Full wwPDB X-ray Structure Validation Report ⓘ

Aug 5, 2025 – 12:33 PM JST

PDB ID	:	9M3M / pdb_00009m3m
Title	:	Structure of FSP1 in complex with FSEN1
Authors	:	Zhang, S.T.; Jia, D.
Deposited on	:	2025-03-03
Resolution	:	2.01 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:

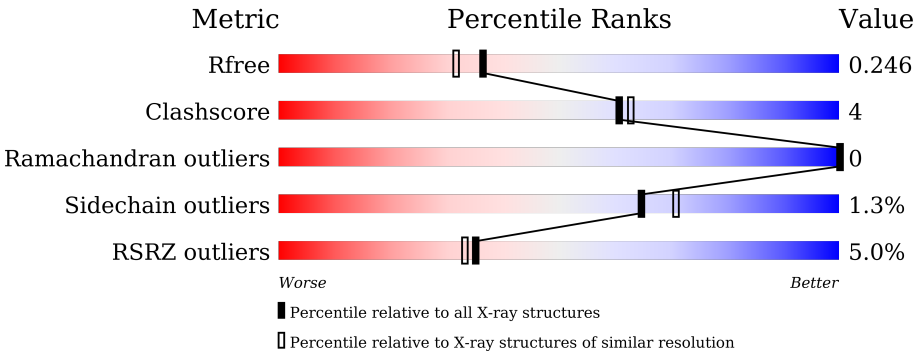
MolProbity	:	4-5-2 with Phenix2.0rc1
Mogul	:	1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.006 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.45.1

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 2.01 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))
R_{free}	164625	9409 (2.00-2.00)
Clashscore	180529	10737 (2.00-2.00)
Ramachandran outliers	177936	10628 (2.00-2.00)
Sidechain outliers	177891	10627 (2.00-2.00)
RSRZ outliers	164620	9409 (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 <=5% The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	C	373	5% 88% 8%

2 Entry composition

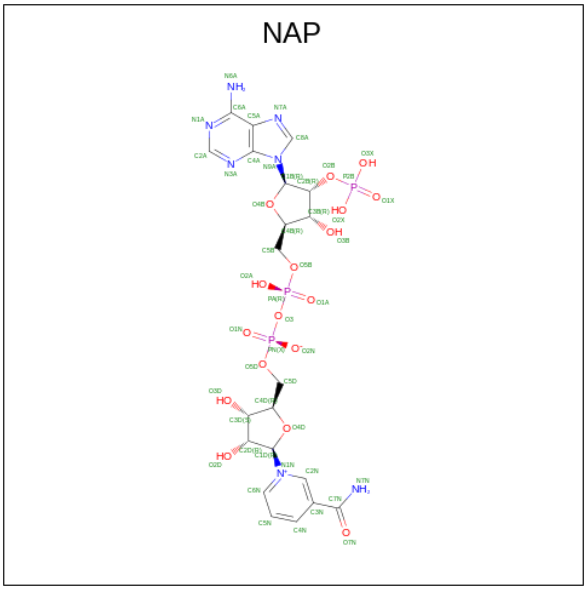
There are 5 unique types of molecules in this entry. The entry contains 3092 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 Ferroptosis suppressor protein 1.

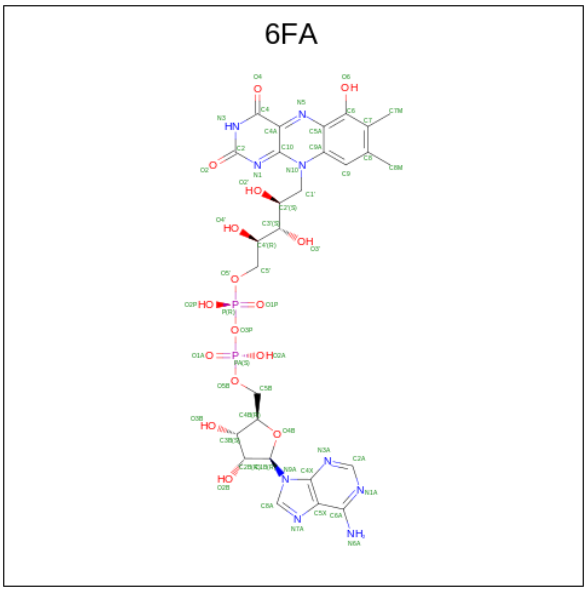
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	C	363	Total	C	N	O	S	0	0	0
			2784	1766	491	516	11			

- Molecule 2 is NADP NICOTINAMIDE-ADENINE-DINUCLEOTIDE PHOSPHATE (CCD ID: NAP) (formula: $C_{21}H_{28}N_7O_{17}P_3$).



