Full wwPDB X-ray Structure Validation Report (i)

Aug 23, 2026 – 10:36 am BST

PDB ID	:	9EOV / pdb_00009eov
Title	:	Crystal structure of domains I and II from the outer membrane cytochrome MtrC
Authors	:	Nash, B.W.; Morales Florez, A.; Lockwood, C.W.J.; Edwards, M.J.; Butt, J.N.; Clarke, T.A.
Deposited on	:	2024-03-15
Resolution	:	1.80 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 (i) 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 (i)) were used in the production of this report:

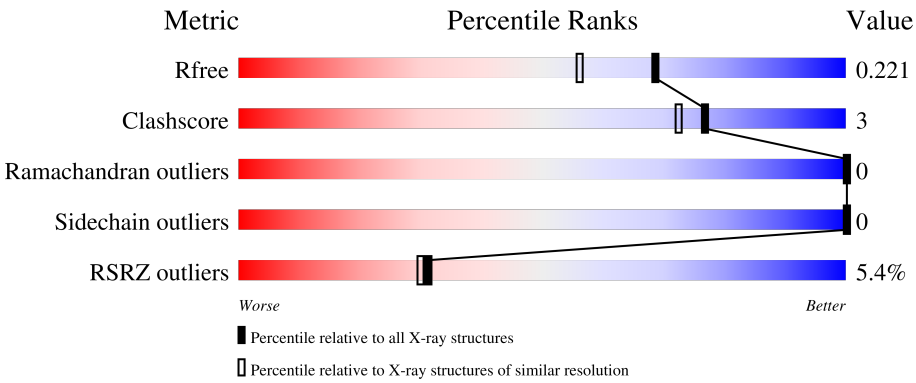
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal 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 (i)

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

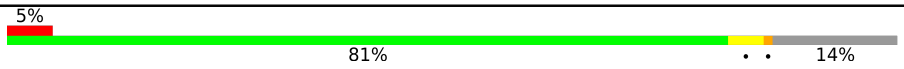
The reported resolution of this entry is 1.80 Å.

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	7662 (1.80-1.80)
Clashscore	190562	8479 (1.80-1.80)
Ramachandran outliers	187476	8391 (1.80-1.80)
Sidechain outliers	187428	8390 (1.80-1.80)
RSRZ outliers	180081	7663 (1.80-1.80)

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	323	

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
2	HEC	A	401	X	-	-	-
2	HEC	A	402	X	-	-	-
2	HEC	A	403	X	-	-	-
2	HEC	A	404	X	-	-	-
2	HEC	A	405	X	-	-	-

2 Entry composition (i)

There are 5 unique types of molecules in this entry. The entry contains 2723 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.

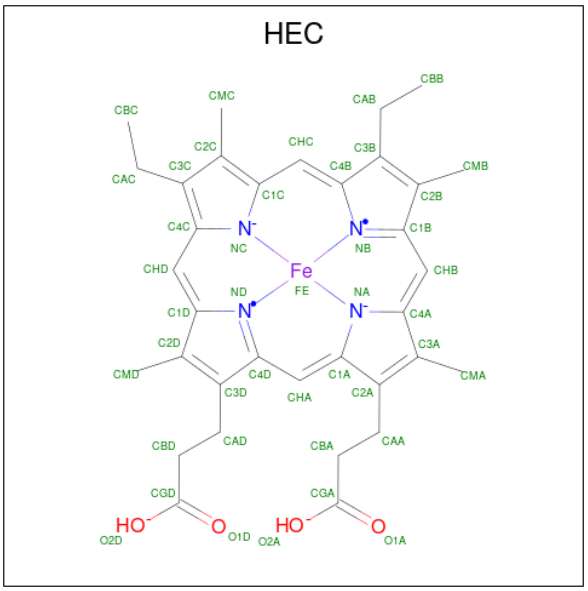
- Molecule 1 is a protein called Extracellular iron oxide respiratory system surface decaheme cytochrome c component MtrC.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	278	2128	1314	374	425	15	0	2	0

There are 23 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	3	MET	-	initiating methionine	UNP Q8EG34
A	4	LYS	-	expression tag	UNP Q8EG34
A	5	PHE	-	expression tag	UNP Q8EG34
A	6	LYS	-	expression tag	UNP Q8EG34
A	7	LEU	-	expression tag	UNP Q8EG34
A	8	ASN	-	expression tag	UNP Q8EG34
A	9	LEU	-	expression tag	UNP Q8EG34
A	10	ILE	-	expression tag	UNP Q8EG34
A	11	THR	-	expression tag	UNP Q8EG34
A	12	LEU	-	expression tag	UNP Q8EG34
A	13	ALA	-	expression tag	UNP Q8EG34
A	14	LEU	-	expression tag	UNP Q8EG34
A	15	LEU	-	expression tag	UNP Q8EG34
A	16	ALA	-	expression tag	UNP Q8EG34
A	17	ASN	-	expression tag	UNP Q8EG34
A	18	THR	-	expression tag	UNP Q8EG34
A	19	GLY	-	expression tag	UNP Q8EG34
A	20	LEU	-	expression tag	UNP Q8EG34
A	21	ALA	-	expression tag	UNP Q8EG34
A	22	VAL	-	expression tag	UNP Q8EG34
A	23	ALA	-	expression tag	UNP Q8EG34
A	24	ALA	-	expression tag	UNP Q8EG34
A	25	ASP	-	expression tag	UNP Q8EG34

- Molecule 2 is HEME C (CCD ID: HEC) (formula: $C_{34}H_{36}FeN_4O_4$) (labeled as "Ligand of Interest" by depositor).

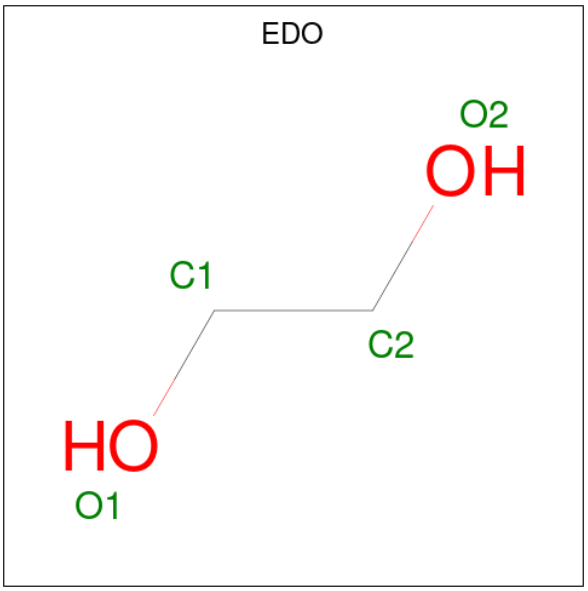


Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0
			Total	C	Fe	N	O		
2	A	1	43	34	1	4	4	0	0

- Molecule 3 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	Mg		
3	A	1	1	1	0	0

- Molecule 4 is 1,2-ETHANEDIOL (CCD ID: EDO) (formula: $C_2H_6O_2$).



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

- Molecule 5 is water.

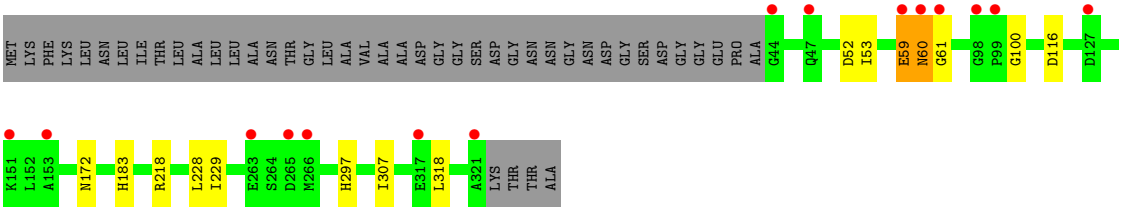
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
5	A	367	367	367	0	0

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: Extracellular iron oxide respiratory system surface decaheme cytochrome c component MtrC

Chain A:



4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	74.28Å 77.35Å 96.53Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	58.87 – 1.80 58.87 – 1.80	Depositor EDS
% Data completeness (in resolution range)	99.8 (58.87-1.80) 99.8 (58.87-1.80)	Depositor EDS
R_{merge}	0.17	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.56 (at 1.80Å)	Xtriage
Refinement program	PHENIX (1.20.1_4487: ???)	Depositor
R, R_{free}	0.188 , 0.221 0.188 , 0.221	Depositor DCC
R_{free} test set	2529 reflections (4.84%)	wwPDB-VP
Wilson B-factor (Å^2)	20.8	Xtriage
Anisotropy	0.955	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.35 , 37.6	EDS
L-test for twinning[2]	$< \|L\| > = 0.51$, $< L^2 > = 0.34$	Xtriage
Estimated twinning fraction	0.000 for k,h,-l	Xtriage
F_o,F_c correlation	0.97	EDS
Total number of atoms	2723	wwPDB-VP
Average B, all atoms (Å^2)	29.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 9.39% of the height of the origin peak. No significant pseudotranslation is detected.*

[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 (i)

5.1 Standard geometry (i)

Bond lengths and bond angles in the following residue types are not validated in this section: MG, EDO, HEC

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	0.75	0/2175	1.08	5/2955 (0.2%)

There are no bond length outliers.

