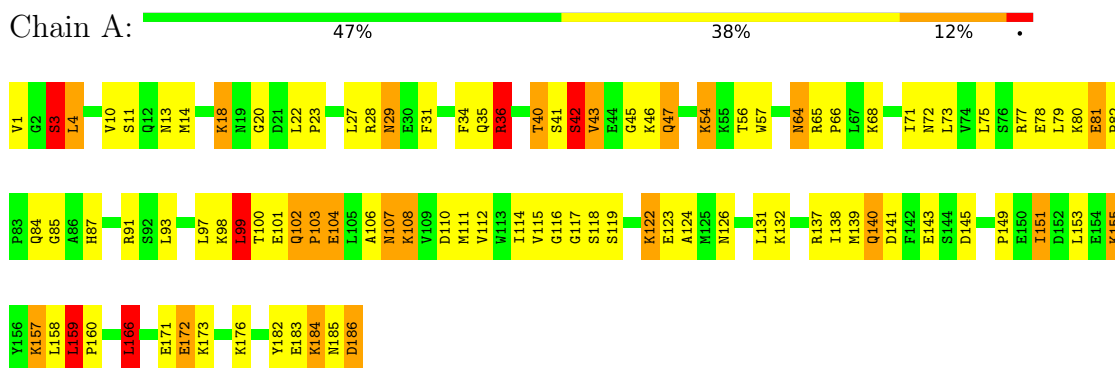
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
4	A	249	249	249	0	0

3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

Note EDS was not executed.

- Molecule 1: DIHYDROFOLATE REDUCTASE



4 Data and refinement statistics

Xtrriage (Phenix) and EDS were not executed - this section is therefore incomplete.

Property	Value	Source
Space group	H 3	Depositor
Cell constants a, b, c, α , β , γ	86.29Å 86.29Å 76.98Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	(Not available) – 2.00	Depositor
% Data completeness (in resolution range)	(Not available) ((Not available)-2.00)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	PROLSQ	Depositor
R, R_{free}	0.189 , (Not available)	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	1788	wwPDB-VP
Average B, all atoms (Å ²)	21.0	wwPDB-VP

5 Model quality [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: FOL, SO4

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	# Z >5	RMSZ	# Z >5
1	A	1.09	2/1532 (0.1%)	1.43	13/2066 (0.6%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	3	SER	CA-CB	5.77	1.61	1.52
1	A	123	GLU	CD-OE1	-5.52	1.19	1.25

All (13) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	159	LEU	CA-CB-CG	8.44	134.71	115.30
1	A	137	ARG	NE-CZ-NH1	7.87	124.24	120.30
1	A	166	LEU	CA-CB-CG	7.51	132.58	115.30
1	A	186	ASP	CB-CG-OD1	7.41	124.96	118.30
1	A	91	ARG	NE-CZ-NH1	6.33	123.47	120.30
1	A	78	GLU	CG-CD-OE1	6.25	130.81	118.30
1	A	123	GLU	CA-CB-CG	6.13	126.89	113.40
1	A	99	LEU	CA-CB-CG	5.67	128.34	115.30
1	A	36	ARG	CA-CB-CG	5.61	125.74	113.40
1	A	78	GLU	OE1-CD-OE2	-5.42	116.79	123.30
1	A	81	GLU	CA-CB-CG	5.38	125.25	113.40
1	A	145	ASP	CB-CG-OD1	5.35	123.11	118.30
1	A	102	GLN	CB-CA-C	5.05	120.50	110.40

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	1497	0	1504	70	0
2	A	10	0	0	2	0
3	A	32	0	18	3	0
4	A	249	0	0	17	1
All	All	1788	0	1522	70	1

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 23.