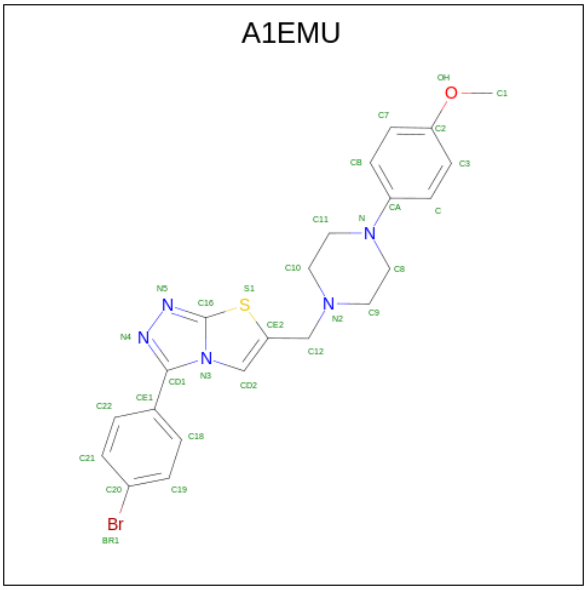
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	C	1	Total	C	N	O	P	0	0
			48	21	7	17	3		

- Molecule 3 is 6-HYDROXY-FLAVIN-ADENINE DINUCLEOTIDE (CCD ID: 6FA) (formula: $C_{27}H_{33}N_9O_{16}P_2$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	C	1	Total	C	N	O	P	0	0
			54	27	9	16	2		

- Molecule 4 is 3-(4-bromophenyl)-6-[[4-(4-methoxyphenyl)piperazin-1-yl]methyl]-[1,3]thiazolo[2,3-c][1,2,4]triazole (CCD ID: A1EMU) (formula: $C_{22}H_{22}BrN_5OS$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms						ZeroOcc	AltConf
4	C	1	Total	Br	C	N	O	S	0	0
			30	1	22	5	1	1		

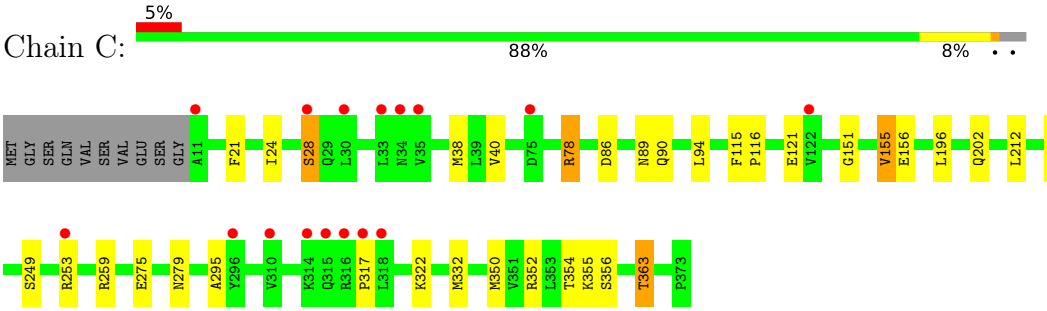
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	C	176	Total	O	0	0
			176	176		

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 and electron density. 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. A red dot above a residue indicates a poor fit to the electron density (RSRZ > 2). 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.

• Molecule 1: Ferroptosis suppressor protein 1



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α, β, γ	65.54Å 38.95Å 70.10Å 90.00° 107.89° 90.00°	Depositor
Resolution (Å)	62.37 – 2.01 62.37 – 2.01	Depositor EDS
% Data completeness (in resolution range)	99.7 (62.37-2.01) 99.8 (62.37-2.01)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.65 (at 2.02Å)	Xtriage
Refinement program	PHENIX 1.19.2_4158, PHENIX 1.19.2_4158	Depositor
R, R_{free}	0.217 , 0.247 0.218 , 0.246	Depositor DCC
R_{free} test set	1089 reflections (4.77%)	wwPDB-VP
Wilson B-factor (Å^2)	27.6	Xtriage
Anisotropy	0.433	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.35 , 41.0	EDS
L-test for twinning[2]	$< \|L\| > = 0.50$, $< L^2 > = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.94	EDS
Total number of atoms	3092	wwPDB-VP
Average B, all atoms (Å^2)	35.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 9.32% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: 6FA, NAP, A1EMU

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	C	0.14	0/2830	0.34	1/3823 (0.0%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	C	363	THR	CB-CA-C	5.31	119.89	110.85

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	C	2784	0	2849	24	0
2	C	48	0	25	0	0
3	C	54	0	30	0	0
4	C	30	0	0	0	0
5	C	176	0	0	6	0
All	All	3092	0	2904	24	0

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 4.

