



Full wwPDB X-ray Structure Validation Report ⓘ

Aug 26, 2025 – 01:09 pm BST

PDB ID : 9H81 / pdb_00009h81
Title : human carbonic anhydrase I in complex with Sonepiprazole
Authors : Angeli, A.; Ferraroni, M.
Deposited on : 2024-10-28
Resolution : 2.35 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 Phenix2.0rc1
Mogul : 1.8.4, CSD as541be (2020)
Xtriage (Phenix) : 2.0rc1
EDS : 3.0
buster-report : 1.1.7 (2018)
Percentile statistics : 20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4 : 9.0.006 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.45.1

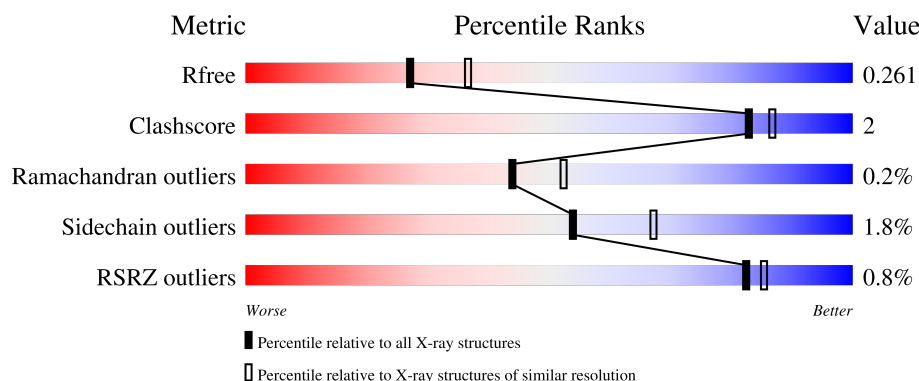
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.35 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}	164625	1460 (2.36-2.36)
Clashscore	180529	1571 (2.36-2.36)
Ramachandran outliers	177936	1559 (2.36-2.36)
Sidechain outliers	177891	1559 (2.36-2.36)
RSRZ outliers	164620	1460 (2.36-2.36)

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	AAA	261	% 92% 6% ..
1	BBB	261	% 91% 7% .

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 4163 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.

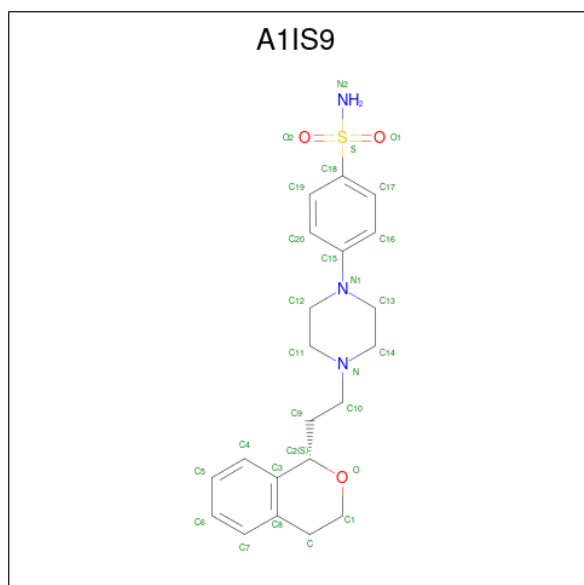
- Molecule 1 is a protein called Carbonic anhydrase 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	AAA	256	Total	C	N	O	S	0	0	0
			2008	1270	349	386	3			
1	BBB	256	Total	C	N	O	S	0	1	0
			2014	1275	350	386	3			

- Molecule 2 is ZINC ION (CCD ID: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	AAA	1	Total	Zn	0	0
			1	1		
2	BBB	1	Total	Zn	0	0
			1	1		

- Molecule 3 is Sonepiprazole (CCD ID: A1IS9) (formula: C₂₁H₂₇N₃O₃S) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	AAA	1	Total	C	N	O	S	0	0
			28	21	3	3	1		
3	BBB	1	Total	C	N	O	S	0	0
			28	21	3	3	1		

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	AAA	43	Total	O	0	0
			43	43		
4	BBB	40	Total	O	0	0
			40	40		

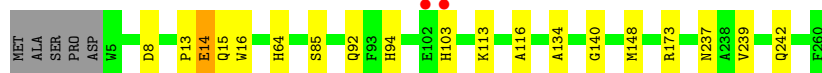
3 Residue-property plots [i](#)

