



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 10, 2026 – 08:56 AM UTC

PDB ID : 2CCP / pdb_00002ccp
Title : X-RAY STRUCTURES OF RECOMBINANT YEAST CYTOCHROME C PEROXIDASE AND THREE HEME-CLEFT MUTANTS PREPARED BY SITE-DIRECTED MUTAGENESIS
Authors : Wang, J.; Mauro, J.M.; Edwards, S.L.; Oatley, S.J.; Fishel, L.A.; Ashford, V.A.; Xuong, N.-H.; Kraut, J.
Deposited on : 1990-02-28
Resolution : 2.20 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)
Xtrriage (Phenix) : **NOT EXECUTED**
EDS : **NOT EXECUTED**
Buster-report : wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics : 20250101.v01 (using entries in the PDB archive January 1st 2025)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.49

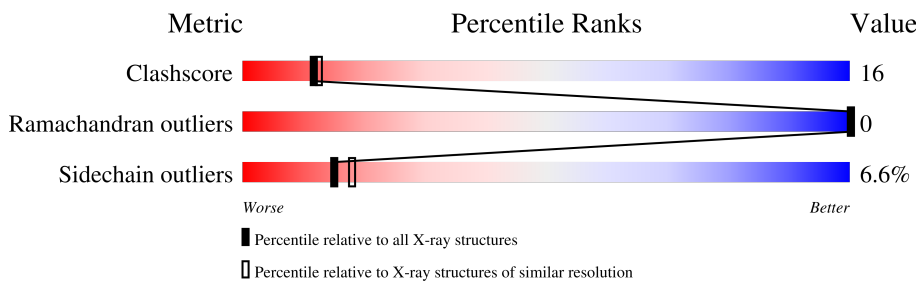
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.20 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	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
Clashscore	190562	6851 (2.20-2.20)
Ramachandran outliers	187476	6768 (2.20-2.20)
Sidechain outliers	187428	6769 (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 $\leq 5\%$

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	296	

- Molecule 3 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	245	Total 245	O 245	0	0

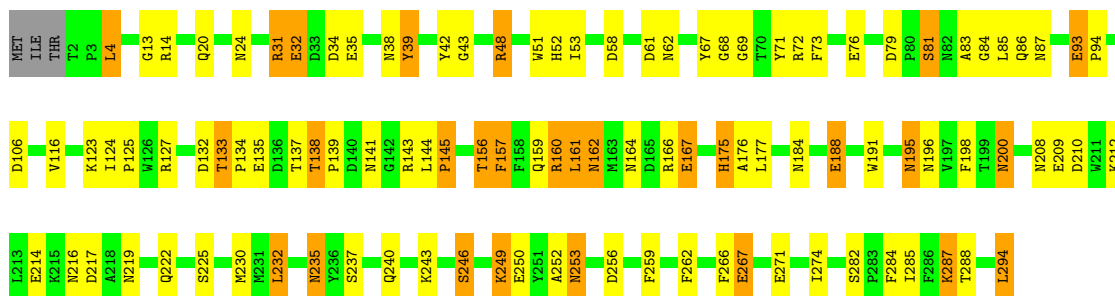
3 Residue-property plots [i](#)

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. 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. 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.

Note EDS was not executed.

- Molecule 1: YEAST CYTOCHROME C PEROXIDASE

Chain A: 



4 Data and refinement statistics

Xtrriage (Phenix) and EDS were not executed - this section is therefore incomplete.

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	104.93Å 74.26Å 45.88Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	(Not available) – 2.20	Depositor
% Data completeness (in resolution range)	(Not available) ((Not available)-2.20)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	JIMIN WANG TO INCLUDE CONTRIBUTIO, LALS	Depositor
R, R_{free}	0.147 , (Not available)	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	2627	wwPDB-VP
Average B, all atoms (Å ²)	23.0	wwPDB-VP

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: HEM

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	1.04	0/2406	1.99	68/3264 (2.1%)

There are no bond length outliers.

