WORLD WIDE PDB PROTEIN DATA BANK

wwPDB X-ray Structure Validation Summary Report (i)

Nov 18, 2024 – 06:08 PM EST

|		
PDB ID	:	9D8Z
Title	:	Crystal structure of the ACVR1 (ALK2) Kinase Domain in complex with inhibitor CDD-2282
Authors	:	Ta, H.M.; Kim, C.; Jimmidi, R.; Matzuk, M.M.
Deposited on	:	2024-08-20
Resolution	:	1.85 Å(reported)

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 1.85 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.
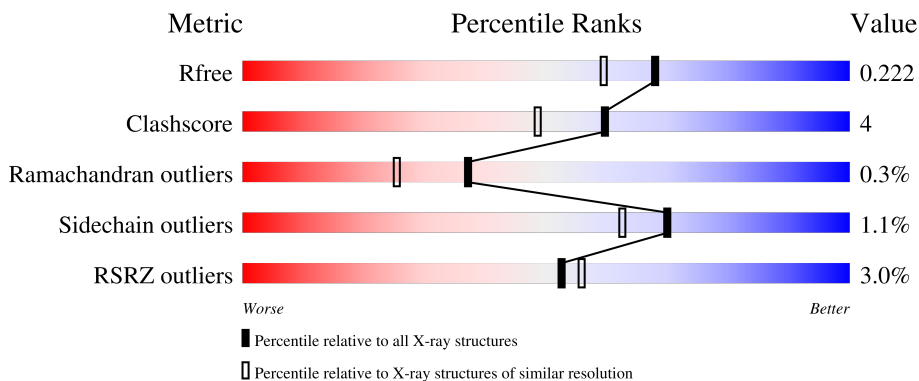
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	3097 (1.86-1.86)
Clashscore	180529	3359 (1.86-1.86)
Ramachandran outliers	177936	3335 (1.86-1.86)
Sidechain outliers	177891	3335 (1.86-1.86)
RSRZ outliers	164620	3097 (1.86-1.86)

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	332	2% red; 82% ; 7% ; 11%
1	B	332	3% red; 80% ; 13% ; 8%

2 Entry composition (i)

There are 4 unique types of molecules in this entry. The entry contains 10249 atoms, of which 4980 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 Activin receptor type-1.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	297	Total	C	H	N	O	S	0	2	0
			4811	1526	2409	420	439	17			
1	B	307	Total	C	H	N	O	S	0	5	0
			4974	1577	2493	436	452	16			

- Molecule 2 is 1-[(1r,3r)-3-(methylcarbamoyl)cyclobutyl]-N-[(1-methylpiperidin-4-yl)methyl]-2-(3,4,5-trimethoxyphenyl)-1H-1,3-benzimidazole-6-carboxamide (three-letter code: A1A3D) (formula: $C_{30}H_{39}N_5O_5$) (labeled as "Ligand of Interest" by depositor).
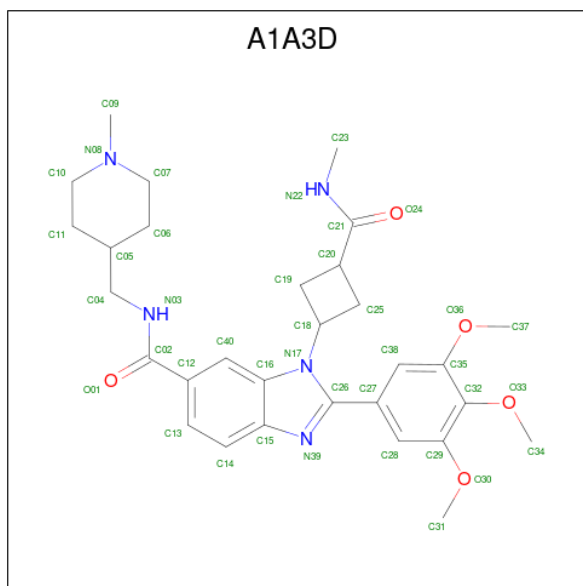
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	H	N	O	0	0
			79	30	39	5	5		
2	B	1	Total	C	H	N	O	0	0
			79	30	39	5	5		

- Molecule 3 is PHOSPHATE ION (three-letter code: PO4) (formula: O_4P).

