



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 17, 2026 – 08:29 PM UTC

PDB ID : 3G4C / pdb_00003g4c
Title : Flavine dependant thymidylate syntahse S88C mutant
Authors : Mathews, I.I.; Lesley, S.A.; Kohen, A.
Deposited on : 2009-02-03
Resolution : 2.05 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

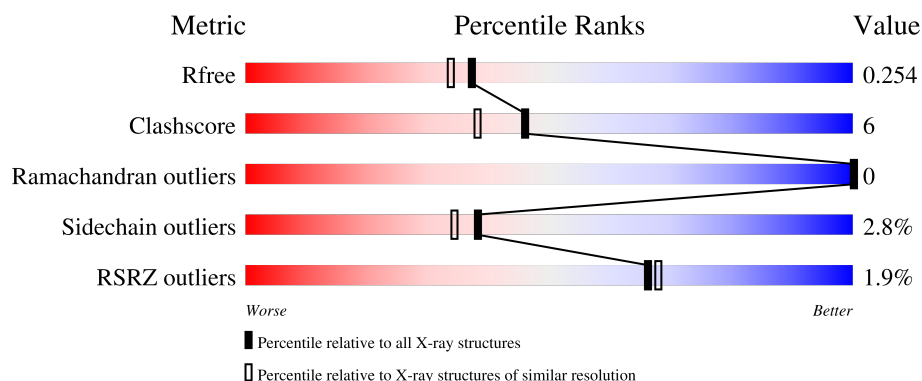
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

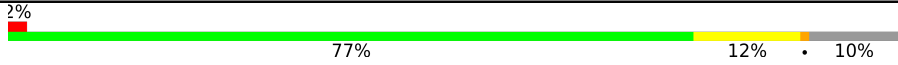
The reported resolution of this entry is 2.05 Å.

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	2260 (2.04-2.04)
Clashscore	190562	2333 (2.04-2.04)
Ramachandran outliers	187476	2318 (2.04-2.04)
Sidechain outliers	187428	2318 (2.04-2.04)
RSRZ outliers	180081	2260 (2.04-2.04)

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	232	
1	B	232	
1	C	232	
1	D	232	

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 7409 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 Thymidylate synthase thyX.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	209	Total	C	N	O	S	0	0	0
			1721	1129	292	294	6			
1	B	211	Total	C	N	O	S	0	0	0
			1723	1133	284	300	6			
1	C	215	Total	C	N	O	S	0	0	0
			1768	1162	296	304	6			
1	D	211	Total	C	N	O	S	0	0	0
			1738	1140	294	298	6			

There are 52 discrepancies between the modelled and reference sequences:

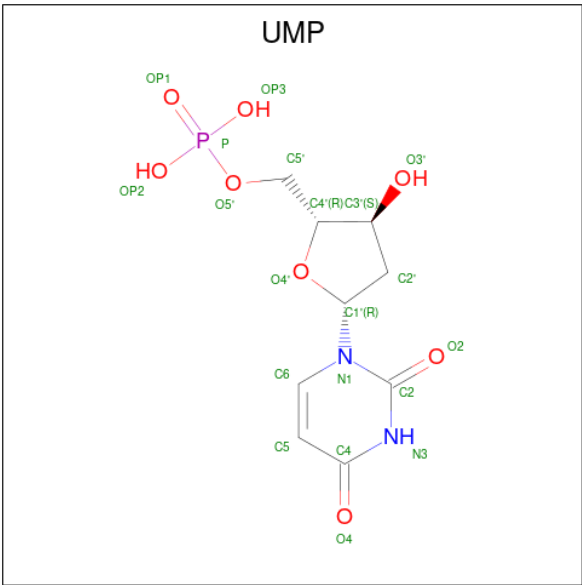
Chain	Residue	Modelled	Actual	Comment	Reference
A	-11	MET	-	expression tag	UNP Q9WYT0
A	-10	GLY	-	expression tag	UNP Q9WYT0
A	-9	SER	-	expression tag	UNP Q9WYT0
A	-8	ASP	-	expression tag	UNP Q9WYT0
A	-7	LYS	-	expression tag	UNP Q9WYT0
A	-6	ILE	-	expression tag	UNP Q9WYT0
A	-5	HIS	-	expression tag	UNP Q9WYT0
A	-4	HIS	-	expression tag	UNP Q9WYT0
A	-3	HIS	-	expression tag	UNP Q9WYT0
A	-2	HIS	-	expression tag	UNP Q9WYT0
A	-1	HIS	-	expression tag	UNP Q9WYT0
A	0	HIS	-	expression tag	UNP Q9WYT0
A	88	CYS	SER	engineered mutation	UNP Q9WYT0
B	-11	MET	-	expression tag	UNP Q9WYT0
B	-10	GLY	-	expression tag	UNP Q9WYT0
B	-9	SER	-	expression tag	UNP Q9WYT0
B	-8	ASP	-	expression tag	UNP Q9WYT0
B	-7	LYS	-	expression tag	UNP Q9WYT0
B	-6	ILE	-	expression tag	UNP Q9WYT0
B	-5	HIS	-	expression tag	UNP Q9WYT0
B	-4	HIS	-	expression tag	UNP Q9WYT0

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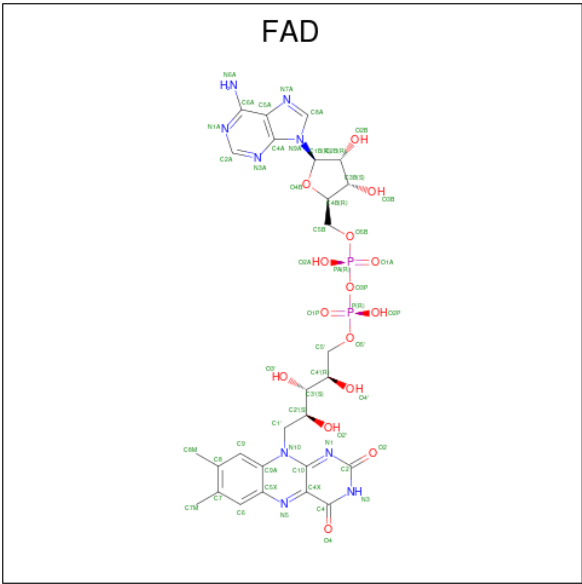
Chain	Residue	Modelled	Actual	Comment	Reference
B	-3	HIS	-	expression tag	UNP Q9WYT0
B	-2	HIS	-	expression tag	UNP Q9WYT0
B	-1	HIS	-	expression tag	UNP Q9WYT0
B	0	HIS	-	expression tag	UNP Q9WYT0
B	88	CYS	SER	engineered mutation	UNP Q9WYT0
C	-11	MET	-	expression tag	UNP Q9WYT0
C	-10	GLY	-	expression tag	UNP Q9WYT0
C	-9	SER	-	expression tag	UNP Q9WYT0
C	-8	ASP	-	expression tag	UNP Q9WYT0
C	-7	LYS	-	expression tag	UNP Q9WYT0
C	-6	ILE	-	expression tag	UNP Q9WYT0
C	-5	HIS	-	expression tag	UNP Q9WYT0
C	-4	HIS	-	expression tag	UNP Q9WYT0
C	-3	HIS	-	expression tag	UNP Q9WYT0
C	-2	HIS	-	expression tag	UNP Q9WYT0
C	-1	HIS	-	expression tag	UNP Q9WYT0
C	0	HIS	-	expression tag	UNP Q9WYT0
C	88	CYS	SER	engineered mutation	UNP Q9WYT0
D	-11	MET	-	expression tag	UNP Q9WYT0
D	-10	GLY	-	expression tag	UNP Q9WYT0
D	-9	SER	-	expression tag	UNP Q9WYT0
D	-8	ASP	-	expression tag	UNP Q9WYT0
D	-7	LYS	-	expression tag	UNP Q9WYT0
D	-6	ILE	-	expression tag	UNP Q9WYT0
D	-5	HIS	-	expression tag	UNP Q9WYT0
D	-4	HIS	-	expression tag	UNP Q9WYT0
D	-3	HIS	-	expression tag	UNP Q9WYT0
D	-2	HIS	-	expression tag	UNP Q9WYT0
D	-1	HIS	-	expression tag	UNP Q9WYT0
D	0	HIS	-	expression tag	UNP Q9WYT0
D	88	CYS	SER	engineered mutation	UNP Q9WYT0

- Molecule 2 is 2'-DEOXYURIDINE 5'-MONOPHOSPHATE (CCD ID: UMP) (formula: $C_9H_{13}N_2O_8P$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	0
			20	9	2	8	1		
2	B	1	Total	C	N	O	P	0	0
			20	9	2	8	1		
2	C	1	Total	C	N	O	P	0	0
			20	9	2	8	1		
2	D	1	Total	C	N	O	P	0	0
			20	9	2	8	1		

- Molecule 3 is FLAVIN-ADENINE DINUCLEOTIDE (CCD ID: FAD) (formula: $C_{27}H_{33}N_9O_{15}P_2$).