All (24) 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:C:155:VAL:HG13	1:C:332:MET:HE1	1.71	0.72
1:C:38:MET:HE1	1:C:78:ARG:HB2	1.80	0.63
1:C:202:GLN:NE2	5:C:505:HOH:O	2.33	0.61
1:C:90:GLN:HE22	1:C:279:ASN:HD21	1.49	0.60
1:C:352:ARG:NE	5:C:514:HOH:O	2.40	0.54
1:C:86:ASP:OD2	1:C:89:ASN:ND2	2.38	0.54
1:C:121:GLU:HG2	5:C:643:HOH:O	2.12	0.49
1:C:322:LYS:NZ	5:C:506:HOH:O	2.33	0.49
1:C:156:GLU:OE2	1:C:355:LYS:NZ	2.46	0.48
1:C:38:MET:CE	1:C:78:ARG:HB2	2.43	0.48
1:C:317:PRO:HA	5:C:658:HOH:O	2.13	0.48
1:C:115:PHE:CG	1:C:116:PRO:HA	2.51	0.46
1:C:212:LEU:HD23	1:C:215:LEU:HD12	1.97	0.46
1:C:78:ARG:NH1	5:C:502:HOH:O	2.26	0.45
1:C:350:MET:HE3	1:C:354:THR:OG1	2.16	0.45
1:C:151:GLY:O	1:C:155:VAL:HB	2.17	0.44
1:C:90:GLN:HE22	1:C:279:ASN:ND2	2.14	0.43
1:C:21:PHE:CG	1:C:295:ALA:HB1	2.54	0.43
1:C:24:ILE:O	1:C:28:SER:HB2	2.19	0.43
1:C:259:ARG:HD3	1:C:275:GLU:O	2.19	0.42
1:C:155:VAL:HG22	1:C:196:LEU:HD11	2.01	0.42
1:C:249:SER:O	1:C:253:ARG:HB2	2.20	0.41
1:C:40:VAL:HG11	1:C:94:LEU:HD11	2.03	0.41
1:C:352:ARG:HA	1:C:356:SER:HB2	2.03	0.41

There are no symmetry-related clashes.

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	C	361/373 (97%)	353 (98%)	8 (2%)	0	100 100

There are no Ramachandran outliers to report.

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	C	300/308 (97%)	296 (99%)	4 (1%)	65 71

All (4) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	28	SER
1	C	78	ARG
1	C	155	VAL
1	C	363	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	C	90	GLN
1	C	140	GLN

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 oligosaccharides 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	NAP	C	401	-	45,52,52	0.78	1 (2%)	56,80,80	1.19	4 (7%)
4	A1EMU	C	403	-	29,34,34	5.88	21 (72%)	36,48,48	1.80	8 (22%)
3	6FA	C	402	-	54,59,59	1.56	7 (12%)	68,91,91	1.31	9 (13%)

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
2	NAP	C	401	-	-	1/31/67/67	0/5/5/5
4	A1EMU	C	403	-	-	3/13/24/24	0/5/5/5
3	6FA	C	402	-	-	7/30/50/50	0/6/6/6

All (29) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	C	403	A1EMU	CE2-S1	-12.39	1.51	1.74
4	C	403	A1EMU	C12-N2	-8.97	1.30	1.47
4	C	403	A1EMU	CB-C7	8.80	1.54	1.38
4	C	403	A1EMU	C3-C	8.63	1.54	1.38
4	C	403	A1EMU	C19-C18	7.86	1.53	1.38
4	C	403	A1EMU	C7-C2	7.72	1.54	1.38
4	C	403	A1EMU	C22-C21	7.61	1.52	1.38
4	C	403	A1EMU	C3-C2	7.42	1.53	1.38