All (68) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	38	ASN	OD1-CG-ND2	12.27	134.87	122.60
1	A	48	ARG	NE-CZ-NH2	11.37	129.43	119.20
1	A	162	ASN	OD1-CG-ND2	10.71	133.31	122.60
1	A	284	PHE	CA-CB-CG	10.52	124.32	113.80
1	A	162	ASN	CA-CB-CG	-10.49	102.11	112.60
1	A	38	ASN	CA-CB-CG	-10.06	102.54	112.60
1	A	48	ARG	NE-CZ-NH1	-9.44	112.06	121.50
1	A	274	ILE	O-C-N	9.38	132.71	123.14
1	A	195	ASN	CA-CB-CG	9.37	121.97	112.60
1	A	175	HIS	N-CA-CB	8.64	123.09	110.57
1	A	162	ASN	N-CA-CB	-8.59	99.25	112.30
1	A	144	LEU	CB-CA-C	8.43	121.00	108.86
1	A	219	ASN	CA-CB-CG	-8.39	104.20	112.60
1	A	259	PHE	CA-CB-CG	8.23	122.03	113.80
1	A	127	ARG	CD-NE-CZ	7.81	135.34	124.40
1	A	79	ASP	CA-C-O	7.68	127.03	119.51
1	A	58	ASP	CA-CB-CG	-7.54	105.06	112.60
1	A	38	ASN	CA-C-O	-7.17	113.26	121.65
1	A	214	GLU	O-C-N	7.11	131.36	123.25
1	A	176	ALA	N-CA-C	-7.08	104.46	113.23
1	A	167	GLU	CB-CG-CD	6.83	124.21	112.60
1	A	141	ASN	CA-CB-CG	6.80	119.40	112.60
1	A	38	ASN	CB-CA-C	-6.77	102.79	111.86
1	A	235	ASN	CA-CB-CG	6.74	119.33	112.60

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	208	ASN	N-CA-C	6.69	121.73	113.50
1	A	288	THR	CA-CB-OG1	-6.55	99.78	109.60
1	A	68	GLY	N-CA-C	6.50	122.02	114.16
1	A	253	ASN	CA-CB-CG	-6.50	106.11	112.60
1	A	106	ASP	CA-CB-CG	6.46	119.06	112.60
1	A	14	ARG	NH1-CZ-NH2	6.44	127.67	119.30
1	A	209	GLU	CA-C-N	6.23	131.99	122.77
1	A	209	GLU	C-N-CA	6.23	131.99	122.77
1	A	87	ASN	CA-CB-CG	6.17	118.78	112.60
1	A	133	THR	CB-CA-C	6.07	118.19	108.91
1	A	252	ALA	N-CA-C	-6.01	104.81	111.36
1	A	67	TYR	CA-C-N	5.97	131.41	120.79
1	A	67	TYR	C-N-CA	5.97	131.41	120.79
1	A	262	PHE	CA-C-O	5.97	127.09	120.82
1	A	196	ASN	OD1-CG-ND2	5.96	128.56	122.60
1	A	267	GLU	CB-CG-CD	5.91	122.65	112.60
1	A	93	GLU	CA-CB-CG	5.88	125.86	114.10
1	A	156	THR	CA-CB-OG1	-5.82	100.86	109.60
1	A	138	THR	O-C-N	5.81	126.58	121.18
1	A	161	LEU	O-C-N	5.76	129.25	122.34
1	A	132	ASP	CB-CA-C	5.70	118.79	109.90
1	A	217	ASP	CA-CB-CG	-5.67	106.92	112.60
1	A	157	PHE	CA-CB-CG	-5.66	108.14	113.80
1	A	246	SER	O-C-N	5.64	128.10	122.12
1	A	127	ARG	NE-CZ-NH2	-5.63	114.13	119.20
1	A	266	PHE	CA-CB-CG	5.58	119.38	113.80
1	A	188	GLU	CB-CG-CD	5.53	122.00	112.60
1	A	24	ASN	OD1-CG-ND2	5.50	128.10	122.60
1	A	31	ARG	CA-C-O	5.48	126.22	120.42
1	A	24	ASN	CA-CB-CG	5.46	118.06	112.60
1	A	39	TYR	N-CA-C	5.41	119.83	113.23
1	A	160	ARG	O-C-N	5.32	129.56	122.43
1	A	81	SER	CA-C-O	-5.30	112.86	119.38
1	A	32	GLU	CA-C-O	-5.29	114.37	120.24
1	A	195	ASN	CB-CG-ND2	5.18	124.17	116.40
1	A	143	ARG	NE-CZ-NH1	-5.17	116.33	121.50
1	A	116	VAL	O-C-N	5.16	126.97	121.91
1	A	145	PRO	N-CA-C	5.15	120.28	111.68
1	A	13	GLY	O-C-N	5.15	128.62	122.34
1	A	62	ASN	CA-CB-CG	-5.14	107.46	112.60
1	A	249	LYS	CA-C-O	5.12	125.98	120.55
1	A	125	PRO	CB-CA-C	5.08	118.01	111.46

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	208	ASN	CA-CB-CG	-5.07	107.53	112.60
1	A	232	LEU	O-C-N	5.01	127.14	121.53

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	A	2339	0	2174	73	0
2	A	43	0	30	0	0
3	A	245	0	0	27	1
All	All	2627	0	2204	73	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 16.

