WORLDWIDE wwPDB PROTEIN DATA BANK

wwPDB X-ray Structure Validation Summary Report (i)

Nov 10, 2025 – 02:26 PM JST

PDB ID	:	9KKI / pdb_00009kki
Title	:	Crystal structure of the CYP153A double mutant L354V/V456G from Marinobacter aquaeolei
Authors	:	Qin, M.M.; Jiang, Y.P.; Cong, Z.Q.; Zhao, P.X.
Deposited on	:	2024-11-13
Resolution	:	2.20 Å(reported)

The following versions of software and data (see references (i)) were used in the production of this report:

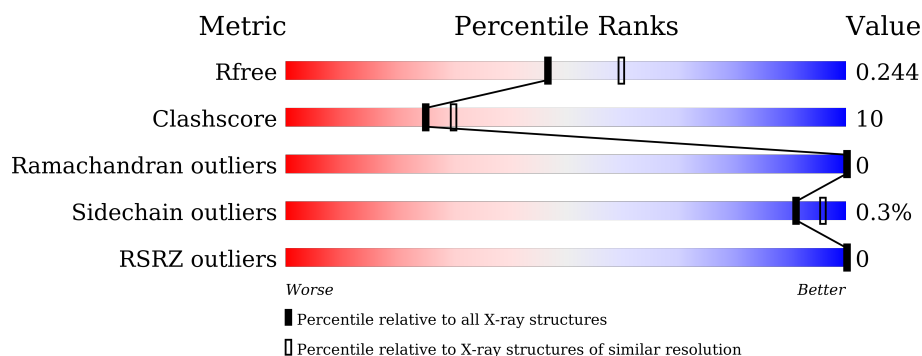|		
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	1.8.5 (274361), CSD as541be (2020)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
buster-report	:	1.1.7 (2018)
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.46

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 2.20 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	Percentile Ranks	Value
Rfree		0.244
Clashscore		10
Ramachandran outliers		0
Sidechain outliers		0.3%
RSRZ outliers		0

Worse ← → Better

▮ Percentile relative to all X-ray structures

▯ Percentile relative to X-ray structures of similar resolution

Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R$_{free}$	164625	5791 (2.20-2.20)
Clashscore	180529	6634 (2.20-2.20)
Ramachandran outliers	177936	6560 (2.20-2.20)
Sidechain outliers	177891	6561 (2.20-2.20)
RSRZ outliers	164620	5791 (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 <=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	480	75%　　　　　12%　　12%
1	B	480	75%　　　　　13%　　12%

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	DAO	A	502[B]	-	-	X	-
3	DAO	B	502[A]	-	-	X	-

2 Entry composition ⓘ

There are 4 unique types of molecules in this entry. The entry contains 7272 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 Cytochrome P450.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	422	Total 3332	C 2108	N 579	O 628	S 17	0	1	0
1	B	422	Total 3327	C 2108	N 579	O 623	S 17	0	1	0

There are 24 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	3	MET	-	initiating methionine	UNP A0A368UNN3
A	4	GLY	-	expression tag	UNP A0A368UNN3
A	358	VAL	LEU	engineered mutation	UNP A0A368UNN3
A	460	GLY	VAL	engineered mutation	UNP A0A368UNN3
A	475	LEU	-	expression tag	UNP A0A368UNN3
A	476	GLU	-	expression tag	UNP A0A368UNN3
A	477	HIS	-	expression tag	UNP A0A368UNN3
A	478	HIS	-	expression tag	UNP A0A368UNN3
A	479	HIS	-	expression tag	UNP A0A368UNN3
A	480	HIS	-	expression tag	UNP A0A368UNN3
A	481	HIS	-	expression tag	UNP A0A368UNN3
A	482	HIS	-	expression tag	UNP A0A368UNN3
B	3	MET	-	initiating methionine	UNP A0A368UNN3
B	4	GLY	-	expression tag	UNP A0A368UNN3
B	358	VAL	LEU	engineered mutation	UNP A0A368UNN3
B	460	GLY	VAL	engineered mutation	UNP A0A368UNN3
B	475	LEU	-	expression tag	UNP A0A368UNN3
B	476	GLU	-	expression tag	UNP A0A368UNN3
B	477	HIS	-	expression tag	UNP A0A368UNN3
B	478	HIS	-	expression tag	UNP A0A368UNN3
B	479	HIS	-	expression tag	UNP A0A368UNN3
B	480	HIS	-	expression tag	UNP A0A368UNN3
B	481	HIS	-	expression tag	UNP A0A368UNN3
B	482	HIS	-	expression tag	UNP A0A368UNN3