All (70) close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:72:ASN:H	1:A:87:HIS:HD2	1.23	0.87
1:A:36:ARG:O	1:A:40:THR:HG23	1.90	0.71
1:A:107:ASN:ND2	1:A:107:ASN:H	1.88	0.71
1:A:56:THR:HG21	1:A:116:GLY:HA3	1.73	0.70
1:A:115:VAL:O	3:A:187:FOL:H7	1.94	0.66
1:A:155:LYS:HD3	4:A:860:HOH:O	1.95	0.66
1:A:166:LEU:H	1:A:166:LEU:HD23	1.62	0.64
1:A:166:LEU:HD11	4:A:739:HOH:O	2.00	0.62
1:A:42:SER:HB3	4:A:699:HOH:O	2.00	0.59
1:A:81:GLU:HG2	1:A:82:PRO:HD2	1.84	0.59
1:A:4:LEU:HD23	1:A:131:LEU:HD12	1.85	0.59
1:A:166:LEU:HD21	4:A:737:HOH:O	2.04	0.57
1:A:72:ASN:H	1:A:87:HIS:CD2	2.13	0.57
1:A:102:GLN:HB2	4:A:742:HOH:O	2.04	0.56
1:A:3:SER:OG	1:A:111:MET:HG2	2.05	0.56
1:A:45:GLY:HA2	1:A:107:ASN:O	2.07	0.55
1:A:184:LYS:HZ3	1:A:186:ASP:HB3	1.71	0.54
1:A:20:GLY:HA3	4:A:758:HOH:O	2.08	0.54
1:A:73:LEU:C	1:A:73:LEU:HD23	2.28	0.53
1:A:122:LYS:HD2	1:A:149:PRO:HB3	1.89	0.53
1:A:41:SER:OG	1:A:42:SER:N	2.41	0.53
1:A:57:TRP:CE2	1:A:65:ARG:HD3	2.44	0.53
1:A:43:VAL:O	1:A:110:ASP:OD2	2.28	0.52

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:35:GLN:HE21	3:A:187:FOL:HG2	1.75	0.51
1:A:64:ASN:HB2	4:A:679:HOH:O	2.10	0.51
1:A:171:GLU:OE2	1:A:176:LYS:HE3	2.11	0.51
1:A:98:LYS:NZ	4:A:830:HOH:O	2.45	0.50
1:A:47:GLN:NE2	4:A:764:HOH:O	2.45	0.50
1:A:139:MET:C	1:A:140:GLN:HG2	2.32	0.50
1:A:132:LYS:HE3	4:A:839:HOH:O	2.11	0.50
1:A:14:MET:HE2	4:A:856:HOH:O	2.11	0.49
1:A:139:MET:O	1:A:140:GLN:HG2	2.12	0.49
1:A:27:LEU:HA	1:A:172:GLU:OE2	2.13	0.49
1:A:18:LYS:HG3	1:A:143:GLU:O	2.13	0.48
1:A:155:LYS:HE2	1:A:155:LYS:HB3	1.66	0.48
1:A:66:PRO:HB3	1:A:85:GLY:O	2.13	0.48
1:A:22:LEU:HA	1:A:23:PRO:HD3	1.77	0.48
1:A:159:LEU:HD21	1:A:183:GLU:HB2	1.96	0.47
1:A:65:ARG:HB3	1:A:66:PRO:HD3	1.96	0.47
1:A:117:GLY:HA3	2:A:614:SO4:O4	2.13	0.47
1:A:1:VAL:HG21	1:A:100:THR:HG21	1.96	0.47
1:A:29:ASN:HD22	1:A:29:ASN:N	2.13	0.46
1:A:166:LEU:HD23	1:A:166:LEU:N	2.28	0.46
1:A:114:ILE:HD13	1:A:124:ALA:CB	2.46	0.46
1:A:1:VAL:HB	1:A:100:THR:HG22	1.98	0.45
1:A:101:GLU:C	1:A:106:ALA:HB2	2.37	0.45
1:A:28:ARG:HH12	1:A:173:LYS:HD3	1.81	0.45
1:A:34:PHE:CE2	3:A:187:FOL:H16	2.51	0.44
1:A:65:ARG:HB3	1:A:66:PRO:CD	2.47	0.44
1:A:108:LYS:HG3	4:A:763:HOH:O	2.18	0.43
1:A:54:LYS:HD3	2:A:613:SO4:O2	2.18	0.43
1:A:41:SER:O	1:A:42:SER:HB2	2.18	0.43
1:A:102:GLN:O	1:A:103:PRO:C	2.58	0.43
1:A:118:SER:HB3	4:A:820:HOH:O	2.18	0.43
1:A:11:SER:HA	1:A:138:ILE:HB	2.01	0.42
1:A:171:GLU:HB2	1:A:176:LYS:HE2	2.01	0.42
1:A:47:GLN:NE2	1:A:71:ILE:HG13	2.34	0.42
1:A:93:LEU:O	1:A:97:LEU:HG	2.19	0.42
1:A:107:ASN:ND2	4:A:652:HOH:O	2.52	0.42
1:A:158:LEU:HB2	1:A:182:TYR:CE2	2.55	0.42
1:A:157:LYS:HE3	1:A:157:LYS:HB3	1.80	0.42
1:A:99:LEU:HD23	4:A:742:HOH:O	2.19	0.42
1:A:102:GLN:HB3	1:A:103:PRO:HD2	2.02	0.42
1:A:57:TRP:CZ2	1:A:65:ARG:HG2	2.55	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:159:LEU:HA	1:A:160:PRO:HD3	1.75	0.41
1:A:75:LEU:HD13	4:A:746:HOH:O	2.21	0.41
1:A:184:LYS:NZ	1:A:186:ASP:HB3	2.36	0.41
1:A:46:LYS:HE3	1:A:108:LYS:HA	2.02	0.40
1:A:151:ILE:HG23	4:A:736:HOH:O	2.21	0.40
1:A:4:LEU:HD23	1:A:131:LEU:CD1	2.51	0.40

