



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 17, 2026 – 09:02 PM UTC

PDB ID : 9U3B / pdb_00009u3b
Title : Monomeric sarcosine oxidase from Bacillus sp. (SoxB) complexed with L-Thioprolin
Authors : Zhang, Y.; Nakajima, Y.; Kurobe, M.; Nakamura, T.; Himiyama, T.; Nishiya, Y.
Deposited on : 2025-03-18
Resolution : 1.30 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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 Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

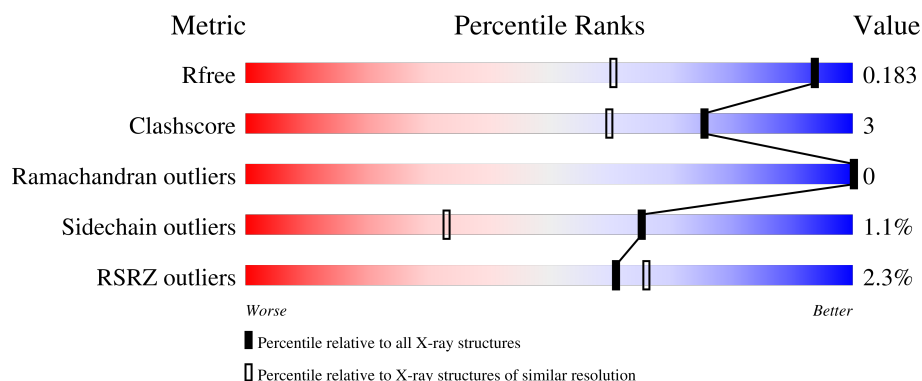
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.30 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}	180053	1553 (1.30-1.30)
Clashscore	190562	1595 (1.30-1.30)
Ramachandran outliers	187476	1551 (1.30-1.30)
Sidechain outliers	187428	1551 (1.30-1.30)
RSRZ outliers	180081	1549 (1.30-1.30)

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 $\leq 5\%$. 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	A	397	89% 7% .
1	B	397	3% 91% 5% ..

2 Entry composition

There are 7 unique types of molecules in this entry. The entry contains 6980 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 Monomeric sarcosine oxidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	381	Total	C	N	O	S	0	24	0
			3106	1993	511	591	11			
1	B	385	Total	C	N	O	S	0	14	0
			3083	1974	505	594	10			

There are 16 discrepancies between the modelled and reference sequences:

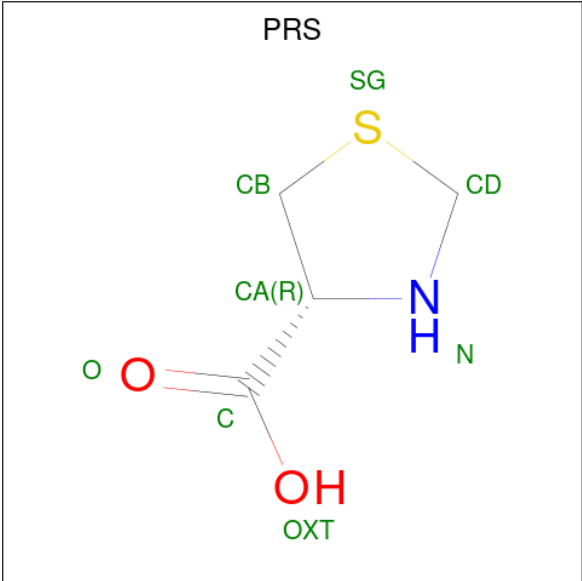
Chain	Residue	Modelled	Actual	Comment	Reference
A	390	GLY	-	expression tag	UNP P40859
A	391	SER	-	expression tag	UNP P40859
A	392	HIS	-	expression tag	UNP P40859
A	393	HIS	-	expression tag	UNP P40859
A	394	HIS	-	expression tag	UNP P40859
A	395	HIS	-	expression tag	UNP P40859
A	396	HIS	-	expression tag	UNP P40859
A	397	HIS	-	expression tag	UNP P40859
B	390	GLY	-	expression tag	UNP P40859
B	391	SER	-	expression tag	UNP P40859
B	392	HIS	-	expression tag	UNP P40859
B	393	HIS	-	expression tag	UNP P40859
B	394	HIS	-	expression tag	UNP P40859
B	395	HIS	-	expression tag	UNP P40859
B	396	HIS	-	expression tag	UNP P40859
B	397	HIS	-	expression tag	UNP P40859

- Molecule 2 is FLAVIN-ADENINE DINUCLEOTIDE (CCD ID: FAD) (formula: C₂₇H₃₃N₉O₁₅P₂) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	0
			53	27	9	15	2		
2	B	1	Total	C	N	O	P	0	0
			53	27	9	15	2		

- Molecule 3 is THIOPROLINE (CCD ID: PRS) (formula: C₄H₇NO₂S) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total	C	N	O	S	0	0
			8	4	1	2	1		

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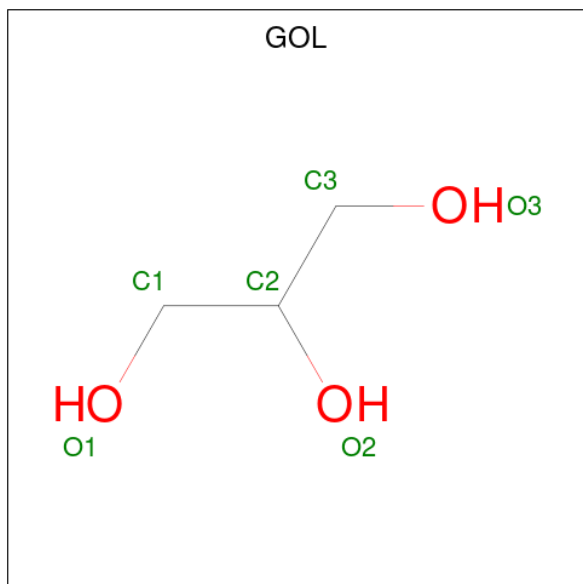
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Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total	C	N	O	S	0	0
			8	4	1	2	1		
3	B	1	Total	C	N	O	S	0	0
			8	4	1	2	1		
3	B	1	Total	C	N	O	S	0	0
			8	4	1	2	1		

- Molecule 4 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	1	Total	Cl	0	0
			1	1		
4	B	1	Total	Cl	0	0
			1	1		

- Molecule 5 is GLYCEROL (CCD ID: GOL) (formula: C₃H₈O₃).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	C	O	0	0
			6	3	3		
5	A	1	Total	C	O	0	0
			6	3	3		
5	A	1	Total	C	O	0	0
			6	3	3		
5	B	1	Total	C	O	0	0
			6	3	3		

