



wwPDB X-ray Structure Validation Summary Report i

Feb 27, 2014 – 03:31 PM GMT

PDB ID : 3P4R
Title : Crystal structure of Menaquinol:fumarate oxidoreductase in complex with glutarate
Authors : Tomasiak, T.M.; Archuleta, T.L.; Andrell, J.; Luna-Chavez, C.; Davis, T.A.; Sarwar, M.; Ham, A.J.; McDonald, W.H.; Yankowskaya, V.; Stern, H.A.; Johnston, J.N.; Maklashina, E.; Cecchini, G.; Iverson, T.M.
Deposited on : 2010-10-07
Resolution : 3.05 Å(reported)

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We welcome your comments at validation@mail.wwpdb.org
A user guide is available at <http://wwpdb.org/ValidationPDFNotes.html>

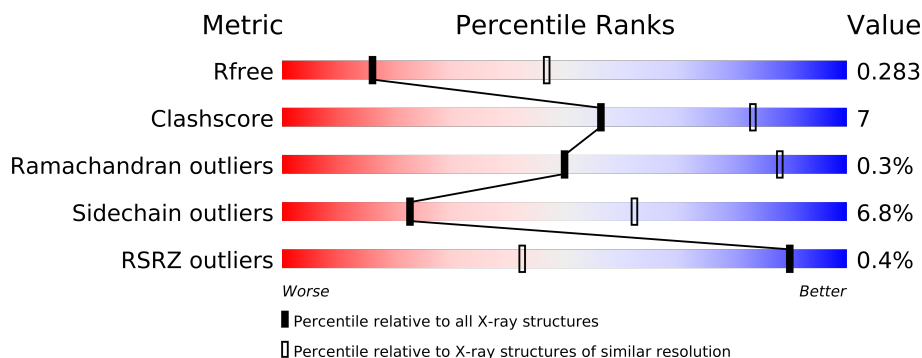
The following versions of software and data (see [references](#)) were used in the production of this report:

MolProbity	:	4.02b-467
Mogul	:	1.15 2013
Xtriage (Phenix)	:	dev-1323
EDS	:	stable22639
Percentile statistics	:	21963
Refmac	:	5.8.0049
CCP4	:	6.3.0 (Settle)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et. al. (1996)
Validation Pipeline (wwPDB-VP)	:	stable22683

1 Overall quality at a glance

The reported resolution of this entry is 3.05 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}	66092	2079 (3.12-3.00)
Clashscore	79885	2629 (3.12-3.00)
Ramachandran outliers	78287	2536 (3.12-3.00)
Sidechain outliers	78261	2539 (3.12-3.00)
RSRZ outliers	66119	2081 (3.12-3.00)

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. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density.

Mol	Chain	Length	Quality of chain
1	A	577	
1	M	577	
2	B	243	
2	N	243	
3	C	130	
3	O	130	
4	D	119	
4	P	119	

2 Entry composition

There are 9 unique types of molecules in this entry. The entry contains 16804 atoms, of which 0 are hydrogen and 0 are deuterium.

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 Fumarate reductase flavoprotein subunit.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	577	Total	C	N	O	S	0	0	0
			4449	2775	802	841	31			
1	M	577	Total	C	N	O	S	0	0	0
			4449	2775	802	841	31			

- Molecule 2 is a protein called Fumarate reductase iron-sulfur subunit.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	243	Total	C	N	O	S	0	0	0
			1888	1189	323	357	19			
2	N	243	Total	C	N	O	S	0	0	0
			1888	1189	323	357	19			

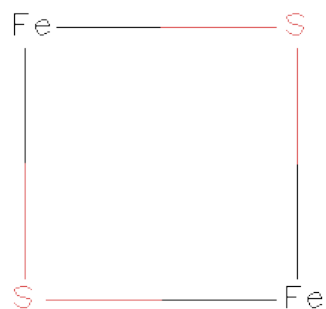
- Molecule 3 is a protein called Fumarate reductase subunit C.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	C	130	Total	C	N	O	S	0	0	0
			1058	720	166	169	3			
3	O	130	Total	C	N	O	S	0	0	0
			1058	720	166	169	3			

- Molecule 4 is a protein called Fumarate reductase subunit D.

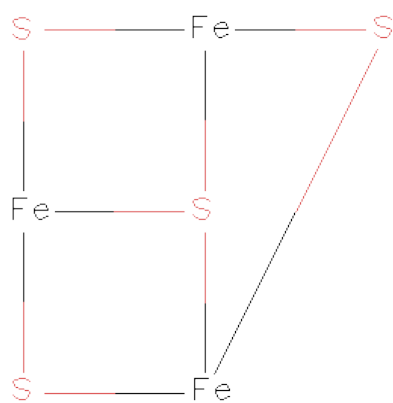
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	119	Total	C	N	O	S	0	0	0
			926	626	151	142	7			
4	P	119	Total	C	N	O	S	0	0	0
			926	626	151	142	7			

- Molecule 5 is FE2/S2 (INORGANIC) CLUSTER (three-letter code: FES) (formula: Fe₂S₂).



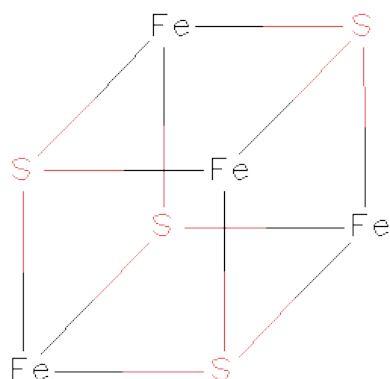
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	B	1	Total	Fe	S	0	0
			4	2	2		
5	N	1	Total	Fe	S	0	0
			4	2	2		

- Molecule 6 is FE3-S4 CLUSTER (three-letter code: F3S) (formula: Fe_3S_4).



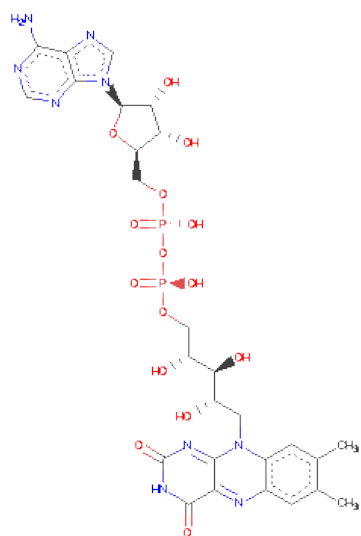
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	B	1	Total	Fe	S	0	0
			7	3	4		
6	N	1	Total	Fe	S	0	0
			7	3	4		

- Molecule 7 is IRON/SULFUR CLUSTER (three-letter code: SF4) (formula: Fe_4S_4).



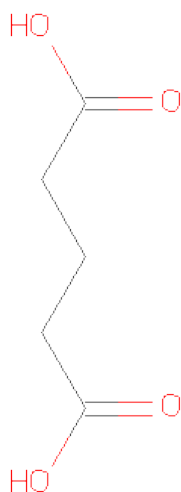
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
7	B	1	Total	Fe	S	0	0
			8	4	4		
7	N	1	Total	Fe	S	0	0
			8	4	4		

- Molecule 8 is FLAVIN-ADENINE DINUCLEOTIDE (three-letter code: FAD) (formula: $\text{C}_{27}\text{H}_{33}\text{N}_9\text{O}_{15}\text{P}_2$).



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

- Molecule 9 is GLUTARIC ACID (three-letter code: GUA) (formula: C₅H₈O₄).



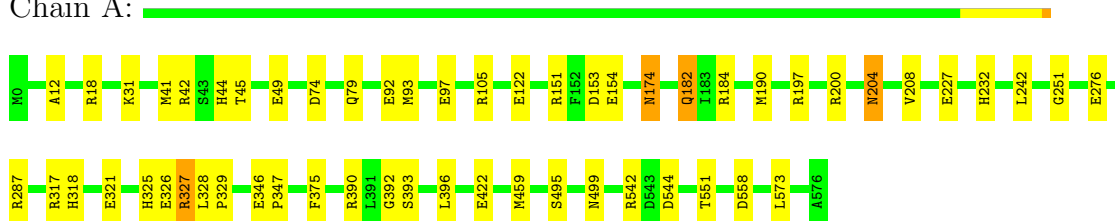
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
9	A	1	Total	C	O	0	0
			9	5	4		
9	M	1	Total	C	O	0	0
			9	5	4		

3 Residue-property plots

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.

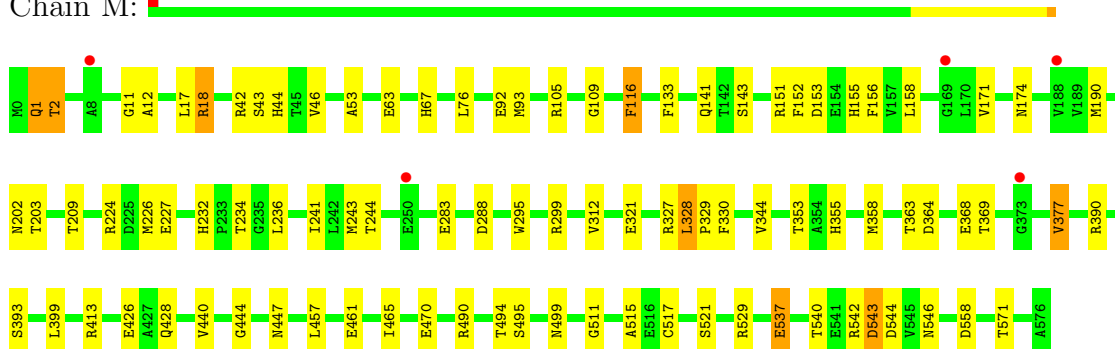
- Molecule 1: Fumarate reductase flavoprotein subunit

Chain A:



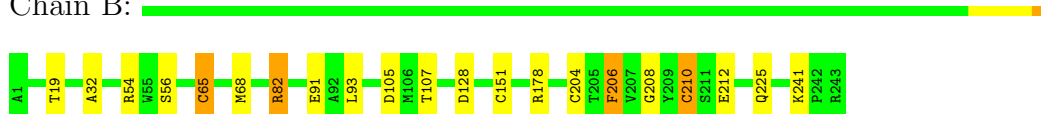
- Molecule 1: Fumarate reductase flavoprotein subunit

Chain M:



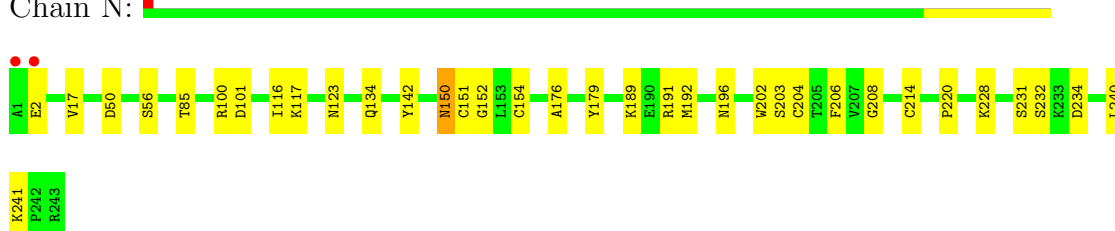
- Molecule 2: Fumarate reductase iron-sulfur subunit

Chain B:



- Molecule 2: Fumarate reductase iron-sulfur subunit

Chain N:



- Molecule 3: Fumarate reductase subunit C

Chain C: 



- Molecule 3: Fumarate reductase subunit C

Chain O: 



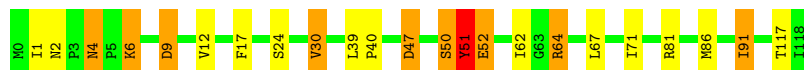
- Molecule 4: Fumarate reductase subunit D

Chain D: 



- Molecule 4: Fumarate reductase subunit D

Chain P: 



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	96.68Å 138.02Å 269.56Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	40.00 – 3.05 91.00 – 3.05	Depositor EDS
% Data completeness (in resolution range)	95.3 (40.00-3.05) 94.6 (91.00-3.05)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.05 (at 3.07Å)	Xtriage
Refinement program	REFMAC5	Depositor
R, R_{free}	0.248 , 0.284 0.248 , 0.283	Depositor DCC
R_{free} test set	1194 reflections (1.85%)	DCC
Wilson B-factor (Å ²)	78.8	Xtriage
Anisotropy	0.452	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.28 , 41.1	EDS
Estimated twinning fraction	No twinning to report.	Xtriage
L-test for twinning	$\langle L \rangle = 0.46$, $\langle L^2 \rangle = 0.29$	Xtriage
Outliers	0 of 69038 reflections	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	16804	wwPDB-VP
Average B, all atoms (Å ²)	95.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.71% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: GUA, F3S, SF4, FAD, FES

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	0.39	0/4541	0.56	0/6139
1	M	0.34	0/4541	0.54	0/6139
2	B	0.40	1/1931 (0.1%)	0.54	0/2617
2	N	0.35	0/1931	0.52	0/2617
3	C	0.39	0/1094	0.53	0/1496
3	O	0.39	0/1094	0.52	0/1496
4	D	1.54	16/956 (1.7%)	1.50	18/1303 (1.4%)
4	P	1.55	20/956 (2.1%)	1.46	18/1303 (1.4%)
All	All	0.63	37/17044 (0.2%)	0.71	36/23110 (0.2%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
4	D	0	2
4	P	0	2
All	All	0	4

The worst 5 of 37 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	D	51	TYR	CE1-CZ	-20.60	1.11	1.38
4	P	51	TYR	CE2-CZ	-19.42	1.13	1.38
4	D	51	TYR	CE2-CZ	-18.05	1.15	1.38
4	D	51	TYR	CG-CD1	-15.85	1.18	1.39
4	P	9	ASP	CG-OD1	15.19	1.60	1.25

The worst 5 of 36 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	D	51	TYR	CB-CG-CD2	28.09	137.85	121.00
4	P	47	ASP	CB-CG-OD2	22.25	138.33	118.30
4	D	51	TYR	CD1-CG-CD2	-15.67	100.66	117.90
4	P	47	ASP	CB-CG-OD1	-15.17	104.64	118.30
4	P	51	TYR	CD1-CG-CD2	-14.84	101.58	117.90

There are no chirality outliers.

All (4) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
4	D	51	TYR	Sidechain
4	D	9	ASP	Sidechain
4	P	51	TYR	Sidechain
4	P	9	ASP	Sidechain

5.2 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 hydrogens added by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, and the number in parentheses is this value normalized per 1000 atoms of the molecule in the chain. The Symm-Clashes column gives symmetry related clashes, in the same way as for the Clashes column.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	4449	0	0	28	0
1	M	4449	0	0	37	0
2	B	1888	0	0	11	0
2	N	1888	0	0	14	0
3	C	1058	0	0	4	0
3	O	1058	0	0	3	0
4	D	926	0	0	6	0
4	P	926	0	0	12	0
5	B	4	0	0	0	0
5	N	4	0	0	0	0
6	B	7	0	0	4	0
6	N	7	0	0	1	0
7	B	8	0	0	1	0
7	N	8	0	0	5	0
8	A	53	0	31	7	0
8	M	53	0	30	7	0
9	A	9	0	0	1	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
9	M	9	0	0	2	0
All	All	16804	0	61	110	0

Clashscore is defined as the number of clashes calculated for the entry per 1000 atoms (including hydrogens) of the entry. The overall clashscore for this entry is 7.

The worst 5 of 110 close contacts within the same asymmetric unit are listed below.

Atom-1	Atom-2	Distance(Å)	Clash(Å)
4:D:6:LYS:CE	4:D:6:LYS:CD	1.78	1.58
4:D:91:ILE:CG1	4:D:91:ILE:CD1	1.76	1.57
4:P:4:ASN:CG	4:P:4:ASN:CB	1.79	1.50
4:P:51:TYR:CZ	4:P:51:TYR:OH	1.63	1.50
1:M:44:HIS:NE2	8:M:601:FAD:HM82	1.44	1.32

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	575/577 (100%)	551 (96%)	24 (4%)	0	100	100
1	M	575/577 (100%)	545 (95%)	28 (5%)	2 (0%)	50	88
2	B	241/243 (99%)	229 (95%)	10 (4%)	2 (1%)	27	74
2	N	241/243 (99%)	225 (93%)	13 (5%)	3 (1%)	19	63
3	C	128/130 (98%)	125 (98%)	3 (2%)	0	100	100
3	O	128/130 (98%)	123 (96%)	5 (4%)	0	100	100
4	D	117/119 (98%)	103 (88%)	14 (12%)	0	100	100
4	P	117/119 (98%)	104 (89%)	13 (11%)	0	100	100
All	All	2122/2138 (99%)	2005 (94%)	110 (5%)	7 (0%)	50	88

5 of 7 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
2	N	56	SER
2	B	56	SER
1	M	444	GLY
2	N	101	ASP
2	B	82	ARG

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	460/460 (100%)	439 (95%)	21 (5%)	37	79
1	M	460/460 (100%)	418 (91%)	42 (9%)	14	46
2	B	205/205 (100%)	196 (96%)	9 (4%)	39	80
2	N	205/205 (100%)	193 (94%)	12 (6%)	28	69
3	C	111/111 (100%)	105 (95%)	6 (5%)	31	72
3	O	111/111 (100%)	106 (96%)	5 (4%)	38	80
4	D	97/97 (100%)	86 (89%)	11 (11%)	9	33
4	P	97/97 (100%)	85 (88%)	12 (12%)	7	27
All	All	1746/1746 (100%)	1628 (93%)	118 (7%)	22	62

5 of 118 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	M	116	PHE
1	M	299	ARG
4	P	12	VAL
1	M	143	SER
1	M	226	MET

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

5.3.3 RNA ⓘ

There are no RNA chains in this entry.

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

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

5.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

5.6 Ligand geometry ⓘ

10 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$
9	GUA	A	577	-	8,8,8	0.92	0	9,9,9	0.90	0
8	FAD	A	601	-	58,58,58	0.91	2 (3%)	85,89,89	2.25	19 (22%)
5	FES	B	244	2	0,4,4	0.00	-	0,4,4	0.00	-
6	F3S	B	245	2	3,9,9	14.69	3 (100%)	0,15,15	0.00	-
7	SF4	B	246	2	12,12,12	28.18	12 (100%)	0,24,24	0.00	-
9	GUA	M	577	-	8,8,8	0.87	0	9,9,9	0.97	0
8	FAD	M	601	-	58,58,58	1.21	4 (6%)	85,89,89	2.20	22 (25%)
5	FES	N	244	2	0,4,4	0.00	-	0,4,4	0.00	-
6	F3S	N	245	2	3,9,9	11.73	2 (66%)	0,15,15	0.00	-
7	SF4	N	246	2	12,12,12	62.26	12 (100%)	0,24,24	0.00	-

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
9	GUA	A	577	-	-	0/6/6/6	0/0/0/0
8	FAD	A	601	-	-	0/34/50/50	0/1/6/6
5	FES	B	244	2	-	0/0/4/4	0/0/1/1
6	F3S	B	245	2	-	0/0/24/24	0/0/3/3

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
7	SF4	B	246	2	-	0/0/48/48	0/0/5/5
9	GUA	M	577	-	-	0/6/6/6	0/0/0/0
8	FAD	M	601	-	-	0/34/50/50	0/1/6/6
5	FES	N	244	2	-	0/0/4/4	0/0/1/1
6	F3S	N	245	2	-	0/0/24/24	0/0/3/3
7	SF4	N	246	2	-	0/0/48/48	0/0/5/5

The worst 5 of 35 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
7	N	246	SF4	S1-FE2	96.29	2.98	2.33
7	N	246	SF4	S2-FE3	-94.92	1.69	2.33
7	N	246	SF4	S2-FE1	93.78	2.96	2.33
7	N	246	SF4	S1-FE4	-82.44	1.77	2.33
7	N	246	SF4	S1-FE3	-58.87	1.93	2.33

The worst 5 of 41 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
8	A	601	FAD	N3A-C2A-N1A	-10.34	120.06	128.71
8	M	601	FAD	N3A-C2A-N1A	-9.70	120.60	128.71
8	A	601	FAD	O4B-C1B-N9A	8.09	115.96	108.44
8	A	601	FAD	C2'-C1'-N10	-6.17	104.26	112.45
8	A	601	FAD	C2-N1-C10	6.06	121.09	114.98

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

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 ⓘ

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	577/577 (100%)	-0.14	0 100 100	44, 61, 96, 134	0
1	M	577/577 (100%)	0.13	5 (0%) 81 24	72, 135, 169, 186	0
2	B	243/243 (100%)	-0.16	0 100 100	46, 67, 104, 154	0
2	N	243/243 (100%)	-0.03	2 (0%) 83 27	65, 106, 151, 167	0
3	C	130/130 (100%)	-0.19	0 100 100	58, 80, 106, 155	0
3	O	130/130 (100%)	-0.11	1 (0%) 83 27	72, 102, 147, 197	0
4	D	119/119 (100%)	-0.16	0 100 100	59, 83, 124, 158	0
4	P	119/119 (100%)	-0.11	0 100 100	72, 91, 178, 254	0
All	All	2138/2138 (100%)	-0.06	8 (0%) 90 42	44, 87, 158, 254	0

The worst 5 of 8 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	N	1	ALA	3.3
1	M	8	ALA	3.1
3	O	1	THR	2.9
2	N	2	GLU	2.5
1	M	373	GLY	2.2

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

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

6.3 Carbohydrates ⓘ

There are no carbohydrates in this entry.

6.4 Ligands

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	RSR	LLDF	B-factors(Å ²)	Q<0.9
6	F3S	B	245	7/7	0.24	1.45	75,77,79,80	0
9	GUA	A	577	9/9	0.27	1.40	61,62,65,65	0
7	SF4	B	246	8/8	0.25	1.16	71,74,76,76	0
6	F3S	N	245	7/7	0.22	1.10	93,95,96,96	0
5	FES	B	244	4/4	0.22	0.37	50,50,54,55	0
9	GUA	M	577	9/9	0.24	0.34	86,87,88,88	0
5	FES	N	244	4/4	0.20	-0.03	72,73,73,74	0
7	SF4	N	246	8/8	0.20	-0.14	88,88,89,89	0
8	FAD	M	601	53/53	0.19	-0.70	65,84,96,96	0
8	FAD	A	601	53/53	0.19	-0.78	35,43,47,48	0

6.5 Other polymers

There are no such residues in this entry.