



Full wwPDB X-ray Structure Validation Report ⓘ

Jun 29, 2026 – 02:06 pm BST

PDB ID : 28OI / pdb_000028oi
Title : The crystal structure of zebrafish HDAC6 CD2 in complex with compound 2
Authors : Sandmark, J.; Ek, M.; Ripa, L.
Deposited on : 2026-02-11
Resolution : 1.98 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 : 1.8.4, CSD as541be (2020)
Xtriage (Phenix) : 2.0
EDS : 3.0
Buster-report : wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4 : 9.0.015 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.50

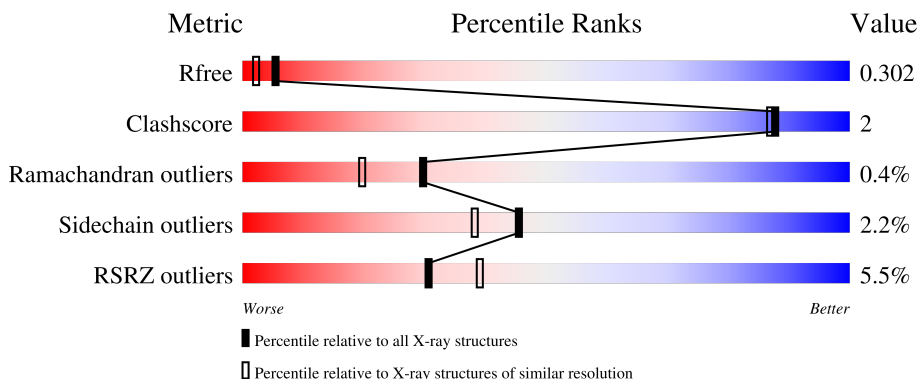
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

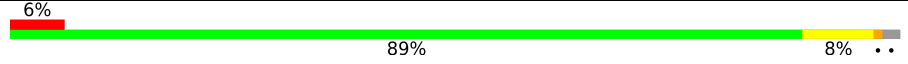
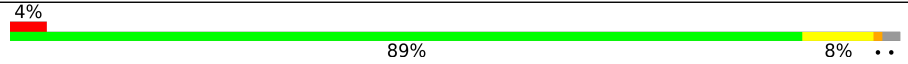
The reported resolution of this entry is 1.98 Å.

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	1506 (1.98-1.98)
Clashscore	190562	1534 (1.98-1.98)
Ramachandran outliers	187476	1518 (1.98-1.98)
Sidechain outliers	187428	1518 (1.98-1.98)
RSRZ outliers	180081	1506 (1.98-1.98)

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	364	 6% 89% 8% ..
1	B	364	 4% 89% 8% ..

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 5891 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 Histone deacetylase 6.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	357	2797	1760	501	518	18	0	2	0
1	B	355	2787	1754	497	518	18	0	5	0

There are 10 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	435	SER	-	expression tag	UNP F8W4B7
A	436	ASN	-	expression tag	UNP F8W4B7
A	437	ALA	-	expression tag	UNP F8W4B7
A	438	GLY	-	expression tag	UNP F8W4B7
A	439	GLY	-	expression tag	UNP F8W4B7
B	435	SER	-	expression tag	UNP F8W4B7
B	436	ASN	-	expression tag	UNP F8W4B7
B	437	ALA	-	expression tag	UNP F8W4B7
B	438	GLY	-	expression tag	UNP F8W4B7
B	439	GLY	-	expression tag	UNP F8W4B7

- Molecule 2 is POTASSIUM ION (CCD ID: K) (formula: K).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	2	Total	K	0	0
			2	2		
2	B	2	Total	K	0	0
			2	2		

- Molecule 3 is ZINC ION (CCD ID: ZN) (formula: Zn).

