



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 02:39 PM UTC

PDB ID : 5HK4 / pdb_00005hk4
Title : Structure function studies of R. palustris RubisCO (A47V-M331A mutant)
Authors : Arbing, M.A.; Shin, A.; Cascio, D.; Satagopan, S.; North, J.A.; Tabita, F.R.
Deposited on : 2016-01-13
Resolution : 2.15 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 Phenix2.0
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

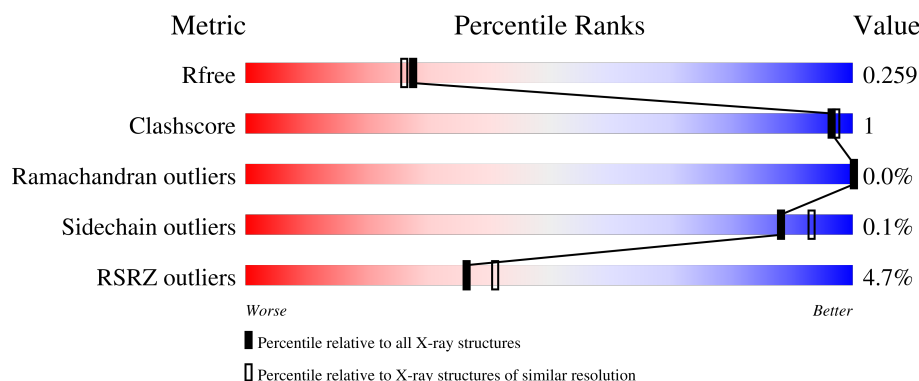
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.15 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	2057 (2.16-2.16)
Clashscore	190562	2159 (2.16-2.16)
Ramachandran outliers	187476	2134 (2.16-2.16)
Sidechain outliers	187428	2133 (2.16-2.16)
RSRZ outliers	180081	2059 (2.16-2.16)

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	481	5% 93% • 5%
1	B	481	2% 93% • 5%
1	C	481	4% 92% • 5%
1	D	481	6% 92% • 5%
1	E	481	4% 92% • 5%

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Mol	Chain	Length	Quality of chain
1	F	481	6% 91% 5%

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 42492 atoms, of which 20284 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 Ribulose biphosphate carboxylase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	457	Total	C	H	N	O	S	0	0	0
			6925	2245	3393	612	657	18			
1	B	455	Total	C	H	N	O	S	0	0	0
			6884	2233	3369	609	655	18			
1	C	455	Total	C	H	N	O	S	0	0	0
			6877	2233	3362	609	655	18			
1	D	456	Total	C	H	N	O	S	0	0	0
			6890	2239	3367	610	656	18			
1	E	455	Total	C	H	N	O	S	0	0	0
			6884	2233	3369	609	655	18			
1	F	455	Total	C	H	N	O	S	0	0	0
			6885	2233	3370	609	655	18			

There are 132 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-19	MET	-	initiating methionine	UNP Q6N0W9
A	-18	GLY	-	expression tag	UNP Q6N0W9
A	-17	SER	-	expression tag	UNP Q6N0W9
A	-16	SER	-	expression tag	UNP Q6N0W9
A	-15	HIS	-	expression tag	UNP Q6N0W9
A	-14	HIS	-	expression tag	UNP Q6N0W9
A	-13	HIS	-	expression tag	UNP Q6N0W9
A	-12	HIS	-	expression tag	UNP Q6N0W9
A	-11	HIS	-	expression tag	UNP Q6N0W9
A	-10	HIS	-	expression tag	UNP Q6N0W9
A	-9	SER	-	expression tag	UNP Q6N0W9
A	-8	SER	-	expression tag	UNP Q6N0W9
A	-7	GLY	-	expression tag	UNP Q6N0W9
A	-6	LEU	-	expression tag	UNP Q6N0W9
A	-5	VAL	-	expression tag	UNP Q6N0W9
A	-4	PRO	-	expression tag	UNP Q6N0W9
A	-3	ARG	-	expression tag	UNP Q6N0W9

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Chain	Residue	Modelled	Actual	Comment	Reference
A	-2	GLY	-	expression tag	UNP Q6N0W9
A	-1	SER	-	expression tag	UNP Q6N0W9
A	0	HIS	-	expression tag	UNP Q6N0W9
A	47	VAL	ALA	engineered mutation	UNP Q6N0W9
A	331	ALA	MET	engineered mutation	UNP Q6N0W9
B	-19	MET	-	initiating methionine	UNP Q6N0W9
B	-18	GLY	-	expression tag	UNP Q6N0W9
B	-17	SER	-	expression tag	UNP Q6N0W9
B	-16	SER	-	expression tag	UNP Q6N0W9
B	-15	HIS	-	expression tag	UNP Q6N0W9
B	-14	HIS	-	expression tag	UNP Q6N0W9
B	-13	HIS	-	expression tag	UNP Q6N0W9
B	-12	HIS	-	expression tag	UNP Q6N0W9
B	-11	HIS	-	expression tag	UNP Q6N0W9
B	-10	HIS	-	expression tag	UNP Q6N0W9
B	-9	SER	-	expression tag	UNP Q6N0W9
B	-8	SER	-	expression tag	UNP Q6N0W9
B	-7	GLY	-	expression tag	UNP Q6N0W9
B	-6	LEU	-	expression tag	UNP Q6N0W9
B	-5	VAL	-	expression tag	UNP Q6N0W9
B	-4	PRO	-	expression tag	UNP Q6N0W9
B	-3	ARG	-	expression tag	UNP Q6N0W9
B	-2	GLY	-	expression tag	UNP Q6N0W9
B	-1	SER	-	expression tag	UNP Q6N0W9
B	0	HIS	-	expression tag	UNP Q6N0W9
B	47	VAL	ALA	engineered mutation	UNP Q6N0W9
B	331	ALA	MET	engineered mutation	UNP Q6N0W9
C	-19	MET	-	initiating methionine	UNP Q6N0W9
C	-18	GLY	-	expression tag	UNP Q6N0W9
C	-17	SER	-	expression tag	UNP Q6N0W9
C	-16	SER	-	expression tag	UNP Q6N0W9
C	-15	HIS	-	expression tag	UNP Q6N0W9
C	-14	HIS	-	expression tag	UNP Q6N0W9
C	-13	HIS	-	expression tag	UNP Q6N0W9
C	-12	HIS	-	expression tag	UNP Q6N0W9
C	-11	HIS	-	expression tag	UNP Q6N0W9
C	-10	HIS	-	expression tag	UNP Q6N0W9
C	-9	SER	-	expression tag	UNP Q6N0W9
C	-8	SER	-	expression tag	UNP Q6N0W9
C	-7	GLY	-	expression tag	UNP Q6N0W9
C	-6	LEU	-	expression tag	UNP Q6N0W9
C	-5	VAL	-	expression tag	UNP Q6N0W9

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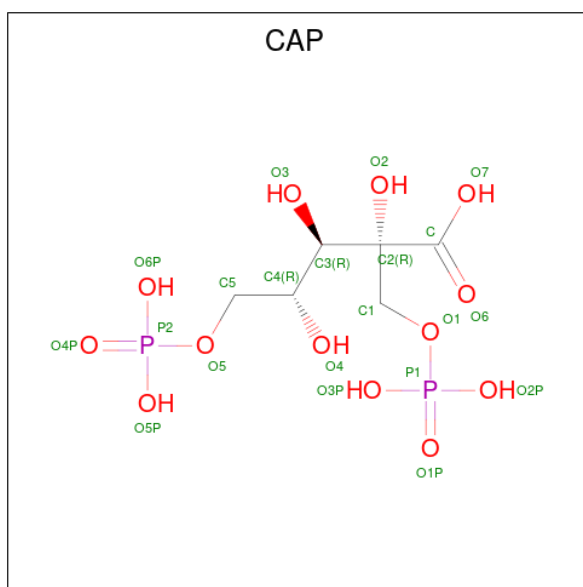
Chain	Residue	Modelled	Actual	Comment	Reference
C	-4	PRO	-	expression tag	UNP Q6N0W9
C	-3	ARG	-	expression tag	UNP Q6N0W9
C	-2	GLY	-	expression tag	UNP Q6N0W9
C	-1	SER	-	expression tag	UNP Q6N0W9
C	0	HIS	-	expression tag	UNP Q6N0W9
C	47	VAL	ALA	engineered mutation	UNP Q6N0W9
C	331	ALA	MET	engineered mutation	UNP Q6N0W9
D	-19	MET	-	initiating methionine	UNP Q6N0W9
D	-18	GLY	-	expression tag	UNP Q6N0W9
D	-17	SER	-	expression tag	UNP Q6N0W9
D	-16	SER	-	expression tag	UNP Q6N0W9
D	-15	HIS	-	expression tag	UNP Q6N0W9
D	-14	HIS	-	expression tag	UNP Q6N0W9
D	-13	HIS	-	expression tag	UNP Q6N0W9
D	-12	HIS	-	expression tag	UNP Q6N0W9
D	-11	HIS	-	expression tag	UNP Q6N0W9
D	-10	HIS	-	expression tag	UNP Q6N0W9
D	-9	SER	-	expression tag	UNP Q6N0W9
D	-8	SER	-	expression tag	UNP Q6N0W9
D	-7	GLY	-	expression tag	UNP Q6N0W9
D	-6	LEU	-	expression tag	UNP Q6N0W9
D	-5	VAL	-	expression tag	UNP Q6N0W9
D	-4	PRO	-	expression tag	UNP Q6N0W9
D	-3	ARG	-	expression tag	UNP Q6N0W9
D	-2	GLY	-	expression tag	UNP Q6N0W9
D	-1	SER	-	expression tag	UNP Q6N0W9
D	0	HIS	-	expression tag	UNP Q6N0W9
D	47	VAL	ALA	engineered mutation	UNP Q6N0W9
D	331	ALA	MET	engineered mutation	UNP Q6N0W9
E	-19	MET	-	initiating methionine	UNP Q6N0W9
E	-18	GLY	-	expression tag	UNP Q6N0W9
E	-17	SER	-	expression tag	UNP Q6N0W9
E	-16	SER	-	expression tag	UNP Q6N0W9
E	-15	HIS	-	expression tag	UNP Q6N0W9
E	-14	HIS	-	expression tag	UNP Q6N0W9
E	-13	HIS	-	expression tag	UNP Q6N0W9
E	-12	HIS	-	expression tag	UNP Q6N0W9
E	-11	HIS	-	expression tag	UNP Q6N0W9
E	-10	HIS	-	expression tag	UNP Q6N0W9
E	-9	SER	-	expression tag	UNP Q6N0W9
E	-8	SER	-	expression tag	UNP Q6N0W9
E	-7	GLY	-	expression tag	UNP Q6N0W9

