



Full wwPDB Geometry-Only Validation Report ⓘ

Mar 5, 2026 – 01:41 PM UTC

PDB ID : 2DXM / pdb_00002dxm
Title : Neutron Structure Analysis of Deoxy Human Hemoglobin
Authors : Morimoto, Y.
Deposited on : 2006-08-28
Resolution : 2.10 Å(reported)

This is a Full wwPDB Geometry-Only 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)
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

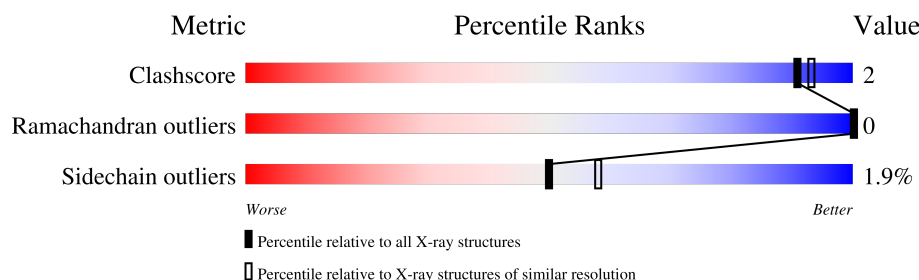
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

NEUTRON DIFFRACTION

The reported resolution of this entry is 2.10 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	7164 (2.10-2.10)
Ramachandran outliers	187476	7099 (2.10-2.10)
Sidechain outliers	187428	7100 (2.10-2.10)

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	141	96% .
1	C	141	98% .
2	B	146	99% .
2	D	146	96% .

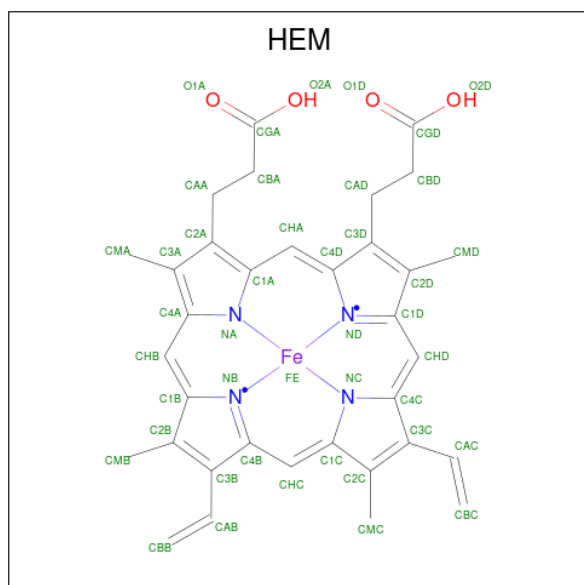
In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 2 is a protein called Hemoglobin subunit beta.

Mol	Chain	Residues	Atoms							ZeroOcc	AltConf	Trace
1	A	141	Total	C	D	H	N	O	S	28	133	0
			2248	685	202	977	187	194	3			
1	C	141	Total	C	D	H	N	O	S	30	133	0
			2237	685	191	977	187	194	3			

Mol	Chain	Residues	Atoms							ZeroOcc	AltConf	Trace
2	B	146	Total 2332	C 724	D 188	H 1021	N 195	O 201	S 3	22	138	0
2	D	146	Total 2332	C 724	D 188	H 1021	N 195	O 201	S 3	19	138	0

- Molecule 3 is PROTOPORPHYRIN IX CONTAINING FE (CCD ID: HEM) (formula: $C_{34}H_{32}FeN_4O_4$).



Mol	Chain	Residues	Atoms						ZeroOcc	AltConf
3	A	1	Total	C	Fe	H	N	O	0	0
			73	34	1	30	4	4		
3	B	1	Total	C	Fe	H	N	O	0	0
			73	34	1	30	4	4		
3	C	1	Total	C	Fe	H	N	O	0	0
			73	34	1	30	4	4		
3	D	1	Total	C	Fe	H	N	O	0	0
			73	34	1	30	4	4		

- Molecule 4 is water.

