wwPDB NMR Structure Validation Summary Report (i)

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PDB ID	:	2MHM
Title	:	Solution structure of cytochrome c Y67H
Authors	:	Lan, W.X.; Wang, Z.H.; Yang, Z.Z.; Ying, T.L.; Wu, H.M.; Tan, X.S.; Cao, C.Y.; Huang, Z.X.
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This is a wwPDB NMR Structure Validation Summary Report for a publicly released PDB entry.
We welcome your comments at validation@mail.wwpdb.org
A user guide is available at
http://wwpdb.org/validation/2016/NMRValidationReportHelp
with specific help available everywhere you see the (i) symbol.

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

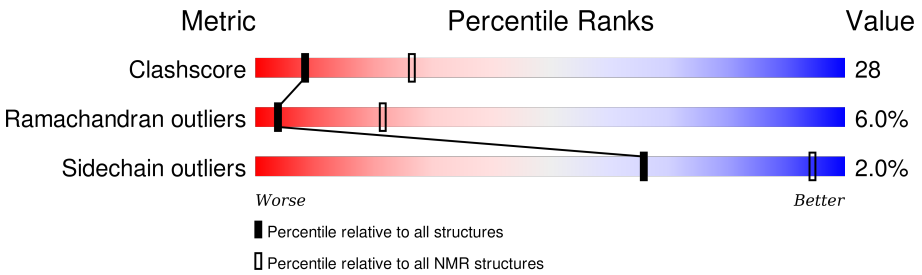
Cyrange	:	Kirchner and Güntert (2011)
NmrClust	:	Kelley et al. (1996)
MolProbity	:	4.02b-467
Mogul	:	1.7.1 (RC1), CSD as537be (2016)
Percentile statistics	:	20151230.v01 (using entries in the PDB archive December 30th 2015)
RCI	:	v_1n_11_5_13_A (Berjanski et al., 2005)
PANAV	:	Wang et al. (2010)
ShiftChecker	:	rb-20027457
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	rb-20027457

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
SOLUTION NMR

The overall completeness of chemical shifts assignment is 42%.

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)	NMR archive (#Entries)
Clashscore	114402	11133
Ramachandran outliers	111179	9975
Sidechain outliers	111093	9958

The table below summarises the geometric issues observed across the polymeric chains and their fit to the experimental data. The red, orange, yellow and green segments indicate the fraction of residues that contain outliers for >=3, 2, 1 and 0 types of geometric quality criteria. A cyan segment indicates the fraction of residues that are not part of the well-defined cores, and 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%

Mol	Chain	Length	Quality of chain
1	A	108	

2 Ensemble composition and analysis (i)

This entry contains 20 models. Model 14 is the overall representative, medoid model (most similar to other models). The authors have identified model 1 as representative, based on the following criterion: *lowest energy*.

The following residues are included in the computation of the global validation metrics.

Well-defined (core) protein residues			
Well-defined core	**Residue range (total)**	**Backbone RMSD (Å)**	**Medoid model**
1	A:-3-A:-1, A:1-A:101 (104)	0.46	14

Ill-defined regions of proteins are excluded from the global statistics.

Ligands and non-protein polymers are included in the analysis.

NmrClust was unable to cluster the ensemble.

Error message: 1 Unexpected character

3 Entry composition (i)

There are 2 unique types of molecules in this entry. The entry contains 1761 atoms, of which 877 are hydrogens and 0 are deuteriums.

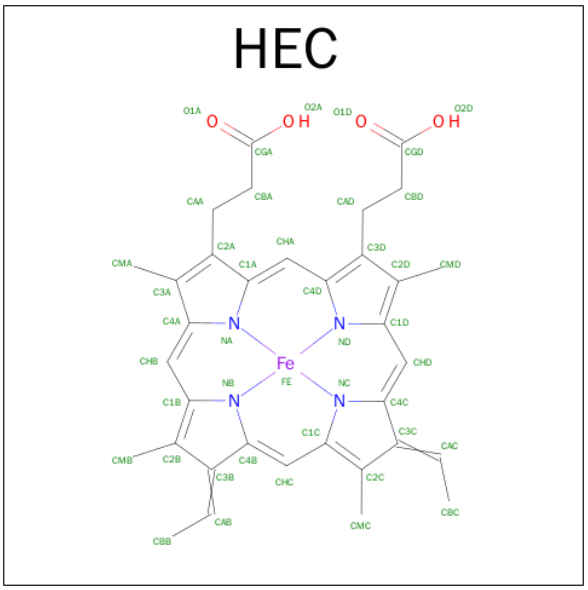
- Molecule 1 is a protein called Cytochrome c iso-1.