PO4

O3

O^-

O2 O^- —— P ══ O O1

P

O^-

O4

Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total 5	O 4	P 1	0	0
3	A	1	Total 5	O 4	P 1	0	0
3	A	1	Total 5	O 4	P 1	0	0
3	A	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0
3	B	1	Total 5	O 4	P 1	0	0

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	100	Total 100	O 100	0	0
4	B	156	Total 156	O 156	0	0

W O R L D W I D E
PDB
PROTEIN DATA BANK

3 Residue-property plots ⓘ

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: Activin receptor type-1

Chain A:

• Molecule 1: Activin receptor type-1

Chain B:
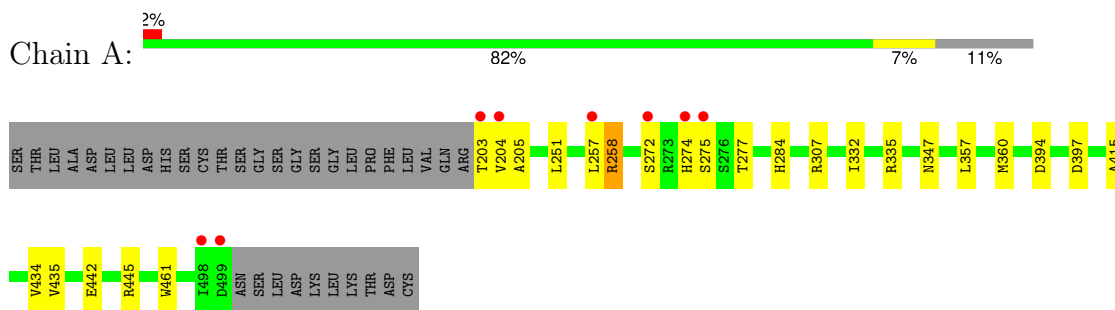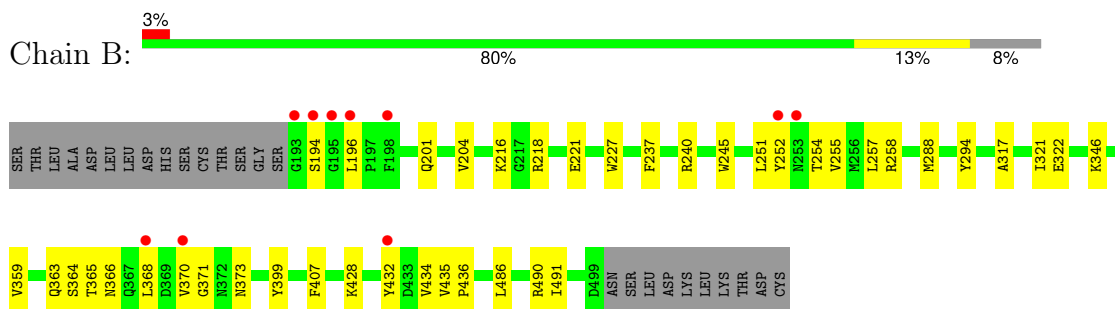
4 Data and refinement statistics ⓘ

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	52.44Å 71.20Å 158.98Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	43.77 – 1.85 43.77 – 1.85	Depositor EDS
% Data completeness (in resolution range)	99.9 (43.77-1.85) 99.9 (43.77-1.85)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.23 (at 1.86Å)	Xtriage
Refinement program	PHENIX (1.21rc1_5049: ???)	Depositor
R, R_{free}	0.189 , 0.223 0.189 , 0.222	Depositor DCC
R_{free} test set	49738 reflections (3.87%)	wwPDB-VP
Wilson B-factor (Å^2)	34.0	Xtriage
Anisotropy	0.126	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.42 , 46.8	EDS
L-test for twinning[2]	$< |L| > = 0.50, < L^2 > = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	10249	wwPDB-VP
Average B, all atoms (Å^2)	51.0	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 21.51 % 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 6.9063e-03. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

---

[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 ⓘ

5.1 Standard geometry ⓘ

Bond lengths and bond angles in the following residue types are not validated in this section: PO4, A1A3D

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	0.50	0/2464	0.60	0/3339
1	B	0.56	0/2552	0.65	0/3459
All	All	0.53	0/5016	0.63	0/6798

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 ⓘ

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	2402	2409	2411	14	0
1	B	2481	2493	2490	28	0
2	A	40	39	0	0	0
2	B	40	39	0	0	0
3	A	20	0	0	1	0
3	B	30	0	0	0	0
4	A	100	0	0	2	0
4	B	156	0	0	0	0
All	All	5269	4980	4901	42	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.

