



Full wwPDB X-ray Structure Validation Report ⓘ

Apr 4, 2026 – 09:59 PM UTC

PDB ID : 2WU8 / pdb_00002wu8
Title : Structural studies of phosphoglucose isomerase from Mycobacterium tuberculosis H37Rv
Authors : Anand, K.
Deposited on : 2009-10-01
Resolution : 2.25 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

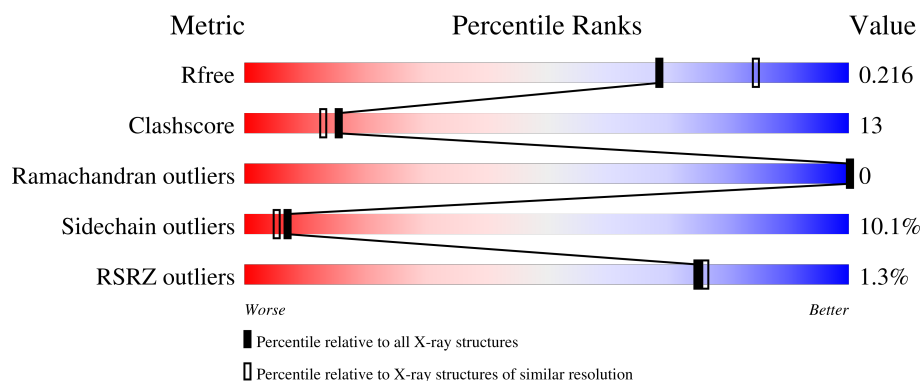
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.25 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	1898 (2.26-2.26)
Clashscore	190562	2005 (2.26-2.26)
Ramachandran outliers	187476	1965 (2.26-2.26)
Sidechain outliers	187428	1966 (2.26-2.26)
RSRZ outliers	180081	1898 (2.26-2.26)

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	549	73% 22% .

2 Entry composition [i](#)

There are 3 unique types of molecules in this entry. The entry contains 4483 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 GLUCOSE-6-PHOSPHATE ISOMERASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	549	Total	C	N	O	S	6	0	0
			4191	2644	738	800	9			

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



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

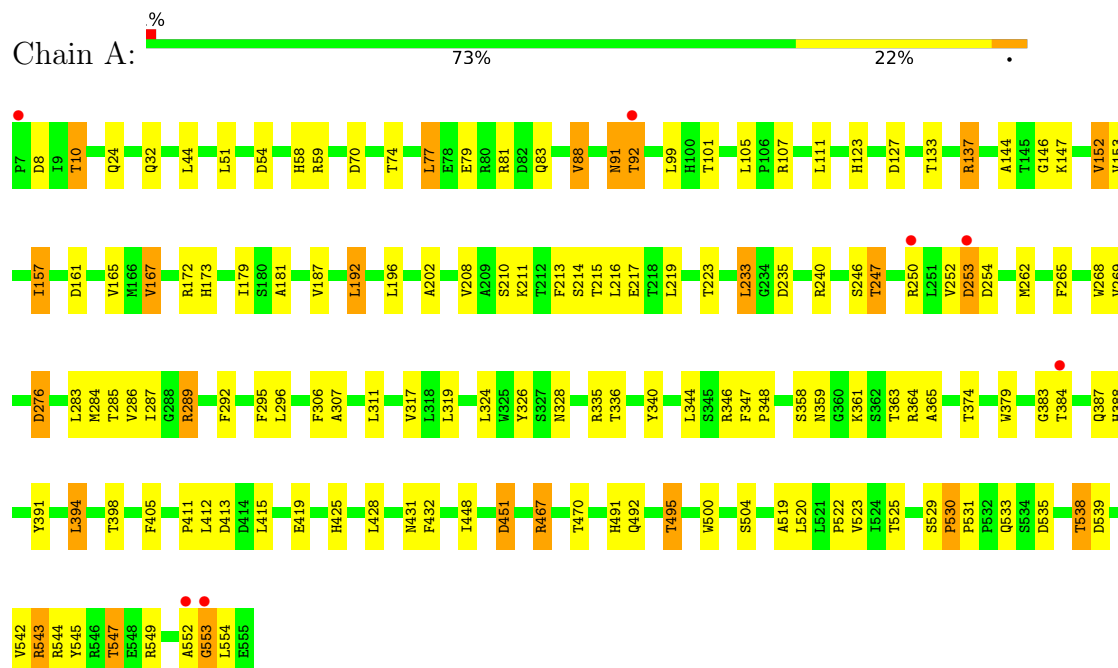
- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	282	Total	O	0	0
			282	282		

