



Full wwPDB X-ray Structure Validation Report ⓘ

Oct 31, 2023 – 10:20 AM JST

PDB ID : 5BOF
Title : Crystal Structure of Staphylococcus aureus Enolase
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Deposited on : 2015-05-27
Resolution : 2.45 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 : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix) : 1.13
EDS : 2.36
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac : 5.8.0158
CCP4 : 7.0.044 (Gargrove)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.36

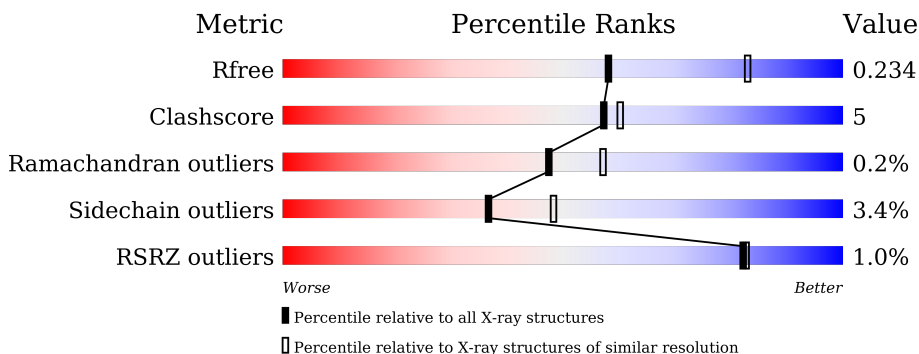
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION



The reported resolution of this entry is 2.45 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}	130704	1544 (2.48-2.44)
Clashscore	141614	1613 (2.48-2.44)
Ramachandran outliers	138981	1598 (2.48-2.44)
Sidechain outliers	138945	1598 (2.48-2.44)
RSRZ outliers	127900	1523 (2.48-2.44)

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	442	 88% 9% ..
1	B	442	 2% 85% 12% ..

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	SO4	B	504	-	-	X	-

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 6581 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 Enolase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	434	3266	2060	542	655	9	0	0	0
1	B	432	3263	2063	543	648	9	0	0	0

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	197	LYS	GLN	engineered mutation	UNP O69174
A	435	LEU	-	expression tag	UNP O69174
A	436	GLU	-	expression tag	UNP O69174
A	437	HIS	-	expression tag	UNP O69174
A	438	HIS	-	expression tag	UNP O69174
A	439	HIS	-	expression tag	UNP O69174
A	440	HIS	-	expression tag	UNP O69174
A	441	HIS	-	expression tag	UNP O69174
A	442	HIS	-	expression tag	UNP O69174
B	197	LYS	GLN	engineered mutation	UNP O69174
B	435	LEU	-	expression tag	UNP O69174
B	436	GLU	-	expression tag	UNP O69174
B	437	HIS	-	expression tag	UNP O69174
B	438	HIS	-	expression tag	UNP O69174
B	439	HIS	-	expression tag	UNP O69174
B	440	HIS	-	expression tag	UNP O69174
B	441	HIS	-	expression tag	UNP O69174
B	442	HIS	-	expression tag	UNP O69174

- Molecule 2 is MAGNESIUM ION (three-letter code: MG) (formula: Mg).

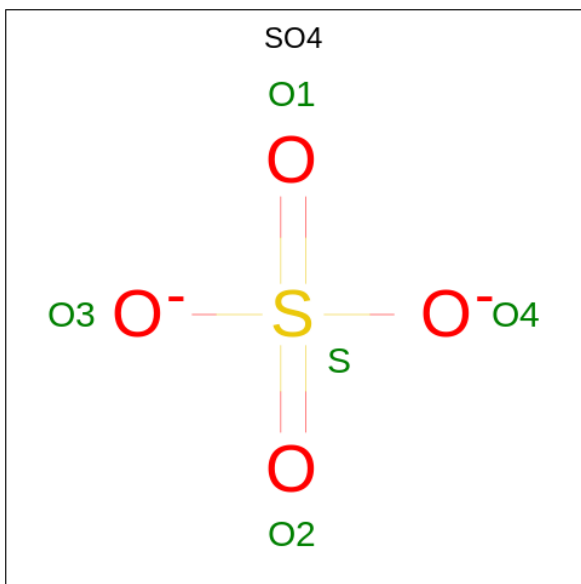
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Mg	0	0
			1	1		

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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	B	1	Total	Mg	0	0
			1	1		

- Molecule 3 is SULFATE ION (three-letter code: SO4) (formula: O₄S).



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

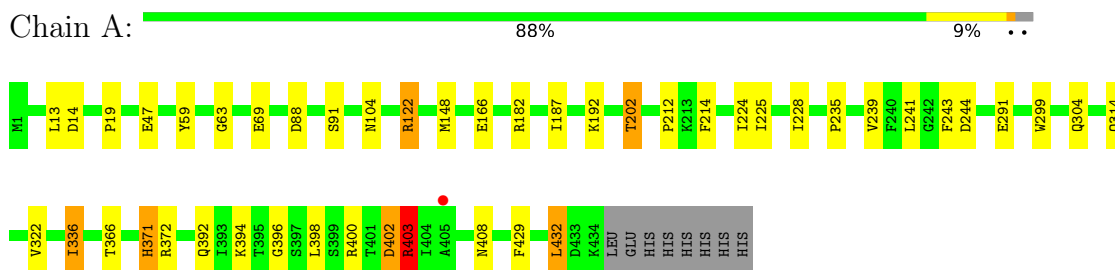
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	12	Total	O	0	0
			12	12		
4	B	8	Total	O	0	0
			8	8		

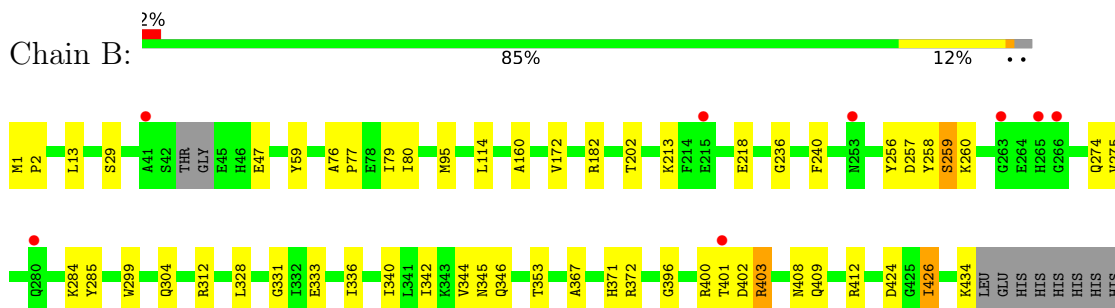
3 Residue-property plots [i](#)

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: Enolase



- Molecule 1: Enolase



4 Data and refinement statistics

Property	Value	Source
Space group	P 4 21 2	Depositor
Cell constants a, b, c, α , β , γ	164.69Å 164.69Å 77.33Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	50.00 – 2.45 46.52 – 2.45	Depositor EDS
% Data completeness (in resolution range)	98.2 (50.00-2.45) 98.3 (46.52-2.45)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.42 (at 2.45Å)	Xtrriage
Refinement program	REFMAC 5.8.0073	Depositor
R, R_{free}	0.186 , 0.229 0.191 , 0.234	Depositor DCC
R_{free} test set	1955 reflections (5.02%)	wwPDB-VP
Wilson B-factor (Å ²)	44.2	Xtrriage
Anisotropy	0.004	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 22.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	6581	wwPDB-VP
Average B, all atoms (Å ²)	45.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.14% 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: SO4, 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	0.47	0/3320	0.68	2/4503 (0.0%)
1	B	0.44	0/3316	0.65	0/4491
All	All	0.46	0/6636	0.66	2/8994 (0.0%)

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
1	A	0	1

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed($^{\circ}$)	Ideal($^{\circ}$)
1	A	122	ARG	NE-CZ-NH2	-5.65	117.47	120.30
1	A	403	ARG	NE-CZ-NH2	5.39	123.00	120.30

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	243	PHE	Peptide

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	3266	0	3170	31	0
1	B	3263	0	3192	39	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
3	A	15	0	0	0	0
3	B	15	0	0	3	0
4	A	12	0	0	1	0
4	B	8	0	0	0	0
All	All	6581	0	6362	63	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 5.

All (63) 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:312:ARG:HB3	1:B:434:LYS:HD2	1.53	0.88
1:A:182:ARG:HG3	1:B:59:TYR:CE2	2.14	0.83
1:A:314:GLN:HE22	1:A:392:GLN:HE22	1.28	0.82
1:B:258:TYR:OH	1:B:274:GLN:NE2	2.16	0.79
1:B:372:ARG:NH2	3:B:504:SO4:O4	2.25	0.70
1:B:79:ILE:HD13	1:B:95:MET:HE1	1.74	0.69
1:B:372:ARG:NH2	3:B:504:SO4:S	2.67	0.68
1:A:182:ARG:HG3	1:B:59:TYR:CZ	2.33	0.63
1:A:59:TYR:CE2	1:B:182:ARG:HG3	2.35	0.62
1:B:218:GLU:HG2	1:B:285:TYR:OH	1.99	0.62
1:A:372:ARG:O	1:A:403:ARG:NH1	2.34	0.61
1:B:79:ILE:HD13	1:B:95:MET:CE	2.31	0.60
1:B:403:ARG:N	1:B:403:ARG:HD2	2.17	0.59
1:B:79:ILE:CD1	1:B:95:MET:CE	2.82	0.58
1:B:396:GLY:HA3	1:B:403:ARG:HG3	1.88	0.55
1:B:1:MET:HB3	1:B:2:PRO:HD3	1.89	0.55
1:A:408:ASN:HD21	1:B:13:LEU:H	1.56	0.53
1:A:299:TRP:CE3	1:A:336:ILE:HD13	2.44	0.52
1:A:225:ILE:HD11	1:A:241:LEU:HD11	1.92	0.52
1:B:342:ILE:HD13	1:B:367:ALA:HB1	1.92	0.52
1:A:47:GLU:HB3	1:A:322:VAL:HG13	1.91	0.51
1:A:212:PRO:HG2	1:A:214:PHE:CE2	2.45	0.51
1:A:122:ARG:NH2	4:A:601:HOH:O	2.44	0.51

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:396:GLY:HA3	1:A:403:ARG:HG3	1.93	0.50
1:A:322:VAL:HG12	1:A:322:VAL:O	2.12	0.50
1:A:192:LYS:HE3	1:A:202:THR:HG23	1.92	0.50
1:B:76:ALA:O	1:B:80:ILE:HG12	2.12	0.50
1:B:79:ILE:CD1	1:B:95:MET:HE1	2.41	0.49
1:A:13:LEU:H	1:B:408:ASN:HD21	1.60	0.48
1:A:322:VAL:O	1:A:322:VAL:CG1	2.60	0.48
1:A:148:MET:CE	1:A:394:LYS:HD2	2.44	0.48
1:A:403:ARG:N	1:A:403:ARG:HD2	2.29	0.48
1:B:344:VAL:HG12	1:B:353:THR:HG21	1.94	0.47
1:A:429:PHE:HB3	1:A:432:LEU:HD22	1.97	0.47
1:A:244:ASP:HA	1:A:291:GLU:HB3	1.96	0.47
1:B:299:TRP:CE3	1:B:336:ILE:HD13	2.49	0.47
1:A:371:HIS:CD2	1:A:403:ARG:HH11	2.32	0.47
1:B:372:ARG:NH2	3:B:504:SO4:O1	2.48	0.46
1:B:236:GLY:O	1:B:240:PHE:CZ	2.69	0.45
1:B:256:TYR:CD1	1:B:274:GLN:HG3	2.52	0.45
1:A:88:ASP:HB3	1:A:91:SER:OG	2.17	0.44
1:B:47:GLU:HG3	1:B:346:GLN:HG3	1.99	0.44
1:B:331:GLY:HA2	1:B:336:ILE:HG12	1.98	0.44
1:B:76:ALA:HB3	1:B:77:PRO:HD3	1.99	0.44
1:B:160:ALA:HB2	1:B:213:LYS:HA	1.99	0.43
1:A:59:TYR:CE2	1:B:182:ARG:CG	3.02	0.43
1:B:340:ILE:HG23	1:B:342:ILE:HD11	2.00	0.43
1:A:235:PRO:O	1:A:239:VAL:O	2.37	0.43
1:A:148:MET:HB2	1:A:148:MET:HE2	1.94	0.42
1:B:409:GLN:HE21	1:B:412:ARG:HH21	1.67	0.42
1:A:228:ILE:HD12	1:A:239:VAL:HG11	2.01	0.42
1:B:256:TYR:CG	1:B:274:GLN:HG3	2.54	0.42
1:B:275:VAL:HG21	1:B:304:GLN:HG2	2.01	0.42
1:A:19:PRO:HG2	1:A:63:GLY:HA2	2.02	0.42
1:B:1:MET:HG3	1:B:29:SER:HB3	2.01	0.42
1:B:172:VAL:HG21	1:B:426:ILE:HD12	2.01	0.41
1:A:402:ASP:HB3	1:B:401:THR:OG1	2.21	0.41
1:B:114:LEU:HD22	1:B:345:ASN:HA	2.03	0.41
1:A:166:GLU:HG2	1:A:244:ASP:HB3	2.03	0.41
1:A:187:ILE:HG21	1:A:228:ILE:HD13	2.02	0.41
1:B:257:ASP:OD1	1:B:259:SER:HB3	2.20	0.41
1:B:372:ARG:O	1:B:403:ARG:NH1	2.53	0.41
1:A:14:ASP:OD1	1:A:14:ASP:C	2.60	0.41

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	432/442 (98%)	416 (96%)	15 (4%)	1 (0%)	47	57
1	B	428/442 (97%)	413 (96%)	14 (3%)	1 (0%)	47	57
All	All	860/884 (97%)	829 (96%)	29 (3%)	2 (0%)	47	57

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	400	ARG
1	A	400	ARG

5.3.2 Protein sidechains [i](#)

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	337/358 (94%)	325 (96%)	12 (4%)	35	46
1	B	337/358 (94%)	326 (97%)	11 (3%)	38	49
All	All	674/716 (94%)	651 (97%)	23 (3%)	37	48

All (23) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	69	GLU
1	A	104	ASN
1	A	202	THR
1	A	224	ILE

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Mol	Chain	Res	Type
1	A	304	GLN
1	A	336	ILE
1	A	366	THR
1	A	371	HIS
1	A	398	LEU
1	A	402	ASP
1	A	403	ARG
1	A	432	LEU
1	B	202	THR
1	B	259	SER
1	B	260	LYS
1	B	284	LYS
1	B	328	LEU
1	B	333	GLU
1	B	371	HIS
1	B	402	ASP
1	B	403	ARG
1	B	424	ASP
1	B	426	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (17) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	70	ASN
1	A	89	GLN
1	A	150	ASN
1	A	189	HIS
1	A	190	ASN
1	A	274	GLN
1	A	371	HIS
1	A	392	GLN
1	A	408	ASN
1	A	409	GLN
1	B	70	ASN
1	B	89	GLN
1	B	150	ASN
1	B	274	GLN
1	B	392	GLN
1	B	408	ASN
1	B	409	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 monosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 8 ligands modelled in this entry, 2 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	$\# Z > 2$
3	SO4	B	501	-	4,4,4	0.25	0	6,6,6	0.23	0
3	SO4	B	504	-	4,4,4	0.35	0	6,6,6	0.62	0
3	SO4	A	503	-	4,4,4	0.44	0	6,6,6	0.20	0
3	SO4	A	502	-	4,4,4	0.31	0	6,6,6	0.48	0
3	SO4	B	502	-	4,4,4	0.38	0	6,6,6	0.53	0
3	SO4	A	504	-	4,4,4	0.36	0	6,6,6	0.31	0

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	B	504	SO4	3	0

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data [i](#)

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

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	434/442 (98%)	-0.27	1 (0%) 95 95	31, 42, 57, 89	0
1	B	432/442 (97%)	-0.02	8 (1%) 66 64	32, 45, 69, 91	0
All	All	866/884 (97%)	-0.15	9 (1%) 82 83	31, 43, 65, 91	0

All (9) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	265	HIS	5.2
1	B	41	ALA	4.9
1	B	266	GLY	3.7
1	B	263	GLY	3.0
1	B	215	GLU	2.6
1	B	253	ASN	2.3
1	B	280	GLN	2.2
1	A	405	ALA	2.0
1	B	401	THR	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 monosaccharides 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(Å ²)	Q<0.9
2	MG	A	501	1/1	0.96	0.33	32,32,32,32	0
3	SO4	B	501	5/5	0.96	0.09	67,69,73,74	0
3	SO4	A	503	5/5	0.97	0.09	54,57,60,60	0
2	MG	B	503	1/1	0.97	0.34	34,34,34,34	0
3	SO4	B	504	5/5	0.97	0.18	48,50,53,54	0
3	SO4	A	502	5/5	0.98	0.11	46,47,48,48	0
3	SO4	B	502	5/5	0.98	0.13	54,56,60,61	0
3	SO4	A	504	5/5	0.98	0.09	65,67,71,73	0

6.5 Other polymers [i](#)

There are no such residues in this entry.