Mol	Chain	Residues	Atoms						Trace
			Total	C	H	N	O	S	
1	A	108	1686	529	845	152	156	4	0

There are 3 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	67	HIS	TYR	ENGINEERED MUTATION	UNP P00044
A	72	ALA	LYS	CONFLICT	UNP P00044
A	102	THR	CYS	CONFLICT	UNP P00044

- Molecule 2 is HEME C (three-letter code: HEC) (formula: $C_{34}H_{34}FeN_4O_4$).



Mol	Chain	Residues	Atoms					
			Total	C	Fe	H	N	O
2	A	1	75	34	1	32	4	4

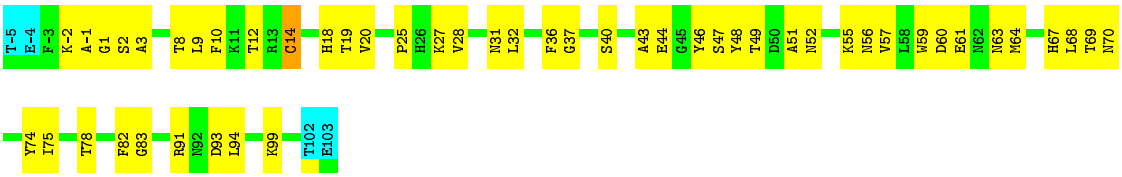
4 Residue-property plots (i)

4.1 Average score per residue in the NMR ensemble

These plots are provided for all protein, RNA and DNA chains in the entry. The first graphic is the same as shown in the summary in section 1 of this report. The second graphic shows the sequence where residues are colour-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 outliers are shown as green connectors. Residues which are classified as ill-defined in the NMR ensemble, are shown in cyan with an underline colour-coded according to the previous scheme. Residues which were present in the experimental sample, but not modelled in the final structure are shown in grey.

- Molecule 1: Cytochrome c iso-1

Chain A:

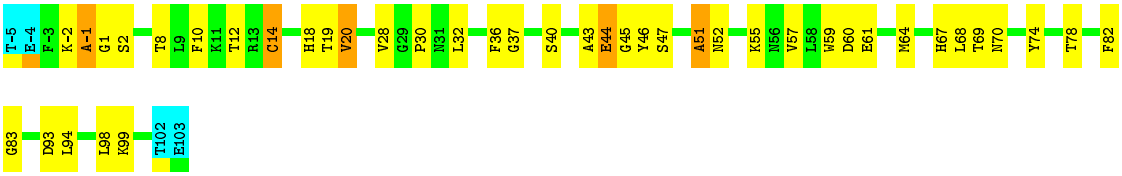


4.2 Residue scores for the representative (medoid) model from the NMR ensemble

The representative model is number 14. Colouring as in section 4.1 above.

- Molecule 1: Cytochrome c iso-1

Chain A:



5 Refinement protocol and experimental data overview (i)

The models were refined using the following method: *simulated annealing*.

Of the 100 calculated structures, 20 were deposited, based on the following criterion: *structures with the lowest energy*.

The following table shows the software used for structure solution, optimisation and refinement.

Software name	Classification	Version
CNS	refinement	
x-plor	refinement	

The following table shows chemical shift validation statistics as aggregates over all chemical shift files. Detailed validation can be found in section 7 of this report.

Chemical shift file(s)	2mhm_cs.str
Number of chemical shift lists	1
Total number of shifts	667
Number of shifts mapped to atoms	667
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Assignment completeness (well-defined parts)	42%

No validations of the models with respect to experimental NMR restraints is performed at this time.

6 Model quality (i)

6.1 Standard geometry (i)

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

There are no covalent bond-length or bond-angle outliers.

There are no bond-length outliers.

There are no bond-angle outliers.

There are no chirality outliers.

There are no planarity outliers.

6.2 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 each 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 averaged over the ensemble.

Mol	Chain	Non-H	H(model)	H(added)	Clashes
1	A	809	817	813	46±7
2	A	43	32	30	5±1
All	All	17040	16980	16860	952

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 28.

5 of 328 unique clashes are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Clash(Å)	Distance(Å)	Models	
				Worst	Total
1:A:8:THR:O	1:A:12:THR:HG23	0.83	1.73	5	19
1:A:57:VAL:HG11	1:A:74:TYR:OH	0.82	1.74	11	20
1:A:39:HIS:CE1	1:A:58:LEU:HD13	0.80	2.11	16	1
1:A:32:LEU:N	1:A:32:LEU:HD12	0.80	1.92	4	9
1:A:57:VAL:HG21	1:A:74:TYR:OH	0.76	1.81	7	7

6.3 Torsion angles (i)

6.3.1 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 PDB entries followed by that with respect to all NMR entries. 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	104/108 (96%)	92±2 (88±2%)	6±1 (6±1%)	6±2 (6±2%)	4 21
All	All	2080/2160 (96%)	1839 (88%)	117 (6%)	124 (6%)	4 21

5 of 29 unique Ramachandran outliers are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	14	CYS	20
1	A	-1	ALA	14
1	A	20	VAL	13
1	A	51	ALA	12
1	A	44	GLU	11

6.3.2 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 PDB entries followed by that with respect to all NMR entries. 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	84/88 (95%)	82±1 (98±1%)	2±1 (2±1%)	66 94
All	All	1680/1760 (95%)	1647 (98%)	33 (2%)	66 94

5 of 13 unique residues with a non-rotameric sidechain are listed below. They are sorted by the frequency of occurrence in the ensemble.