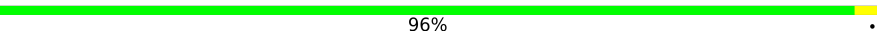
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	53	Total	D	O	0	0
			111	58	53		
4	B	44	Total	D	O	0	0
			80	36	44		
4	C	62	Total	D	O	0	0
			148	86	62		
4	D	42	Total	D	O	0	0
			88	46	42		

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. 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.

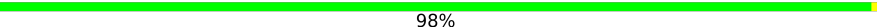
Note EDS was not executed.

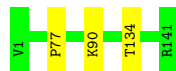
- Molecule 1: Hemoglobin subunit alpha

Chain A:  96%



- Molecule 1: Hemoglobin subunit alpha

Chain C:  98%

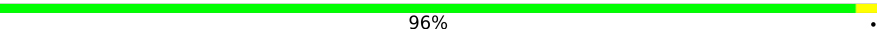


- Molecule 2: Hemoglobin subunit beta

Chain B:  99%



- Molecule 2: Hemoglobin subunit beta

Chain D:  96%



4 Model quality

4.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: DOD, 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	0.47	0/2131	0.87	2/2895 (0.1%)
1	C	0.46	0/2131	0.89	0/2895
2	B	0.48	0/2243	0.91	0/3044
2	D	0.46	0/2243	0.96	6/3044 (0.2%)
All	All	0.47	0/8748	0.91	8/11878 (0.1%)

There are no bond length outliers.

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	D	35[A]	TYR	CA-C-N	6.57	127.09	119.47
2	D	35[A]	TYR	C-N-CA	6.57	127.09	119.47
2	D	35[B]	TYR	CA-C-N	6.57	127.09	119.47
2	D	35[B]	TYR	C-N-CA	6.57	127.09	119.47
2	D	18[A]	VAL	N-CA-C	5.21	116.09	108.58
2	D	18[B]	VAL	N-CA-C	5.21	116.09	108.58
1	A	47[A]	ASP	N-CA-C	-5.07	100.24	108.41
1	A	47[B]	ASP	N-CA-C	-5.07	100.24	108.41

There are no chirality outliers.

There are no planarity outliers.

4.2 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	1271	977	60	3	0
1	C	1260	977	60	1	0
2	B	1311	1021	60	1	0
2	D	1311	1021	60	1	0
3	A	43	30	30	0	0
3	B	43	30	30	0	0
3	C	43	30	30	0	0
3	D	43	30	30	0	0
4	A	111	0	0	1	0
4	B	80	0	0	3	0
4	C	148	0	0	3	0
4	D	88	0	0	0	0
All	All	5752	4116	360	12	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 2.

All (12) 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:77:PRO:O	4:A:183:DOD:O	2.03	0.75

There are no symmetry-related clashes.

4.3 Torsion angles [i](#)

4.3.1 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	271/141 (192%)	265 (98%)	6 (2%)	0	100	100
1	C	271/141 (192%)	264 (97%)	7 (3%)	0	100	100
2	B	281/146 (192%)	275 (98%)	6 (2%)	0	100	100
2	D	281/146 (192%)	275 (98%)	6 (2%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
All	All	1104/574 (192%)	1079 (98%)	25 (2%)	0	100	100

There are no Ramachandran outliers to report.

4.3.2 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	218/113 (193%)	213 (98%)	5 (2%)	44	51
1	C	218/113 (193%)	214 (98%)	4 (2%)	51	60
2	B	228/118 (193%)	226 (99%)	2 (1%)	70	78
2	D	228/118 (193%)	222 (97%)	6 (3%)	40	46
All	All	892/462 (193%)	875 (98%)	17 (2%)	50	58

All (17) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	1	VAL
1	A	2[A]	LEU
1	A	2[B]	LEU
1	A	16[A]	LYS
1	A	16[B]	LYS
2	B	68[A]	LEU
2	B	68[B]	LEU
1	C	90[A]	LYS
1	C	90[B]	LYS
1	C	134[A]	THR
1	C	134[B]	THR
2	D	6[A]	GLU
2	D	6[B]	GLU
2	D	26[A]	GLU
2	D	26[B]	GLU
2	D	75[A]	LEU
2	D	75[B]	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. There are no such sidechains identified.

