



wwPDB X-ray Structure Validation Summary Report ⓘ

Jun 15, 2016 – 04:59 PM EDT

PDB ID : 5IOT
Title : Flavin-dependent thymidylate synthase R174A variant in complex with FAD and dUMP
Authors : Bernard, S.M.; Stull, F.W.; Smith, J.L.
Deposited on : 2016-03-08
Resolution : 2.00 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
<http://wwpdb.org/validation/2016/XrayValidationReportHelp>
with specific help available everywhere you see the ⓘ symbol.

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

MolProbity : 4.02b-467
Mogul : 1.7.1 (RC1), CSD as537be (2016)
Xtriage (Phenix) : 1.9-1692
EDS : rb-20027790
Percentile statistics : 20151230.v01 (using entries in the PDB archive December 30th 2015)
Refmac : 5.8.0135
CCP4 : 6.5.0
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : rb-20027790

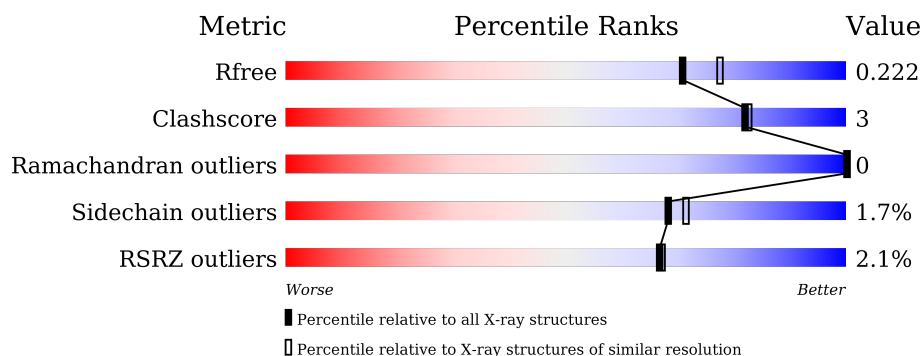
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.00 Å.

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



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	91344	6249 (2.00-2.00)
Clashscore	102246	7340 (2.00-2.00)
Ramachandran outliers	100387	7248 (2.00-2.00)
Sidechain outliers	100360	7247 (2.00-2.00)
RSRZ outliers	91569	6262 (2.00-2.00)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments on the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria. 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	<div> <div>5%</div> <div> <div></div> <div>85%</div> <div>7%</div> <div>7%</div> </div> </div>
1	B	232	<div> <div>%</div> <div> <div></div> <div>83%</div> <div>9%</div> <div>6%</div> </div> </div>
1	C	232	<div> <div>%</div> <div> <div></div> <div>83%</div> <div>9%</div> <div>8%</div> </div> </div>
1	D	232	<div> <div>%</div> <div> <div></div> <div>84%</div> <div>9%</div> <div>6%</div> </div> </div>

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 7739 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	215	Total	C	N	O	S	0	1	0
			1783	1160	306	312	5			
1	B	217	Total	C	N	O	S	0	0	0
			1812	1180	309	317	6			
1	C	213	Total	C	N	O	S	0	1	0
			1777	1155	304	313	5			
1	D	218	Total	C	N	O	S	0	0	0
			1812	1180	308	318	6			

There are 52 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-11	MET	-	initiating methionine	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	174	ALA	ARG	engineered mutation	UNP Q9WYT0
B	-11	MET	-	initiating methionine	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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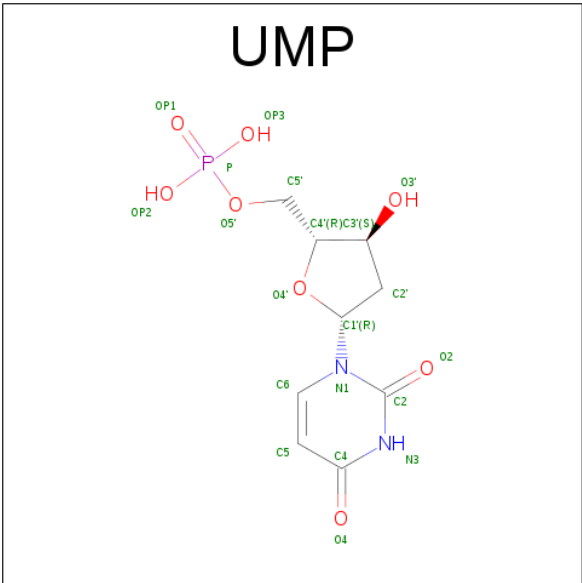
Chain	Residue	Modelled	Actual	Comment	Reference
B	-3	HIS	-	expression tag	UNP Q9WYT0
B	-2	HIS	-	expression tag	UNP Q9WYT0
B	-1	HIS	-	expression tag	UNP Q9WYT0
B	0	HIS	-	expression tag	UNP Q9WYT0
B	174	ALA	ARG	engineered mutation	UNP Q9WYT0
C	-11	MET	-	initiating methionine	UNP Q9WYT0
C	-10	GLY	-	expression 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	174	ALA	ARG	engineered mutation	UNP Q9WYT0
D	-11	MET	-	initiating methionine	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	174	ALA	ARG	engineered mutation	UNP Q9WYT0