All (5) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	A	60	ASN	N-CA-C	-7.66	103.51	112.86
1	A	183	HIS	CA-CB-CG	-7.30	106.50	113.80
1	A	59	GLU	N-CA-C	-5.52	100.32	108.99
1	A	297	HIS	CA-CB-CG	5.33	119.13	113.80
1	A	116	ASP	CA-CB-CG	5.05	117.65	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	A	2128	0	2008	12	0
2	A	215	0	150	3	0
3	A	1	0	0	0	0
4	A	12	0	18	1	0
5	A	367	0	0	6	1
All	All	2723	0	2176	13	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 3.

All (13) 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:100:GLY:HA2	4:A:409:EDO:H21	1.78	0.65
1:A:52[A]:ASP:OD1	5:A:501:HOH:O	2.14	0.64
1:A:218:ARG:HG3	5:A:534:HOH:O	1.98	0.64
2:A:404:HEC:HBD2	5:A:740:HOH:O	2.05	0.55
1:A:318:LEU:C	1:A:318:LEU:HD12	2.36	0.51
1:A:53:ILE:O	5:A:502:HOH:O	2.18	0.50
1:A:59:GLU:C	1:A:61:GLY:N	2.66	0.50
1:A:228:LEU:C	1:A:228:LEU:HD23	2.37	0.48
1:A:172:ASN:HB3	5:A:683:HOH:O	2.19	0.43
1:A:59:GLU:O	1:A:60:ASN:CB	2.67	0.41
1:A:307:ILE:HB	5:A:735:HOH:O	2.20	0.40
1:A:229:ILE:HG12	2:A:402:HEC:HMD2	2.04	0.40
1:A:229:ILE:HG21	2:A:402:HEC:C2D	2.51	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)
5:A:586:HOH:O	5:A:783:HOH:O[2_454]	2.15	0.05

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	278/323 (86%)	270 (97%)	8 (3%)	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	234/262 (89%)	234 (100%)	0	100 100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	47	GLN
1	A	141	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)

Of 9 ligands modelled in this entry, 1 is monoatomic - leaving 8 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	HEC	A	404	1	50,50,50	2.44	22 (44%)	68,82,82	2.53	32 (47%)
2	HEC	A	402	1	50,50,50	2.17	21 (42%)	68,82,82	2.58	29 (42%)
2	HEC	A	403	1	50,50,50	2.09	20 (40%)	68,82,82	2.60	37 (54%)
4	EDO	A	407	-	3,3,3	0.65	0	2,2,2	0.56	0
2	HEC	A	405	1	50,50,50	2.39	23 (46%)	68,82,82	2.46	30 (44%)
4	EDO	A	408	-	3,3,3	0.41	0	2,2,2	0.27	0
4	EDO	A	409	-	3,3,3	0.38	0	2,2,2	0.26	0
2	HEC	A	401	1	50,50,50	2.14	21 (42%)	68,82,82	2.50	25 (36%)

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	HEC	A	404	1	1/1/3/7	6/14/54/54	-
2	HEC	A	402	1	1/1/3/7	4/14/54/54	-
2	HEC	A	403	1	1/1/3/7	6/14/54/54	-
4	EDO	A	407	-	-	1/1/1/1	-
2	HEC	A	405	1	1/1/3/7	6/14/54/54	-
4	EDO	A	408	-	-	0/1/1/1	-
4	EDO	A	409	-	-	1/1/1/1	-
2	HEC	A	401	1	1/1/3/7	9/14/54/54	-

All (107) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	405	HEC	C4A-NA	-5.36	1.29	1.39
2	A	404	HEC	C4B-NB	-5.00	1.31	1.40
2	A	402	HEC	C1C-NC	-4.89	1.30	1.39
2	A	404	HEC	C1D-ND	-4.86	1.31	1.40
2	A	401	HEC	C3B-C2B	4.70	1.46	1.36
2	A	405	HEC	C3D-C2D	4.63	1.46	1.36
2	A	401	HEC	C3D-C2D	4.61	1.46	1.36
2	A	403	HEC	C1D-ND	-4.53	1.32	1.40
2	A	405	HEC	C1D-ND	-4.31	1.32	1.40
2	A	404	HEC	CHD-C1D	4.31	1.47	1.38
2	A	402	HEC	C4B-NB	-4.27	1.32	1.40
2	A	402	HEC	C1D-ND	-4.17	1.33	1.40
2	A	404	HEC	C4D-ND	-4.15	1.30	1.38

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	403	HEC	C3D-C2D	4.14	1.45	1.36
2	A	405	HEC	C4B-NB	-4.05	1.33	1.40
2	A	404	HEC	C3B-C2B	3.97	1.45	1.36
2	A	403	HEC	C1A-NA	-3.97	1.32	1.39
2	A	402	HEC	C3B-C2B	3.95	1.45	1.36
2	A	404	HEC	C1C-NC	-3.95	1.32	1.39
2	A	405	HEC	CHA-C1A	3.94	1.46	1.38
2	A	404	HEC	C4C-NC	-3.92	1.32	1.39
2	A	405	HEC	C2A-C3A	3.86	1.44	1.36
2	A	401	HEC	FE-ND	3.76	2.06	1.94
2	A	405	HEC	C3B-C2B	3.61	1.44	1.36
2	A	402	HEC	C1A-NA	-3.60	1.32	1.39
2	A	404	HEC	C1A-NA	-3.59	1.32	1.39
2	A	405	HEC	C1A-NA	-3.57	1.32	1.39
2	A	402	HEC	C1B-NB	-3.57	1.31	1.38
2	A	402	HEC	C3D-C2D	3.56	1.44	1.36
2	A	404	HEC	C3D-C2D	3.56	1.44	1.36
2	A	404	HEC	FE-NC	3.50	2.07	1.95
2	A	404	HEC	CHA-C1A	3.46	1.45	1.38
2	A	403	HEC	C4C-NC	-3.45	1.33	1.39
2	A	404	HEC	FE-ND	3.40	2.05	1.94
2	A	405	HEC	C1B-NB	-3.37	1.31	1.38
2	A	401	HEC	CBA-CGA	3.36	1.58	1.50
2	A	401	HEC	CHB-C4A	3.32	1.44	1.38
2	A	405	HEC	C1C-NC	-3.29	1.33	1.39
2	A	403	HEC	C4A-NA	-3.25	1.33	1.39
2	A	403	HEC	CHA-C1A	3.21	1.44	1.38
2	A	403	HEC	C1B-NB	-3.21	1.32	1.38
2	A	401	HEC	C1A-NA	-3.21	1.33	1.39
2	A	403	HEC	C2A-C3A	3.18	1.43	1.36
2	A	401	HEC	C1C-NC	-3.15	1.33	1.39
2	A	405	HEC	FE-NC	3.13	2.05	1.95
2	A	404	HEC	C4A-NA	-3.07	1.33	1.39
2	A	404	HEC	FE-NB	3.06	2.04	1.94
2	A	401	HEC	C4B-NB	-3.05	1.35	1.40
2	A	403	HEC	C1C-NC	-3.04	1.33	1.39
2	A	403	HEC	C4B-NB	-3.03	1.35	1.40
2	A	405	HEC	CHB-C4A	3.00	1.44	1.38
2	A	402	HEC	C4D-ND	-2.99	1.32	1.38
2	A	401	HEC	C4A-NA	-2.95	1.34	1.39
2	A	401	HEC	FE-NB	2.94	2.03	1.94
2	A	405	HEC	CHC-C1C	2.90	1.45	1.39

