Full wwPDB X-ray Structure Validation Report ⓘ

May 10, 2025 – 07:17 pm BST

PDB ID	:	9F85 / pdb_00009f85
Title	:	Structure of Choline O-acetyltransferase in complex with 1-Methyl-4-[2-(1-naphthyl)ethyl]pyridinium at 1.6 Angstrom resolution
Authors	:	Forsgren, N.; Ekstrom, F.
Deposited on	:	2024-05-06
Resolution	:	1.60 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:

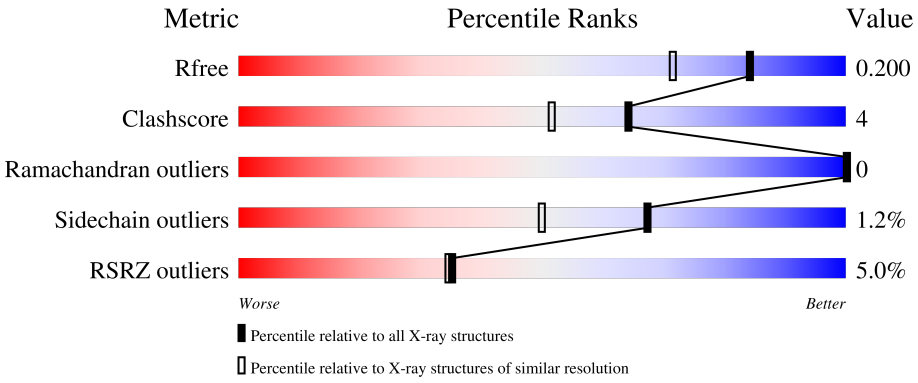
MolProbity	:	4-5-2 with Phenix2.0rc1
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	2.0rc1
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.003 (Gargrove)
Density-Fitness	:	1.0.11
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.43.1

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 1.60 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	4274 (1.60-1.60)
Clashscore	180529	4682 (1.60-1.60)
Ramachandran outliers	177936	4583 (1.60-1.60)
Sidechain outliers	177891	4582 (1.60-1.60)
RSRZ outliers	164620	4272 (1.60-1.60)

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	612	5% 86% 8% 6%

2 Entry composition (i)

There are 4 unique types of molecules in this entry. The entry contains 4992 atoms, of which 14 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.

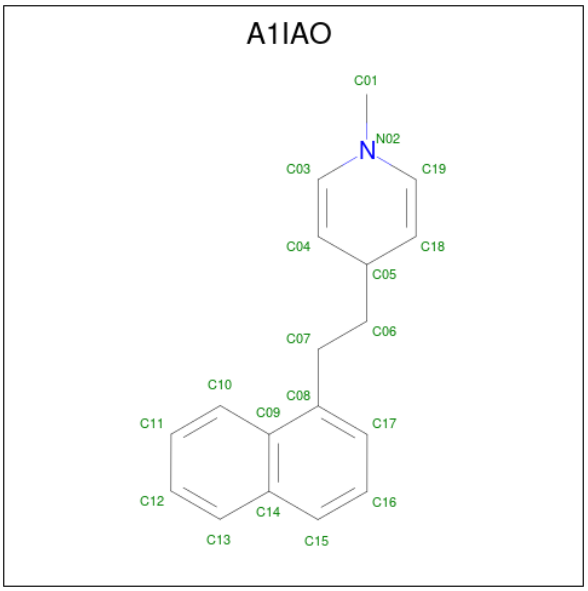
- Molecule 1 is a protein called Choline O-acetyltransferase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
			Total	C	H	N	O	S			
1	A	575	4569	2886	14	800	833	36	0	11	0

There are 19 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1	ALA	-	expression tag	UNP P28329
A	225	ALA	GLU	engineered mutation	UNP P28329
A	226	ALA	ASP	engineered mutation	UNP P28329
A	227	ALA	GLU	engineered mutation	UNP P28329
A	343	MET	VAL	conflict	UNP P28329
A	349	PRO	-	linker	UNP P28329
A	350	GLU	-	linker	UNP P28329
A	351	LEU	-	linker	UNP P28329
A	352	VAL	-	linker	UNP P28329
A	353	ARG	-	linker	UNP P28329
A	354	SER	-	linker	UNP P28329
A	355	PRO	-	linker	UNP P28329
A	356	MET	-	linker	UNP P28329
A	357	VAL	-	linker	UNP P28329
A	358	PRO	-	linker	UNP P28329
A	518	ALA	LYS	engineered mutation	UNP P28329
A	519	ALA	GLU	engineered mutation	UNP P28329
A	582	ALA	LYS	engineered mutation	UNP P28329
A	583	ALA	GLU	engineered mutation	UNP P28329