The worst 5 of 42 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:B:428:LYS:HD2	1:B:432:TYR:CD1	2.08	0.89
1:B:370:VAL:HG21	1:B:399:TYR:CZ	2.24	0.72
1:B:365:THR:O	1:B:366:ASN:ND2	2.23	0.71
1:B:359:VAL:HG11	1:B:370:VAL:HG22	1.79	0.65
1:B:216:LYS:HG2	1:B:221:GLU:HG2	1.80	0.63

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	A	298/332 (90%)	292 (98%)	6 (2%)	0	100	100
1	B	310/332 (93%)	300 (97%)	8 (3%)	2 (1%)	22	10
All	All	608/664 (92%)	592 (97%)	14 (2%)	2 (0%)	37	25

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	368	LEU
1	B	371	GLY

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	A	269/297 (91%)	265 (98%)	4 (2%)	60	50
1	B	277/297 (93%)	275 (99%)	2 (1%)	81	78
All	All	546/594 (92%)	540 (99%)	6 (1%)	70	62

5 of 6 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	445	ARG
1	B	218	ARG
1	B	240	ARG
1	A	394	ASP
1	A	258	ARG

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	284	HIS
1	B	366	ASN

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 ⓘ

12 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	$\#\|Z\|>2$
3	PO4	B	604	-	4,4,4	1.77	1 (25%)	6,6,6	1.07	0
3	PO4	B	603	-	4,4,4	1.71	1 (25%)	6,6,6	0.81	0
3	PO4	B	606	-	4,4,4	1.93	1 (25%)	6,6,6	0.49	0
3	PO4	A	604	-	4,4,4	1.36	0	6,6,6	0.56	0
2	A1A3D	B	600	-	41,44,44	1.76	12 (29%)	53,63,63	2.23	15 (28%)
3	PO4	A	601	-	4,4,4	1.61	1 (25%)	6,6,6	0.91	0
3	PO4	B	602	-	4,4,4	2.25	1 (25%)	6,6,6	1.15	1 (16%)
3	PO4	B	601	-	4,4,4	1.63	1 (25%)	6,6,6	0.94	0
3	PO4	B	605	-	4,4,4	1.87	1 (25%)	6,6,6	0.93	0
3	PO4	A	603	-	4,4,4	1.60	1 (25%)	6,6,6	1.07	0
3	PO4	A	602	-	4,4,4	1.92	1 (25%)	6,6,6	0.72	0
2	A1A3D	A	600	-	41,44,44	1.76	7 (17%)	53,63,63	1.51	11 (20%)

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	A1A3D	A	600	-	-	3/25/47/47	0/5/5/5
2	A1A3D	B	600	-	-	4/25/47/47	0/5/5/5

The worst 5 of 28 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	600	A1A3D	C21-N22	4.77	1.39	1.33
2	B	600	A1A3D	C21-N22	4.54	1.39	1.33
3	B	602	PO4	P-O1	4.43	1.60	1.50
2	A	600	A1A3D	C02-N03	4.07	1.42	1.33
2	A	600	A1A3D	C19-C18	3.96	1.59	1.53

The worst 5 of 27 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	B	600	A1A3D	C12-C02-N03	7.08	131.83	117.12

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	B	600	A1A3D	C05-C04-N03	-5.45	103.31	112.77
2	B	600	A1A3D	C04-N03-C02	5.07	131.87	122.54
2	B	600	A1A3D	O01-C02-N03	-4.83	113.17	122.59
2	A	600	A1A3D	C12-C02-N03	3.53	124.46	117.12