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
4:A:822:HOH:O	4:A:842:HOH:O[6_555]	2.13	0.07

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles
1	A	184/186 (99%)	168 (91%)	12 (6%)	4 (2%)	6 2

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	42	SER
1	A	104	GLU
1	A	103	PRO
1	A	43	VAL

5.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar

resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
1	A	167/168 (99%)	130 (78%)	37 (22%)	1 0

All (37) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	3	SER
1	A	4	LEU
1	A	10	VAL
1	A	13	ASN
1	A	18	LYS
1	A	29	ASN
1	A	31	PHE
1	A	36	ARG
1	A	40	THR
1	A	42	SER
1	A	47	GLN
1	A	54	LYS
1	A	64	ASN
1	A	68	LYS
1	A	77	ARG
1	A	79	LEU
1	A	80	LYS
1	A	84	GLN
1	A	99	LEU
1	A	104	GLU
1	A	107	ASN
1	A	108	LYS
1	A	112	VAL
1	A	119	SER
1	A	122	LYS
1	A	126	ASN
1	A	140	GLN
1	A	141	ASP
1	A	151	ILE
1	A	153	LEU
1	A	155	LYS
1	A	157	LYS
1	A	159	LEU
1	A	166	LEU

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Mol	Chain	Res	Type
1	A	172	GLU
1	A	184	LYS
1	A	185	ASN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	29	ASN
1	A	35	GLN
1	A	47	GLN
1	A	87	HIS
1	A	102	GLN
1	A	107	ASN
1	A	127	HIS
1	A	185	ASN

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates [i](#)

There are no monosaccharides in this entry.

5.6 Ligand geometry [i](#)

3 ligands are modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the Chemical Component Dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	# Z > 2	Counts	RMSZ	# Z > 2
2	SO4	A	613	-	4,4,4	0.65	0	6,6,6	0.85	0
3	FOL	A	187	-	34,34,34	3.48	18 (52%)	44,47,47	4.14	28 (63%)
2	SO4	A	614	-	4,4,4	0.54	0	6,6,6	2.85	1 (16%)

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the Chemical Component Dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
3	FOL	A	187	-	-	5/22/22/22	0/3/3/3

