



wwPDB X-ray Structure Validation Summary Report ⓘ

Sep 16, 2021 – 02:05 pm BST

PDB ID : 6Y91
Title : Crystal structure of malate dehydrogenase from Plasmodium Falciparum in complex with NADH
Authors : Romero, A.R.; Calderone, V.; Gentili, M.; Lunev, S.; Groves, M.; Popowicz, G.; Domling, A.; Sattler, M.
Deposited on : 2020-03-06
Resolution : 2.50 Å(reported)

This is a wwPDB X-ray 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

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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

MolProbity : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtrriage (Phenix) : **NOT EXECUTED**
EDS : **NOT EXECUTED**
buster-report : 1.1.7 (2018)
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)
Ideal geometry (proteins) : Engh & Huber (2001)
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP) : 2.23.1

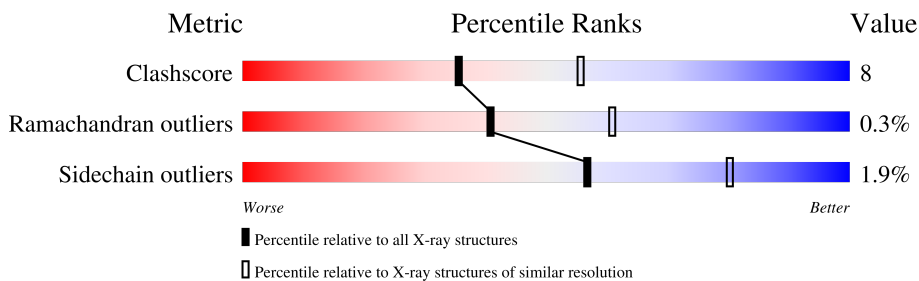
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.50 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	141614	5346 (2.50-2.50)
Ramachandran outliers	138981	5231 (2.50-2.50)
Sidechain outliers	138945	5233 (2.50-2.50)

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	324	
1	B	324	
1	C	324	
1	D	324	

2 Entry composition i

There are 3 unique types of molecules in this entry. The entry contains 9452 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 Malate dehydrogenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	302	2287	1459	384	429	15	0	0	0
1	B	302	2290	1461	384	431	14	0	0	0
1	C	300	2274	1450	380	429	15	0	0	0
1	D	301	2282	1455	383	430	14	0	0	0

There are 44 discrepancies between the modelled and reference sequences:

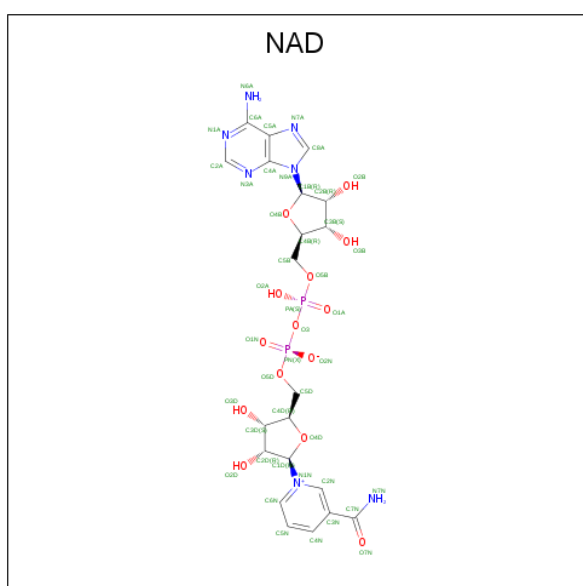
Chain	Residue	Modelled	Actual	Comment	Reference
A	314	ALA	-	expression tag	UNP Q6VVP7
A	315	ALA	-	expression tag	UNP Q6VVP7
A	316	ALA	-	expression tag	UNP Q6VVP7
A	317	LEU	-	expression tag	UNP Q6VVP7
A	318	GLU	-	expression tag	UNP Q6VVP7
A	319	HIS	-	expression tag	UNP Q6VVP7
A	320	HIS	-	expression tag	UNP Q6VVP7
A	321	HIS	-	expression tag	UNP Q6VVP7
A	322	HIS	-	expression tag	UNP Q6VVP7
A	323	HIS	-	expression tag	UNP Q6VVP7
A	324	HIS	-	expression tag	UNP Q6VVP7
B	314	ALA	-	expression tag	UNP Q6VVP7
B	315	ALA	-	expression tag	UNP Q6VVP7
B	316	ALA	-	expression tag	UNP Q6VVP7
B	317	LEU	-	expression tag	UNP Q6VVP7
B	318	GLU	-	expression tag	UNP Q6VVP7
B	319	HIS	-	expression tag	UNP Q6VVP7
B	320	HIS	-	expression tag	UNP Q6VVP7
B	321	HIS	-	expression tag	UNP Q6VVP7
B	322	HIS	-	expression tag	UNP Q6VVP7
B	323	HIS	-	expression tag	UNP Q6VVP7