- Molecule 6 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



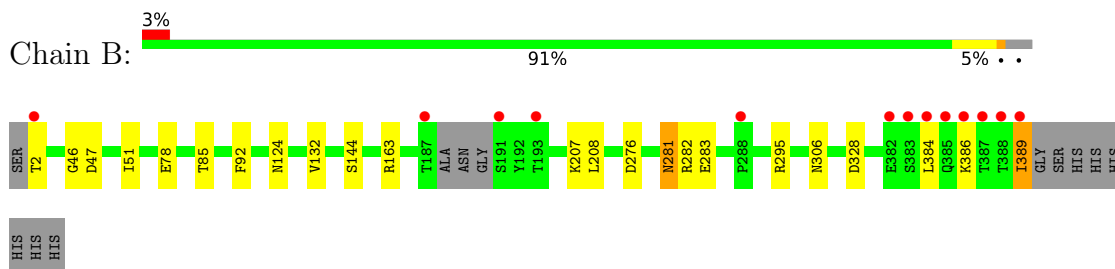
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	B	1	Total	O	S	0	0
			5	4	1		

- Molecule 7 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	A	309	Total	O	0	0
			309	309		
7	B	313	Total	O	0	0
			313	313		

i

- Molecule 1: Monomeric sarcosine oxidase



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	72.88Å 69.40Å 73.03Å 90.00° 93.72° 90.00°	Depositor
Resolution (Å)	40.51 – 1.30 40.51 – 1.30	Depositor EDS
% Data completeness (in resolution range)	93.0 (40.51-1.30) 93.0 (40.51-1.30)	Depositor EDS
R_{merge}	0.06	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.97 (at 1.30Å)	Xtriage
Refinement program	REFMAC 5.8.0425	Depositor
R, R_{free}	0.153 , 0.175 0.163 , 0.183	Depositor DCC
R_{free} test set	8108 reflections (4.55%)	wwPDB-VP
Wilson B-factor (Å ²)	12.8	Xtriage
Anisotropy	0.106	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.38 , 31.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.016 for l,-k,h	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	6980	wwPDB-VP
Average B, all atoms (Å ²)	16.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 14.05% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ 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: GOL, CL, SO4, FAD, PRS

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	0.75	0/3257	1.07	5/4404 (0.1%)
1	B	0.72	0/3197	1.10	6/4326 (0.1%)
All	All	0.74	0/6454	1.08	11/8730 (0.1%)

There are no bond length outliers.

The worst 5 of 11 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	2	THR	CA-CB-OG1	-8.24	97.25	109.60
1	A	92	PHE	CA-CB-CG	7.94	121.74	113.80
1	B	92	PHE	CA-CB-CG	6.62	120.42	113.80
1	B	276	ASP	CA-CB-CG	6.50	119.11	112.60
1	B	282	ARG	NE-CZ-NH1	-6.37	115.13	121.50

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	3106	0	3079	18	0
1	B	3083	0	3010	18	0
2	A	53	0	30	1	0
2	B	53	0	30	1	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	16	0	12	0	0
3	B	16	0	12	1	0
4	A	1	0	0	0	0
4	B	1	0	0	0	0
5	A	18	0	24	0	0
5	B	6	0	8	0	0
6	B	5	0	0	0	0
7	A	309	0	0	5	0
7	B	313	0	0	4	0
All	All	6980	0	6205	37	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 3.

The worst 5 of 37 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:B:47[B]:ASP:OD1	7:B:501:HOH:O	1.59	1.16
1:A:121[B]:ASP:OD2	1:A:125[B]:LYS:CE	2.07	1.03
1:A:121[B]:ASP:OD2	1:A:125[B]:LYS:HE3	1.61	0.99
1:A:124:ASN:HD21	1:A:132:VAL:H	1.23	0.85
1:A:121[B]:ASP:OD2	1:A:125[B]:LYS:HE2	1.77	0.81

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	A	404/397 (102%)	396 (98%)	8 (2%)	0	100	100
1	B	395/397 (100%)	384 (97%)	11 (3%)	0	100	100
All	All	799/794 (101%)	780 (98%)	19 (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	A	343/333 (103%)	340 (99%)	3 (1%)	70	42
1	B	335/333 (101%)	331 (99%)	4 (1%)	63	29
All	All	678/666 (102%)	671 (99%)	7 (1%)	65	37

5 of 7 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	281	ASN
1	B	384	LEU
1	B	389	ILE
1	B	386	LYS
1	A	381	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 18 such sidechains are listed below:

Mol	Chain	Res	Type
1	B	250	ASN
1	B	306	ASN
1	B	293	ASN
1	B	41	ASN
1	B	219	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](#)

Of 13 ligands modelled in this entry, 2 are monoatomic - leaving 11 for Mogul analysis.

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	$\# Z > 2$
3	PRS	B	402	-	8,8,8	0.75	0	8,10,10	0.99	0
3	PRS	A	402	-	8,8,8	0.81	0	8,10,10	1.02	0
5	GOL	B	404	-	5,5,5	0.42	0	5,5,5	0.65	0
3	PRS	A	407	-	8,8,8	1.87	2 (25%)	8,10,10	2.18	2 (25%)
5	GOL	A	405	-	5,5,5	0.11	0	5,5,5	0.42	0
6	SO4	B	405	-	4,4,4	0.29	0	6,6,6	0.11	0
3	PRS	B	406	-	8,8,8	2.09	2 (25%)	8,10,10	3.16	3 (37%)
5	GOL	A	404	-	5,5,5	0.12	0	5,5,5	0.26	0
2	FAD	A	401	1	58,58,58	0.78	1 (1%)	85,89,89	0.78	2 (2%)
5	GOL	A	406	-	5,5,5	0.10	0	5,5,5	0.19	0
2	FAD	B	401	1	58,58,58	0.74	1 (1%)	85,89,89	0.76	1 (1%)

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	PRS	B	402	-	-	0/4/11/11	0/1/1/1
3	PRS	A	402	-	-	1/4/11/11	0/1/1/1
5	GOL	B	404	-	-	0/4/4/4	-
3	PRS	A	407	-	-	0/4/11/11	0/1/1/1
5	GOL	A	405	-	-	4/4/4/4	-
3	PRS	B	406	-	-	0/4/11/11	0/1/1/1
5	GOL	A	404	-	-	0/4/4/4	-
2	FAD	A	401	1	-	0/34/50/50	0/6/6/6

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	GOL	A	406	-	-	4/4/4/4	-
2	FAD	B	401	1	-	0/34/50/50	0/6/6/6

The worst 5 of 6 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	B	406	PRS	OXT-C	-4.33	1.16	1.30
3	A	407	PRS	OXT-C	-3.51	1.19	1.30
2	A	401	FAD	P-O3P	3.50	1.63	1.59
3	A	407	PRS	CD-SG	3.37	1.85	1.81
3	B	406	PRS	CD-SG	3.09	1.85	1.81

The worst 5 of 8 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	406	PRS	CB-CA-C	-7.65	100.44	111.32
3	A	407	PRS	CB-CA-C	-4.70	104.64	111.32
3	B	406	PRS	CD-N-CA	2.95	114.42	107.99
3	A	407	PRS	CD-N-CA	2.47	113.37	107.99
3	B	406	PRS	CB-SG-CD	2.41	97.40	91.43

There are no chirality outliers.