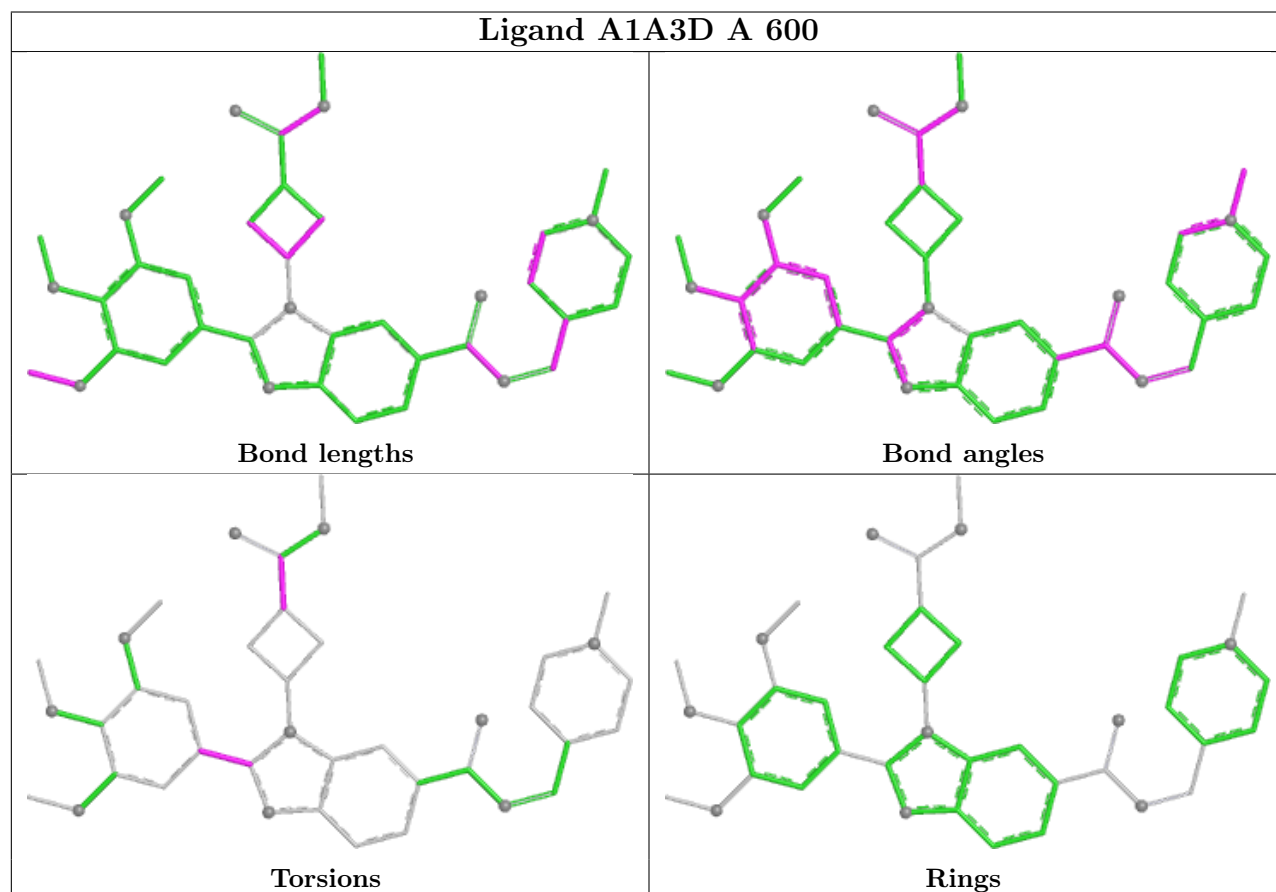