



Full wwPDB X-ray Structure Validation Report ⓘ

Aug 7, 2023 – 04:17 pm BST

PDB ID : 8AIQ
Title : Mpro of SARS COV-2 in complex with the MG-87 inhibitor
Authors : El Kilani, H.; Hilgenfeld, R.
Deposited on : 2022-07-27
Resolution : 2.19 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 : 2.34
buster-report : 1.1.7 (2018)
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Refmac : 5.8.0158
CCP4 : 7.0.044 (Gargrove)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.34

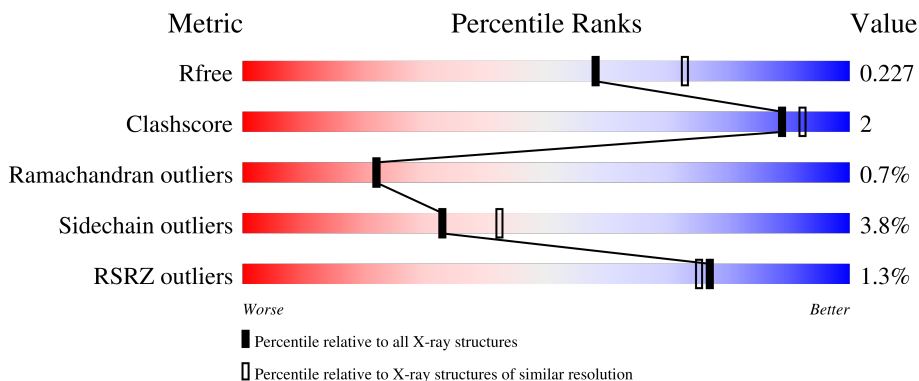
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.19 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}	130704	4898 (2.20-2.20)
Clashscore	141614	5594 (2.20-2.20)
Ramachandran outliers	138981	5503 (2.20-2.20)
Sidechain outliers	138945	5504 (2.20-2.20)
RSRZ outliers	127900	4800 (2.20-2.20)

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	306	
1	BBB	306	

2 Entry composition [i](#)

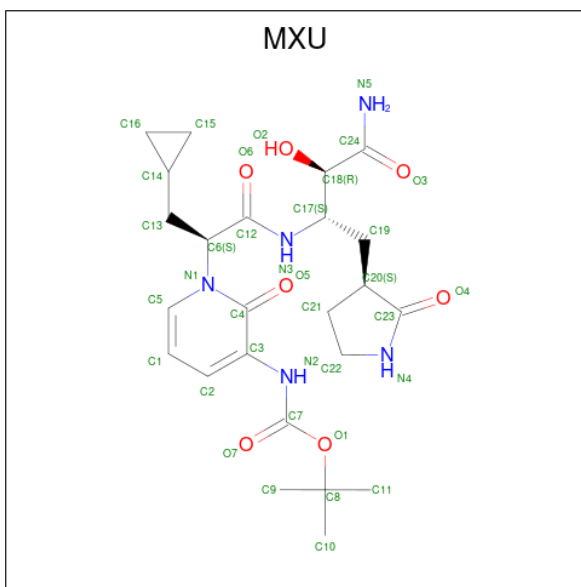
There are 4 unique types of molecules in this entry. The entry contains 4990 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 Replicase polypeptide 1ab.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	AAA	306	Total 2367	C 1499	N 402	O 444	S 22	0	0	0
1	BBB	306	Total 2367	C 1499	N 402	O 444	S 22	0	0	0

- Molecule 2 is {tert}-butyl {N}-[1-[(2 {S})-1-[[2 {S},3 {R}]-4-azanyl-3-oxidanyl-4-oxidanlydene-1-[(3 {S})-2-oxidanylidenepyrrolidin-3-yl]butan-2-yl]amino]-3-cyclopropyl-1-oxidanylidene-propan-2-yl]-2-oxidanylidene-pyridin-3-yl]carbamate (three-letter code: MXU) (formula: C₂₄H₃₅N₅O₇) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
			Total	C	N	O		
2	AAA	1	Total 36	C 24	N 5	O 7	0	0
2	BBB	1	Total 36	C 24	N 5	O 7	0	0

- Molecule 3 is CHLORIDE ION (three-letter code: CL) (formula: Cl).