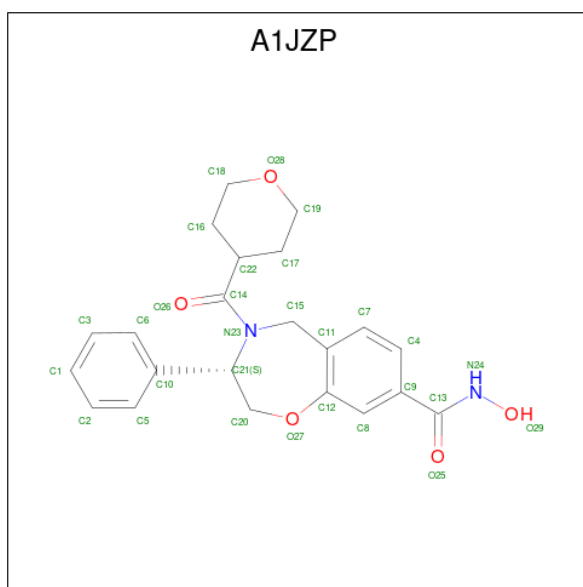
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	Zn	0	0
			1	1		

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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	B	1	Total	Zn	0	0
			1	1		

- Molecule 4 is (3 {S})-4-(oxan-4-ylcarbonyl)- {N}-oxidanyl-3-phenyl-3,5-dihydro-2 {H}-1,4-benzoxazepine-8-carboxamide (CCD ID: A1JZP) (formula: C₂₂H₂₄N₂O₅) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
4	A	1	Total	C	N	O	0	0
			29	22	2	5		
4	B	1	Total	C	N	O	0	0
			29	22	2	5		

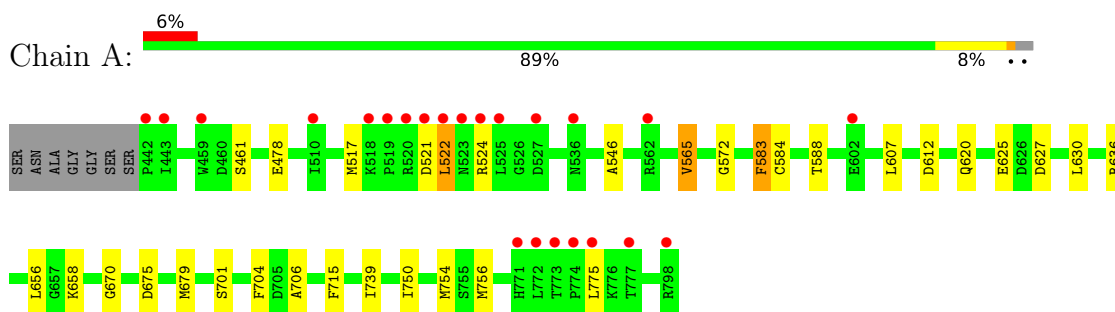
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	122	Total	O	0	0
			122	122		
5	B	121	Total	O	0	0
			121	121		

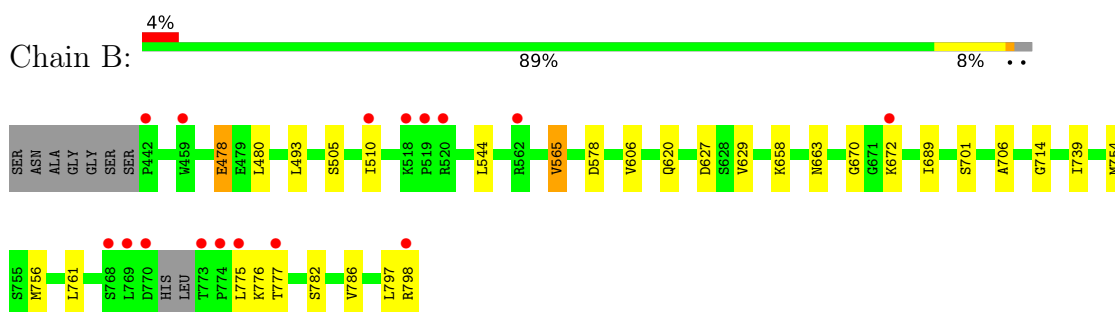
3 Residue-property plots [i](#)