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

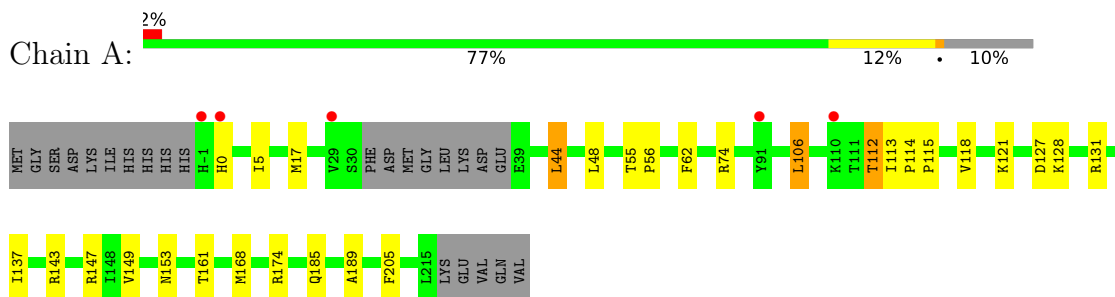
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	46	Total	O	0	0
			46	46		
4	B	42	Total	O	0	0
			42	42		
4	C	47	Total	O	0	0
			47	47		
4	D	32	Total	O	0	0
			32	32		

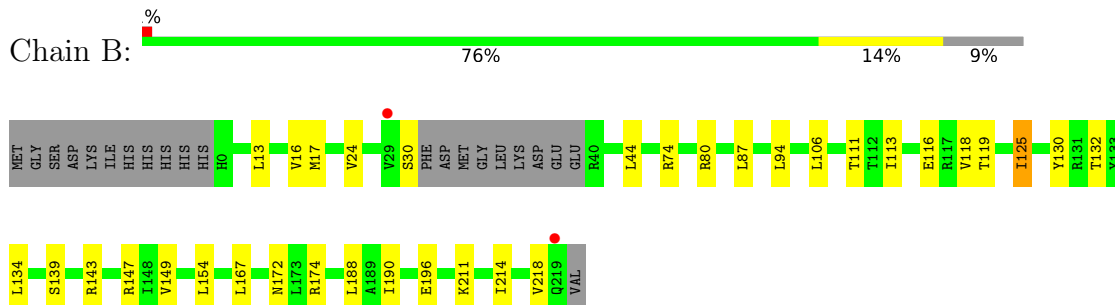
3 Residue-property plots [i](#)

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.

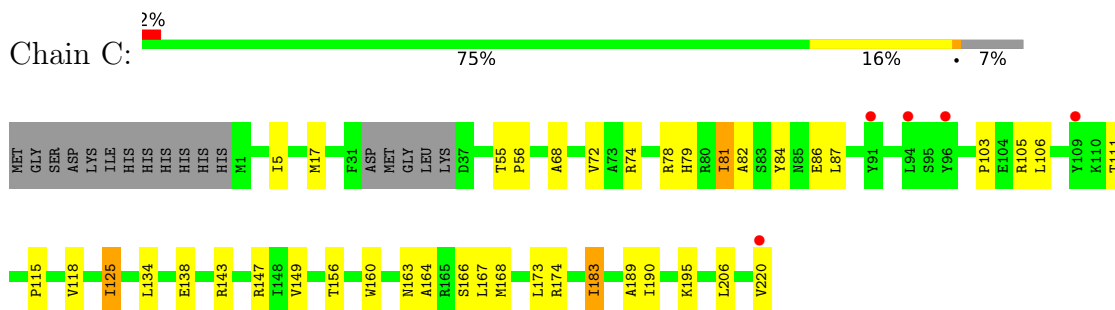
- Molecule 1: Thymidylate synthase thyX



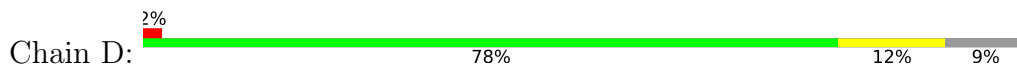
- Molecule 1: Thymidylate synthase thyX

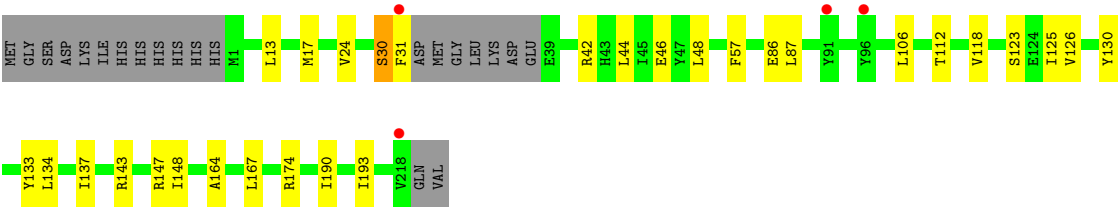


- Molecule 1: Thymidylate synthase thyX



- Molecule 1: Thymidylate synthase thyX





4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	53.90Å 116.50Å 140.99Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	46.22 – 2.05 46.22 – 2.05	Depositor EDS
% Data completeness (in resolution range)	99.9 (46.22-2.05) 99.9 (46.22-2.05)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.07	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.11 (at 2.05Å)	Xtriage
Refinement program	REFMAC - rigid body	Depositor
R, R_{free}	0.200 , 0.254 0.204 , 0.254	Depositor DCC
R_{free} test set	2843 reflections (5.02%)	wwPDB-VP
Wilson B-factor (Å ²)	37.2	Xtriage
Anisotropy	0.040	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 47.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	7409	wwPDB-VP
Average B, all atoms (Å ²)	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.19% 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 [i](#)

5.1 Standard geometry [i](#)

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

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	0.82	0/1769	0.89	1/2395 (0.0%)
1	B	0.77	0/1770	0.90	2/2399 (0.1%)
1	C	0.99	3/1816 (0.2%)	1.00	1/2456 (0.0%)
1	D	0.77	0/1785	0.90	0/2417
All	All	0.84	3/7140 (0.0%)	0.93	4/9667 (0.0%)

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	82	ALA	CA-CB	-7.85	1.38	1.53
1	C	82	ALA	C-O	-6.11	1.17	1.23
1	C	81	ILE	C-O	5.36	1.30	1.24

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	214	ILE	N-CA-C	6.45	117.23	110.72
1	B	80	ARG	N-CA-CB	-5.52	101.23	110.39
1	A	0	HIS	N-CA-C	5.49	116.99	107.93
1	C	163	ASN	N-CA-C	-5.02	103.03	110.46

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts [i](#)

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	1721	0	1704	19	0
1	B	1723	0	1691	25	0
1	C	1768	0	1750	35	0
1	D	1738	0	1721	21	0
2	A	20	0	11	1	0
2	B	20	0	11	2	0
2	C	20	0	11	2	0
2	D	20	0	11	2	0
3	A	53	0	31	0	0
3	B	53	0	31	0	0
3	C	53	0	31	3	0
3	D	53	0	31	0	0
4	A	46	0	0	1	0
4	B	42	0	0	0	0
4	C	47	0	0	0	0
4	D	32	0	0	0	0
All	All	7409	0	7034	83	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 6.

All (83) 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:132:THR:HG21	1:C:125:ILE:HD13	1.40	1.03
1:B:132:THR:HG21	1:C:125:ILE:CD1	1.94	0.96
1:B:167:LEU:HD11	1:B:190:ILE:HG21	1.51	0.93
1:D:167:LEU:HD11	1:D:190:ILE:CG2	2.00	0.92
1:B:167:LEU:HD11	1:B:190:ILE:CG2	2.03	0.89
1:C:167:LEU:HD11	1:C:190:ILE:CG2	2.02	0.88
1:B:149:VAL:HB	1:C:125:ILE:HD12	1.59	0.85
1:A:174:ARG:HH22	2:D:318:UMP:HN3	1.19	0.84
1:D:167:LEU:HD11	1:D:190:ILE:HG21	1.61	0.82
1:C:17:MET:HB2	1:D:17:MET:HB2	1.64	0.79
2:B:308:UMP:HN3	1:C:174:ARG:HH12	1.29	0.79
1:B:174:ARG:HH12	2:C:313:UMP:HN3	1.27	0.79
1:C:167:LEU:HD11	1:C:190:ILE:HG21	1.62	0.78
2:A:303:UMP:HN3	1:D:174:ARG:HH12	1.32	0.78
1:B:132:THR:CG2	1:C:125:ILE:HD13	2.17	0.75
1:B:106:LEU:HD11	1:B:118:VAL:HG11	1.71	0.73

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:164:ALA:O	1:C:168:MET:HG3	1.90	0.71
1:A:5:ILE:HD11	1:A:189:ALA:HB2	1.77	0.67
1:C:195:LYS:HD3	1:C:220:VAL:HG12	1.76	0.66
1:D:133:TYR:CZ	1:D:137:ILE:HD11	2.31	0.66
1:B:132:THR:HG21	1:C:125:ILE:HD11	1.79	0.64
1:A:17:MET:HB2	1:B:17:MET:HB2	1.79	0.62
1:C:134:LEU:O	1:C:138:GLU:HG2	1.99	0.62
1:D:130:TYR:CE2	1:D:134:LEU:HD11	2.35	0.61
1:C:72:VAL:HG13	1:C:183:ILE:HG13	1.83	0.60
1:A:185:GLN:NE2	4:A:251:HOH:O	2.35	0.59
1:A:137:ILE:HD11	1:A:143:ARG:HA	1.89	0.55
1:D:106:LEU:HD11	1:D:118:VAL:HG11	1.88	0.55
1:A:128:LYS:HG3	1:D:125:ILE:HD11	1.89	0.54
1:A:143:ARG:O	1:A:147:ARG:HG3	2.07	0.53
1:C:86:GLU:HB3	2:C:313:UMP:H4'	1.91	0.53
1:D:13:LEU:HD13	1:D:193:ILE:HG21	1.91	0.52
1:B:24:VAL:HG13	1:B:44:LEU:HD23	1.91	0.52
1:C:81:ILE:HD11	3:C:305:FAD:H8A	1.92	0.52
1:B:94:LEU:HD13	1:B:154:LEU:HD21	1.92	0.51
1:C:5:ILE:HD11	1:C:189:ALA:HB2	1.92	0.51
1:B:139:SER:O	1:C:111:THR:HA	2.10	0.51
1:A:106:LEU:HD21	1:A:118:VAL:HG11	1.92	0.50
1:A:44:LEU:HD22	1:A:48:LEU:HG	1.92	0.50
1:D:143:ARG:O	1:D:147:ARG:HG3	2.12	0.50
1:B:143:ARG:O	1:B:147:ARG:HG3	2.12	0.50
1:A:112:THR:HG22	1:A:113:ILE:HG23	1.93	0.49
1:B:111:THR:HG22	1:B:113:ILE:H	1.76	0.49
1:B:130:TYR:CE2	1:B:134:LEU:HD11	2.48	0.49
1:B:13:LEU:HD21	1:B:16:VAL:CG2	2.42	0.49
1:A:127:ASP:OD2	1:A:131:ARG:NH1	2.46	0.48
1:D:57:PHE:O	1:D:164:ALA:HB3	2.13	0.48
1:B:132:THR:CG2	1:C:125:ILE:CD1	2.79	0.48
1:C:79:HIS:HE1	1:C:173:LEU:HD12	1.79	0.47
1:D:42:ARG:O	1:D:46:GLU:HG3	2.15	0.47
1:B:149:VAL:HB	1:C:125:ILE:CD1	2.40	0.46
1:A:128:LYS:HG3	1:D:125:ILE:CD1	2.45	0.46
1:C:55:THR:N	1:C:56:PRO:CD	2.79	0.46
1:A:55:THR:N	1:A:56:PRO:CD	2.78	0.46
1:A:55:THR:OG1	1:A:56:PRO:HD3	2.16	0.45
1:C:173:LEU:HD13	3:C:305:FAD:O4'	2.16	0.45
1:A:149:VAL:HB	1:D:125:ILE:HG21	1.99	0.44