All (73) 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:175:HIS:CG	3:A:352:HOH:O	1.89	1.22
1:A:138:THR:C	3:A:311:HOH:O	1.87	1.16
1:A:137:THR:C	3:A:311:HOH:O	1.90	1.14
1:A:137:THR:O	3:A:311:HOH:O	1.67	1.12
1:A:4:LEU:HD22	1:A:4:LEU:H	1.14	1.11
1:A:84:GLY:N	1:A:86:GLN:HE22	1.54	1.04
1:A:4:LEU:H	1:A:4:LEU:CD2	1.70	1.03
1:A:210:ASP:O	3:A:526:HOH:O	1.81	0.97
1:A:84:GLY:H	1:A:86:GLN:HE22	1.05	0.96
1:A:4:LEU:HD22	1:A:4:LEU:N	1.85	0.92
1:A:184:ASN:CG	3:A:324:HOH:O	2.15	0.89
1:A:84:GLY:H	1:A:86:GLN:NE2	1.71	0.87
1:A:83:ALA:C	3:A:324:HOH:O	2.19	0.85
1:A:235:ASN:OD1	3:A:535:HOH:O	1.95	0.85
1:A:84:GLY:N	1:A:86:GLN:NE2	2.25	0.84

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:216:ASN:HD22	1:A:222:GLN:HE21	1.29	0.80
1:A:166:ARG:HG2	3:A:959:HOH:O	1.82	0.80
1:A:20:GLN:HE22	1:A:287:LYS:H	1.28	0.79
1:A:216:ASN:HD22	1:A:222:GLN:NE2	1.80	0.79
1:A:84:GLY:CA	1:A:86:GLN:NE2	2.46	0.77
1:A:84:GLY:C	1:A:86:GLN:NE2	2.43	0.77
1:A:31:ARG:O	3:A:303:HOH:O	2.03	0.75
1:A:84:GLY:C	1:A:86:GLN:HE21	1.95	0.73
1:A:86:GLN:NE2	1:A:86:GLN:H	1.90	0.70
1:A:166:ARG:NH1	3:A:332:HOH:O	2.24	0.69
1:A:35:GLU:CG	1:A:39:TYR:CE2	2.79	0.66
1:A:34:ASP:HB3	3:A:303:HOH:O	1.97	0.64
1:A:175:HIS:CB	3:A:352:HOH:O	2.27	0.62
1:A:184:ASN:OD1	3:A:324:HOH:O	2.15	0.62
1:A:123:LYS:CE	3:A:889:HOH:O	2.50	0.60
1:A:48:ARG:NH1	3:A:949:HOH:O	2.35	0.60
1:A:184:ASN:CB	3:A:324:HOH:O	2.49	0.59
1:A:210:ASP:HB3	3:A:526:HOH:O	2.02	0.59
1:A:69:GLY:O	1:A:72:ARG:HG2	2.03	0.59
1:A:93:GLU:N	1:A:94:PRO:HD2	2.18	0.58
1:A:133:THR:HB	1:A:134:PRO:HD2	1.86	0.57
1:A:250:GLU:CD	3:A:332:HOH:O	2.46	0.57
1:A:84:GLY:N	3:A:324:HOH:O	2.36	0.56
1:A:249:LYS:O	1:A:253:ASN:ND2	2.35	0.56
1:A:86:GLN:H	1:A:86:GLN:CD	2.17	0.53
1:A:166:ARG:CD	3:A:959:HOH:O	2.56	0.52
1:A:72:ARG:NH2	1:A:133:THR:O	2.43	0.52
1:A:4:LEU:CD2	1:A:4:LEU:N	2.45	0.51
1:A:4:LEU:HD23	1:A:61:ASP:O	2.11	0.51
1:A:85:LEU:N	1:A:86:GLN:NE2	2.59	0.51
1:A:4:LEU:H	1:A:4:LEU:HD23	1.70	0.51
1:A:164:ASN:OD1	1:A:167:GLU:HG3	2.12	0.50
1:A:177:LEU:HD11	1:A:198:PHE:CD1	2.47	0.50
1:A:84:GLY:CA	1:A:86:GLN:HE21	2.21	0.49
1:A:71:TYR:HA	1:A:76:GLU:HG2	1.95	0.48
1:A:177:LEU:HD11	1:A:198:PHE:HD1	1.79	0.47
1:A:145:PRO:HD3	1:A:157:PHE:CZ	2.49	0.47
1:A:138:THR:N	3:A:311:HOH:O	2.16	0.47
1:A:230:MET:HE1	1:A:232:LEU:HD23	1.97	0.46
1:A:200:ASN:HD22	1:A:200:ASN:N	2.14	0.46
1:A:52:HIS:HE1	1:A:81:SER:O	2.00	0.45