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: GLUCOSE-6-PHOSPHATE ISOMERASE



4 Data and refinement statistics

Property	Value	Source
Space group	I 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	109.70Å 118.50Å 137.60Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	29.62 – 2.25 29.62 – 2.25	Depositor EDS
% Data completeness (in resolution range)	99.4 (29.62-2.25) 99.4 (29.62-2.25)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.58 (at 2.24Å)	Xtriage
Refinement program	PHENIX (PHENIX.REFINE)	Depositor
R, R_{free}	0.182 , 0.223 0.173 , 0.216	Depositor DCC
R_{free} test set	1278 reflections (3.00%)	wwPDB-VP
Wilson B-factor (Å ²)	41.5	Xtriage
Anisotropy	0.314	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 48.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	4483	wwPDB-VP
Average B, all atoms (Å ²)	46.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.64% 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: SO4

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	0/4288	0.85	6/5846 (0.1%)

There are no bond length outliers.

All (6) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	253	ASP	N-CA-C	-8.69	95.08	109.24
1	A	529	SER	CA-C-N	7.90	125.43	119.66
1	A	529	SER	C-N-CA	7.90	125.43	119.66
1	A	553	GLY	N-CA-C	-6.03	98.89	113.18
1	A	146	GLY	N-CA-C	5.89	122.62	115.31
1	A	530	PRO	O-C-N	5.50	123.84	121.31

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	4191	0	4068	111	0
2	A	10	0	0	0	0
3	A	282	0	0	11	1
All	All	4483	0	4068	111	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 13.

All (111) 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:543:ARG:HH11	1:A:543:ARG:HG2	1.22	1.01
1:A:289:ARG:HH21	1:A:289:ARG:HG3	1.25	0.99
1:A:374:THR:O	1:A:500:TRP:CH2	2.16	0.98
1:A:92:THR:HG21	1:A:365:ALA:HB1	1.56	0.87
1:A:192:LEU:CD2	1:A:196:LEU:HD22	2.10	0.82
1:A:374:THR:O	1:A:500:TRP:CZ3	2.34	0.81
1:A:328:ASN:HD21	1:A:500:TRP:HE1	1.29	0.80
1:A:335:ARG:HH12	1:A:492:GLN:HE22	1.26	0.80
1:A:144:ALA:HA	1:A:240:ARG:HD2	1.67	0.77
1:A:328:ASN:ND2	1:A:500:TRP:HE1	1.88	0.72
1:A:543:ARG:HG2	1:A:543:ARG:NH1	2.00	0.70
1:A:491:HIS:O	1:A:495:THR:HG23	1.92	0.69
1:A:250:ARG:C	1:A:253:ASP:O	2.37	0.68
1:A:413:ASP:OD2	3:A:2216:HOH:O	2.11	0.67
1:A:543:ARG:HH11	1:A:543:ARG:CG	2.04	0.66
1:A:213:PHE:O	1:A:219:LEU:HD11	1.97	0.65
1:A:328:ASN:HD21	1:A:500:TRP:NE1	1.96	0.64
1:A:289:ARG:HG3	1:A:289:ARG:NH2	2.04	0.64
1:A:543:ARG:O	1:A:547:THR:HG23	1.98	0.64
1:A:58:HIS:HE1	1:A:470:THR:OG1	1.80	0.64
1:A:91:ASN:HD22	1:A:91:ASN:C	2.07	0.62
1:A:167:VAL:HG13	1:A:283:LEU:HD13	1.81	0.62
1:A:363:THR:HG22	1:A:364:ARG:O	2.02	0.60
1:A:553:GLY:O	1:A:554:LEU:HB2	2.01	0.60
1:A:250:ARG:O	1:A:253:ASP:O	2.20	0.60
1:A:107:ARG:NH1	1:A:127:ASP:OD2	2.35	0.59
1:A:250:ARG:O	1:A:250:ARG:HG2	2.02	0.59
1:A:535:ASP:OD2	1:A:538:THR:HG23	2.03	0.58
1:A:133:THR:HG21	1:A:284:MET:HG2	1.85	0.57
1:A:359:ASN:OD1	1:A:504:SER:HB3	2.03	0.57
1:A:167:VAL:CG1	1:A:283:LEU:HD13	2.34	0.56
1:A:289:ARG:HH21	1:A:289:ARG:CG	2.09	0.56
1:A:547:THR:HA	1:A:552:ALA:HB3	1.87	0.56
1:A:219:LEU:O	1:A:223:THR:HG22	2.05	0.56
1:A:394:LEU:O	1:A:467:ARG:HD2	2.06	0.56
1:A:210:SER:OG	1:A:213:PHE:HA	2.06	0.56
1:A:70:ASP:O	1:A:74:THR:HG23	2.06	0.55

