



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 03:10 PM UTC

PDB ID : 4G2O / pdb_00004g2o
Title : Human Thymidylate Synthase M190K with bound Purpurogallin
Authors : Celeste, L.R.; Lebioda, L.
Deposited on : 2012-07-12
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

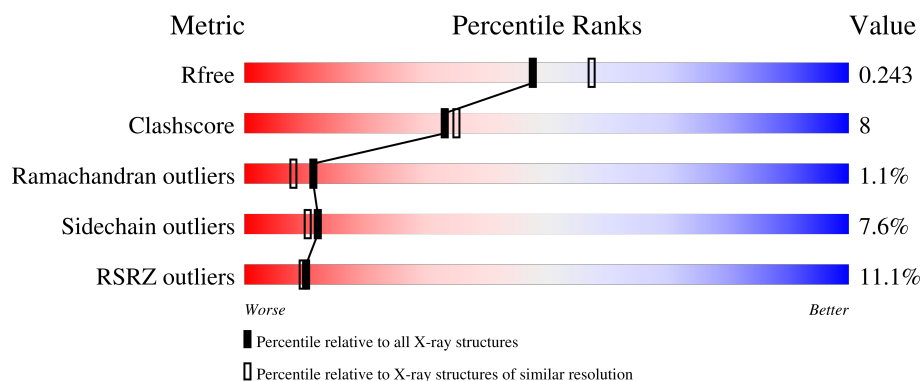
1 Overall quality at a glance

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	X	313	

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
2	TIY	X	500	-	-	-	X

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 2243 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.

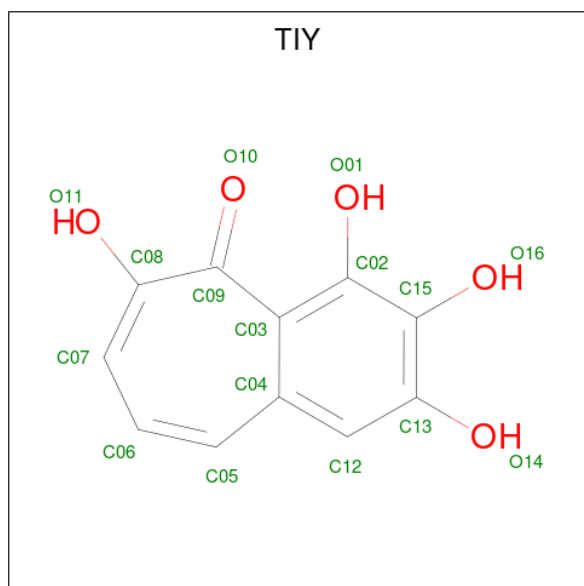
- Molecule 1 is a protein called Thymidylate synthase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	X	273	2155	1374	371	398	12	0	0	0

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
X	190	LYS	MET	engineered mutation	UNP P04818

- Molecule 2 is 2,3,4,6-tetrahydroxy-5H-benzo[7]annulen-5-one (CCD ID: TIY) (formula: $C_{11}H_8O_5$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	C	O		
2	X	1	16	11	5	0	0

- Molecule 3 is SULFATE ION (CCD ID: SO4) (formula: O_4S).



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

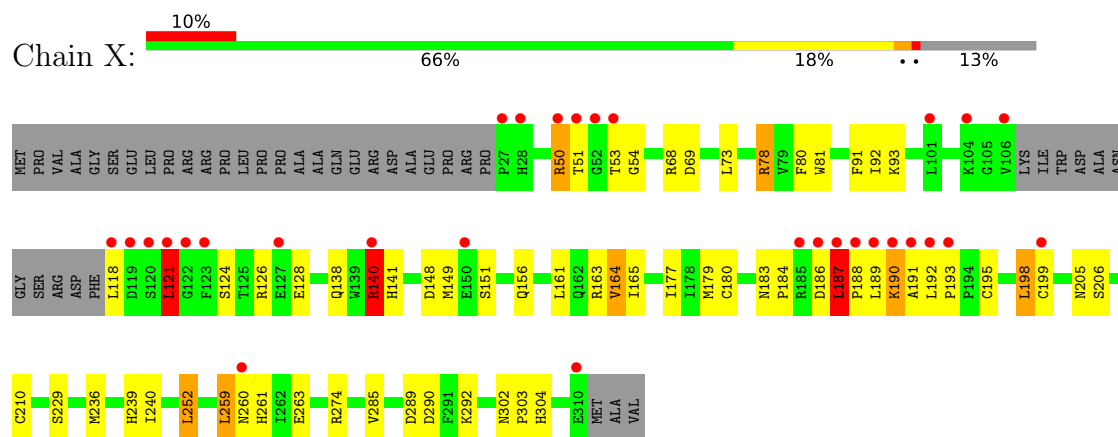
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	X	62	Total	O	0	0
			62	62		