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	402	HEC	C4C-NC	-2.88	1.34	1.39
2	A	401	HEC	CHA-C4D	2.86	1.45	1.39
2	A	404	HEC	FE-NA	2.86	2.04	1.95
2	A	401	HEC	CHA-C1A	2.85	1.43	1.38
2	A	403	HEC	C3B-C2B	2.84	1.42	1.36
2	A	405	HEC	C3C-C2C	2.83	1.46	1.38
2	A	402	HEC	C4A-NA	-2.83	1.34	1.39
2	A	405	HEC	FE-NA	2.83	2.04	1.95
2	A	402	HEC	FE-NA	2.82	2.04	1.95
2	A	402	HEC	C2A-C3A	2.78	1.42	1.36
2	A	404	HEC	C2A-C3A	2.71	1.42	1.36
2	A	405	HEC	CHA-C4D	2.69	1.45	1.39
2	A	404	HEC	CHC-C4B	2.69	1.44	1.38
2	A	403	HEC	O2D-CGD	-2.68	1.21	1.30
2	A	404	HEC	C1B-NB	-2.65	1.33	1.38
2	A	404	HEC	CHB-C1B	2.64	1.45	1.39
2	A	404	HEC	CHA-C4D	2.64	1.45	1.39
2	A	401	HEC	C1D-ND	-2.61	1.35	1.40
2	A	401	HEC	CBD-CGD	2.58	1.56	1.50
2	A	405	HEC	C4D-ND	-2.58	1.33	1.38
2	A	402	HEC	CHB-C1B	2.57	1.45	1.39
2	A	405	HEC	C4C-NC	-2.56	1.34	1.39
2	A	401	HEC	C4C-NC	-2.55	1.34	1.39
2	A	403	HEC	CHB-C4A	2.53	1.43	1.38
2	A	401	HEC	C4D-ND	-2.53	1.33	1.38
2	A	404	HEC	CHC-C1C	2.51	1.45	1.39
2	A	402	HEC	CHA-C4D	2.49	1.44	1.39
2	A	402	HEC	FE-NB	2.46	2.02	1.94
2	A	405	HEC	O2A-CGA	-2.46	1.22	1.30
2	A	401	HEC	CHC-C4B	2.45	1.43	1.38
2	A	401	HEC	C3C-C2C	2.40	1.45	1.38
2	A	401	HEC	CHD-C4C	2.39	1.44	1.39
2	A	402	HEC	CHA-C1A	2.38	1.43	1.38
2	A	405	HEC	CHC-C4B	2.37	1.43	1.38
2	A	401	HEC	C2A-C3A	2.37	1.41	1.36
2	A	405	HEC	FE-ND	2.34	2.02	1.94
2	A	403	HEC	CHD-C1D	2.26	1.43	1.38
2	A	403	HEC	CBD-CGD	2.24	1.55	1.50
2	A	405	HEC	CHD-C4C	2.24	1.44	1.39
2	A	402	HEC	C1C-C2C	2.24	1.48	1.43
2	A	403	HEC	CHA-C4D	2.23	1.44	1.39
2	A	403	HEC	CHC-C4B	2.23	1.43	1.38

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	403	HEC	FE-NC	2.23	2.02	1.95
2	A	401	HEC	CHB-C1B	2.19	1.44	1.39
2	A	405	HEC	C1B-C2B	2.18	1.48	1.44
2	A	402	HEC	C3C-C2C	2.12	1.44	1.38
2	A	403	HEC	CHC-C1C	2.12	1.44	1.39
2	A	404	HEC	CBD-CGD	2.11	1.55	1.50
2	A	402	HEC	O1A-CGA	2.10	1.29	1.22
2	A	403	HEC	FE-NB	2.10	2.01	1.94
2	A	402	HEC	C1B-C2B	2.08	1.48	1.44
2	A	402	HEC	C4D-C3D	2.06	1.48	1.45

All (153) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	404	HEC	C2A-C1A-NA	7.22	117.35	110.32
2	A	402	HEC	C2A-C1A-NA	7.03	117.17	110.32
2	A	405	HEC	C2A-C1A-NA	6.31	116.46	110.32
2	A	404	HEC	C3D-C4D-ND	5.71	115.89	110.36
2	A	401	HEC	C1B-C2B-C3B	-5.68	100.98	106.96
2	A	403	HEC	C3C-C4C-NC	5.60	116.41	110.15
2	A	401	HEC	C1D-C2D-C3D	-5.48	101.20	106.96
2	A	403	HEC	C2D-C1D-ND	5.47	116.33	109.84
2	A	401	HEC	C2D-C1D-ND	5.46	116.31	109.84
2	A	403	HEC	C1B-C2B-C3B	-5.30	101.39	106.96
2	A	402	HEC	CAB-C3B-C4B	5.29	131.67	124.81
2	A	403	HEC	C2B-C1B-NB	5.20	116.11	109.88
2	A	404	HEC	C1C-C2C-C3C	-5.10	100.87	106.83
2	A	402	HEC	C1C-C2C-C3C	-4.85	101.15	106.83
2	A	405	HEC	C1A-C2A-C3A	-4.82	100.84	107.13
2	A	405	HEC	C2B-C1B-NB	4.76	115.58	109.88
2	A	405	HEC	C1B-C2B-C3B	-4.76	101.95	106.96
2	A	405	HEC	C3D-C4D-ND	4.72	114.92	110.36
2	A	403	HEC	C2A-C1A-NA	4.66	114.86	110.32
2	A	401	HEC	C2B-C1B-NB	4.66	115.47	109.88
2	A	404	HEC	C2C-C1C-NC	4.55	117.01	110.08
2	A	401	HEC	C2A-C1A-NA	4.51	114.71	110.32
2	A	402	HEC	C1B-C2B-C3B	-4.49	102.23	106.96
2	A	403	HEC	C1C-C2C-C3C	-4.45	101.63	106.83
2	A	403	HEC	C2C-C1C-NC	4.44	116.84	110.08
2	A	404	HEC	C1A-C2A-C3A	-4.43	101.35	107.13
2	A	403	HEC	C1D-C2D-C3D	-4.40	102.33	106.96
2	A	402	HEC	CMC-C2C-C3C	4.33	134.97	125.61

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	404	HEC	C2B-C1B-NB	4.27	115.00	109.88
2	A	404	HEC	C1B-C2B-C3B	-4.25	102.49	106.96
2	A	401	HEC	O2A-CGA-CBA	4.24	127.67	114.03
2	A	402	HEC	C3D-C4D-ND	4.23	114.46	110.36
2	A	401	HEC	C1C-C2C-C3C	-4.21	101.90	106.83
2	A	402	HEC	C4A-NA-C1A	-4.20	101.24	105.35
2	A	404	HEC	C1D-C2D-C3D	-4.17	102.58	106.96
2	A	402	HEC	C2C-C1C-NC	4.14	116.39	110.08
2	A	402	HEC	C1D-C2D-C3D	-4.13	102.61	106.96
2	A	404	HEC	C2D-C1D-ND	4.13	114.73	109.84
2	A	402	HEC	C3B-C4B-NB	4.12	114.75	110.17
2	A	401	HEC	O1A-CGA-CBA	-4.11	109.87	123.08
2	A	405	HEC	C3B-C4B-NB	4.04	114.66	110.17
2	A	402	HEC	C3C-C4C-NC	4.01	114.63	110.15
2	A	403	HEC	C3D-C4D-ND	3.99	114.22	110.36
2	A	405	HEC	CAD-C3D-C4D	3.99	131.62	124.66
2	A	401	HEC	CHA-C1A-C2A	-3.96	118.53	124.94
2	A	401	HEC	C3C-C4C-NC	3.92	114.53	110.15
2	A	405	HEC	C1C-C2C-C3C	-3.91	102.25	106.83
2	A	402	HEC	C2D-C1D-ND	3.89	114.45	109.84
2	A	401	HEC	C2C-C1C-NC	3.85	115.94	110.08
2	A	403	HEC	CMB-C2B-C1B	3.85	130.90	125.04
2	A	402	HEC	CAD-C3D-C4D	3.82	131.33	124.66
2	A	402	HEC	C2B-C1B-NB	3.80	114.43	109.88
2	A	403	HEC	C4C-NC-C1C	-3.75	101.67	105.35
2	A	401	HEC	CAD-CBD-CGD	-3.67	105.71	113.60
2	A	405	HEC	C2D-C1D-ND	3.63	114.14	109.84
2	A	401	HEC	CHC-C1C-C2C	-3.60	117.06	127.24
2	A	401	HEC	O2D-CGD-CBD	3.60	125.59	114.03
2	A	401	HEC	CMA-C3A-C4A	3.59	131.05	124.71
2	A	405	HEC	CHA-C4D-C3D	-3.58	119.57	124.84
2	A	404	HEC	C4A-NA-C1A	-3.58	101.84	105.35
2	A	404	HEC	CMD-C2D-C1D	3.53	130.42	125.04
2	A	401	HEC	CHB-C1B-C2B	-3.52	119.47	124.98
2	A	402	HEC	C3A-C4A-NA	3.51	116.17	109.69
2	A	403	HEC	CMD-C2D-C1D	3.49	130.35	125.04
2	A	403	HEC	CMC-C2C-C3C	3.48	133.13	125.61
2	A	402	HEC	C1A-C2A-C3A	-3.44	102.64	107.13
2	A	401	HEC	CAA-CBA-CGA	-3.42	106.24	113.60
2	A	405	HEC	CMC-C2C-C3C	3.41	132.99	125.61
2	A	403	HEC	C3B-C4B-NB	3.41	113.96	110.17
2	A	405	HEC	CHA-C1A-C2A	-3.39	119.45	124.94