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:523:VAL:HG13	1:A:530:PRO:HB3	1.89	0.55
1:A:192:LEU:HD21	1:A:196:LEU:HD22	1.86	0.54
1:A:8:ASP:CG	1:A:10:THR:HG22	2.33	0.54
1:A:173:HIS:HE1	3:A:2216:HOH:O	1.91	0.54
1:A:246:SER:C	1:A:262:MET:HE3	2.32	0.54
1:A:523:VAL:HG12	1:A:542:VAL:HG11	1.89	0.54
1:A:167:VAL:CG1	1:A:283:LEU:HD22	2.38	0.54
1:A:448:ILE:O	1:A:451:ASP:HB3	2.07	0.53
1:A:58:HIS:HD2	1:A:326:TYR:OH	1.91	0.53
1:A:211:LYS:HD2	1:A:247:THR:HB	1.90	0.53
1:A:77:LEU:HD11	1:A:495:THR:HB	1.91	0.53
1:A:161:ASP:O	1:A:165:VAL:HG12	2.08	0.53
1:A:336:THR:HA	1:A:379:TRP:O	2.09	0.53
1:A:133:THR:HG23	3:A:2074:HOH:O	2.08	0.52
1:A:374:THR:O	1:A:500:TRP:CZ2	2.63	0.52
1:A:211:LYS:HE2	1:A:265:PHE:O	2.10	0.52
1:A:32:GLN:HG3	3:A:2017:HOH:O	2.10	0.52
1:A:361:LYS:HE3	3:A:2254:HOH:O	2.09	0.51
1:A:387:GLN:HE22	1:A:431:ASN:ND2	2.09	0.51
1:A:157:ILE:CD1	1:A:215:THR:HG21	2.41	0.51
1:A:133:THR:OG1	1:A:285:THR:HA	2.11	0.51
1:A:346:ARG:HD3	3:A:2174:HOH:O	2.09	0.51
1:A:317:VAL:HA	1:A:495:THR:HG21	1.91	0.51
1:A:324:LEU:HG	1:A:328:ASN:HD22	1.75	0.51
1:A:387:GLN:HA	1:A:391:TYR:CG	2.46	0.51
1:A:286:VAL:HG23	1:A:287:ILE:HG23	1.92	0.51
1:A:387:GLN:HA	1:A:391:TYR:CD1	2.46	0.50
1:A:535:ASP:CG	1:A:538:THR:HG23	2.36	0.50
1:A:167:VAL:HG11	1:A:283:LEU:HD22	1.93	0.50
1:A:202:ALA:HA	1:A:233:LEU:HD21	1.94	0.50
1:A:83:GLN:HB3	1:A:88:VAL:CG2	2.43	0.48
1:A:99:LEU:HB2	1:A:268:TRP:CE3	2.48	0.48
1:A:187:VAL:HB	1:A:217:GLU:HG3	1.96	0.47
1:A:83:GLN:HB3	1:A:88:VAL:HG21	1.96	0.47
1:A:519:ALA:O	1:A:522:PRO:HD2	2.16	0.46
1:A:144:ALA:CA	1:A:240:ARG:HD2	2.41	0.46
1:A:539:ASP:O	1:A:543:ARG:HD3	2.17	0.45
1:A:123:HIS:HD2	3:A:2071:HOH:O	1.99	0.45
1:A:44:LEU:HD13	3:A:2034:HOH:O	2.15	0.45
1:A:347:PHE:HB3	1:A:348:PRO:HD3	1.98	0.45
1:A:543:ARG:NH1	1:A:543:ARG:CG	2.69	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:81:ARG:HD2	1:A:307:ALA:HA	1.98	0.45
1:A:105:LEU:O	1:A:123:HIS:HE1	2.00	0.45
1:A:79:GLU:HB2	3:A:2047:HOH:O	2.16	0.44
1:A:384:THR:O	1:A:384:THR:CG2	2.65	0.44
1:A:54:ASP:OD1	1:A:54:ASP:C	2.61	0.44
1:A:101:THR:HG22	3:A:2058:HOH:O	2.17	0.44
1:A:192:LEU:HD22	1:A:196:LEU:HD22	1.94	0.44
1:A:250:ARG:O	1:A:250:ARG:CG	2.65	0.43
1:A:58:HIS:CD2	1:A:326:TYR:OH	2.70	0.43
1:A:544:ARG:HA	1:A:544:ARG:HD3	1.89	0.43
1:A:8:ASP:OD2	1:A:10:THR:HG22	2.18	0.43
1:A:405:PHE:HB3	1:A:432:PHE:CE1	2.54	0.43
1:A:137:ARG:HD2	1:A:285:THR:O	2.19	0.42
1:A:276:ASP:OD1	1:A:276:ASP:N	2.52	0.42
1:A:91:ASN:C	1:A:91:ASN:ND2	2.72	0.42
1:A:411:PRO:HB3	1:A:425:HIS:CG	2.55	0.42
1:A:289:ARG:NH2	1:A:289:ARG:CG	2.75	0.41
1:A:59:ARG:HD3	3:A:2013:HOH:O	2.19	0.41
1:A:530:PRO:HA	1:A:531:PRO:HD3	1.91	0.41
1:A:92:THR:HG21	1:A:365:ALA:CB	2.40	0.41
1:A:340:TYR:CD1	1:A:383:GLY:HA3	2.56	0.41
1:A:219:LEU:HD23	1:A:219:LEU:HA	1.78	0.41
1:A:81:ARG:HG3	1:A:306:PHE:CE2	2.56	0.41
1:A:152:VAL:O	1:A:181:ALA:HA	2.20	0.41
1:A:252:VAL:HG21	1:A:262:MET:HG3	2.02	0.41
1:A:292:PHE:O	1:A:295:PHE:HB3	2.21	0.41
1:A:384:THR:O	1:A:388:HIS:HD2	2.04	0.40
1:A:358:SER:HB3	1:A:504:SER:HB2	2.03	0.40
1:A:545:TYR:OH	1:A:549:ARG:HD2	2.21	0.40
1:A:157:ILE:HD11	1:A:215:THR:HG21	2.02	0.40
1:A:187:VAL:HB	1:A:217:GLU:CG	2.51	0.40
1:A:276:ASP:HB2	1:A:296:LEU:HD22	2.04	0.40
1:A:214:SER:HA	1:A:219:LEU:HD12	2.04	0.40