5 of 9 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	A	405	GOL	O1-C1-C2-C3
5	A	405	GOL	C1-C2-C3-O3
5	A	405	GOL	O2-C2-C3-O3
5	A	406	GOL	C1-C2-C3-O3
5	A	406	GOL	O1-C1-C2-C3

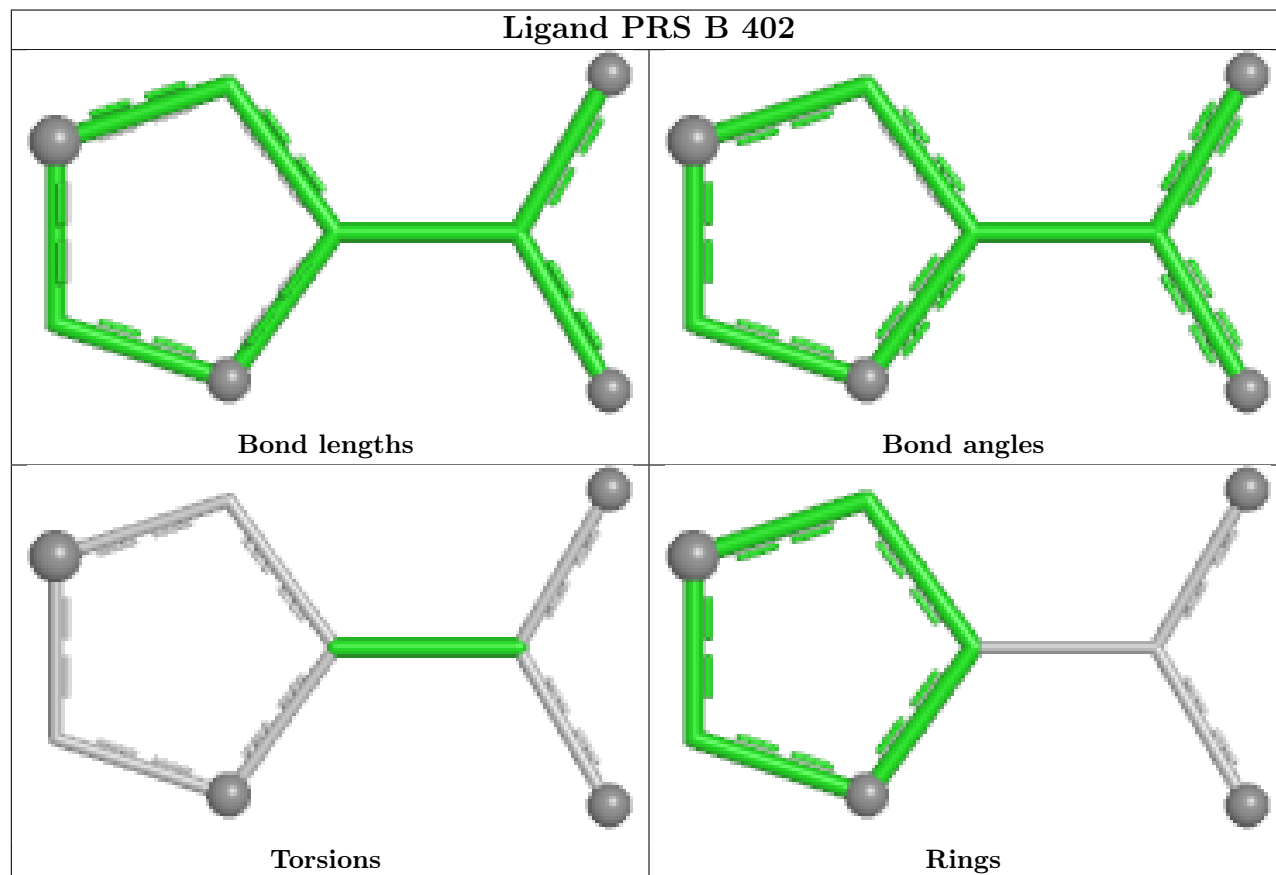
There are no ring outliers.

3 monomers are involved in 2 short contacts:

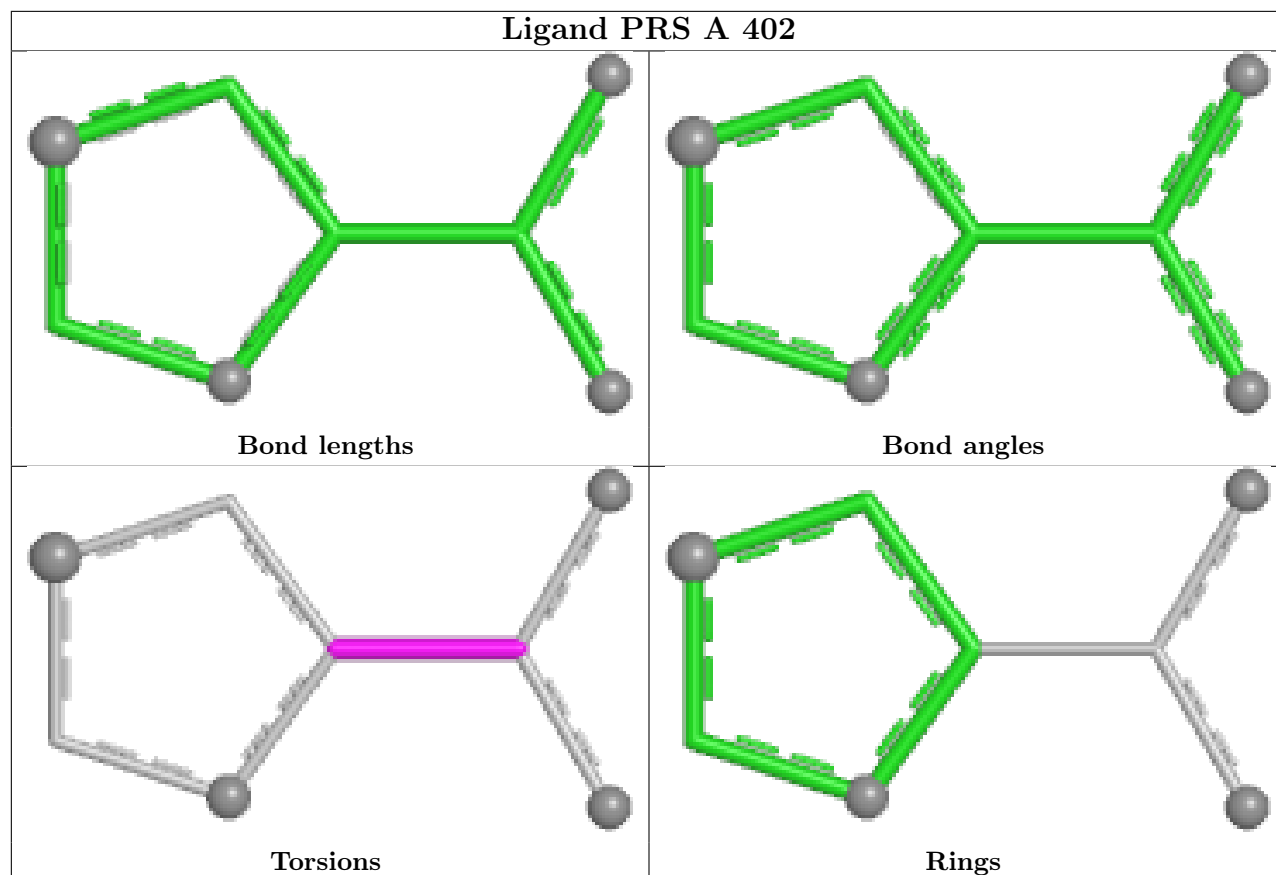
Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	B	402	PRS	1	0
2	A	401	FAD	1	0
2	B	401	FAD	1	0