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:175:HIS:CD2	3:A:352:HOH:O	2.39	0.45
1:A:159:GLN:NE2	1:A:159:GLN:HA	2.32	0.45
1:A:139:PRO:N	3:A:311:HOH:O	2.27	0.45
1:A:200:ASN:HD22	1:A:200:ASN:H	1.66	0.44
1:A:237:SER:HA	1:A:240:GLN:OE1	2.18	0.44
1:A:160:ARG:O	1:A:160:ARG:HG2	2.18	0.43
1:A:243:LYS:HD3	3:A:947:HOH:O	2.19	0.43
1:A:42:TYR:O	1:A:43:GLY:C	2.59	0.43
1:A:188:GLU:H	1:A:222:GLN:HE22	1.67	0.42
1:A:72:ARG:HG2	1:A:72:ARG:HH11	1.85	0.42
1:A:175:HIS:O	1:A:191:TRP:CG	2.73	0.41
1:A:294:LEU:HD12	1:A:294:LEU:HA	1.87	0.41
1:A:73:PHE:CE1	1:A:135:GLU:HA	2.56	0.41
1:A:161:LEU:O	1:A:162:ASN:CB	2.67	0.40
1:A:166:ARG:CG	3:A:959:HOH:O	2.51	0.40
1:A:123:LYS:HE3	3:A:889:HOH:O	2.20	0.40
1:A:267:GLU:OE1	1:A:271:GLU:OE1	2.39	0.40

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)
3:A:303:HOH:O	3:A:463:HOH:O[3_545]	1.80	0.40

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	291/296 (98%)	288 (99%)	3 (1%)	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	241/254 (95%)	225 (93%)	16 (7%)	15 18

All (16) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	4	LEU
1	A	32	GLU
1	A	51	TRP
1	A	53	ILE
1	A	124	ILE
1	A	156	THR
1	A	195	ASN
1	A	200	ASN
1	A	212	LYS
1	A	225	SER
1	A	246	SER
1	A	256	ASP
1	A	282	SER
1	A	285	ILE
1	A	287	LYS
1	A	294	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (10) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	6	HIS
1	A	20	GLN
1	A	24	ASN
1	A	86	GLN
1	A	141	ASN
1	A	159	GLN
1	A	200	ASN
1	A	208	ASN
1	A	222	GLN

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Mol	Chain	Res	Type
1	A	292	GLN

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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

1 ligand is 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	HEM	A	296	1,3	50,50,50	1.24	4 (8%)	67,82,82	1.39	12 (17%)

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	HEM	A	296	1,3	-	2/14/54/54	-

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	296	HEM	CAC-C3C	3.32	1.56	1.47
2	A	296	HEM	C3B-C2B	-2.46	1.32	1.37
2	A	296	HEM	CAB-C3B	2.27	1.53	1.47
2	A	296	HEM	O2D-CGD	-2.20	1.23	1.30

All (12) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	296	HEM	CHC-C1C-NC	-3.56	120.58	124.45
2	A	296	HEM	CBA-CAA-C2A	3.29	121.62	112.53
2	A	296	HEM	CAD-CBD-CGD	3.14	121.98	113.67
2	A	296	HEM	O1D-CGD-CBD	-3.04	113.44	123.09
2	A	296	HEM	CBC-CAC-C3C	-2.85	113.28	127.53
2	A	296	HEM	O2A-CGA-O1A	2.58	129.97	123.33
2	A	296	HEM	CMA-C3A-C2A	2.37	130.64	125.62
2	A	296	HEM	C4A-CHB-C1B	-2.27	120.91	126.25
2	A	296	HEM	CAA-CBA-CGA	2.25	119.63	113.67
2	A	296	HEM	CMA-C3A-C4A	-2.18	122.11	125.42
2	A	296	HEM	CHB-C1B-NB	2.01	126.86	124.37
2	A	296	HEM	C4C-C3C-C2C	2.01	108.56	106.81

There are no chirality outliers.