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: Histone deacetylase 6



- Molecule 1: Histone deacetylase 6



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	74.66Å 92.16Å 97.25Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	66.89 – 1.98 66.89 – 1.98	Depositor EDS
% Data completeness (in resolution range)	97.3 (66.89-1.98) 97.3 (66.89-1.98)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.20 (at 1.98Å)	Xtrriage
Refinement program	BUSTER 2.11.7	Depositor
R, R_{free}	0.229 , 0.282 0.246 , 0.302	Depositor DCC
R_{free} test set	2297 reflections (4.98%)	wwPDB-VP
Wilson B-factor (Å ²)	13.7	Xtrriage
Anisotropy	0.945	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 32.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.28$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	5891	wwPDB-VP
Average B, all atoms (Å ²)	16.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 50.20 % 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 6.6964e-05. 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 i

5.1 Standard geometry i

Bond lengths and bond angles in the following residue types are not validated in this section: ZN, K, A1JZP

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	0.85	0/2874	1.34	8/3898 (0.2%)
1	B	0.83	0/2871	1.31	11/3892 (0.3%)
All	All	0.84	0/5745	1.32	19/7790 (0.2%)

There are no bond length outliers.

All (19) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	583	PHE	CA-CB-CG	6.87	120.67	113.80
1	A	522	LEU	N-CA-C	-6.66	103.83	112.23
1	B	478	GLU	CA-C-N	6.35	129.31	120.29
1	B	478	GLU	C-N-CA	6.35	129.31	120.29
1	B	706	ALA	N-CA-C	-5.90	105.74	113.17
1	A	478	GLU	CA-C-N	5.88	128.16	120.28
1	A	478	GLU	C-N-CA	5.88	128.16	120.28
1	B	510	ILE	N-CA-CB	5.63	117.78	110.57
1	B	776	LYS	CA-C-N	5.31	127.71	120.54
1	B	776	LYS	C-N-CA	5.31	127.71	120.54
1	A	612	ASP	N-CA-C	-5.25	102.61	110.23
1	A	620	GLN	CA-C-N	5.23	127.72	120.29
1	A	620	GLN	C-N-CA	5.23	127.72	120.29
1	B	480	LEU	CA-C-N	5.20	129.53	122.19
1	B	480	LEU	C-N-CA	5.20	129.53	122.19
1	B	578	ASP	CA-CB-CG	5.04	117.64	112.60
1	B	505	SER	CA-C-N	5.04	126.99	120.44
1	B	505	SER	C-N-CA	5.04	126.99	120.44
1	A	706	ALA	N-CA-C	-5.03	106.99	113.02

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	2797	0	2722	12	0
1	B	2787	0	2715	10	0
2	A	2	0	0	0	0
2	B	2	0	0	0	0
3	A	1	0	0	0	0
3	B	1	0	0	0	0
4	A	29	0	0	0	0
4	B	29	0	0	0	0
5	A	122	0	0	1	0
5	B	121	0	0	0	0
All	All	5891	0	5437	22	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 (22) 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:546:ALA:HA	1:A:588:THR:HG23	1.90	0.54
1:A:565[B]:VAL:CG2	1:A:754:MET:HE2	2.39	0.53
1:A:625:GLU:HA	1:A:656:LEU:O	2.12	0.49
1:A:517:MET:HB2	1:A:522:LEU:HD13	1.95	0.49
1:B:565[A]:VAL:HG13	1:B:761:LEU:HD12	1.93	0.49
1:A:565[A]:VAL:HG12	1:A:739:ILE:HB	1.96	0.48
1:B:565[A]:VAL:HG12	1:B:739:ILE:HB	1.96	0.47
1:A:572:GLY:HA2	1:A:584:CYS:HB3	1.97	0.47
1:B:620:GLN:HG3	1:B:663:ASN:OD1	2.16	0.46
1:B:627:ASP:HB3	1:B:658:LYS:O	2.15	0.46
1:B:565[B]:VAL:CG2	1:B:754:MET:HE2	2.46	0.45
1:A:636:ARG:HD2	1:A:715:PHE:CE1	2.51	0.45
1:A:704:PHE:HB2	1:A:750:ILE:HG22	2.00	0.43
1:B:606:VAL:O	1:B:629:VAL:HA	2.17	0.43
1:B:493:LEU:HD23	1:B:544:LEU:HG	2.00	0.43
1:B:782:SER:O	1:B:786:VAL:HG23	2.19	0.43
1:B:689:ILE:HG13	1:B:797:LEU:HD21	2.01	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:627:ASP:HB3	1:A:658:LYS:O	2.19	0.42
1:A:756:MET:HG2	5:A:910:HOH:O	2.19	0.41
1:A:607:LEU:HD13	1:A:630:LEU:HD23	2.03	0.40
1:A:675:ASP:O	1:A:679:MET:HG2	2.21	0.40
1:B:672:LYS:HG3	1:B:714:GLY:O	2.21	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	A	357/364 (98%)	343 (96%)	12 (3%)	2 (1%)	21	12
1	B	356/364 (98%)	343 (96%)	12 (3%)	1 (0%)	36	27
All	All	713/728 (98%)	686 (96%)	24 (3%)	3 (0%)	30	20