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

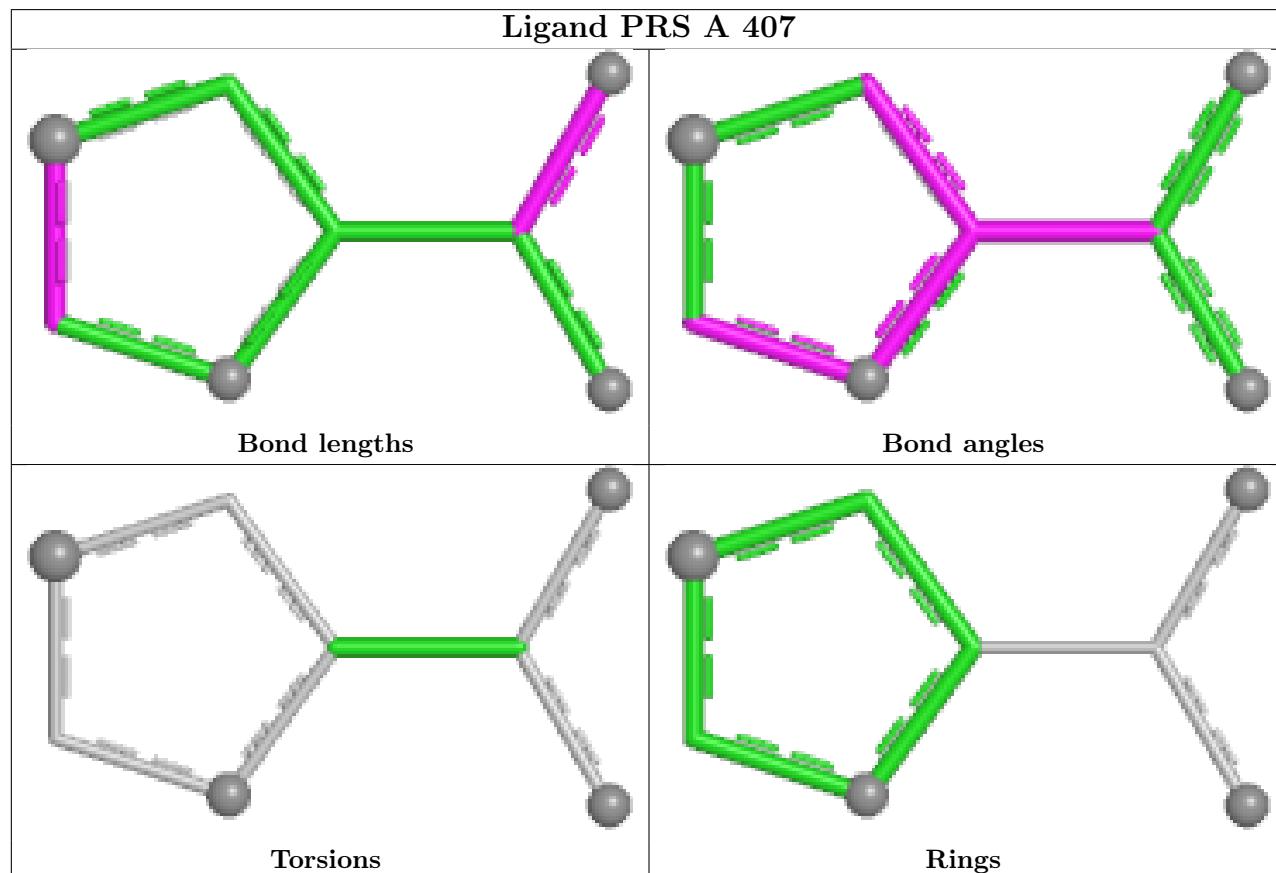
addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. 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.