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	C	403	A1EMU	C-CA	7.40	1.53	1.39
4	C	403	A1EMU	CB-CA	7.32	1.53	1.39
4	C	403	A1EMU	C19-C20	7.10	1.53	1.38
4	C	403	A1EMU	C21-C20	6.98	1.52	1.38
4	C	403	A1EMU	C18-CE1	6.35	1.52	1.39
4	C	403	A1EMU	C22-CE1	6.29	1.52	1.39
3	C	402	6FA	C9A-C5A	5.48	1.49	1.41
4	C	403	A1EMU	C12-CE2	4.52	1.57	1.51
3	C	402	6FA	C8-C7	4.48	1.49	1.40
3	C	402	6FA	C6-C5A	4.13	1.49	1.38
3	C	402	6FA	C6-C7	4.07	1.48	1.40
4	C	403	A1EMU	CA-N	3.93	1.49	1.38
4	C	403	A1EMU	CE1-CD1	3.64	1.53	1.48
4	C	403	A1EMU	C9-N2	-3.53	1.37	1.46
4	C	403	A1EMU	C10-N2	-3.30	1.37	1.46
4	C	403	A1EMU	CD2-CE2	2.84	1.44	1.37
3	C	402	6FA	C4A-N5	2.50	1.35	1.30
3	C	402	6FA	C5X-C4X	2.46	1.47	1.40
3	C	402	6FA	C4-N3	-2.35	1.34	1.38
2	C	401	NAP	C5A-C4A	2.31	1.47	1.40
4	C	403	A1EMU	OH-C2	2.23	1.42	1.37

All (21) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
4	C	403	A1EMU	CE1-CD1-N4	6.30	128.75	123.43
4	C	403	A1EMU	CD2-CE2-S1	-3.65	108.37	112.00
2	C	401	NAP	N3A-C2A-N1A	-3.34	123.46	128.68
3	C	402	6FA	N3A-C2A-N1A	-3.31	123.51	128.68
4	C	403	A1EMU	C9-N2-C10	3.15	115.93	108.83
4	C	403	A1EMU	C10-C11-N	2.95	116.42	110.70
2	C	401	NAP	C4A-C5A-N7A	-2.78	106.50	109.40
4	C	403	A1EMU	C11-C10-N2	2.76	116.30	110.64
4	C	403	A1EMU	CE1-CD1-N3	-2.71	122.53	126.85
3	C	402	6FA	C4-C4A-N5	2.70	122.07	118.23
3	C	402	6FA	C4X-C5X-N7A	-2.67	106.61	109.40
2	C	401	NAP	C3D-C2D-C1D	2.67	104.99	100.98
3	C	402	6FA	C4A-C10-N1	-2.63	118.63	124.73
2	C	401	NAP	PN-O3-PA	-2.61	123.88	132.83
3	C	402	6FA	O4-C4-C4A	-2.46	120.07	126.60
3	C	402	6FA	C4'-C3'-C2'	-2.39	108.38	113.36
3	C	402	6FA	C10-N1-C2	2.32	121.54	116.90

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	C	402	6FA	C4A-C4-N3	2.25	118.90	113.19
4	C	403	A1EMU	C-CA-N	-2.22	118.32	121.38
3	C	402	6FA	PA-O3P-P	-2.04	125.83	132.83
4	C	403	A1EMU	C22-CE1-CD1	-2.03	116.91	120.76

There are no chirality outliers.

All (11) torsion outliers are listed below:

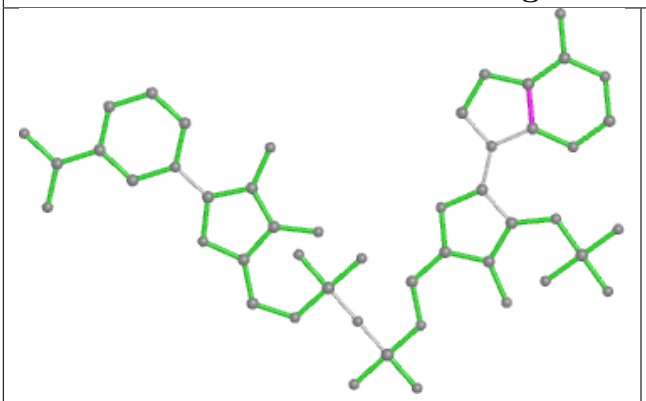
Mol	Chain	Res	Type	Atoms
3	C	402	6FA	C5'-O5'-P-O1P
4	C	403	A1EMU	N3-CD1-CE1-C22
4	C	403	A1EMU	N3-CD1-CE1-C18
4	C	403	A1EMU	N2-C12-CE2-CD2
3	C	402	6FA	PA-O3P-P-O5'
3	C	402	6FA	P-O3P-PA-O2A
3	C	402	6FA	PA-O3P-P-O1P
2	C	401	NAP	O4B-C4B-C5B-O5B
3	C	402	6FA	C5'-O5'-P-O3P
3	C	402	6FA	P-O3P-PA-O1A
3	C	402	6FA	O4B-C4B-C5B-O5B

There are no ring outliers.