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:149:VAL:CB	1:C:125:ILE:HD12	2.40	0.44
1:C:81:ILE:O	1:C:166:SER:OG	2.31	0.43
1:D:167:LEU:CD1	1:D:190:ILE:HG21	2.42	0.43
1:C:106:LEU:CD1	1:C:118:VAL:HG11	2.49	0.43
1:B:74:ARG:HG3	1:C:74:ARG:HD2	2.01	0.42
1:C:78:ARG:HH12	3:C:305:FAD:C2	2.32	0.42
1:C:68:ALA:O	1:C:156:THR:HG22	2.18	0.42
1:D:24:VAL:HG13	1:D:44:LEU:HD23	2.01	0.42
1:B:188:LEU:HD22	1:B:218:VAL:HG11	2.02	0.42
1:C:84:TYR:CE1	1:C:160:TRP:CD1	3.07	0.42
1:C:143:ARG:O	1:C:147:ARG:HG3	2.19	0.42
1:D:86:GLU:HB3	2:D:318:UMP:H4'	2.02	0.42
1:B:172:ASN:ND2	1:B:211:LYS:HD3	2.34	0.41
1:C:105:ARG:C	1:C:106:LEU:HD23	2.45	0.41
1:B:125:ILE:HD12	1:B:125:ILE:HG23	1.82	0.41
1:C:167:LEU:CD1	1:C:190:ILE:HG21	2.42	0.41
1:D:30:SER:O	1:D:31:PHE:CB	2.68	0.41
1:D:44:LEU:O	1:D:48:LEU:HG	2.20	0.41
1:D:13:LEU:HD13	1:D:193:ILE:CG2	2.51	0.41
1:A:114:PRO:HA	1:A:115:PRO:HD3	2.01	0.41
1:A:168:MET:HB3	1:A:205:PHE:CE1	2.56	0.41
1:A:62:PHE:O	1:A:161:THR:HA	2.22	0.40
2:B:308:UMP:HN3	1:C:174:ARG:NH1	2.07	0.40
1:C:103:PRO:HB3	1:C:115:PRO:HB2	2.03	0.40
1:A:153:ASN:HB3	1:D:148:ILE:HB	2.03	0.40
1:B:125:ILE:HG21	1:C:149:VAL:HB	2.03	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	205/232 (88%)	201 (98%)	4 (2%)	0	100	100
1	B	207/232 (89%)	199 (96%)	8 (4%)	0	100	100
1	C	211/232 (91%)	205 (97%)	6 (3%)	0	100	100
1	D	207/232 (89%)	201 (97%)	6 (3%)	0	100	100
All	All	830/928 (89%)	806 (97%)	24 (3%)	0	100	100

There are no Ramachandran outliers to report.

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	177/207 (86%)	172 (97%)	5 (3%)	38	34
1	B	175/207 (84%)	169 (97%)	6 (3%)	32	27
1	C	181/207 (87%)	177 (98%)	4 (2%)	45	44
1	D	178/207 (86%)	173 (97%)	5 (3%)	38	34
All	All	711/828 (86%)	691 (97%)	20 (3%)	38	34

All (20) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	44	LEU
1	A	74	ARG
1	A	106	LEU
1	A	112	THR
1	A	121	LYS
1	B	30	SER
1	B	87	LEU
1	B	116	GLU
1	B	119	THR
1	B	125	ILE
1	B	196	GLU
1	C	87	LEU
1	C	125	ILE

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Mol	Chain	Res	Type
1	C	183	ILE
1	C	206	LEU
1	D	30	SER
1	D	87	LEU
1	D	112	THR
1	D	123	SER
1	D	126	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	51	HIS
1	B	185	GLN
1	C	185	GLN
1	D	85	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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

8 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
3	FAD	A	315	-	58,58,58	2.83	19 (32%)	85,89,89	1.81	14 (16%)
2	UMP	A	303	-	21,21,21	1.80	4 (19%)	30,31,31	1.36	4 (13%)
3	FAD	C	305	-	58,58,58	2.79	20 (34%)	85,89,89	1.77	18 (21%)
2	UMP	D	318	-	21,21,21	2.05	5 (23%)	30,31,31	1.28	3 (10%)
2	UMP	B	308	-	21,21,21	2.02	5 (23%)	30,31,31	1.52	5 (16%)
3	FAD	D	300	-	58,58,58	2.85	20 (34%)	85,89,89	1.77	18 (21%)
3	FAD	B	310	-	58,58,58	2.88	20 (34%)	85,89,89	1.97	22 (25%)
2	UMP	C	313	-	21,21,21	1.85	6 (28%)	30,31,31	1.40	2 (6%)

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	FAD	A	315	-	-	1/34/50/50	0/6/6/6
2	UMP	A	303	-	-	0/10/22/22	0/2/2/2
3	FAD	C	305	-	-	2/34/50/50	0/6/6/6
2	UMP	D	318	-	-	0/10/22/22	0/2/2/2
2	UMP	B	308	-	-	0/10/22/22	0/2/2/2
3	FAD	D	300	-	-	1/34/50/50	0/6/6/6
3	FAD	B	310	-	-	3/34/50/50	0/6/6/6
2	UMP	C	313	-	-	0/10/22/22	0/2/2/2

All (99) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	D	300	FAD	C9-C8	9.62	1.52	1.39
3	B	310	FAD	C6-C7	9.08	1.52	1.39
3	A	315	FAD	C9-C8	8.57	1.51	1.39
3	C	305	FAD	C6-C7	8.54	1.51	1.39
3	B	310	FAD	C9-C8	8.20	1.50	1.39
3	A	315	FAD	C6-C7	7.92	1.50	1.39
3	D	300	FAD	C6-C7	7.68	1.50	1.39
3	C	305	FAD	C6-C5X	7.64	1.51	1.40
3	D	300	FAD	C6-C5X	7.58	1.51	1.40
3	B	310	FAD	C6-C5X	7.49	1.51	1.40
3	C	305	FAD	C9-C8	7.38	1.49	1.39
3	A	315	FAD	C6-C5X	7.18	1.50	1.40
3	D	300	FAD	C9-C9A	7.01	1.51	1.39

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	315	FAD	C9-C9A	6.90	1.50	1.39
3	B	310	FAD	C9-C9A	6.54	1.50	1.39
3	A	315	FAD	C9A-C5X	6.34	1.51	1.41
3	C	305	FAD	C9-C9A	6.15	1.49	1.39
3	C	305	FAD	C9A-C5X	5.86	1.50	1.41
3	D	300	FAD	C9A-C5X	5.81	1.50	1.41
3	B	310	FAD	C9A-C5X	5.69	1.50	1.41
3	C	305	FAD	C6A-N6A	4.96	1.46	1.34
2	A	303	UMP	C6-C5	-4.82	1.23	1.35
3	A	315	FAD	C8-C7	4.65	1.52	1.40
2	B	308	UMP	C5-C4	4.63	1.53	1.43
3	B	310	FAD	C6A-N6A	4.54	1.45	1.34
3	B	310	FAD	C8-C7	4.51	1.51	1.40
3	C	305	FAD	C8-C7	4.48	1.51	1.40
2	D	318	UMP	C2-N1	4.45	1.45	1.38
2	D	318	UMP	C5-C4	4.42	1.53	1.43
2	D	318	UMP	C6-C5	-4.40	1.24	1.35
2	C	313	UMP	C6-C5	-4.36	1.25	1.35
3	D	300	FAD	C6A-N6A	4.34	1.45	1.34
3	D	300	FAD	C8-C7	4.13	1.50	1.40
3	A	315	FAD	C6A-N6A	4.06	1.44	1.34
3	A	315	FAD	C10-N10	4.04	1.46	1.37
3	B	310	FAD	C5A-N7A	4.01	1.46	1.39
3	A	315	FAD	C5A-N7A	3.99	1.46	1.39
3	D	300	FAD	C8A-N9A	3.96	1.44	1.37
3	C	305	FAD	C10-N10	3.90	1.45	1.37
2	B	308	UMP	C6-N1	3.90	1.47	1.38
3	B	310	FAD	C2-N1	3.88	1.45	1.36
2	C	313	UMP	C6-N1	3.85	1.47	1.38
3	B	310	FAD	C10-N10	3.84	1.45	1.37
3	C	305	FAD	C2-N1	3.78	1.45	1.36
2	B	308	UMP	C6-C5	-3.68	1.26	1.35
2	C	313	UMP	C5-C4	3.62	1.51	1.43
3	D	300	FAD	C5A-N7A	3.59	1.45	1.39
2	A	303	UMP	C5-C4	3.56	1.51	1.43
2	D	318	UMP	C6-N1	3.56	1.46	1.38
3	D	300	FAD	C10-N10	3.49	1.44	1.37
3	C	305	FAD	C5X-N5	3.48	1.45	1.39
2	A	303	UMP	C6-N1	3.48	1.46	1.38
3	D	300	FAD	C2-N1	3.47	1.44	1.36
3	B	310	FAD	C4A-N3A	3.40	1.40	1.34
2	B	308	UMP	C2-N1	3.30	1.43	1.38