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: Thymidylate synthase



4 Data and refinement statistics

Property	Value	Source
Space group	P 31 2 1	Depositor
Cell constants a, b, c, α , β , γ	95.73Å 95.73Å 80.41Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	50.00 – 2.25 50.00 – 2.25	Depositor EDS
% Data completeness (in resolution range)	87.2 (50.00-2.25) 87.2 (50.00-2.25)	Depositor EDS
R_{merge}	0.05	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	5.47 (at 2.24Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.224 , 0.246 0.218 , 0.243	Depositor DCC
R_{free} test set	910 reflections (4.42%)	wwPDB-VP
Wilson B-factor (Å ²)	42.2	Xtriage
Anisotropy	0.424	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.35 , 38.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.028 for -h,-k,l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	2243	wwPDB-VP
Average B, all atoms (Å ²)	44.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.71% 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: TIY, CSD, SO4, CME

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	X	1.30	9/2190 (0.4%)	1.23	13/2971 (0.4%)

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	X	140	ARG	C-N	8.51	1.43	1.33
1	X	165	ILE	CA-C	7.90	1.63	1.52
1	X	198	LEU	C-N	-7.63	1.22	1.33
1	X	184	PRO	C-N	-7.37	1.24	1.34
1	X	252	LEU	CA-C	-6.33	1.45	1.52
1	X	229	SER	CA-C	6.16	1.60	1.52
1	X	164	VAL	CA-CB	5.84	1.61	1.54
1	X	240	ILE	CA-C	5.55	1.58	1.52
1	X	80	PHE	CA-C	5.10	1.58	1.53

All (13) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	X	184	PRO	CA-C-N	10.57	135.50	120.28
1	X	184	PRO	C-N-CA	10.57	135.50	120.28
1	X	190	LYS	N-CA-C	-8.70	100.99	111.69
1	X	187	LEU	CA-C-N	-6.80	111.34	119.84
1	X	187	LEU	C-N-CA	-6.80	111.34	119.84
1	X	263	GLU	CA-C-N	-6.61	112.01	119.28
1	X	263	GLU	C-N-CA	-6.61	112.01	119.28
1	X	184	PRO	O-C-N	-6.05	114.85	122.17
1	X	304	HIS	N-CA-C	-5.50	102.03	110.07
1	X	121	LEU	N-CA-C	5.42	122.35	110.80
1	X	183	ASN	CA-C-N	5.26	125.58	119.47
1	X	183	ASN	C-N-CA	5.26	125.58	119.47

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	X	198	LEU	O-C-N	-5.03	117.43	123.31

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	X	2155	0	2064	33	0
2	X	16	0	5	0	0
3	X	10	0	0	1	0
4	X	62	0	0	1	0
All	All	2243	0	2069	33	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 8.

All (33) 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:X:51:THR:OG1	1:X:53:THR:HG22	1.61	1.00
1:X:189:LEU:HD23	1:X:189:LEU:O	1.78	0.82
1:X:78:ARG:HD2	3:X:502:SO4:O1	1.88	0.73
1:X:199:CYS:SG	1:X:210:CYS:SG	2.86	0.72
1:X:239:HIS:HE1	1:X:285:VAL:H	1.34	0.71
1:X:51:THR:HG1	1:X:53:THR:HG22	1.54	0.70
1:X:121:LEU:HD12	1:X:121:LEU:H	1.57	0.68
1:X:260:ASN:O	1:X:261:HIS:HD2	1.77	0.68
1:X:290:ASP:HB3	4:X:650:HOH:O	1.97	0.64
1:X:50:ARG:HH12	1:X:118:LEU:HD12	1.63	0.63
1:X:260:ASN:OD1	1:X:261:HIS:CD2	2.59	0.56
1:X:92:ILE:CD1	1:X:236:MET:HE1	2.38	0.53
1:X:260:ASN:O	1:X:261:HIS:CD2	2.60	0.53
1:X:121:LEU:HD12	1:X:121:LEU:N	2.25	0.52
1:X:189:LEU:O	1:X:189:LEU:CD2	2.56	0.48

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:X:205:ASN:O	1:X:206:SER:HB2	2.14	0.48
1:X:189:LEU:HA	1:X:193:PRO:HD3	1.93	0.48
1:X:140:ARG:NE	1:X:161:LEU:HD23	2.28	0.48
1:X:124:SER:O	1:X:128:GLU:HB2	2.13	0.48
1:X:187:LEU:O	1:X:188:PRO:C	2.56	0.48
1:X:187:LEU:HD22	1:X:189:LEU:HD12	1.96	0.48
1:X:78:ARG:NH1	1:X:303:PRO:HG2	2.30	0.47
1:X:186:ASP:C	1:X:188:PRO:HD2	2.40	0.45
1:X:68:ARG:O	1:X:69:ASP:HB2	2.17	0.45
1:X:92:ILE:HD12	1:X:236:MET:HE1	1.99	0.44
1:X:140:ARG:NH2	1:X:289:ASP:OD1	2.50	0.44
1:X:54:GLY:HA3	1:X:259:LEU:HD22	2.00	0.44
1:X:141:HIS:HD2	1:X:156:GLN:O	2.01	0.44
1:X:239:HIS:CE1	1:X:285:VAL:H	2.24	0.43
1:X:148:ASP:O	1:X:151:SER:HB3	2.18	0.43
1:X:73:LEU:HD21	1:X:81:TRP:HB2	2.01	0.42
1:X:164:VAL:HG21	1:X:179:MET:HE2	2.02	0.41
1:X:190:LYS:C	1:X:192:LEU:H	2.29	0.41

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	X	267/313 (85%)	245 (92%)	19 (7%)	3 (1%)	11 8

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	X	121	LEU
1	X	187	LEU
1	X	191	ALA

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	X	223/269 (83%)	206 (92%)	17 (8%)	12	10

All (17) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	X	50	ARG
1	X	78	ARG
1	X	91	PHE
1	X	93	LYS
1	X	121	LEU
1	X	126	ARG
1	X	138	GLN
1	X	140	ARG
1	X	149	MET
1	X	163	ARG
1	X	177	ILE
1	X	198	LEU
1	X	252	LEU
1	X	259	LEU
1	X	274	ARG
1	X	292	LYS
1	X	302	ASN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (9) such sidechains are listed below:

Mol	Chain	Res	Type
1	X	141	HIS
1	X	160	GLN
1	X	171	ASN
1	X	205	ASN
1	X	239	HIS
1	X	261	HIS
1	X	268	GLN
1	X	270	GLN

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Mol	Chain	Res	Type
1	X	302	ASN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

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
1	CME	X	180	1	8,9,10	1.03	0	6,9,11	3.02	2 (33%)
1	CSD	X	195	1	4,7,8	2.78	2 (50%)	1,8,10	1.97	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
1	CME	X	180	1	-	1/5/8/10	-
1	CSD	X	195	1	-	2/2/6/8	-

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	X	195	CSD	OD1-SG	-4.95	1.43	1.47
1	X	195	CSD	CB-SG	-2.17	1.67	1.79

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	X	180	CME	CZ-CE-SD	-5.48	95.05	113.39
1	X	180	CME	CB-CA-C	-3.90	100.21	110.80

There are no chirality outliers.

All (3) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	X	180	CME	SD-CE-CZ-OH
1	X	195	CSD	CA-CB-SG-OD1
1	X	195	CSD	N-CA-CB-SG

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

3 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	TIY	X	500	-	17,17,17	1.44	3 (17%)	21,25,25	1.22	2 (9%)
3	SO4	X	501	-	4,4,4	0.34	0	6,6,6	0.56	0
3	SO4	X	502	-	4,4,4	0.20	0	6,6,6	0.86	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	TIY	X	500	-	-	-	0/2/2/2

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	X	500	TIY	C08-C09	-3.86	1.33	1.45
2	X	500	TIY	C03-C04	-2.60	1.38	1.42
2	X	500	TIY	C06-C07	2.07	1.45	1.40

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	X	500	TIY	C12-C13-C15	-3.07	118.32	120.45
2	X	500	TIY	C12-C04-C05	-2.93	112.76	118.09

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	X	502	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 ⓘ

6.1 Protein, DNA and RNA chains ⓘ

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	X	271/313 (86%)	0.68	30 (11%) 10 9	22, 40, 80, 86	0

All (30) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	X	192	LEU	7.9
1	X	106	VAL	5.7
1	X	260	ASN	5.7
1	X	121	LEU	5.7
1	X	120	SER	5.6
1	X	118	LEU	5.5
1	X	28	HIS	5.2
1	X	122	GLY	4.6
1	X	191	ALA	4.4
1	X	119	ASP	4.4
1	X	123	PHE	4.2
1	X	188	PRO	4.2
1	X	190	LYS	3.9
1	X	189	LEU	3.9
1	X	187	LEU	3.8
1	X	52	GLY	3.8
1	X	101	LEU	3.4
1	X	50	ARG	2.9
1	X	186	ASP	2.7
1	X	185	ARG	2.7
1	X	51	THR	2.7
1	X	104	LYS	2.7
1	X	127	GLU	2.7
1	X	310	GLU	2.6
1	X	193	PRO	2.5
1	X	53	THR	2.5
1	X	140	ARG	2.4

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Mol	Chain	Res	Type	RSRZ
1	X	27	PRO	2.1
1	X	199	CYS	2.1
1	X	150	GLU	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
1	CSD	X	195	8/9	0.89	0.11	31,39,49,52	0
1	CME	X	180	10/11	0.92	0.15	37,39,65,72	0

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	TIY	X	500	16/16	0.64	0.44	46,49,52,52	16
3	SO4	X	502	5/5	0.94	0.11	58,58,59,59	0
3	SO4	X	501	5/5	0.96	0.07	45,53,55,55	0

6.5 Other polymers [i](#)

There are no such residues in this entry.