



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 10, 2026 – 02:50 AM UTC

PDB ID : 1E46 / pdb_00001e46
Title : L-Fucose 1-Phosphate Aldolase from Escherichia coli Mutant E73S
Authors : Joerger, A.C.; Schulz, G.E.
Deposited on : 2000-06-30
Resolution : 2.55 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	:	9.0.010 (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

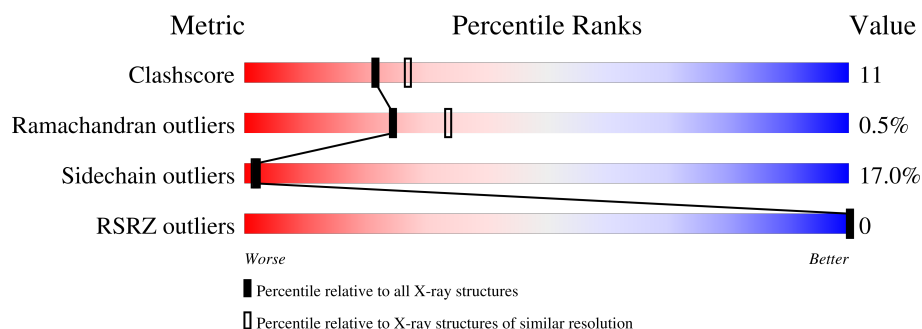
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.55 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))
Clashscore	190562	1120 (2.54-2.54)
Ramachandran outliers	187476	1106 (2.54-2.54)
Sidechain outliers	187428	1106 (2.54-2.54)
RSRZ outliers	180081	1091 (2.54-2.54)

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	P	215	

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 1715 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.

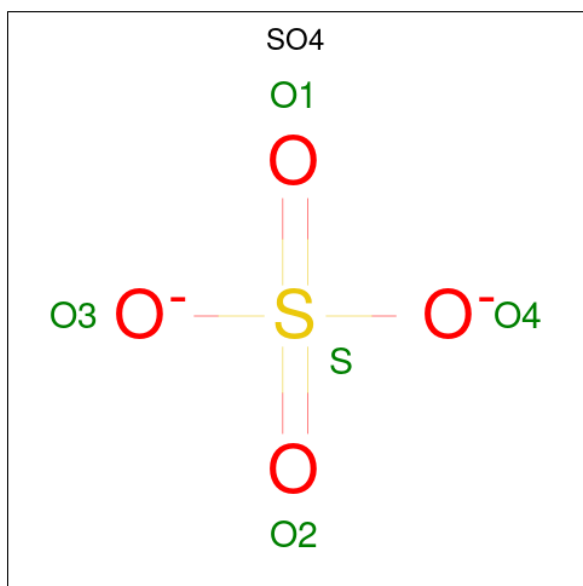
- Molecule 1 is a protein called L-FUCULOSE 1-PHOSPHATE ALDOLASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	P	206	1605	1018	281	295	11	0	5	0

There is a discrepancy between the modelled and reference sequences:

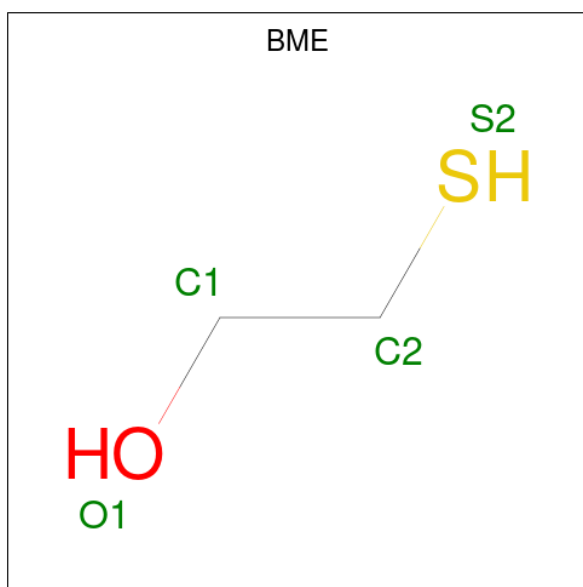
Chain	Residue	Modelled	Actual	Comment	Reference
P	73	SER	GLU	engineered mutation	UNP P11550

- Molecule 2 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	O	S		
2	P	1	5	4	1	0	0

- Molecule 3 is BETA-MERCAPTOETHANOL (CCD ID: BME) (formula: C₂H₆OS).



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

- Molecule 4 is ZINC ION (CCD ID: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	P	1	Total	Zn	0	0
			1	1		

- Molecule 5 is water.

