



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 04:37 PM UTC

PDB ID : 8AIU / pdb_00008aiu
Title : Mpro of SARS COV-2 in complex with the MG-97 inhibitor
Authors : El Kilani, H.; Hilgenfeld, R.
Deposited on : 2022-07-27
Resolution : 2.00 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 : 2022.3.0, CSD as543be (2022)
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 : 9.0.010 (Gargrove)
Density-Fitness : 1.0.12
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

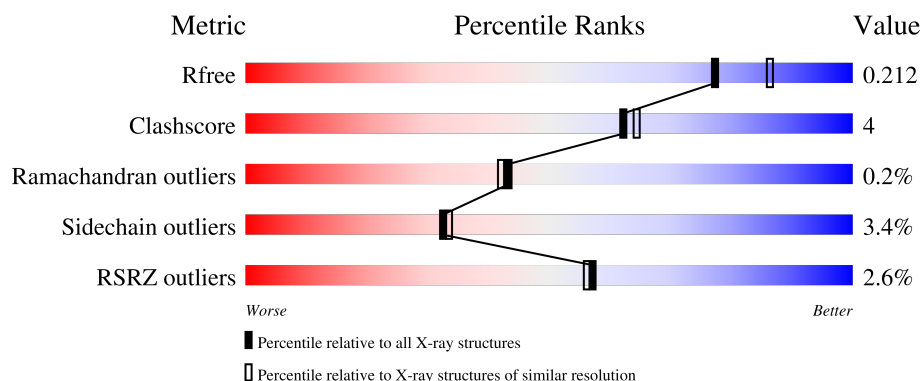
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.00 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	10052 (2.00-2.00)
Clashscore	190562	11152 (2.00-2.00)
Ramachandran outliers	187476	11031 (2.00-2.00)
Sidechain outliers	187428	11029 (2.00-2.00)
RSRZ outliers	180081	10067 (2.00-2.00)

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	305	2% 88% 11%
1	BBB	305	3% 87% 12%

2 Entry composition [i](#)

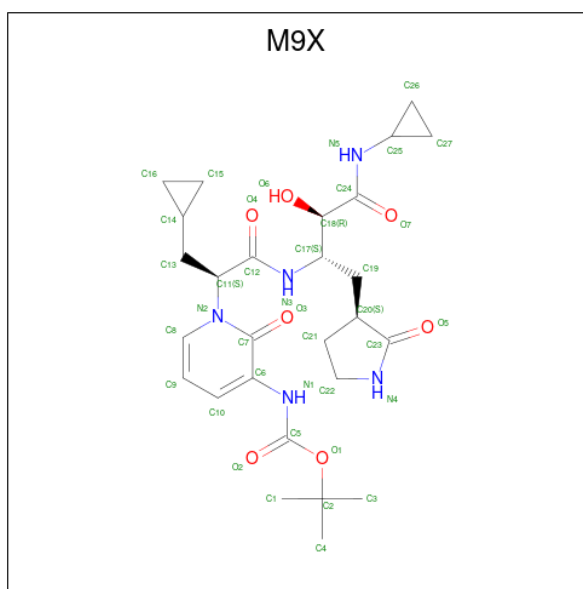
There are 4 unique types of molecules in this entry. The entry contains 5099 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 3C-like proteinase nsp5.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	AAA	305	Total	C	N	O	S	0	0	0
			2358	1494	400	442	22			
1	BBB	304	Total	C	N	O	S	0	0	0
			2347	1485	399	441	22			

- Molecule 2 is tert-butyl N-[1-[(2S)-3-cyclopropyl-1-[[[(2S,3R)-4-(cyclopropylamino)-3-oxidanyl-4-oxidanylidene-1-[(3S)-2-oxidanylidene-pyrrolidin-3-yl]butan-2-yl]amino]-1-oxidanylidene-propan-2-yl]-2-oxidanylidene-pyridin-3-yl]carbamate (CCD ID: M9X) (formula: C₂₇H₃₉N₅O₇) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
2	AAA	1	Total	C	N	O	0	0
			39	27	5	7		
2	BBB	1	Total	C	N	O	0	0
			39	27	5	7		

- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	AAA	1	Total 1	Cl 1	0	0

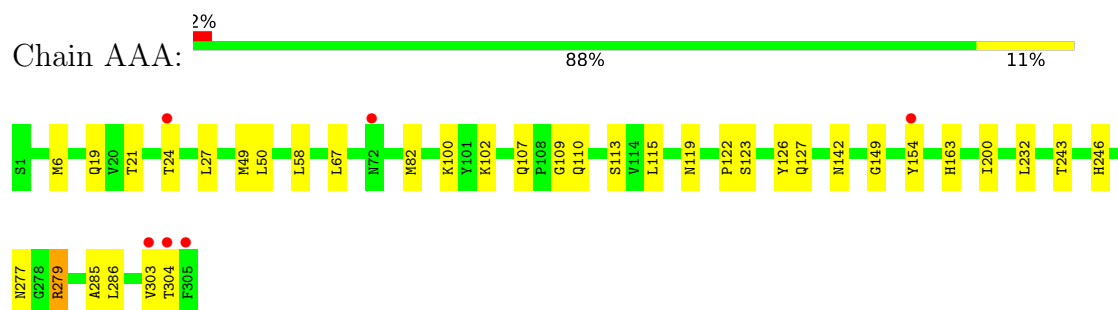
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	AAA	158	Total 158	O 158	0	0
4	BBB	157	Total 157	O 157	0	0

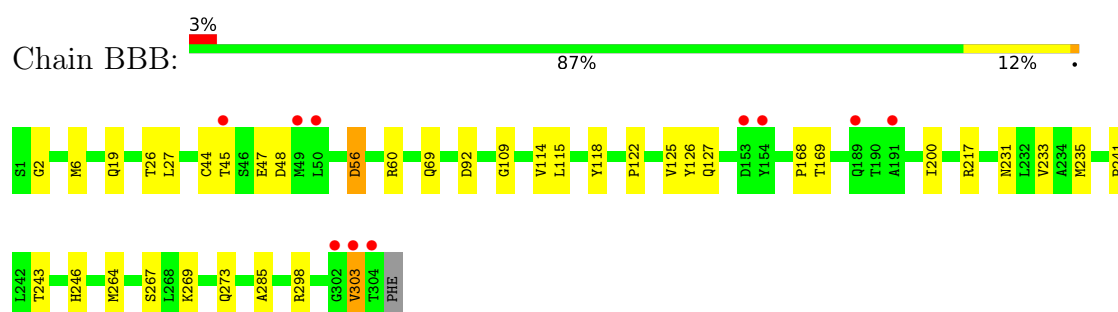
3 Residue-property plots [i](#)

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: 3C-like proteinase nsp5



- Molecule 1: 3C-like proteinase nsp5



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	45.78Å 63.66Å 103.65Å 90.00° 91.06° 90.00°	Depositor
Resolution (Å)	42.19 – 2.00 42.19 – 2.00	Depositor EDS
% Data completeness (in resolution range)	95.4 (42.19-2.00) 95.4 (42.19-2.00)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	5.42 (at 2.00Å)	Xtriage
Refinement program	REFMAC 5.8.0267	Depositor
R, R_{free}	0.161 , 0.206 0.171 , 0.212	Depositor DCC
R_{free} test set	1909 reflections (4.70%)	wwPDB-VP
Wilson B-factor (Å ²)	19.2	Xtriage
Anisotropy	0.069	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.38 , 38.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.028 for h,-k,-l	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	5099	wwPDB-VP
Average B, all atoms (Å ²)	22.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.81% of the height of the origin peak. No significant pseudotranslation is detected.*

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: M9X, CL

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	1.05	1/2411 (0.0%)	1.27	1/3277 (0.0%)
1	BBB	1.06	0/2399	1.25	1/3261 (0.0%)
All	All	1.05	1/4810 (0.0%)	1.26	2/6538 (0.0%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	AAA	163	HIS	CE1-NE2	5.30	1.37	1.32

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	BBB	2	GLY	CA-C-O	-6.15	117.99	122.23
1	AAA	142	ASN	CB-CA-C	5.77	118.90	109.90