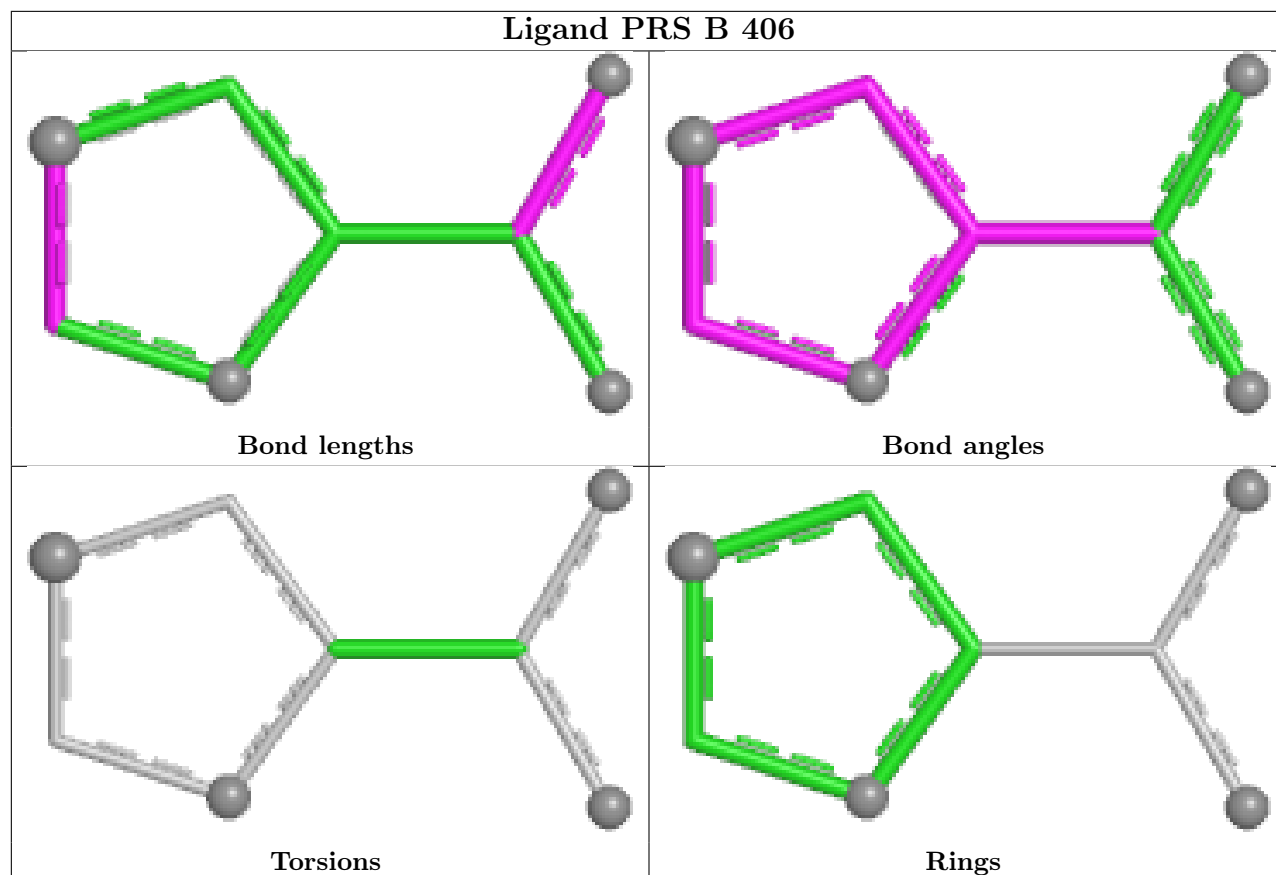
Ligand PRS A 402



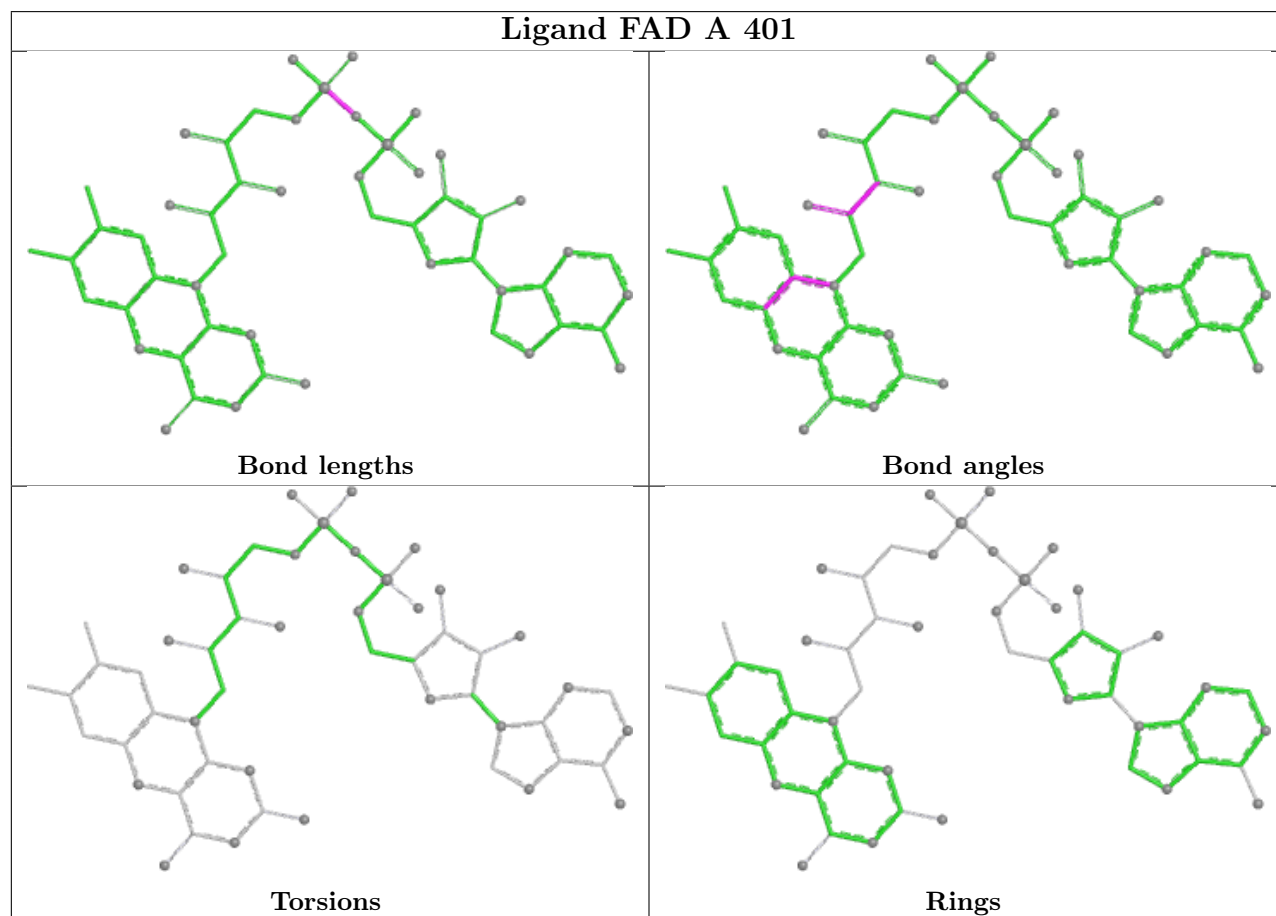
Ligand PRS A 407

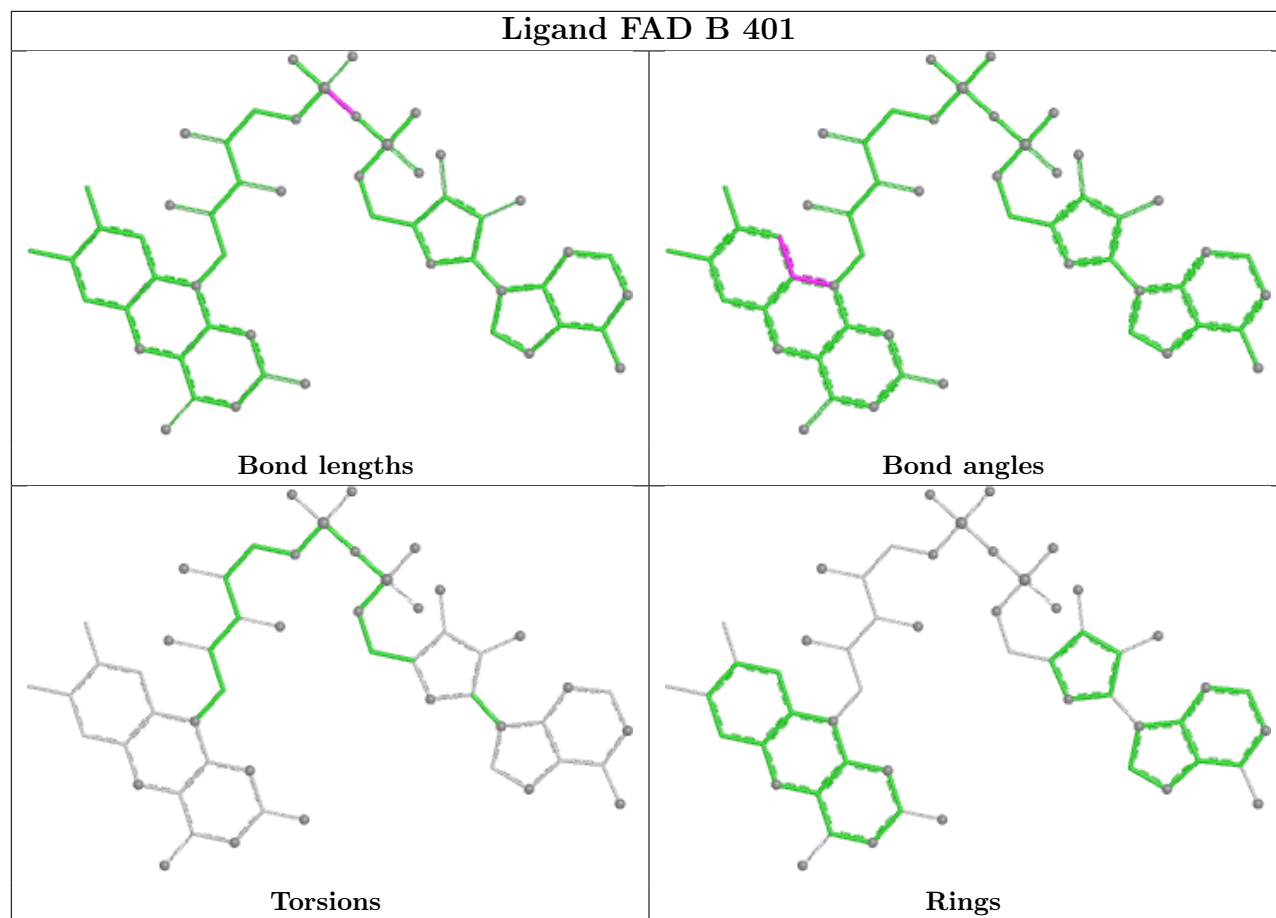


Ligand PRS B 406



Ligand FAD A 401





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 [i](#)

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

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, 95th 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	A	381/397 (95%)	-0.01	5 (1%) 75 78	6, 13, 25, 48	24 (6%)
1	B	385/397 (96%)	0.13	13 (3%) 48 54	6, 14, 28, 60	14 (3%)
All	All	766/794 (96%)	0.06	18 (2%) 61 66	6, 13, 26, 60	38 (4%)

The worst 5 of 18 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	384	LEU	7.5
1	B	389	ILE	6.2
1	B	2	THR	4.4
1	B	387	THR	4.4
1	B	386	LYS	4.0

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

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](#)