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Chain	Residue	Modelled	Actual	Comment	Reference
E	-6	LEU	-	expression tag	UNP Q6N0W9
E	-5	VAL	-	expression tag	UNP Q6N0W9
E	-4	PRO	-	expression tag	UNP Q6N0W9
E	-3	ARG	-	expression tag	UNP Q6N0W9
E	-2	GLY	-	expression tag	UNP Q6N0W9
E	-1	SER	-	expression tag	UNP Q6N0W9
E	0	HIS	-	expression tag	UNP Q6N0W9
E	47	VAL	ALA	engineered mutation	UNP Q6N0W9
E	331	ALA	MET	engineered mutation	UNP Q6N0W9
F	-19	MET	-	initiating methionine	UNP Q6N0W9
F	-18	GLY	-	expression tag	UNP Q6N0W9
F	-17	SER	-	expression tag	UNP Q6N0W9
F	-16	SER	-	expression tag	UNP Q6N0W9
F	-15	HIS	-	expression tag	UNP Q6N0W9
F	-14	HIS	-	expression tag	UNP Q6N0W9
F	-13	HIS	-	expression tag	UNP Q6N0W9
F	-12	HIS	-	expression tag	UNP Q6N0W9
F	-11	HIS	-	expression tag	UNP Q6N0W9
F	-10	HIS	-	expression tag	UNP Q6N0W9
F	-9	SER	-	expression tag	UNP Q6N0W9
F	-8	SER	-	expression tag	UNP Q6N0W9
F	-7	GLY	-	expression tag	UNP Q6N0W9
F	-6	LEU	-	expression tag	UNP Q6N0W9
F	-5	VAL	-	expression tag	UNP Q6N0W9
F	-4	PRO	-	expression tag	UNP Q6N0W9
F	-3	ARG	-	expression tag	UNP Q6N0W9
F	-2	GLY	-	expression tag	UNP Q6N0W9
F	-1	SER	-	expression tag	UNP Q6N0W9
F	0	HIS	-	expression tag	UNP Q6N0W9
F	47	VAL	ALA	engineered mutation	UNP Q6N0W9
F	331	ALA	MET	engineered mutation	UNP Q6N0W9

- Molecule 2 is 2-CARBOXYARABINITOL-1,5-DIPHOSPHATE (CCD ID: CAP) (formula: $C_6H_{14}O_{13}P_2$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total 30	C 6	H 9	O 13	P 2	0	0
2	B	1	Total 30	C 6	H 9	O 13	P 2	0	0
2	C	1	Total 30	C 6	H 9	O 13	P 2	0	0
2	D	1	Total 30	C 6	H 9	O 13	P 2	0	0
2	E	1	Total 30	C 6	H 9	O 13	P 2	0	0
2	F	1	Total 30	C 6	H 9	O 13	P 2	0	0

- Molecule 3 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total Mg 1 1	0	0
3	B	1	Total Mg 1 1	0	0
3	C	1	Total Mg 1 1	0	0
3	D	1	Total Mg 1 1	0	0
3	E	1	Total Mg 1 1	0	0
3	F	1	Total Mg 1 1	0	0

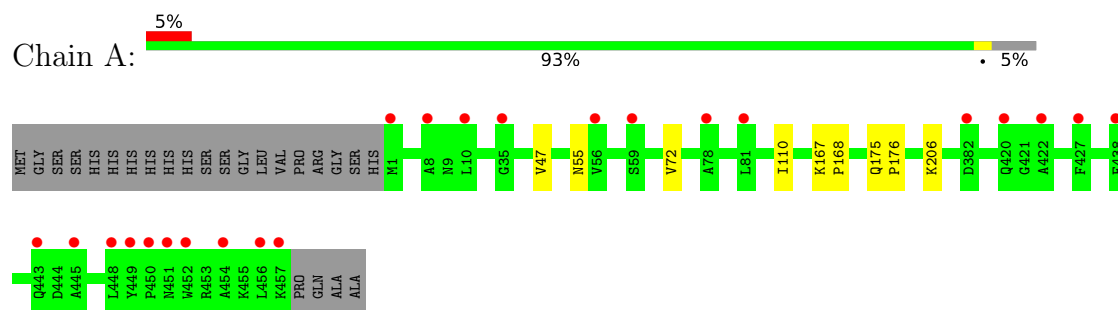
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	147	Total 147	O 147	0	0
4	B	173	Total 173	O 173	0	0
4	C	171	Total 171	O 171	0	0
4	D	176	Total 176	O 176	0	0
4	E	146	Total 146	O 146	0	0
4	F	148	Total 148	O 148	0	0

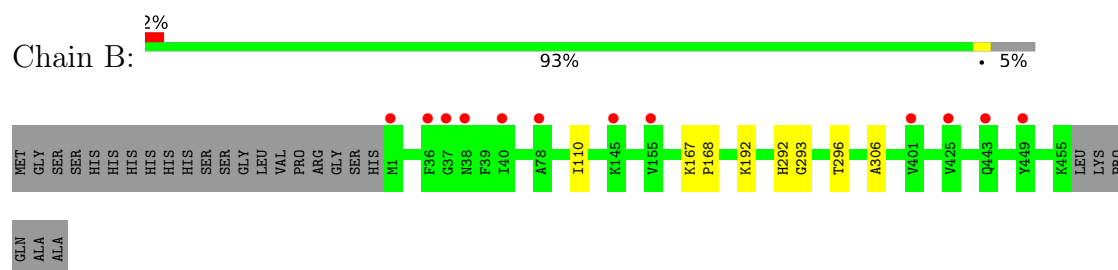
3 Residue-property plots [i](#)

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 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.

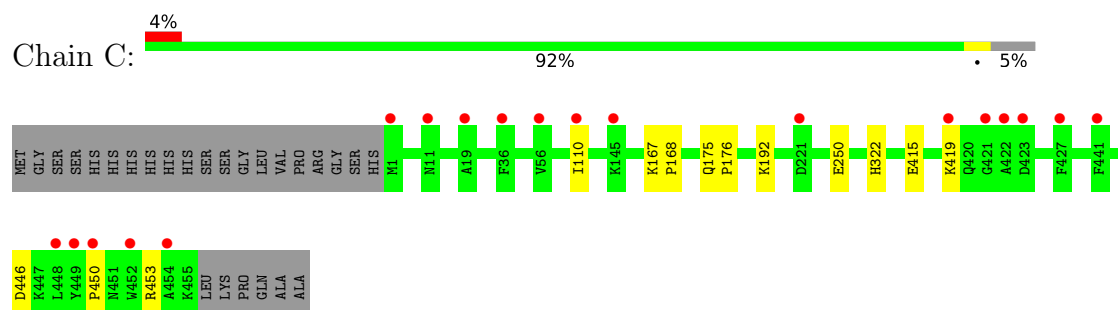
- Molecule 1: Ribulose biphosphate carboxylase



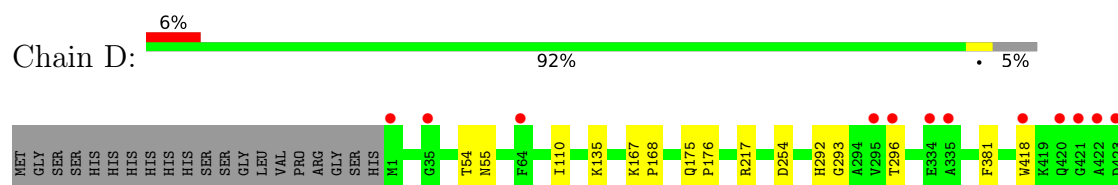
- Molecule 1: Ribulose biphosphate carboxylase

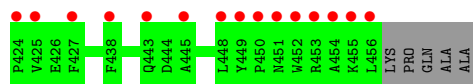


- Molecule 1: Ribulose biphosphate carboxylase



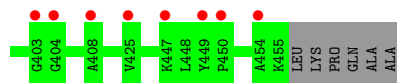
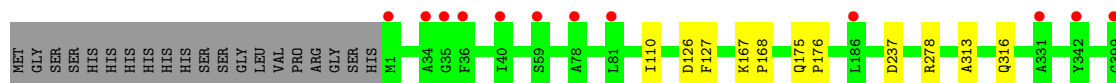
- Molecule 1: Ribulose biphosphate carboxylase