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Chain	Residue	Modelled	Actual	Comment	Reference
B	324	HIS	-	expression tag	UNP Q6VVP7
C	314	ALA	-	expression tag	UNP Q6VVP7
C	315	ALA	-	expression tag	UNP Q6VVP7
C	316	ALA	-	expression tag	UNP Q6VVP7
C	317	LEU	-	expression tag	UNP Q6VVP7
C	318	GLU	-	expression tag	UNP Q6VVP7
C	319	HIS	-	expression tag	UNP Q6VVP7
C	320	HIS	-	expression tag	UNP Q6VVP7
C	321	HIS	-	expression tag	UNP Q6VVP7
C	322	HIS	-	expression tag	UNP Q6VVP7
C	323	HIS	-	expression tag	UNP Q6VVP7
C	324	HIS	-	expression tag	UNP Q6VVP7
D	314	ALA	-	expression tag	UNP Q6VVP7
D	315	ALA	-	expression tag	UNP Q6VVP7
D	316	ALA	-	expression tag	UNP Q6VVP7
D	317	LEU	-	expression tag	UNP Q6VVP7
D	318	GLU	-	expression tag	UNP Q6VVP7
D	319	HIS	-	expression tag	UNP Q6VVP7
D	320	HIS	-	expression tag	UNP Q6VVP7
D	321	HIS	-	expression tag	UNP Q6VVP7
D	322	HIS	-	expression tag	UNP Q6VVP7
D	323	HIS	-	expression tag	UNP Q6VVP7
D	324	HIS	-	expression tag	UNP Q6VVP7

- Molecule 2 is NICOTINAMIDE-ADENINE-DINUCLEOTIDE (three-letter code: NAD) (formula: C₂₁H₂₇N₇O₁₄P₂) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
			Total	C	N	O	P		
2	A	1	44	21	7	14	2	0	0
2	B	1	44	21	7	14	2	0	0
2	C	1	44	21	7	14	2	0	0
2	D	1	44	21	7	14	2	0	0

- Molecule 3 is water.


Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
			Total	O		
3	A	33	33	33	0	0
3	B	35	35	35	0	0
3	C	46	46	46	0	0
3	D	29	29	29	0	0

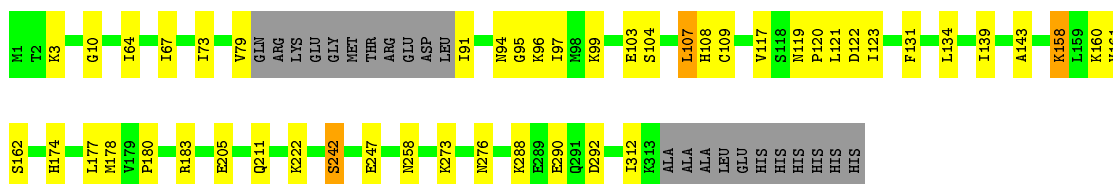
3 Residue-property plots [i](#)

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.