- Molecule 2 is FLAVIN-ADENINE DINUCLEOTIDE (three-letter code: FAD) (formula: $C_{27}H_{33}N_9O_{15}P_2$).



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		
2	C	1	Total	C	N	O	P	0	0
			53	27	9	15	2		
2	D	1	Total	C	N	O	P	0	0
			53	27	9	15	2		

- Molecule 3 is 2'-DEOXYURIDINE 5'-MONOPHOSPHATE (three-letter code: UMP) (formula: C₉H₁₃N₂O₈P).



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

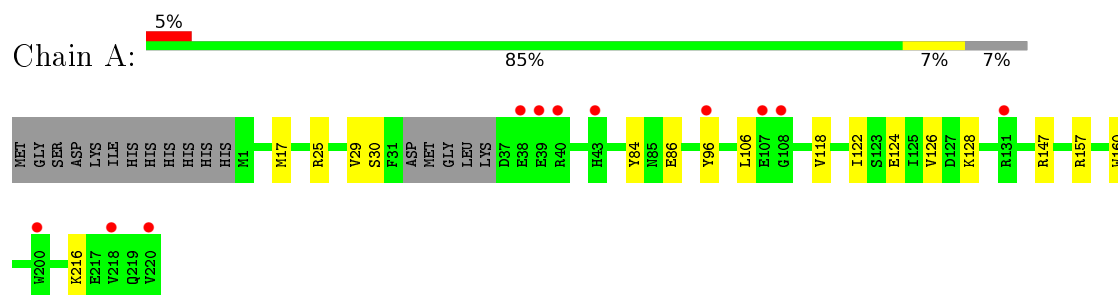
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	53	Total	O	0	0
			53	53		
4	B	74	Total	O	0	0
			74	74		
4	C	76	Total	O	0	0
			76	76		
4	D	60	Total	O	0	0
			60	60		

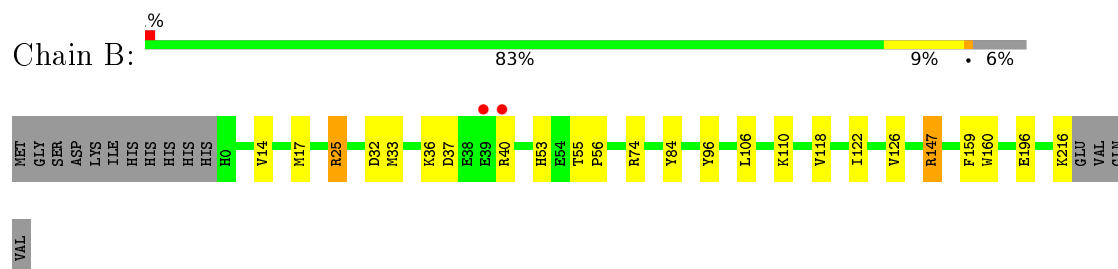
3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors 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.