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts [i](#)

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	2358	0	2305	17	0
1	BBB	2347	0	2296	25	0
2	AAA	39	0	0	1	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	BBB	39	0	0	0	0
3	AAA	1	0	0	0	0
4	AAA	158	0	0	1	0
4	BBB	157	0	0	2	0
All	All	5099	0	4601	38	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 (38) 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:107:GLN:H	1:AAA:110:GLN:HE21	1.26	0.82
1:BBB:231:ASN:HB3	1:BBB:235:MET:HE3	1.60	0.82
1:BBB:19:GLN:HE21	1:BBB:26:THR:HG21	1.56	0.71
1:AAA:107:GLN:H	1:AAA:110:GLN:NE2	1.93	0.64
1:BBB:235:MET:HE2	1:BBB:241:PRO:HA	1.78	0.64
1:AAA:279:ARG:CG	1:AAA:279:ARG:HH11	2.10	0.64
1:BBB:231:ASN:CB	1:BBB:235:MET:HE3	2.28	0.61
1:BBB:45:THR:OG1	1:BBB:47:GLU:HB3	2.01	0.60
1:BBB:48:ASP:HA	4:BBB:558:HOH:O	2.03	0.57
1:BBB:233:VAL:HG11	1:BBB:269:LYS:HG3	1.86	0.57
1:BBB:235:MET:HE2	1:BBB:241:PRO:CA	2.35	0.57
1:AAA:246:HIS:HE1	4:AAA:640:HOH:O	1.88	0.55
1:BBB:273:GLN:NE2	4:BBB:501:HOH:O	2.40	0.55
1:AAA:49:MET:HE1	2:AAA:401:M9X:C15	2.36	0.54
1:AAA:58:LEU:HD22	1:AAA:82:MET:HE3	1.91	0.53
1:BBB:56:ASP:O	1:BBB:60:ARG:HD3	2.10	0.52
1:BBB:6:MET:SD	1:BBB:298:ARG:NH2	2.85	0.49
1:AAA:279:ARG:HH11	1:AAA:279:ARG:HG2	1.77	0.48
1:AAA:243:THR:H	1:AAA:246:HIS:CD2	2.32	0.48
1:BBB:235:MET:HE2	1:BBB:241:PRO:CB	2.44	0.47
1:AAA:285:ALA:HB3	1:BBB:285:ALA:HB3	1.97	0.47
1:AAA:109:GLY:HA2	1:AAA:200:ILE:HD13	1.97	0.47
1:AAA:19:GLN:NE2	1:AAA:119:ASN:HB3	2.31	0.46
1:BBB:114:VAL:O	1:BBB:125:VAL:HA	2.15	0.46
1:AAA:126:TYR:CD2	1:BBB:6:MET:HE2	2.52	0.45
1:BBB:243:THR:H	1:BBB:246:HIS:CD2	2.35	0.45
1:AAA:304:THR:HG21	1:BBB:118:TYR:HB2	1.99	0.44
1:AAA:115:LEU:HD11	1:AAA:122:PRO:HB3	2.00	0.44
1:BBB:92:ASP:OD1	1:BBB:92:ASP:C	2.59	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:AAA:6:MET:HE2	1:BBB:126:TYR:CE2	2.55	0.42
1:AAA:113:SER:O	1:AAA:149:GLY:HA2	2.20	0.42
1:BBB:115:LEU:HD11	1:BBB:122:PRO:HB3	2.01	0.42
1:BBB:264:MET:O	1:BBB:267:SER:HB2	2.20	0.42
1:BBB:298:ARG:HA	1:BBB:303:VAL:HG13	2.02	0.42
1:BBB:44:CYS:HB3	1:BBB:48:ASP:HB2	2.02	0.41
1:BBB:168:PRO:O	1:BBB:169:THR:OG1	2.36	0.41
1:BBB:109:GLY:HA2	1:BBB:200:ILE:HD13	2.03	0.41
1:AAA:21:THR:HB	1:AAA:67:LEU:HB3	2.03	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	303/305 (99%)	295 (97%)	7 (2%)	1 (0%)	36	35
1	BBB	302/305 (99%)	297 (98%)	5 (2%)	0	100	100
All	All	605/610 (99%)	592 (98%)	12 (2%)	1 (0%)	43	42