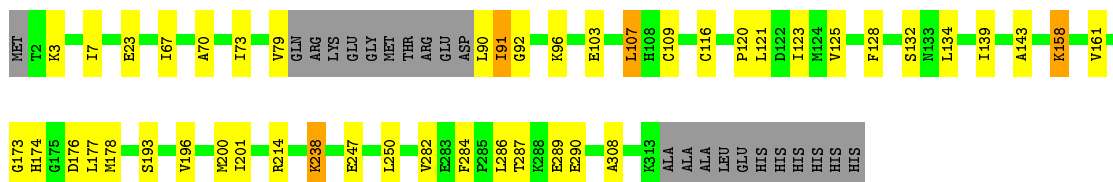
- Molecule 1: Malate dehydrogenase

Chain A: 




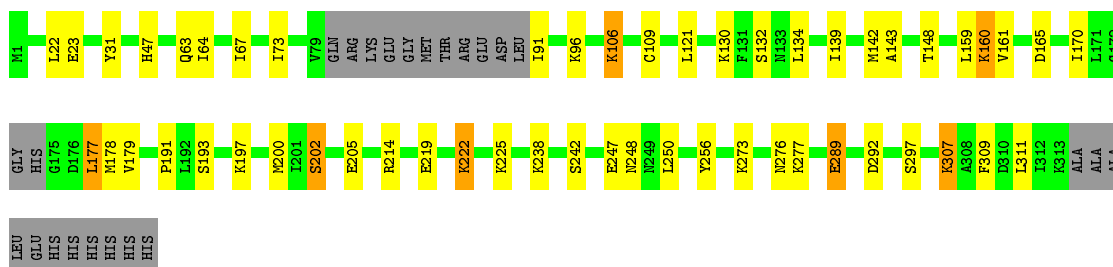
- Molecule 1: Malate dehydrogenase

Chain B: 




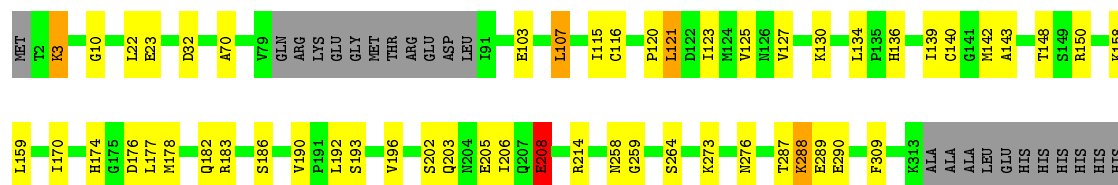
- Molecule 1: Malate dehydrogenase

Chain C: 



- Molecule 1: Malate dehydrogenase

Chain D: 



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	84.62Å 107.42Å 145.08Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	18.27 – 2.50	Depositor
% Data completeness (in resolution range)	99.7 (18.27-2.50)	Depositor
R_{merge}	0.20	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	PHENIX (dev_3753: ???)	Depositor
R, R_{free}	0.239 , 0.286	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	9452	wwPDB-VP
Average B, all atoms (Å ²)	38.0	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:
NAD

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	0.35	0/2319	0.59	2/3134 (0.1%)
1	B	0.36	2/2322 (0.1%)	0.57	3/3139 (0.1%)
1	C	0.36	1/2304 (0.0%)	0.63	4/3112 (0.1%)
1	D	0.32	0/2314	0.62	4/3128 (0.1%)
All	All	0.35	3/9259 (0.0%)	0.60	13/12513 (0.1%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	D	0	1

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	160	LYS	CD-CE	6.26	1.67	1.51
1	B	158	LYS	CE-NZ	5.53	1.62	1.49
1	B	158	LYS	CD-CE	-5.27	1.38	1.51

The worst 5 of 13 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	D	177	LEU	CB-CG-CD2	-13.24	88.49	111.00
1	B	158	LYS	CD-CE-NZ	-9.44	89.99	111.70
1	D	177	LEU	CB-CG-CD1	9.03	126.36	111.00
1	A	177	LEU	CA-CB-CG	-7.13	98.91	115.30
1	A	158	LYS	CA-CB-CG	-6.64	98.79	113.40

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	D	208	GLU	Sidechain

5.2 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	2287	0	2367	47	0
1	B	2290	0	2368	34	0
1	C	2274	0	2351	41	0
1	D	2282	0	2357	37	0
2	A	44	0	26	6	0
2	B	44	0	26	0	0
2	C	44	0	26	0	0
2	D	44	0	26	3	0
3	A	33	0	0	9	0
3	B	35	0	0	3	0
3	C	46	0	0	6	0
3	D	29	0	0	8	0
All	All	9452	0	9547	153	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 8.

The worst 5 of 153 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:158:LYS:NZ	1:A:205:GLU:OE1	1.86	1.07
1:A:211:GLN:OE1	3:A:501:HOH:O	1.86	0.93
1:A:119:ASN:OD1	1:A:121:LEU:N	2.00	0.92
1:C:307:LYS:HD2	1:C:311:LEU:HD11	1.52	0.92
1:A:158:LYS:NZ	1:A:205:GLU:CD	2.22	0.92

There are no symmetry-related clashes.

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	298/324 (92%)	286 (96%)	11 (4%)	1 (0%)	41	61
1	B	298/324 (92%)	283 (95%)	14 (5%)	1 (0%)	41	61
1	C	294/324 (91%)	282 (96%)	11 (4%)	1 (0%)	41	61
1	D	297/324 (92%)	285 (96%)	11 (4%)	1 (0%)	41	61
All	All	1187/1296 (92%)	1136 (96%)	47 (4%)	4 (0%)	41	61

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	91	ILE
1	C	276	ASN
1	D	276	ASN
1	A	276	ASN

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	254/273 (93%)	252 (99%)	2 (1%)	81	93
1	B	255/273 (93%)	252 (99%)	3 (1%)	71	88
1	C	253/273 (93%)	247 (98%)	6 (2%)	49	74
1	D	254/273 (93%)	246 (97%)	8 (3%)	40	67
All	All	1016/1092 (93%)	997 (98%)	19 (2%)	57	80

5 of 19 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	121	LEU
1	D	208	GLU
1	D	288	LYS
1	D	202	SER
1	C	202	SER

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (5) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	258	ASN
1	C	204	ASN
1	C	249	ASN
1	D	55	ASN
1	D	203	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 monosaccharides in this entry.

5.6 Ligand geometry [i](#)

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
2	NAD	B	401	-	42,48,48	4.25	20 (47%)	50,73,73	1.50	7 (14%)
2	NAD	D	401	-	42,48,48	4.23	21 (50%)	50,73,73	1.39	7 (14%)
2	NAD	C	401	-	42,48,48	4.25	21 (50%)	50,73,73	1.37	6 (12%)
2	NAD	A	401	-	42,48,48	4.36	20 (47%)	50,73,73	1.71	11 (22%)

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	NAD	B	401	-	-	5/26/62/62	0/5/5/5
2	NAD	D	401	-	-	5/26/62/62	0/5/5/5
2	NAD	C	401	-	-	6/26/62/62	0/5/5/5
2	NAD	A	401	-	-	5/26/62/62	0/5/5/5

The worst 5 of 82 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	401	NAD	C2N-C3N	12.76	1.58	1.39
2	B	401	NAD	C2N-C3N	12.40	1.58	1.39
2	C	401	NAD	C2N-C3N	12.40	1.58	1.39
2	A	401	NAD	C4A-N3A	-12.19	1.18	1.35
2	B	401	NAD	C4A-N3A	-12.13	1.18	1.35

The worst 5 of 31 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	B	401	NAD	C1B-N9A-C4A	-4.71	118.37	126.64
2	A	401	NAD	C1B-N9A-C4A	-4.54	118.67	126.64
2	D	401	NAD	C1B-N9A-C4A	-4.45	118.81	126.64
2	A	401	NAD	O4D-C1D-C2D	-4.33	100.60	106.93
2	A	401	NAD	C6N-N1N-C2N	-4.25	118.10	121.97

There are no chirality outliers.