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

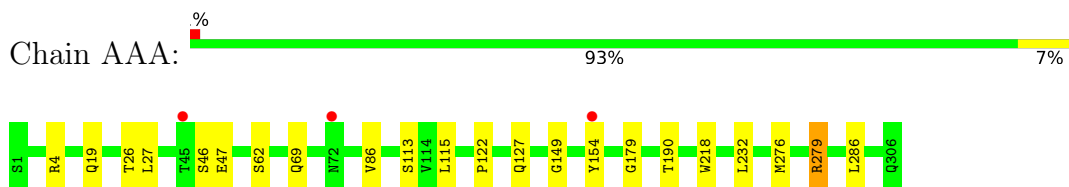
- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	AAA	109	Total O 109 109	0	0
4	BBB	74	Total O 74 74	0	0

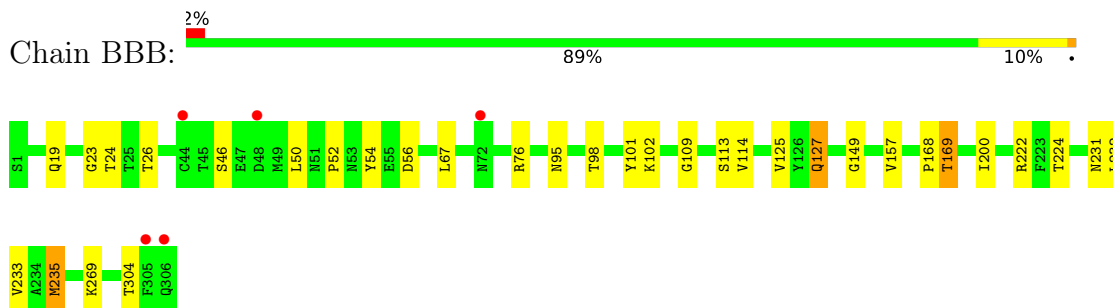
3 Residue-property plots [i](#)

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: Replicase polyprotein 1ab



- Molecule 1: Replicase polyprotein 1ab



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	45.94Å 63.77Å 103.51Å 90.00° 91.25° 90.00°	Depositor
Resolution (Å)	45.97 – 2.19 45.93 – 2.19	Depositor EDS
% Data completeness (in resolution range)	98.6 (45.97-2.19) 98.6 (45.93-2.19)	Depositor EDS
R_{merge}	0.13	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.04 (at 2.18Å)	Xtrriage
Refinement program	REFMAC 5.8.0267	Depositor
R, R_{free}	0.168 , 0.223 0.176 , 0.227	Depositor DCC
R_{free} test set	1411 reflections (4.62%)	wwPDB-VP
Wilson B-factor (Å ²)	25.3	Xtrriage
Anisotropy	0.075	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 35.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtrriage
Estimated twinning fraction	0.028 for h,-k,-l	Xtrriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	4990	wwPDB-VP
Average B, all atoms (Å ²)	28.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.64% 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: CL, MXU

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	0.69	0/2420	0.86	0/3289
1	BBB	0.69	0/2420	0.84	0/3289
All	All	0.69	0/4840	0.85	0/6578

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 [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	2367	0	2313	8	0
1	BBB	2367	0	2313	11	0
2	AAA	36	0	0	0	0
2	BBB	36	0	0	0	0
3	AAA	1	0	0	0	0
4	AAA	109	0	0	1	0
4	BBB	74	0	0	0	0
All	All	4990	0	4626	18	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 (18) 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:19:GLN:HE21	1:BBB:26:THR:HG21	1.45	0.79
1:AAA:19:GLN:HE21	1:AAA:26:THR:HG21	1.54	0.73
1:AAA:276:MET:HE3	1:AAA:286:LEU:HA	1.79	0.65
1:BBB:168:PRO:O	1:BBB:169:THR:OG1	2.11	0.65
1:AAA:218:TRP:CE2	1:AAA:279:ARG:HD2	2.35	0.62
1:BBB:233:VAL:HG21	1:BBB:269:LYS:HD2	1.90	0.54
1:BBB:109:GLY:HA2	1:BBB:200:ILE:HD13	1.92	0.52
1:AAA:113:SER:O	1:AAA:149:GLY:HA2	2.14	0.48
1:AAA:69:GLN:NE2	4:AAA:506:HOH:O	2.48	0.47
1:BBB:95:ASN:HB3	1:BBB:98:THR:OG1	2.15	0.47
1:AAA:115:LEU:HD11	1:AAA:122:PRO:HB3	1.96	0.46
1:BBB:52:PRO:HG2	1:BBB:54:TYR:CE2	2.52	0.45
1:AAA:86:VAL:HG13	1:AAA:179:GLY:HA2	1.98	0.45
1:AAA:4:ARG:NH2	1:BBB:127:GLN:O	2.51	0.43
1:BBB:114:VAL:O	1:BBB:125:VAL:HA	2.19	0.42
1:BBB:101:TYR:HA	1:BBB:157:VAL:O	2.20	0.41
1:BBB:231:ASN:O	1:BBB:235:MET:HB2	2.21	0.41
1:BBB:113:SER:O	1:BBB:149:GLY:HA2	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	AAA	304/306 (99%)	295 (97%)	8 (3%)	1 (0%)	41	46
1	BBB	304/306 (99%)	294 (97%)	7 (2%)	3 (1%)	15	14
All	All	608/612 (99%)	589 (97%)	15 (2%)	4 (1%)	22	22

