Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 03:05 PM UTC

PDB ID	:	1KXM / pdb_00001kxm
Title	:	Crystal structure of Cytochrome c Peroxidase with a Proposed Electron Transfer Pathway Excised to Form a Ligand Binding Channel.
Authors	:	Rosenfeld, R.J.; Hayes, A.M.A.; Musah, R.A.; Goodin, D.B.
Deposited on	:	2002-02-01
Resolution	:	1.74 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:

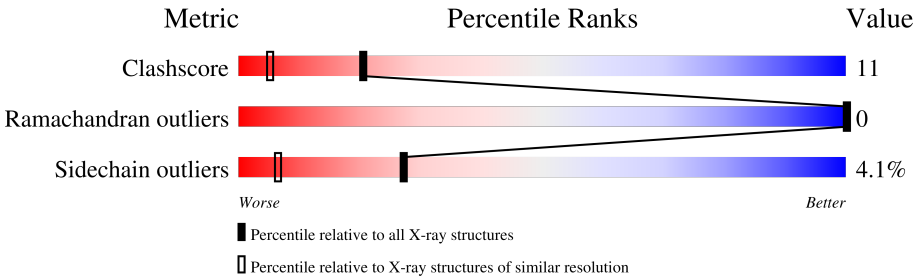
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	NOT EXECUTED
EDS	:	NOT EXECUTED
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 1.74 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	1207 (1.74-1.74)
Ramachandran outliers	187476	1200 (1.74-1.74)
Sidechain outliers	187428	1200 (1.74-1.74)

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%

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	290	75% 21% .

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 2716 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.

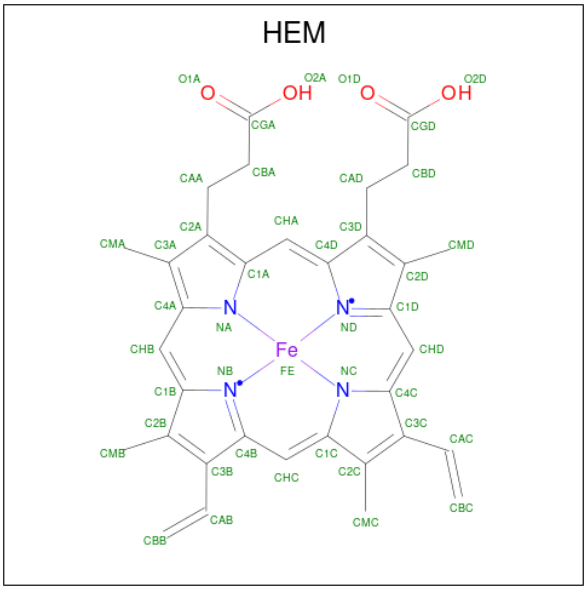
- Molecule 1 is a protein called Cytochrome c Peroxidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	290	2317	1477	385	449	6	0	0	0

There are 4 discrepancies between the modelled and reference sequences:

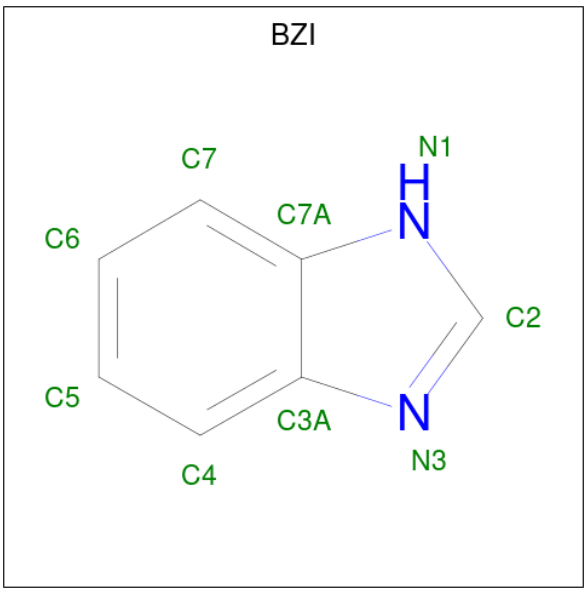
Chain	Residue	Modelled	Actual	Comment	Reference
A	3	THR	-	cloning artifact	UNP P00431
A	190	GLY	PRO	engineered mutation	UNP P00431
A	?	-	TRP	deletion	UNP P00431
A	?	-	ALA	deletion	UNP P00431

- Molecule 2 is PROTOPORPHYRIN IX CONTAINING FE (CCD ID: HEM) (formula: $C_{34}H_{32}FeN_4O_4$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0

- Molecule 3 is BENZIMIDAZOLE (CCD ID: BZI) (formula: $C_7H_6N_2$).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	1	Total C N 9 7 2	0	0

- Molecule 4 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	347	Total O 347 347	0	0

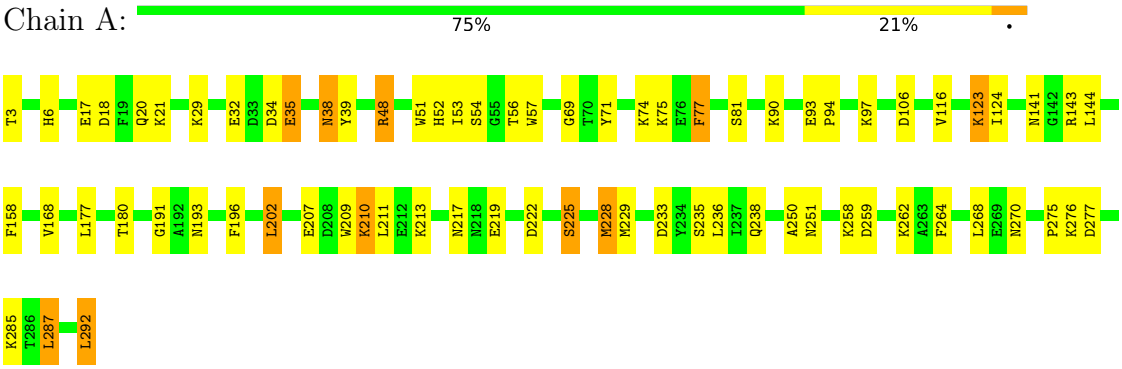
3 Residue-property plots (i)

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: Cytochrome c Peroxidase

Chain A:



4 Data and refinement statistics (i)

Xtriage (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	106.50Å 75.00Å 50.90Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	10.00 – 1.74	Depositor
% Data completeness (in resolution range)	77.8 (10.00-1.74)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	0.05	Depositor
Refinement program	SHELXL	Depositor
R, R_{free}	0.194 , 0.214	Depositor
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	2716	wwPDB-VP
Average B, all atoms (Å^2)	16.0	wwPDB-VP

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: BZI, 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	1.11	2/2379 (0.1%)	1.51	13/3222 (0.4%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	292	LEU	C-OXT	39.35	2.02	1.23
1	A	123	LYS	CE-NZ	28.62	2.35	1.49

All (13) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	276	LYS	CA-C-N	26.75	156.13	120.28
1	A	276	LYS	C-N-CA	26.75	156.13	120.28
1	A	77	PHE	CA-CB-CG	12.48	126.28	113.80
1	A	191	GLY	CA-C-N	8.76	136.08	122.94
1	A	191	GLY	C-N-CA	8.76	136.08	122.94
1	A	48	ARG	NE-CZ-NH2	6.97	125.47	119.20
1	A	191	GLY	O-C-N	-6.75	116.24	122.93
1	A	48	ARG	CD-NE-CZ	5.51	132.12	124.40
1	A	236	LEU	CA-C-N	-5.48	115.25	122.16
1	A	236	LEU	C-N-CA	-5.48	115.25	122.16
1	A	106	ASP	O-C-N	5.43	128.34	122.15
1	A	287	LEU	CA-C-O	5.02	126.09	120.82
1	A	233	ASP	CA-C-O	5.01	126.08	120.82

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	2317	0	2164	50	1
2	A	43	0	30	1	0
3	A	9	0	6	1	0
4	A	347	0	0	7	2
All	All	2716	0	2200	51	2

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 11.

All (51) 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:292:LEU:OXT	1:A:292:LEU:C	2.02	1.03
1:A:141:ASN:OD1	4:A:712:HOH:O	1.77	1.01
1:A:292:LEU:OXT	1:A:292:LEU:O	1.77	1.00
1:A:20:GLN:HE22	1:A:285:LYS:H	1.14	0.94
1:A:123:LYS:CE	1:A:123:LYS:NZ	2.35	0.90
1:A:210:LYS:HE2	1:A:222:ASP:O	1.80	0.82
1:A:287:LEU:HB3	1:A:292:LEU:OXT	1.88	0.74
1:A:116:VAL:HG11	1:A:124:ILE:HD11	1.78	0.66
1:A:180:THR:HG21	1:A:228:MET:HE1	1.78	0.64
1:A:69:GLY:HA2	4:A:499:HOH:O	1.97	0.63
1:A:20:GLN:HE22	1:A:285:LYS:N	1.92	0.62
1:A:53:ILE:HG22	1:A:71:TYR:HB2	1.86	0.57
1:A:258:LYS:HG2	1:A:262:LYS:HE2	1.86	0.56
1:A:17:GLU:O	1:A:21:LYS:HG3	2.07	0.55
1:A:6:HIS:HD2	4:A:493:HOH:O	1.89	0.54
1:A:81:SER:HA	4:A:785:HOH:O	2.07	0.54
1:A:235:SER:HA	1:A:238:GLN:HE21	1.73	0.52
1:A:202:LEU:HD12	1:A:250:ALA:HB1	1.92	0.52
1:A:93:GLU:O	1:A:97:LYS:HG2	2.09	0.51
1:A:18:ASP:HA	1:A:21:LYS:HE3	1.93	0.51
1:A:93:GLU:HG3	1:A:97:LYS:HZ3	1.77	0.49
1:A:207:GLU:HB2	1:A:209:TRP:CE2	2.48	0.49
1:A:34:ASP:O	1:A:39:TYR:HA	2.12	0.49

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:29:LYS:HE2	1:A:94:PRO:CG	2.43	0.48
2:A:1:HEM:CHA	3:A:2:BZI:H6	2.44	0.48
1:A:259:ASP:HA	1:A:262:LYS:HE3	1.96	0.47
1:A:207:GLU:OE1	1:A:225:SER:OG	2.30	0.47
1:A:54:SER:OG	1:A:268:LEU:HD23	2.14	0.47
1:A:48:ARG:NH1	4:A:434:HOH:O	2.49	0.46
1:A:35:GLU:CD	1:A:35:GLU:H	2.24	0.45
1:A:228:MET:HG2	1:A:229:MET:N	2.33	0.44
1:A:52:HIS:ND1	1:A:144:LEU:HD13	2.33	0.44
1:A:29:LYS:HE2	1:A:94:PRO:HG3	2.00	0.43
1:A:211:LEU:HD11	1:A:219:GLU:HB3	2.00	0.43
1:A:285:LYS:HD3	4:A:761:HOH:O	2.18	0.43
1:A:38:ASN:O	1:A:39:TYR:HB2	2.18	0.43
1:A:56:THR:O	1:A:143:ARG:HD3	2.19	0.43
1:A:32:GLU:OE2	1:A:32:GLU:HA	2.17	0.43
1:A:93:GLU:HG3	1:A:97:LYS:NZ	2.34	0.43
1:A:158:PHE:CG	1:A:168:VAL:HG22	2.54	0.43
1:A:213:LYS:NZ	1:A:217:ASN:HD21	2.16	0.43
1:A:124:ILE:HD13	1:A:264:PHE:HD1	1.83	0.43
1:A:57:TRP:CD2	1:A:270:ASN:HB3	2.54	0.42
1:A:20:GLN:NE2	1:A:285:LYS:H	1.97	0.42
1:A:75:LYS:O	4:A:712:HOH:O	2.21	0.42
1:A:210:LYS:HB2	1:A:210:LYS:HE3	1.24	0.42
1:A:177:LEU:HD11	1:A:196:PHE:HD2	1.86	0.41
1:A:124:ILE:HD13	1:A:264:PHE:CD1	2.56	0.41
1:A:74:LYS:HA	1:A:77:PHE:CE2	2.56	0.41
1:A:202:LEU:HD11	1:A:250:ALA:O	2.21	0.41
1:A:275:PRO:HB2	1:A:277:ASP:HB3	2.03	0.40

All (2) 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)
4:A:706:HOH:O	4:A:821:HOH:O[2_574]	1.97	0.23
1:A:251:ASN:OD1	4:A:723:HOH:O[2_574]	2.19	0.01

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	288/290 (99%)	285 (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	241/248 (97%)	231 (96%)	10 (4%)	27 6

All (10) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	3	THR
1	A	35	GLU
1	A	38	ASN
1	A	51	TRP
1	A	90	LYS
1	A	193	ASN
1	A	202	LEU
1	A	210	LYS
1	A	225	SER
1	A	228	MET

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (11) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	6	HIS
1	A	20	GLN
1	A	24	ASN
1	A	78	ASN
1	A	159	GLN
1	A	193	ASN
1	A	206	ASN
1	A	217	ASN
1	A	218	ASN
1	A	238	GLN
1	A	290	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)

2 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	BZI	A	2	-	10,10,10	1.26	1 (10%)	13,13,13	1.98	5 (38%)
2	HEM	A	1	1,4	50,50,50	2.32	21 (42%)	67,82,82	1.27	10 (14%)

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	BZI	A	2	-	-	-	0/2/2/2
2	HEM	A	1	1,4	-	3/14/54/54	-

All (22) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	1	HEM	FE-NB	5.06	2.10	1.94
2	A	1	HEM	FE-ND	4.34	2.08	1.94
2	A	1	HEM	C1B-NB	-4.31	1.32	1.40
2	A	1	HEM	C3C-C4C	-4.02	1.39	1.46
2	A	1	HEM	FE-NA	3.97	2.08	1.95
2	A	1	HEM	C4D-ND	-3.52	1.34	1.40
2	A	1	HEM	C4B-NB	-3.42	1.32	1.38
2	A	1	HEM	C1A-C2A	-3.16	1.38	1.44
2	A	1	HEM	CBC-CAC	2.97	1.44	1.30
2	A	1	HEM	C4D-C3D	-2.86	1.40	1.45
3	A	2	BZI	C2-N3	2.85	1.38	1.32
2	A	1	HEM	CBB-CAB	2.75	1.43	1.30
2	A	1	HEM	C1D-C2D	-2.70	1.39	1.44
2	A	1	HEM	C1C-C2C	-2.66	1.40	1.45
2	A	1	HEM	C1C-NC	-2.65	1.34	1.39
2	A	1	HEM	O2D-CGD	-2.60	1.22	1.30
2	A	1	HEM	CAB-C3B	-2.57	1.40	1.47
2	A	1	HEM	C1D-ND	-2.30	1.34	1.38
2	A	1	HEM	CAC-C3C	-2.28	1.41	1.47
2	A	1	HEM	FE-NC	2.22	2.02	1.95
2	A	1	HEM	CHC-C1C	2.15	1.42	1.38
2	A	1	HEM	O2A-CGA	-2.10	1.23	1.30

All (15) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	2	BZI	C7-C7A-C3A	-4.03	117.68	122.10
3	A	2	BZI	N1-C2-N3	-3.51	108.52	113.87
2	A	1	HEM	CAD-C3D-C4D	2.99	129.91	124.70
2	A	1	HEM	C4A-C3A-C2A	-2.67	103.75	106.82
2	A	1	HEM	O2A-CGA-O1A	-2.64	116.53	123.33
2	A	1	HEM	CMD-C2D-C1D	2.64	129.15	125.03

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
3	A	2	BZI	C7-C7A-N1	2.60	134.90	130.74
3	A	2	BZI	C4-C3A-C7A	2.55	123.07	120.26
2	A	1	HEM	CHD-C4C-NC	-2.53	121.70	124.45
2	A	1	HEM	CMA-C3A-C4A	2.38	129.04	125.42
2	A	1	HEM	C3C-C2C-C1C	-2.26	104.91	107.05
2	A	1	HEM	CAD-C3D-C2D	-2.11	123.92	127.87
2	A	1	HEM	C4C-CHD-C1D	2.09	130.45	126.02
2	A	1	HEM	C1B-NB-C4B	2.07	107.65	105.21
3	A	2	BZI	C3A-N3-C2	2.00	109.06	105.18

There are no chirality outliers.

All (3) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	1	HEM	CAA-CBA-CGA-O2A
2	A	1	HEM	CAA-CBA-CGA-O1A
2	A	1	HEM	CAD-CBD-CGD-O2D

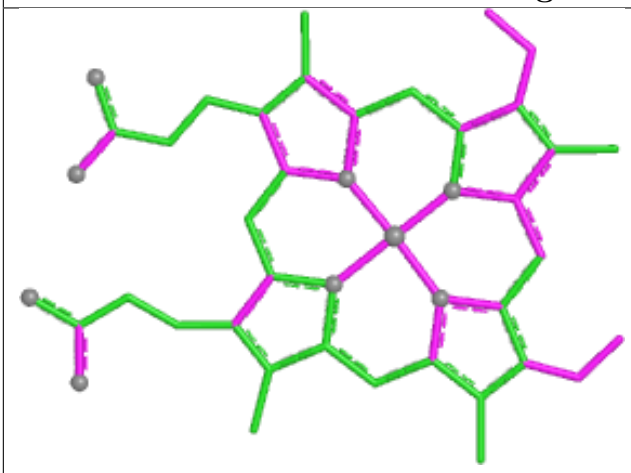
There are no ring outliers.

2 monomers are involved in 1 short contact:

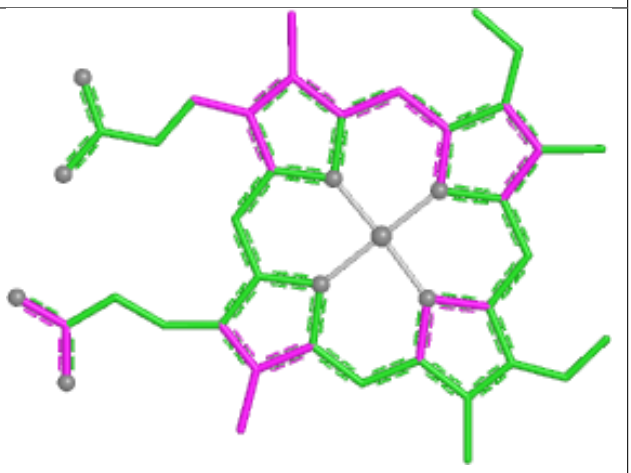
Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	2	BZI	1	0
2	A	1	HEM	1	0

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 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.

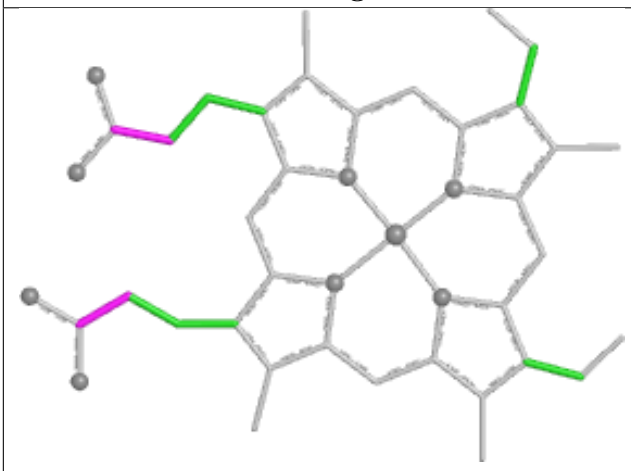
Ligand HEM A 1



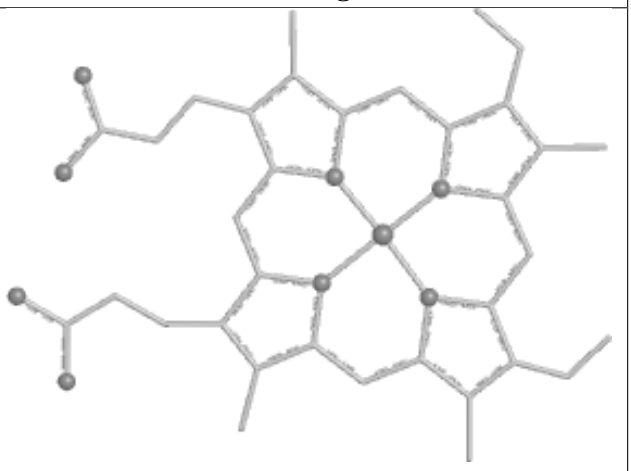
Bond lengths



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

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.