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	401	HEC	O1D-CGD-CBD	-3.38	112.24	123.08
2	A	404	HEC	C3C-C4C-NC	3.36	113.90	110.15
2	A	403	HEC	CBA-CAA-C2A	-3.31	103.42	112.63
2	A	404	HEC	C4D-C3D-C2D	-3.31	102.07	106.90
2	A	403	HEC	CHC-C4B-C3B	-3.30	119.14	125.33
2	A	405	HEC	C1D-C2D-C3D	-3.20	103.59	106.96
2	A	403	HEC	CAC-C3C-C2C	3.20	131.98	126.86
2	A	405	HEC	C4D-C3D-C2D	-3.20	102.24	106.90
2	A	404	HEC	CBA-CAA-C2A	-3.19	103.76	112.63
2	A	405	HEC	CHB-C1B-C2B	-3.18	120.01	124.98
2	A	404	HEC	CHA-C4D-C3D	-3.18	120.17	124.84
2	A	405	HEC	C3C-C4C-NC	3.16	113.68	110.15
2	A	405	HEC	C2C-C1C-NC	3.14	114.87	110.08
2	A	401	HEC	CMC-C2C-C3C	3.11	132.33	125.61
2	A	404	HEC	CHB-C1B-C2B	-3.11	120.13	124.98
2	A	404	HEC	C3A-C4A-NA	3.11	115.42	109.69
2	A	405	HEC	CAB-C3B-C4B	3.10	128.83	124.81
2	A	403	HEC	CMA-C3A-C4A	3.07	130.12	124.71
2	A	405	HEC	CBA-CAA-C2A	-3.00	104.29	112.63
2	A	404	HEC	CAD-C3D-C4D	3.00	129.90	124.66
2	A	404	HEC	CHA-C1A-C2A	-3.00	120.08	124.94
2	A	402	HEC	CHB-C1B-C2B	-2.98	120.33	124.98
2	A	402	HEC	O2D-CGD-CBD	2.95	123.52	114.03
2	A	403	HEC	CHB-C4A-C3A	-2.95	119.30	125.48
2	A	403	HEC	CAD-CBD-CGD	-2.93	107.30	113.60
2	A	402	HEC	CHA-C4D-C3D	-2.91	120.56	124.84
2	A	404	HEC	CAC-C3C-C4C	2.91	128.96	124.92
2	A	402	HEC	CHD-C1D-C2D	-2.89	118.71	126.73
2	A	401	HEC	CHD-C1D-C2D	-2.89	118.71	126.73
2	A	402	HEC	C4A-C3A-C2A	-2.87	102.75	106.94
2	A	405	HEC	CMD-C2D-C1D	2.83	129.35	125.04
2	A	402	HEC	CHC-C1C-C2C	-2.77	119.40	127.24
2	A	405	HEC	CHD-C1D-C2D	-2.77	119.02	126.73
2	A	402	HEC	CHA-C1A-C2A	-2.77	120.46	124.94
2	A	401	HEC	C4A-C3A-C2A	-2.73	102.96	106.94
2	A	402	HEC	C4D-C3D-C2D	-2.71	102.94	106.90
2	A	403	HEC	C1A-C2A-C3A	-2.71	103.59	107.13
2	A	403	HEC	CAB-C3B-C4B	2.70	128.32	124.81
2	A	403	HEC	C4A-C3A-C2A	-2.70	103.00	106.94
2	A	403	HEC	CHA-C1A-C2A	-2.69	120.58	124.94
2	A	405	HEC	C3A-C4A-NA	2.68	114.64	109.69
2	A	405	HEC	CHB-C4A-NA	-2.68	121.55	124.44

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
2	A	401	HEC	C3B-C4B-NB	2.67	113.14	110.17
2	A	404	HEC	CMA-C3A-C4A	2.66	129.40	124.71
2	A	404	HEC	CMC-C2C-C3C	2.65	131.34	125.61
2	A	402	HEC	C4B-C3B-C2B	-2.64	103.05	106.90
2	A	403	HEC	CAA-C2A-C1A	2.64	129.88	124.89
2	A	403	HEC	CHA-C4D-C3D	-2.63	120.97	124.84
2	A	402	HEC	CMD-C2D-C1D	2.60	129.00	125.04
2	A	405	HEC	CBB-CAB-C3B	-2.56	105.37	112.43
2	A	405	HEC	CMB-C2B-C1B	2.56	128.94	125.04
2	A	404	HEC	CAA-C2A-C1A	2.54	129.69	124.89
2	A	403	HEC	CHD-C1D-C2D	-2.54	119.67	126.73
2	A	403	HEC	CHB-C1B-C2B	-2.54	121.02	124.98
2	A	405	HEC	C4B-C3B-C2B	-2.53	103.20	106.90
2	A	401	HEC	C3D-C4D-ND	2.52	112.80	110.36
2	A	401	HEC	CMB-C2B-C3B	2.52	132.96	126.12
2	A	404	HEC	C3B-C4B-NB	2.51	112.96	110.17
2	A	403	HEC	C4D-C3D-C2D	-2.42	103.38	106.90
2	A	405	HEC	CAA-C2A-C3A	2.39	132.33	127.88
2	A	403	HEC	CBD-CAD-C3D	-2.38	106.01	112.63
2	A	404	HEC	CHC-C1C-C2C	-2.38	120.52	127.24
2	A	405	HEC	CAC-C3C-C4C	2.33	128.15	124.92
2	A	403	HEC	C3A-C4A-NA	2.32	113.96	109.69
2	A	403	HEC	CHD-C4C-C3C	-2.30	120.34	125.36
2	A	403	HEC	CHC-C1C-C2C	-2.27	120.82	127.24
2	A	403	HEC	C4C-C3C-C2C	-2.24	103.37	106.89
2	A	405	HEC	C4A-C3A-C2A	-2.23	103.69	106.94
2	A	404	HEC	C4B-C3B-C2B	-2.19	103.70	106.90
2	A	404	HEC	O1A-CGA-CBA	-2.19	116.04	123.08
2	A	404	HEC	O2A-CGA-CBA	2.19	121.07	114.03
2	A	402	HEC	CHC-C4B-C3B	-2.16	121.27	125.33
2	A	403	HEC	O1A-CGA-CBA	-2.16	116.15	123.08
2	A	401	HEC	C3A-C4A-NA	2.14	113.64	109.69
2	A	402	HEC	O1D-CGD-CBD	-2.14	116.21	123.08
2	A	404	HEC	C4A-C3A-C2A	-2.13	103.82	106.94
2	A	404	HEC	C4C-NC-C1C	-2.13	103.26	105.35
2	A	403	HEC	CHB-C4A-NA	2.12	126.73	124.44
2	A	405	HEC	CAA-CBA-CGA	-2.11	109.06	113.60
2	A	404	HEC	CHD-C1D-C2D	-2.10	120.90	126.73
2	A	402	HEC	CHB-C4A-NA	-2.07	122.20	124.44
2	A	403	HEC	O2A-CGA-CBA	2.04	120.59	114.03
2	A	404	HEC	CHA-C1A-NA	-2.01	122.27	124.44

All (5) chirality outliers are listed below:

Mol	Chain	Res	Type	Atom
2	A	401	HEC	NA
2	A	402	HEC	NA
2	A	403	HEC	NA
2	A	404	HEC	NA
2	A	405	HEC	NA

All (33) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	403	HEC	C2C-C3C-CAC-CBC
2	A	401	HEC	C4C-C3C-CAC-CBC
2	A	403	HEC	C4C-C3C-CAC-CBC
2	A	402	HEC	C2B-C3B-CAB-CBB
2	A	401	HEC	C2C-C3C-CAC-CBC
2	A	402	HEC	C4C-C3C-CAC-CBC
2	A	402	HEC	C2C-C3C-CAC-CBC
2	A	403	HEC	C2B-C3B-CAB-CBB
2	A	405	HEC	C2C-C3C-CAC-CBC
2	A	405	HEC	C4C-C3C-CAC-CBC
2	A	402	HEC	C4B-C3B-CAB-CBB
2	A	405	HEC	C2B-C3B-CAB-CBB
2	A	404	HEC	C4C-C3C-CAC-CBC
2	A	401	HEC	C2B-C3B-CAB-CBB
2	A	403	HEC	C4B-C3B-CAB-CBB
2	A	404	HEC	C2B-C3B-CAB-CBB
2	A	405	HEC	C4B-C3B-CAB-CBB
2	A	404	HEC	C2C-C3C-CAC-CBC
2	A	401	HEC	C2A-CAA-CBA-CGA
2	A	405	HEC	CAA-CBA-CGA-O1A
2	A	403	HEC	CAD-CBD-CGD-O2D
2	A	403	HEC	CAD-CBD-CGD-O1D
2	A	405	HEC	CAA-CBA-CGA-O2A
2	A	404	HEC	C4B-C3B-CAB-CBB
2	A	401	HEC	CAD-CBD-CGD-O2D
4	A	407	EDO	O1-C1-C2-O2
2	A	401	HEC	CAA-CBA-CGA-O1A
2	A	404	HEC	CAA-CBA-CGA-O1A
2	A	401	HEC	CAD-CBD-CGD-O1D
4	A	409	EDO	O1-C1-C2-O2
2	A	404	HEC	CAA-CBA-CGA-O2A
2	A	401	HEC	C4B-C3B-CAB-CBB
2	A	401	HEC	CAA-CBA-CGA-O2A