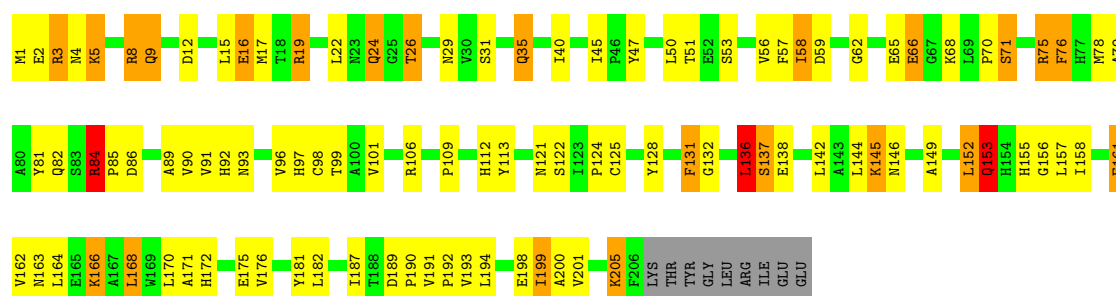
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	P	100	Total	O	0	0
			100	100		

3 Residue-property plots

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: L-FUCULOSE 1-PHOSPHATE ALDOLASE

Chain P: 



4 Data and refinement statistics

Property	Value	Source
Space group	P 4 21 2	Depositor
Cell constants a, b, c, α , β , γ	94.10Å 94.10Å 43.50Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	10.00 – 2.55 10.00 – 2.55	Depositor EDS
% Data completeness (in resolution range)	95.0 (10.00-2.55) 93.7 (10.00-2.55)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.06	Depositor
$\langle I/\sigma(I) \rangle$ ¹	4.39 (at 2.56Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.149 , 0.229 (Not available) , (Not available)	Depositor DCC
R_{free} test set	No test flags present.	wwPDB-VP
Wilson B-factor (Å ²)	32.7	Xtriage
Anisotropy	0.122	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 89.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.28$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	1715	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 7.00% 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: BME, SO4, ZN

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	P	0.96	1/1658 (0.1%)	2.33	89/2255 (3.9%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	P	112	HIS	C-O	5.70	1.30	1.23

All (89) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	P	84	ARG	CD-NE-CZ	11.71	140.79	124.40
1	P	156	GLY	O-C-N	-9.99	115.51	123.80
1	P	106	ARG	NE-CZ-NH2	-9.26	110.86	119.20
1	P	137	SER	CA-C-O	-9.26	110.55	120.92
1	P	172	HIS	CA-C-O	-9.20	110.95	121.07
1	P	200	ALA	CA-C-O	-8.68	111.61	120.90
1	P	98	CYS	CA-C-N	8.43	131.92	120.38
1	P	98	CYS	C-N-CA	8.43	131.92	120.38
1	P	124	PRO	O-C-N	-8.30	112.56	122.86
1	P	175	GLU	CB-CG-CD	8.28	126.67	112.60
1	P	153	GLN	CA-C-O	-8.21	112.84	121.55
1	P	99	THR	CA-C-O	-7.91	112.08	120.63
1	P	136	LEU	CB-CA-C	7.73	123.11	110.90
1	P	136	LEU	N-CA-C	-7.66	102.87	111.14
1	P	50	LEU	N-CA-C	7.63	121.78	110.48
1	P	153	GLN	OE1-CD-NE2	7.37	129.97	122.60
1	P	92	HIS	CA-C-O	-7.22	113.01	121.16
1	P	96[A]	VAL	CA-C-O	-7.18	113.48	120.95
1	P	96[B]	VAL	CA-C-O	-7.18	113.48	120.95
1	P	152	LEU	CA-C-O	-7.11	112.70	120.30

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	P	131	PHE	CA-CB-CG	7.00	120.80	113.80
1	P	26	THR	CA-C-O	6.99	130.51	120.51
1	P	56	VAL	O-C-N	-6.96	115.55	122.93
1	P	101	VAL	N-CA-CB	6.93	119.97	110.54
1	P	163	ASN	CA-C-N	6.92	129.55	120.28
1	P	163	ASN	C-N-CA	6.92	129.55	120.28
1	P	193	VAL	CA-C-O	-6.85	114.47	121.67
1	P	194	LEU	CA-C-O	-6.85	113.59	121.47
1	P	66	GLU	CA-C-O	-6.75	113.73	121.15
1	P	145	LYS	CA-C-O	6.67	127.62	120.55
1	P	91	VAL	CA-C-N	-6.67	112.13	122.87
1	P	91	VAL	C-N-CA	-6.67	112.13	122.87
1	P	193	VAL	O-C-N	6.61	130.37	123.04
1	P	4	ASN	CA-C-O	-6.53	112.47	119.97
1	P	82	GLN	OE1-CD-NE2	6.50	129.10	122.60
1	P	182	LEU	O-C-N	-6.49	115.24	122.12
1	P	35	GLN	CB-CG-CD	6.44	123.55	112.60
1	P	75	ARG	NH1-CZ-NH2	6.39	127.60	119.30
1	P	181	TYR	O-C-N	-6.33	115.44	122.03
1	P	62	GLY	CA-C-O	6.18	125.63	118.96
1	P	16	GLU	CA-C-O	6.14	126.93	120.42
1	P	56	VAL	CA-C-O	-6.09	113.78	120.84
1	P	93	ASN	CA-CB-CG	6.08	118.68	112.60
1	P	9	GLN	O-C-N	5.92	128.90	122.15
1	P	125	CYS	O-C-N	-5.87	116.32	123.30
1	P	109	PRO	CA-C-N	5.84	132.69	121.54
1	P	109	PRO	C-N-CA	5.84	132.69	121.54
1	P	113	TYR	CA-C-O	-5.83	112.73	119.61
1	P	122	SER	O-C-N	5.83	128.66	123.41
1	P	9	GLN	CA-C-O	-5.80	114.28	120.42
1	P	121	ASN	OD1-CG-ND2	5.77	128.37	122.60
1	P	182	LEU	N-CA-CB	-5.75	101.66	110.12
1	P	5	LYS	N-CA-CB	5.74	118.65	110.16
1	P	84	ARG	NE-CZ-NH1	5.74	127.23	121.50
1	P	101	VAL	CB-CA-C	-5.74	104.40	112.14
1	P	149	ALA	N-CA-CB	5.73	120.91	111.62
1	P	26	THR	CB-CA-C	5.68	121.72	110.42
1	P	76	PHE	CB-CA-C	5.68	119.57	110.09
1	P	93	ASN	O-C-N	-5.66	117.16	123.04
1	P	79	ALA	CA-C-O	5.57	126.42	120.24
1	P	8	ARG	NE-CZ-NH2	-5.53	114.23	119.20
1	P	199	ILE	O-C-N	5.53	127.33	121.91

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	P	58	ILE	CA-C-O	-5.51	114.67	120.57
1	P	199	ILE	CA-C-O	-5.50	115.34	121.17
1	P	200	ALA	N-CA-CB	5.48	118.11	109.94
1	P	4	ASN	CA-CB-CG	5.45	118.05	112.60
1	P	19	ARG	CA-C-O	-5.44	115.09	121.07
1	P	171	ALA	CA-C-O	5.44	126.53	120.82
1	P	65	GLU	N-CA-CB	5.43	118.07	109.71
1	P	4	ASN	O-C-N	5.42	128.94	122.27
1	P	176	VAL	CA-C-O	5.42	126.59	120.95
1	P	97	HIS	CA-CB-CG	-5.42	108.38	113.80
1	P	86	ASP	CB-CG-OD1	5.40	130.83	118.40
1	P	112	HIS	CA-CB-CG	5.40	119.20	113.80
1	P	12	ASP	CA-C-O	-5.30	114.93	120.55
1	P	75	ARG	CG-CD-NE	-5.25	100.44	112.00
1	P	99	THR	O-C-N	5.23	127.66	122.12
1	P	91	VAL	CA-C-O	-5.22	114.96	120.39
1	P	75	ARG	NE-CZ-NH2	-5.22	114.50	119.20
1	P	124	PRO	N-CA-C	5.15	118.44	111.22
1	P	4	ASN	CB-CG-OD1	5.15	131.10	120.80
1	P	187	ILE	N-CA-C	-5.12	107.41	111.81
1	P	109	PRO	O-C-N	-5.11	115.74	122.64
1	P	106	ARG	CD-NE-CZ	5.10	131.55	124.40
1	P	172	HIS	CA-CB-CG	-5.08	108.72	113.80
1	P	8	ARG	CB-CA-C	-5.08	102.36	110.79
1	P	124	PRO	CA-C-O	5.04	129.42	122.31
1	P	155	HIS	CE1-NE2-CD2	-5.04	103.96	109.00
1	P	155	HIS	ND1-CE1-NE2	5.02	113.42	108.40

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	P	1605	0	1617	35	0
2	P	5	0	0	1	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	P	4	0	5	0	0
4	P	1	0	0	0	0
5	P	100	0	0	11	0
All	All	1715	0	1622	35	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 11.