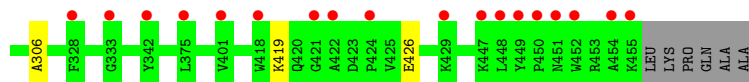
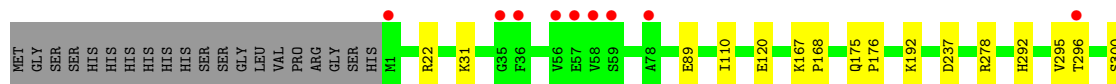
- Molecule 1: Ribulose biphosphate carboxylase

Chain E: 4% 92% 5%



- Molecule 1: Ribulose biphosphate carboxylase

Chain F: 6% 91% 5%



4 Data and refinement statistics

Property	Value	Source
Space group	P 1	Depositor
Cell constants a, b, c, α , β , γ	76.09Å 100.41Å 100.32Å 113.06° 88.86° 108.01°	Depositor
Resolution (Å)	81.96 – 2.15 81.96 – 2.15	Depositor EDS
% Data completeness (in resolution range)	95.3 (81.96-2.15) 95.3 (81.96-2.15)	Depositor EDS
R_{merge}	0.12	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.39 (at 2.14Å)	Xtriage
Refinement program	PHENIX 1.9_1692	Depositor
R, R_{free}	0.225 , 0.255 0.229 , 0.259	Depositor DCC
R_{free} test set	13384 reflections (10.00%)	wwPDB-VP
Wilson B-factor (Å ²)	35.3	Xtriage
Anisotropy	0.246	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.39 , 47.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	42492	wwPDB-VP
Average B, all atoms (Å ²)	50.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.41% 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: CAP, KCX, MG

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	0.31	0/3608	0.65	0/4883
1	B	0.31	0/3591	0.64	0/4861
1	C	0.31	0/3591	0.65	0/4861
1	D	0.31	0/3599	0.66	0/4872
1	E	0.31	0/3591	0.63	0/4861
1	F	0.31	0/3591	0.64	0/4861
All	All	0.31	0/21571	0.64	0/29199

There are no bond length outliers.

There are no bond angle outliers.

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	3532	3393	3405	6	0
1	B	3515	3369	3381	5	0
1	C	3515	3362	3381	7	0
1	D	3523	3367	3392	9	0
1	E	3515	3369	3381	7	0
1	F	3515	3370	3381	10	0
2	A	21	9	7	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	B	21	9	7	0	0
2	C	21	9	7	1	0
2	D	21	9	7	0	0
2	E	21	9	7	0	0
2	F	21	9	7	0	0
3	A	1	0	0	0	0
3	B	1	0	0	0	0
3	C	1	0	0	0	0
3	D	1	0	0	0	0
3	E	1	0	0	0	0
3	F	1	0	0	0	0
4	A	147	0	0	1	0
4	B	173	0	0	0	0
4	C	171	0	0	0	0
4	D	176	0	0	1	0
4	E	146	0	0	0	0
4	F	148	0	0	0	0
All	All	22208	20284	20363	41	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 1.

All (41) 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:F:296:THR:OG1	1:F:306:ALA:N	2.37	0.57
1:B:292:HIS:ND1	1:B:296:THR:HG21	2.23	0.53
1:F:292:HIS:ND1	1:F:296:THR:HG21	2.27	0.50
1:C:446:ASP:OD1	1:C:453:ARG:NH2	2.45	0.50
1:D:217:ARG:NH2	1:D:254:ASP:OD1	2.32	0.49
1:E:237:ASP:OD2	1:F:278:ARG:NH1	2.45	0.49
1:F:31:LYS:NZ	1:F:120:GLU:OE1	2.40	0.48
1:E:313:ALA:HA	1:E:316:GLN:HE21	1.77	0.48
1:E:278:ARG:NH1	1:F:237:ASP:OD2	2.47	0.48
1:F:110:ILE:O	1:F:110:ILE:HG23	2.14	0.47
1:A:206:LYS:NZ	1:C:250:GLU:OE1	2.35	0.47
1:C:415:GLU:OE2	1:C:419:LYS:NZ	2.47	0.46
1:B:293:GLY:HA2	1:B:296:THR:HG22	1.99	0.46
1:D:292:HIS:ND1	1:D:296:THR:HG21	2.31	0.45
1:E:110:ILE:O	1:E:110:ILE:HG23	2.15	0.45
1:B:296:THR:OG1	1:B:306:ALA:N	2.50	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:F:295:VAL:O	1:F:300:SER:OG	2.35	0.44
1:C:110:ILE:HG23	1:C:110:ILE:O	2.16	0.44
1:D:167:LYS:HA	1:D:168:PRO:C	2.43	0.44
1:A:110:ILE:O	1:A:110:ILE:HG23	2.16	0.44
1:B:110:ILE:O	1:B:110:ILE:HG23	2.17	0.44
1:D:293:GLY:HA2	1:D:296:THR:HG22	1.99	0.44
1:E:126:ASP:OD1	1:E:127:PHE:N	2.51	0.44
1:F:167:LYS:HA	1:F:168:PRO:C	2.44	0.43
1:D:135:LYS:NZ	4:D:631:HOH:O	2.52	0.42
1:F:22:ARG:NH2	1:F:89:GLU:OE2	2.53	0.42
1:A:167:LYS:HA	1:A:168:PRO:C	2.44	0.42
1:D:110:ILE:HG23	1:D:110:ILE:O	2.19	0.42
1:B:167:LYS:HA	1:B:168:PRO:C	2.45	0.41
1:C:175:GLN:HB3	1:C:176:PRO:HD3	2.02	0.41
1:C:322:HIS:ND1	2:C:500:CAP:O5P	2.48	0.41
1:A:175:GLN:HB3	1:A:176:PRO:HD3	2.03	0.41
1:A:47:VAL:HG21	1:A:72:VAL:HG23	2.02	0.41
1:D:175:GLN:HB3	1:D:176:PRO:HD3	2.02	0.41
1:F:175:GLN:HB3	1:F:176:PRO:HD3	2.01	0.41
1:E:175:GLN:HB3	1:E:176:PRO:HD3	2.03	0.41
1:D:54:THR:OG1	1:D:55:ASN:N	2.52	0.41
1:D:381:PHE:HB3	1:D:418:TRP:CE2	2.56	0.41
1:A:55:ASN:ND2	4:A:621:HOH:O	2.49	0.40
1:C:167:LYS:HA	1:C:168:PRO:C	2.46	0.40
1:E:167:LYS:HA	1:E:168:PRO:C	2.46	0.40

There are no symmetry-related clashes.

5.3 Torsion angles

5.3.1 Protein backbone

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	454/481 (94%)	440 (97%)	14 (3%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	B	452/481 (94%)	438 (97%)	14 (3%)	0	100	100
1	C	452/481 (94%)	436 (96%)	15 (3%)	1 (0%)	43	44
1	D	453/481 (94%)	440 (97%)	13 (3%)	0	100	100
1	E	452/481 (94%)	438 (97%)	14 (3%)	0	100	100
1	F	452/481 (94%)	436 (96%)	16 (4%)	0	100	100
All	All	2715/2886 (94%)	2628 (97%)	86 (3%)	1 (0%)	100	100

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	C	450	PRO

5.3.2 Protein sidechains ⓘ

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	352/372 (95%)	352 (100%)	0	100	100
1	B	350/372 (94%)	350 (100%)	0	100	100
1	C	350/372 (94%)	350 (100%)	0	100	100
1	D	351/372 (94%)	351 (100%)	0	100	100
1	E	350/372 (94%)	350 (100%)	0	100	100
1	F	350/372 (94%)	348 (99%)	2 (1%)	78	84
All	All	2103/2232 (94%)	2101 (100%)	2 (0%)	88	93

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	F	419	LYS
1	F	426	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (6) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	23	HIS
1	C	388	ASN
1	D	79	ASN
1	E	23	HIS
1	F	383	ASN
1	F	451	ASN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

6 non-standard protein/DNA/RNA residues 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
1	KCX	E	192	1,3	10,11,12	0.69	0	6,12,14	0.67	0
1	KCX	F	192	1,3	10,11,12	2.17	1 (10%)	6,12,14	1.62	1 (16%)
1	KCX	C	192	1,3	10,11,12	2.15	1 (10%)	6,12,14	1.45	1 (16%)
1	KCX	A	192	1,3	10,11,12	0.64	0	6,12,14	0.81	0
1	KCX	B	192	1,3	10,11,12	2.16	1 (10%)	6,12,14	1.55	1 (16%)
1	KCX	D	192	1,3	10,11,12	0.69	0	6,12,14	0.93	0

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
1	KCX	E	192	1,3	-	1/9/10/12	-
1	KCX	F	192	1,3	-	1/9/10/12	-
1	KCX	C	192	1,3	-	0/9/10/12	-
1	KCX	A	192	1,3	-	1/9/10/12	-

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
1	KCX	B	192	1,3	-	0/9/10/12	-
1	KCX	D	192	1,3	-	0/9/10/12	-

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	F	192	KCX	OQ1-CX	6.36	1.33	1.21
1	B	192	KCX	OQ1-CX	6.36	1.33	1.21
1	C	192	KCX	OQ1-CX	6.32	1.33	1.21

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	F	192	KCX	OQ1-CX-NZ	-3.86	119.05	124.92
1	B	192	KCX	OQ1-CX-NZ	-3.70	119.30	124.92
1	C	192	KCX	OQ1-CX-NZ	-3.40	119.75	124.92

There are no chirality outliers.

