Full wwPDB X-ray Structure Validation Report (i)

Apr 28, 2024 – 01:45 am BST

PDB ID	:	4CCH
Title	:	Crystal structure of the large fragment of DNA polymerase I from Thermus Aquaticus in an open binary complex with d5SICS as templating nucleotide
Authors	:	Betz, K.; Malyshev, D.A.; Lavergne, T.; Welte, W.; Diederichs, K.; Romesberg, F.E.; Marx, A.
Deposited on	:	2013-10-23
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 (i) 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 (i)) were used in the production of this report:

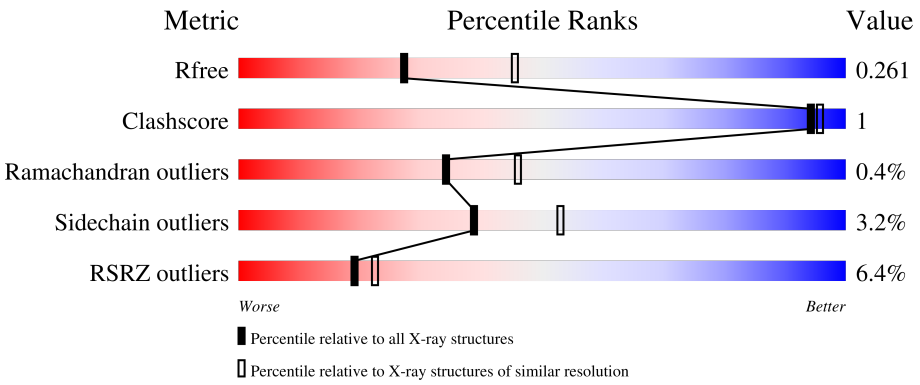
MolProbity	:	4.02b-467
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	1.13
EDS	:	2.36.2
Percentile statistics	:	20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac	:	5.8.0158
CCP4	:	7.0.044 (Gargrove)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.36.2

1 Overall quality at a glance (i)

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))
R_{free}	130704	1284 (2.56-2.52)
Clashscore	141614	1332 (2.56-2.52)
Ramachandran outliers	138981	1315 (2.56-2.52)
Sidechain outliers	138945	1315 (2.56-2.52)
RSRZ outliers	127900	1272 (2.56-2.52)

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 <=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	540	6%; 91%; 6% •
2	B	12	92%; 8%
3	C	16	69%; 12%; 19%

2 Entry composition (i)

There are 7 unique types of molecules in this entry. The entry contains 9408 atoms, of which 4551 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 DNA POLYMERASE I, THERMOSTABLE.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	H	N	O	S			
1	A	528	8458	2672	4253	757	764	12	0	0	0

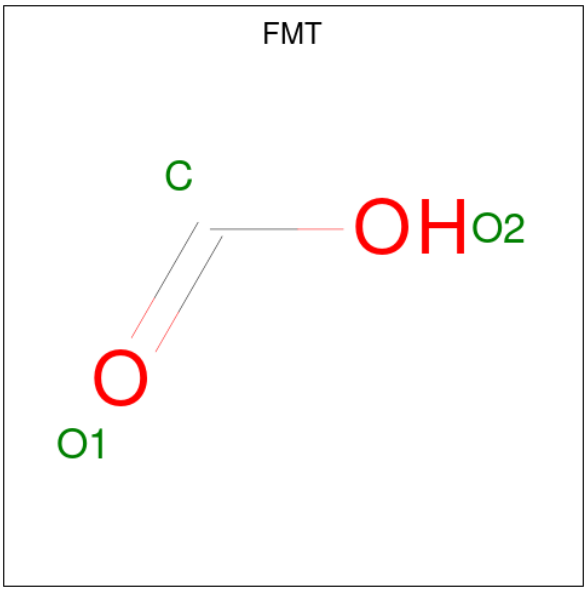
- Molecule 2 is a DNA chain called 5'-D(*GP*AP*CP*CP*AP*CP*GP*GP*CP*GP*CP*DOC)-3'.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	H	N	O	P			
2	B	12	374	114	134	48	67	11	0	0	0

- Molecule 3 is a DNA chain called 5'-D(*AP*AP*CP*LHOP*GP*GP*CP*GP*CP*CP*GP*TP*GP*GP*TP* C)-3'.

Mol	Chain	Residues	Atoms							ZeroOcc	AltConf	Trace
			Total	C	H	N	O	P	S			
3	C	13	421	131	150	47	79	13	1	0	0	0

- Molecule 4 is FORMIC ACID (three-letter code: FMT) (formula: CH_2O_2).

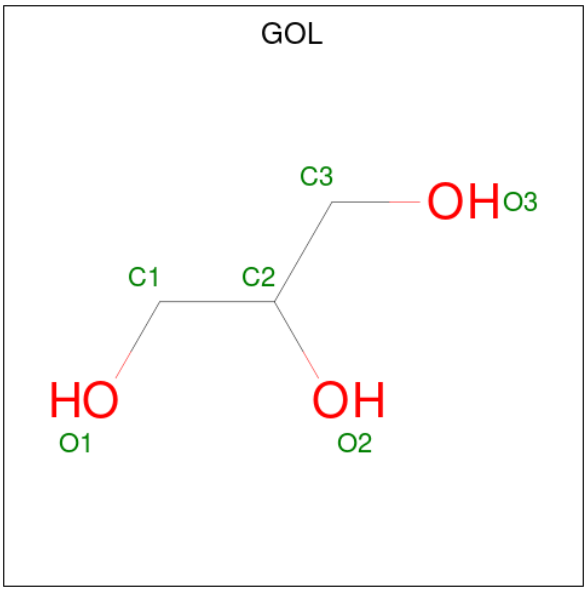


Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	H	O		
4	A	1	5	1	2	2	0	0
			Total	C	H	O		
4	A	1	5	1	2	2	0	0
			Total	C	H	O		
4	A	1	4	1	1	2	0	0
			Total	C	H	O		
4	A	1	4	1	1	2	0	0

- Molecule 5 is MAGNESIUM ION (three-letter code: MG) (formula: Mg).

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

- Molecule 6 is GLYCEROL (three-letter code: GOL) (formula: $C_3H_8O_3$).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	H	O		
6	C	1	14	3	8	3	0	0

- Molecule 7 is water.

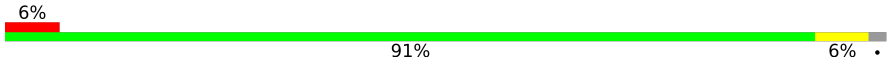
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
7	A	105	105	105	0	0
			Total	O		
7	B	13	13	13	0	0
			Total	O		
7	C	4	4	4	0	0

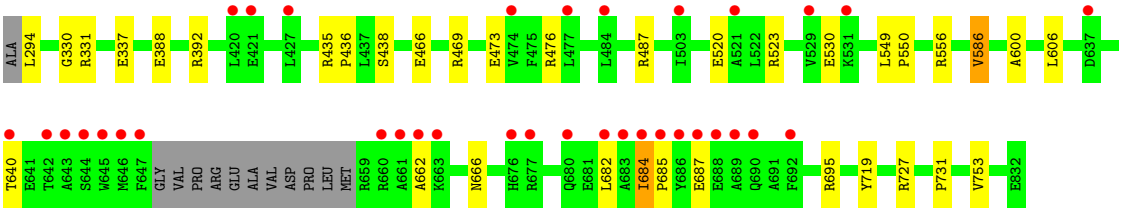
3 Residue-property plots (i)

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: DNA POLYMERASE I, THERMOSTABLE

Chain A:



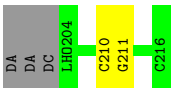


• Molecule 2: 5'-D(*GP*AP*CP*CP*AP*CP*GP*GP*CP*GP*CP*DOC)-3'

Chain B:

• Molecule 3: 5'-D(*AP*AP*CP*LHOP*GP*GP*CP*GP*CP*CP*GP*TP*GP*GP*TP*C)-3'

Chain C:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 31 2 1	Depositor
Cell constants a, b, c, α, β, γ	114.26Å 114.26Å 91.54Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	43.53 – 2.55 48.47 – 2.55	Depositor EDS
% Data completeness (in resolution range)	99.9 (43.53-2.55) 99.9 (48.47-2.55)	Depositor EDS
R_{merge}	0.20	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	0.99 (at 2.54Å)	Xtriage
Refinement program	PHENIX (PHENIX.REFINE)	Depositor
R, R_{free}	0.207 , 0.261 0.212 , 0.261	Depositor DCC
R_{free} test set	1193 reflections (5.22%)	wwPDB-VP
Wilson B-factor (Å^2)	46.8	Xtriage
Anisotropy	0.188	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.38 , 49.2	EDS
L-test for twinning[2]	$< \|L\| > = 0.46$, $< L^2 > = 0.29$	Xtriage
Estimated twinning fraction	0.037 for -h,-k,l	Xtriage
F_o,F_c correlation	0.93	EDS
Total number of atoms	9408	wwPDB-VP
Average B, all atoms (Å^2)	65.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.68% of the height of the origin peak. No significant pseudotranslation is detected.*

[1]Intensities estimated from amplitudes.

[2]Theoretical values of $< |L| >$, $< L^2 >$ 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: DOC, MG, GOL, LHO, FMT

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	0.27	0/4292	0.41	0/5810
2	B	0.61	0/249	0.82	0/382
3	C	0.57	0/277	0.80	0/426
All	All	0.32	0/4818	0.48	0/6618

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 (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	4205	4253	4252	11	0
2	B	240	134	134	0	0
3	C	271	150	150	1	0
4	A	12	6	4	0	0
5	B	1	0	0	0	0
6	C	6	8	8	0	0
7	A	105	0	0	0	0
7	B	13	0	0	0	0
7	C	4	0	0	0	0
All	All	4857	4551	4548	12	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 1.

All (12) 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:294:LEU:N	1:A:330:GLY:O	2.34	0.60
1:A:388:GLU:OE2	1:A:392:ARG:NH2	2.35	0.59
1:A:523:ARG:NE	1:A:530:GLU:OE1	2.38	0.56
1:A:520:GLU:OE2	1:A:523:ARG:NH1	2.40	0.55
1:A:466:GLU:OE1	1:A:469:ARG:NH1	2.45	0.50
3:C:210:DC:H2'	3:C:211:DG:C8	2.48	0.48
1:A:662:ALA:O	1:A:666:ASN:ND2	2.46	0.47
1:A:600:ALA:HB2	1:A:606:LEU:HG	1.98	0.45
1:A:473:GLU:OE2	1:A:476:ARG:NE	2.51	0.44
1:A:549:LEU:HB2	1:A:550:PRO:HD3	2.02	0.42
1:A:435:ARG:N	1:A:436:PRO:HD2	2.35	0.41
1:A:684:ILE:HG13	1:A:685:PRO:HD2	2.03	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	524/540 (97%)	498 (95%)	24 (5%)	2 (0%)	34 46

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	731	PRO
1	A	586	VAL

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	432/441 (98%)	418 (97%)	14 (3%)	39 53

All (14) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	331	ARG
1	A	337	GLU
1	A	438	SER
1	A	487	ARG
1	A	556	ARG
1	A	586	VAL
1	A	640	THR
1	A	682	LEU
1	A	684	ILE
1	A	687	GLU
1	A	695	ARG
1	A	719	TYR
1	A	727	ARG
1	A	753	VAL

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

5.3.3 RNA (i)

There are no RNA molecules in this entry.

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

2 non-standard protein/DNA/RNA residues 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	DOC	B	112	2,3	16,19,20	3.10	7 (43%)	20,26,29	1.36	3 (15%)
3	LHO	C	204	3	20,25,26	0.12	0	27,36,39	0.50	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
2	DOC	B	112	2,3	-	0/7/18/19	0/2/2/2
3	LHO	C	204	3	-	2/7/21/22	0/3/3/3

All (7) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	B	112	DOC	O2-C2	7.16	1.36	1.23
2	B	112	DOC	C2-N3	6.12	1.48	1.36
2	B	112	DOC	C4-N4	4.49	1.44	1.33
2	B	112	DOC	C5-C4	4.34	1.52	1.42
2	B	112	DOC	C6-C5	2.67	1.41	1.35
2	B	112	DOC	C2-N1	2.36	1.45	1.40
2	B	112	DOC	O4'-C1'	-2.29	1.37	1.42

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	B	112	DOC	C3'-C2'-C1'	2.36	105.51	102.78
2	B	112	DOC	O4'-C1'-C2'	2.11	108.96	106.67
2	B	112	DOC	C1'-N1-C2	2.11	121.44	117.74

There are no chirality outliers.

All (2) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	C	204	LHO	O4'-C4'-C5'-O5'
3	C	204	LHO	C3'-C4'-C5'-O5'

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates (i)

There are no monosaccharides in this entry.

5.6 Ligand geometry (i)

Of 6 ligands modelled in this entry, 1 is monoatomic - leaving 5 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	$\#\|Z\| > 2$
4	FMT	A	1836	-	2,2,2	0.71	0	1,1,1	0.45	0
4	FMT	A	1834	-	2,2,2	0.68	0	1,1,1	0.40	0
4	FMT	A	1833	-	2,2,2	0.73	0	1,1,1	0.44	0
4	FMT	A	1835	-	2,2,2	0.70	0	1,1,1	0.44	0
6	GOL	C	1217	-	5,5,5	0.36	0	5,5,5	0.14	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
6	GOL	C	1217	-	-	0/4/4/4	-

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 (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	528/540 (97%)	0.58	35 (6%) 18 21	30, 56, 108, 145	0
2	B	11/12 (91%)	-0.07	0 100 100	36, 42, 70, 73	0
3	C	12/16 (75%)	0.01	0 100 100	30, 43, 59, 66	0
All	All	551/568 (97%)	0.56	35 (6%) 19 22	30, 55, 108, 145	0

All (35) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	689	ALA	6.3
1	A	687	GLU	4.8
1	A	690	GLN	4.8
1	A	661	ALA	4.5
1	A	647	PHE	4.4
1	A	685	PRO	4.3
1	A	688	GLU	4.3
1	A	684	ILE	4.2
1	A	420	LEU	4.2
1	A	676	HIS	4.2
1	A	662	ALA	4.1
1	A	642	THR	4.1
1	A	682	LEU	3.9
1	A	683	ALA	3.2
1	A	646	MET	3.1
1	A	680	GLN	3.1
1	A	474	VAL	3.0
1	A	637	ASP	2.8
1	A	692	PHE	2.7
1	A	503	ILE	2.7
1	A	640	THR	2.6
1	A	677	ARG	2.5
1	A	645	TRP	2.5

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Mol	Chain	Res	Type	RSRZ
1	A	521	ALA	2.5
1	A	663	LYS	2.4
1	A	660	ARG	2.4
1	A	644	SER	2.3
1	A	427	LEU	2.2
1	A	484	LEU	2.2
1	A	529	VAL	2.2
1	A	421	GLU	2.1
1	A	686	TYR	2.1
1	A	531	LYS	2.1
1	A	643	ALA	2.0
1	A	477	LEU	2.0

6.2 Non-standard residues in protein, DNA, RNA chains (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
3	LHO	C	204	23/24	0.82	0.26	52,77,97,98	0
2	DOC	B	112	18/19	0.97	0.15	19,31,42,48	0

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
6	GOL	C	1217	6/6	0.74	0.22	47,63,82,94	0
4	FMT	A	1836	3/3	0.89	0.11	53,60,64,72	0
4	FMT	A	1834	3/3	0.90	0.15	19,19,23,23	5
4	FMT	A	1835	3/3	0.91	0.23	13,13,14,15	4

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
4	FMT	A	1833	3/3	0.93	0.18	20,20,24,24	5
5	MG	B	1112	1/1	0.95	0.06	62,62,62,62	0

6.5 Other polymers (i)

There are no such residues in this entry.