4.3.3 RNA ⓘ

There are no RNA molecules in this entry.

4.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

4.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

4.6 Ligand geometry ⓘ

4 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	HEM	A	142	1	50,50,50	1.34	7 (14%)	67,82,82	1.17	4 (5%)
3	HEM	B	147	2	50,50,50	1.31	6 (12%)	67,82,82	1.14	3 (4%)
3	HEM	C	142	1	50,50,50	1.35	7 (14%)	67,82,82	0.89	1 (1%)
3	HEM	D	147	2	50,50,50	1.32	5 (10%)	67,82,82	1.17	5 (7%)

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	HEM	A	142	1	-	8/14/54/54	-

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
3	HEM	B	147	2	-	0/14/54/54	-
3	HEM	C	142	1	-	5/14/54/54	-
3	HEM	D	147	2	-	1/14/54/54	-

All (25) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	D	147	HEM	CAC-C3C	-3.53	1.38	1.47
3	B	147	HEM	CBB-CAB	3.42	1.46	1.30
3	B	147	HEM	CBC-CAC	3.41	1.46	1.30
3	C	142	HEM	CBB-CAB	3.34	1.46	1.30
3	C	142	HEM	CAB-C3B	-3.27	1.38	1.47
3	A	142	HEM	CBB-CAB	3.25	1.46	1.30
3	D	147	HEM	CBC-CAC	3.16	1.45	1.30
3	D	147	HEM	CAB-C3B	-3.14	1.39	1.47
3	A	142	HEM	CAC-C3C	-3.13	1.39	1.47
3	B	147	HEM	CAB-C3B	-3.06	1.39	1.47
3	A	142	HEM	CAB-C3B	-3.04	1.39	1.47
3	D	147	HEM	CBB-CAB	2.95	1.44	1.30
3	C	142	HEM	CAC-C3C	-2.92	1.39	1.47
3	A	142	HEM	CBC-CAC	2.82	1.43	1.30
3	C	142	HEM	CBC-CAC	2.78	1.43	1.30
3	B	147	HEM	FE-NC	2.67	2.04	1.95
3	B	147	HEM	CAC-C3C	-2.60	1.40	1.47
3	B	147	HEM	FE-ND	2.58	2.02	1.94
3	C	142	HEM	FE-ND	2.55	2.02	1.94
3	D	147	HEM	C4D-C3D	2.32	1.49	1.45
3	C	142	HEM	FE-NA	2.28	2.02	1.95
3	C	142	HEM	CMB-C2B	2.09	1.55	1.50
3	A	142	HEM	FE-NA	2.09	2.02	1.95
3	A	142	HEM	FE-ND	2.07	2.01	1.94
3	A	142	HEM	C4A-C3A	2.04	1.47	1.43

All (13) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	142	HEM	C3B-C4B-NB	4.23	112.50	109.47
3	D	147	HEM	CAD-C3D-C4D	3.56	130.90	124.70
3	B	147	HEM	CBB-CAB-C3B	3.36	144.32	127.53
3	B	147	HEM	C3B-C4B-NB	3.11	111.70	109.47
3	D	147	HEM	C3B-C4B-NB	2.94	111.58	109.47
3	B	147	HEM	CBC-CAC-C3C	2.85	141.78	127.53

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	D	147	HEM	CBC-CAC-C3C	2.48	139.91	127.53
3	C	142	HEM	C3B-C4B-NB	2.33	111.14	109.47
3	A	142	HEM	C2B-C1B-NB	2.31	112.49	109.84
3	D	147	HEM	CAD-C3D-C2D	-2.22	123.71	127.87
3	D	147	HEM	CHD-C1D-C2D	-2.09	121.73	125.03
3	A	142	HEM	CAA-C2A-C1A	2.08	128.99	124.94
3	A	142	HEM	C4B-C3B-C2B	-2.03	105.41	107.28

There are no chirality outliers.

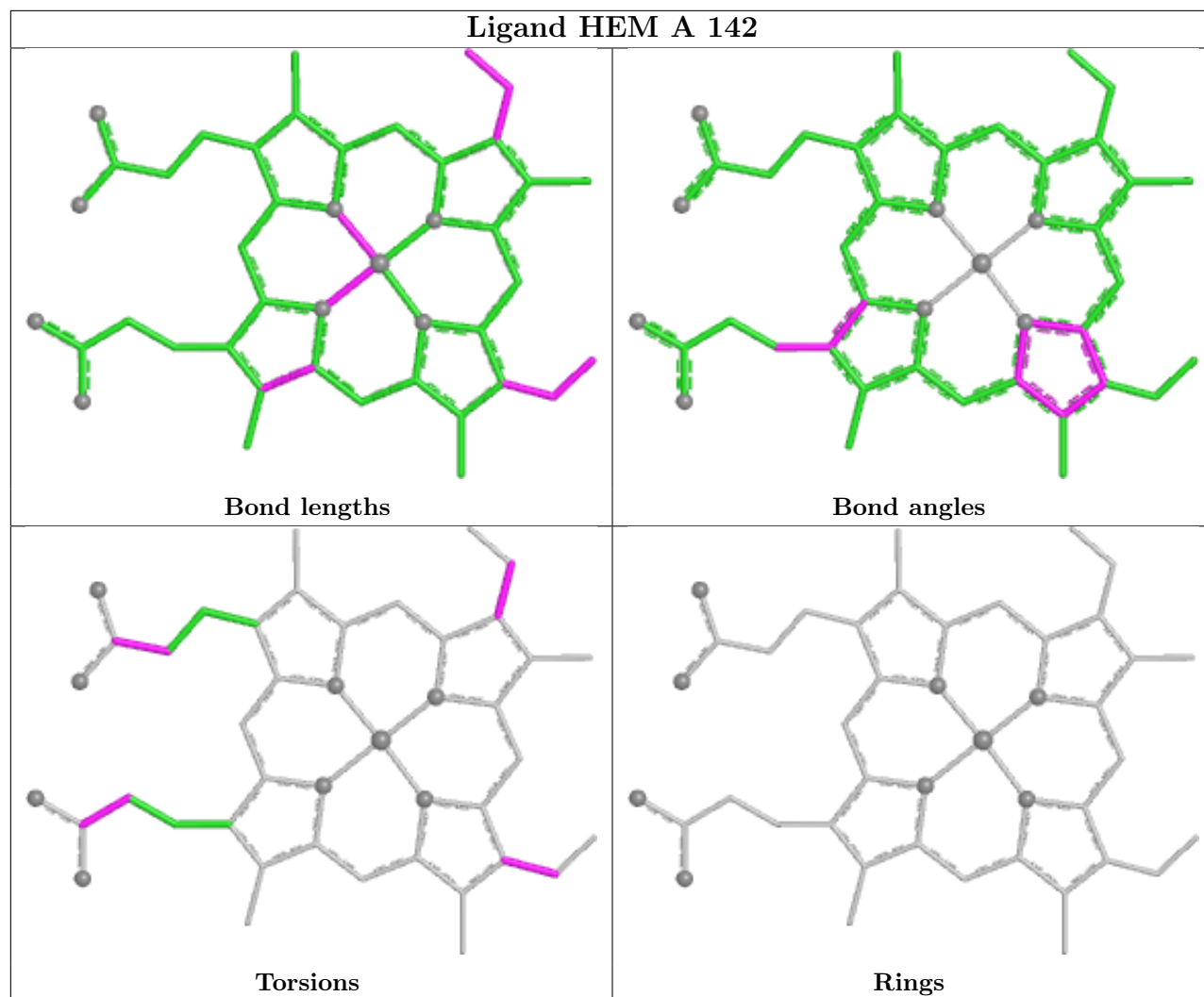
All (14) torsion outliers are listed below:

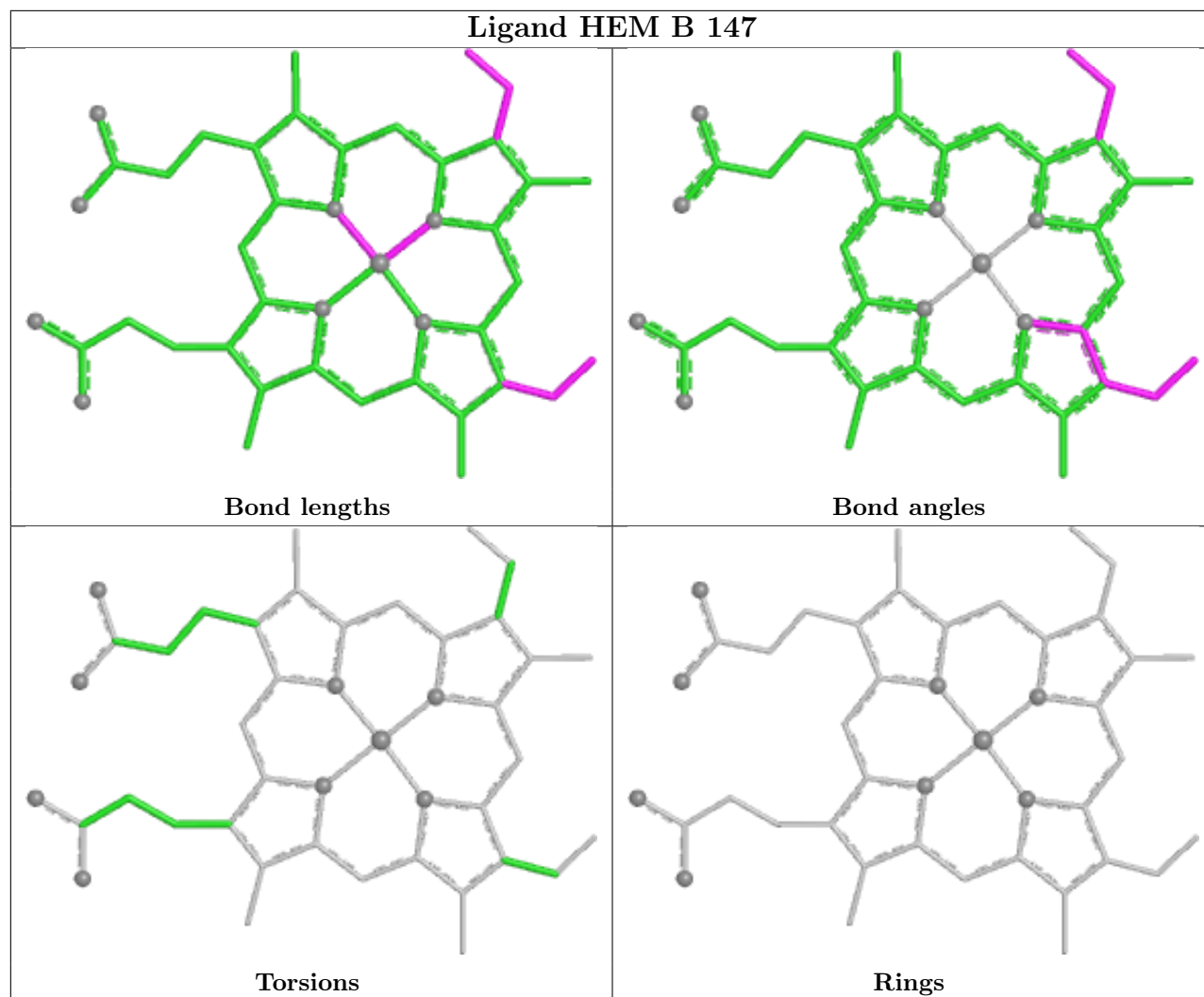
Mol	Chain	Res	Type	Atoms
3	A	142	HEM	C2C-C3C-CAC-CBC
3	A	142	HEM	C4C-C3C-CAC-CBC
3	A	142	HEM	C4B-C3B-CAB-CBB
3	A	142	HEM	CAA-CBA-CGA-O2A
3	A	142	HEM	CAA-CBA-CGA-O1A
3	A	142	HEM	CAD-CBD-CGD-O1D
3	A	142	HEM	CAD-CBD-CGD-O2D
3	A	142	HEM	C2B-C3B-CAB-CBB
3	C	142	HEM	CAA-CBA-CGA-O2A
3	C	142	HEM	CAA-CBA-CGA-O1A
3	C	142	HEM	CAD-CBD-CGD-O2D
3	C	142	HEM	CAD-CBD-CGD-O1D
3	C	142	HEM	C2B-C3B-CAB-CBB
3	D	147	HEM	CAD-CBD-CGD-O2D

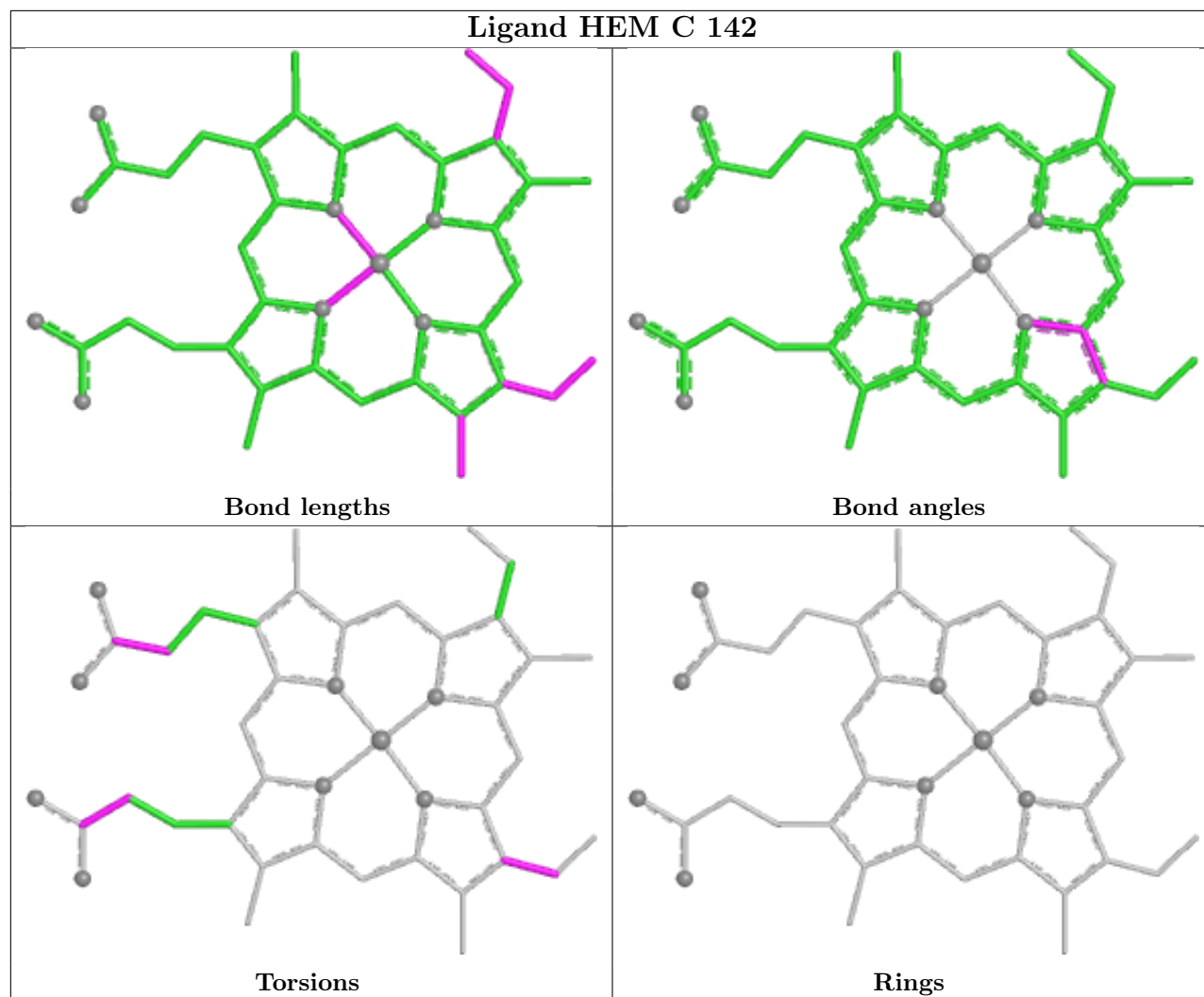
There are no ring outliers.