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	521	ASP
1	A	670	GLY
1	B	670	GLY

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	303/305 (99%)	296 (98%)	7 (2%)	44	37
1	B	303/305 (99%)	295 (97%)	8 (3%)	40	32
All	All	606/610 (99%)	591 (98%)	15 (2%)	45	33

All (15) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	461	SER
1	A	524	ARG
1	A	565[A]	VAL
1	A	565[B]	VAL
1	A	583	PHE
1	A	701	SER
1	A	775	LEU
1	B	478	GLU
1	B	565[A]	VAL
1	B	565[B]	VAL
1	B	701	SER
1	B	756	MET
1	B	775	LEU
1	B	777	THR
1	B	798	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (7) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	457	ASN
1	A	516	HIS
1	A	645	ASN
1	A	663	ASN
1	B	462	HIS
1	B	530	ASN
1	B	727	HIS

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 8 ligands modelled in this entry, 6 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
4	A1JZP	A	804	3	30,32,32	0.99	2 (6%)	35,44,44	1.03	1 (2%)
4	A1JZP	B	804	3	30,32,32	0.95	2 (6%)	35,44,44	1.13	2 (5%)

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	A1JZP	A	804	3	-	4/18/39/39	1/3/4/4
4	A1JZP	B	804	3	-	2/18/39/39	1/3/4/4

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	A	804	A1JZP	C13-N24	3.96	1.37	1.32
4	B	804	A1JZP	C13-N24	2.97	1.36	1.32
4	B	804	A1JZP	C14-N23	2.44	1.40	1.34
4	A	804	A1JZP	C14-N23	2.19	1.39	1.34

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	A	804	A1JZP	O29-N24-C13	-3.30	111.48	119.64
4	B	804	A1JZP	O29-N24-C13	-2.38	113.75	119.64
4	B	804	A1JZP	C10-C21-N23	2.08	115.53	111.02

There are no chirality outliers.

All (6) torsion outliers are listed below:

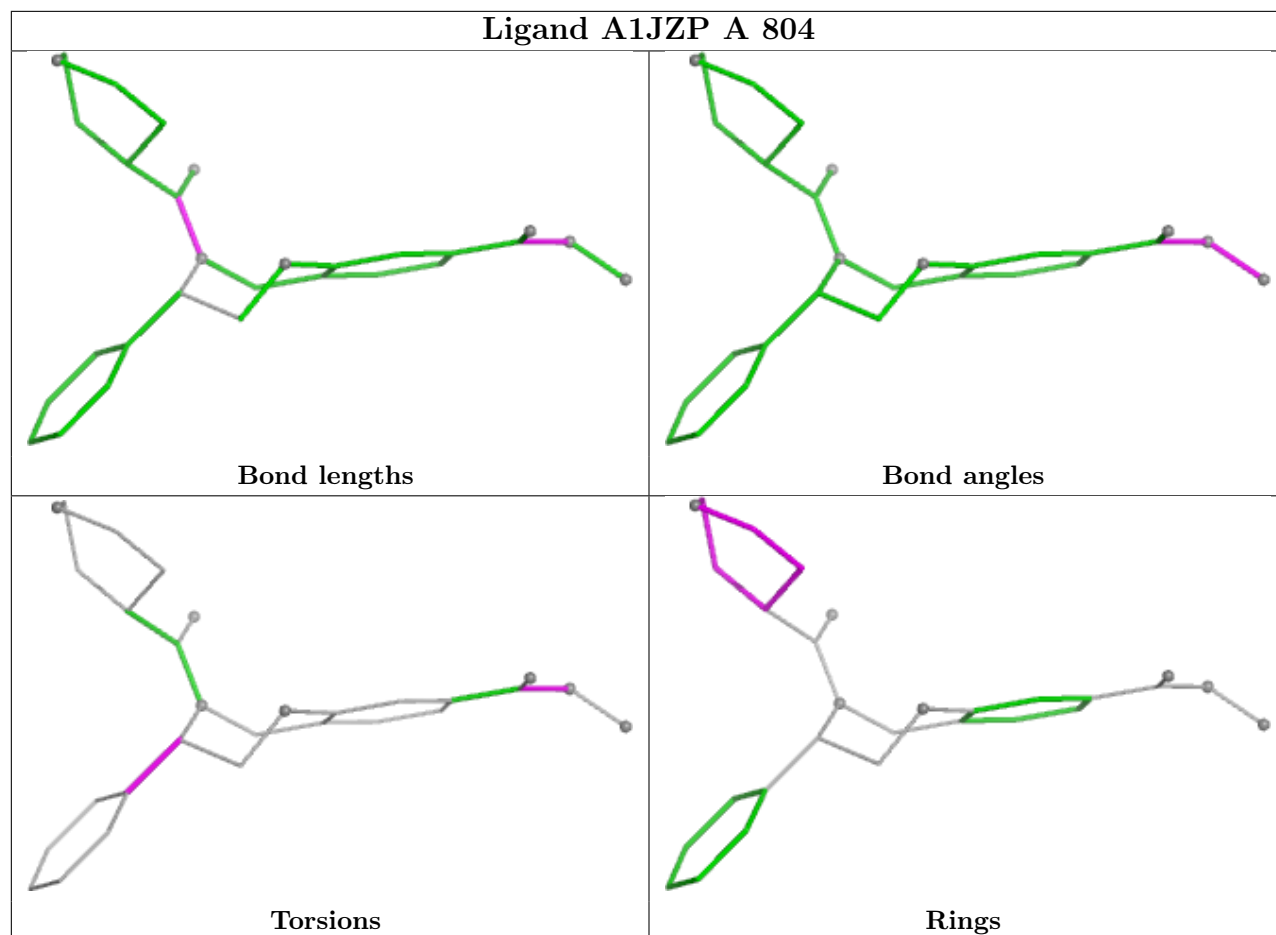
Mol	Chain	Res	Type	Atoms
4	A	804	A1JZP	C9-C13-N24-O29
4	A	804	A1JZP	O25-C13-N24-O29
4	B	804	A1JZP	C6-C10-C21-N23
4	A	804	A1JZP	C5-C10-C21-N23
4	A	804	A1JZP	C6-C10-C21-N23
4	B	804	A1JZP	C5-C10-C21-N23