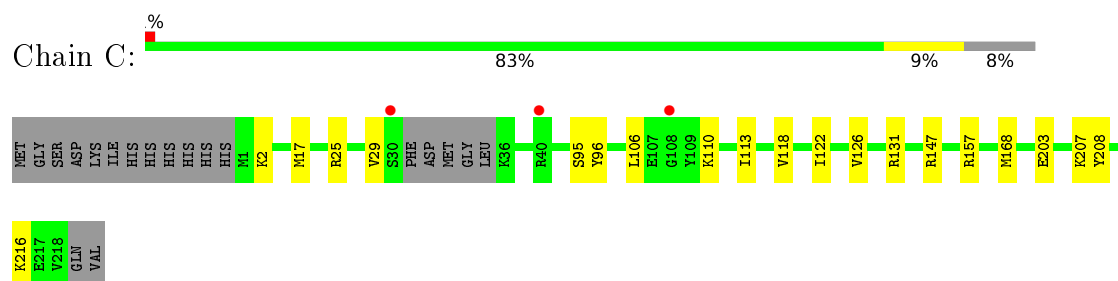
- Molecule 1: Thymidylate synthase ThyX



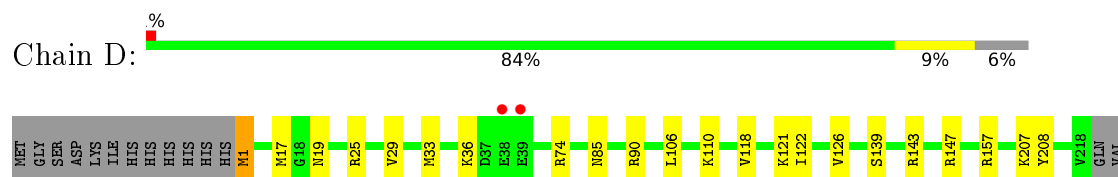
- Molecule 1: Thymidylate synthase ThyX



- 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	54.06Å 115.86Å 141.10Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	89.54 – 2.00 46.28 – 2.00	Depositor EDS
% Data completeness (in resolution range)	90.2 (89.54-2.00) 90.2 (46.28-2.00)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.13 (at 2.00Å)	Xtriage
Refinement program	REFMAC 5.8.0069	Depositor
R, R_{free}	0.183 , 0.217 0.191 , 0.222	Depositor DCC
R_{free} test set	2753 reflections (5.29%)	DCC
Wilson B-factor (Å ²)	28.6	Xtriage
Anisotropy	0.393	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 47.5	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	0.96	EDS
Total number of atoms	7739	wwPDB-VP
Average B, all atoms (Å ²)	34.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.66% 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: UMP, FAD

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	0.49	0/1830	0.68	0/2477
1	B	0.50	0/1862	0.73	1/2518 (0.0%)
1	C	0.52	0/1824	0.73	2/2468 (0.1%)
1	D	0.50	0/1861	0.70	1/2517 (0.0%)
All	All	0.50	0/7377	0.71	4/9980 (0.0%)

There are no bond length outliers.

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	C	131	ARG	NE-CZ-NH1	5.94	123.27	120.30
1	D	1	MET	CG-SD-CE	-5.43	91.50	100.20
1	C	25	ARG	NE-CZ-NH1	5.29	122.94	120.30
1	B	25	ARG	NE-CZ-NH1	5.21	122.90	120.30

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	1783	0	1759	10	0
1	B	1812	0	1806	21	1
1	C	1777	0	1760	10	1

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	D	1812	0	1803	21	0
2	A	53	0	31	0	0
2	B	53	0	31	0	0
2	C	53	0	31	0	0
2	D	53	0	31	0	0
3	A	20	0	11	0	0
3	B	20	0	11	0	0
3	C	20	0	11	0	0
3	D	20	0	11	0	0
4	A	53	0	0	0	0
4	B	74	0	0	3	0
4	C	76	0	0	4	0
4	D	60	0	0	3	0
All	All	7739	0	7296	47	1

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 3.

The worst 5 of 47 close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:17:MET:HB2	1:C:17:MET:HB2	1.67	0.76
1:B:159:PHE:CD2	1:D:29:VAL:HG21	2.28	0.69
1:B:37:ASP:OD2	1:B:40:ARG:NH1	2.26	0.68
1:B:17:MET:HB2	1:D:17:MET:HB2	1.76	0.67
1:D:74:ARG:NH2	4:D:402:HOH:O	2.28	0.67

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

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:196:GLU:OE1	1:C:2:LYS:NZ[3_544]	2.06	0.14

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	212/232 (91%)	207 (98%)	5 (2%)	0	100	100
1	B	215/232 (93%)	210 (98%)	5 (2%)	0	100	100
1	C	210/232 (90%)	204 (97%)	6 (3%)	0	100	100
1	D	216/232 (93%)	210 (97%)	6 (3%)	0	100	100
All	All	853/928 (92%)	831 (97%)	22 (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	185/206 (90%)	182 (98%)	3 (2%)	70	73
1	B	192/206 (93%)	188 (98%)	4 (2%)	61	63
1	C	187/206 (91%)	183 (98%)	4 (2%)	61	63
1	D	191/206 (93%)	189 (99%)	2 (1%)	82	85
All	All	755/824 (92%)	742 (98%)	13 (2%)	68	71

5 of 13 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	147	ARG
1	B	216	LYS
1	C	147	ARG
1	B	110	LYS
1	C	110	LYS

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 7 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	53	HIS
1	D	185	GLN
1	D	85	ASN
1	B	85	ASN
1	D	184	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 carbohydrates 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	$\# Z > 2$
2	FAD	A	301	-	52,58,58	1.30	6 (11%)	52,89,89	2.25	12 (23%)
3	UMP	A	302	-	17,21,21	0.95	1 (5%)	23,31,31	1.70	4 (17%)
2	FAD	B	301	-	52,58,58	1.40	7 (13%)	52,89,89	2.52	12 (23%)
3	UMP	B	302	-	17,21,21	0.99	2 (11%)	23,31,31	1.69	3 (13%)
2	FAD	C	301	-	52,58,58	1.33	7 (13%)	52,89,89	2.38	11 (21%)
3	UMP	C	302	-	17,21,21	0.89	1 (5%)	23,31,31	1.91	4 (17%)
2	FAD	D	301	-	52,58,58	1.27	7 (13%)	52,89,89	2.31	12 (23%)
3	UMP	D	302	-	17,21,21	0.98	0	23,31,31	1.74	3 (13%)

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

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
2	FAD	A	301	-	-	0/30/50/50	0/6/6/6
3	UMP	A	302	-	-	0/6/22/22	0/2/2/2
2	FAD	B	301	-	-	0/30/50/50	0/6/6/6
3	UMP	B	302	-	-	0/6/22/22	0/2/2/2
2	FAD	C	301	-	-	0/30/50/50	0/6/6/6
3	UMP	C	302	-	-	0/6/22/22	0/2/2/2
2	FAD	D	301	-	-	0/30/50/50	0/6/6/6
3	UMP	D	302	-	-	0/6/22/22	0/2/2/2

The worst 5 of 31 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	301	FAD	C2B-C1B	-2.22	1.50	1.53
2	B	301	FAD	C6-C5X	-2.22	1.38	1.41
3	B	302	UMP	C2-N3	-2.13	1.33	1.38
3	A	302	UMP	C2-N3	-2.10	1.33	1.38
2	B	301	FAD	C2B-C1B	-2.08	1.50	1.53

The worst 5 of 61 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	301	FAD	N3A-C2A-N1A	-8.41	122.27	128.87
2	C	301	FAD	N3A-C2A-N1A	-7.69	122.83	128.87
2	A	301	FAD	N3A-C2A-N1A	-7.39	123.07	128.87
2	C	301	FAD	C4-C4X-C10	-7.07	115.42	119.94
2	D	301	FAD	N3A-C2A-N1A	-6.36	123.87	128.87

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

5.7 Other polymers ⓘ

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	215/232 (92%)	-0.00	11 (5%) 32 33	21, 32, 56, 80	0
1	B	217/232 (93%)	-0.08	2 (0%) 85 86	22, 31, 53, 61	0
1	C	213/232 (91%)	-0.16	3 (1%) 78 78	20, 31, 55, 68	1 (0%)
1	D	218/232 (93%)	-0.17	2 (0%) 85 86	21, 31, 55, 77	0
All	All	863/928 (92%)	-0.10	18 (2%) 67 67	20, 31, 55, 80	1 (0%)

The worst 5 of 18 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	40	ARG	4.0
1	A	38	GLU	3.4
1	D	39	GLU	3.3
1	A	39	GLU	3.0
1	A	220	VAL	2.9

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 carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors(\AA^2)	Q<0.9
3	UMP	D	302	20/20	0.98	0.12	0.28	23,25,28,28	0
2	FAD	C	301	53/53	0.98	0.13	-0.11	21,23,26,27	0
2	FAD	D	301	53/53	0.97	0.10	-0.46	21,25,29,32	0
2	FAD	B	301	53/53	0.97	0.11	-0.49	20,24,30,31	0
2	FAD	A	301	53/53	0.98	0.11	-0.53	20,24,26,28	0
3	UMP	C	302	20/20	0.97	0.09	-0.68	25,27,31,31	0
3	UMP	A	302	20/20	0.98	0.09	-0.81	26,29,31,32	0
3	UMP	B	302	20/20	0.98	0.09	-0.93	24,26,28,30	0

6.5 Other polymers [i](#)

There are no such residues in this entry.