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	315	FAD	C2-N1	3.30	1.44	1.36
3	A	315	FAD	C8A-N9A	3.28	1.43	1.37
3	D	300	FAD	C9A-N10	3.27	1.46	1.41
3	A	315	FAD	C4X-C10	3.24	1.53	1.44
3	B	310	FAD	C5X-N5	3.23	1.45	1.39
3	B	310	FAD	C2A-N1A	3.22	1.39	1.33
3	A	315	FAD	C5X-N5	3.20	1.45	1.39
2	B	308	UMP	C2-N3	3.18	1.43	1.38
3	B	310	FAD	C8A-N9A	3.15	1.42	1.37
3	D	300	FAD	C5X-N5	3.10	1.45	1.39
3	C	305	FAD	C8A-N9A	3.06	1.42	1.37
3	C	305	FAD	C2A-N1A	3.02	1.39	1.33
2	A	303	UMP	C2-N1	3.01	1.43	1.38
3	C	305	FAD	C4X-C10	2.97	1.52	1.44
3	C	305	FAD	C4A-N3A	2.91	1.39	1.34
3	C	305	FAD	C5A-N7A	2.83	1.44	1.39
2	C	313	UMP	C2-N3	2.75	1.42	1.38
3	A	315	FAD	C4A-N3A	2.71	1.39	1.34
3	B	310	FAD	C2A-N3A	2.70	1.38	1.33
3	C	305	FAD	C2A-N3A	2.70	1.38	1.33
3	A	315	FAD	C2A-N3A	2.69	1.38	1.33
3	B	310	FAD	C9A-N10	2.69	1.45	1.41
3	C	305	FAD	C9A-N10	2.68	1.45	1.41
3	C	305	FAD	C4X-N5	2.68	1.36	1.30
3	A	315	FAD	C2A-N1A	2.65	1.38	1.33
2	D	318	UMP	C2-N3	2.65	1.42	1.38
3	A	315	FAD	C9A-N10	2.60	1.45	1.41
3	B	310	FAD	C4X-C10	2.60	1.51	1.44
3	B	310	FAD	C8A-N7A	2.59	1.36	1.31
3	D	300	FAD	C4X-C10	2.55	1.51	1.44
2	C	313	UMP	C4-N3	2.55	1.43	1.38
3	D	300	FAD	C2A-N1A	2.53	1.38	1.33
3	A	315	FAD	C4-N3	2.41	1.43	1.38
3	D	300	FAD	C2A-N3A	2.40	1.38	1.33
3	D	300	FAD	C8A-N7A	2.40	1.36	1.31
3	B	310	FAD	PA-O3P	2.35	1.62	1.59
3	C	305	FAD	C4-N3	2.35	1.43	1.38
3	D	300	FAD	C4A-N3A	2.31	1.38	1.34
3	B	310	FAD	C4X-N5	2.21	1.35	1.30
3	A	315	FAD	C4X-N5	2.16	1.35	1.30
3	D	300	FAD	C4X-N5	2.15	1.35	1.30
3	C	305	FAD	C8A-N7A	2.15	1.35	1.31

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	D	300	FAD	C4-N3	2.14	1.42	1.38
2	C	313	UMP	C2-N1	2.07	1.41	1.38

All (86) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	310	FAD	C4A-N9A-C8A	8.47	114.63	105.74
3	A	315	FAD	C4A-N9A-C8A	7.17	113.27	105.74
3	C	305	FAD	C4A-N9A-C8A	6.53	112.59	105.74
3	D	300	FAD	N3A-C2A-N1A	-6.37	118.94	128.58
3	B	310	FAD	N9A-C8A-N7A	-6.00	105.42	113.94
3	A	315	FAD	N9A-C8A-N7A	-5.91	105.55	113.94
3	D	300	FAD	C4A-N9A-C8A	5.91	111.95	105.74
3	B	310	FAD	N3A-C2A-N1A	-5.64	120.04	128.58
3	C	305	FAD	N3A-C2A-N1A	-5.32	120.52	128.58
3	A	315	FAD	N3A-C2A-N1A	-5.31	120.54	128.58
3	C	305	FAD	N9A-C8A-N7A	-5.26	106.47	113.94
3	D	300	FAD	N9A-C8A-N7A	-5.23	106.52	113.94
2	B	308	UMP	C4-N3-C2	-4.51	121.01	126.61
2	A	303	UMP	C4-N3-C2	-4.44	121.09	126.61
3	A	315	FAD	N3A-C4A-N9A	4.33	134.53	127.17
3	C	305	FAD	C2B-C1B-N9A	4.08	123.43	113.30
3	A	315	FAD	O4B-C1B-N9A	3.91	115.60	108.09
2	C	313	UMP	C4-N3-C2	-3.80	121.89	126.61
3	B	310	FAD	C5A-C4A-N9A	-3.79	101.68	105.81
2	D	318	UMP	C4-N3-C2	-3.74	121.97	126.61
3	D	300	FAD	C2B-C1B-N9A	3.70	122.51	113.30
3	D	300	FAD	N3A-C4A-N9A	3.60	133.30	127.17
2	C	313	UMP	O2-C2-N1	-3.59	118.12	122.80
3	A	315	FAD	C5A-N7A-C8A	3.45	108.87	103.45
3	B	310	FAD	N3A-C4A-N9A	3.39	132.93	127.17
3	C	305	FAD	N3A-C4A-N9A	3.36	132.88	127.17
3	B	310	FAD	O2A-PA-O3P	3.32	116.24	107.27
3	D	300	FAD	O4B-C1B-N9A	3.27	114.38	108.09
3	C	305	FAD	O4B-C1B-N9A	3.25	114.33	108.09
3	A	315	FAD	C2B-C1B-N9A	3.22	121.32	113.30
3	D	300	FAD	C4-N3-C2	-3.18	120.00	125.64
3	B	310	FAD	C4A-N9A-C1B	-3.14	119.29	126.63
2	B	308	UMP	N3-C2-N1	3.13	118.97	114.89
3	A	315	FAD	C5A-C4A-N3A	-3.11	122.43	126.72
3	B	310	FAD	C4-N3-C2	-3.08	120.18	125.64
3	B	310	FAD	C2B-C1B-N9A	2.99	120.73	113.30

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	308	UMP	O2-C2-N1	-2.95	118.95	122.80
3	C	305	FAD	C4-C4X-N5	2.79	122.06	118.21
3	D	300	FAD	C2A-N3A-C4A	2.77	118.59	111.83
3	B	310	FAD	O4B-C1B-C2B	2.75	112.50	106.62
3	D	300	FAD	C10-N1-C2	2.74	122.79	116.85
2	D	318	UMP	C5-C4-N3	2.67	118.54	114.80
3	B	310	FAD	C2A-N1A-C6A	2.66	123.09	118.73
3	C	305	FAD	C4X-C10-N10	2.65	120.28	116.48
3	C	305	FAD	C2A-N1A-C6A	2.64	123.07	118.73
3	C	305	FAD	C4-N3-C2	-2.63	120.97	125.64
3	D	300	FAD	C2A-N1A-C6A	2.59	122.99	118.73
3	A	315	FAD	C4-N3-C2	-2.58	121.06	125.64
3	B	310	FAD	C4X-C10-N10	2.58	120.17	116.48
3	D	300	FAD	C5A-C4A-N3A	-2.57	123.18	126.72
3	A	315	FAD	C5A-C4A-N9A	-2.55	103.03	105.81
3	D	300	FAD	C4X-C4-N3	2.52	119.67	113.25
3	D	300	FAD	C4X-C10-N10	2.52	120.09	116.48
2	A	303	UMP	C5-C4-N3	2.48	118.27	114.80
2	B	308	UMP	O4'-C1'-N1	2.48	112.26	107.86
3	A	315	FAD	C4X-C10-N10	2.46	120.00	116.48
3	C	305	FAD	C5A-N7A-C8A	2.43	107.27	103.45
3	A	315	FAD	C2A-N3A-C4A	2.42	117.74	111.83
3	D	300	FAD	C5A-N7A-C8A	2.42	107.25	103.45
3	B	310	FAD	C4X-C4-N3	2.41	119.38	113.25
3	C	305	FAD	C5A-C4A-N9A	-2.37	103.22	105.81
3	B	310	FAD	C4-C4X-N5	2.37	121.48	118.21
3	D	300	FAD	C4-C4X-N5	2.37	121.48	118.21
3	A	315	FAD	O2-C2-N1	-2.36	117.87	121.80
3	C	305	FAD	O2A-PA-O1A	2.35	123.36	112.44
3	B	310	FAD	O2P-P-O1P	2.33	123.28	112.44
3	B	310	FAD	C9A-C5X-N5	-2.32	119.99	122.45
2	D	318	UMP	O4'-C1'-C2'	2.32	110.58	106.25
3	C	305	FAD	C9A-C5X-N5	-2.30	120.01	122.45
3	D	300	FAD	O4-C4-C4X	-2.26	120.56	126.53
3	B	310	FAD	O3P-PA-O1A	-2.24	103.96	110.70
2	A	303	UMP	O2-C2-N1	-2.21	119.91	122.80
3	B	310	FAD	C5A-N7A-C8A	2.17	106.87	103.45
3	B	310	FAD	C10-N1-C2	2.16	121.52	116.85
3	A	315	FAD	O4-C4-C4X	-2.15	120.85	126.53
3	C	305	FAD	C4X-C4-N3	2.14	118.71	113.25
3	C	305	FAD	C10-N1-C2	2.13	121.45	116.85
3	C	305	FAD	C10-C4X-N5	-2.11	120.51	124.81

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	D	300	FAD	C5A-C4A-N9A	-2.10	103.53	105.81
2	A	303	UMP	OP2-P-O5'	2.09	112.13	106.67
3	B	310	FAD	C5X-N5-C4X	2.07	121.44	118.09
3	C	305	FAD	C5A-C4A-N3A	-2.07	123.87	126.72
3	B	310	FAD	C10-C4X-N5	-2.04	120.64	124.81
3	B	310	FAD	C4X-C10-N1	-2.03	119.61	124.59
2	B	308	UMP	OP2-P-O5'	2.02	111.94	106.67
3	D	300	FAD	C4X-C10-N1	-2.02	119.64	124.59

There are no chirality outliers.