All (3) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	A	192	KCX	O-C-CA-CB
1	E	192	KCX	O-C-CA-CB
1	F	192	KCX	O-C-CA-CB

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 12 ligands modelled in this entry, 6 are monoatomic - leaving 6 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
2	CAP	C	500	3	18,20,20	0.82	0	23,31,31	1.19	2 (8%)
2	CAP	F	500	3	18,20,20	0.85	0	23,31,31	1.19	2 (8%)
2	CAP	B	500	3	18,20,20	0.84	0	23,31,31	1.22	1 (4%)
2	CAP	A	500	3	18,20,20	0.82	0	23,31,31	1.20	2 (8%)
2	CAP	D	500	3	18,20,20	0.85	0	23,31,31	1.19	2 (8%)
2	CAP	E	500	3	18,20,20	0.86	0	23,31,31	1.20	2 (8%)

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	CAP	C	500	3	-	9/29/29/29	-
2	CAP	F	500	3	-	7/29/29/29	-
2	CAP	B	500	3	-	9/29/29/29	-
2	CAP	A	500	3	-	7/29/29/29	-
2	CAP	D	500	3	-	7/29/29/29	-
2	CAP	E	500	3	-	7/29/29/29	-

There are no bond length outliers.

All (11) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	500	CAP	O7-C-C2	3.99	120.74	114.06
2	E	500	CAP	O7-C-C2	3.82	120.45	114.06
2	C	500	CAP	O7-C-C2	3.81	120.44	114.06
2	A	500	CAP	O7-C-C2	3.79	120.41	114.06
2	F	500	CAP	O7-C-C2	3.71	120.28	114.06
2	D	500	CAP	O7-C-C2	3.64	120.16	114.06
2	A	500	CAP	O3-C3-C4	2.36	114.18	109.13
2	D	500	CAP	O3-C3-C4	2.29	114.03	109.13
2	E	500	CAP	O3-C3-C4	2.17	113.78	109.13
2	C	500	CAP	O3-C3-C4	2.15	113.73	109.13
2	F	500	CAP	O3-C3-C4	2.10	113.63	109.13

There are no chirality outliers.

All (46) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	500	CAP	O7-C-C2-C1
2	A	500	CAP	O6-C-C2-O2
2	A	500	CAP	O7-C-C2-O2
2	A	500	CAP	C2-C3-C4-O4
2	A	500	CAP	O3-C3-C4-O4
2	B	500	CAP	O6-C-C2-O2
2	B	500	CAP	O7-C-C2-O2
2	B	500	CAP	O3-C3-C4-O4
2	C	500	CAP	O6-C-C2-O2
2	C	500	CAP	C2-C3-C4-O4
2	C	500	CAP	O3-C3-C4-O4
2	D	500	CAP	O6-C-C2-C1
2	D	500	CAP	O7-C-C2-C1
2	D	500	CAP	O6-C-C2-O2
2	D	500	CAP	O7-C-C2-O2
2	D	500	CAP	C2-C3-C4-O4
2	D	500	CAP	O3-C3-C4-O4
2	E	500	CAP	O6-C-C2-C1
2	E	500	CAP	O7-C-C2-C1
2	E	500	CAP	O6-C-C2-O2
2	E	500	CAP	O7-C-C2-O2
2	E	500	CAP	C2-C3-C4-O4
2	E	500	CAP	O3-C3-C4-O4
2	F	500	CAP	O6-C-C2-C1
2	F	500	CAP	O7-C-C2-C1
2	F	500	CAP	O6-C-C2-O2
2	F	500	CAP	O7-C-C2-O2
2	F	500	CAP	C2-C3-C4-O4
2	F	500	CAP	O3-C3-C4-O4
2	B	500	CAP	O7-C-C2-C1
2	C	500	CAP	O7-C-C2-O2
2	A	500	CAP	O6-C-C2-C1
2	C	500	CAP	O7-C-C2-C1
2	B	500	CAP	O6-C-C2-C3
2	C	500	CAP	O6-C-C2-C3
2	A	500	CAP	O2-C2-C3-C4
2	B	500	CAP	O2-C2-C3-C4
2	C	500	CAP	O2-C2-C3-C4
2	D	500	CAP	O2-C2-C3-C4
2	E	500	CAP	O2-C2-C3-C4

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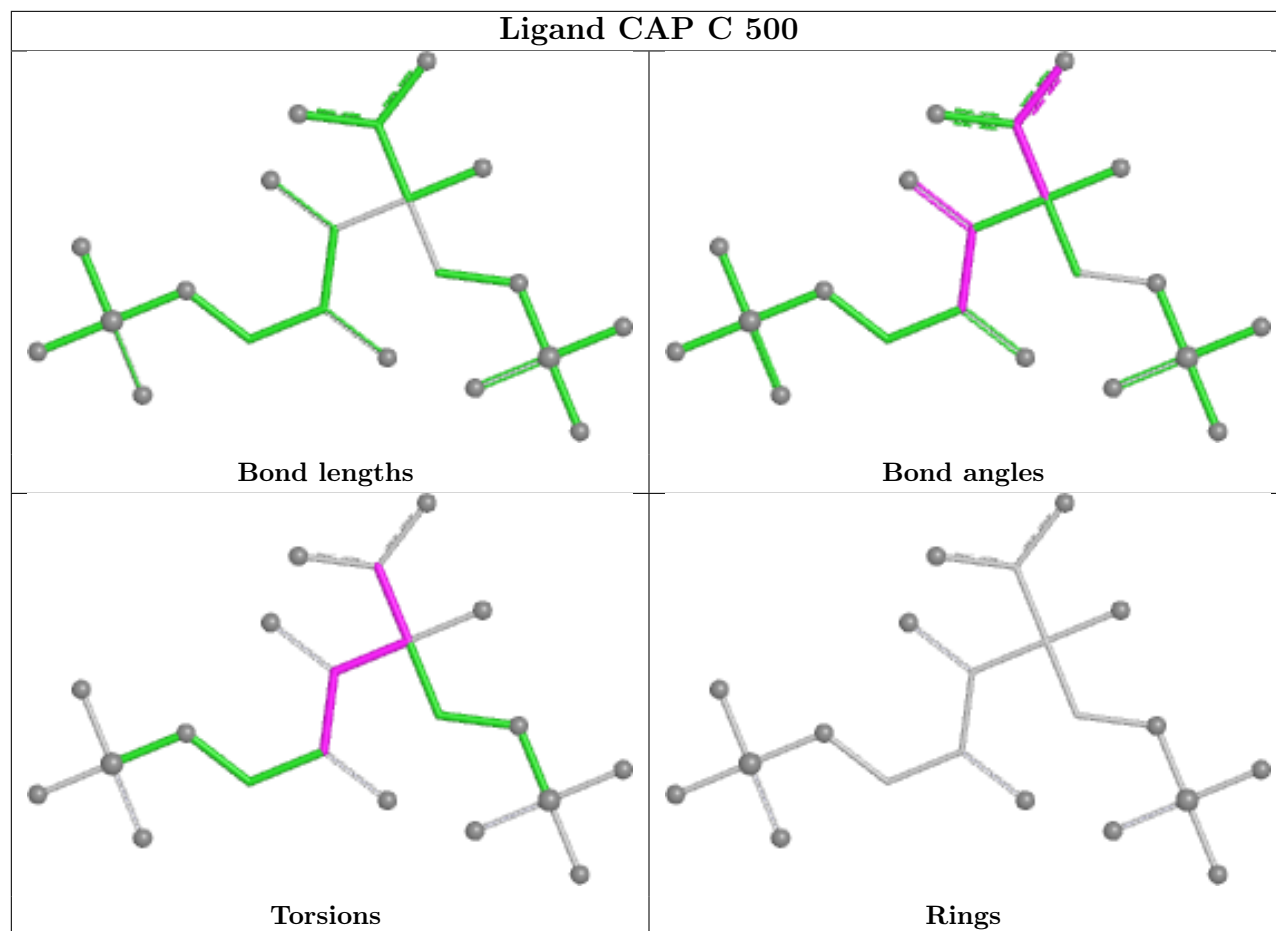
Mol	Chain	Res	Type	Atoms
2	F	500	CAP	O2-C2-C3-C4
2	B	500	CAP	O6-C-C2-C1
2	B	500	CAP	O7-C-C2-C3
2	C	500	CAP	O7-C-C2-C3
2	B	500	CAP	C2-C3-C4-O4
2	C	500	CAP	O6-C-C2-C1