All (18) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	187	FOL	CG-CD	7.55	1.68	1.50
3	A	187	FOL	C4A-C8A	-7.26	1.27	1.40
3	A	187	FOL	CA-N	6.04	1.58	1.45
3	A	187	FOL	C4A-C4	6.01	1.51	1.41
3	A	187	FOL	C14-N10	5.37	1.54	1.38
3	A	187	FOL	C15-C14	4.92	1.47	1.39
3	A	187	FOL	C8A-N8	4.80	1.43	1.37
3	A	187	FOL	C7-C6	4.79	1.47	1.39
3	A	187	FOL	O-C	4.78	1.33	1.23
3	A	187	FOL	OE1-CD	3.99	1.35	1.22
3	A	187	FOL	CB-CA	-3.93	1.44	1.53
3	A	187	FOL	CA-CT	-3.65	1.43	1.52
3	A	187	FOL	C4A-N5	3.11	1.37	1.33
3	A	187	FOL	C9-N10	3.03	1.54	1.45
3	A	187	FOL	C-N	2.64	1.39	1.34
3	A	187	FOL	C11-C	2.53	1.55	1.50
3	A	187	FOL	C16-C11	-2.22	1.35	1.39
3	A	187	FOL	CB-CG	2.08	1.59	1.52

All (29) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	187	FOL	C4A-C4-N3	-11.88	107.18	123.43
3	A	187	FOL	N8-C8A-N1	-9.37	105.13	115.82
3	A	187	FOL	CB-CG-CD	7.96	133.64	112.51
3	A	187	FOL	C2-N1-C8A	-7.60	106.68	115.36

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	187	FOL	C2-N3-C4	6.99	127.03	115.93
2	A	614	SO4	O4-S-O3	-6.57	81.00	109.06
3	A	187	FOL	O2-CT-CA	6.33	134.44	113.40
3	A	187	FOL	CT-CA-N	-5.99	96.35	110.55
3	A	187	FOL	O-C-C11	-4.97	112.07	120.94
3	A	187	FOL	C4A-C8A-N1	4.93	130.06	121.80
3	A	187	FOL	O-C-N	4.66	131.03	122.45
3	A	187	FOL	O2-CT-O1	-4.63	113.57	124.09
3	A	187	FOL	OE1-CD-CG	4.34	137.01	123.08
3	A	187	FOL	C9-C6-N5	3.96	123.69	116.66
3	A	187	FOL	CG-CB-CA	3.82	120.30	113.16
3	A	187	FOL	OE2-CD-CG	-3.76	101.94	114.03
3	A	187	FOL	CB-CA-N	-3.62	103.56	110.88
3	A	187	FOL	NA2-C2-N1	-3.53	112.03	117.79
3	A	187	FOL	C6-C7-N8	-3.44	119.75	123.13
3	A	187	FOL	CA-N-C	3.17	129.35	121.60
3	A	187	FOL	O1-CT-CA	-3.13	111.96	122.26
3	A	187	FOL	C9-N10-C14	3.06	130.01	122.15
3	A	187	FOL	C9-C6-C7	-2.82	116.64	121.55
3	A	187	FOL	C8A-C4A-C4	2.80	121.80	119.95
3	A	187	FOL	C13-C12-C11	2.75	123.97	120.78
3	A	187	FOL	C12-C13-C14	-2.70	117.17	120.30
3	A	187	FOL	NA2-C2-N3	2.40	120.99	117.25
3	A	187	FOL	C6-C9-N10	2.29	118.13	113.07
3	A	187	FOL	C7-C6-N5	-2.23	119.39	120.85

There are no chirality outliers.

All (5) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	187	FOL	CT-CA-CB-CG
3	A	187	FOL	CA-CB-CG-CD
3	A	187	FOL	OE1-CD-CG-CB
3	A	187	FOL	OE2-CD-CG-CB
3	A	187	FOL	C6-C9-N10-C14

There are no ring outliers.