All (7) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	C	305	FAD	C5'-O5'-P-O1P
3	B	310	FAD	C2'-C3'-C4'-O4'
3	D	300	FAD	PA-O3P-P-O2P
3	B	310	FAD	O3'-C3'-C4'-C5'
3	A	315	FAD	PA-O3P-P-O2P
3	B	310	FAD	PA-O3P-P-O2P
3	C	305	FAD	PA-O3P-P-O2P

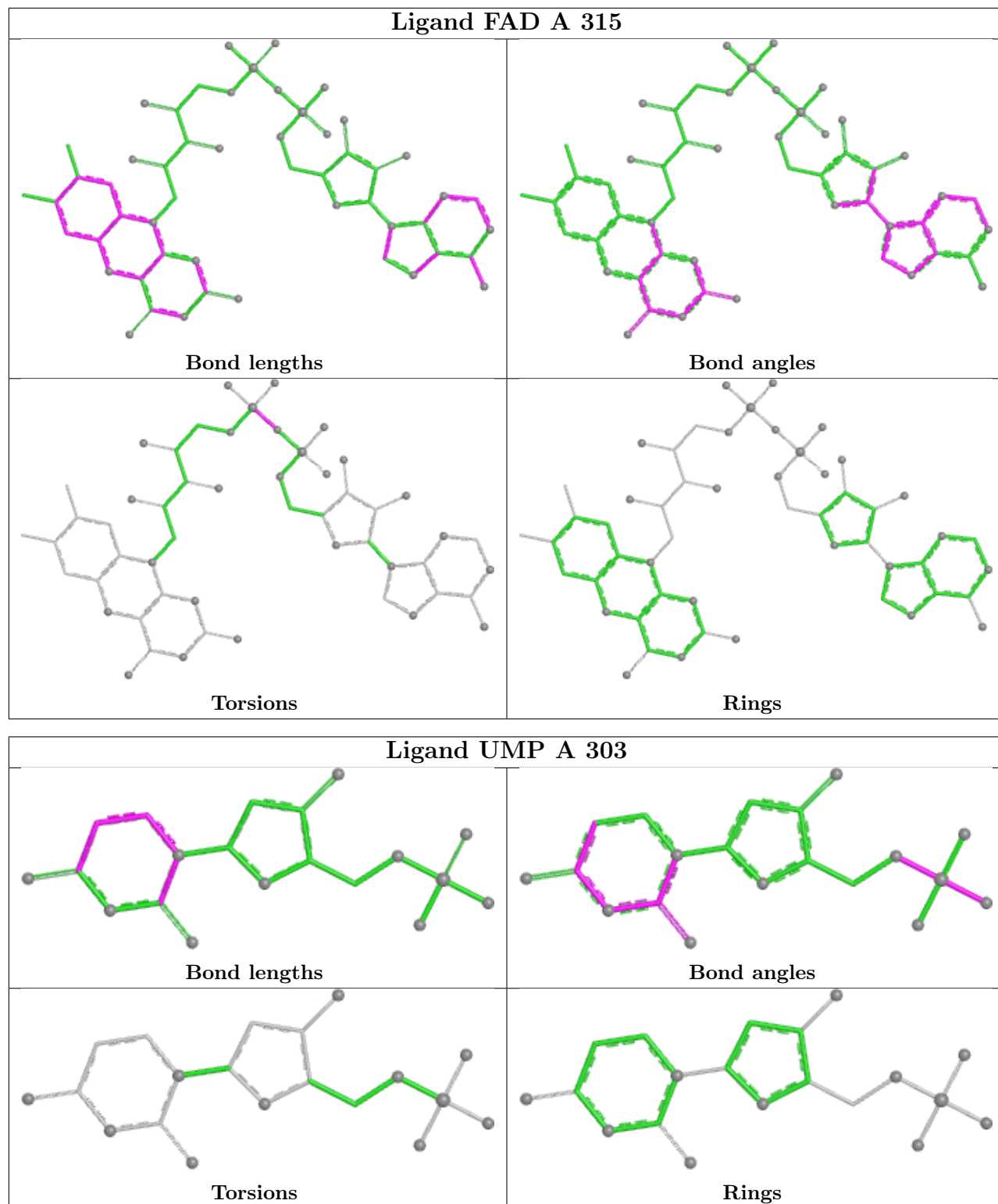
There are no ring outliers.

5 monomers are involved in 10 short contacts:

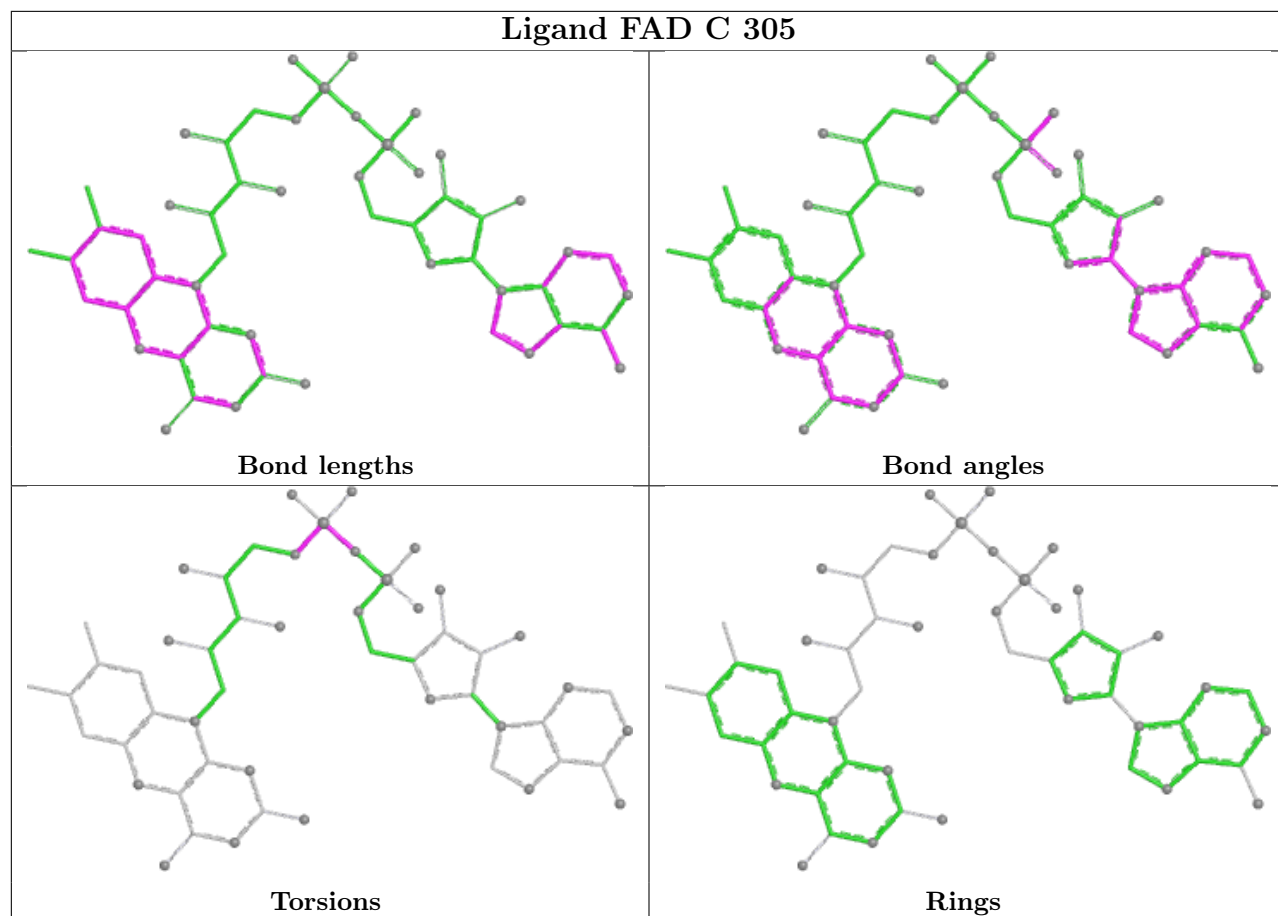
Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	303	UMP	1	0
3	C	305	FAD	3	0
2	D	318	UMP	2	0
2	B	308	UMP	2	0
2	C	313	UMP	2	0

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

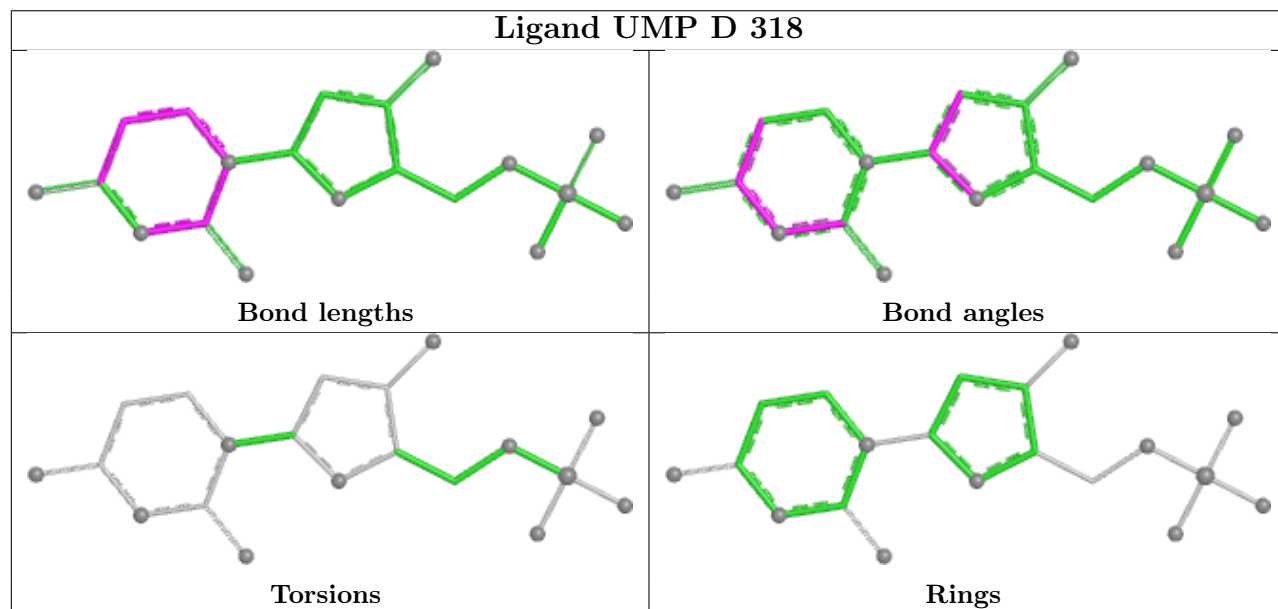
equivalents in the CSD to analyse the geometry.