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	BBB	50	LEU
1	BBB	23	GLY
1	BBB	169	THR
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	263/263 (100%)	255 (97%)	8 (3%)	41	53
1	BBB	263/263 (100%)	251 (95%)	12 (5%)	27	34
All	All	526/526 (100%)	506 (96%)	20 (4%)	33	42

All (20) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	AAA	27	LEU
1	AAA	46	SER
1	AAA	47	GLU
1	AAA	62	SER
1	AAA	127	GLN
1	AAA	190	THR
1	AAA	232	LEU
1	AAA	279	ARG
1	BBB	24	THR
1	BBB	46	SER
1	BBB	56	ASP
1	BBB	67	LEU
1	BBB	76	ARG
1	BBB	102	LYS
1	BBB	127	GLN
1	BBB	222	ARG
1	BBB	224	THR
1	BBB	232	LEU
1	BBB	235	MET
1	BBB	304	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

5.3.3 RNA [i](#)

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 monosaccharides 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	MXU	BBB	401	1	37,38,38	0.96	2 (5%)	44,55,55	1.74	6 (13%)
2	MXU	AAA	401	1	37,38,38	0.90	2 (5%)	44,55,55	1.29	7 (15%)

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	MXU	BBB	401	1	-	10/37/49/49	0/3/3/3
2	MXU	AAA	401	1	-	11/37/49/49	0/3/3/3

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	BBB	401	MXU	C24-N5	3.61	1.42	1.32
2	AAA	401	MXU	C3-C4	-3.21	1.39	1.47
2	AAA	401	MXU	C24-N5	2.86	1.40	1.32
2	BBB	401	MXU	C3-C4	-2.80	1.40	1.47

All (13) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	BBB	401	MXU	C4-C3-N2	6.92	118.62	112.30
2	BBB	401	MXU	C2-C3-N2	-5.65	119.57	127.20
2	AAA	401	MXU	C4-C3-N2	3.95	115.91	112.30
2	BBB	401	MXU	C18-C17-N3	-3.51	103.42	110.03
2	AAA	401	MXU	C2-C3-N2	-3.43	122.56	127.20
2	BBB	401	MXU	O5-C4-C3	3.39	126.24	122.29
2	AAA	401	MXU	O5-C4-C3	3.10	125.91	122.29
2	AAA	401	MXU	C14-C13-C6	-2.67	111.01	114.54
2	BBB	401	MXU	C2-C3-C4	2.64	121.80	120.30
2	AAA	401	MXU	C12-C6-N1	-2.54	107.10	111.87
2	BBB	401	MXU	O5-C4-N1	-2.18	117.92	122.43
2	AAA	401	MXU	C2-C3-C4	2.15	121.53	120.30
2	AAA	401	MXU	C18-C17-N3	-2.10	106.07	110.03

There are no chirality outliers.

All (21) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	AAA	401	MXU	C13-C6-N1-C5
2	AAA	401	MXU	C6-C13-C14-C16
2	AAA	401	MXU	C17-C18-C24-N5
2	AAA	401	MXU	O2-C18-C24-N5
2	AAA	401	MXU	C17-C18-C24-O3
2	BBB	401	MXU	C13-C6-N1-C4
2	BBB	401	MXU	C13-C6-N1-C5
2	BBB	401	MXU	C14-C13-C6-C12
2	BBB	401	MXU	C17-C18-C24-O3
2	BBB	401	MXU	C4-C3-N2-C7
2	AAA	401	MXU	C14-C13-C6-N1
2	BBB	401	MXU	C14-C13-C6-N1
2	AAA	401	MXU	C14-C13-C6-C12
2	BBB	401	MXU	C11-C8-O1-C7
2	AAA	401	MXU	C13-C6-N1-C4
2	BBB	401	MXU	C2-C3-N2-C7