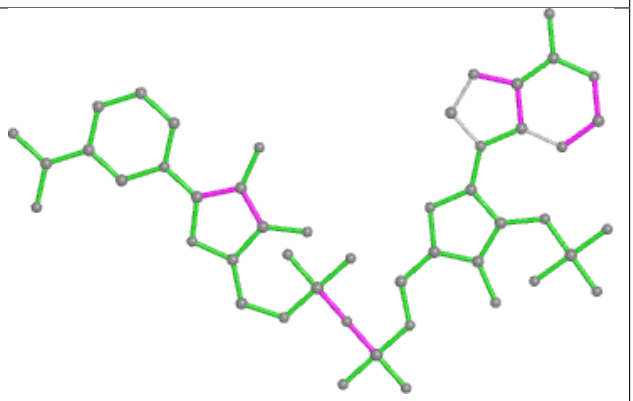
No monomer is involved in short contacts.

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 then 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.

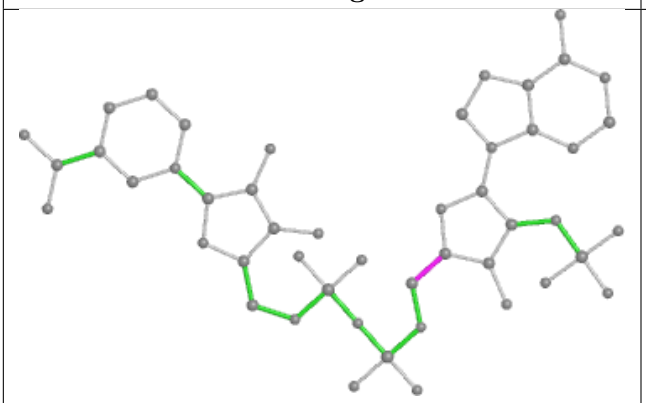
Ligand NAP C 401



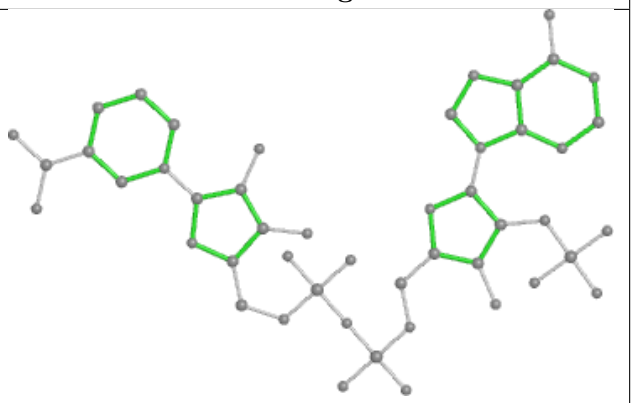
Bond lengths



Bond angles

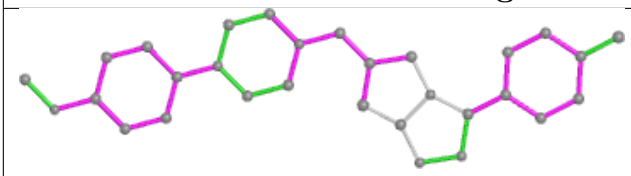


Torsions

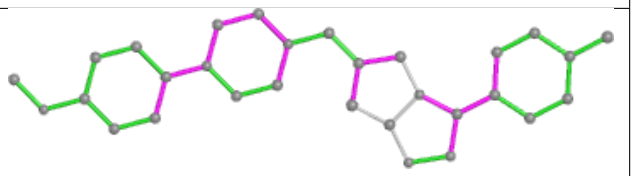


Rings

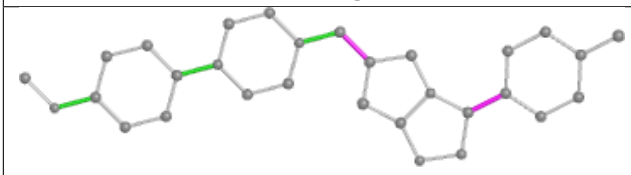
Ligand A1EMU C 403



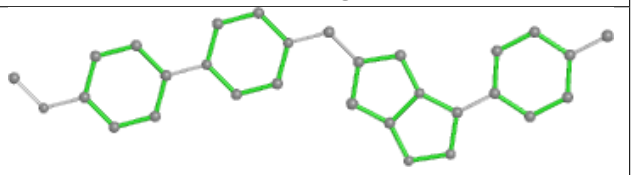
Bond lengths



Bond angles

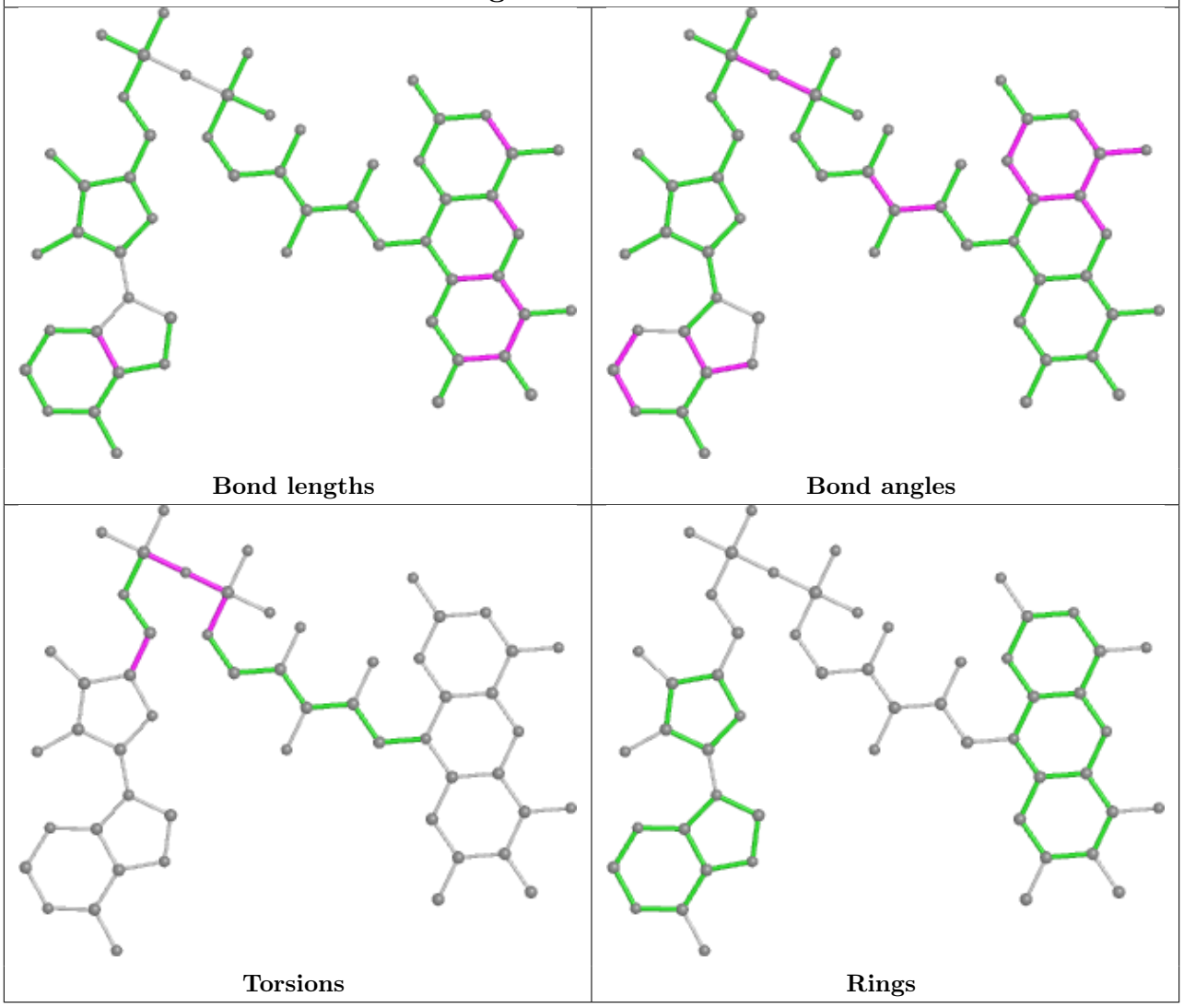


Torsions



Rings

Ligand 6FA C 402



5.7 Other polymers (i)

There are no such residues in this entry.

5.8 Polymer linkage issues (i)

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

In the following table, the column labelled '#RSRZ> 2' contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95^{th} percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled 'Q< 0.9' lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å^2)	Q<0.9
1	C	363/373 (97%)	0.35	18 (4%) 35 33	19, 32, 59, 80	0

All (18) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	11	ALA	3.4
1	C	310	VAL	3.3
1	C	315	GLN	3.0
1	C	318	LEU	2.8
1	C	33	LEU	2.8
1	C	30	LEU	2.7
1	C	28	SER	2.6
1	C	296	TYR	2.6
1	C	314	LYS	2.3
1	C	35	VAL	2.3
1	C	316	ARG	2.3
1	C	222	GLU	2.2
1	C	122	VAL	2.2
1	C	75	ASP	2.2
1	C	317	PRO	2.2
1	C	34	ASN	2.2
1	C	223	TYR	2.1
1	C	253	ARG	2.0

6.2 Non-standard residues in protein, DNA, RNA chains

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

6.3 Carbohydrates (i)

There are no oligosaccharides in this entry.