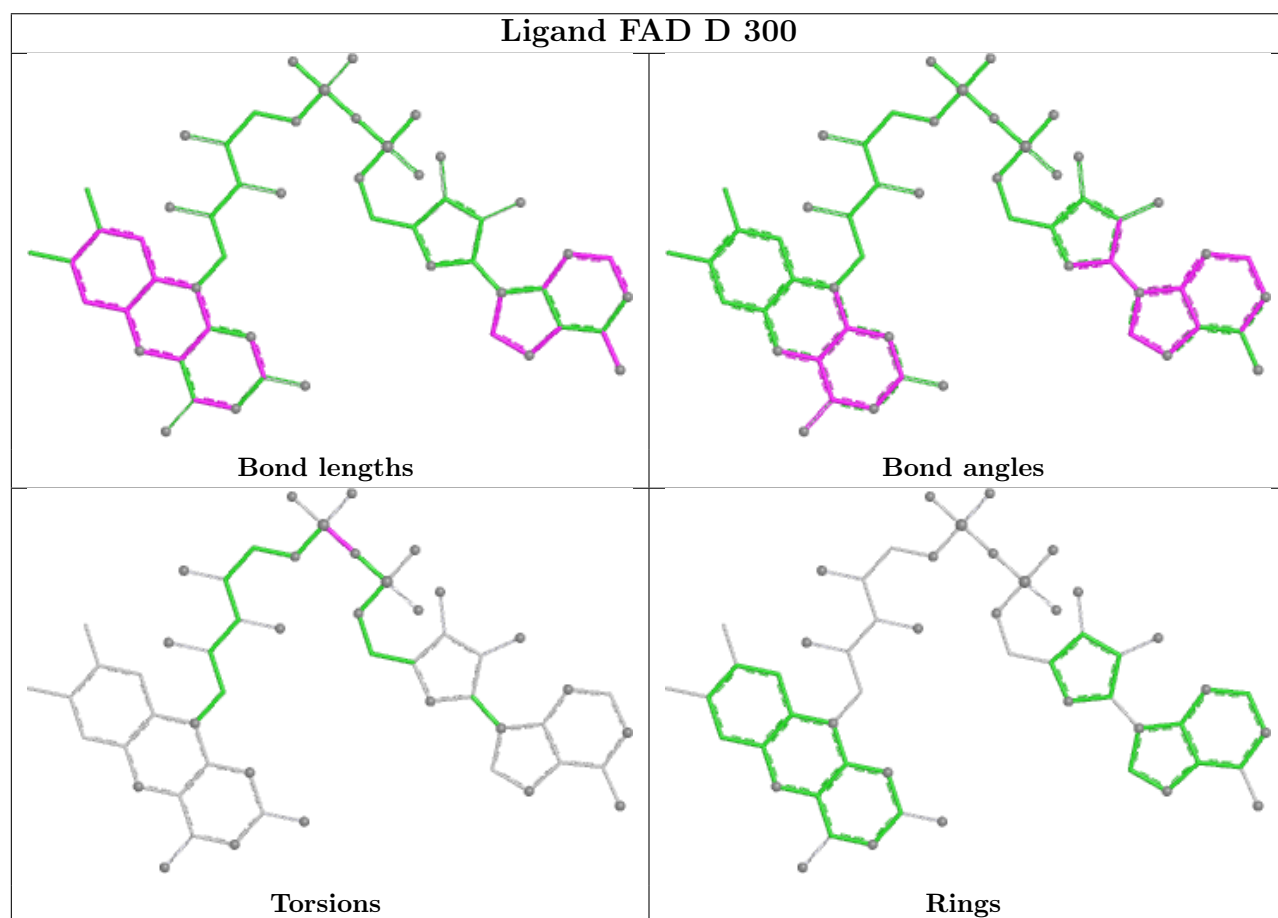
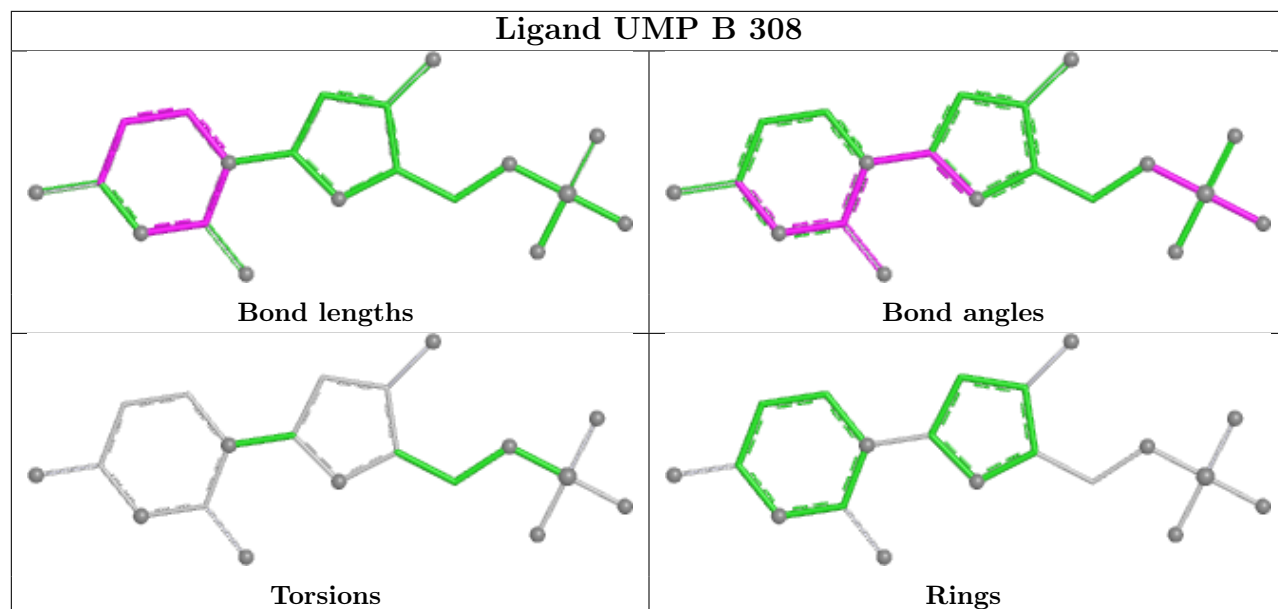


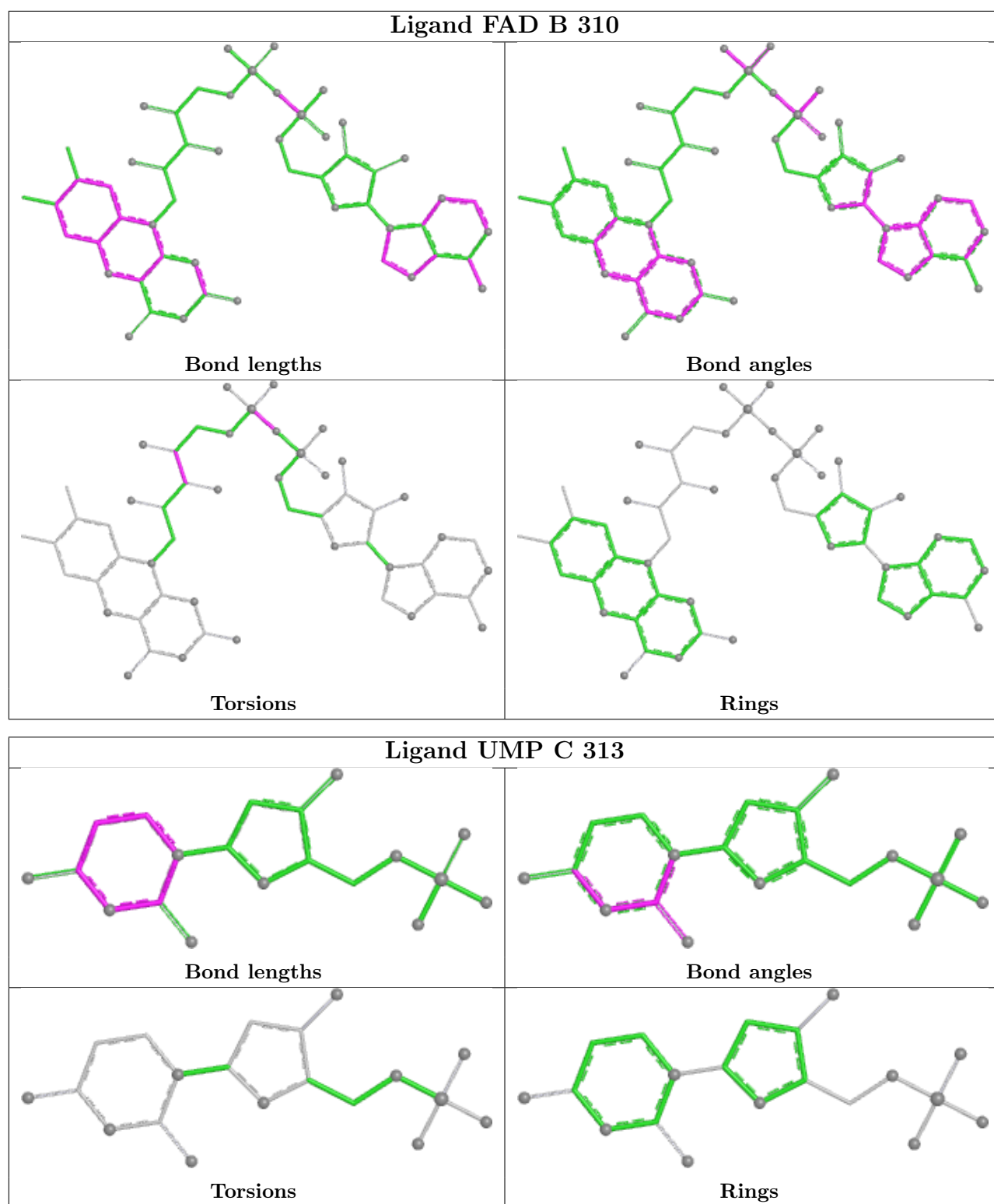
Ligand FAD C 305



Ligand UMP D 318







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](#)