- Molecule 2 is PROTOPORPHYRIN IX CONTAINING FE (CCD ID: HEM) (formula: $C_{34}H_{32}FeN_4O_4$) (labeled as "Ligand of Interest" by depositor).
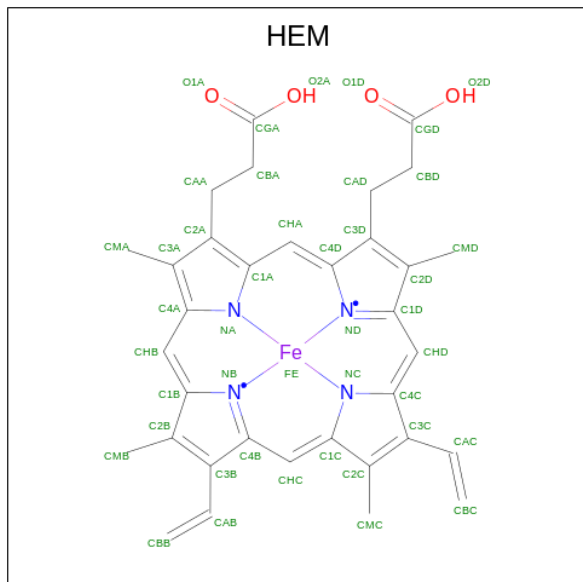
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	Fe	N	O	0	0
			43	34	1	4	4		
2	B	1	Total	C	Fe	N	O	0	0
			43	34	1	4	4		

- Molecule 3 is LAURIC ACID (CCD ID: DAO) (formula: $C_{12}H_{24}O_2$) (labeled as "Ligand of Interest" by depositor).
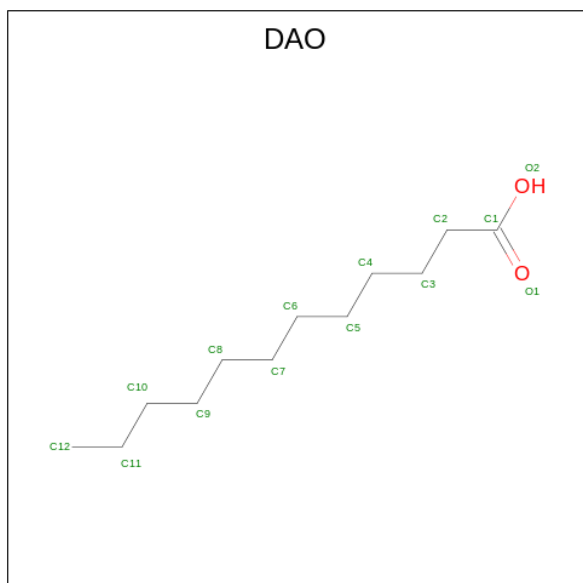
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total 28	C 24	O 4	0	1
3	B	1	Total 28	C 24	O 4	0	1

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	224	Total 224	O 224	0	0
4	B	247	Total 247	O 247	0	0

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.
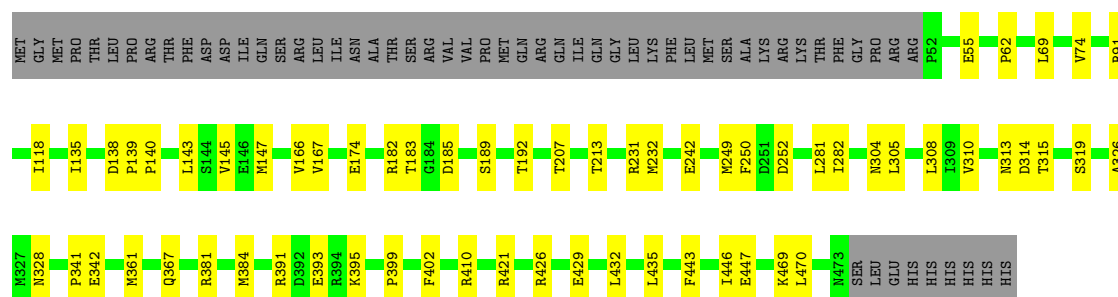
• Molecule 1: Cytochrome P450

Chain A:
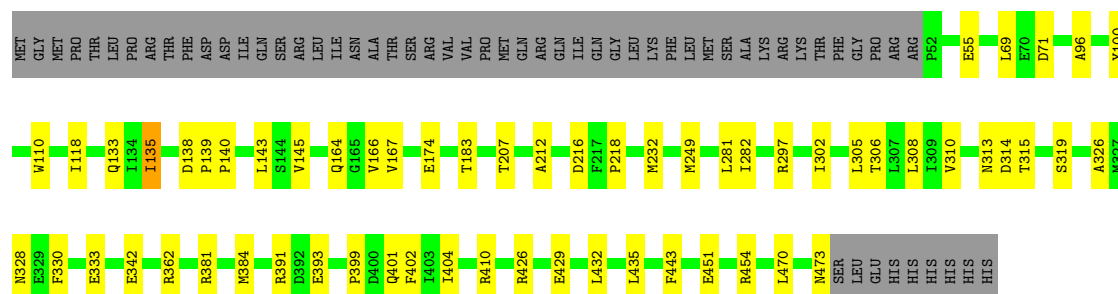
• Molecule 1: Cytochrome P450

Chain B:

4 Data and refinement statistics (i)

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants	100.31Å 100.49Å 223.07Å	Depositor
a, b, c, α, β, γ	90.00° 90.00° 90.00°	
Resolution (Å)	55.77 – 2.20	Depositor
	55.77 – 2.20	EDS
% Data completeness	99.6 (55.77-2.20)	Depositor
(in resolution range)	99.1 (55.77-2.20)	EDS
R_{merge}	0.17	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.88 (at 2.20Å)	Xtriage
Refinement program	PHENIX (1.18.2_3874: ???)	Depositor
R, R_{free}	0.219 , 0.241	Depositor
	0.221 , 0.244	DCC
R_{free} test set	2001 reflections (3.48%)	wwPDB-VP
Wilson B-factor (Å^2)	33.6	Xtriage
Anisotropy	0.256	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.37 , 34.4	EDS
L-test for twinning[2]	$< |L| > = 0.49, < L^2 > = 0.32$	Xtriage
Estimated twinning fraction	0.439 for -k,-h,-l	Xtriage
F_o,F_c correlation	0.96	EDS
Total number of atoms	7272	wwPDB-VP
Average B, all atoms (Å^2)	42.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.99% of the height of the origin peak. No significant pseudotranslation is detected.*

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[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: HEM, DAO

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	0.19	0/3411	0.37	0/4626
1	B	0.18	0/3406	0.35	0/4620
All	All	0.18	0/6817	0.36	0/9246

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	3332	0	3176	50	1
1	B	3327	0	3176	72	0
2	A	43	0	30	2	0
2	B	43	0	30	3	0
3	A	28	0	46	13	0
3	B	28	0	46	13	0
4	A	224	0	0	18	0
4	B	247	0	0	34	1
All	All	7272	0	6504	128	1

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 10.

The worst 5 of 128 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:143:LEU:O	3:A:502[A]:DAO:H92	1.51	1.08
1:B:91:ARG:NH2	4:B:603:HOH:O	1.88	1.03
1:B:469:LYS:O	4:B:602:HOH:O	1.81	0.95
1:B:410:ARG:NE	4:B:605:HOH:O	1.91	0.95
1:B:447:GLU:N	4:B:602:HOH:O	1.82	0.94

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:55:GLU:O	4:B:746:HOH:O[5_545]	1.93	0.27

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	421/480 (88%)	414 (98%)	7 (2%)	0	100	100
1	B	421/480 (88%)	415 (99%)	6 (1%)	0	100	100
All	All	842/960 (88%)	829 (98%)	13 (2%)	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	A	348/421 (83%)	347 (100%)	1 (0%)	91	96
1	B	346/421 (82%)	345 (100%)	1 (0%)	91	96
All	All	694/842 (82%)	692 (100%)	2 (0%)	91	96

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	135	ILE
1	B	135	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 7 such sidechains are listed below:

Mol	Chain	Res	Type
1	A	411	ASN
1	B	133	GLN
1	B	355	GLN
1	B	171	ASN
1	A	355	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 ⓘ

6 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	DAO	A	502[B]	-	13,13,13	0.56	0	13,13,13	1.37	1 (7%)
2	HEM	A	501	4	41,50,50	1.43	4 (9%)	45,82,82	1.48	8 (17%)
3	DAO	B	502[B]	-	13,13,13	0.87	1 (7%)	13,13,13	1.20	1 (7%)
2	HEM	B	501	-	41,50,50	1.44	4 (9%)	45,82,82	1.43	8 (17%)
3	DAO	A	502[A]	-	13,13,13	0.54	0	13,13,13	1.33	2 (15%)
3	DAO	B	502[A]	-	13,13,13	0.46	0	13,13,13	1.35	2 (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
3	DAO	A	502[B]	-	-	8/11/11/11	-
2	HEM	A	501	4	-	0/12/54/54	-
3	DAO	B	502[B]	-	-	6/11/11/11	-
2	HEM	B	501	-	-	0/12/54/54	-
3	DAO	A	502[A]	-	-	6/11/11/11	-
3	DAO	B	502[A]	-	-	7/11/11/11	-

The worst 5 of 9 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	501	HEM	C3C-CAC	3.75	1.55	1.47
2	B	501	HEM	C3C-CAC	3.73	1.55	1.47
2	B	501	HEM	C3C-C2C	-3.73	1.35	1.40
2	A	501	HEM	C3C-C2C	-3.68	1.35	1.40
2	B	501	HEM	CAB-C3B	2.89	1.55	1.47

The worst 5 of 22 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	B	502[B]	DAO	O2-C1-O1	-3.53	114.50	123.30
2	A	501	HEM	C4D-ND-C1D	3.20	108.38	105.07
3	A	502[B]	DAO	O2-C1-C2	3.04	123.81	114.03
2	B	501	HEM	C4D-ND-C1D	3.01	108.18	105.07

Continued on next page...

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	501	HEM	C4C-CHD-C1D	2.74	126.17	122.56

There are no chirality outliers.

5 of 27 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	502[B]	DAO	C5-C6-C7-C8
3	B	502[A]	DAO	C3-C4-C5-C6
3	B	502[B]	DAO	C5-C6-C7-C8
3	A	502[A]	DAO	C2-C3-C4-C5
3	A	502[A]	DAO	C3-C4-C5-C6

There are no ring outliers.

6 monomers are involved in 31 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	502[B]	DAO	7	0
2	A	501	HEM	2	0
3	B	502[B]	DAO	6	0
2	B	501	HEM	3	0
3	A	502[A]	DAO	6	0
3	B	502[A]	DAO	7	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.
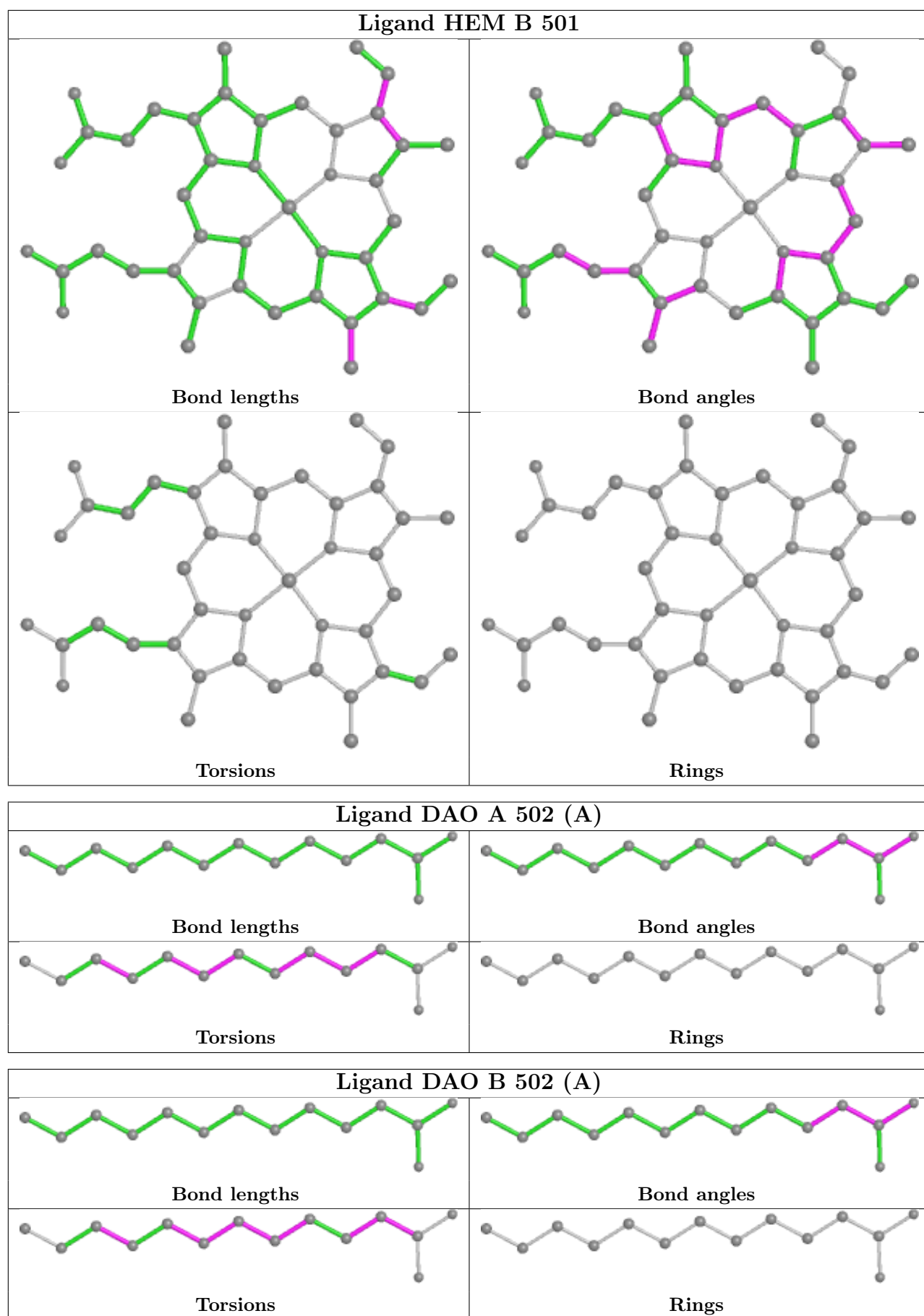
Ligand DAO A 502 (B)
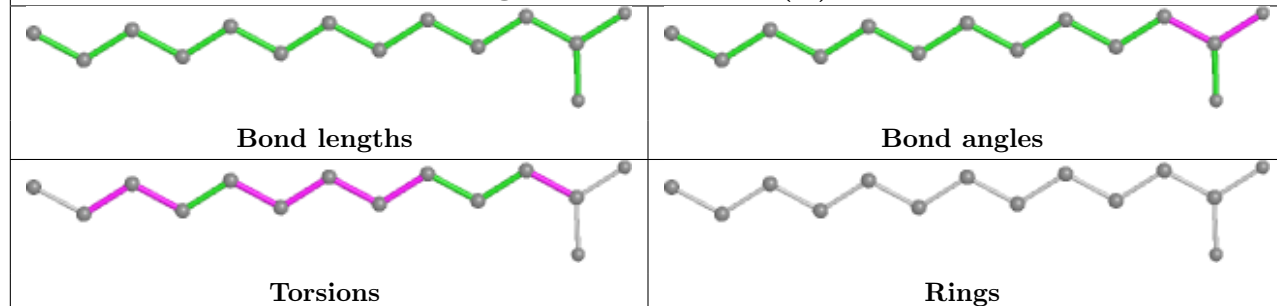
Bond lengths

Bond angles

Torsions

Rings

Ligand HEM A 501

Bond lengths

Bond angles

Torsions

Rings

Ligand DAO B 502 (B)

Bond lengths

Bond angles

Torsions

Rings

Ligand HEM B 501

Bond lengths

Bond angles

Torsions

Rings

Ligand DAO A 502 (A)

Bond lengths

Bond angles

Torsions

Rings

Ligand DAO B 502 (A)

Bond lengths

Bond angles

Torsions

Rings
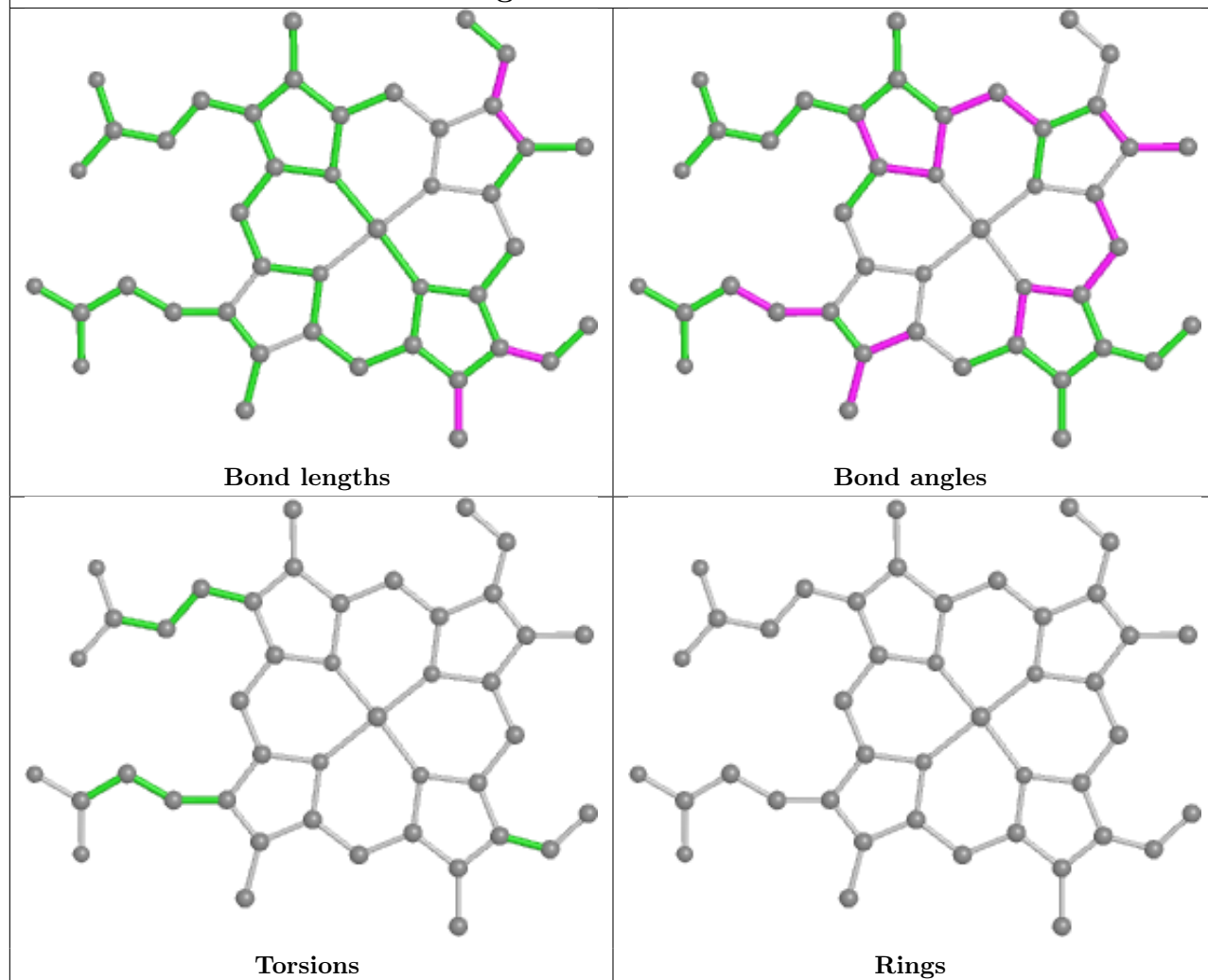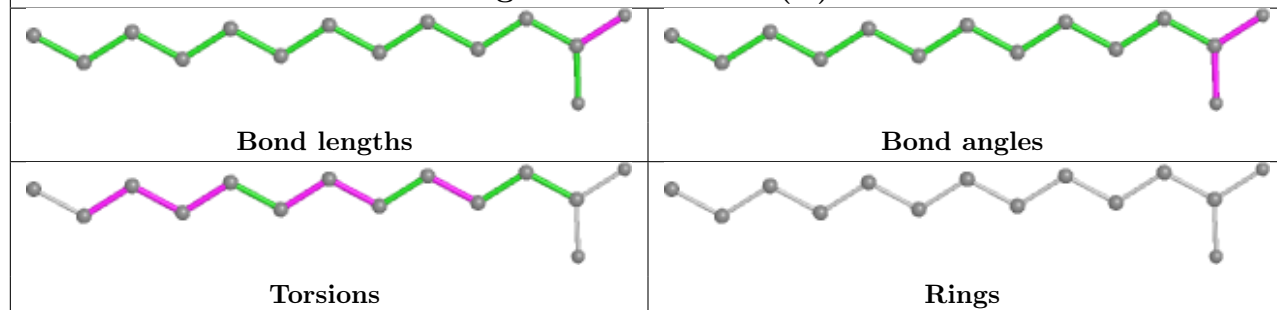
5.7 Other polymers ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

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	422/480 (87%)	-1.39	0	100	100	18, 39, 64, 80	2 (0%)
1	B	422/480 (87%)	-1.39	0	100	100	18, 38, 65, 80	2 (0%)
All	All	844/960 (87%)	-1.39	0	100	100	18, 38, 65, 80	4 (0%)

There are no RSRZ outliers to report.

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 oligosaccharides 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.
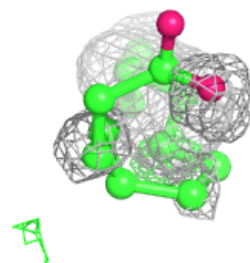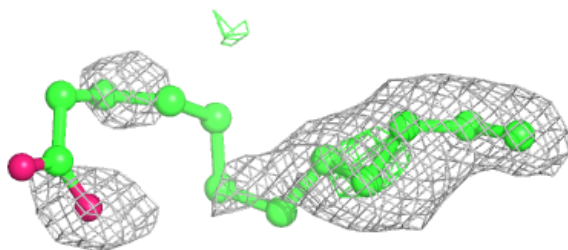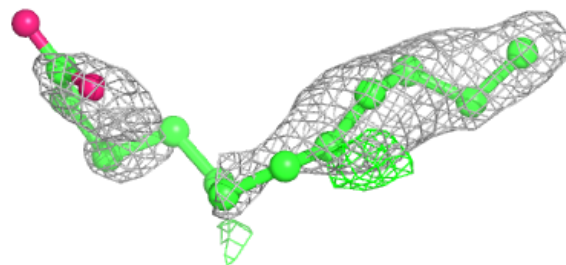
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
3	DAO	A	502[A]	14/14	0.99	0.12	67,71,78,78	14
3	DAO	A	502[B]	14/14	0.99	0.12	67,73,79,80	14
3	DAO	B	502[A]	14/14	0.99	0.11	69,72,77,78	14
3	DAO	B	502[B]	14/14	0.99	0.11	70,75,77,78	14
2	HEM	A	501	43/43	1.00	0.03	24,26,30,34	0
2	HEM	B	501	43/43	1.00	0.04	25,29,32,38	0

WORLDWIDE
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PROTEIN DATA BANK

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.
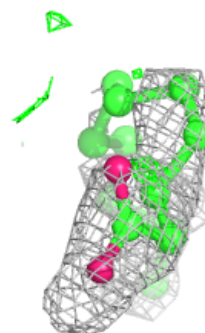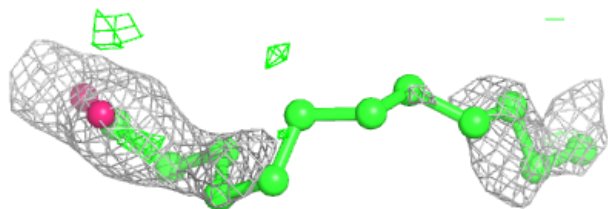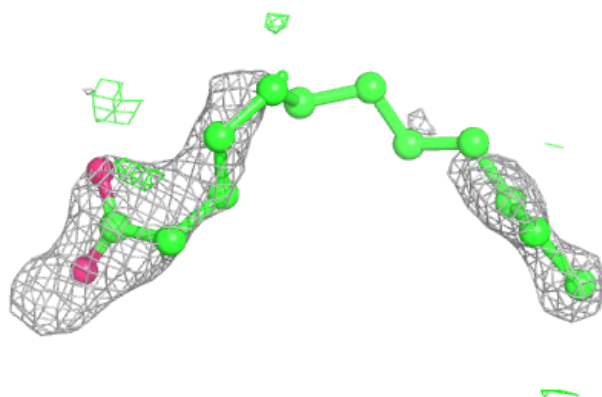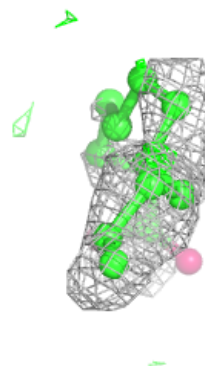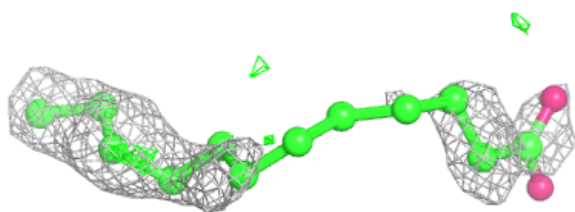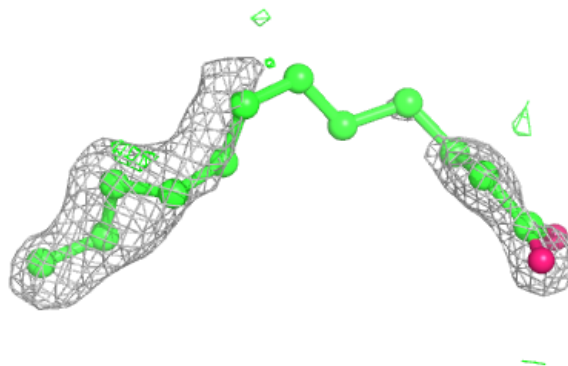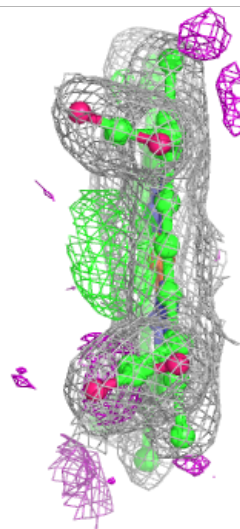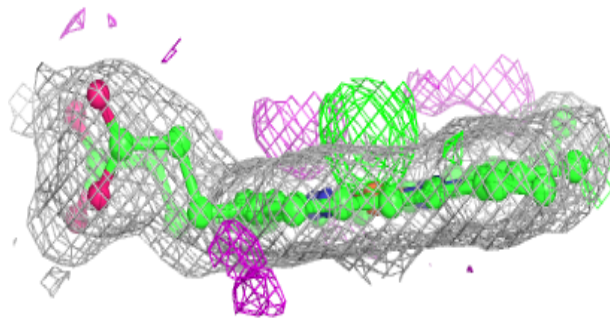
Electron density around DAO A 502 (A):

