



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 16, 2025 – 03:08 pm GMT

PDB ID : 9EP2
Title : Crystal structure of the complex of human carbonic anhydrase I with 4-sulfamoylphenyl 3-(p-tolylthio)propanoate
Authors : Angeli, A.; Ferraroni, M.
Deposited on : 2024-03-16
Resolution : 1.47 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	:	4.02b-467
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	1.13
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.003 (Gargrove)
Density-Fitness	:	1.0.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.41

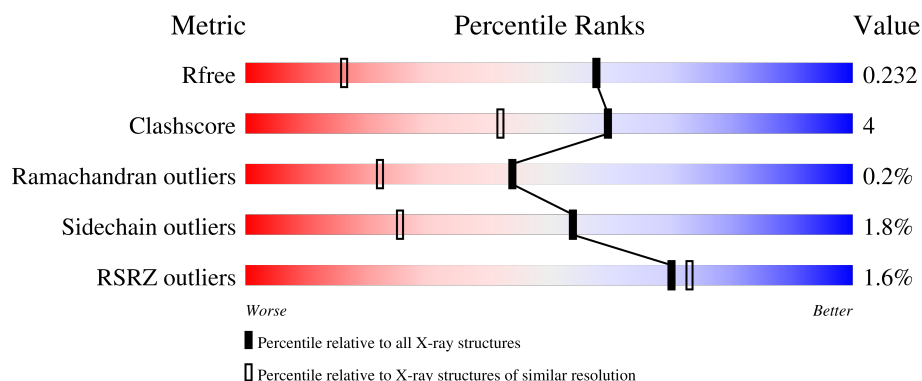
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.47 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	6131 (1.50-1.46)
Clashscore	180529	6623 (1.50-1.46)
Ramachandran outliers	177936	6521 (1.50-1.46)
Sidechain outliers	177891	6518 (1.50-1.46)
RSRZ outliers	164620	6132 (1.50-1.46)

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	<div> <div>%</div> <div> <div></div> <div>90%</div> <div>8%</div> <div>.</div> </div> </div>
1	BBB	261	<div> <div>2%</div> <div> <div></div> <div>91%</div> <div>7%</div> <div>..</div> </div> </div>

2 Entry composition [i](#)

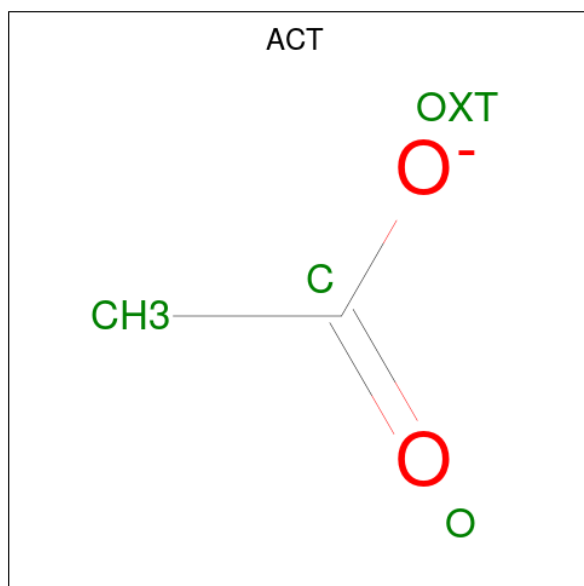
There are 5 unique types of molecules in this entry. The entry contains 4599 atoms, of which 0 are hydrogens and 0 are deuteriums.

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	257	Total	C	N	O	S	0	5	0
			2040	1291	354	392	3			
1	BBB	259	Total	C	N	O	S	0	7	0
			2061	1305	356	397	3			

- Molecule 2 is ACETATE ION (three-letter code: ACT) (formula: $C_2H_3O_2$).