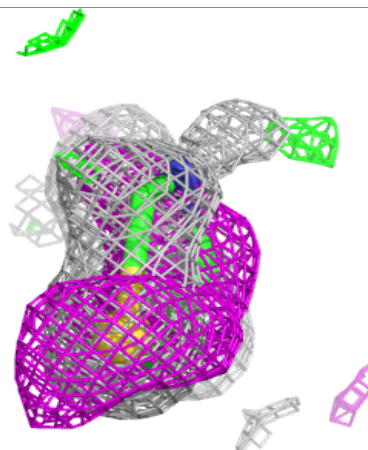
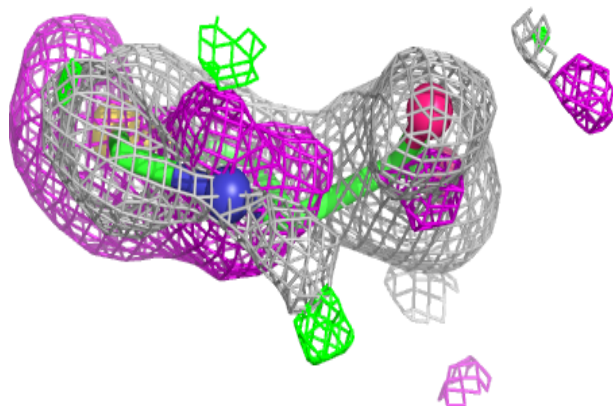
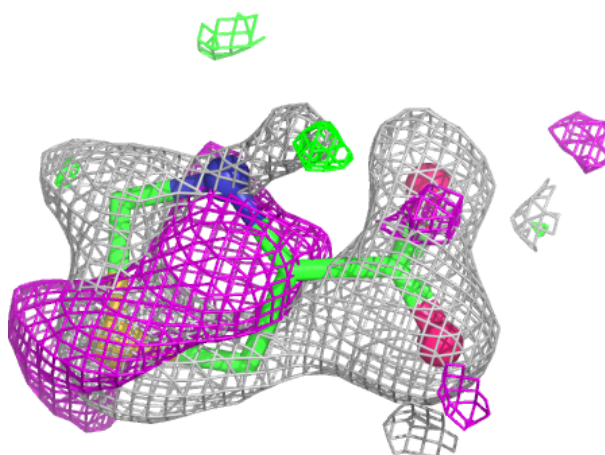
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled ‘Q< 0.9’ lists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

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
5	GOL	A	405	6/6	0.75	0.17	44,47,49,52	0
5	GOL	A	406	6/6	0.77	0.18	42,47,54,58	0
6	SO4	B	405	5/5	0.80	0.11	52,54,62,70	0
3	PRS	B	406	8/8	0.84	0.14	27,31,33,34	0
5	GOL	B	404	6/6	0.85	0.13	26,27,28,28	0
3	PRS	A	407	8/8	0.88	0.13	29,32,34,34	0
5	GOL	A	404	6/6	0.88	0.12	23,27,32,34	0
3	PRS	A	402	8/8	0.98	0.05	11,12,14,14	0
3	PRS	B	402	8/8	0.98	0.05	12,13,14,14	0
4	CL	A	403	1/1	0.99	0.02	10,10,10,10	0
2	FAD	A	401	53/53	0.99	0.04	8,9,13,15	0
2	FAD	B	401	53/53	0.99	0.04	8,9,15,17	0
4	CL	B	403	1/1	1.00	0.02	10,10,10,10	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.