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	AAA	154	TYR

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	262/262 (100%)	250 (95%)	12 (5%)	24	22
1	BBB	261/262 (100%)	255 (98%)	6 (2%)	44	49
All	All	523/524 (100%)	505 (97%)	18 (3%)	32	33

All (18) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	AAA	24	THR
1	AAA	27	LEU
1	AAA	50	LEU
1	AAA	100	LYS
1	AAA	102	LYS
1	AAA	123	SER
1	AAA	127	GLN
1	AAA	232	LEU
1	AAA	277	ASN
1	AAA	279	ARG
1	AAA	286	LEU
1	AAA	303	VAL
1	BBB	27	LEU
1	BBB	56	ASP
1	BBB	69	GLN
1	BBB	127	GLN
1	BBB	217	ARG
1	BBB	303	VAL

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 [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 3 ligands modelled in this entry, 1 is 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	$\# Z > 2$
2	M9X	BBB	401	1	42,42,42	0.92	2 (4%)	51,61,61	1.17	5 (9%)
2	M9X	AAA	401	1	42,42,42	0.88	2 (4%)	51,61,61	1.18	5 (9%)

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	M9X	BBB	401	1	-	4/41/55/55	0/4/4/4
2	M9X	AAA	401	1	-	6/41/55/55	0/4/4/4

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	AAA	401	M9X	C6-C7	-3.66	1.39	1.48
2	BBB	401	M9X	C6-C7	-3.66	1.39	1.48
2	BBB	401	M9X	C18-C24	-2.27	1.48	1.52
2	AAA	401	M9X	C18-C24	-2.03	1.48	1.52

All (10) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	BBB	401	M9X	C10-C6-N1	-3.82	122.30	127.12
2	BBB	401	M9X	C7-C6-N1	3.66	115.40	112.00

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	AAA	401	M9X	C7-C6-N1	3.32	115.09	112.00
2	AAA	401	M9X	C10-C6-N1	-2.98	123.35	127.12
2	AAA	401	M9X	C27-C25-N5	-2.60	115.11	118.52
2	BBB	401	M9X	C14-C13-C11	-2.54	111.19	114.54
2	BBB	401	M9X	C10-C6-C7	2.49	122.29	120.46
2	BBB	401	M9X	O3-C7-C6	2.44	125.02	122.00
2	AAA	401	M9X	O3-C7-C6	2.42	125.00	122.00
2	AAA	401	M9X	C18-C17-N3	-2.17	105.90	109.93

There are no chirality outliers.

All (10) torsion outliers are listed below:

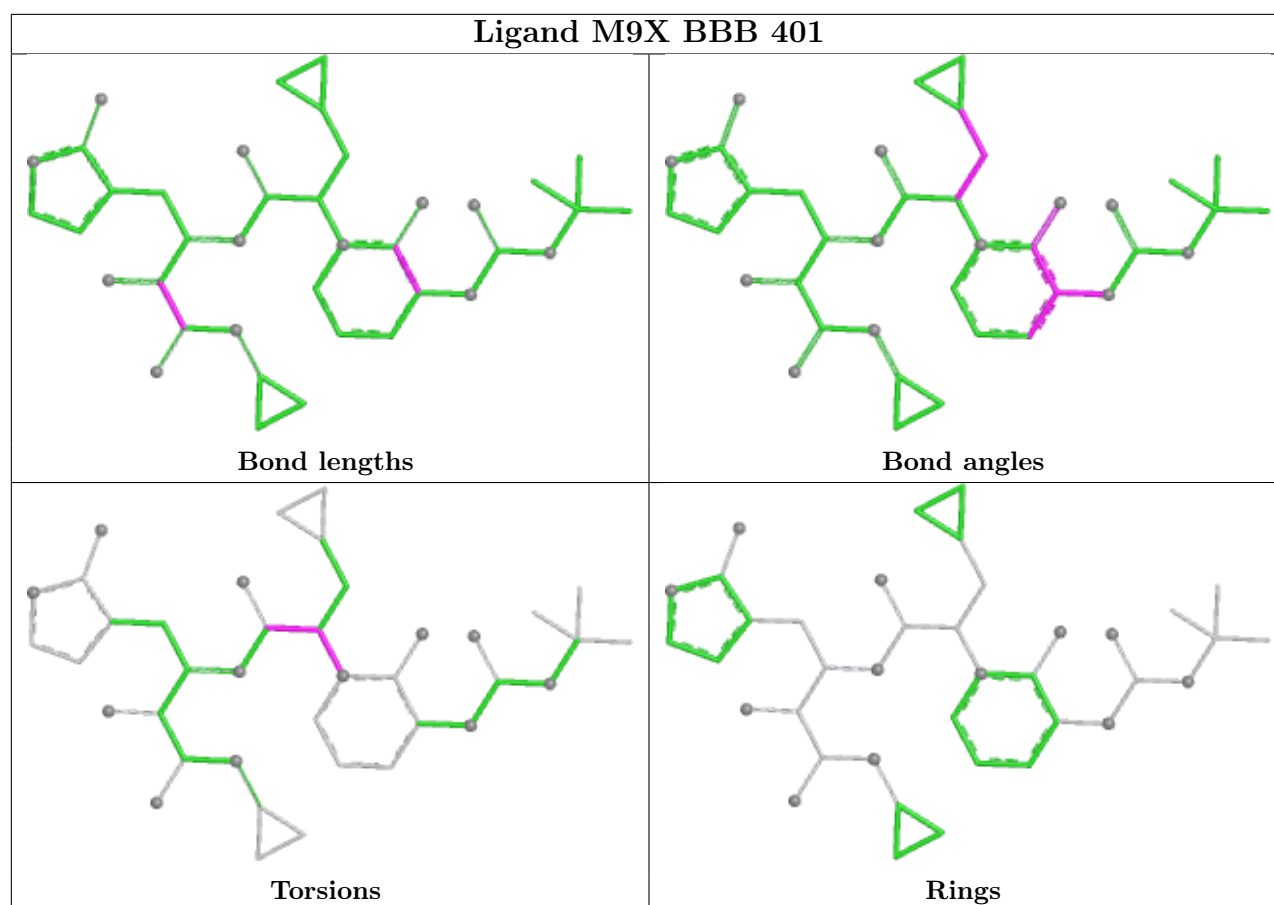
Mol	Chain	Res	Type	Atoms
2	AAA	401	M9X	C13-C11-N2-C8
2	BBB	401	M9X	C13-C11-N2-C7
2	BBB	401	M9X	C13-C11-N2-C8
2	AAA	401	M9X	C13-C11-N2-C7
2	AAA	401	M9X	C12-C11-N2-C7
2	AAA	401	M9X	C26-C25-N5-C24
2	AAA	401	M9X	C27-C25-N5-C24
2	AAA	401	M9X	N2-C11-C12-N3
2	BBB	401	M9X	N2-C11-C12-N3
2	BBB	401	M9X	N2-C11-C12-O4