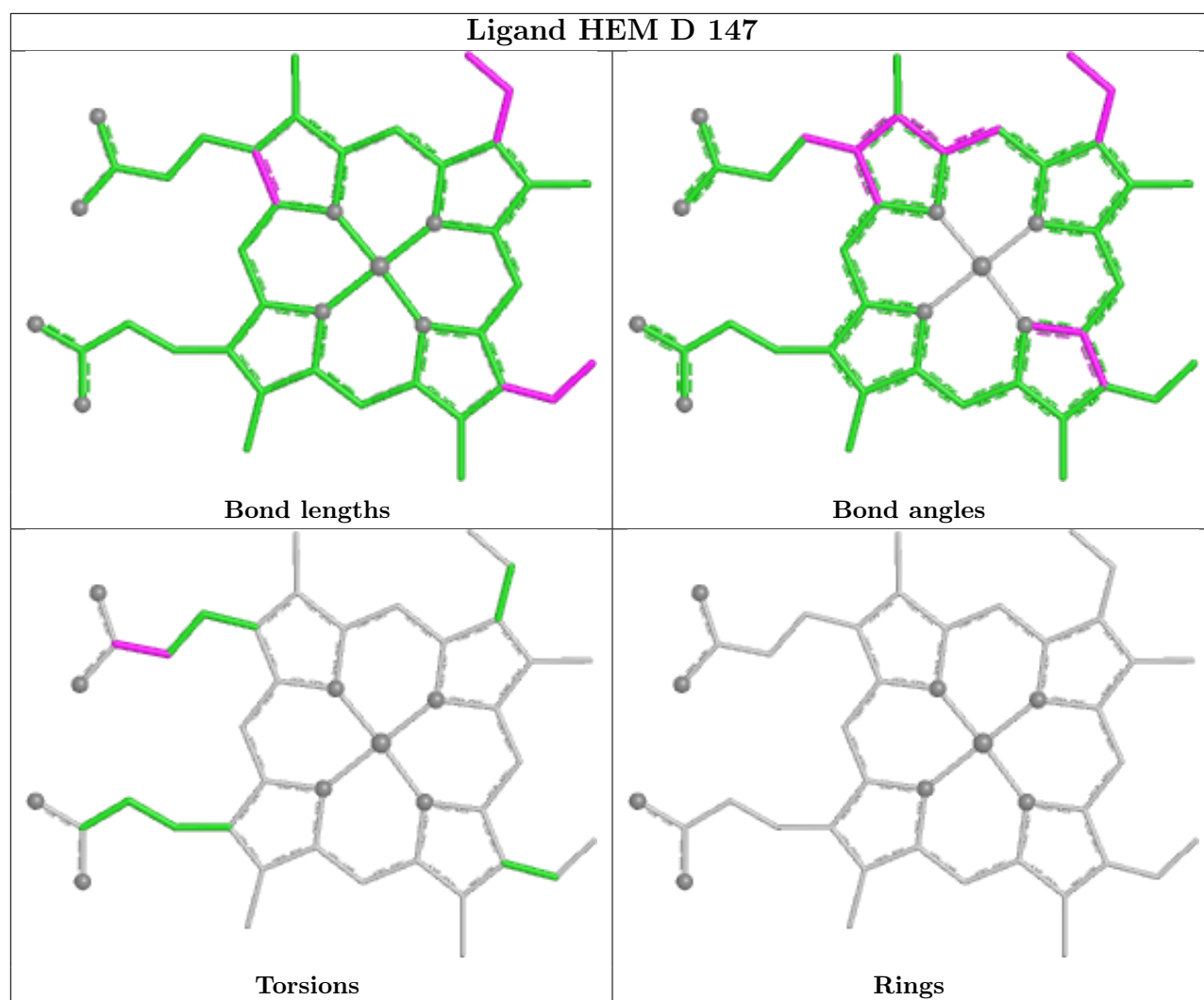
No monomer is involved in short contacts.

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.









4.7 Other polymers [i](#)

There are no such residues in this entry.

4.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.