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: Carbonic anhydrase 1



- Molecule 1: Carbonic anhydrase 1



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	62.62Å 71.23Å 121.87Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	61.50 – 2.35 61.50 – 2.35	Depositor EDS
% Data completeness (in resolution range)	99.6 (61.50-2.35) 99.6 (61.50-2.35)	Depositor EDS
R_{merge}	0.12	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.36 (at 2.34Å)	Xtriage
Refinement program	REFMAC 5.8.0258	Depositor
R, R_{free}	0.196 , 0.262 0.202 , 0.261	Depositor DCC
R_{free} test set	1108 reflections (4.74%)	wwPDB-VP
Wilson B-factor (Å ²)	35.9	Xtriage
Anisotropy	0.070	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 18.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	4163	wwPDB-VP
Average B, all atoms (Å ²)	37.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 21.81 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 6.4864e-03. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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: ZN, A1IS9

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	AAA	1.04	1/2065 (0.0%)	1.32	4/2808 (0.1%)
1	BBB	1.06	1/2074 (0.0%)	1.29	0/2819
All	All	1.05	2/4139 (0.0%)	1.31	4/5627 (0.1%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	BBB	239	VAL	N-CA	5.52	1.50	1.46
1	AAA	239	VAL	N-CA	5.10	1.50	1.46

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	AAA	41	ASP	CA-C-N	5.50	128.09	120.29
1	AAA	41	ASP	C-N-CA	5.50	128.09	120.29
1	AAA	98	GLY	CA-C-N	5.05	127.36	120.54
1	AAA	98	GLY	C-N-CA	5.05	127.36	120.54

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	AAA	2008	0	1935	9	0
1	BBB	2014	0	1948	11	0
2	AAA	1	0	0	0	0
2	BBB	1	0	0	0	0
3	AAA	28	0	0	0	0
3	BBB	28	0	0	0	0
4	AAA	43	0	0	0	0
4	BBB	40	0	0	1	0
All	All	4163	0	3883	18	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 2.

All (18) 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:AAA:100:THR:HB	1:BBB:237:ASN:HD21	1.39	0.84
1:BBB:92:GLN:HE21	1:BBB:94:HIS:HD1	1.24	0.84
1:AAA:92:GLN:HE21	1:AAA:94:HIS:HD1	1.28	0.79
1:AAA:232:ASN:ND2	1:AAA:239:VAL:H	1.83	0.76
1:BBB:103:HIS:HB2	1:BBB:113[B]:LYS:HD3	1.76	0.66
1:AAA:158:GLN:NE2	1:AAA:162:ASP:OD1	2.42	0.53
1:AAA:13:PRO:HA	1:AAA:16:TRP:CD2	2.43	0.53
1:AAA:92:GLN:NE2	1:AAA:94:HIS:HD1	2.02	0.52
1:AAA:100:THR:HB	1:BBB:237:ASN:ND2	2.18	0.52
1:BBB:14:GLU:H	1:BBB:14:GLU:CD	2.19	0.51
1:BBB:13:PRO:HA	1:BBB:16:TRP:CD2	2.46	0.50
1:BBB:134:ALA:O	1:BBB:140:GLY:HA3	2.12	0.50
1:AAA:30:PRO:HG3	1:AAA:106:GLU:HB3	1.95	0.48
1:BBB:92:GLN:NE2	1:BBB:94:HIS:HD1	2.03	0.45
1:BBB:14:GLU:HG2	1:BBB:15:GLN:OE1	2.17	0.45
1:AAA:180:ASP:C	1:AAA:180:ASP:OD1	2.60	0.44
1:BBB:64:HIS:HD2	4:BBB:437:HOH:O	2.01	0.43
1:BBB:116:ALA:HB3	1:BBB:148:MET:HB2	2.04	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	AAA	254/261 (97%)	244 (96%)	10 (4%)	0	100	100
1	BBB	255/261 (98%)	242 (95%)	12 (5%)	1 (0%)	30	34
All	All	509/522 (98%)	486 (96%)	22 (4%)	1 (0%)	44	52

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	BBB	8	ASP

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	AAA	222/226 (98%)	218 (98%)	4 (2%)	54	67
1	BBB	223/226 (99%)	219 (98%)	4 (2%)	54	67
All	All	445/452 (98%)	437 (98%)	8 (2%)	54	67

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	AAA	19	LEU
1	AAA	92	GLN
1	AAA	99	SER
1	AAA	213	LYS
1	BBB	14	GLU

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Mol	Chain	Res	Type
1	BBB	85	SER
1	BBB	173	ARG
1	BBB	242	GLN

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

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 ⓘ

Of 4 ligands modelled in this entry, 2 are 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	A1IS9	BBB	302	2	31,31,31	0.49	0	40,44,44	0.84	1 (2%)
3	A1IS9	AAA	302	2	31,31,31	0.47	0	40,44,44	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
3	A1IS9	BBB	302	2	-	6/15/35/35	0/4/4/4
3	A1IS9	AAA	302	2	-	6/15/35/35	1/4/4/4

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	BBB	302	A1IS9	C13-N1-C12	3.25	118.70	111.52

There are no chirality outliers.