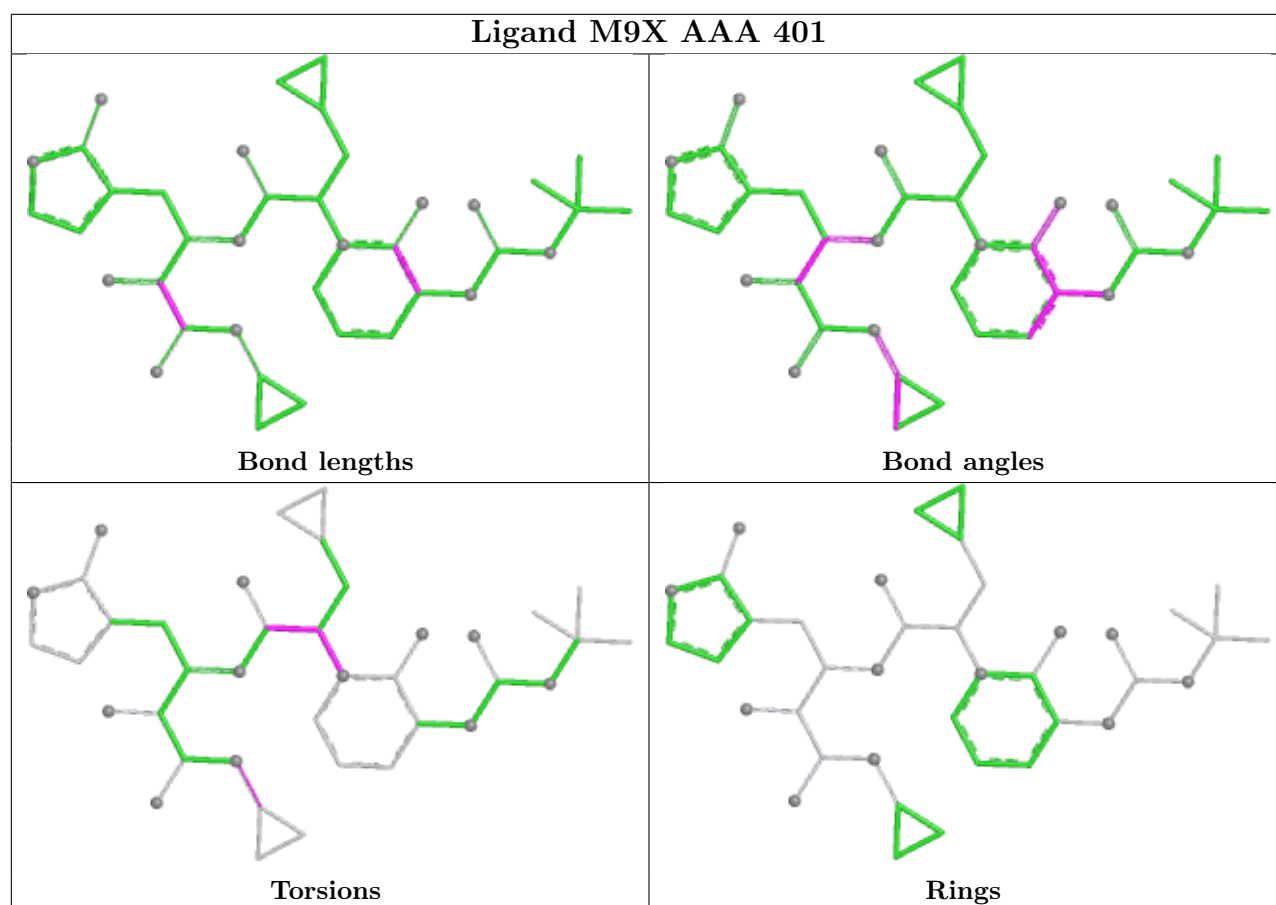
There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	AAA	401	M9X	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	305/305 (100%)	-0.11	6 (1%) 65 64	11, 19, 36, 58	0
1	BBB	304/305 (99%)	0.02	10 (3%) 49 48	11, 20, 44, 72	0
All	All	609/610 (99%)	-0.04	16 (2%) 57 56	11, 19, 38, 72	0

All (16) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	BBB	303	VAL	5.6
1	AAA	154	TYR	5.0
1	BBB	304	THR	4.5
1	BBB	50	LEU	4.3
1	AAA	305	PHE	4.0
1	AAA	303	VAL	3.7
1	BBB	302	GLY	3.2
1	BBB	154	TYR	3.0
1	BBB	45	THR	2.6
1	BBB	153	ASP	2.5
1	AAA	304	THR	2.4
1	BBB	189	GLN	2.3
1	BBB	49	MET	2.2
1	AAA	24	THR	2.2
1	BBB	191	ALA	2.1
1	AAA	72	ASN	2.1

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](#)