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)
3:A:2195:HOH:O	3:A:2195:HOH:O[6_545]	1.99	0.21

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	547/549 (100%)	535 (98%)	12 (2%)	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	437/440 (99%)	393 (90%)	44 (10%)	7	5

All (44) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	10	THR
1	A	24	GLN
1	A	51	LEU
1	A	77	LEU
1	A	88	VAL
1	A	91	ASN
1	A	92	THR
1	A	111	LEU
1	A	137	ARG
1	A	147	LYS
1	A	152	VAL
1	A	153	VAL
1	A	157	ILE

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Mol	Chain	Res	Type
1	A	167	VAL
1	A	172	ARG
1	A	179	ILE
1	A	192	LEU
1	A	208	VAL
1	A	216	LEU
1	A	233	LEU
1	A	235	ASP
1	A	247	THR
1	A	254	ASP
1	A	269	VAL
1	A	276	ASP
1	A	289	ARG
1	A	311	LEU
1	A	319	LEU
1	A	344	LEU
1	A	394	LEU
1	A	398	THR
1	A	412	LEU
1	A	415	LEU
1	A	419	GLU
1	A	428	LEU
1	A	451	ASP
1	A	467	ARG
1	A	495	THR
1	A	520	LEU
1	A	525	THR
1	A	533	GLN
1	A	538	THR
1	A	543	ARG
1	A	547	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (14) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	58	HIS
1	A	91	ASN
1	A	123	HIS
1	A	154	ASN
1	A	169	GLN
1	A	173	HIS
1	A	258	ASN

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Mol	Chain	Res	Type
1	A	328	ASN
1	A	388	HIS
1	A	392	GLN
1	A	425	HIS
1	A	431	ASN
1	A	456	HIS
1	A	492	GLN

5.3.3 RNA ⓘ

There are no RNA molecules 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 oligosaccharides in this entry.

5.6 Ligand geometry ⓘ

2 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	SO4	A	1556	-	4,4,4	0.23	0	6,6,6	0.16	0
2	SO4	A	1557	-	4,4,4	0.95	0	6,6,6	0.43	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.

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	549/549 (100%)	-0.31	7 (1%) 75 76	24, 43, 72, 99	2 (0%)

All (7) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	7	PRO	4.3
1	A	553	GLY	4.2
1	A	384	THR	3.2
1	A	552	ALA	3.0
1	A	92	THR	2.3
1	A	253	ASP	2.2
1	A	250	ARG	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 [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	A	1557	5/5	0.81	0.15	116,121,126,127	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
2	SO4	A	1556	5/5	0.88	0.10	85,85,86,88	0

6.5 Other polymers [i](#)

There are no such residues in this entry.