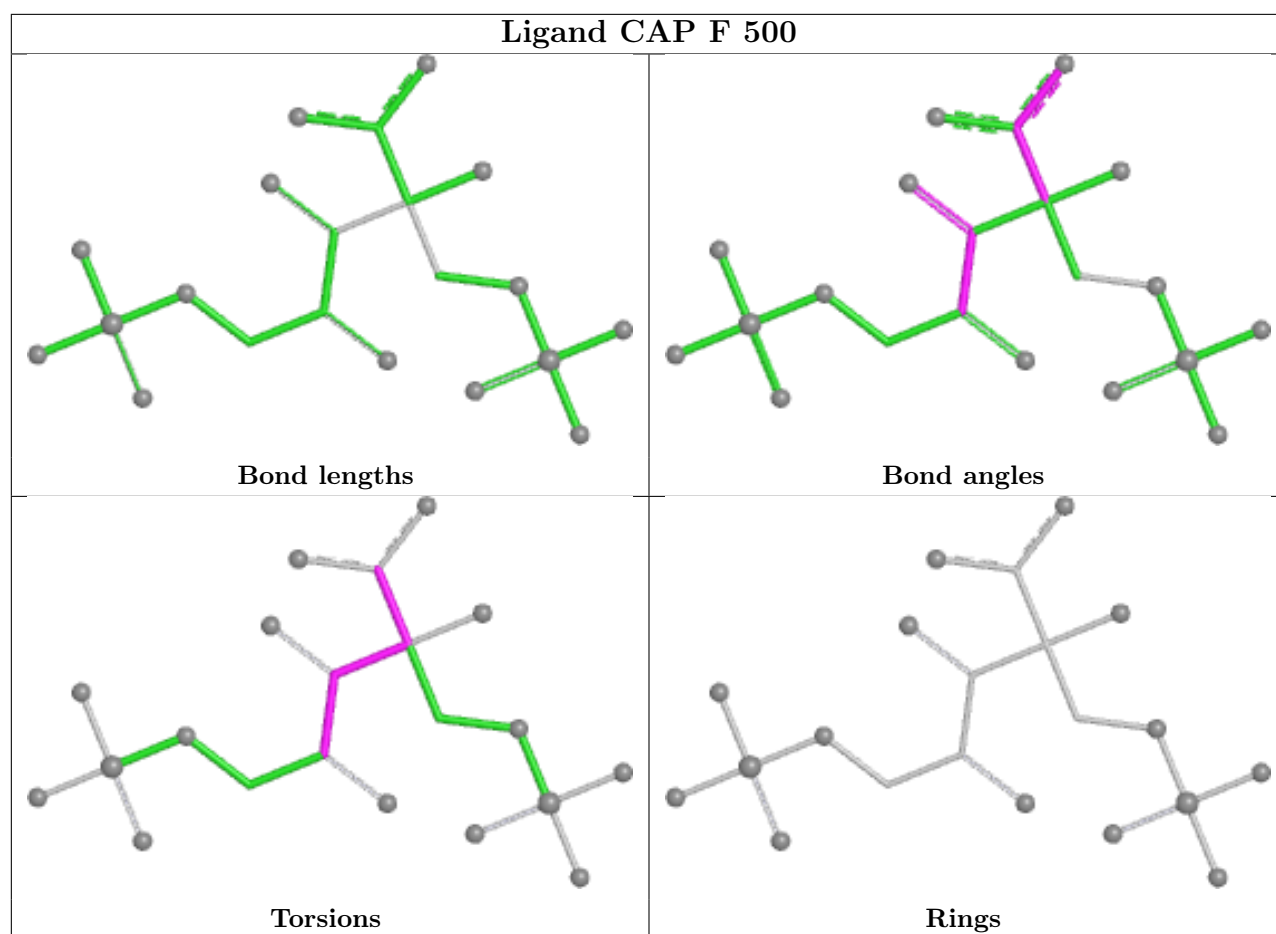
There are no ring outliers.

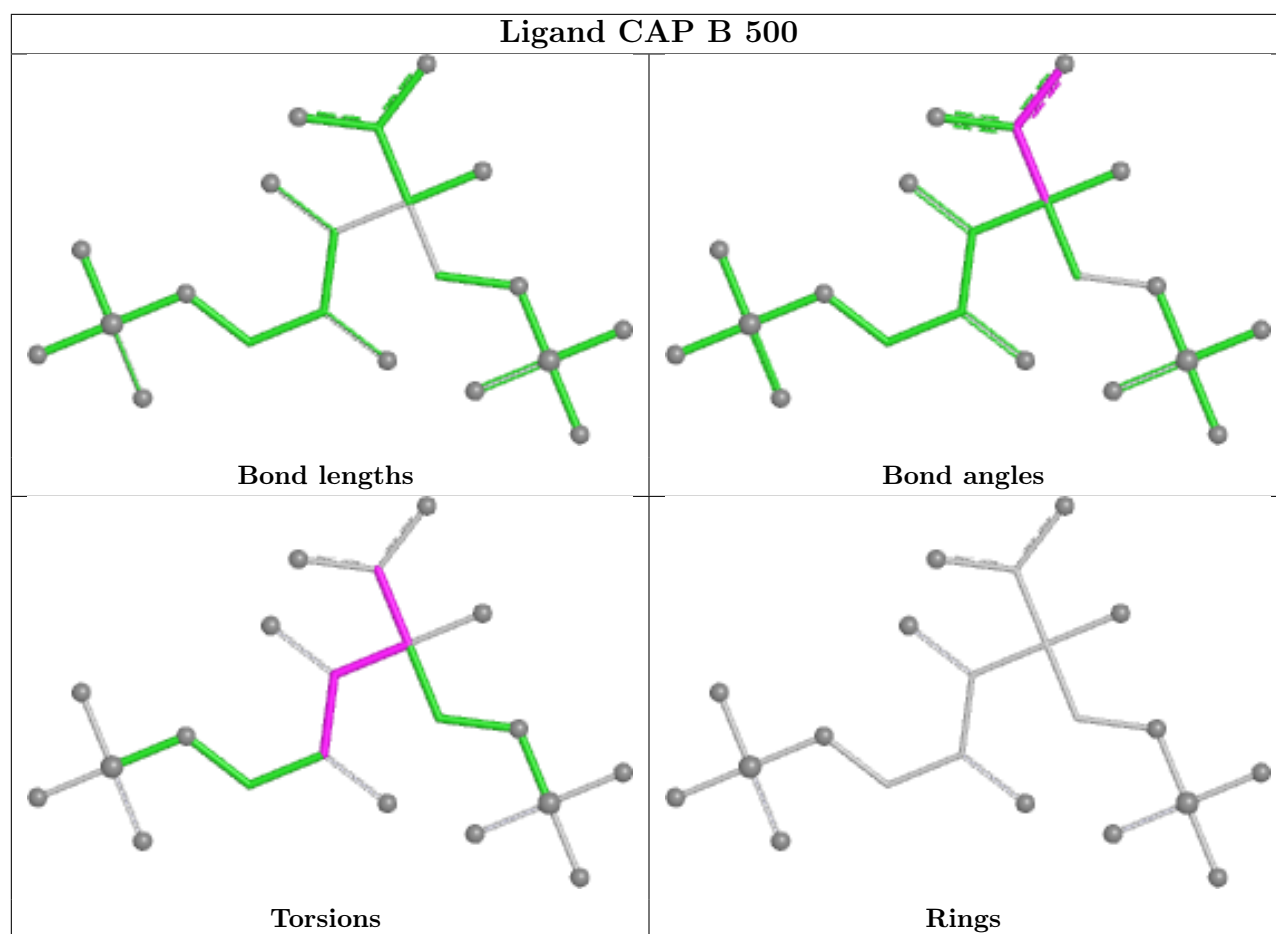
1 monomer is involved in 1 short contact:

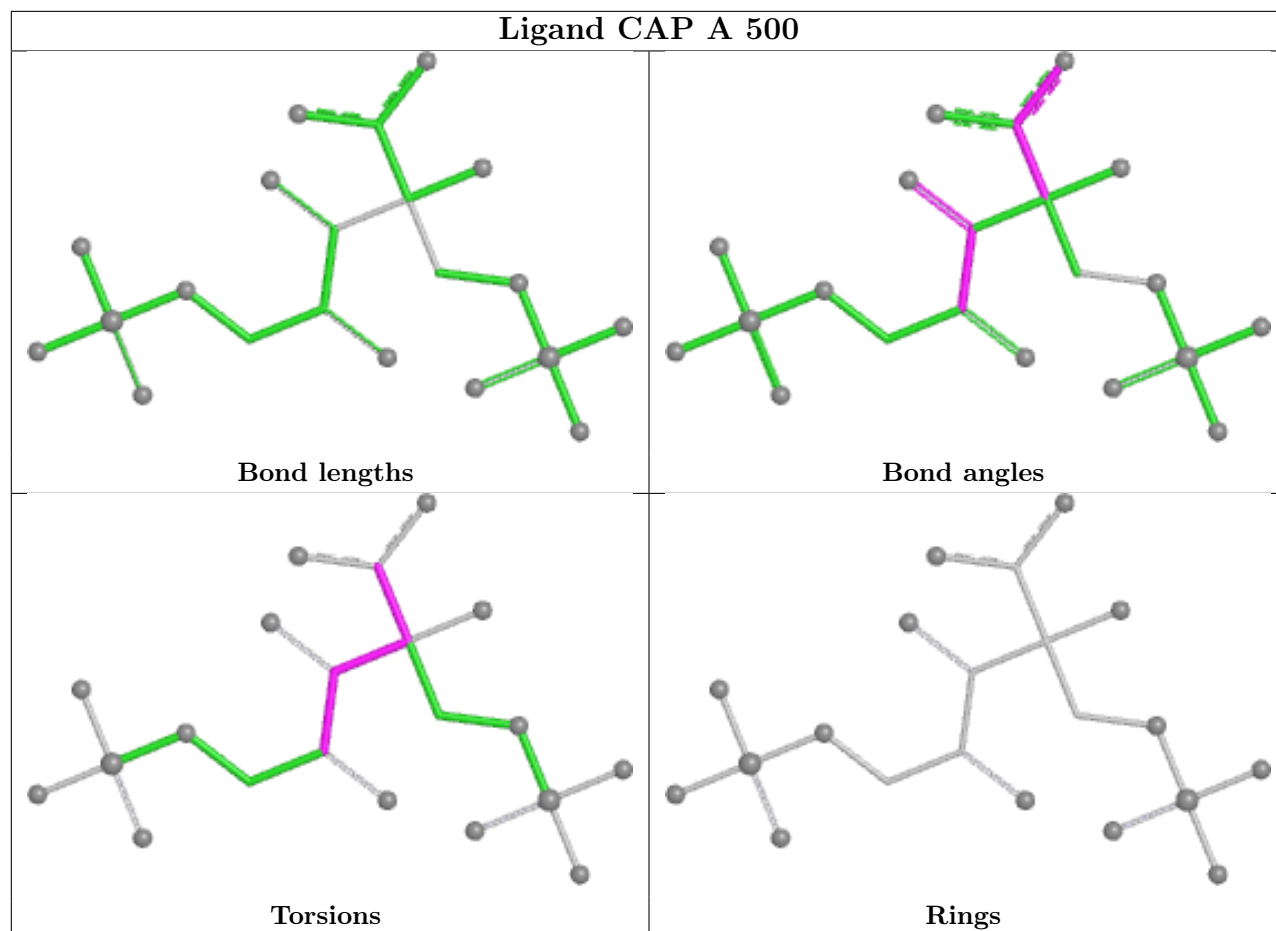
Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	C	500	CAP	1	0