3 monomers are involved in 5 short contacts:

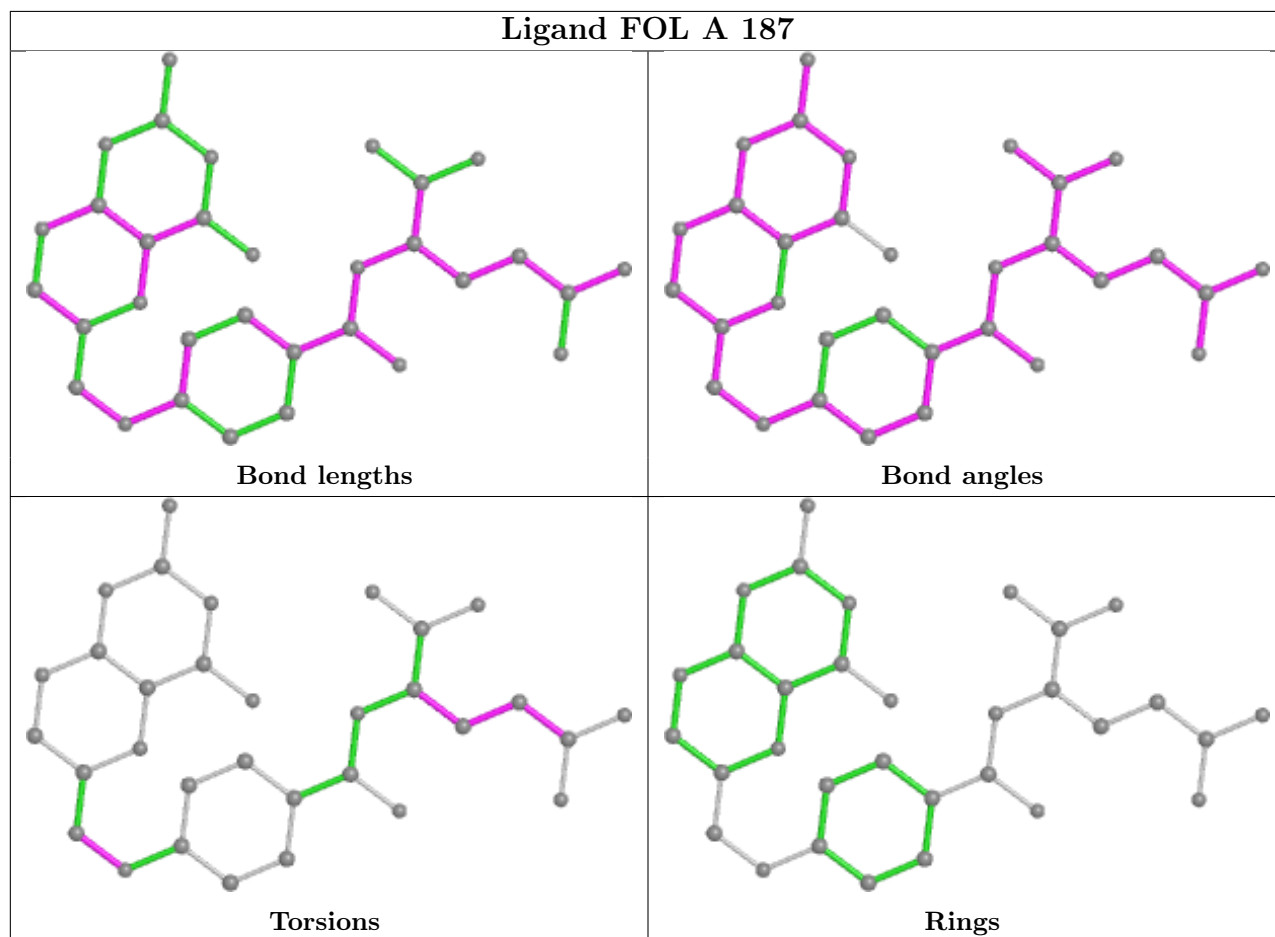
Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	613	SO4	1	0

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Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	187	FOL	3	0
2	A	614	SO4	1	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.



5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues

There are no chain breaks in this entry.

6 Fit of model and data [i](#)

6.1 Protein, DNA and RNA chains [i](#)

EDS was not executed - this section is therefore empty.

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

EDS was not executed - this section is therefore empty.

6.3 Carbohydrates [i](#)

EDS was not executed - this section is therefore empty.

6.4 Ligands [i](#)

EDS was not executed - this section is therefore empty.

6.5 Other polymers [i](#)

EDS was not executed - this section is therefore empty.