- Molecule 2 is 1-methyl-4-(2-naphthalen-1-ylethyl)-4H-pyridine (CCD ID: A1IAO) (formula: $C_{18}H_{19}N$) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	1	Total C N 19 18 1	0	0

- Molecule 3 is SODIUM ION (CCD ID: NA) (formula: Na).

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	2	Total Na 2 2	0	0

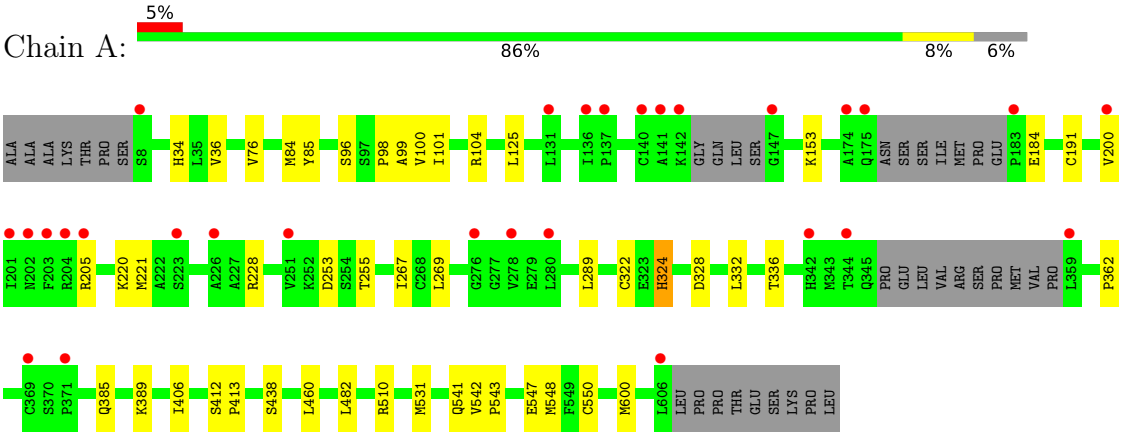
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	402	Total O 402 402	0	0

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: Choline O-acetyltransferase



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	54.76Å 76.35Å 164.11Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	34.61 – 1.60 34.61 – 1.60	Depositor EDS
% Data completeness (in resolution range)	99.9 (34.61-1.60) 99.9 (34.61-1.60)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	2.61 (at 1.60Å)	Xtriage
Refinement program	PHENIX 1.21_5207	Depositor
R, R_{free}	0.175 , 0.200 0.175 , 0.200	Depositor DCC
R_{free} test set	1905 reflections (2.08%)	wwPDB-VP
Wilson B-factor (Å^2)	23.5	Xtriage
Anisotropy	0.282	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.34 , 37.2	EDS
L-test for twinning[2]	$< \|L\| > = 0.48$, $< L^2 > = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o,F_c correlation	0.96	EDS
Total number of atoms	4992	wwPDB-VP
Average B, all atoms (Å^2)	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.43% of the height of the origin peak. No significant pseudotranslation is detected.*