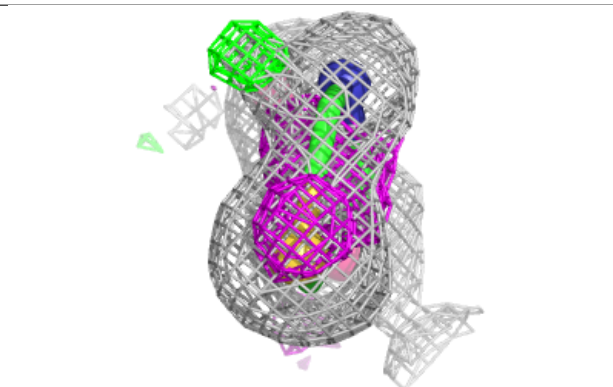
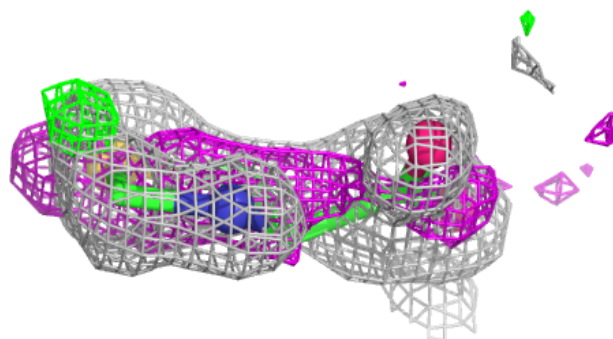
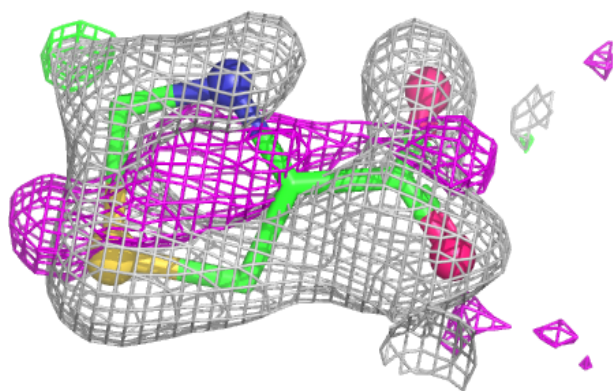
Electron density around PRS B 406:

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

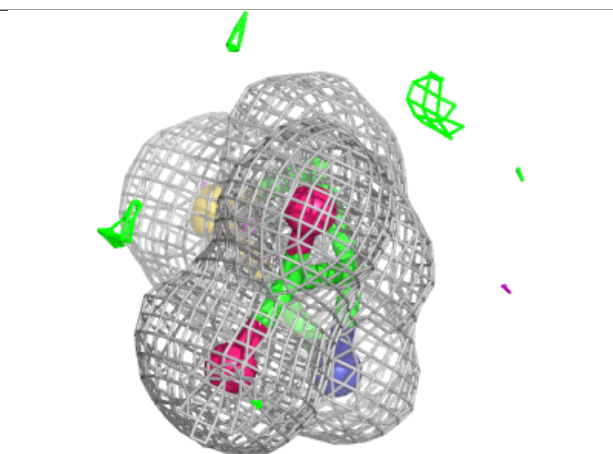
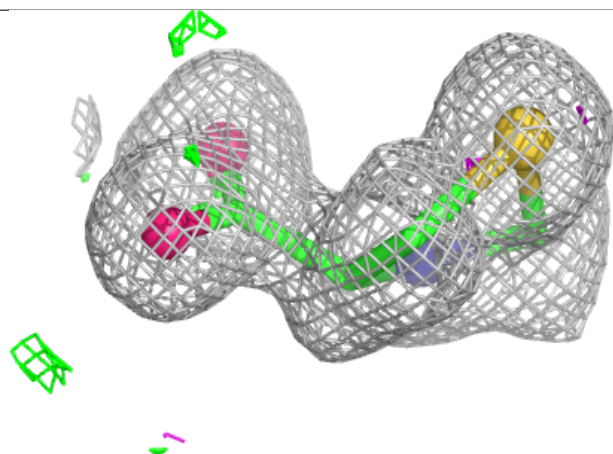
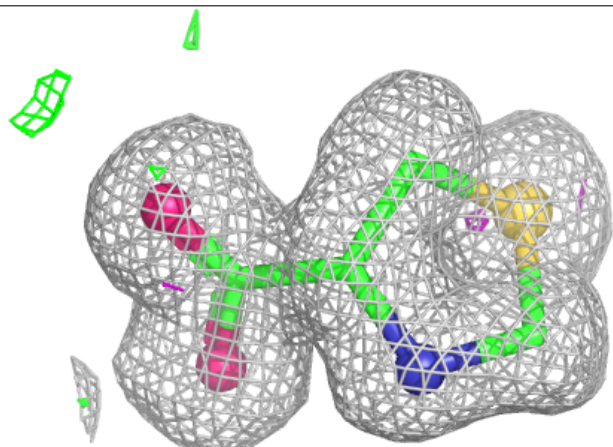


Electron density around PRS A 407:

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

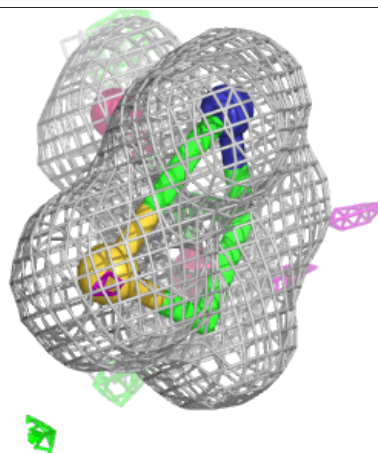
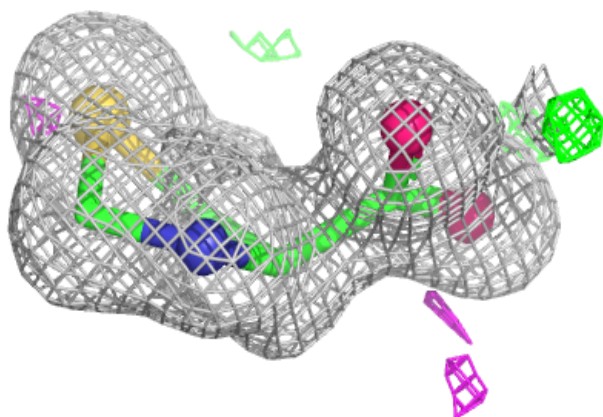
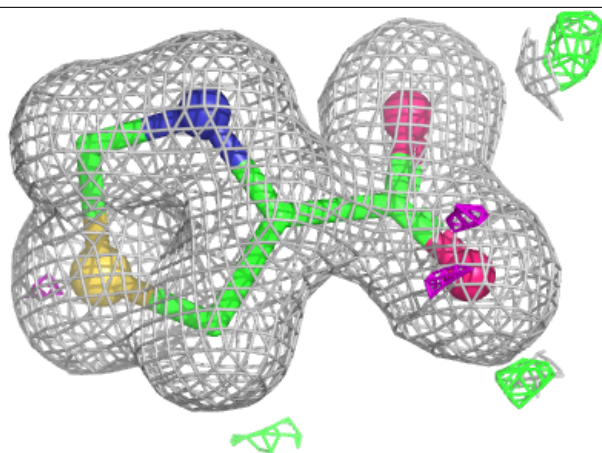
**Electron density around PRS A 402:**

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

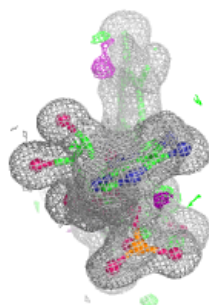
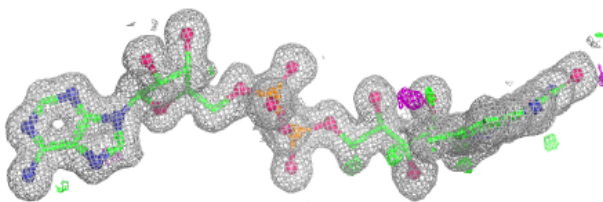
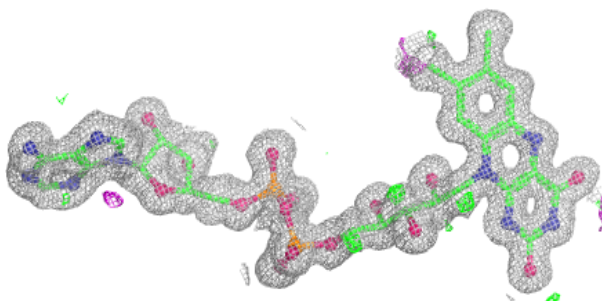


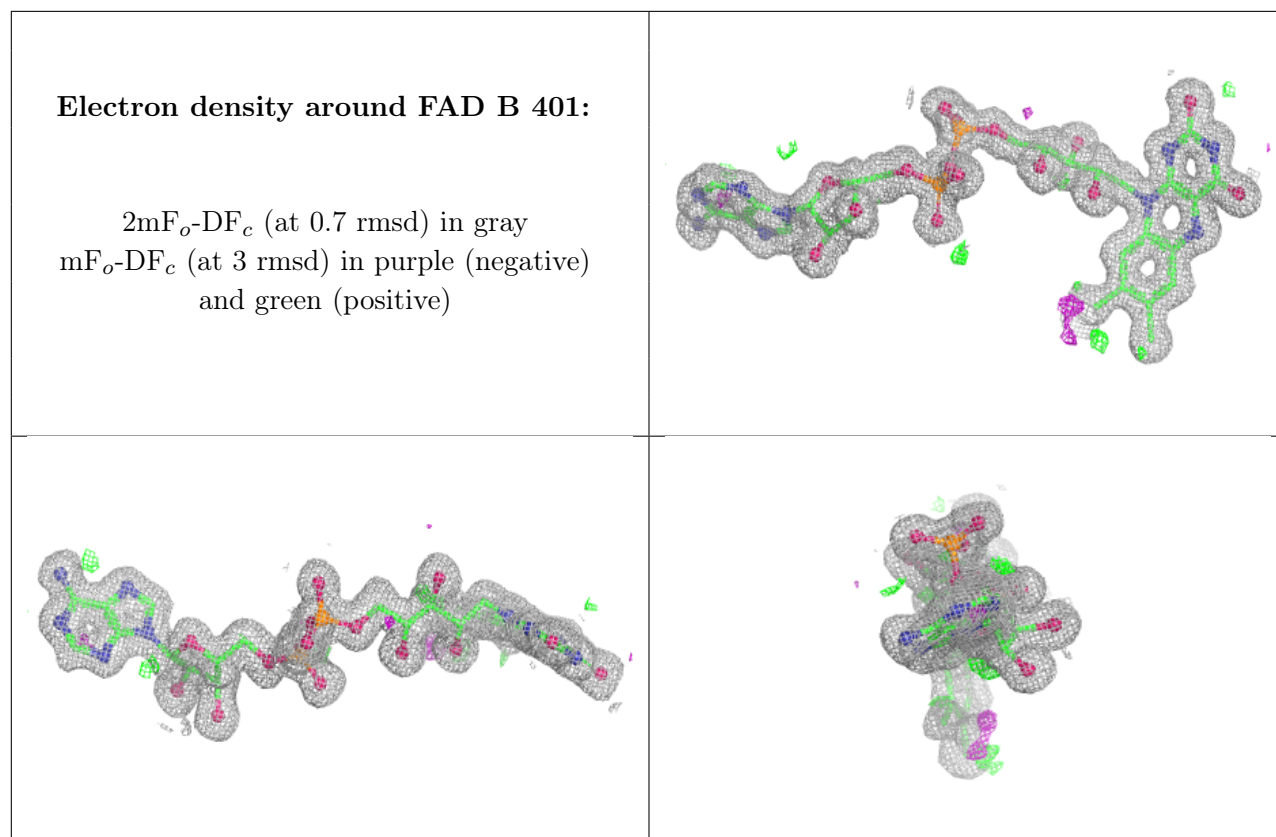
Electron density around PRS B 402:

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

**Electron density around FAD A 401:**

$2mF_o-DF_c$ (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.