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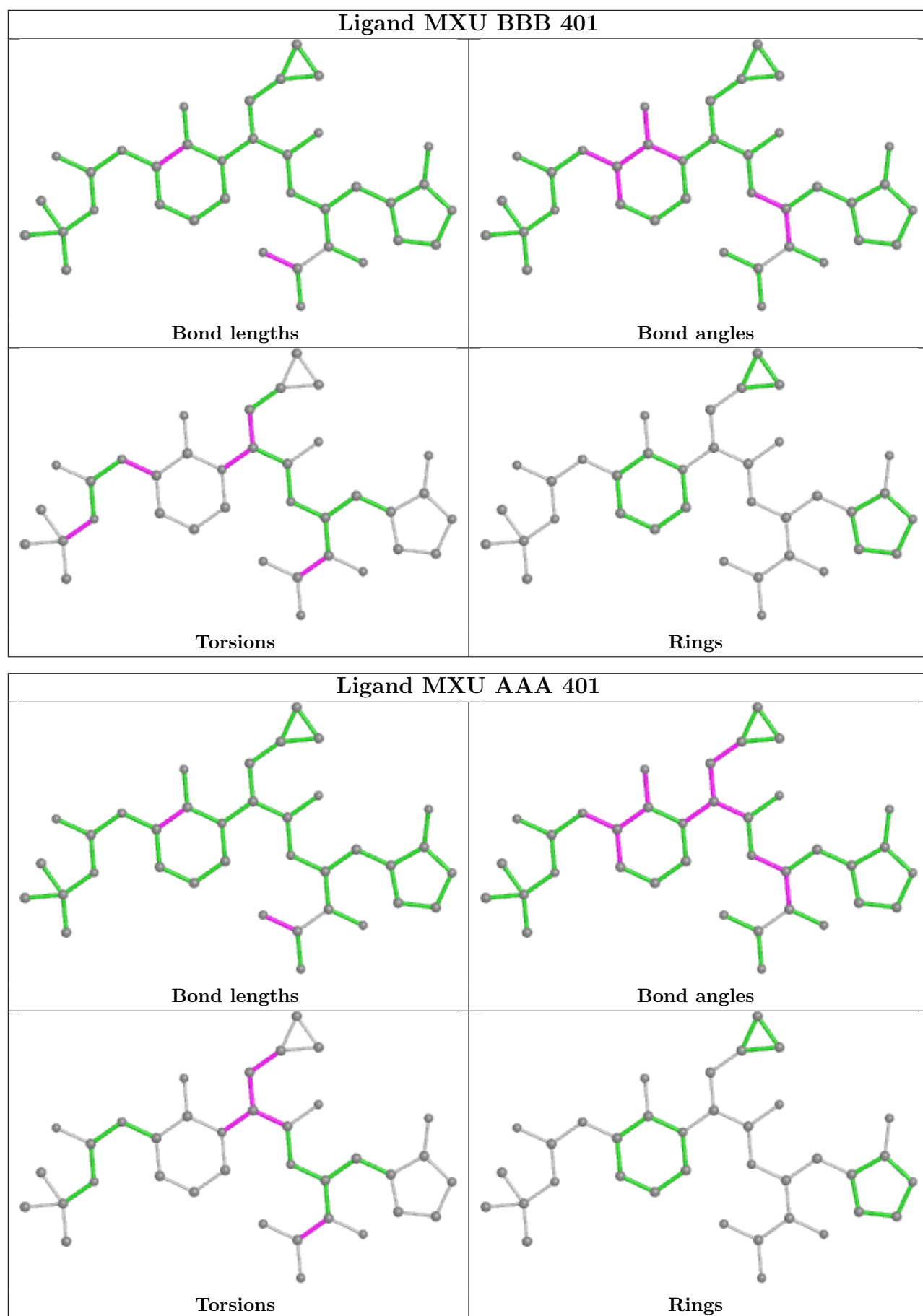
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Mol	Chain	Res	Type	Atoms
2	AAA	401	MXU	O2-C18-C24-O3
2	BBB	401	MXU	O2-C18-C24-O3
2	AAA	401	MXU	C12-C6-N1-C4
2	BBB	401	MXU	C9-C8-O1-C7
2	AAA	401	MXU	N3-C12-C6-N1

There are no ring outliers.