All (12) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	AAA	302	A1IS9	O-C2-C9-C10
3	AAA	302	A1IS9	C9-C10-N-C14
3	BBB	302	A1IS9	C9-C10-N-C14
3	BBB	302	A1IS9	C9-C10-N-C11
3	AAA	302	A1IS9	C3-C2-C9-C10
3	BBB	302	A1IS9	C16-C15-N1-C12
3	BBB	302	A1IS9	C19-C18-S-O1
3	AAA	302	A1IS9	C19-C18-S-O1
3	AAA	302	A1IS9	C17-C18-S-O1
3	BBB	302	A1IS9	C17-C18-S-O1
3	BBB	302	A1IS9	C20-C15-N1-C12
3	AAA	302	A1IS9	N-C10-C9-C2

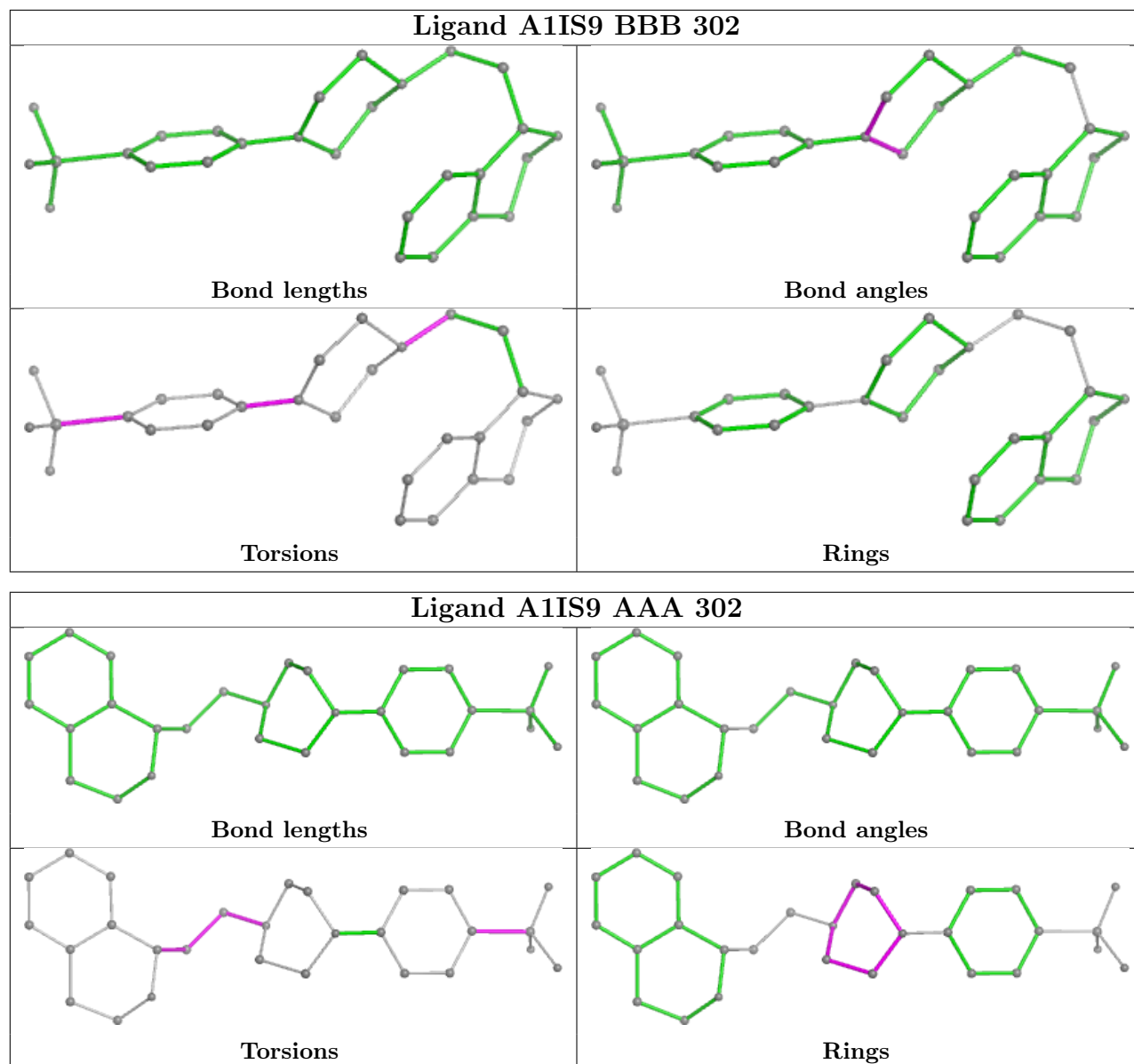
All (1) ring outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	AAA	302	A1IS9	C11-C12-C13-C14-N-N1