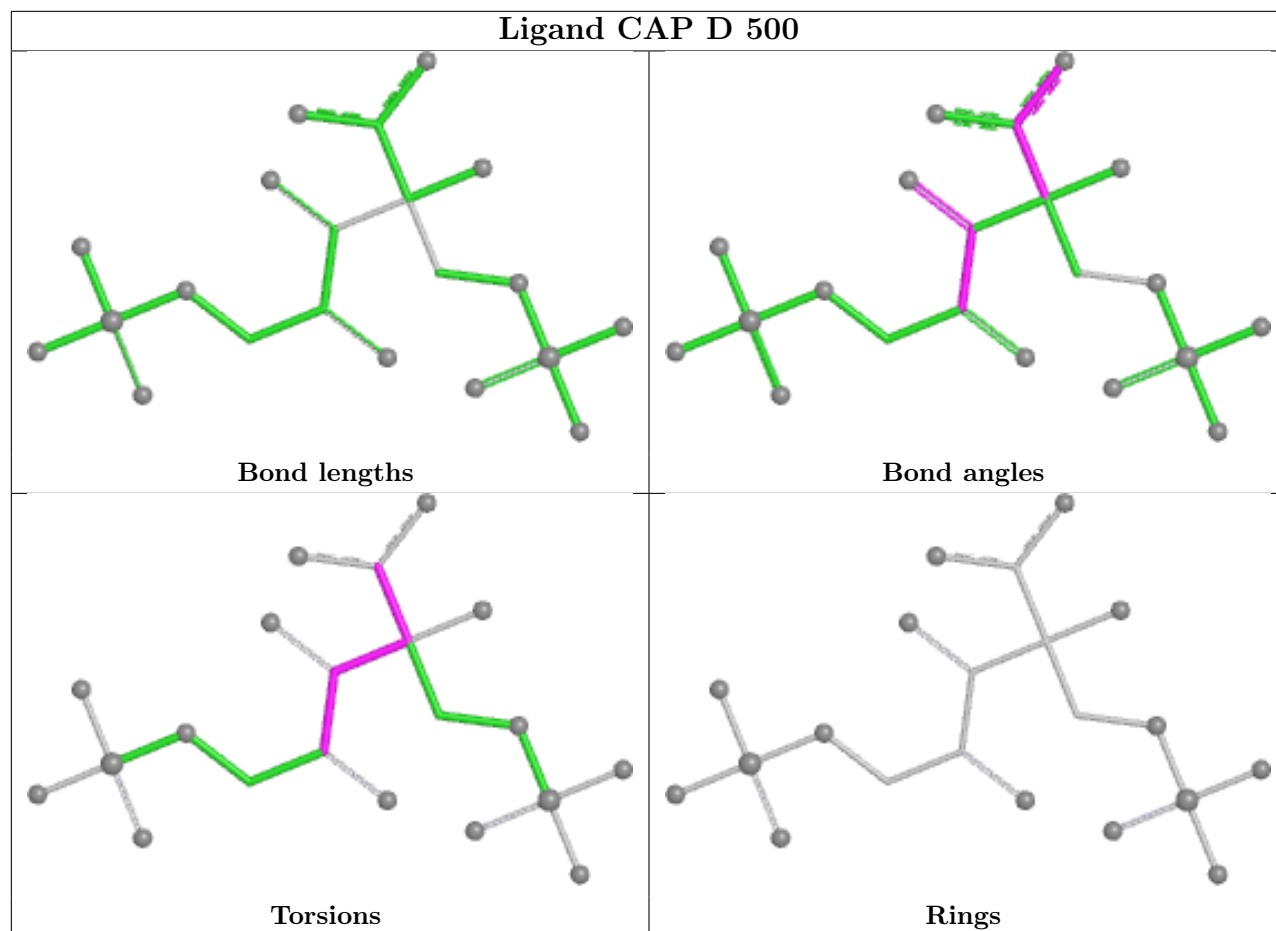
The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. 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.

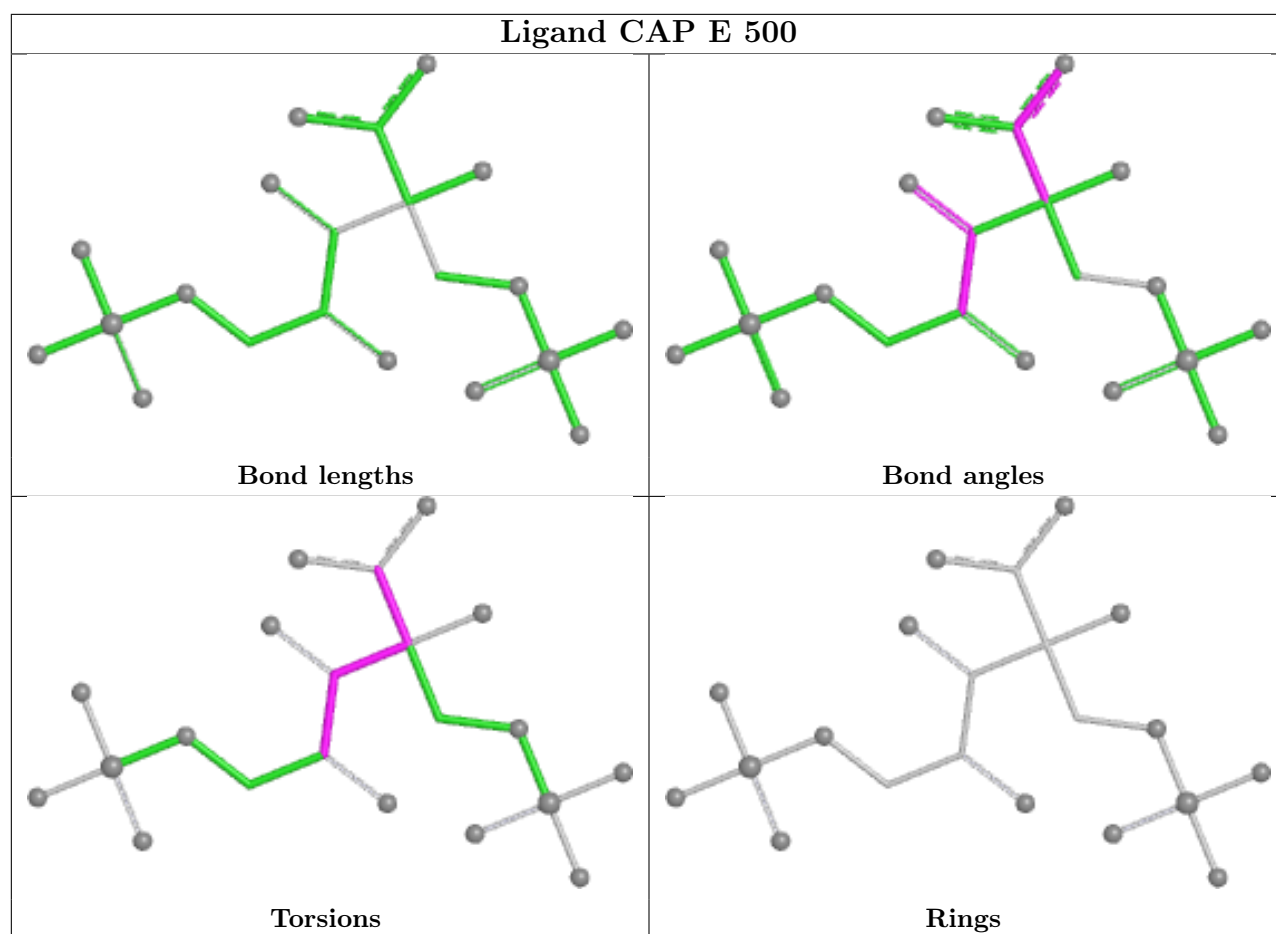












5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [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, 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	456/481 (94%)	0.65	23 (5%)	34	38	24, 48, 72, 96	0
1	B	454/481 (94%)	0.57	12 (2%)	57	61	25, 45, 70, 84	0
1	C	454/481 (94%)	0.61	19 (4%)	40	45	25, 47, 78, 108	0
1	D	455/481 (94%)	0.69	27 (5%)	28	32	25, 49, 78, 107	0
1	E	454/481 (94%)	0.73	20 (4%)	39	44	25, 51, 78, 96	0
1	F	454/481 (94%)	0.75	27 (5%)	28	32	26, 52, 83, 113	0
All	All	2727/2886 (94%)	0.67	128 (4%)	36	41	24, 49, 77, 113	0