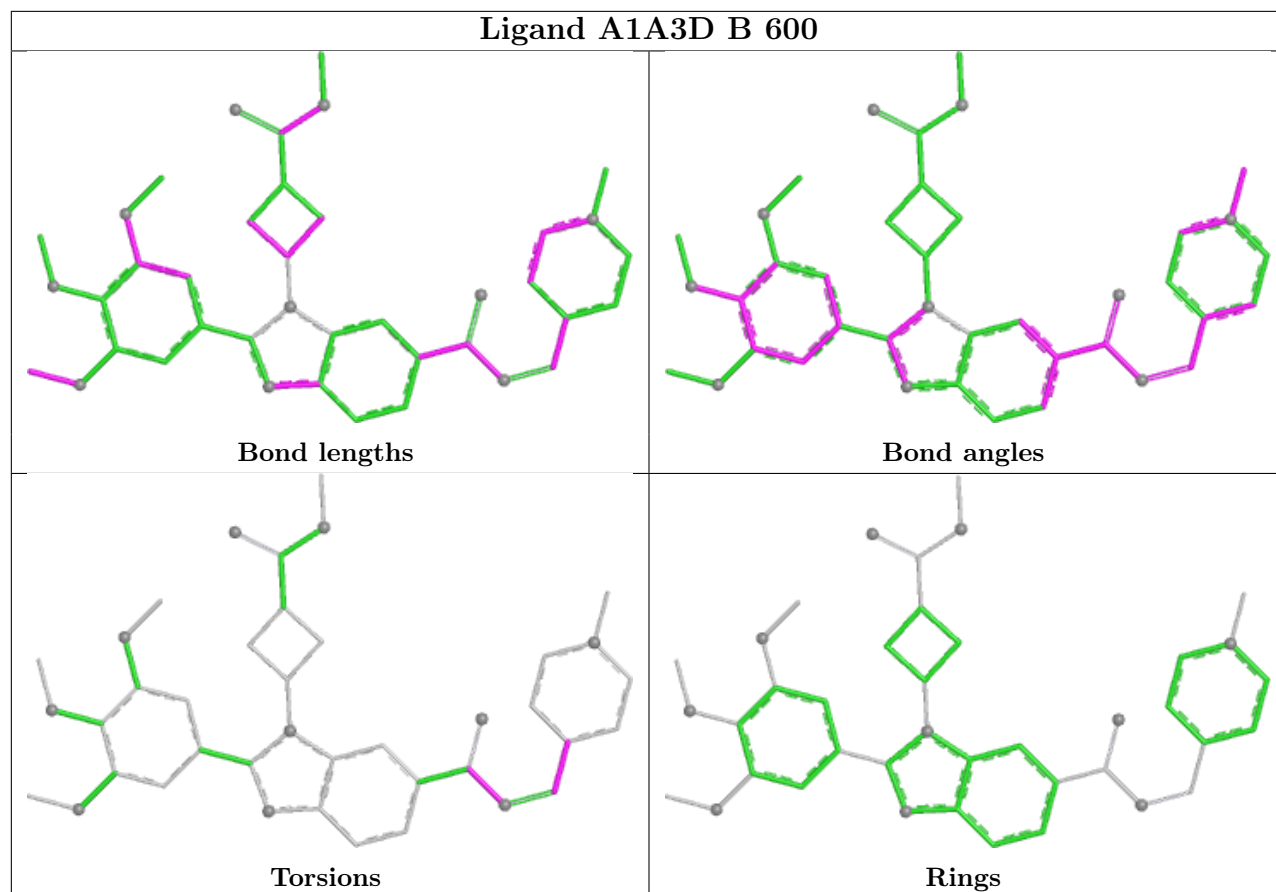There are no chirality outliers.