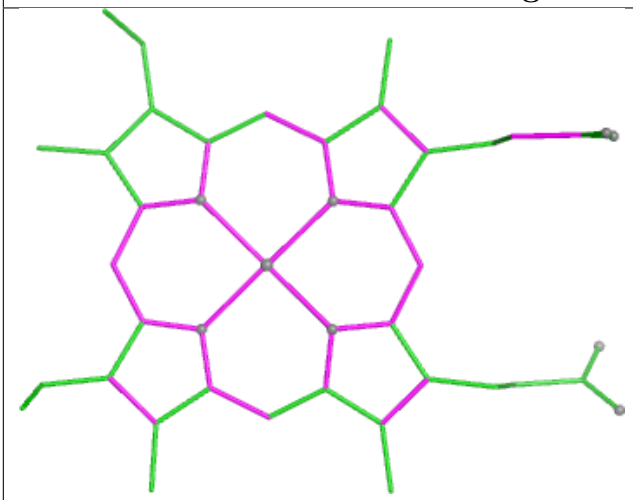
There are no ring outliers.

3 monomers are involved in 4 short contacts:

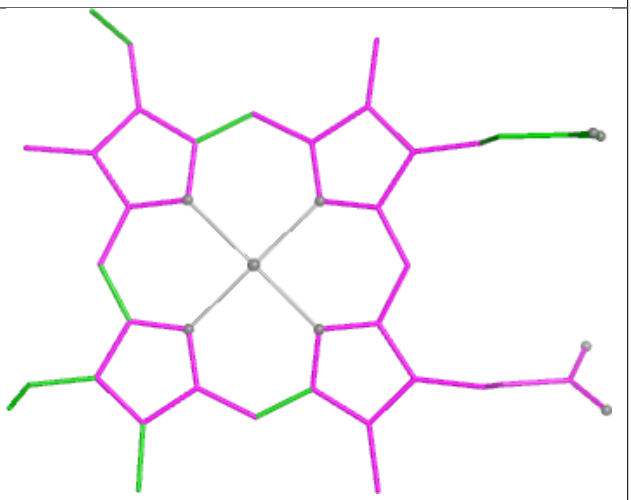
Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	404	HEC	1	0
2	A	402	HEC	2	0
4	A	409	EDO	1	0

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.