$2mF_o$-DF_c (at 0.7 rmsd) in gray
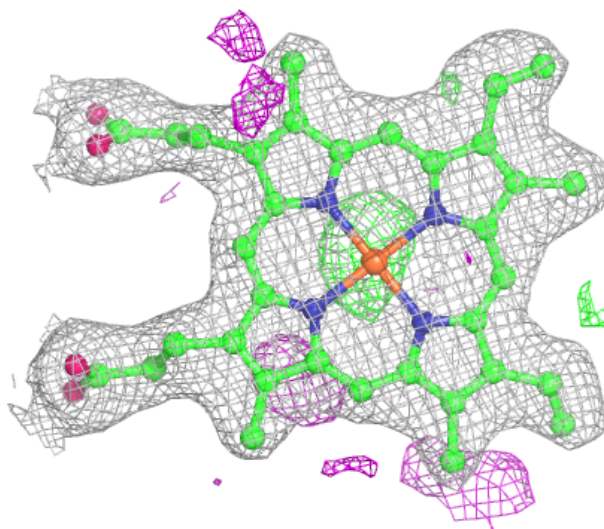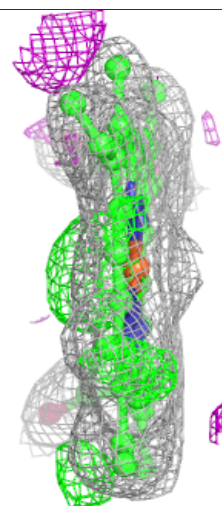mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)
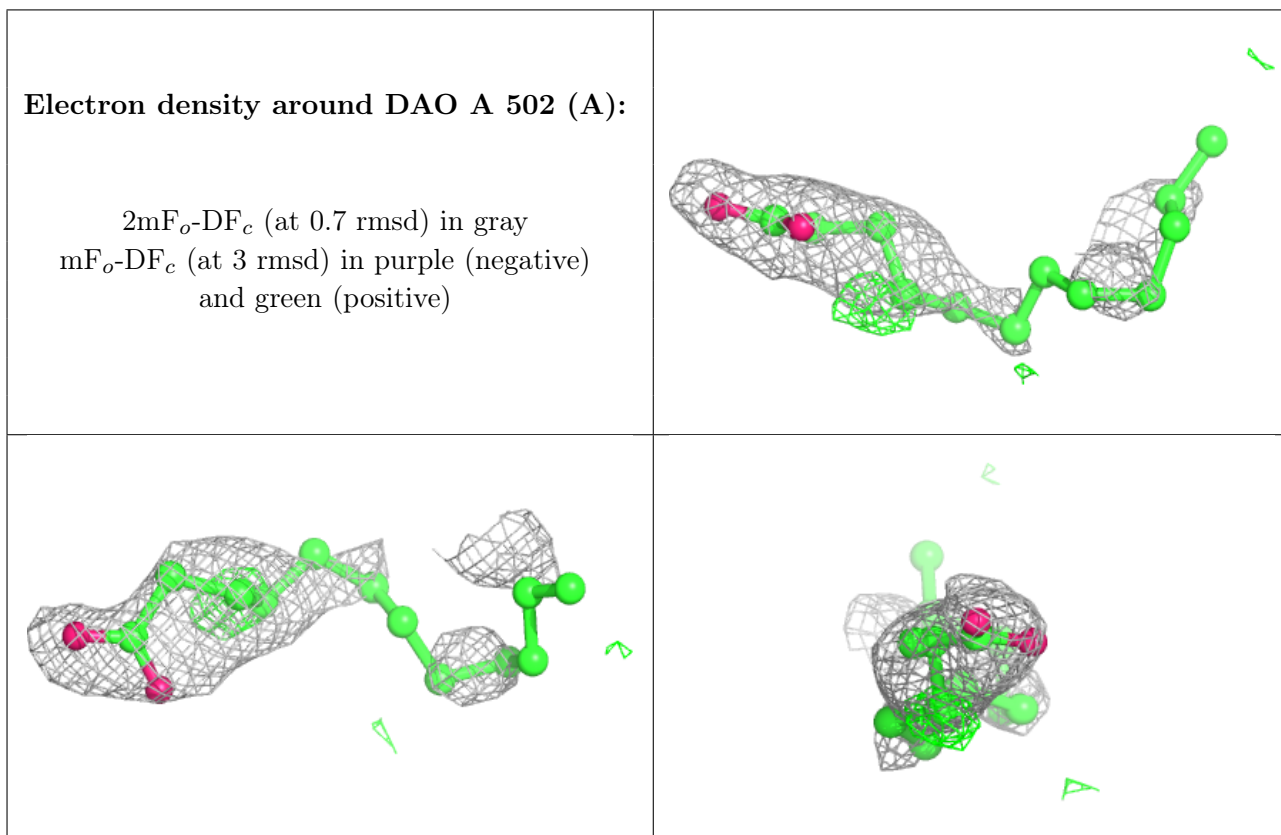
Electron density around DAO A 502 (B):

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

Electron density around DAO B 502 (A):

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

Electron density around DAO B 502 (B):

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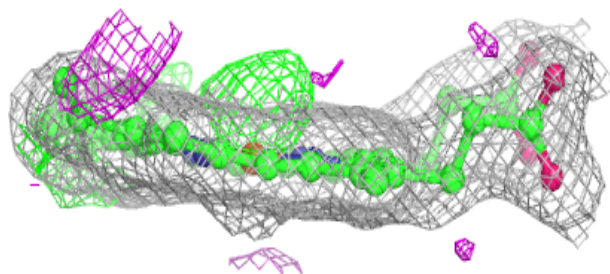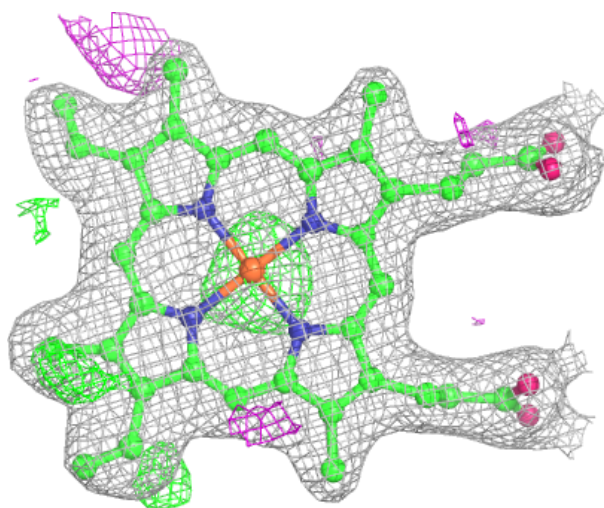mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

Electron density around HEM A 501:

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

Electron density around HEM B 501:

$2mF_o$-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.