5 of 21 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	A	401	NAD	O4D-C1D-N1N-C2N
2	A	401	NAD	O4D-C1D-N1N-C6N

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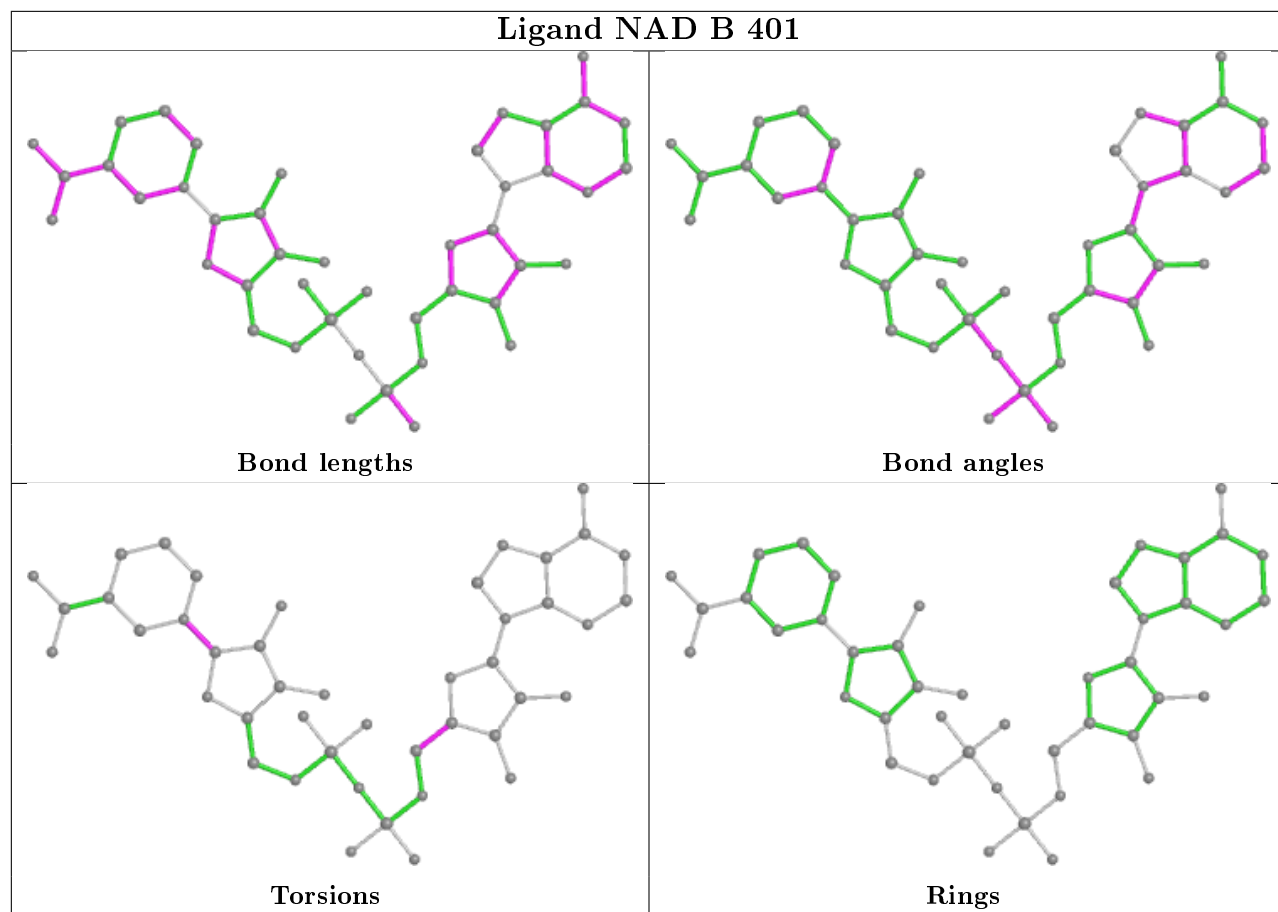
Mol	Chain	Res	Type	Atoms
2	A	401	NAD	C2D-C1D-N1N-C2N
2	A	401	NAD	C2D-C1D-N1N-C6N
2	B	401	NAD	O4D-C1D-N1N-C2N

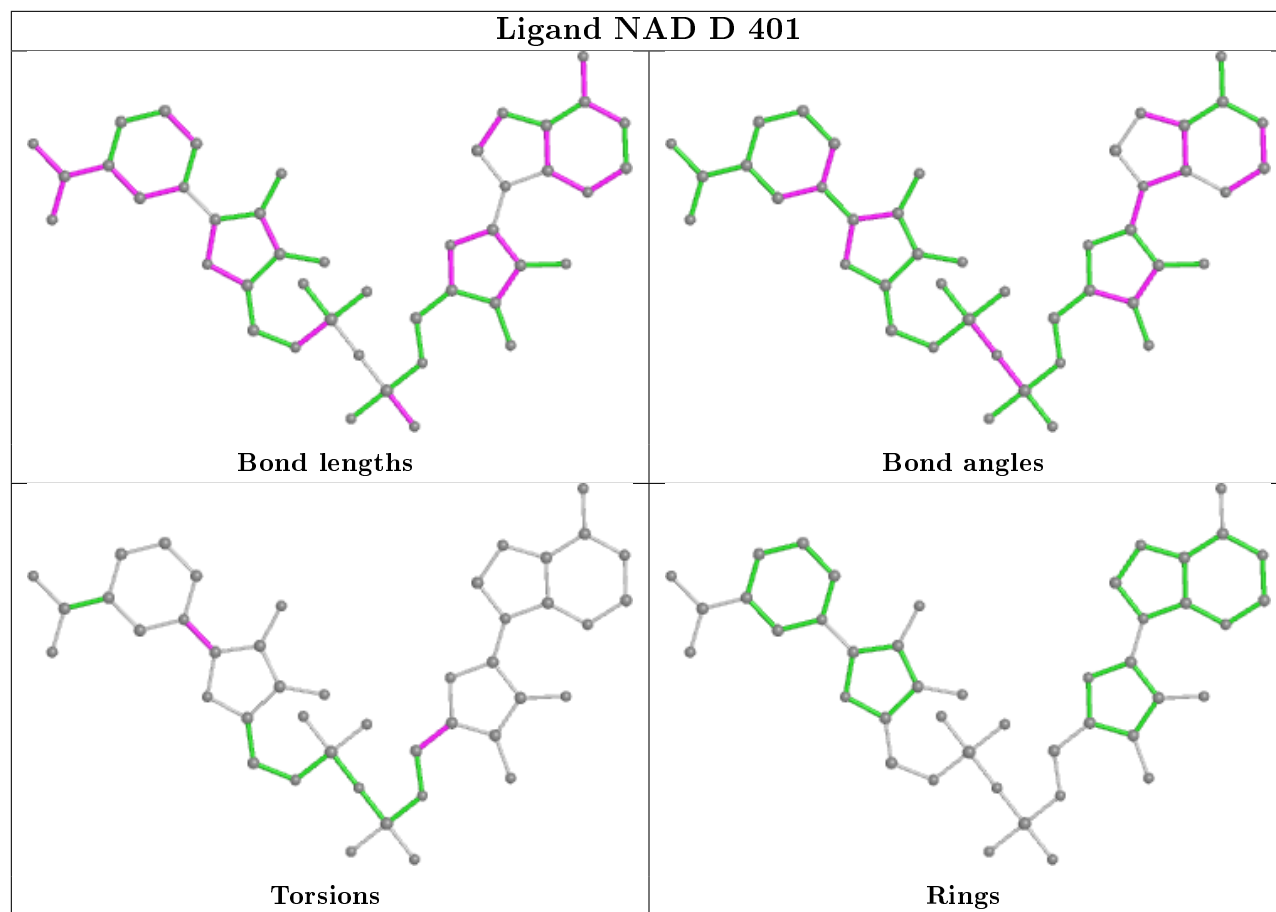
There are no ring outliers.

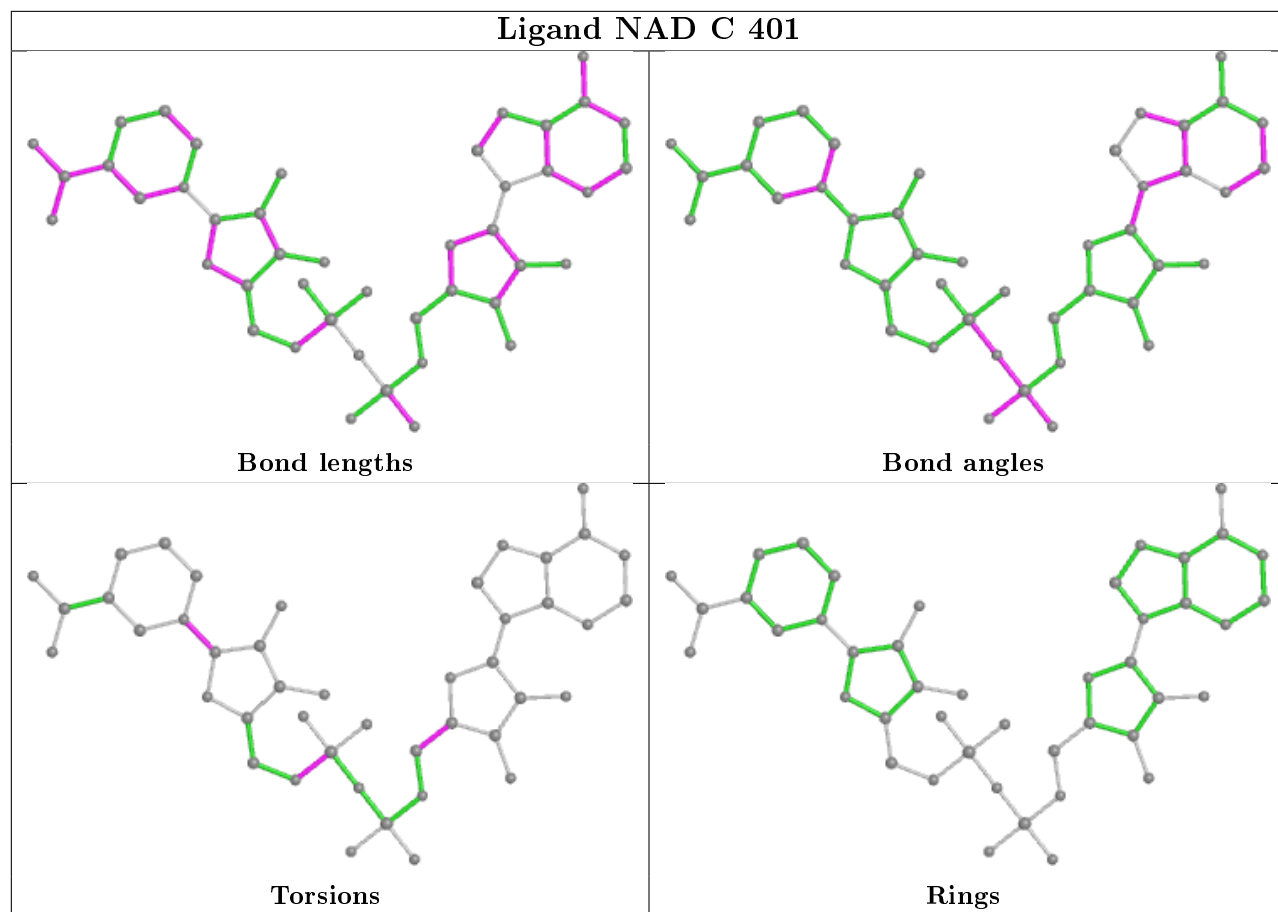
2 monomers are involved in 9 short contacts:

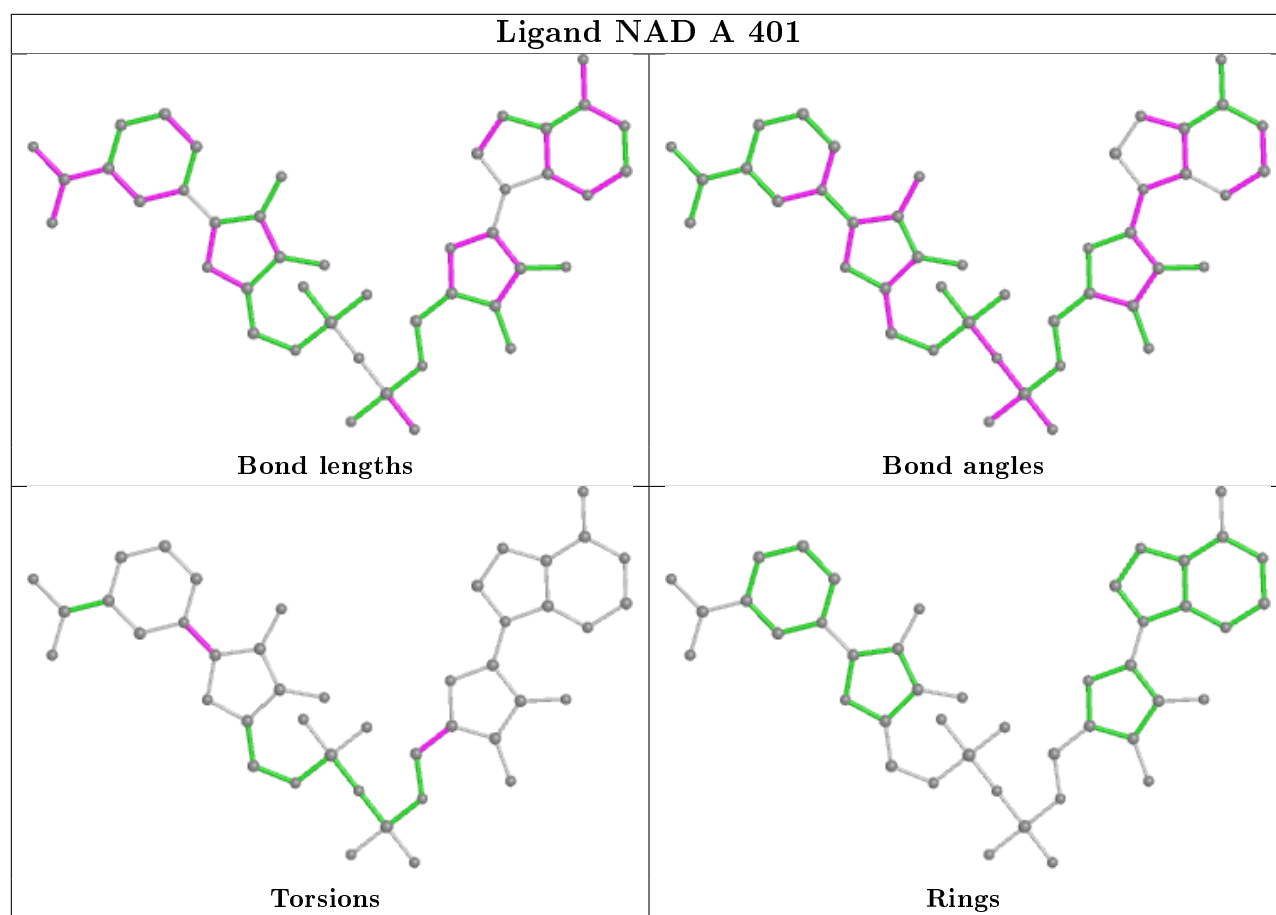
Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	D	401	NAD	3	0
2	A	401	NAD	6	0

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 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.