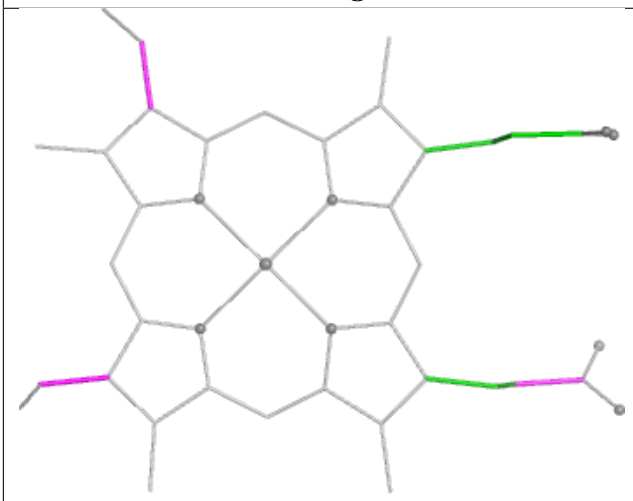
Ligand HEC A 404



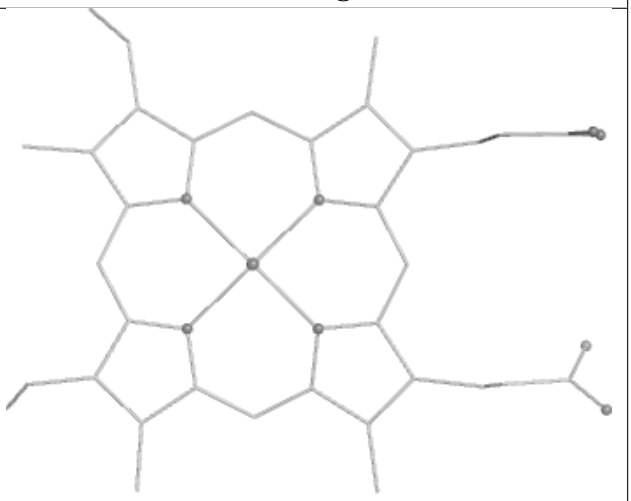
Bond lengths



Bond angles

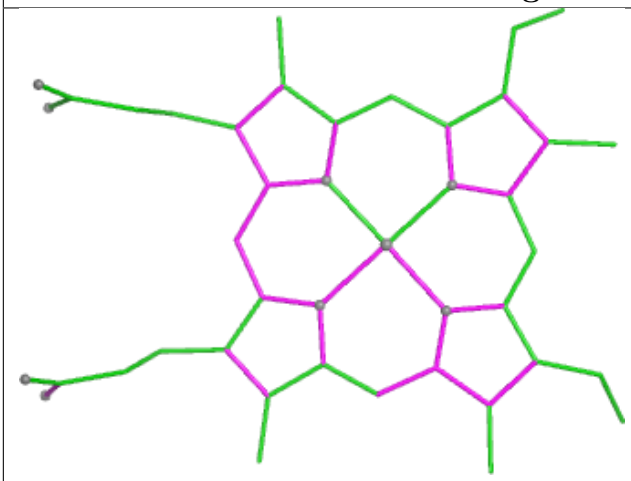


Torsions

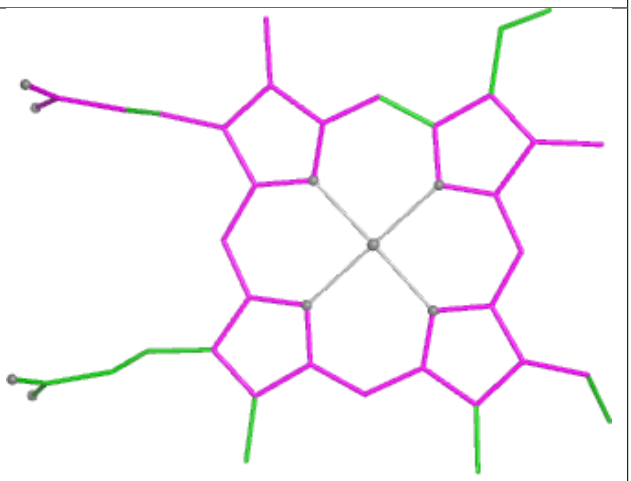


Rings

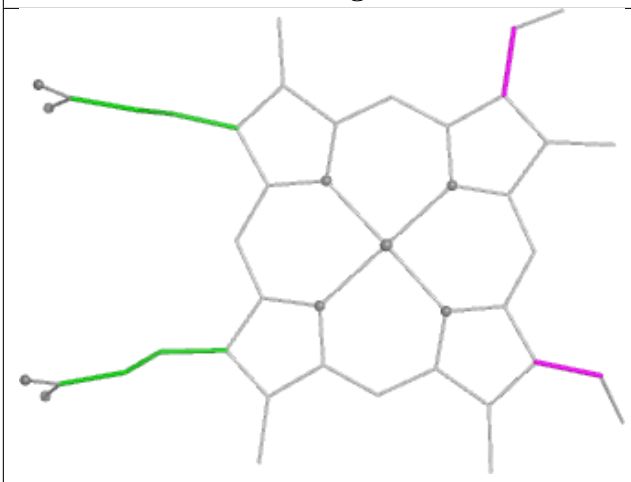
Ligand HEC A 402



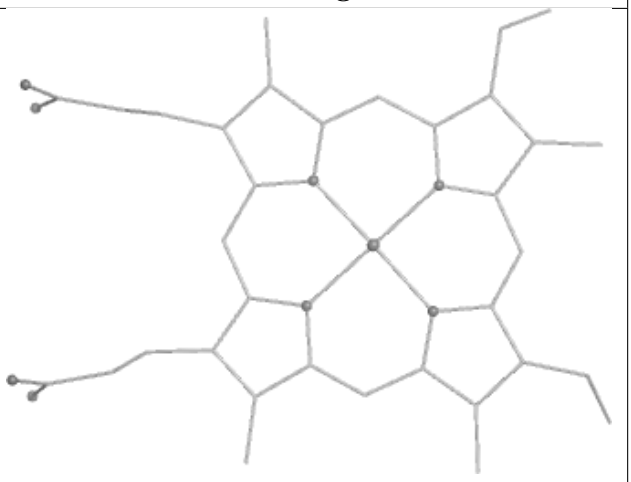
Bond lengths



Bond angles

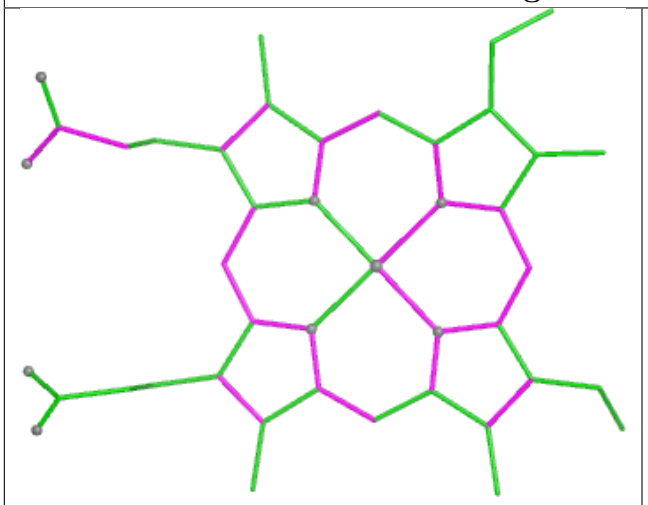


Torsions

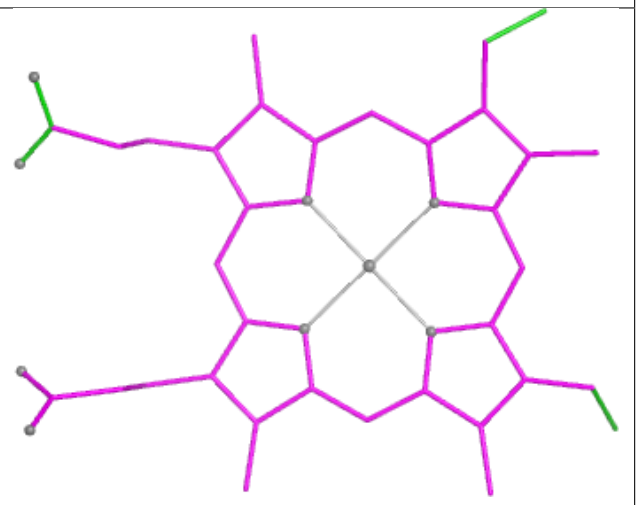


Rings

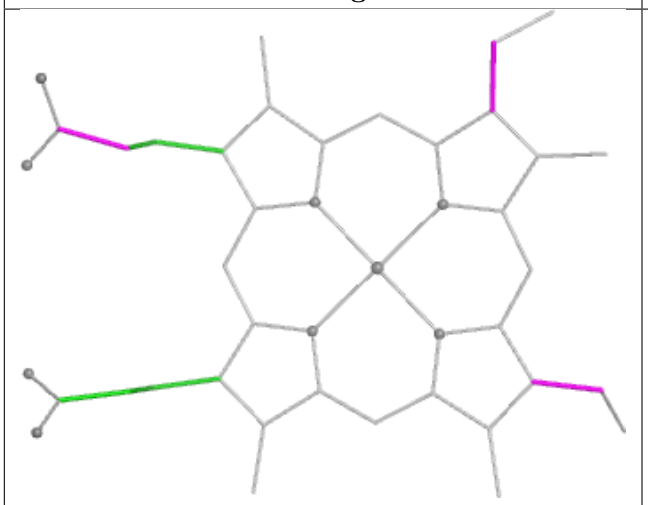
Ligand HEC A 403



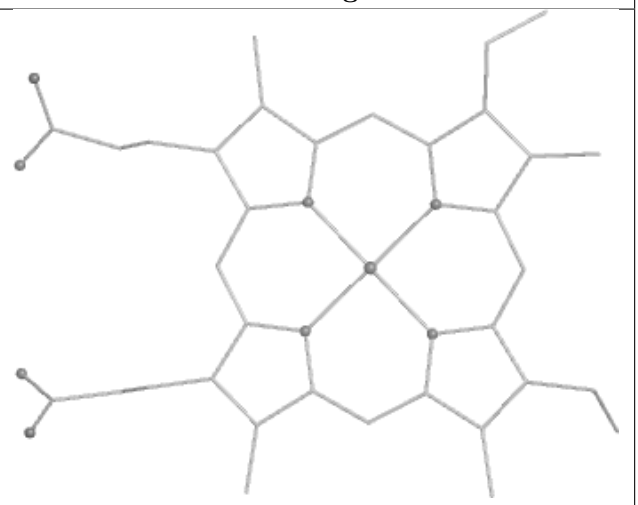
Bond lengths



Bond angles

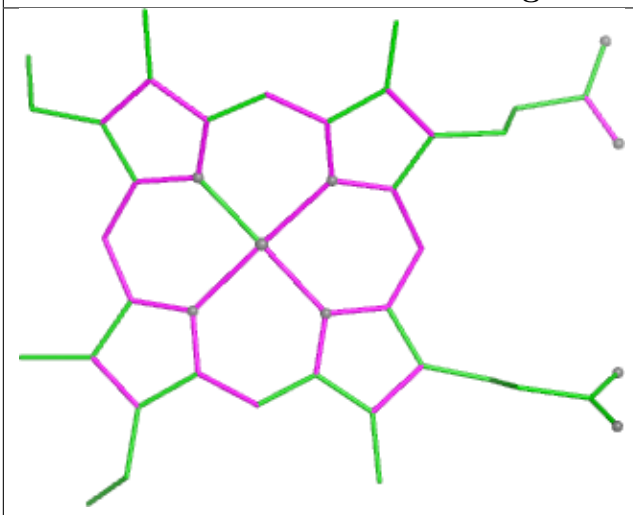


Torsions

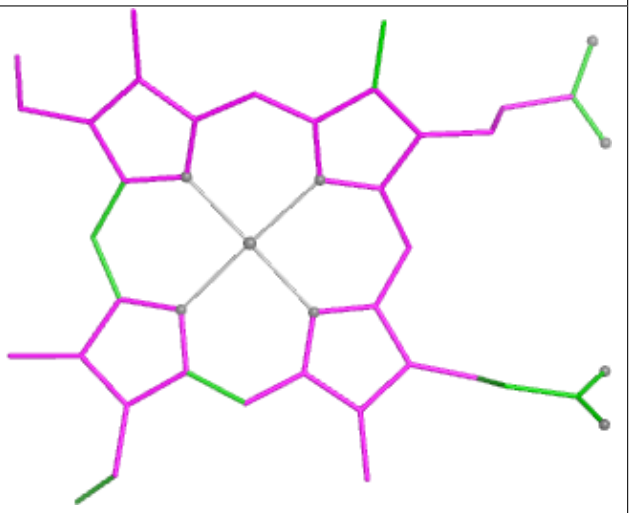


Rings

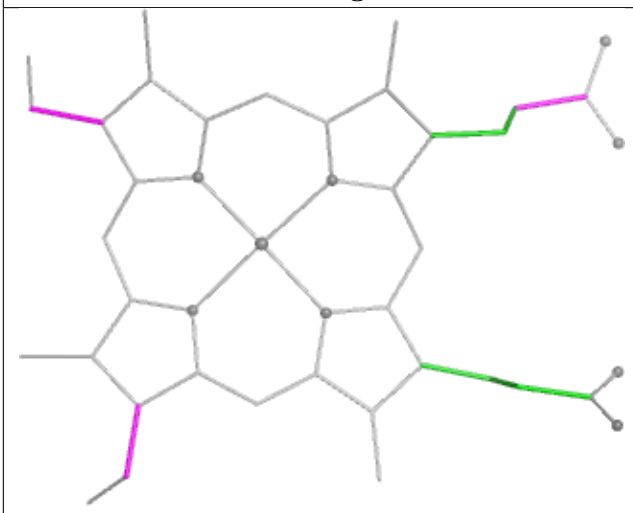
Ligand HEC A 405



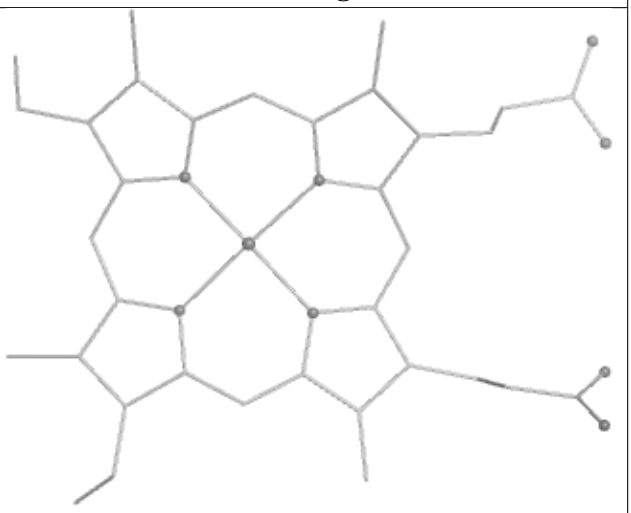
Bond lengths



Bond angles

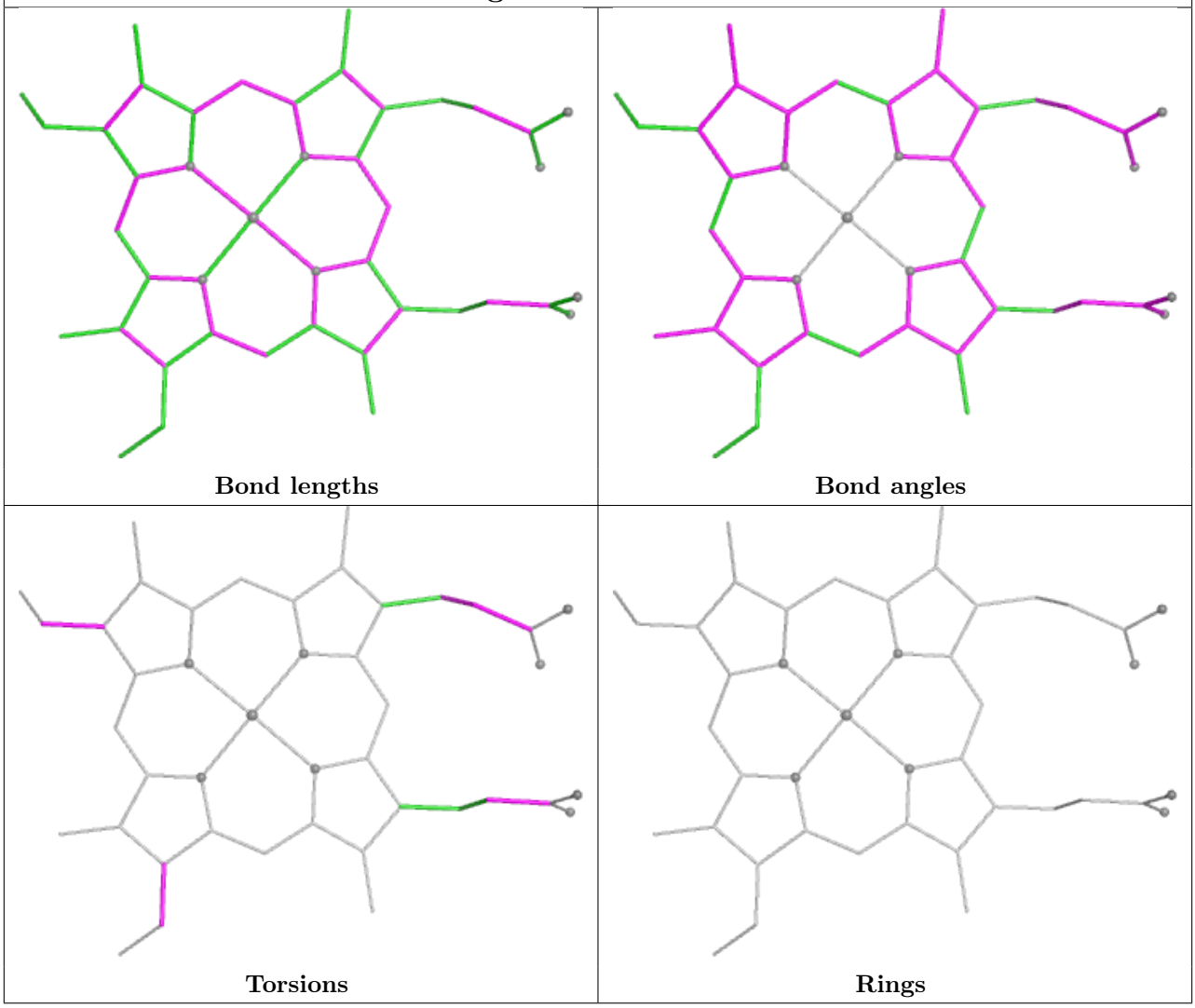


Torsions



Rings

Ligand HEC A 401