6.4 Ligands (i)

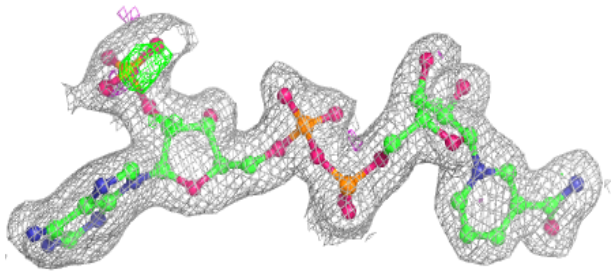
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95^{th} percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

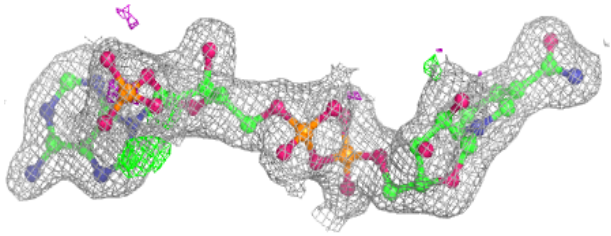
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
2	NAP	C	401	48/48	0.94	0.07	20,24,30,33	0
3	6FA	C	402	54/54	0.95	0.08	20,29,40,43	0
4	A1EMU	C	403	30/30	0.96	0.11	27,34,48,49	0

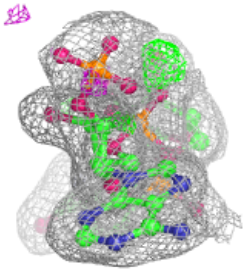
The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.

Electron density around NAP C 401:

$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative) and green (positive)

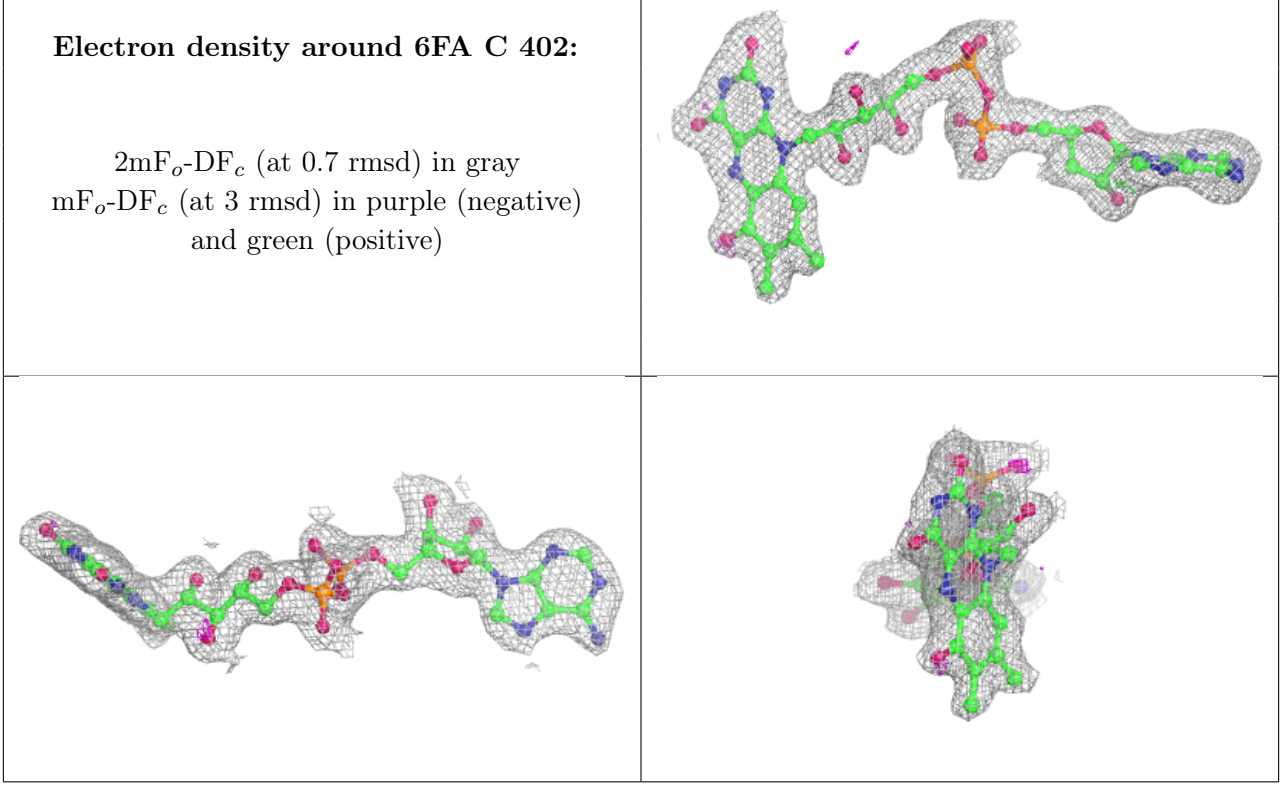






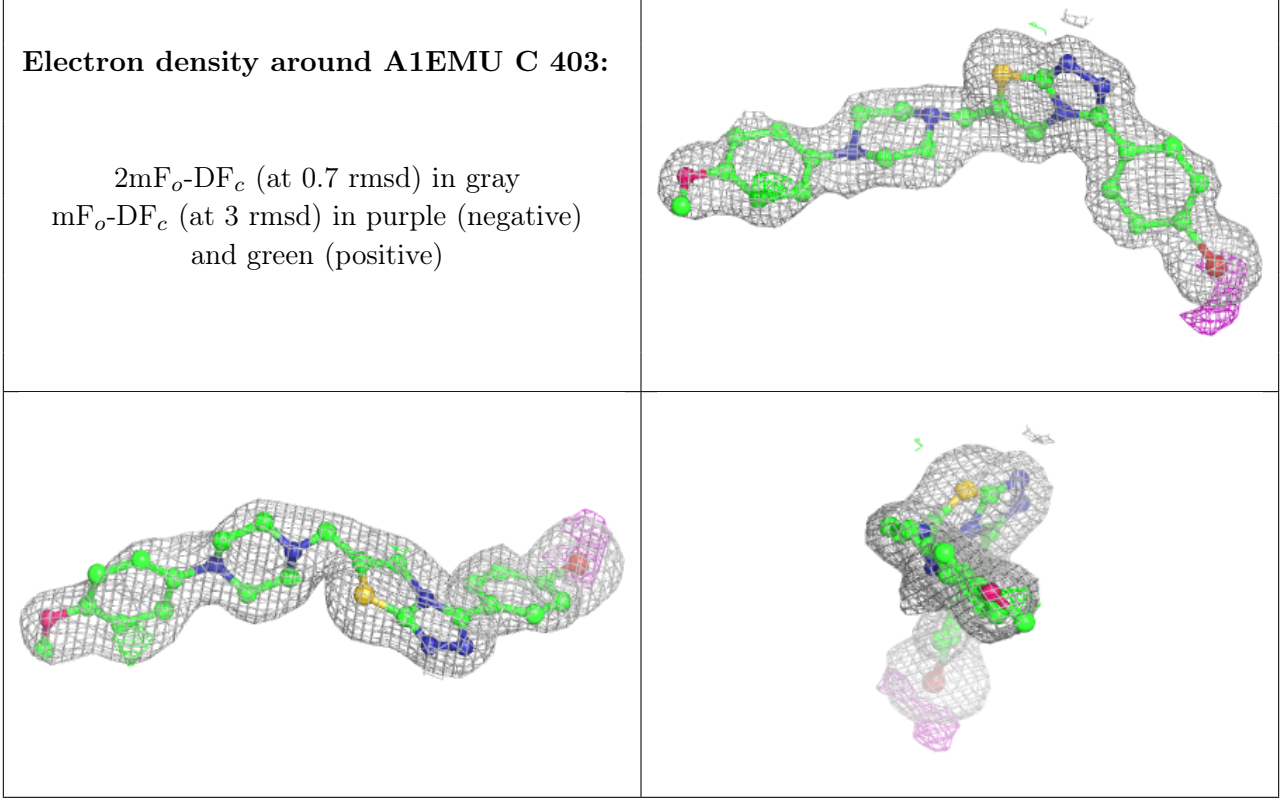
Electron density around 6FA C 402:

$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative) and green (positive)



Electron density around A1EMU C 403:

$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative) and green (positive)



6.5 Other polymers (i)

There are no such residues in this entry.