All (128) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	F	449	TYR	5.6
1	C	1	MET	4.3
1	D	449	TYR	4.3
1	C	450	PRO	4.1
1	A	35	GLY	4.0
1	D	456	LEU	3.9
1	F	35	GLY	3.7
1	C	421	GLY	3.3
1	E	35	GLY	3.3
1	F	342	TYR	3.2
1	B	78	ALA	3.2
1	A	1	MET	3.2
1	A	454	ALA	3.1
1	A	420	GLN	3.1
1	A	451	ASN	3.1
1	F	454	ALA	3.1
1	A	449	TYR	3.1
1	F	450	PRO	3.1
1	E	1	MET	3.1

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Mol	Chain	Res	Type	RSRZ
1	B	36	PHE	3.0
1	D	445	ALA	3.0
1	E	449	TYR	3.0
1	D	424	PRO	2.9
1	C	448	LEU	2.9
1	A	438	PHE	2.9
1	D	451	ASN	2.9
1	B	1	MET	2.8
1	F	333	GLY	2.8
1	E	59	SER	2.8
1	E	342	TYR	2.8
1	D	448	LEU	2.8
1	B	37	GLY	2.8
1	D	427	PHE	2.8
1	B	449	TYR	2.8
1	A	457	LYS	2.8
1	A	443	GLN	2.7
1	A	452	TRP	2.7
1	D	452	TRP	2.7
1	B	401	VAL	2.7
1	F	1	MET	2.7
1	D	35	GLY	2.7
1	F	57	GLU	2.6
1	A	81	LEU	2.6
1	D	420	GLN	2.6
1	D	335	ALA	2.6
1	F	78	ALA	2.6
1	D	455	LYS	2.6
1	A	8	ALA	2.6
1	A	450	PRO	2.6
1	E	399	GLY	2.6
1	C	145	LYS	2.6
1	D	422	ALA	2.6
1	C	221	ASP	2.6
1	D	64	PHE	2.5
1	F	328	PHE	2.5
1	D	450	PRO	2.5
1	D	418	TRP	2.5
1	F	58	VAL	2.5
1	E	447	LYS	2.5
1	E	450	PRO	2.5
1	C	419	LYS	2.5

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Mol	Chain	Res	Type	RSRZ
1	F	401	VAL	2.5
1	F	455	LYS	2.5
1	A	445	ALA	2.4
1	C	36	PHE	2.4
1	B	38	ASN	2.4
1	D	454	ALA	2.4
1	A	448	LEU	2.4
1	F	59	SER	2.4
1	C	423	ASP	2.4
1	F	422	ALA	2.3
1	B	443	GLN	2.3
1	E	454	ALA	2.3
1	A	427	PHE	2.3
1	E	404	GLY	2.3
1	D	1	MET	2.3
1	C	427	PHE	2.3
1	C	441	PHE	2.3
1	F	36	PHE	2.3
1	C	110	ILE	2.3
1	D	425	VAL	2.3
1	D	296	THR	2.3
1	F	451	ASN	2.3
1	A	382	ASP	2.3
1	A	10	LEU	2.3
1	F	448	LEU	2.3
1	C	449	TYR	2.3
1	D	423	ASP	2.2
1	E	34	ALA	2.2
1	E	78	ALA	2.2
1	E	331	ALA	2.2
1	D	334	GLU	2.2
1	F	424	PRO	2.2
1	A	78	ALA	2.2
1	E	186	LEU	2.2
1	F	452	TRP	2.2
1	B	145	LYS	2.2
1	B	40	ILE	2.2
1	D	438	PHE	2.2
1	C	56	VAL	2.2
1	A	422	ALA	2.2
1	C	19	ALA	2.2
1	D	443	GLN	2.2

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Mol	Chain	Res	Type	RSRZ
1	F	296	THR	2.2
1	E	36	PHE	2.1
1	F	56	VAL	2.1
1	D	421	GLY	2.1
1	F	421	GLY	2.1
1	C	422	ALA	2.1
1	C	454	ALA	2.1
1	A	59	SER	2.1
1	E	408	ALA	2.1
1	E	81	LEU	2.1
1	F	375	LEU	2.1
1	C	11	ASN	2.1
1	B	425	VAL	2.1
1	A	456	LEU	2.1
1	E	40	ILE	2.1
1	F	429	LYS	2.1
1	B	155	VAL	2.1
1	C	452	TRP	2.1
1	F	447	LYS	2.0
1	A	56	VAL	2.0
1	D	295	VAL	2.0
1	E	425	VAL	2.0
1	F	418	TRP	2.0
1	D	453	ARG	2.0
1	E	403	GLY	2.0

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

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(Å ²)	Q<0.9
1	KCX	F	192	12/13	0.88	0.11	37,44,47,47	0
1	KCX	A	192	12/13	0.91	0.09	32,36,39,40	0
1	KCX	D	192	12/13	0.92	0.09	34,38,43,44	0
1	KCX	C	192	12/13	0.92	0.09	34,43,50,51	0
1	KCX	E	192	12/13	0.93	0.09	32,38,43,43	0
1	KCX	B	192	12/13	0.93	0.09	29,36,42,42	0

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

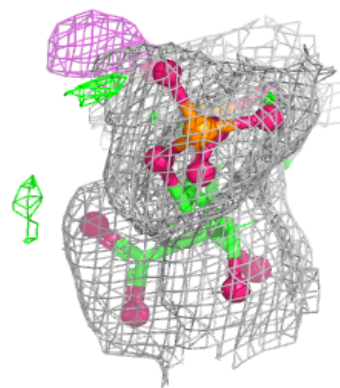
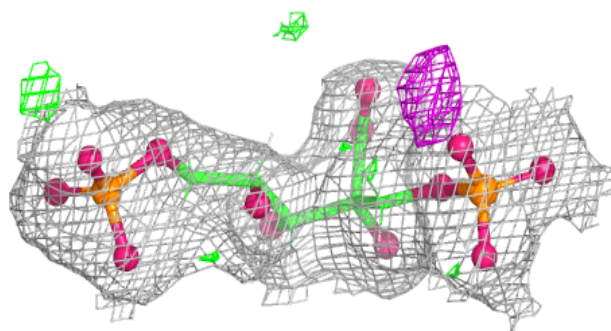
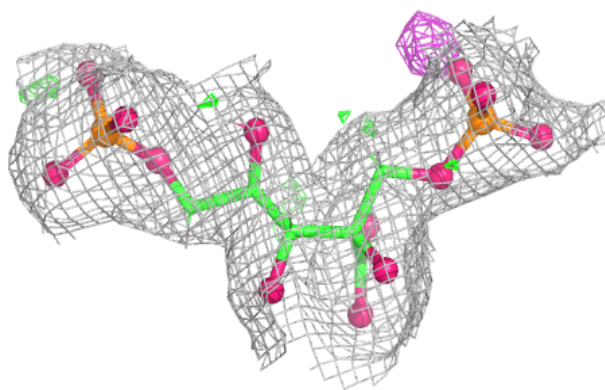
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists 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
2	CAP	E	500	21/21	0.92	0.09	37,42,50,51	0
2	CAP	A	500	21/21	0.94	0.08	34,42,49,50	0
2	CAP	D	500	21/21	0.95	0.08	38,43,52,54	0
2	CAP	F	500	21/21	0.95	0.07	40,48,58,60	0
2	CAP	C	500	21/21	0.96	0.07	37,43,52,53	0
2	CAP	B	500	21/21	0.96	0.07	35,38,48,50	0
3	MG	A	501	1/1	0.96	0.06	32,32,32,32	0
3	MG	C	501	1/1	0.96	0.05	44,44,44,44	0
3	MG	D	501	1/1	0.98	0.05	38,38,38,38	0
3	MG	E	501	1/1	0.98	0.03	37,37,37,37	0
3	MG	F	501	1/1	0.98	0.04	37,37,37,37	0
3	MG	B	501	1/1	0.99	0.05	34,34,34,34	0

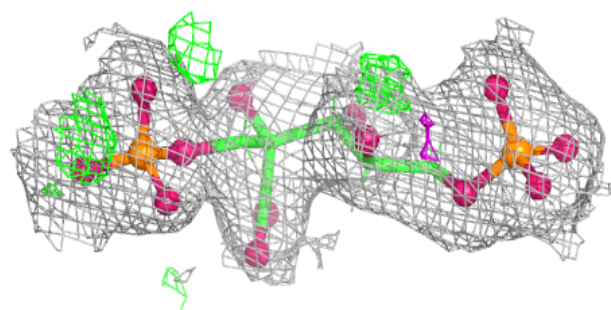
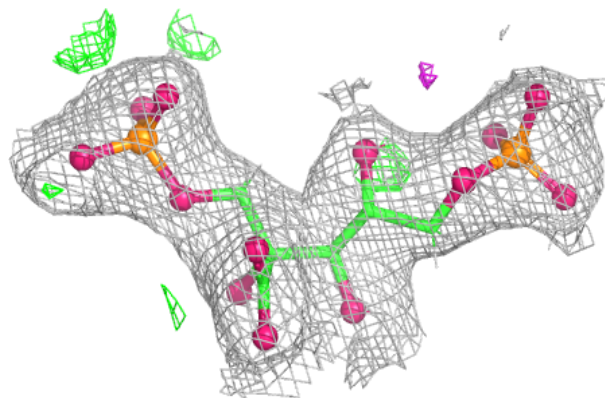
The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation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

Electron density around CAP E 500:

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

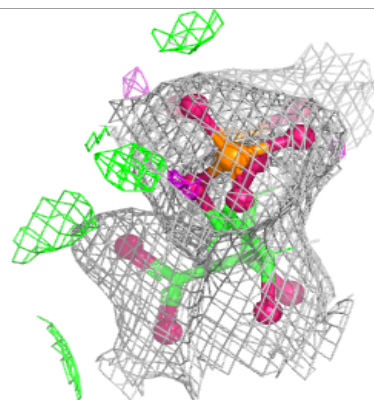
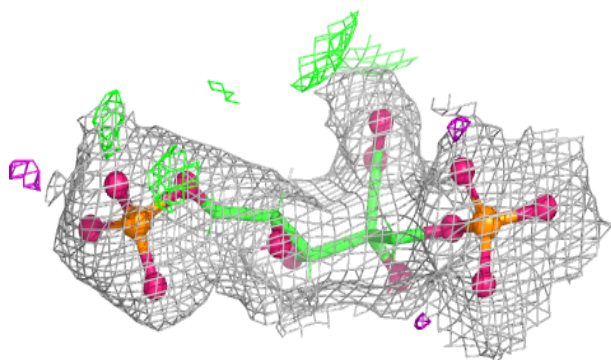
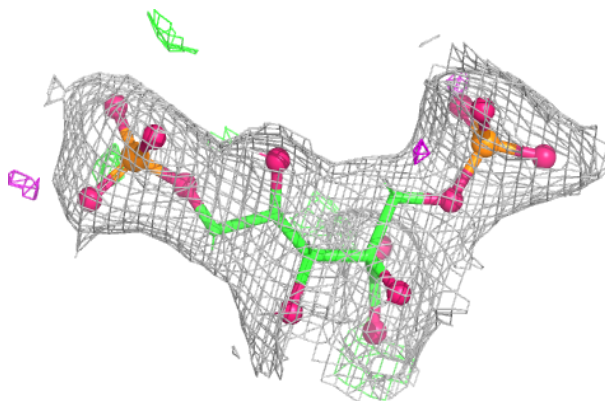
**Electron density around CAP A 500:**

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

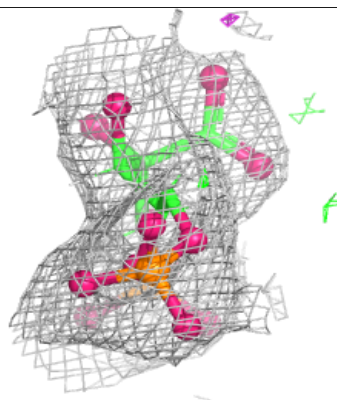
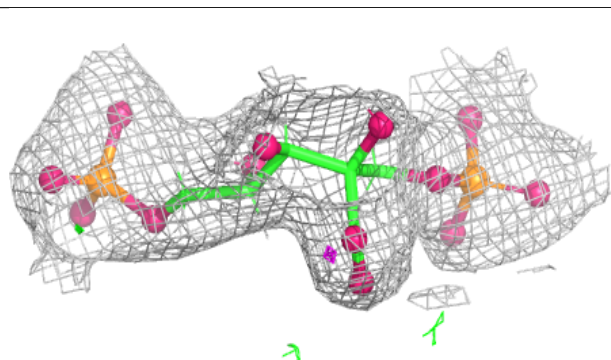
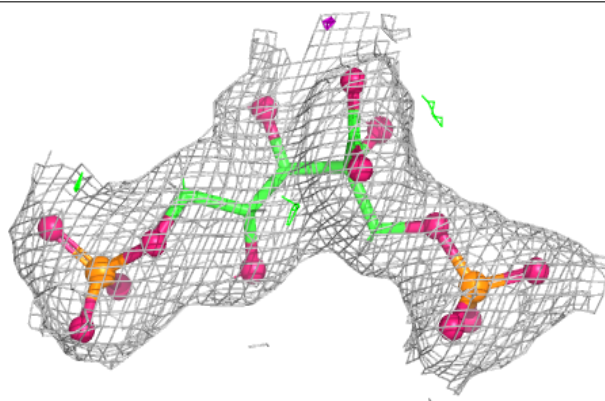


Electron density around CAP D 500:

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

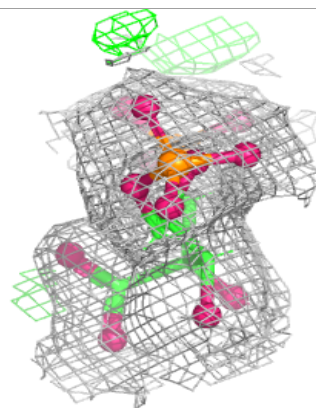
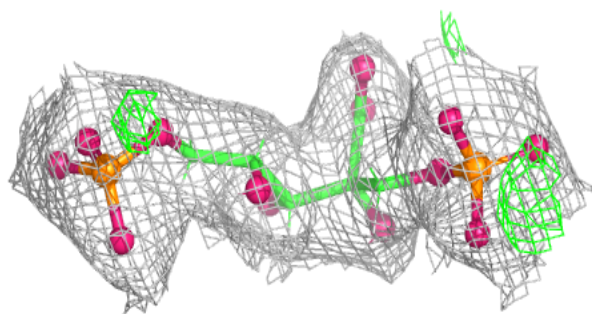
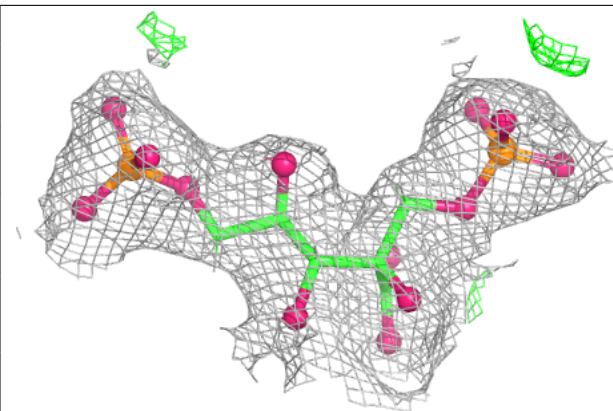
**Electron density around CAP F 500:**

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

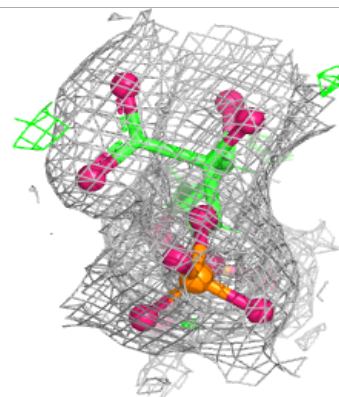
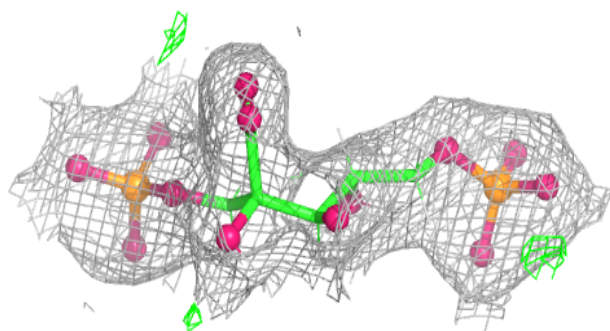
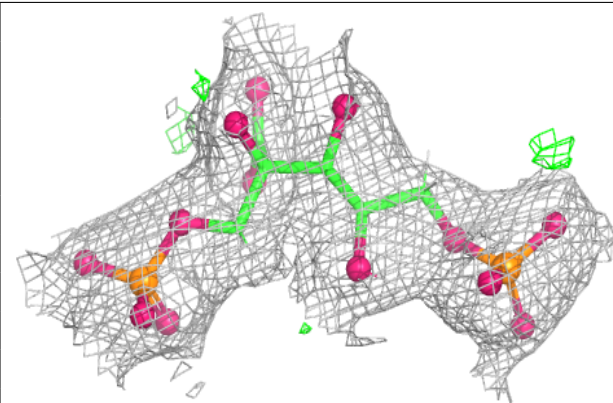


Electron density around CAP C 500:

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

**Electron density around CAP B 500:**

$2mF_o-DF_c$ (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.