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	209/232 (90%)	0.02	5 (2%) 59 61	22, 28, 42, 47	0
1	B	211/232 (90%)	0.07	2 (0%) 81 83	21, 28, 41, 47	0
1	C	215/232 (92%)	0.15	5 (2%) 61 63	19, 29, 43, 50	0
1	D	211/232 (90%)	0.06	4 (1%) 66 68	21, 29, 42, 49	0
All	All	846/928 (91%)	0.08	16 (1%) 66 68	19, 29, 42, 50	0

All (16) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	91	TYR	5.2
1	B	29	VAL	4.5
1	C	96	TYR	3.8
1	C	91	TYR	3.7
1	D	91	TYR	3.6
1	C	94	LEU	3.3
1	D	218	VAL	2.7
1	C	220	VAL	2.5
1	A	0	HIS	2.5
1	D	31	PHE	2.4
1	D	96	TYR	2.3
1	A	110	LYS	2.2
1	C	109	TYR	2.1
1	B	219	GLN	2.1
1	A	-1	HIS	2.0
1	A	29	VAL	2.0

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](#)

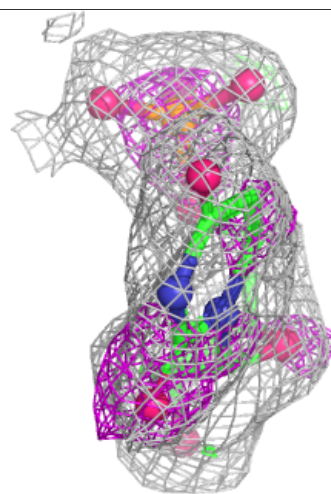
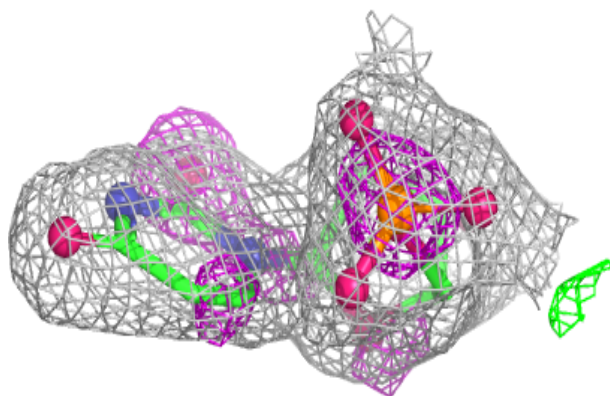
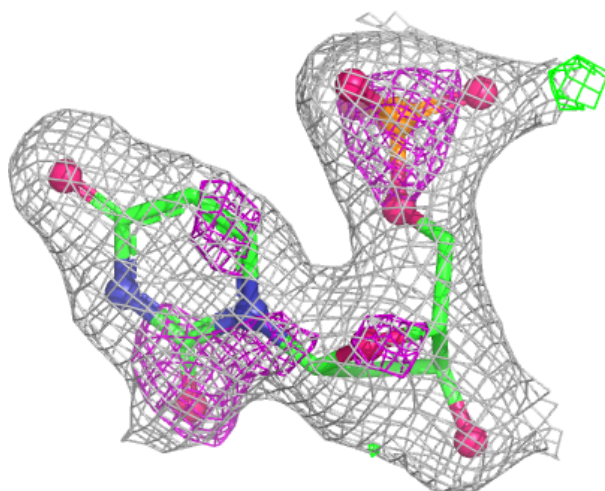
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists 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
2	UMP	C	313	20/20	0.90	0.09	28,32,41,43	0
2	UMP	B	308	20/20	0.91	0.09	29,31,41,41	0
2	UMP	D	318	20/20	0.91	0.10	28,30,35,36	0
2	UMP	A	303	20/20	0.92	0.09	30,33,40,41	0
3	FAD	B	310	53/53	0.92	0.09	25,34,36,39	0
3	FAD	D	300	53/53	0.93	0.09	25,32,38,38	0
3	FAD	C	305	53/53	0.94	0.08	23,32,35,37	0
3	FAD	A	315	53/53	0.94	0.09	24,31,37,37	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.

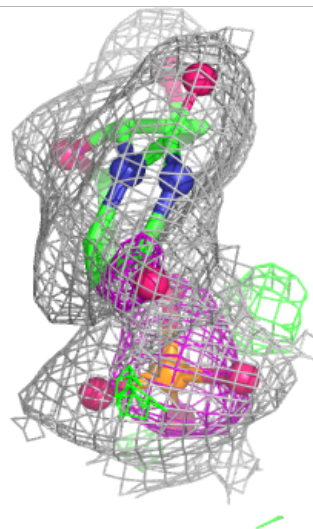
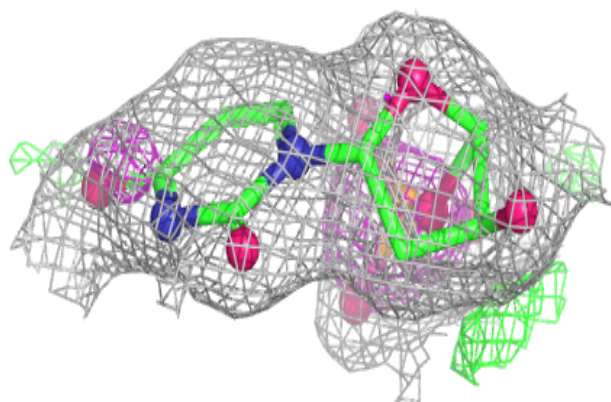
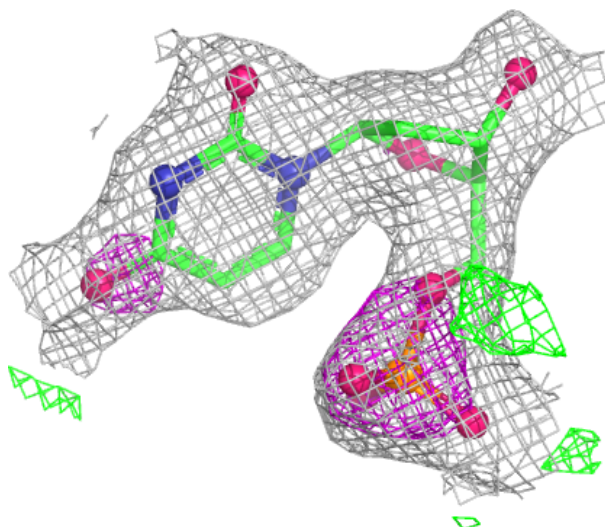
Electron density around UMP C 313:

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



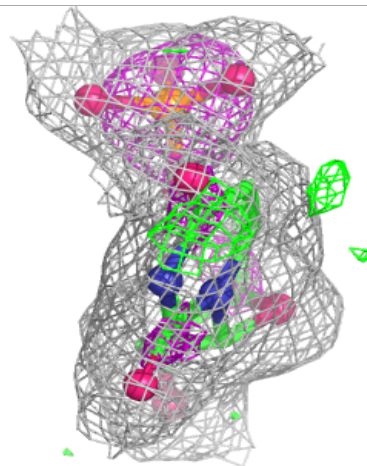
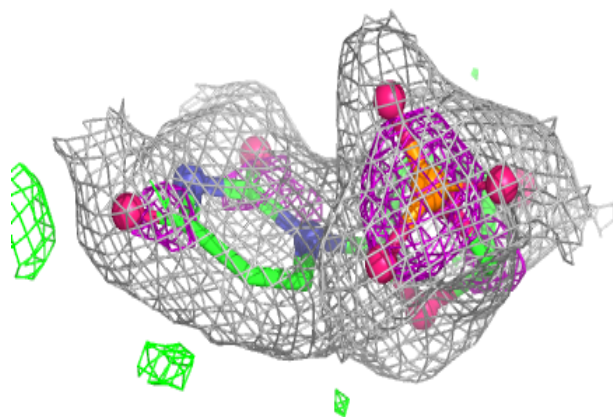
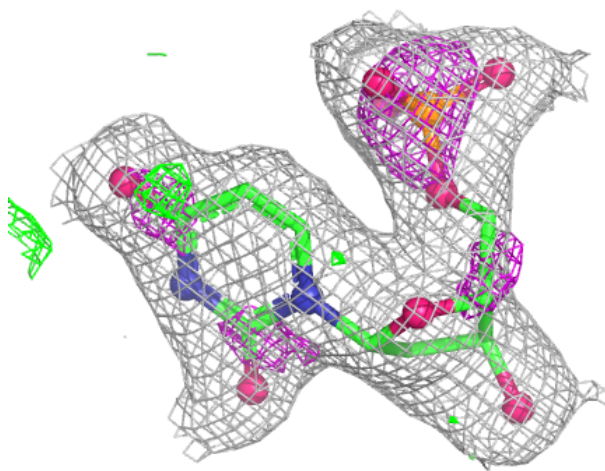
Electron density around UMP B 308:

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



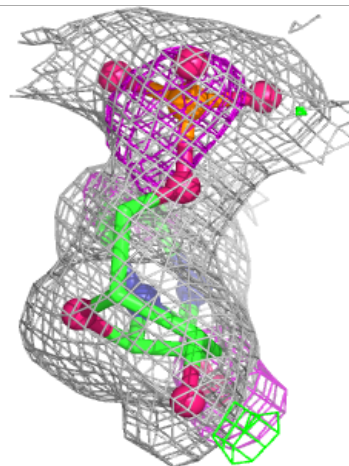
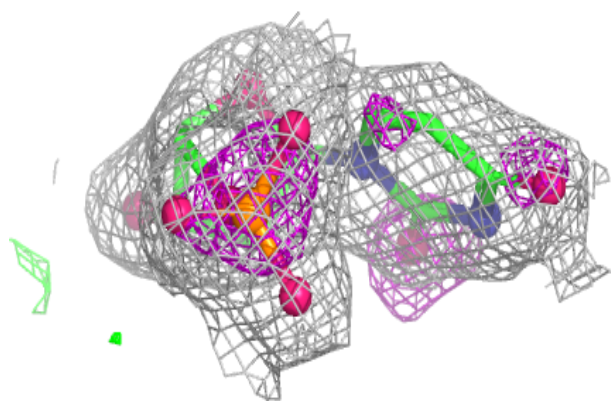
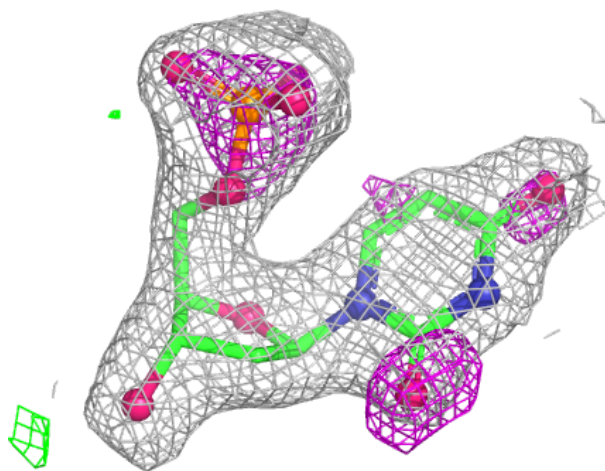
Electron density around UMP D 318:

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



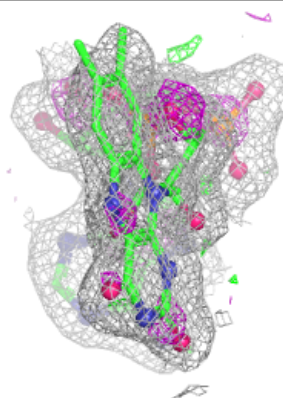
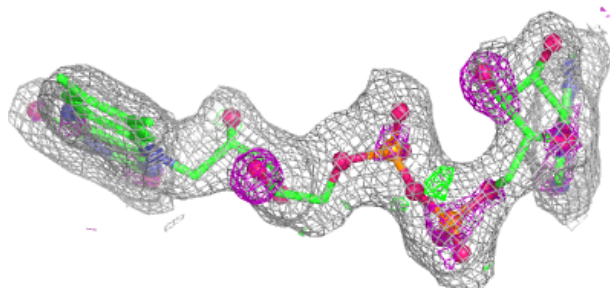
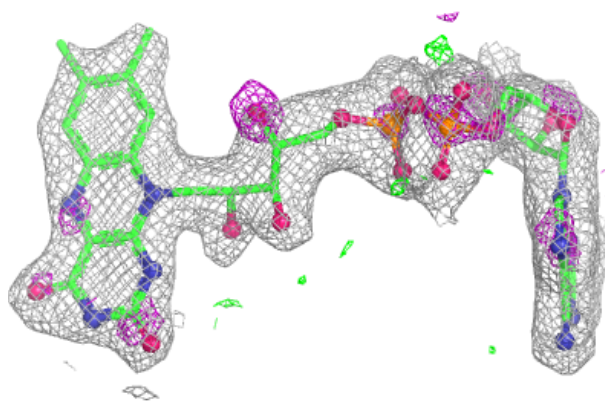
Electron density around UMP A 303:

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

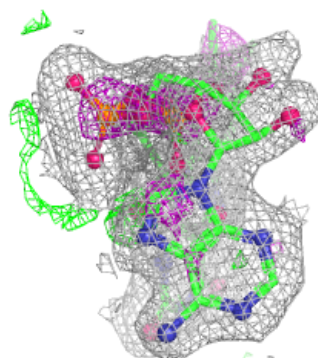
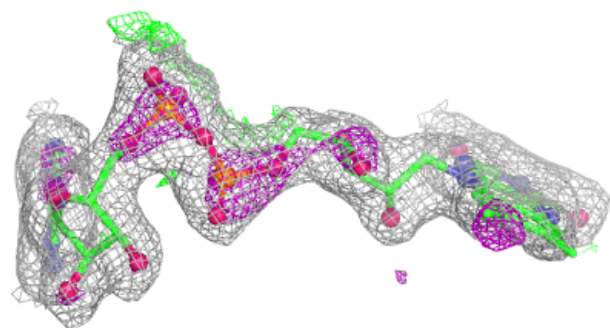
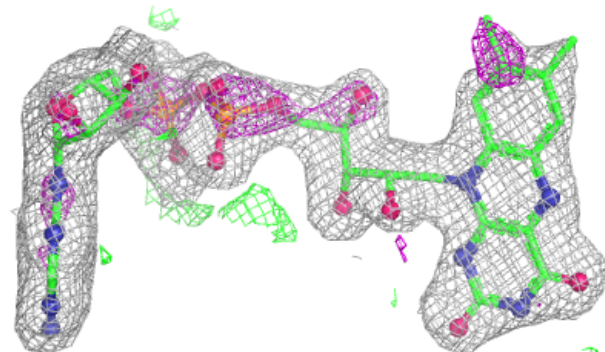


Electron density around FAD B 310:

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

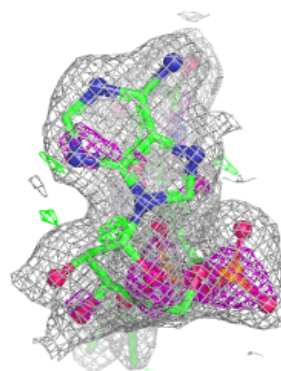
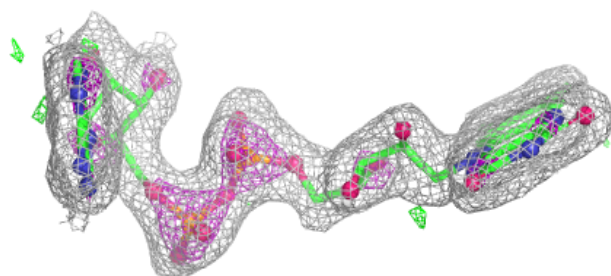
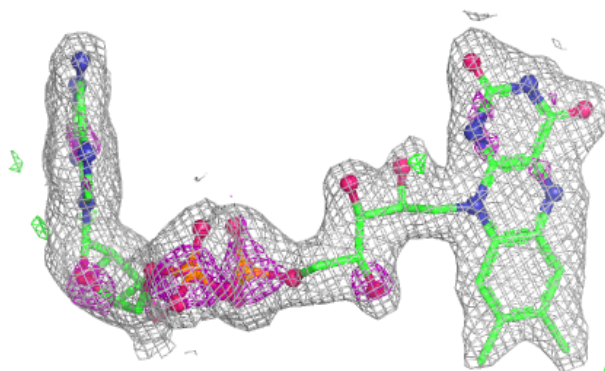
**Electron density around FAD D 300:**

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

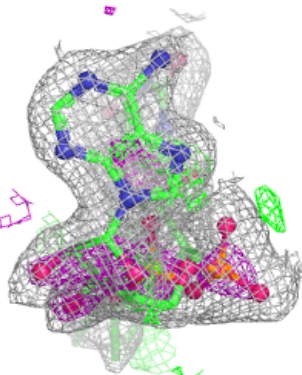
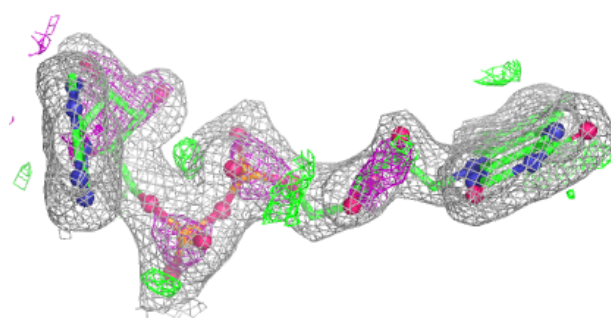
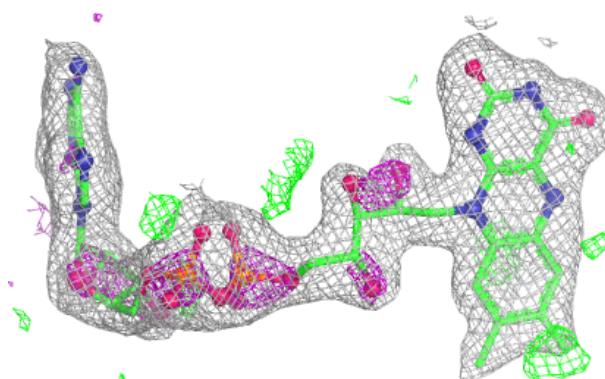


Electron density around FAD C 305:

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

**Electron density around FAD A 315:**

$2mF_o - DF_c$ (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.