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	A	278/323 (86%)	0.35	15 (5%) 31 30	14, 27, 47, 89	2 (0%)

All (15) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	321	ALA	6.5
1	A	61	GLY	6.3
1	A	60	ASN	5.4
1	A	59	GLU	4.8
1	A	44	GLY	4.2
1	A	99	PRO	3.4
1	A	266	MET	3.1
1	A	98	GLY	3.0
1	A	263	GLU	2.9
1	A	151	LYS	2.4
1	A	265	ASP	2.3
1	A	47	GLN	2.1
1	A	317	GLU	2.1
1	A	153	ALA	2.0
1	A	127	ASP	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 oligosaccharides in this entry.

6.4 Ligands (i)

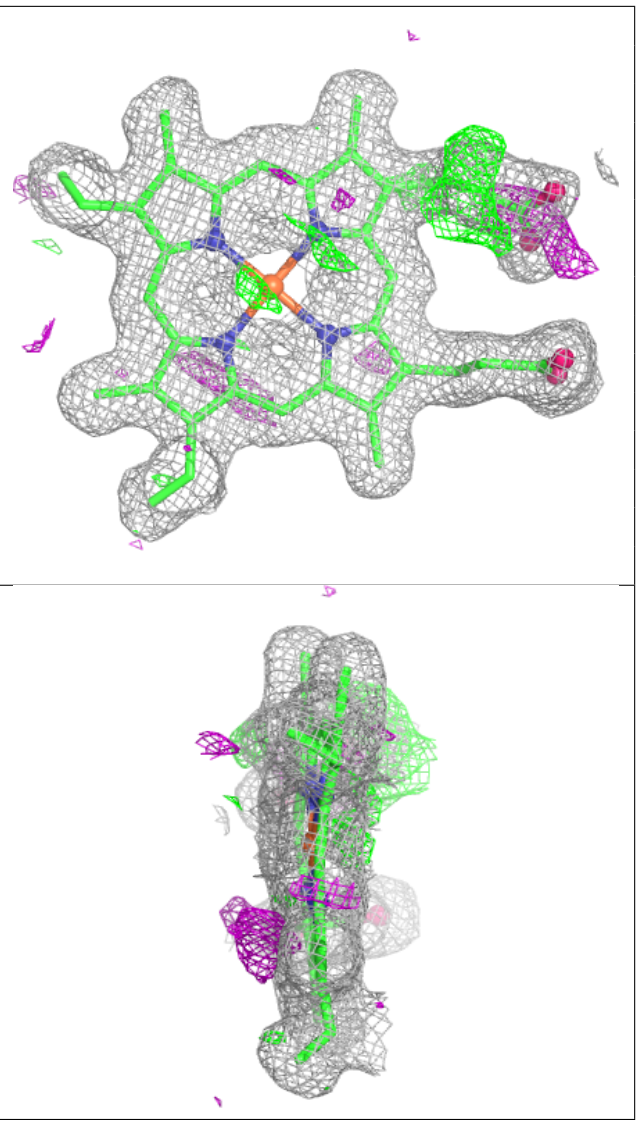
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
4	EDO	A	409	4/4	0.84	0.28	30,38,38,53	0
4	EDO	A	408	4/4	0.89	0.20	29,29,33,38	0
4	EDO	A	407	4/4	0.90	0.13	32,33,34,38	0
3	MG	A	406	1/1	0.97	0.05	17,17,17,17	0
2	HEC	A	401	43/43	0.98	0.07	13,18,27,43	0
2	HEC	A	402	43/43	0.98	0.06	14,17,21,25	0
2	HEC	A	404	43/43	0.98	0.09	16,21,57,61	0
2	HEC	A	405	43/43	0.98	0.08	16,20,34,50	0
2	HEC	A	403	43/43	0.99	0.06	16,22,27,30	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.

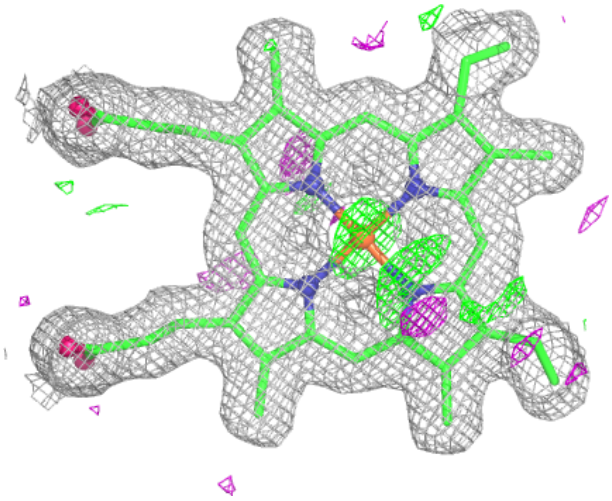
Electron density around HEC A 401:

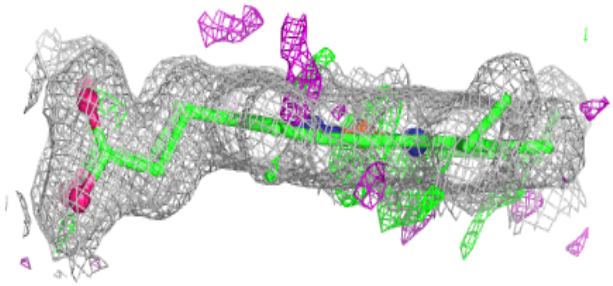
$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

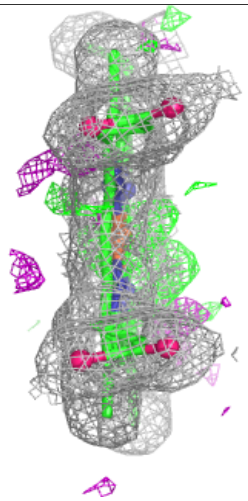


Electron density around HEC A 402:

2mF$_o$-DF$_c$ (at 0.7 rmsd) in gray
mF$_o$-DF$_c$ (at 3 rmsd) in purple (negative)
and green (positive)

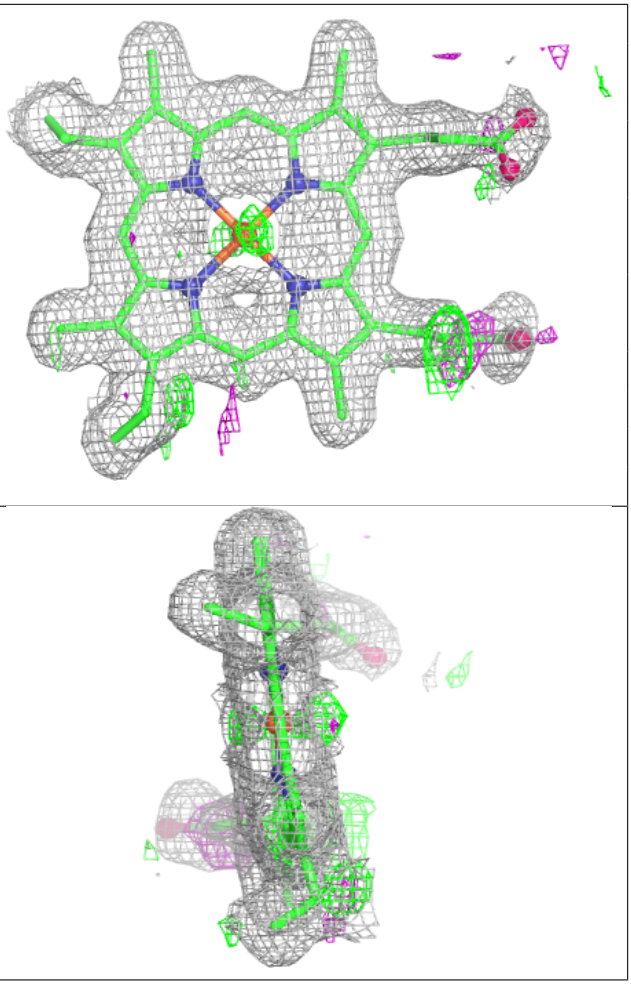






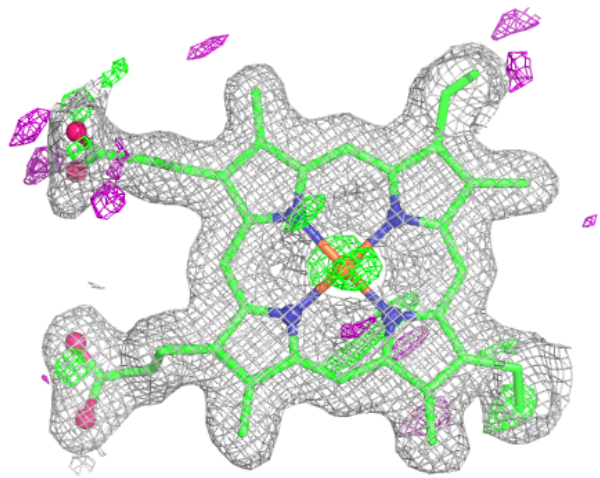
Electron density around HEC A 404:

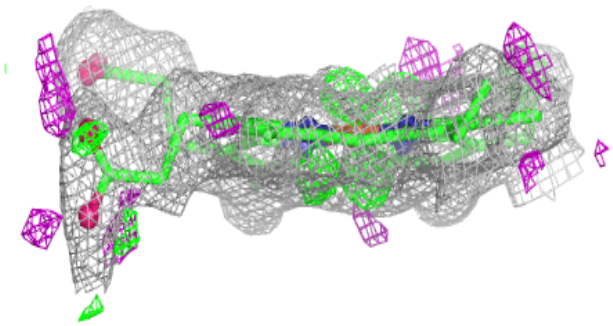
$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)

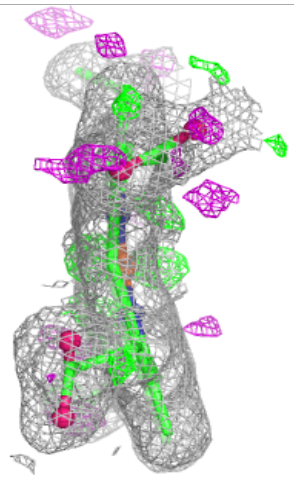


Electron density around HEC A 405:

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

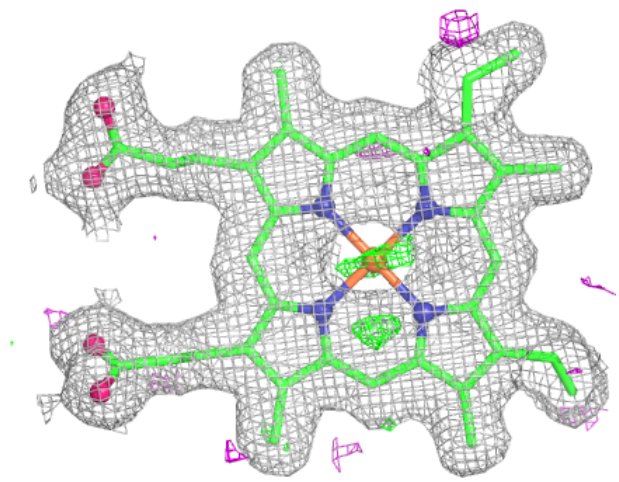


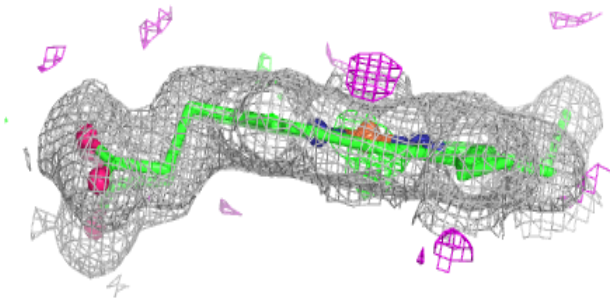


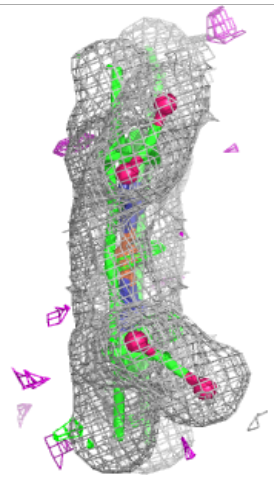


Electron density around HEC A 403:

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 (i)

There are no such residues in this entry.