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 [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	306/306 (100%)	-0.19	3 (0%) 82 81	12, 24, 47, 71	0
1	BBB	306/306 (100%)	-0.12	5 (1%) 72 70	14, 25, 51, 82	0
All	All	612/612 (100%)	-0.15	8 (1%) 77 75	12, 24, 50, 82	0

All (8) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	AAA	154	TYR	3.4
1	BBB	48	ASP	3.0
1	BBB	306	GLN	2.6
1	AAA	72	ASN	2.3
1	BBB	72	ASN	2.2
1	BBB	44	CYS	2.2
1	BBB	305	PHE	2.2
1	AAA	45	THR	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.

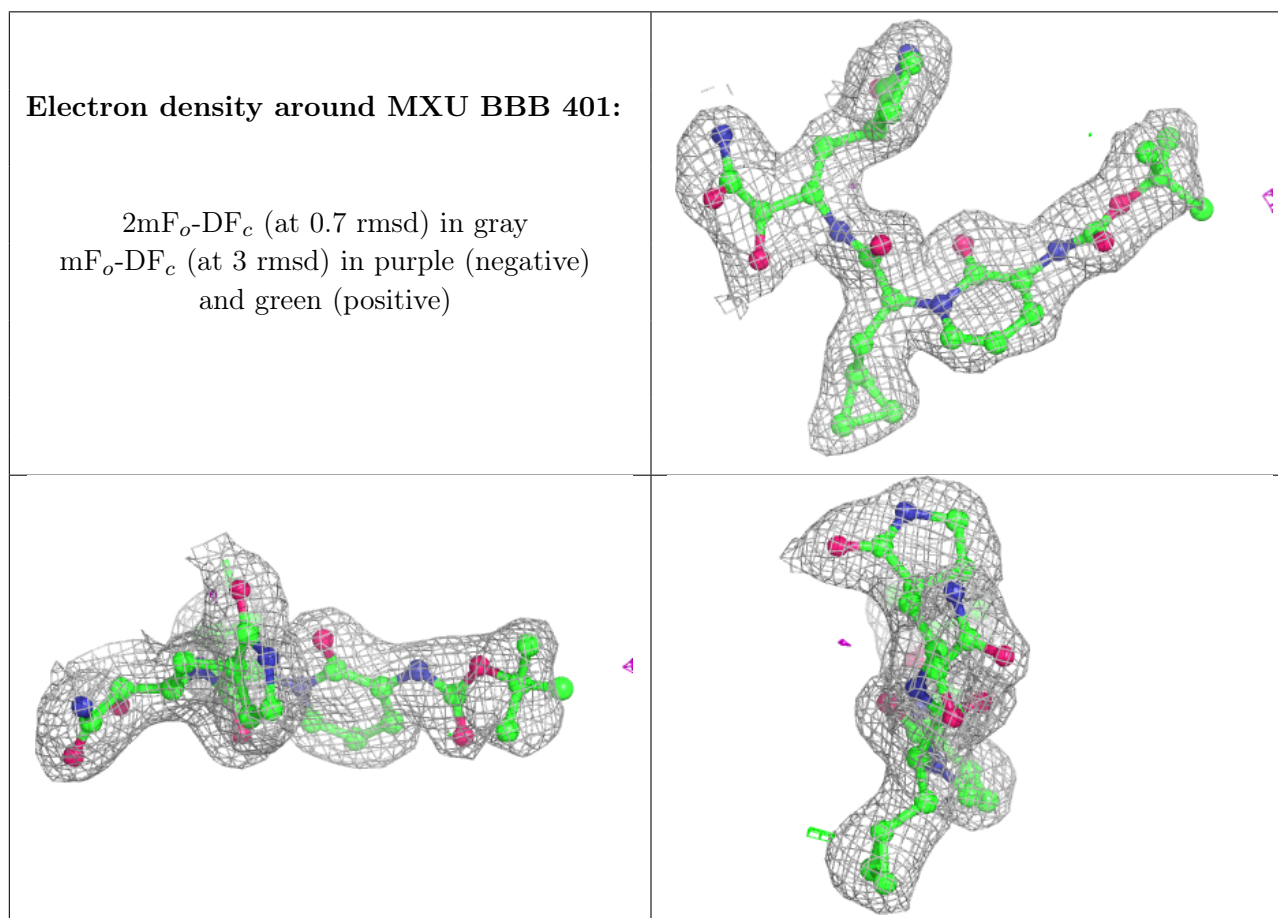
6.4 Ligands [i](#)