No monomer is involved in short contacts.

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and

any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.



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	AAA	256/261 (98%)	-0.11	2 (0%) 82 85	22, 36, 59, 74	0
1	BBB	256/261 (98%)	-0.11	2 (0%) 82 85	21, 34, 53, 84	1 (0%)
All	All	512/522 (98%)	-0.11	4 (0%) 82 85	21, 35, 55, 84	1 (0%)

All (4) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	BBB	103	HIS	4.3
1	AAA	42	THR	3.2
1	BBB	102	GLU	3.2
1	AAA	9	ASP	2.5

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
3	A1IS9	AAA	302	28/28	0.94	0.12	32,60,65,67	0

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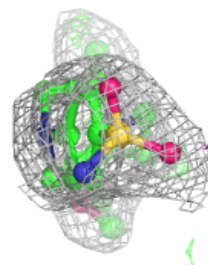
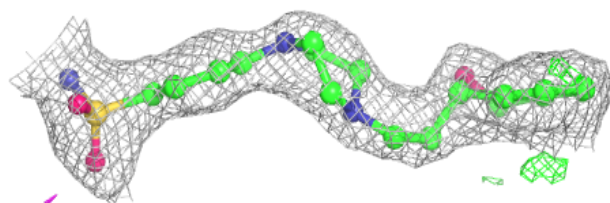
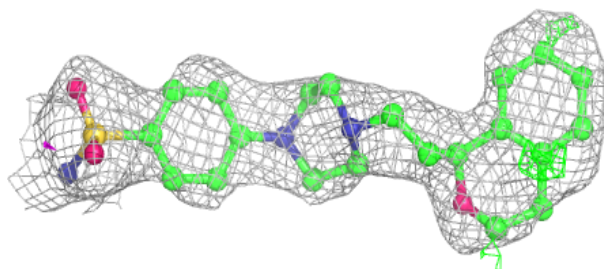
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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	A1IS9	BBB	302	28/28	0.94	0.15	27,74,95,97	0
2	ZN	AAA	301	1/1	1.00	0.02	24,24,24,24	0
2	ZN	BBB	301	1/1	1.00	0.01	22,22,22,22	0

The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.

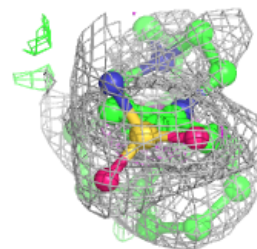
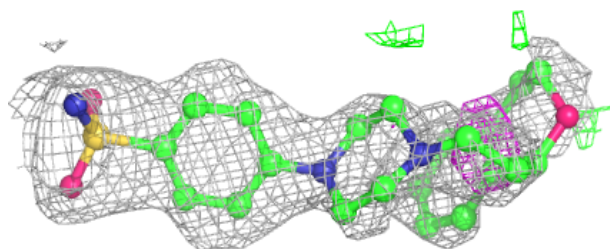
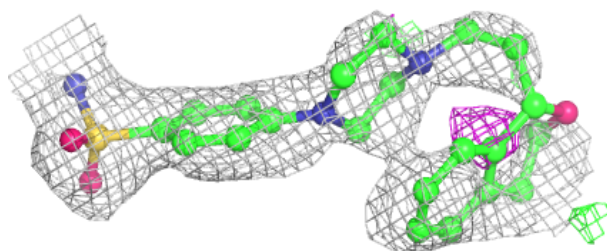
Electron density around A1IS9 AAA 302:

2mF_o-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)



Electron density around A1IS9 BBB 302:

$2mF_o - DF_c$ (at 0.7 rmsd) in gray
 $mF_o - DF_c$ (at 3 rmsd) in purple (negative)
and green (positive)



6.5 Other polymers [i](#)

There are no such residues in this entry.