[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: A1IAO, NA

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	0.63	0/4651	0.73	0/6301

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	A	0	1

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	510	ARG	Sidechain

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	4555	14	4536	35	0
2	A	19	0	0	3	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	2	0	0	0	0
4	A	402	0	0	2	0
All	All	4978	14	4536	35	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 (35) 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:550[B]:CYS:SG	2:A:701:A1IAO:C15	2.56	0.93
1:A:550[B]:CYS:SG	2:A:701:A1IAO:C16	2.76	0.73
1:A:36:VAL:HG12	1:A:531[B]:MET:CE	2.19	0.72
1:A:385:GLN:HG3	1:A:389:LYS:HE3	1.76	0.66
1:A:104:ARG:HH11	1:A:104:ARG:HB3	1.65	0.62
1:A:85:TYR:CE1	1:A:324[A]:HIS:CE1	2.90	0.59
1:A:85:TYR:HE1	1:A:324[A]:HIS:CE1	2.20	0.59
1:A:96:SER:O	1:A:324[A]:HIS:CE1	2.56	0.59
1:A:482[B]:LEU:HD11	1:A:600:MET:HE3	1.86	0.58
1:A:98[A]:PRO:HD2	1:A:322:CYS:O	2.03	0.58
1:A:221:MET:HE1	1:A:362:PRO:O	2.06	0.56
1:A:96:SER:O	1:A:98[B]:PRO:HD3	2.06	0.55
1:A:184:GLU:HB3	1:A:267:ILE:HD11	1.89	0.55
1:A:324[B]:HIS:HE1	1:A:328:ASP:OD1	1.91	0.54
1:A:332:LEU:C	1:A:332:LEU:HD13	2.35	0.52
1:A:324[B]:HIS:NE2	2:A:701:A1IAO:C07	2.73	0.52
1:A:36:VAL:CG1	1:A:531[B]:MET:CE	2.88	0.51
1:A:542:VAL:HG11	1:A:550[A]:CYS:SG	2.51	0.51
1:A:36:VAL:CG1	1:A:531[B]:MET:HE1	2.40	0.50
1:A:99:ALA:HB1	1:A:289:LEU:HB3	1.96	0.47
1:A:191:CYS:HB3	1:A:228:ARG:HH12	1.79	0.47
1:A:220:LYS:HB2	1:A:220:LYS:HE2	1.77	0.45
1:A:253:ASP:OD1	1:A:255:THR:HB	2.17	0.45
1:A:101:ILE:N	1:A:101:ILE:HD12	2.33	0.43
1:A:153[B]:LYS:HD3	4:A:1120:HOH:O	2.19	0.43
1:A:541:GLN:NE2	1:A:543:PRO:HG3	2.34	0.42
1:A:336[B]:THR:OG1	1:A:548:MET:HE1	2.19	0.42
1:A:541:GLN:HE21	1:A:543:PRO:HG3	1.85	0.42
1:A:84:MET:HE1	4:A:1189:HOH:O	2.19	0.42
1:A:104:ARG:CB	1:A:104:ARG:NH1	2.83	0.41
1:A:406:ILE:HG21	1:A:413:PRO:HA	2.01	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:547:GLU:O	1:A:547:GLU:CG	2.69	0.40
1:A:125:LEU:CD1	1:A:205:ARG:HD3	2.51	0.40
1:A:34:HIS:HB2	1:A:460:LEU:HD22	2.03	0.40
1:A:100:VAL:HG22	1:A:550[A]:CYS:SG	2.62	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	578/612 (94%)	564 (98%)	14 (2%)	0	100 100

There are no Ramachandran outliers to report.

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	497/527 (94%)	490 (99%)	7 (1%)	62 43

All (7) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	76	VAL
1	A	200	VAL

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Mol	Chain	Res	Type
1	A	269	LEU
1	A	324[A]	HIS
1	A	324[B]	HIS
1	A	412	SER
1	A	438	SER

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (4) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	30	GLN
1	A	169	GLN
1	A	192	ASN
1	A	541	GLN

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 3 ligands modelled in this entry, 2 are monoatomic - leaving 1 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	A1IAO	A	701	-	21,21,21	2.73	14 (66%)	24,28,28	2.19	9 (37%)

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	A1IAO	A	701	-	-	2/5/15/15	0/3/3/3

All (14) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	701	A1IAO	C03-C04	4.70	1.43	1.33
2	A	701	A1IAO	C09-C14	-4.36	1.35	1.43
2	A	701	A1IAO	C05-C18	-4.31	1.42	1.50
2	A	701	A1IAO	C05-C04	-4.25	1.42	1.50
2	A	701	A1IAO	C19-C18	4.23	1.42	1.33
2	A	701	A1IAO	C16-C15	2.96	1.43	1.36
2	A	701	A1IAO	C01-N02	2.58	1.53	1.46
2	A	701	A1IAO	C07-C08	-2.54	1.44	1.51
2	A	701	A1IAO	C15-C14	-2.49	1.35	1.41
2	A	701	A1IAO	C06-C05	-2.34	1.50	1.53
2	A	701	A1IAO	C11-C10	2.27	1.41	1.36
2	A	701	A1IAO	C19-N02	2.16	1.40	1.36
2	A	701	A1IAO	C10-C09	-2.06	1.38	1.42
2	A	701	A1IAO	C12-C13	2.01	1.41	1.36

All (9) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	701	A1IAO	C13-C14-C09	5.67	126.58	119.12
2	A	701	A1IAO	C12-C13-C14	-3.92	114.32	120.44
2	A	701	A1IAO	C15-C14-C13	-3.68	114.58	123.19
2	A	701	A1IAO	C19-N02-C03	2.68	122.92	119.26
2	A	701	A1IAO	C08-C09-C14	2.58	122.19	118.98
2	A	701	A1IAO	C07-C08-C09	2.22	125.77	120.93
2	A	701	A1IAO	C06-C05-C18	2.18	121.20	111.62
2	A	701	A1IAO	C06-C05-C04	2.05	120.62	111.62
2	A	701	A1IAO	C01-N02-C03	-2.01	117.94	120.17

There are no chirality outliers.

All (2) torsion outliers are listed below:

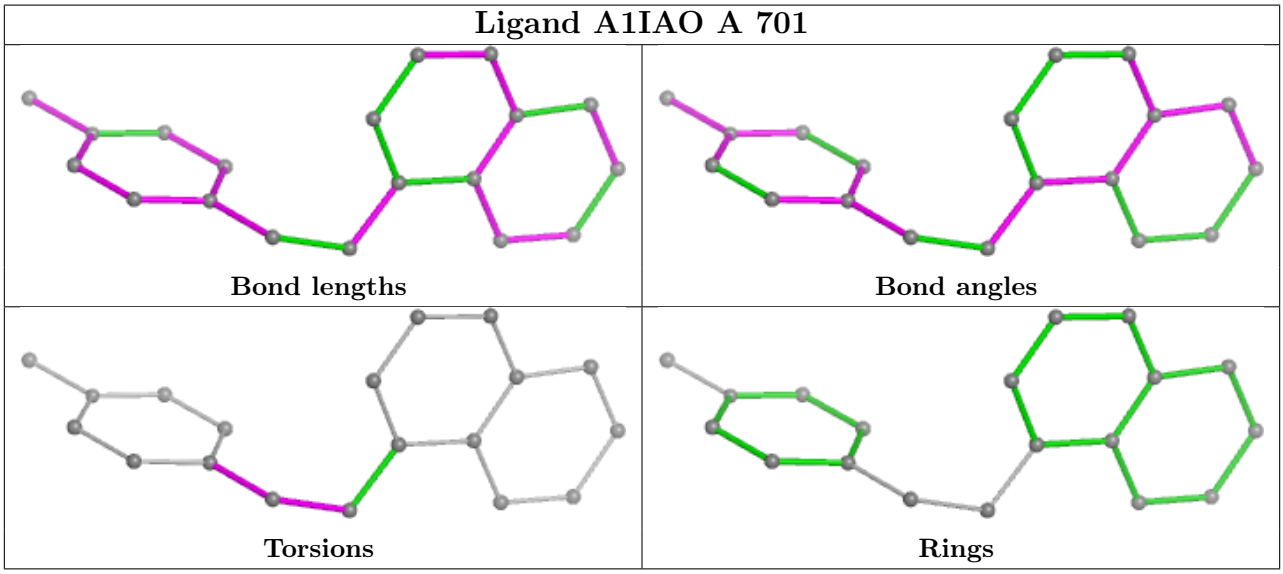
Mol	Chain	Res	Type	Atoms
2	A	701	A1IAO	C04-C05-C06-C07
2	A	701	A1IAO	C05-C06-C07-C08

There are no ring outliers.

1 monomer is involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	701	A1IAO	3	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.



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, 95^{th} 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	575/612 (93%)	0.12	29 (5%) 35 34	9, 26, 52, 71	11 (1%)

All (29) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	200	VAL	5.2
1	A	201	ILE	4.9
1	A	369	CYS	4.5
1	A	140	CYS	4.1
1	A	183	PRO	3.7
1	A	278	VAL	3.4
1	A	226	ALA	3.4
1	A	175	GLN	3.3
1	A	203	PHE	3.1
1	A	342	HIS	3.0
1	A	359	LEU	3.0
1	A	8	SER	2.8
1	A	202	ASN	2.7
1	A	371	PRO	2.6
1	A	136	ILE	2.5
1	A	142	LYS	2.5
1	A	147	GLY	2.5
1	A	204	ARG	2.4
1	A	141	ALA	2.4
1	A	344	THR	2.3
1	A	137	PRO	2.3
1	A	174	ALA	2.3
1	A	251	VAL	2.3
1	A	223	SER	2.2
1	A	205	ARG	2.2
1	A	131	LEU	2.2
1	A	276	GLY	2.2

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Mol	Chain	Res	Type	RSRZ
1	A	606	LEU	2.1
1	A	280	LEU	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 monosaccharides in this entry.

6.4 Ligands (i)

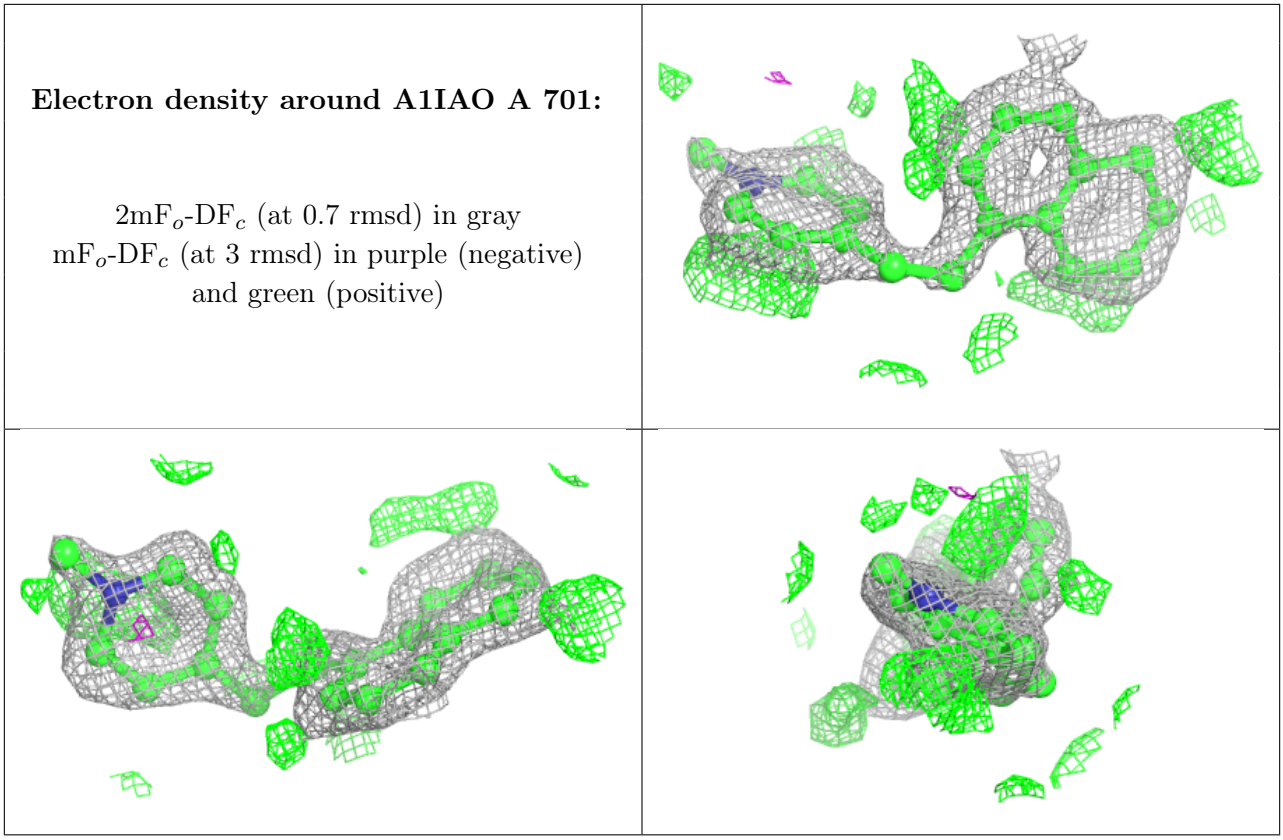
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95^{th} percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' 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	A1IAO	A	701	19/19	0.82	0.18	23,27,30,31	19
3	NA	A	703	1/1	0.95	0.17	37,37,37,37	0
3	NA	A	702	1/1	0.99	0.03	19,19,19,19	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 A1IAO A 701:

$2mF_o$-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.