Mol	Chain	Res	Type	Models (Total)
1	A	56	ASN	11
1	A	62	ASN	4
1	A	70	ASN	3
1	A	9	LEU	3
1	A	80	MET	2

6.3.3 RNA (i)

There are no RNA molecules in this entry.

6.4 Non-standard residues in protein, DNA, RNA chains (i)

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

6.5 Carbohydrates (i)

There are no carbohydrates in this entry.

6.6 Ligand geometry (i)

1 ligand is modelled in this entry.

In the following table, the Counts columns list the number of bonds for which Mogul statistics could be retrieved, the number of bonds that are observed in the model and the number of bonds 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 is the number of standard deviations the observed value is removed from the expected value. A bond length with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond lengths.

Mol	Type	Chain	Res	Link	Bond lengths		
					Counts	RMSZ	#Z>2
2	HEC	A	201	1	24,50,50	1.59±0.02	1±0 (2±1%)

In the following table, the Counts columns list the number of angles for which Mogul statistics could be retrieved, the number of angles that are observed in the model and the number of 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 angle is the number of standard deviations the observed value is removed from the expected value. A bond angle with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the average root-mean-square of all Z scores of the bond angles.

Mol	Type	Chain	Res	Link	Bond angles		
					Counts	RMSZ	#Z>2
2	HEC	A	201	1	19,82,82	2.19±0.01	2±0 (10±0%)

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	201	1	-	0±0,6,54,54	0±0,0,8,8

All unique bond outliers are listed below.

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)	Models	
								Worst	Total
2	A	201	HEC	C3C-C2C	5.20	1.35	1.40	17	13

All unique angle outliers are listed below. They are sorted according to the Z-score of the worst occurrence in the ensemble.

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})	Models	
								Worst	Total
2	A	201	HEC	CBC-CAC-C3C	6.59	112.94	127.34	7	20
2	A	201	HEC	CBB-CAB-C3B	6.08	114.06	127.34	2	20

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

6.7 Other polymers (i)

There are no such molecules in this entry.

6.8 Polymer linkage issues (i)

There are no chain breaks in this entry.

7 Chemical shift validation (i)

The completeness of assignment taking into account all chemical shift lists is 42% for the well-defined parts and 42% for the entire structure.

7.1 Chemical shift list 1

File name: 2mhm_cs.str

Chemical shift list name: *assigned_chem_shift_list_1*

7.1.1 Bookkeeping (i)

The following table shows the results of parsing the chemical shift list and reports the number of nuclei with statistically unusual chemical shifts.

Total number of shifts	667
Number of shifts mapped to atoms	667
Number of unparsed shifts	0
Number of shifts with mapping errors	0
Number of shifts with mapping warnings	0
Number of shift outliers (ShiftChecker)	34

7.1.2 Chemical shift referencing (i)

No chemical shift referencing corrections were calculated (not enough data).

7.1.3 Completeness of resonance assignments (i)

The following table shows the completeness of the chemical shift assignments for the well-defined regions of the structure. The overall completeness is 42%, i.e. 542 atoms were assigned a chemical shift out of a possible 1282. 0 out of 11 assigned methyl groups (LEU and VAL) were assigned stereospecifically.

