



Full wwPDB X-ray Structure Validation Report ⓘ

Jul 28, 2026 – 04:29 PM EDT

PDB ID : 9PU9 / pdb_00009pu9
Title : Crystal structure of thermostable variant of phosphite dehydrogenase from *Pseudomonas stutzeri*
Authors : Chang, C.; Joachimiak, A.; Michalska, K.; Osipiuk, J.; Endres, M.; Ping, Y.
Deposited on : 2025-07-30
Resolution : 1.44 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
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.50

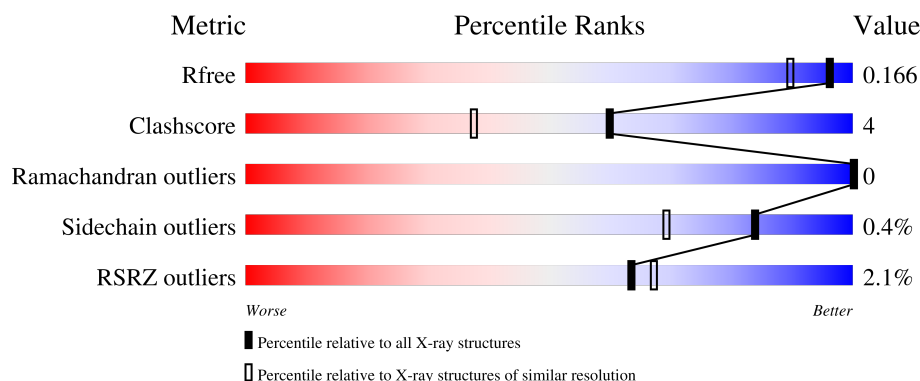
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

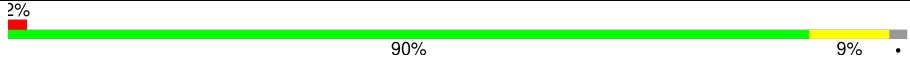
The reported resolution of this entry is 1.44 Å.

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	3234 (1.46-1.42)
Clashscore	190562	3289 (1.46-1.42)
Ramachandran outliers	187476	3248 (1.46-1.42)
Sidechain outliers	187428	3248 (1.46-1.42)
RSRZ outliers	180081	3234 (1.46-1.42)

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	339	
1	B	339	

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
5	PGE	B	403	-	-	X	-

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 6484 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 Phosphonate dehydrogenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	333	Total	C	N	O	S	0	46	0
			2840	1811	511	499	19			
1	B	329	Total	C	N	O	S	0	37	0
			2748	1755	492	483	18			

There are 50 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-2	SER	-	expression tag	UNP O69054
A	-1	ASN	-	expression tag	UNP O69054
A	0	ALA	-	expression tag	UNP O69054
A	13	GLU	ASP	engineered mutation	UNP O69054
A	26	ILE	MET	engineered mutation	UNP O69054
A	71	ILE	VAL	engineered mutation	UNP O69054
A	98	GLU	ASP	engineered mutation	UNP O69054
A	130	LYS	GLU	engineered mutation	UNP O69054
A	132	ARG	GLN	engineered mutation	UNP O69054
A	137	ARG	GLN	engineered mutation	UNP O69054
A	150	PHE	ILE	engineered mutation	UNP O69054
A	154	GLN	GLY	engineered mutation	UNP O69054
A	155	SER	ALA	engineered mutation	UNP O69054
A	175	ALA	GLU	engineered mutation	UNP O69054
A	176	PHE	ALA	engineered mutation	UNP O69054
A	177	GLU	LYS	engineered mutation	UNP O69054
A	215	LEU	GLN	engineered mutation	UNP O69054
A	275	GLN	ARG	engineered mutation	UNP O69054
A	276	GLN	LEU	engineered mutation	UNP O69054
A	313	LEU	ILE	engineered mutation	UNP O69054
A	315	ALA	VAL	engineered mutation	UNP O69054
A	319	GLU	ALA	engineered mutation	UNP O69054
A	325	VAL	ALA	engineered mutation	UNP O69054
A	332	ASN	GLU	engineered mutation	UNP O69054
A	336	ASP	CYS	engineered mutation	UNP O69054

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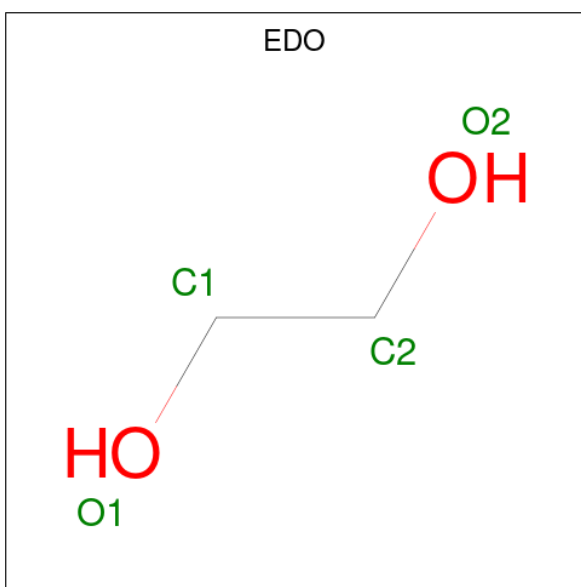
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Chain	Residue	Modelled	Actual	Comment	Reference
B	-2	SER	-	expression tag	UNP O69054
B	-1	ASN	-	expression tag	UNP O69054
B	0	ALA	-	expression tag	UNP O69054
B	13	GLU	ASP	engineered mutation	UNP O69054
B	26	ILE	MET	engineered mutation	UNP O69054
B	71	ILE	VAL	engineered mutation	UNP O69054
B	98	GLU	ASP	engineered mutation	UNP O69054
B	130	LYS	GLU	engineered mutation	UNP O69054
B	132	ARG	GLN	engineered mutation	UNP O69054
B	137	ARG	GLN	engineered mutation	UNP O69054
B	150	PHE	ILE	engineered mutation	UNP O69054
B	154	GLN	GLY	engineered mutation	UNP O69054
B	155	SER	ALA	engineered mutation	UNP O69054
B	175	ALA	GLU	engineered mutation	UNP O69054
B	176	PHE	ALA	engineered mutation	UNP O69054
B	177	GLU	LYS	engineered mutation	UNP O69054
B	215	LEU	GLN	engineered mutation	UNP O69054
B	275	GLN	ARG	engineered mutation	UNP O69054
B	276	GLN	LEU	engineered mutation	UNP O69054
B	313	LEU	ILE	engineered mutation	UNP O69054
B	315	ALA	VAL	engineered mutation	UNP O69054
B	319	GLU	ALA	engineered mutation	UNP O69054
B	325	VAL	ALA	engineered mutation	UNP O69054
B	332	ASN	GLU	engineered mutation	UNP O69054
B	336	ASP	CYS	engineered mutation	UNP O69054

- Molecule 2 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

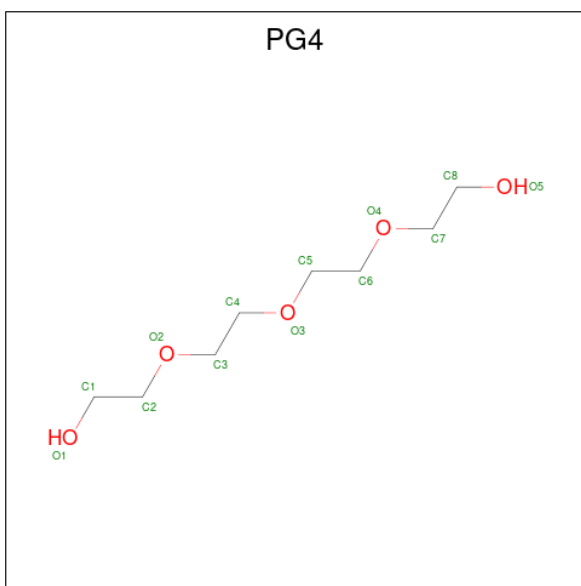
Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	1	Total Cl 1 1	0	0
2	B	1	Total Cl 1 1	0	0

- Molecule 3 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: C₂H₆O₂).



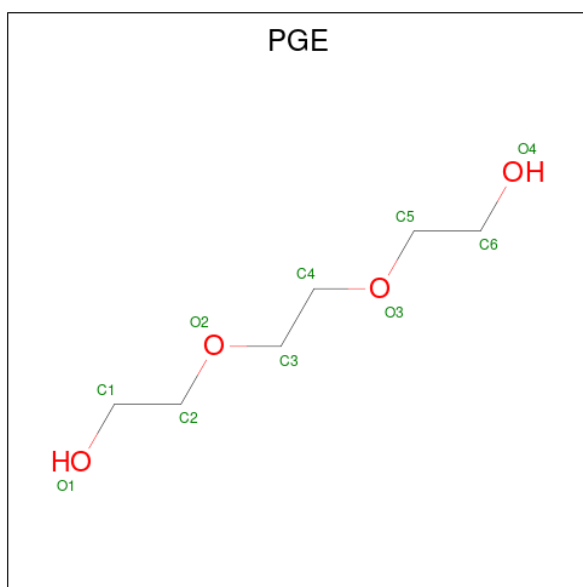
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			4	2	2		

- Molecule 4 is TETRAETHYLENE GLYCOL (CCD ID: PG4) (formula: $C_8H_{18}O_5$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	B	1	Total	C	O	0	0
			13	8	5		

- Molecule 5 is TRIETHYLENE GLYCOL (CCD ID: PGE) (formula: $C_6H_{14}O_4$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	B	1	Total	C	O	0	0
			10	6	4		

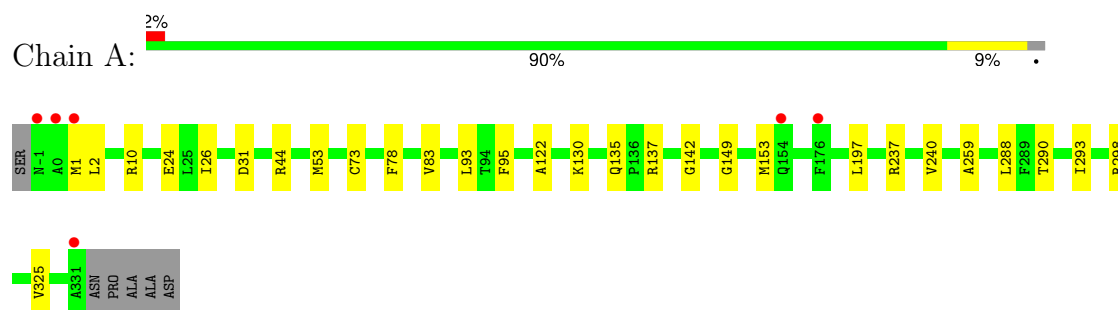
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	461	Total	O	0	12
			461	461		
6	B	406	Total	O	0	4
			406	406		

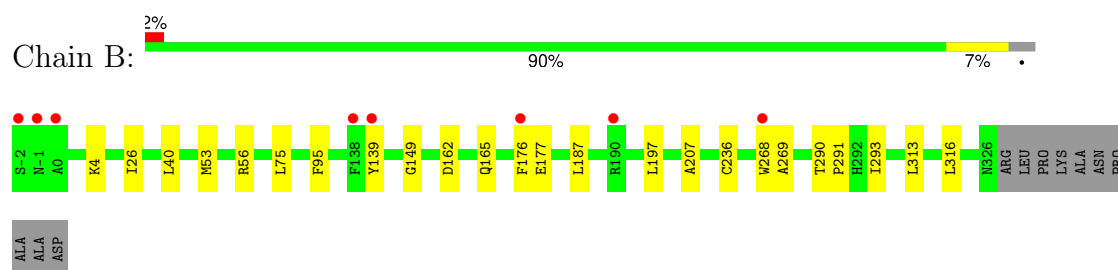
3 Residue-property plots [i](#)

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: Phosphonate dehydrogenase



- Molecule 1: Phosphonate dehydrogenase



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	65.50Å 91.12Å 144.62Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	49.92 – 1.44 49.92 – 1.44	Depositor EDS
% Data completeness (in resolution range)	99.9 (49.92-1.44) 100.0 (49.92-1.44)	Depositor EDS
R_{merge}	0.15	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.95 (at 1.44Å)	Xtriage
Refinement program	PHENIX (1.21.2_5419: ???)	Depositor
R, R_{free}	0.128 , 0.165 0.128 , 0.166	Depositor DCC
R_{free} test set	8062 reflections (5.12%)	wwPDB-VP
Wilson B-factor (Å ²)	13.5	Xtriage
Anisotropy	0.243	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 44.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.98	EDS
Total number of atoms	6484	wwPDB-VP
Average B, all atoms (Å ²)	20.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.38% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: PGE, CL, EDO, PG4

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	0.62	0/3012	0.68	0/4083
1	B	0.64	0/2899	0.68	0/3932
All	All	0.63	0/5911	0.68	0/8015

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry-related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2840	0	2967	26	0
1	B	2748	0	2872	23	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
3	A	4	0	6	1	0
4	B	13	0	18	4	0
5	B	10	0	14	7	0
6	A	461	0	0	2	0
6	B	406	0	0	3	0
All	All	6484	0	5877	49	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 4.

All (49) 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:78:PHE:HB3	1:A:95[B]:PHE:CE1	2.02	0.94
1:B:4[B]:LYS:HG3	1:B:26[B]:ILE:HD13	1.64	0.78
1:B:269:ALA:H	5:B:403:PGE:H5	1.49	0.78
5:B:403:PGE:H12	6:B:513:HOH:O	1.86	0.74
1:A:78:PHE:CB	1:A:95[B]:PHE:CE1	2.76	0.67
1:B:4[B]:LYS:HE3	1:B:26[B]:ILE:HG12	1.81	0.61
1:A:73:CYS:SG	1:A:95[B]:PHE:CE1	2.96	0.57
1:B:176:PHE:CD2	1:B:177[B]:GLU:HG3	2.40	0.57
1:A:83[A]:VAL:HG22	1:A:93:LEU:HD23	1.88	0.56
1:B:268[A]:TRP:NE1	5:B:403:PGE:H1	2.21	0.55
1:B:313:LEU:HB3	4:B:402:PG4:H42	1.88	0.55
1:B:313:LEU:HD13	4:B:402:PG4:H62	1.90	0.54
1:A:78:PHE:CB	1:A:95[B]:PHE:CZ	2.90	0.54
1:A:78:PHE:CG	1:A:95[B]:PHE:CZ	2.96	0.53
1:B:269:ALA:N	5:B:403:PGE:H5	2.21	0.53
1:A:135:GLN:OE1	1:A:137[B]:ARG:HD3	2.09	0.52
1:B:56:ARG:HD2	1:B:268[B]:TRP:CE3	2.44	0.52
1:A:73:CYS:HB2	1:A:95[B]:PHE:CD1	2.45	0.50
1:B:268[A]:TRP:CD1	5:B:403:PGE:HO1	2.31	0.48
1:B:316:LEU:HB2	4:B:402:PG4:H21	1.94	0.48
1:A:44[A]:ARG:HD3	6:A:797:HOH:O	2.14	0.47
1:A:237:ARG:O	1:A:240[B]:VAL:HG22	2.15	0.47
1:B:53[A]:MET:SD	5:B:403:PGE:H22	2.54	0.47
1:B:56:ARG:HD3	6:B:836:HOH:O	2.16	0.46
1:B:269:ALA:H	5:B:403:PGE:C5	2.24	0.46
1:A:149:GLY:CA	1:A:197[A]:LEU:HD21	2.45	0.46
1:A:290:THR:HB	1:A:293:ILE:HG12	1.99	0.45
1:A:130:LYS:HA	1:A:130:LYS:HD3	1.79	0.44
1:A:149:GLY:HA3	1:A:197[A]:LEU:HD21	2.00	0.44
1:A:10[A]:ARG:HH22	1:A:31[A]:ASP:HB3	1.82	0.44
1:A:53[B]:MET:HA	1:A:53[B]:MET:HE2	1.99	0.44
1:A:95[B]:PHE:HD2	1:A:325[B]:VAL:HG13	1.81	0.44
1:B:162[B]:ASP:O	1:B:165[B]:GLN:HG2	2.18	0.43
1:B:75:LEU:HD12	1:B:75:LEU:C	2.43	0.43
1:A:122:ALA:HB1	1:B:291:PRO:HD2	2.01	0.42
1:A:142:GLY:O	3:A:402:EDO:H22	2.19	0.42
1:B:290:THR:HB	1:B:293:ILE:HG12	2.01	0.42
4:B:402:PG4:H72	6:B:828:HOH:O	2.19	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:149:GLY:HA3	1:B:197[B]:LEU:HD21	2.02	0.42
1:B:162[B]:ASP:OD1	1:B:187:LEU:HD21	2.20	0.42
1:A:259:ALA:HA	1:A:288:LEU:O	2.20	0.41
1:B:40:LEU:HD23	1:B:40:LEU:HA	1.91	0.41
1:A:2:LEU:HB2	1:A:24[A]:GLU:HG3	2.02	0.41
1:A:83[B]:VAL:HG21	1:A:325[B]:VAL:HG23	2.03	0.41
1:A:153:MET:O	1:A:153:MET:HG3	2.20	0.41
1:A:298[B]:ARG:NH1	6:A:505:HOH:O	2.55	0.40
1:A:298[B]:ARG:HG3	1:B:139:TYR:HB3	2.04	0.40
1:B:207:ALA:HA	1:B:236[B]:CYS:SG	2.62	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	378/339 (112%)	367 (97%)	11 (3%)	0	100	100
1	B	365/339 (108%)	356 (98%)	9 (2%)	0	100	100
All	All	743/678 (110%)	723 (97%)	20 (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	308/267 (115%)	307 (100%)	1 (0%)	86	74
1	B	297/267 (111%)	296 (100%)	1 (0%)	86	74
All	All	605/534 (113%)	603 (100%)	2 (0%)	84	74

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

Mol	Chain	Res	Type
1	A	26	ILE
1	B	95	PHE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	174	HIS
1	A	275	GLN
1	B	80	ASN
1	B	174	HIS
1	B	185	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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 5 ligands modelled in this entry, 2 are monoatomic - leaving 3 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	$\# Z > 2$
5	PGE	B	403	-	9,9,9	0.32	0	8,8,8	0.52	0
4	PG4	B	402	-	12,12,12	0.37	0	11,11,11	0.46	0
3	EDO	A	402	-	3,3,3	0.45	0	2,2,2	0.42	0

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

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
5	PGE	B	403	-	-	4/7/7/7	-
4	PG4	B	402	-	-	5/10/10/10	-
3	EDO	A	402	-	-	0/1/1/1	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (9) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	B	402	PG4	O3-C5-C6-O4
5	B	403	PGE	O3-C5-C6-O4
5	B	403	PGE	O2-C3-C4-O3
5	B	403	PGE	C1-C2-O2-C3
4	B	402	PG4	O4-C7-C8-O5
5	B	403	PGE	C6-C5-O3-C4
4	B	402	PG4	C1-C2-O2-C3
4	B	402	PG4	C8-C7-O4-C6
4	B	402	PG4	O2-C3-C4-O3

There are no ring outliers.

3 monomers are involved in 12 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	B	403	PGE	7	0
4	B	402	PG4	4	0

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Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	402	EDO	1	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	333/339 (98%)	-0.59	6 (1%) 67 72	5, 14, 28, 56	47 (14%)
1	B	329/339 (97%)	-0.51	8 (2%) 59 63	6, 14, 31, 47	40 (12%)
All	All	662/678 (97%)	-0.55	14 (2%) 63 67	5, 14, 30, 56	87 (13%)

All (14) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	0	ALA	6.0
1	A	331	ALA	4.7
1	A	-1	ASN	3.7
1	B	176	PHE	3.3
1	A	1[A]	MET	3.2
1	B	138	PHE	3.1
1	B	190	ARG	2.9
1	B	-2	SER	2.9
1	A	176	PHE	2.8
1	B	268[A]	TRP	2.7
1	A	154	GLN	2.7
1	B	139	TYR	2.4
1	B	0	ALA	2.3
1	B	-1	ASN	2.1

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

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
5	PGE	B	403	10/10	0.61	0.32	62,70,72,72	0
4	PG4	B	402	13/13	0.83	0.26	28,66,87,89	0
3	EDO	A	402	4/4	0.98	0.07	15,23,28,32	0
2	CL	B	401	1/1	1.00	0.03	24,24,24,24	1
2	CL	A	401	1/1	1.00	0.04	14,14,14,14	0

6.5 Other polymers

There are no such residues in this entry.