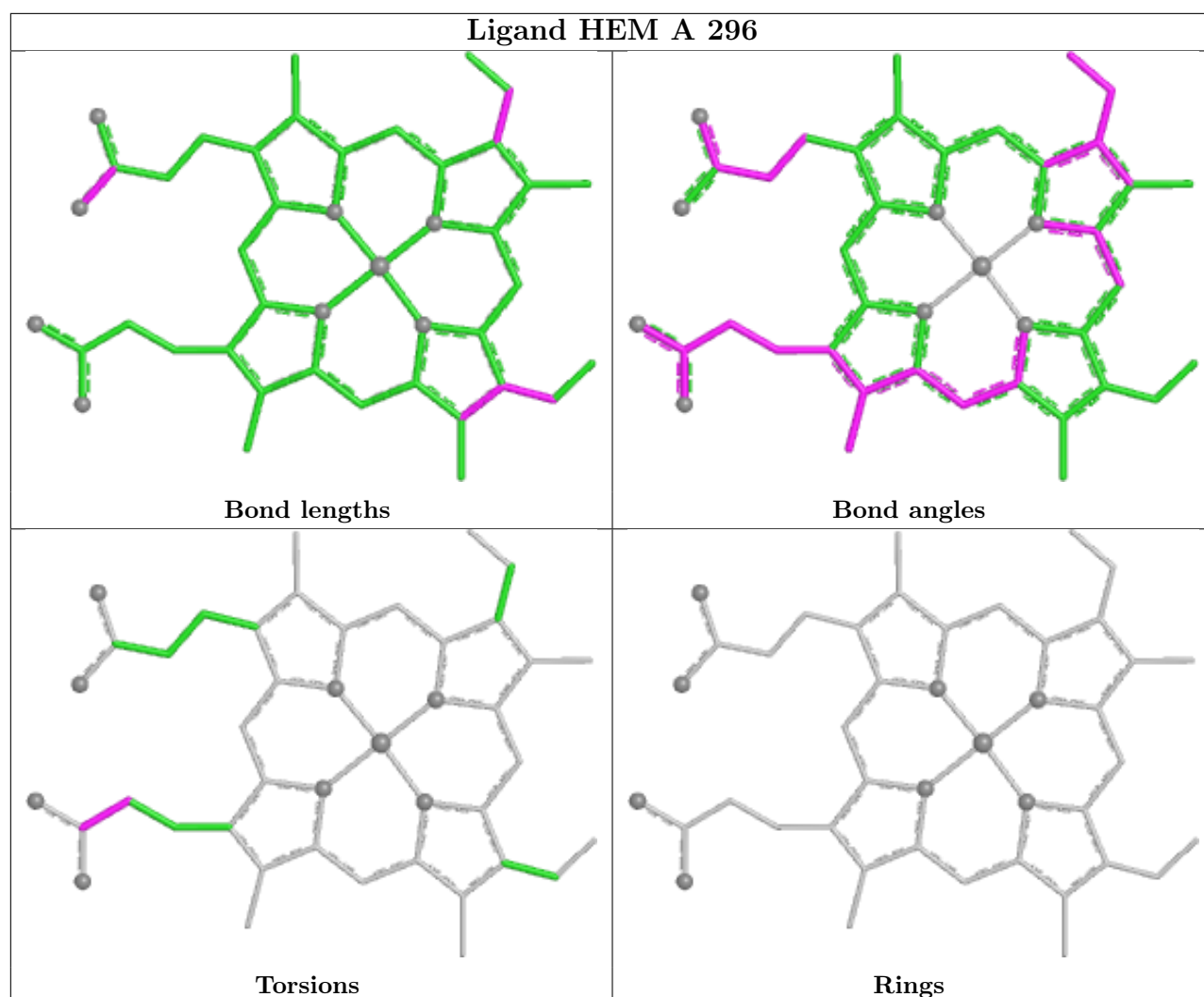
All (2) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	296	HEM	CAA-CBA-CGA-O1A
2	A	296	HEM	CAA-CBA-CGA-O2A

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

6.1 Protein, DNA and RNA chains

EDS was not executed - this section is therefore empty.

6.2 Non-standard residues in protein, DNA, RNA chains

EDS was not executed - this section is therefore empty.

6.3 Carbohydrates

EDS was not executed - this section is therefore empty.

6.4 Ligands

EDS was not executed - this section is therefore empty.

6.5 Other polymers

EDS was not executed - this section is therefore empty.