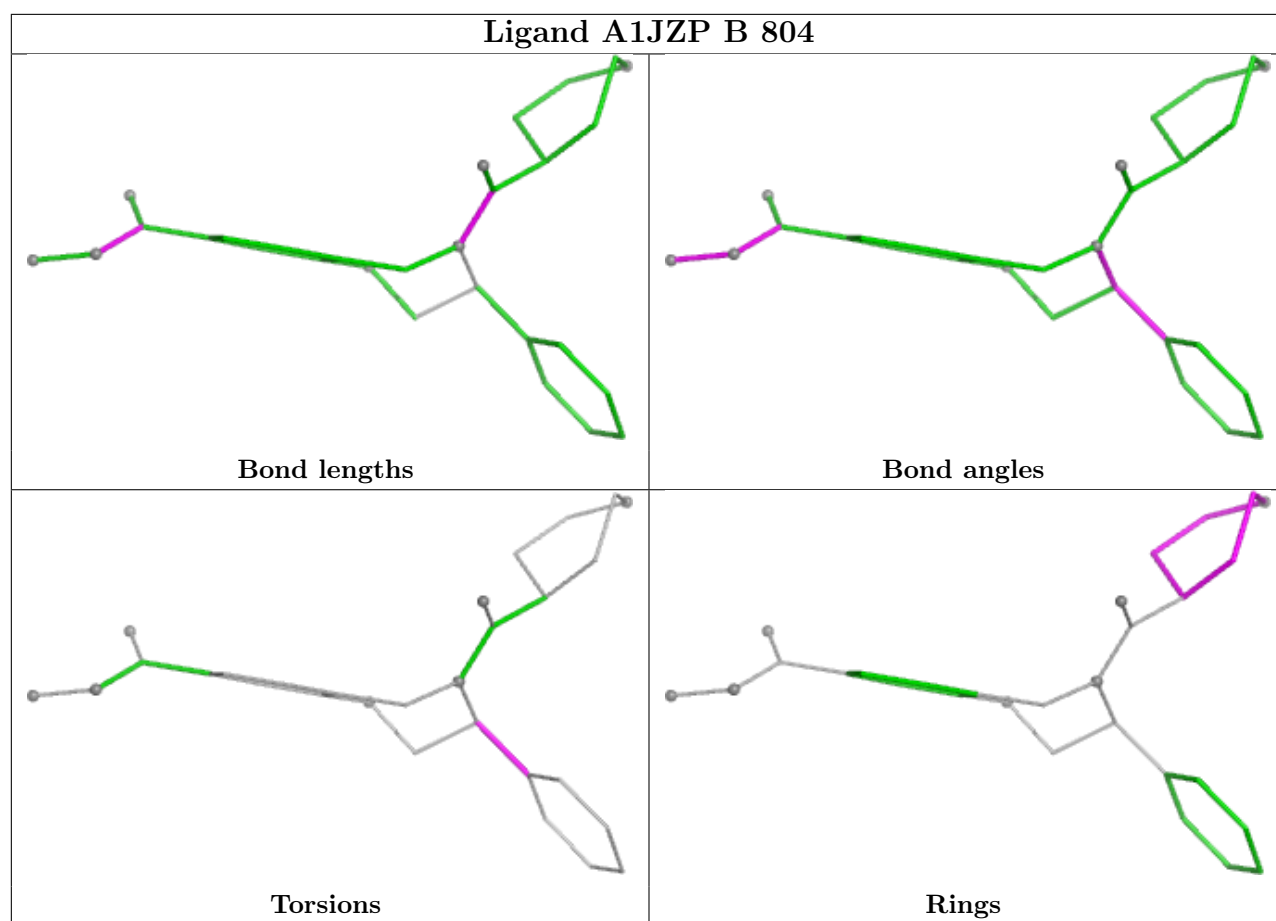
All (2) ring outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	B	804	A1JZP	C16-C17-C18-C19-C22-O28
4	A	804	A1JZP	C16-C17-C18-C19-C22-O28

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

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	A	357/364 (98%)	0.53	23 (6%) 25 33	4, 13, 39, 71	2 (0%)
1	B	355/364 (97%)	0.43	16 (4%) 38 47	4, 13, 31, 82	5 (1%)
All	All	712/728 (97%)	0.48	39 (5%) 30 39	4, 13, 35, 82	7 (0%)

All (39) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	521	ASP	5.8
1	B	770	ASP	4.7
1	A	518	LYS	4.5
1	A	524	ARG	4.5
1	A	520	ARG	4.5
1	A	522	LEU	4.3
1	B	773	THR	4.3
1	A	519	PRO	4.0
1	A	459	TRP	3.9
1	A	771	HIS	3.7
1	B	774	PRO	3.5
1	A	772	LEU	3.4
1	A	525	LEU	3.3
1	B	672	LYS	3.2
1	A	523	ASN	3.1
1	B	459	TRP	3.1
1	A	562	ARG	3.0
1	B	769	LEU	3.0
1	B	442	PRO	2.9
1	A	773	THR	2.8
1	B	520	ARG	2.8
1	A	602	GLU	2.8
1	B	777	THR	2.8
1	B	775	LEU	2.7

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Mol	Chain	Res	Type	RSRZ
1	A	798	ARG	2.7
1	A	442	PRO	2.7
1	A	774	PRO	2.6
1	A	775	LEU	2.4
1	A	527	ASP	2.4
1	B	510	ILE	2.4
1	B	768	SER	2.4
1	B	798	ARG	2.3
1	B	518	LYS	2.3
1	A	443	ILE	2.2
1	A	777	THR	2.2
1	B	519	PRO	2.1
1	A	510	ILE	2.0
1	B	562	ARG	2.0
1	A	536	ASN	2.0

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](#)

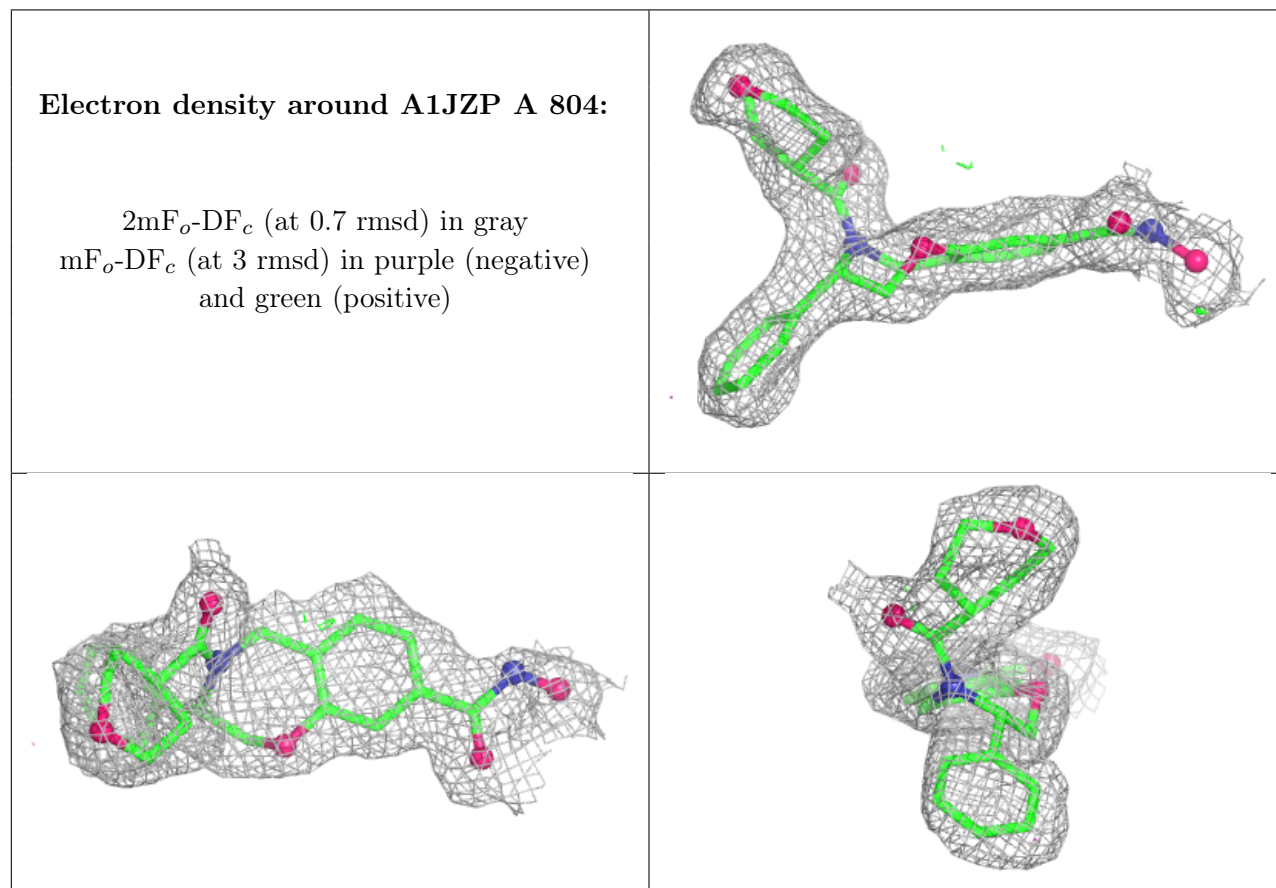
There are no oligosaccharides in this entry.