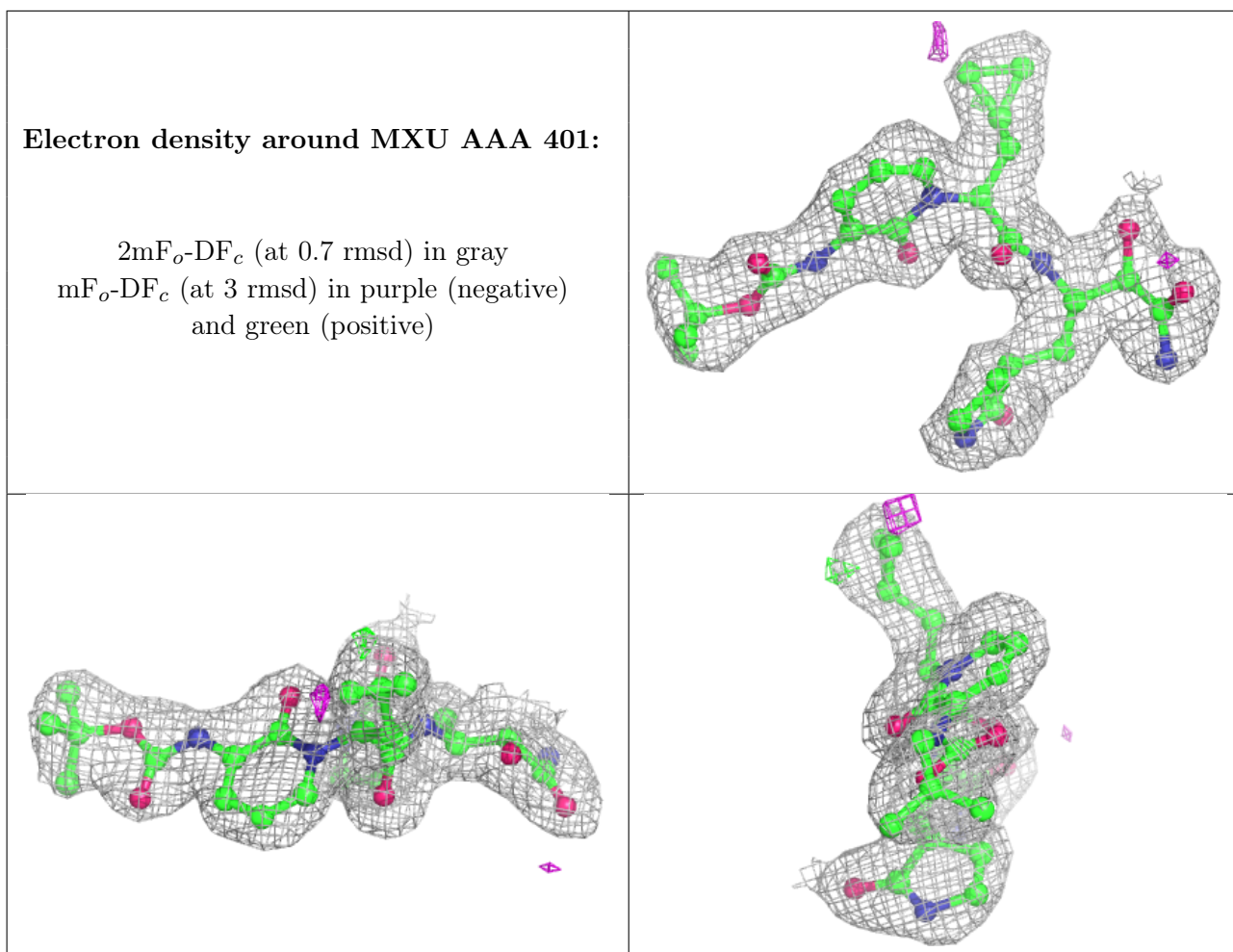
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum,

median, 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	MXU	BBB	401	36/36	0.94	0.11	22,27,36,39	0
2	MXU	AAA	401	36/36	0.95	0.10	21,25,36,37	0
3	CL	AAA	402	1/1	0.95	0.10	44,44,44,44	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.