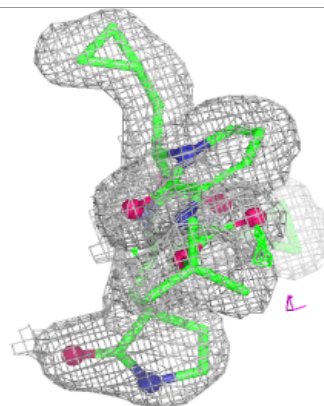
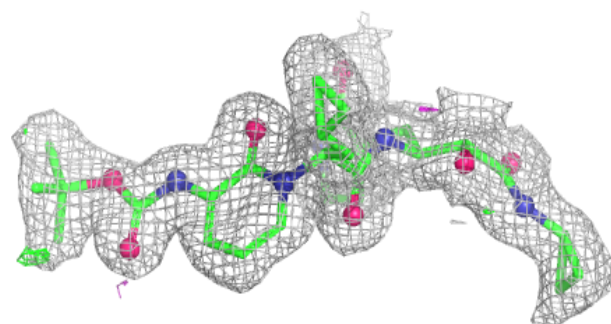
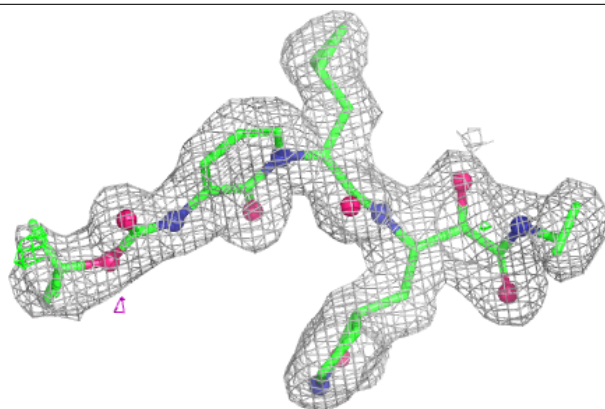
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
2	M9X	AAA	401	39/39	0.95	0.07	17,20,33,35	0
2	M9X	BBB	401	39/39	0.96	0.06	16,19,27,29	0
3	CL	AAA	402	1/1	0.99	0.13	32,32,32,32	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.

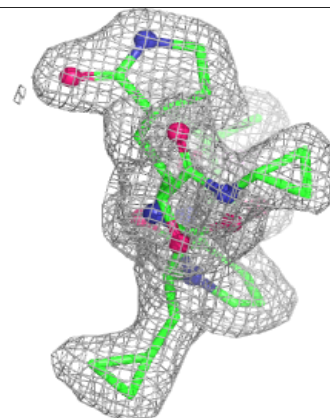
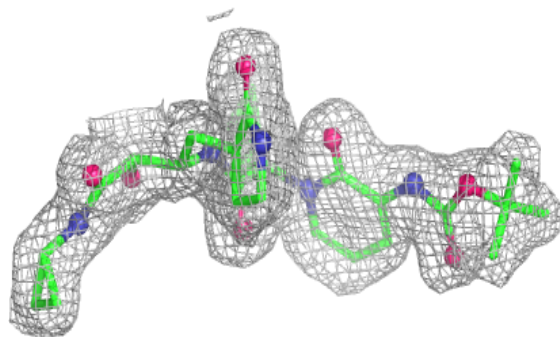
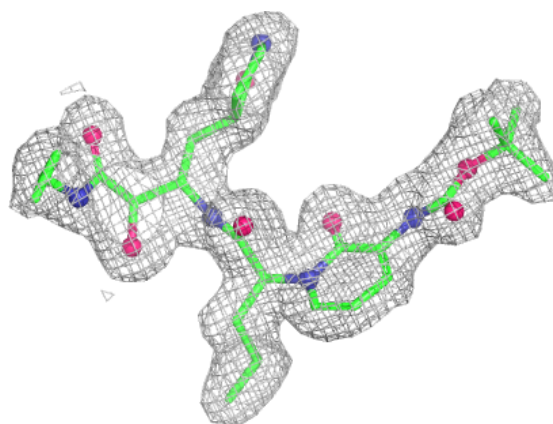
Electron density around M9X AAA 401:

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 M9X BBB 401:

$2mF_o - DF_c$ (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.