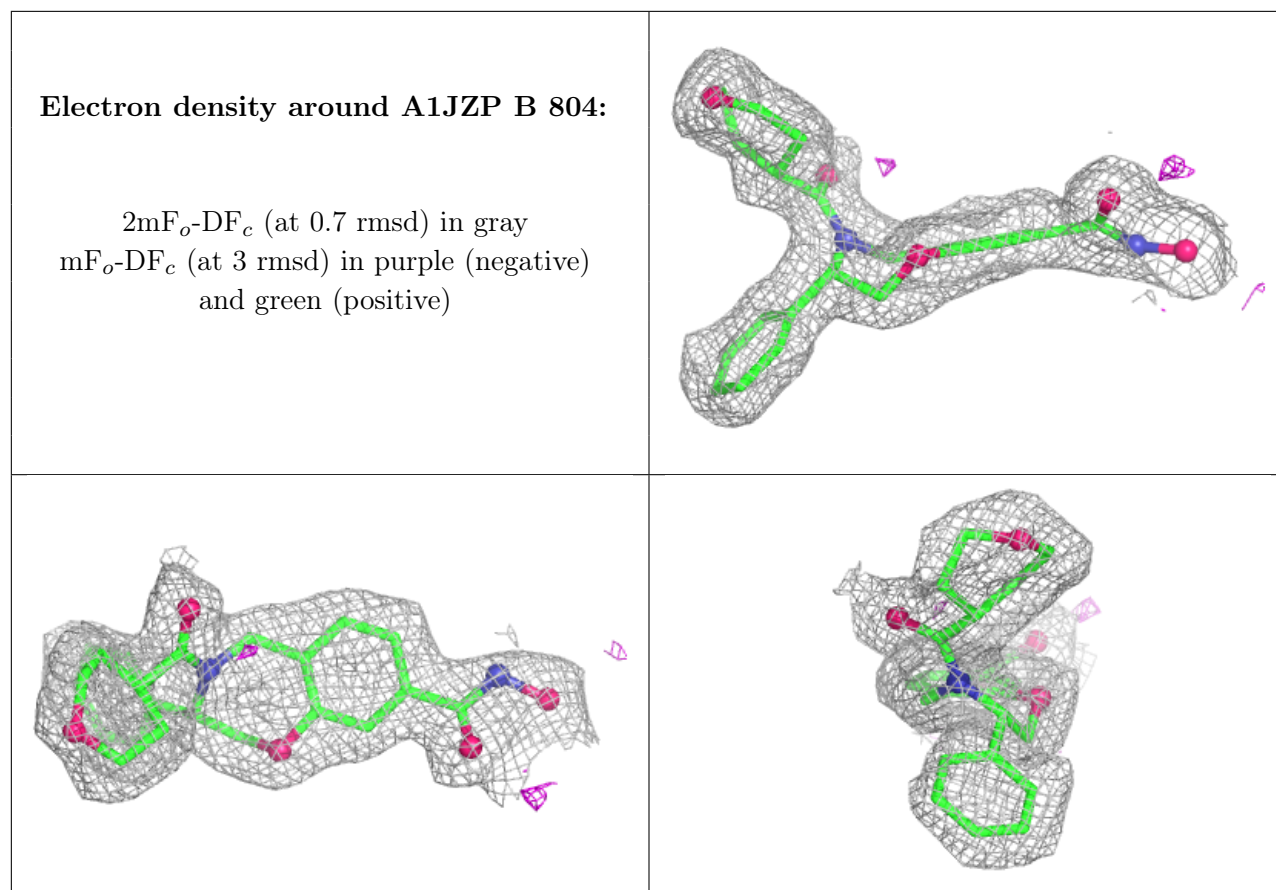
6.4 Ligands [i](#)

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
4	A1JZP	A	804	29/29	0.87	0.11	16,19,22,26	0
4	A1JZP	B	804	29/29	0.93	0.07	3,10,15,16	0
3	ZN	B	803	1/1	0.98	0.06	27,27,27,27	0
2	K	A	802	1/1	0.98	0.04	8,8,8,8	0
2	K	B	802	1/1	0.98	0.03	8,8,8,8	0
2	K	B	801	1/1	0.99	0.04	8,8,8,8	0
2	K	A	801	1/1	0.99	0.02	7,7,7,7	0
3	ZN	A	803	1/1	0.99	0.04	29,29,29,29	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.





6.5 Other polymers [i](#)

There are no such residues in this entry.