5 of 7 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	B	600	A1A3D	C12-C02-N03-C04
2	B	600	A1A3D	O01-C02-N03-C04
2	B	600	A1A3D	N03-C04-C05-C06
2	B	600	A1A3D	N03-C04-C05-C11
2	A	600	A1A3D	C19-C20-C21-O24

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	604	PO4	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 then 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.

Ligand A1A3D B 600

Bond lengths

Bond angles

Torsions

Rings

Ligand A1A3D A 600

Bond lengths

Bond angles

Torsions

Rings

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	297/332 (89%)	0.15	8 (2%)	56	59	19, 53, 91, 176	2 (0%)
1	B	307/332 (92%)	-0.06	10 (3%)	49	53	18, 42, 82, 143	4 (1%)
All	All	604/664 (90%)	0.04	18 (2%)	52	56	18, 47, 90, 176	6 (0%)

The worst 5 of 18 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	204	VAL	5.7
1	B	370	VAL	4.0
1	B	195	GLY	3.6
1	A	203	THR	3.5
1	B	196	LEU	3.1

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

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates ⓘ
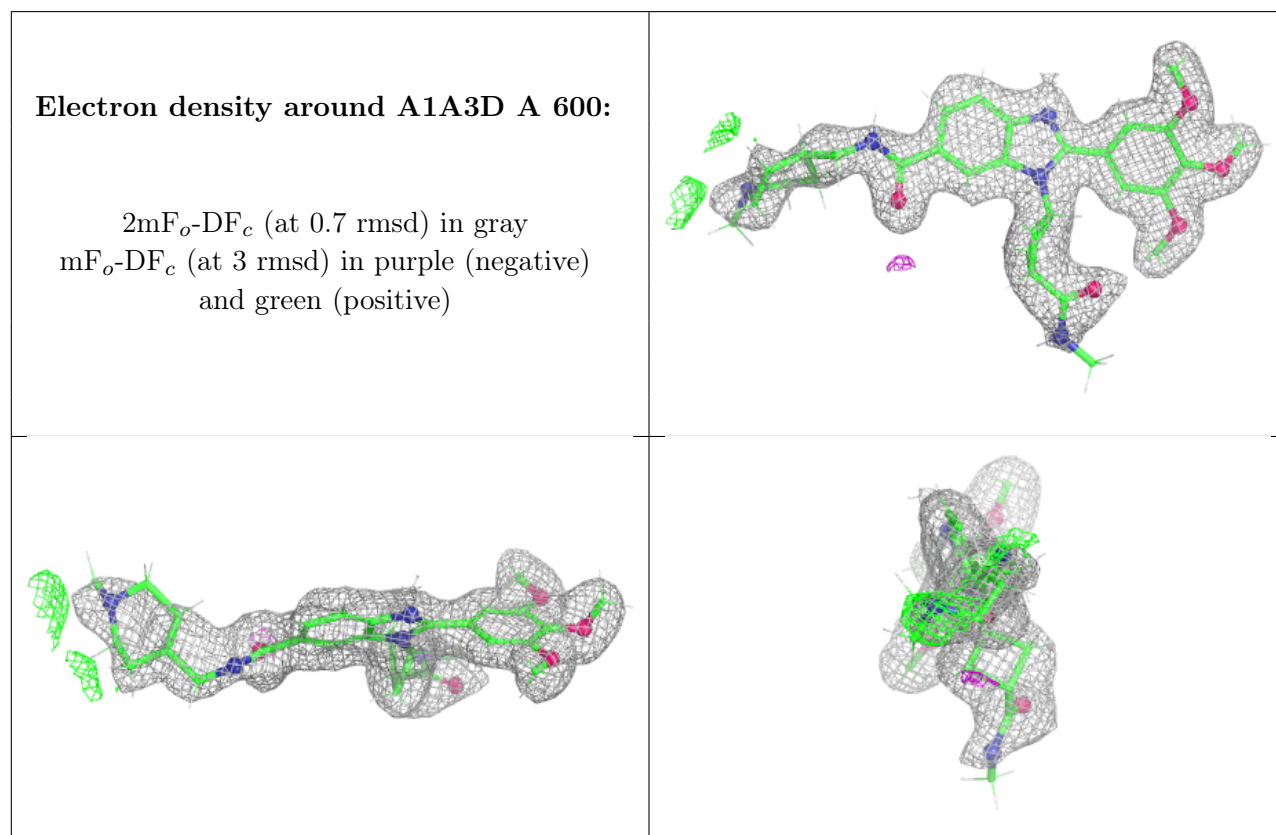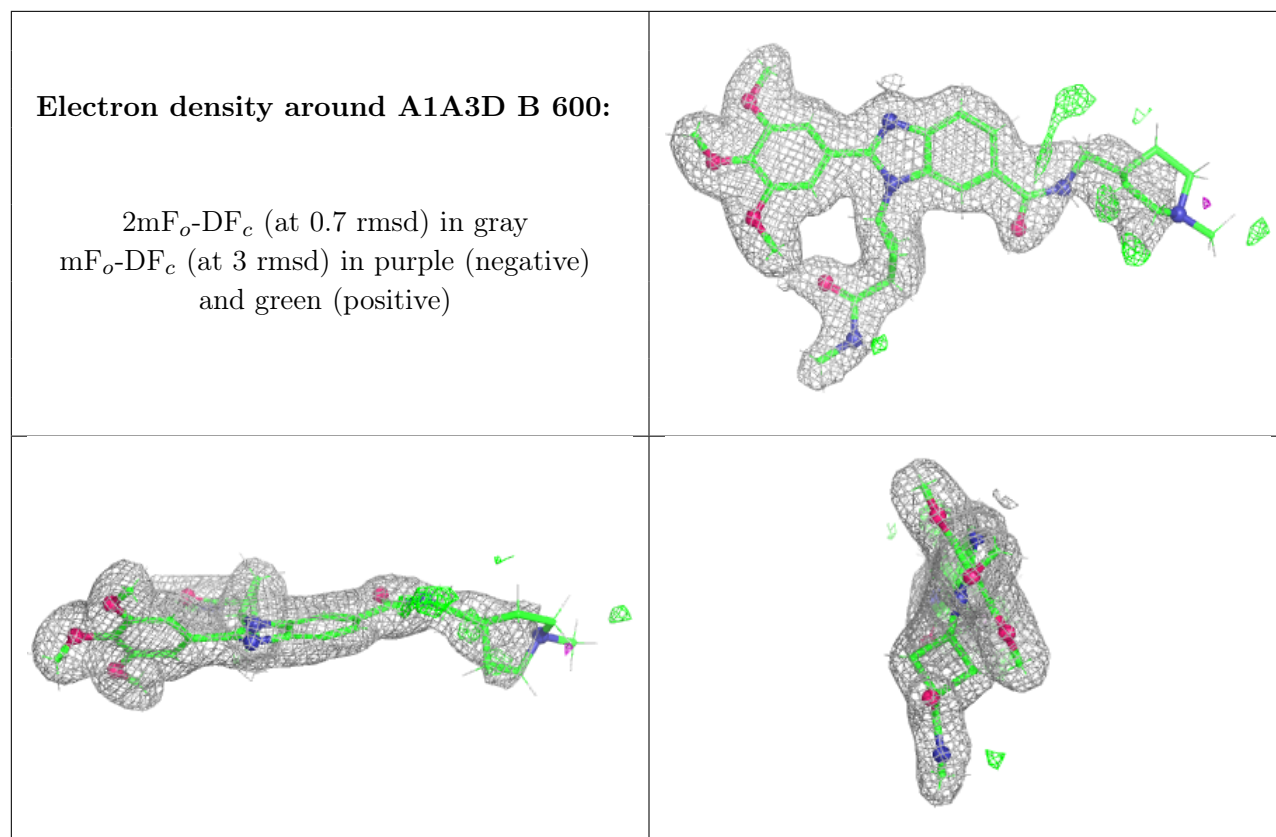
There are no monosaccharides in this entry.

6.4 Ligands ⓘ

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($\mathring{A}^2$)	Q<0.9
3	PO4	B	605	5/5	0.91	0.11	37,37,45,45	0
2	A1A3D	A	600	40/40	0.92	0.11	29,50,101,108	0
3	PO4	A	602	5/5	0.94	0.08	40,42,44,47	0
2	A1A3D	B	600	40/40	0.94	0.11	24,40,136,140	0
3	PO4	B	606	5/5	0.94	0.08	42,47,52,60	0
3	PO4	A	603	5/5	0.95	0.07	38,41,43,45	0
3	PO4	A	601	5/5	0.96	0.07	36,37,38,39	0
3	PO4	B	604	5/5	0.96	0.07	32,35,37,38	0
3	PO4	B	603	5/5	0.98	0.05	36,38,41,44	0
3	PO4	A	604	5/5	0.98	0.05	35,39,43,44	0
3	PO4	B	601	5/5	0.98	0.05	28,29,32,32	0
3	PO4	B	602	5/5	0.98	0.05	32,33,34,35	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 A1A3D A 600:

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

Electron density around A1A3D B 600:

$2mF_o$-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 ⓘ

There are no such residues in this entry.