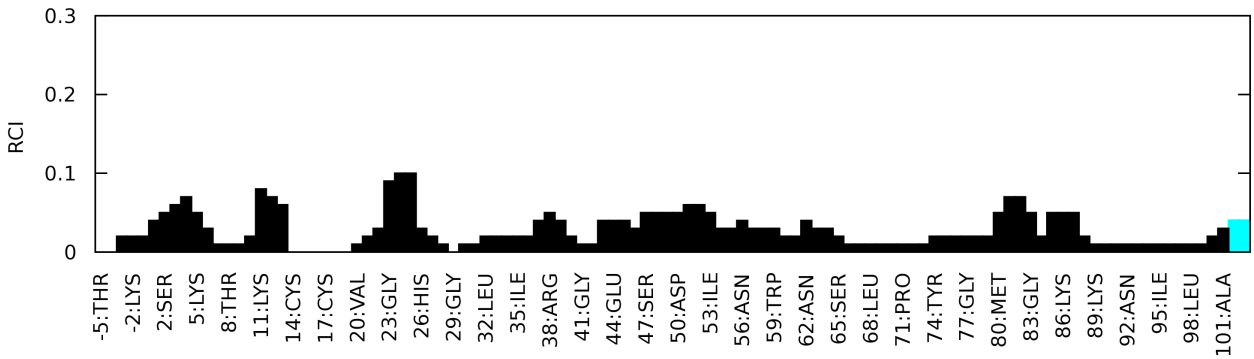
	Total	**^{1}H**	**^{13}C**	**^{15}N**
Backbone	195/512 (38%)	195/204 (96%)	0/208 (0%)	0/100 (0%)
Sidechain	299/651 (46%)	299/386 (77%)	0/232 (0%)	0/33 (0%)
Aromatic	48/119 (40%)	48/62 (77%)	0/47 (0%)	0/10 (0%)
Overall	542/1282 (42%)	542/652 (83%)	0/487 (0%)	0/143 (0%)

7.1.4 Statistically unusual chemical shifts (i)

The following table lists the statistically unusual chemical shifts. These are statistical measures, and large deviations from the mean do not necessarily imply incorrect assignments. Molecules containing paramagnetic centres or hemes are expected to give rise to anomalous chemical shifts.

Mol	Chain	Res	Type	Atom	Shift, *ppm*	Expected range, *ppm*	Z-score
1	A	80	MET	HB2	-27.31	3.73 – 0.33	-86.3
1	A	80	MET	HB3	-27.31	3.70 – 0.30	-86.2
1	A	18	HIS	HB2	15.55	4.91 – 1.31	34.6
1	A	29	GLY	HA3	-3.07	5.80 – 2.00	-18.3
1	A	30	PRO	HD3	-1.61	5.52 – 1.72	-13.8
1	A	18	HIS	HB3	8.37	5.00 – 1.10	13.6
1	A	68	LEU	HD13	-3.04	2.16 – -0.64	-13.6
1	A	68	LEU	HD11	-3.04	2.16 – -0.64	-13.6
1	A	68	LEU	HD12	-3.04	2.16 – -0.64	-13.6
1	A	46	TYR	HE1	3.69	7.86 – 5.56	-13.1
1	A	29	GLY	HA2	-0.49	5.87 – 2.07	-11.7
1	A	18	HIS	HA	8.84	6.81 – 2.41	9.6
1	A	71	PRO	HB2	5.38	3.82 – 0.32	9.5
1	A	78	THR	HG21	3.14	2.29 – -0.01	8.7
1	A	78	THR	HG22	3.14	2.29 – -0.01	8.7
1	A	78	THR	HG23	3.14	2.29 – -0.01	8.7
1	A	30	PRO	HG2	-0.71	3.48 – 0.38	-8.5
1	A	71	PRO	HG2	4.54	3.48 – 0.38	8.4
1	A	71	PRO	HB3	5.00	3.81 – 0.21	8.3
1	A	41	GLY	HA3	1.11	5.80 – 2.00	-7.3
1	A	46	TYR	HE2	5.12	7.86 – 5.56	-6.9
1	A	48	TYR	HE2	8.30	7.86 – 5.56	6.9
1	A	48	TYR	HE1	8.30	7.86 – 5.56	6.9
1	A	61	GLU	HG2	0.83	3.33 – 1.23	-6.9
1	A	61	GLU	HG3	0.83	3.31 – 1.21	-6.8
1	A	14	CYS	HA	0.91	7.47 – 1.87	-6.7
1	A	68	LEU	HD23	-1.02	2.14 – -0.66	-6.3
1	A	68	LEU	HD21	-1.02	2.14 – -0.66	-6.3
1	A	68	LEU	HD22	-1.02	2.14 – -0.66	-6.3
1	A	31	ASN	H	11.99	11.45 – 5.25	5.9
1	A	30	PRO	HG3	0.01	3.56 – 0.26	-5.7
1	A	46	TYR	HB3	0.69	4.75 – 0.95	-5.7
1	A	75	ILE	HB	3.39	3.24 – 0.34	5.5
1	A	30	PRO	HB3	0.13	3.81 – 0.21	-5.2

7.1.5 Random Coil Index (RCI) plots (i)

The image below reports *random coil index* values for the protein chains in the structure. The height of each bar gives a probability of a given residue to be disordered, as predicted from the available chemical shifts and the amino acid sequence. A value above 0.2 is an indication of significant predicted disorder. The colour of the bar shows whether the residue is in the well-defined core (black) or in the ill-defined residue ranges (cyan), as described in section 2 on ensemble composition.

Random coil index (RCI) for chain A: