



Full wwPDB X-ray Structure Validation Report ⓘ

Jul 27, 2026 – 10:22 am BST

PDB ID : 9TD1 / pdb_00009td1
Title : Structure of an LPMO expressed in E.coli (LsAA9A) at 4.24×10^4 Gy
Authors : Wei, Q.; Huang, Z.; Lo Leggio, L.
Deposited on : 2025-11-22
Resolution : 1.94 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
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

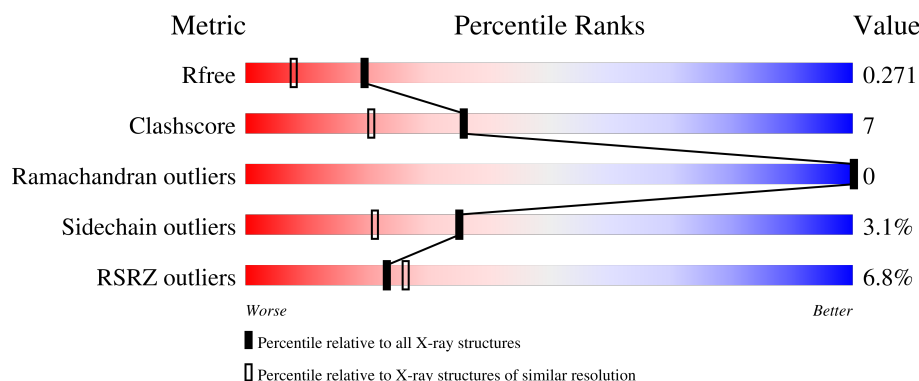
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.94 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	1452 (1.94-1.94)
Clashscore	190562	1494 (1.94-1.94)
Ramachandran outliers	187476	1479 (1.94-1.94)
Sidechain outliers	187428	1479 (1.94-1.94)
RSRZ outliers	180081	1453 (1.94-1.94)

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	235	7% 83% 15%
2	EEE	3	100%
2	EcE	3	100%

2 Entry composition [i](#)

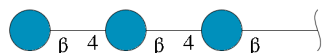
There are 8 unique types of molecules in this entry. The entry contains 2004 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 Auxiliary activity 9.

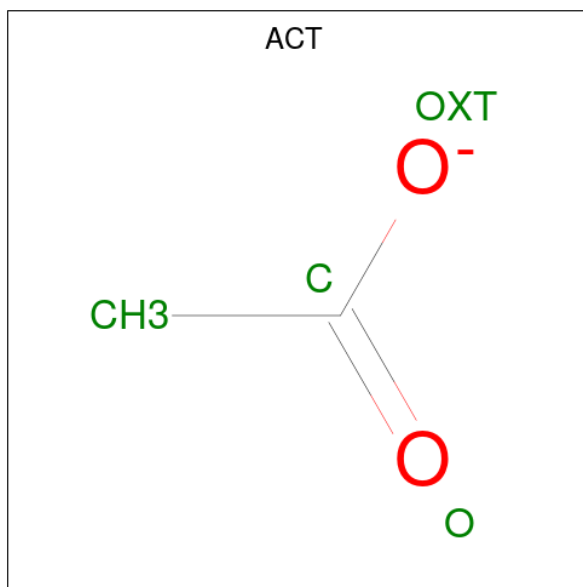
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	AAA	235	Total	C	N	O	S	0	7	0
			1823	1152	310	358	3			

- Molecule 2 is an oligosaccharide called beta-D-glucopyranose-(1-4)-beta-D-glucopyranose-(1-4)-beta-D-glucopyranose.



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf	Trace
2	EEE	3	Total	C	O	0	0	0
			34	18	16			
2	EcE	3	Total	C	O	0	0	0
			34	18	16			

- Molecule 3 is ACETATE ION (CCD ID: ACT) (formula: C₂H₃O₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	AAA	1	Total	C	O	0	0
			4	2	2		
3	AAA	1	Total	C	O	0	0
			4	2	2		

- Molecule 4 is COPPER (II) ION (CCD ID: CU) (formula: Cu).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	AAA	1	Total	Cu	0	0
			1	1		

- Molecule 5 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	AAA	4	Total	Cl	0	0
			4	4		

- Molecule 6 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	AAA	1	Total	O	S	0	0
			5	4	1		

- Molecule 7 is SODIUM ION (CCD ID: NA) (formula: Na).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
7	AAA	1	Total	Na	0	0
			1	1		

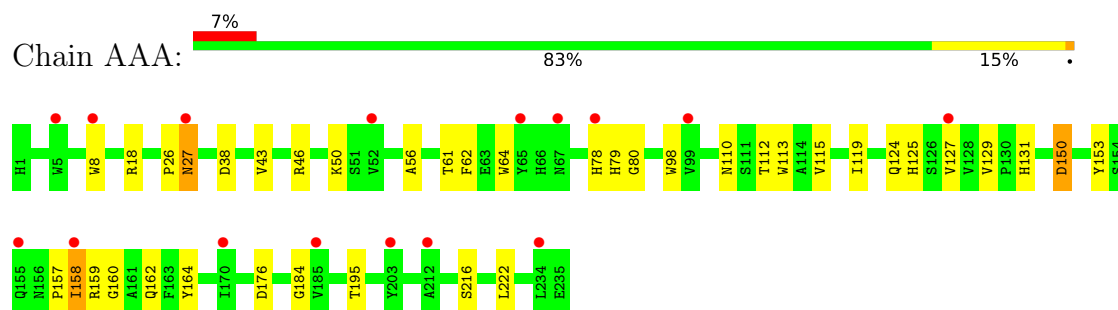
- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	AAA	91	Total	O	0	3
			94	94		

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: Auxiliary activity 9



- Molecule 2: beta-D-glucopyranose-(1-4)-beta-D-glucopyranose-(1-4)-beta-D-glucopyranose



- Molecule 2: beta-D-glucopyranose-(1-4)-beta-D-glucopyranose-(1-4)-beta-D-glucopyranose



4 Data and refinement statistics

Property	Value	Source
Space group	P 41	Depositor
Cell constants a, b, c, α , β , γ	48.01Å 48.01Å 108.83Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	48.06 – 1.94 48.01 – 1.94	Depositor EDS
% Data completeness (in resolution range)	100.0 (48.06-1.94) 99.9 (48.01-1.94)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.02 (at 1.94Å)	Xtriage
Refinement program	REFMAC 5.8.0267	Depositor
R, R_{free}	0.219 , 0.269 0.228 , 0.271	Depositor DCC
R_{free} test set	929 reflections (5.09%)	wwPDB-VP
Wilson B-factor (Å ²)	33.6	Xtriage
Anisotropy	0.187	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 38.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.51$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	0.112 for h,-k,-l	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	2004	wwPDB-VP
Average B, all atoms (Å ²)	38.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.14% 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: BGC, SO4, CL, ACT, CU, 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	AAA	1.08	0/1890	1.35	4/2604 (0.2%)

There are no bond length outliers.

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed($^{\circ}$)	Ideal($^{\circ}$)
1	AAA	160	GLY	CA-C-O	-7.29	117.20	122.45
1	AAA	119	ILE	CA-C-N	5.19	127.24	120.28
1	AAA	119	ILE	C-N-CA	5.19	127.24	120.28
1	AAA	176	ASP	CA-CB-CG	5.10	117.70	112.60

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	1823	0	1730	26	0
2	EEE	34	0	30	0	0
2	EcE	34	0	30	2	0
3	AAA	8	0	6	1	0
4	AAA	1	0	0	0	0
5	AAA	4	0	0	2	0
6	AAA	5	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
7	AAA	1	0	0	0	0
8	AAA	94	0	0	2	0
All	All	2004	0	1796	27	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 7.

All (27) 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:127[B]:VAL:HG13	8:AAA:419:HOH:O	1.79	0.83
1:AAA:195:THR:O	5:AAA:306:CL:CL	2.36	0.79
1:AAA:38:ASP:OD2	5:AAA:305:CL:CL	2.38	0.79
1:AAA:158:ILE:N	1:AAA:158:ILE:HD12	2.03	0.72
1:AAA:110[B]:ASN:ND2	1:AAA:112:THR:OG1	2.28	0.67
1:AAA:162:GLN:OE1	1:AAA:164:TYR:OH	2.09	0.65
1:AAA:125:HIS:HD2	8:AAA:453:HOH:O	1.79	0.64
1:AAA:79:HIS:HB3	1:AAA:113:TRP:CD1	2.40	0.55
1:AAA:158:ILE:N	1:AAA:158:ILE:CD1	2.71	0.53
1:AAA:150[A]:ASP:CG	1:AAA:159:ARG:HH22	2.19	0.51
1:AAA:27:ASN:HD22	1:AAA:27:ASN:C	2.21	0.48
1:AAA:131:HIS:CD2	1:AAA:222:LEU:HD11	2.48	0.48
1:AAA:64:TRP:HE1	1:AAA:125:HIS:HE1	1.61	0.47
1:AAA:26:PRO:HD2	1:AAA:43:VAL:CG2	2.45	0.46
1:AAA:150[A]:ASP:OD1	1:AAA:150[A]:ASP:N	2.48	0.46
1:AAA:80:GLY:O	1:AAA:115:VAL:HG23	2.16	0.45
1:AAA:98:TRP:O	1:AAA:184:GLY:HA3	2.17	0.45
1:AAA:27:ASN:HB3	2:EcE:3:BGC:C6	2.47	0.44
1:AAA:158:ILE:HD12	1:AAA:158:ILE:H	1.80	0.42
1:AAA:8:TRP:HB2	1:AAA:61:THR:HB	2.01	0.42
1:AAA:18:ARG:HH22	3:AAA:301:ACT:H3	1.84	0.42
1:AAA:56:ALA:HA	1:AAA:129:VAL:HG12	2.02	0.42
1:AAA:78:HIS:O	1:AAA:115:VAL:HG11	2.19	0.42
2:EcE:1:BGC:O3	2:EcE:2:BGC:O5	2.24	0.41
1:AAA:153:TYR:CD1	1:AAA:157:PRO:HA	2.55	0.41
1:AAA:62:PHE:O	1:AAA:124:GLN:HA	2.21	0.40
1:AAA:64:TRP:HE1	1:AAA:125:HIS:CE1	2.38	0.40

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	AAA	240/235 (102%)	223 (93%)	17 (7%)	0	100	100

There are no Ramachandran outliers to report.

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	AAA	202/195 (104%)	194 (96%)	8 (4%)	28	14

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	AAA	27	ASN
1	AAA	46	ARG
1	AAA	50	LYS
1	AAA	150[A]	ASP
1	AAA	150[B]	ASP
1	AAA	158	ILE
1	AAA	216[A]	SER
1	AAA	216[B]	SER

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 ⓘ

6 monosaccharides 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	$\# Z > 2$
2	BGC	EEE	1	2	12,12,12	0.61	0	17,17,17	0.99	1 (5%)
2	BGC	EEE	2	2	11,11,12	0.68	0	15,15,17	1.26	1 (6%)
2	BGC	EEE	3	2	11,11,12	0.61	0	15,15,17	0.94	1 (6%)
2	BGC	EcE	1	2	12,12,12	0.46	0	17,17,17	1.60	4 (23%)
2	BGC	EcE	2	2	11,11,12	0.64	0	15,15,17	1.50	4 (26%)
2	BGC	EcE	3	2	11,11,12	0.58	0	15,15,17	1.74	3 (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	BGC	EEE	1	2	-	2/2/22/22	0/1/1/1
2	BGC	EEE	2	2	-	1/2/19/22	0/1/1/1
2	BGC	EEE	3	2	-	0/2/19/22	0/1/1/1
2	BGC	EcE	1	2	-	0/2/22/22	0/1/1/1
2	BGC	EcE	2	2	-	2/2/19/22	0/1/1/1
2	BGC	EcE	3	2	-	0/2/19/22	0/1/1/1

There are no bond length outliers.

All (14) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	EcE	3	BGC	O5-C5-C6	3.40	112.54	107.20
2	EcE	3	BGC	O2-C2-C1	-3.30	102.40	109.15
2	EcE	2	BGC	O5-C5-C6	3.09	112.05	107.20
2	EcE	2	BGC	O6-C6-C5	-2.79	101.71	111.29
2	EcE	1	BGC	O1-C1-C2	2.56	116.25	109.03
2	EEE	2	BGC	O2-C2-C1	-2.46	104.12	109.15
2	EcE	3	BGC	O2-C2-C3	2.38	114.91	110.14
2	EcE	1	BGC	C6-C5-C4	2.28	118.35	113.00
2	EcE	1	BGC	O2-C2-C3	2.24	115.52	110.35
2	EEE	3	BGC	C1-C2-C3	2.23	112.41	109.67
2	EcE	1	BGC	O5-C5-C6	2.14	111.76	106.44
2	EEE	1	BGC	C1-O5-C5	2.10	117.62	113.66
2	EcE	2	BGC	C2-C3-C4	-2.09	107.27	110.89
2	EcE	2	BGC	C3-C4-C5	-2.09	106.51	110.24

There are no chirality outliers.

All (5) torsion outliers are listed below:

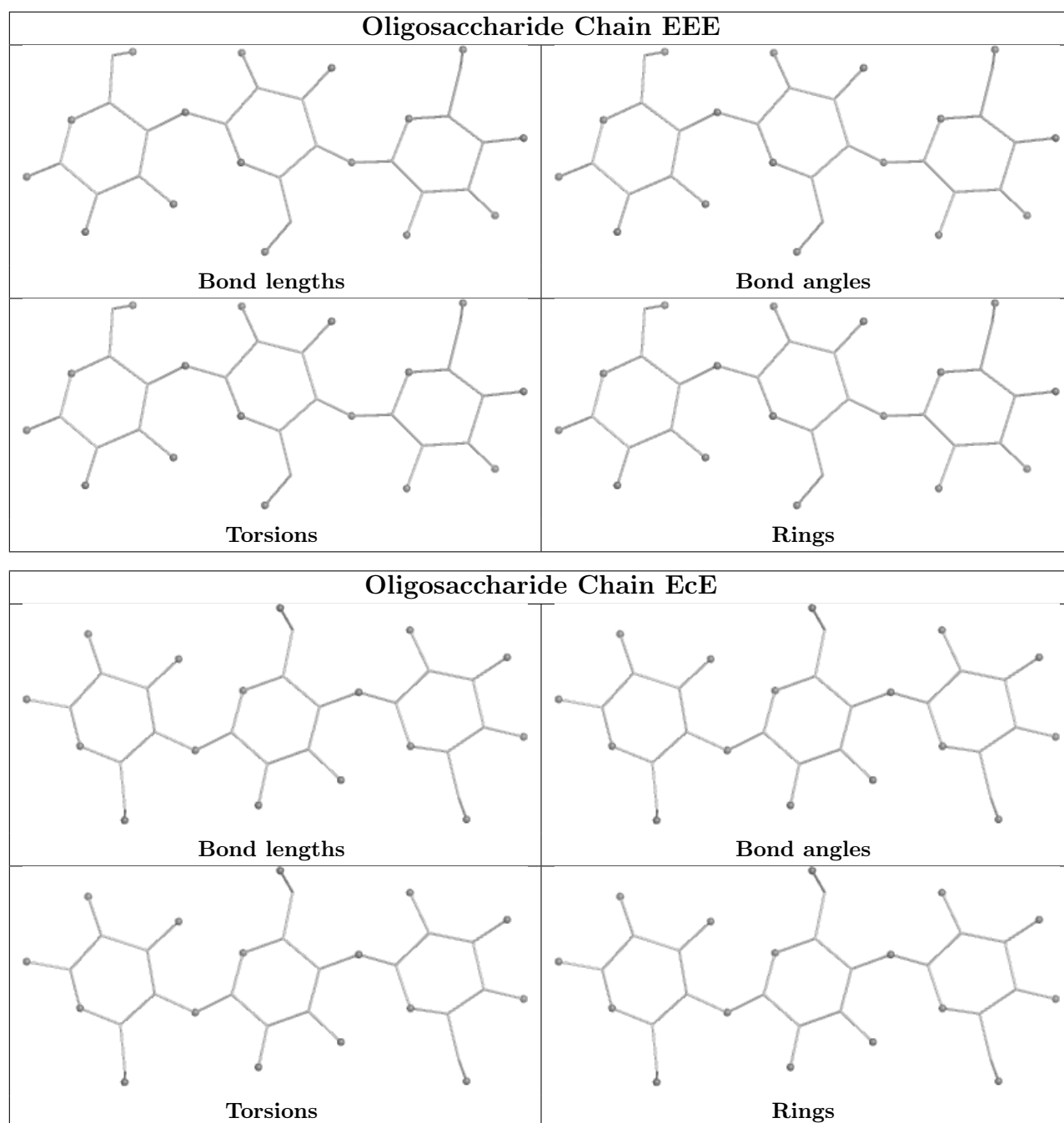
Mol	Chain	Res	Type	Atoms
2	EcE	2	BGC	C4-C5-C6-O6
2	EcE	2	BGC	O5-C5-C6-O6
2	EEE	2	BGC	C4-C5-C6-O6
2	EEE	1	BGC	C4-C5-C6-O6
2	EEE	1	BGC	O5-C5-C6-O6

There are no ring outliers.

3 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	EcE	3	BGC	1	0
2	EcE	2	BGC	1	0
2	EcE	1	BGC	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 oligosaccharide.



5.6 Ligand geometry ⓘ

Of 9 ligands modelled in this entry, 6 are monoatomic - leaving 3 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	$\# Z > 2$
3	ACT	AAA	301	-	3,3,3	1.24	0	3,3,3	0.67	0
6	SO4	AAA	308	-	4,4,4	0.34	0	6,6,6	0.06	0
3	ACT	AAA	302	-	3,3,3	1.10	0	3,3,3	0.76	0

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	AAA	301	ACT	1	0

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	235/235 (100%)	0.66	16 (6%)	23 26	16, 37, 45, 66	7 (2%)

All (16) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	AAA	158	ILE	3.4
1	AAA	99	VAL	3.3
1	AAA	203	TYR	2.9
1	AAA	127[A]	VAL	2.8
1	AAA	212	ALA	2.7
1	AAA	52	VAL	2.6
1	AAA	67	ASN	2.6
1	AAA	185	VAL	2.3
1	AAA	8	TRP	2.2
1	AAA	65	TYR	2.2
1	AAA	78	HIS	2.2
1	AAA	155	GLN	2.2
1	AAA	234	LEU	2.1
1	AAA	5	TRP	2.1
1	AAA	27	ASN	2.1
1	AAA	170	ILE	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.

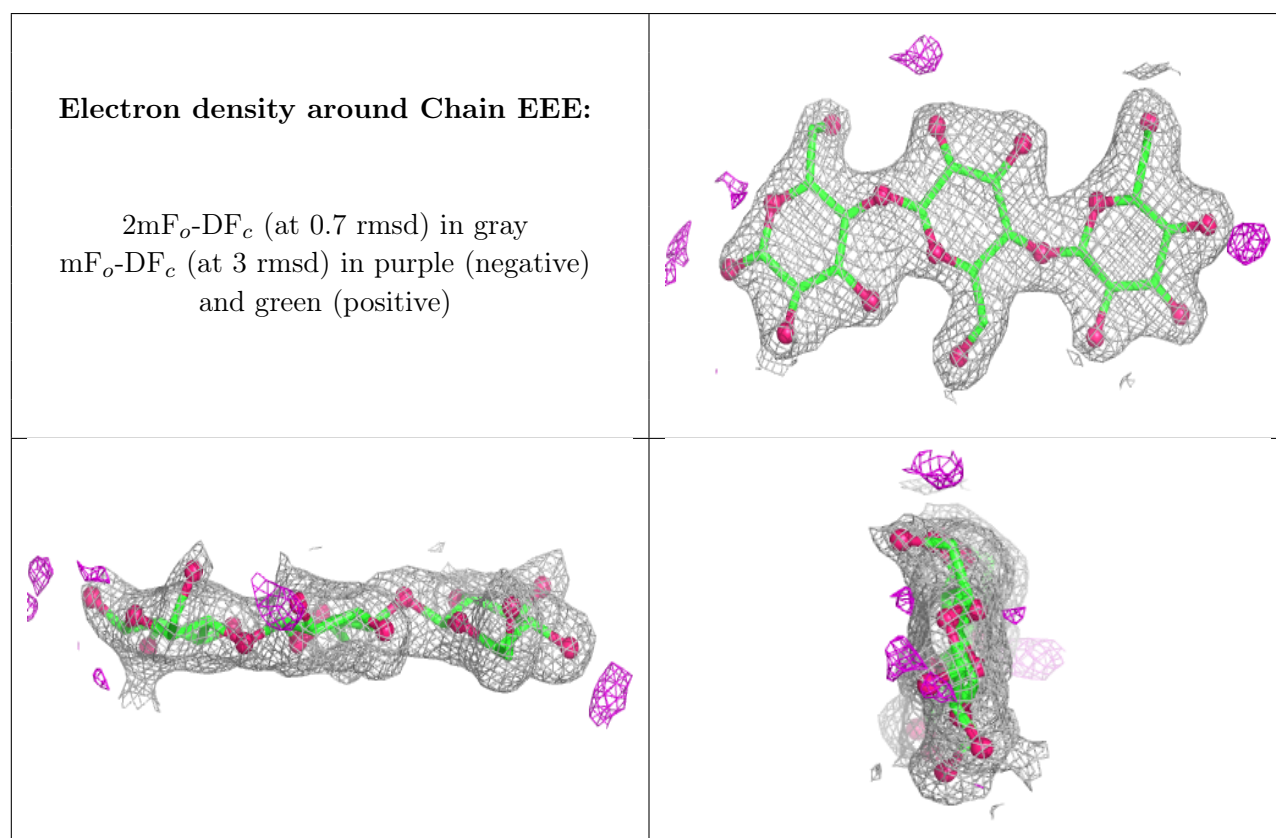
6.3 Carbohydrates [i](#)

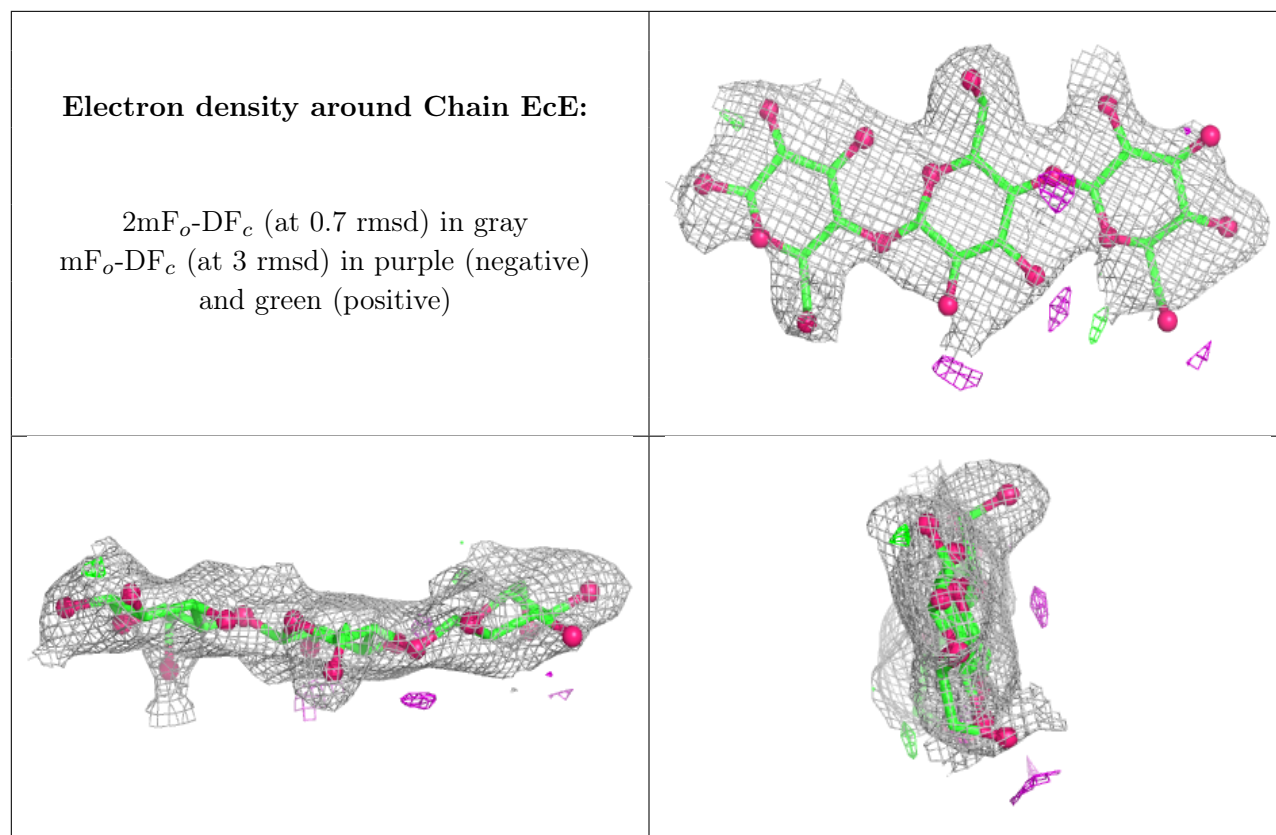
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum,

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	BGC	EEE	1	12/12	-	-	45,51,54,58	0
2	BGC	EEE	2	11/12	-	-	41,47,51,52	0
2	BGC	EEE	3	11/12	-	-	41,46,53,55	0
2	BGC	EcE	1	12/12	-	-	51,55,67,69	0
2	BGC	EcE	2	11/12	-	-	45,55,66,67	0
2	BGC	EcE	3	11/12	-	-	60,70,75,83	0

The following is a graphical depiction of the model fit to experimental electron density for oligosaccharide. Each fit is shown from different orientation to approximate a three-dimensional view.





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
6	SO4	AAA	308	5/5	0.52	0.13	112,116,120,130	0
7	NA	AAA	309	1/1	0.91	0.10	51,51,51,51	0
5	CL	AAA	307	1/1	0.92	0.18	81,81,81,81	0
3	ACT	AAA	301	4/4	0.93	0.10	35,40,40,42	0
5	CL	AAA	304	1/1	0.94	0.08	49,49,49,49	0
3	ACT	AAA	302	4/4	0.94	0.10	52,54,56,57	0
5	CL	AAA	306	1/1	0.95	0.13	75,75,75,75	0
5	CL	AAA	305	1/1	0.96	0.13	63,63,63,63	0
4	CU	AAA	303	1/1	1.00	0.02	38,38,38,38	0

6.5 Other polymers [i](#)

There are no such residues in this entry.