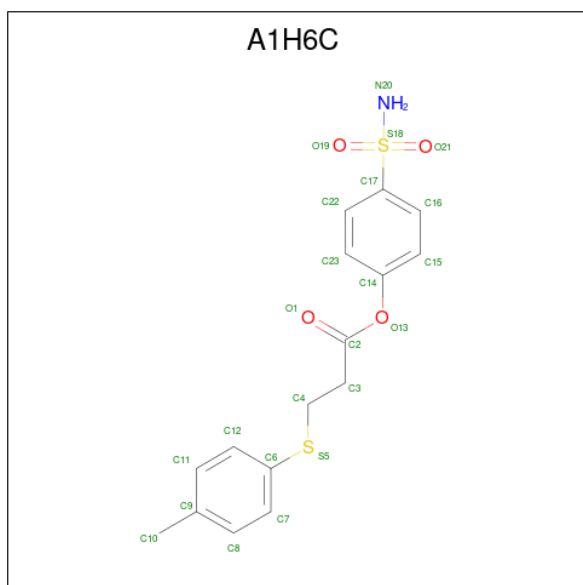


Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	AAA	1	Total	C	O	0	0
			4	2	2		
2	AAA	1	Total	C	O	0	0
			4	2	2		

- Molecule 3 is ZINC ION (three-letter code: ZN) (formula: Zn).

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

- Molecule 4 is (4-sulfamoylphenyl) 3-(4-methylphenyl)sulfanylpropanoate (three-letter code: A1H6C) (formula: C₁₆H₁₇NO₄S₂) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
4	AAA	1	Total	C	N	O	S	0	0
			23	16	1	4	2		
4	BBB	1	Total	C	N	O	S	0	0
			23	16	1	4	2		

- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	AAA	219	Total	O	0	0
			219	219		
5	BBB	223	Total	O	0	0
			223	223		

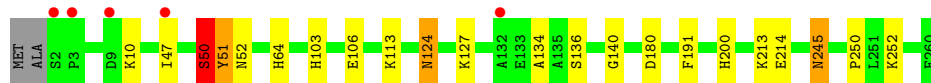
3 Residue-property plots [i](#)

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	62.64Å 70.90Å 121.25Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	61.20 – 1.47 61.20 – 1.47	Depositor EDS
% Data completeness (in resolution range)	99.9 (61.20-1.47) 99.9 (61.20-1.47)	Depositor EDS
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.36 (at 1.47Å)	Xtriage
Refinement program	REFMAC 5.8.0258	Depositor
R, R_{free}	0.160 , 0.209 0.181 , 0.232	Depositor DCC
R_{free} test set	4712 reflections (5.11%)	wwPDB-VP
Wilson B-factor (Å ²)	11.5	Xtriage
Anisotropy	1.648	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 41.5	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	4599	wwPDB-VP
Average B, all atoms (Å ²)	28.0	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 21.44 % 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 7.0042e-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: A1H6C, ZN, ACT

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	0.84	2/2113 (0.1%)	0.92	1/2872 (0.0%)
1	BBB	0.93	3/2138 (0.1%)	0.98	2/2907 (0.1%)
All	All	0.89	5/4251 (0.1%)	0.95	3/5779 (0.1%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	BBB	0	2

All (5) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	BBB	106	GLU	CD-OE2	7.22	1.33	1.25
1	BBB	50[A]	SER	C-O	6.71	1.36	1.23
1	BBB	50[B]	SER	C-O	6.71	1.36	1.23
1	AAA	14	GLU	CD-OE2	6.51	1.32	1.25
1	AAA	14	GLU	CD-OE1	5.17	1.31	1.25

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	BBB	51[A]	TYR	CB-CG-CD2	-6.00	117.40	121.00
1	BBB	51[B]	TYR	CB-CG-CD2	-6.00	117.40	121.00
1	AAA	173	ARG	NE-CZ-NH2	-5.57	117.52	120.30

There are no chirality outliers.

All (2) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	BBB	50[A]	SER	Mainchain
1	BBB	50[B]	SER	Mainchain

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	2040	0	1975	15	0
1	BBB	2061	0	1995	19	0
2	AAA	8	0	6	1	0
3	AAA	1	0	0	0	0
3	BBB	1	0	0	0	0
4	AAA	23	0	0	0	0
4	BBB	23	0	0	0	0
5	AAA	219	0	0	4	0
5	BBB	223	0	0	8	0
All	All	4599	0	3976	34	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 4.

All (34) 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:BBB:52:ASN:OD1	5:BBB:401:HOH:O	1.59	1.20
1:BBB:136:SER:OG	5:BBB:402:HOH:O	1.74	1.05
1:BBB:47:ILE:HD13	1:BBB:191:PHE:CE1	2.12	0.84
1:BBB:213:LYS:HE3	1:BBB:214:GLU:OE2	1.77	0.83
1:AAA:92:GLN:HE21	1:AAA:94:HIS:HD1	1.29	0.79
1:AAA:103[B]:HIS:CD2	1:AAA:113:LYS:HD2	2.20	0.76
1:AAA:156:LYS:HE2	1:AAA:183:THR:O	1.87	0.75
1:AAA:245:ASN:HD22	1:AAA:245:ASN:H	1.44	0.65
1:BBB:200:HIS:HE1	5:BBB:513:HOH:O	1.86	0.57
1:AAA:200:HIS:HE1	5:AAA:476:HOH:O	1.86	0.57
1:BBB:245:ASN:H	1:BBB:245:ASN:HD22	1.52	0.57
1:BBB:47:ILE:CD1	1:BBB:191:PHE:CE1	2.88	0.57
1:BBB:103:HIS:CD2	1:BBB:113:LYS:HB3	2.40	0.56

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:BBB:213:LYS:CE	5:BBB:408:HOH:O	2.53	0.56
1:BBB:213:LYS:NZ	5:BBB:408:HOH:O	2.38	0.55
1:AAA:232:ASN:ND2	1:AAA:239:VAL:H	2.04	0.54
1:AAA:4:ASP:N	5:AAA:402:HOH:O	2.41	0.53
1:BBB:124:ASN:HD22	1:BBB:124:ASN:C	2.13	0.52
1:BBB:47:ILE:HD13	1:BBB:191:PHE:CD1	2.46	0.51
1:BBB:134:ALA:O	1:BBB:140:GLY:HA3	2.13	0.49
1:AAA:103[B]:HIS:CE1	1:AAA:105:SER:O	2.66	0.49
1:BBB:51[A]:TYR:HB2	1:BBB:180:ASP:OD1	2.14	0.47
1:AAA:134:ALA:O	1:AAA:140:GLY:HA3	2.15	0.47
1:BBB:64:HIS:HD2	5:BBB:548:HOH:O	1.98	0.47
1:AAA:64:HIS:HE1	5:AAA:577:HOH:O	1.98	0.46
1:AAA:214:GLU:OE1	5:AAA:401:HOH:O	2.21	0.46
1:BBB:64:HIS:HE1	5:BBB:587:HOH:O	2.00	0.45
1:AAA:137:LYS:HD2	2:AAA:302:ACT:H3	2.00	0.44
1:BBB:214:GLU:HG3	5:BBB:568:HOH:O	2.19	0.43
1:AAA:103[B]:HIS:CG	1:AAA:113:LYS:HD2	2.54	0.42
1:BBB:250:PRO:HB2	1:BBB:252:LYS:HG2	2.02	0.42
1:AAA:245:ASN:HD22	1:AAA:245:ASN:N	2.16	0.40
1:BBB:127:LYS:HE3	1:BBB:127:LYS:HB3	1.89	0.40
1:AAA:92:GLN:NE2	1:AAA:94:HIS:HD1	2.08	0.40

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	AAA	260/261 (100%)	252 (97%)	8 (3%)	0	100	100
1	BBB	264/261 (101%)	253 (96%)	10 (4%)	1 (0%)	30	12
All	All	524/522 (100%)	505 (96%)	18 (3%)	1 (0%)	44	22

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	BBB	10	LYS

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	AAA	228/226 (101%)	222 (97%)	6 (3%)	41	13
1	BBB	231/226 (102%)	227 (98%)	4 (2%)	56	27
All	All	459/452 (102%)	449 (98%)	10 (2%)	54	17

All (10) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	AAA	10	LYS
1	AAA	19	LEU
1	AAA	48	SER
1	AAA	237[A]	ASN
1	AAA	237[B]	ASN
1	AAA	245	ASN
1	BBB	50[A]	SER
1	BBB	50[B]	SER
1	BBB	124	ASN
1	BBB	245	ASN

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 [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 6 ligands modelled in this entry, 2 are monoatomic - leaving 4 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	$\# Z > 2$
2	ACT	AAA	302	-	3,3,3	0.91	0	3,3,3	0.82	0
4	A1H6C	BBB	302	3	24,24,24	0.60	0	33,33,33	0.82	1 (3%)
4	A1H6C	AAA	304	3	24,24,24	0.74	1 (4%)	33,33,33	0.81	1 (3%)
2	ACT	AAA	301	-	3,3,3	1.09	0	3,3,3	0.43	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
4	A1H6C	BBB	302	3	-	8/16/16/16	0/2/2/2
4	A1H6C	AAA	304	3	-	5/16/16/16	0/2/2/2

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	AAA	304	A1H6C	S18-N20	-2.32	1.55	1.60

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	BBB	302	A1H6C	C14-O13-C2	2.80	126.72	119.42
4	AAA	304	A1H6C	O21-S18-N20	2.54	111.12	107.36

There are no chirality outliers.

All (13) torsion outliers are listed below:

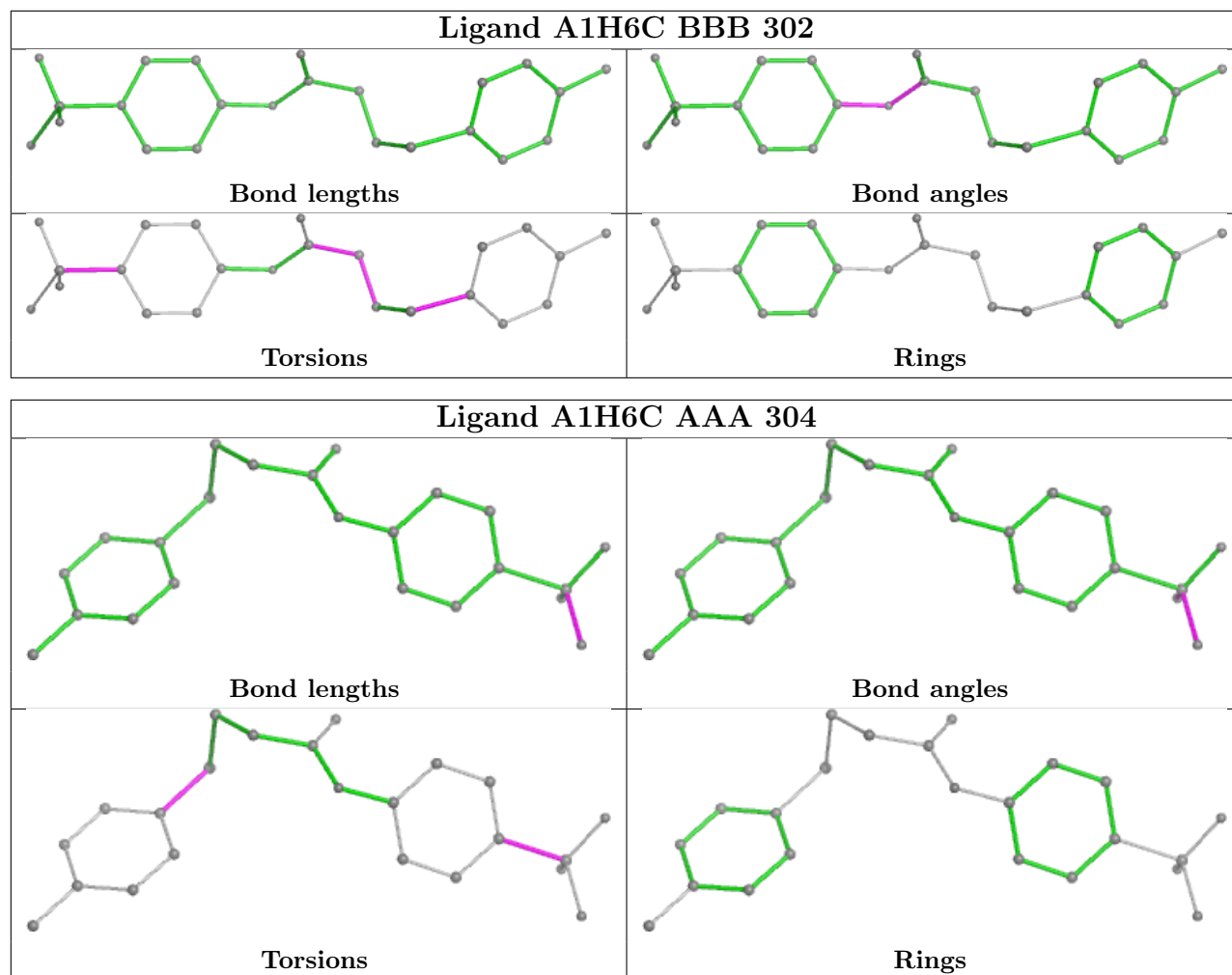
Mol	Chain	Res	Type	Atoms
4	BBB	302	A1H6C	O13-C2-C3-C4
4	BBB	302	A1H6C	C2-C3-C4-S5
4	AAA	304	A1H6C	C22-C17-S18-O21
4	AAA	304	A1H6C	C16-C17-S18-O21
4	BBB	302	A1H6C	O1-C2-C3-C4
4	BBB	302	A1H6C	C16-C17-S18-O19
4	AAA	304	A1H6C	C12-C6-S5-C4
4	AAA	304	A1H6C	C7-C6-S5-C4
4	BBB	302	A1H6C	C7-C6-S5-C4
4	BBB	302	A1H6C	C12-C6-S5-C4
4	BBB	302	A1H6C	C22-C17-S18-O19
4	BBB	302	A1H6C	C16-C17-S18-N20
4	AAA	304	A1H6C	C22-C17-S18-N20

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	AAA	302	ACT	1	0

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	257/261 (98%)	-0.08	3 (1%) 76 79	14, 25, 44, 66	5 (1%)
1	BBB	259/261 (99%)	0.06	5 (1%) 66 69	13, 25, 45, 69	7 (2%)
All	All	516/522 (98%)	-0.01	8 (1%) 70 73	13, 25, 45, 69	12 (2%)

All (8) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	BBB	9	ASP	3.5
1	AAA	19	LEU	3.2
1	BBB	47	ILE	3.2
1	BBB	2	SER	2.8
1	BBB	3	PRO	2.6
1	AAA	42	THR	2.4
1	BBB	132	ALA	2.4
1	AAA	4	ASP	2.3

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 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,

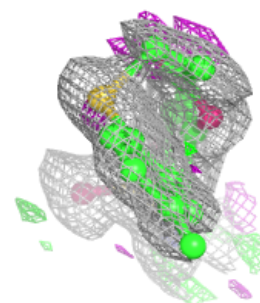
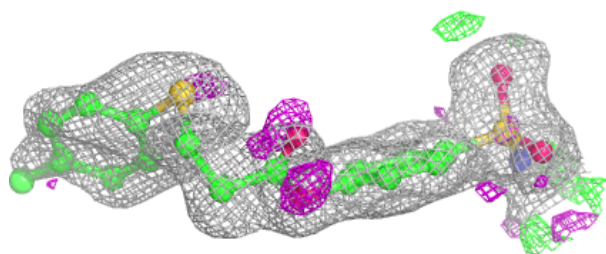
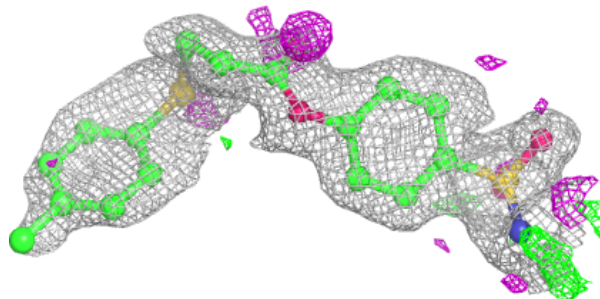
median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å ²)	Q<0.9
2	ACT	AAA	302	4/4	0.82	0.14	45,54,61,62	0
2	ACT	AAA	301	4/4	0.89	0.12	40,40,41,49	0
4	A1H6C	AAA	304	23/23	0.97	0.11	18,35,55,56	0
4	A1H6C	BBB	302	23/23	0.97	0.13	18,43,62,68	0
3	ZN	AAA	303	1/1	0.99	0.02	19,19,19,19	0
3	ZN	BBB	301	1/1	0.99	0.06	21,21,21,21	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.

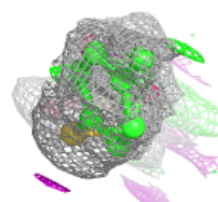
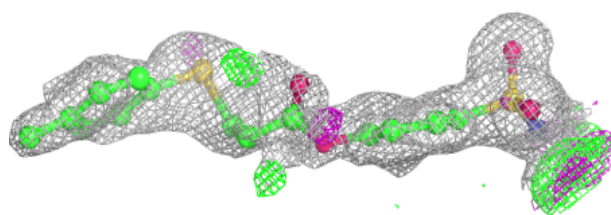
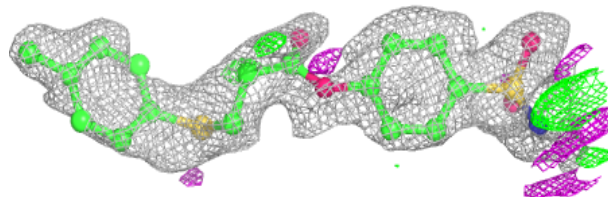
Electron density around A1H6C AAA 304:

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 A1H6C 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.