All (35) 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:P:2:GLU:HG3	5:P:496:HOH:O	1.90	0.71
1:P:31:SER:HB3	1:P:40:ILE:HG13	1.71	0.71
1:P:166:LYS:HZ2	1:P:166:LYS:HB3	1.59	0.66
1:P:128:TYR:HB2	1:P:153:GLN:HG2	1.80	0.64
1:P:71:SER:HB2	2:P:301:SO4:O2	1.98	0.64
1:P:205:LYS:HB3	5:P:439:HOH:O	2.00	0.62
1:P:89:ALA:HB1	1:P:164:LEU:HD23	1.83	0.60
1:P:152:LEU:HD11	1:P:158[A]:ILE:HD12	1.80	0.60
1:P:131:PHE:HB2	5:P:405:HOH:O	2.03	0.59
1:P:85:PRO:HG2	5:P:497:HOH:O	2.03	0.59
1:P:75:ARG:HB2	5:P:434:HOH:O	2.04	0.58
1:P:84:ARG:HD2	1:P:144:LEU:O	2.03	0.57
1:P:2:GLU:OE1	1:P:5:LYS:NZ	2.33	0.55
1:P:189:ASP:OD1	1:P:190:PRO:HA	2.07	0.55
1:P:24:GLN:HB2	5:P:410:HOH:O	2.09	0.52
1:P:131:PHE:HD2	5:P:476:HOH:O	1.93	0.51
1:P:17:MET:HG3	1:P:22:LEU:HB2	1.93	0.50
1:P:132:GLY:N	5:P:405:HOH:O	2.45	0.48
1:P:201:VAL:O	1:P:205:LYS:HB2	2.13	0.48
1:P:146:ASN:N	1:P:146:ASN:OD1	2.48	0.47
1:P:2:GLU:HG2	1:P:3:ARG:H	1.79	0.46
1:P:75:ARG:NH1	5:P:407:HOH:O	2.47	0.46
1:P:16:GLU:OE1	1:P:16:GLU:HA	2.15	0.46
1:P:198:GLU:HB2	5:P:483:HOH:O	2.16	0.46
1:P:191:VAL:HG12	1:P:192:PRO:HD2	1.98	0.45
1:P:161:GLU:OE1	1:P:162:VAL:HG13	2.18	0.44
1:P:136:LEU:O	1:P:137:SER:C	2.60	0.44
1:P:81:TYR:CZ	1:P:90:VAL:HG23	2.53	0.43
1:P:1:MET:SD	1:P:1:MET:O	2.77	0.43
1:P:16:GLU:HG3	1:P:168:LEU:HD11	2.02	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:P:58:ILE:HD11	1:P:70:PRO:CB	2.50	0.42
1:P:161:GLU:HA	5:P:467:HOH:O	2.20	0.42
1:P:166:LYS:HB3	1:P:166:LYS:NZ	2.29	0.41
1:P:57:PHE:CZ	1:P:59:ASP:HA	2.56	0.41
1:P:199:ILE:HD13	1:P:199:ILE:HA	1.83	0.40

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	P	209/215 (97%)	195 (93%)	13 (6%)	1 (0%)	24 34

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	P	26	THR

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	P	176/179 (98%)	146 (83%)	30 (17%)	2 2

All (30) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	P	3	ARG
1	P	8	ARG
1	P	9	GLN
1	P	15	LEU
1	P	19	ARG
1	P	24	GLN
1	P	29	ASN
1	P	35	GLN
1	P	45	ILE
1	P	47	TYR
1	P	51	THR
1	P	53	SER
1	P	66	GLU
1	P	68	LYS
1	P	71	SER
1	P	76	PHE
1	P	78[A]	MET
1	P	78[B]	MET
1	P	84	ARG
1	P	136	LEU
1	P	138	GLU
1	P	142	LEU
1	P	145	LYS
1	P	153	GLN
1	P	157	LEU
1	P	161	GLU
1	P	166	LYS
1	P	168	LEU
1	P	170	LEU
1	P	205	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	P	64	HIS
1	P	139	HIS

5.3.3 RNA ⓘ

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 3 ligands modelled in this entry, 1 is monoatomic - leaving 2 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	BME	P	302	1	3,3,3	0.52	0	2,2,2	1.12	0
2	SO4	P	301	-	4,4,4	0.77	0	6,6,6	0.40	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
3	BME	P	302	1	-	1/1/1/1	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	P	302	BME	O1-C1-C2-S2

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	P	301	SO4	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	P	206/215 (95%)	-0.97	0 100 100	10, 26, 52, 72	5 (2%)

There are no RSRZ outliers to report.

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(Å ²)	Q<0.9
2	SO4	P	301	5/5	0.92	0.09	77,77,78,78	0
3	BME	P	302	4/4	0.99	0.03	25,27,29,33	0
4	ZN	P	303	1/1	0.99	0.06	22,22,22,22	0

6.5 Other polymers [i](#)

There are no such residues in this entry.