



Full wwPDB X-ray Structure Validation Report ⓘ

Jan 28, 2024 – 12:44 PM EST

PDB ID : 1EMD
Title : CRYSTAL STRUCTURE OF A TERNARY COMPLEX OF ESCHERICHIA COLI MALATE DEHYDROGENASE, CITRATE AND NAD AT 1.9 ANGSTROMS RESOLUTION
Authors : Hall, M.D.; Banaszak, L.J.
Deposited on : 1993-03-25
Resolution : 1.90 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 : 4.02b-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) : 2.36

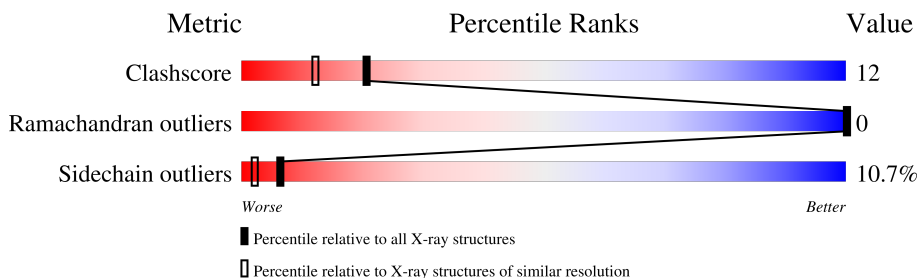
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.90 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	6847 (1.90-1.90)
Ramachandran outliers	138981	6760 (1.90-1.90)
Sidechain outliers	138945	6760 (1.90-1.90)

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	312	

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	CIT	A	313	-	X	-	-

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 2421 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.

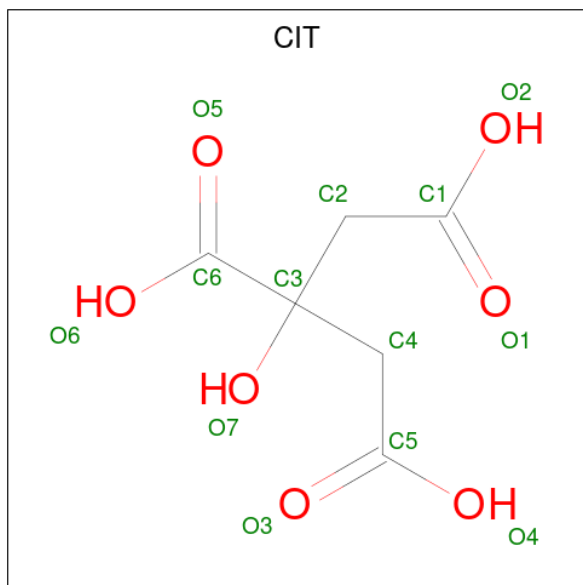
- Molecule 1 is a protein called MALATE DEHYDROGENASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	312	2278	1441	390	440	7	0	0	0

There are 2 discrepancies between the modelled and reference sequences:

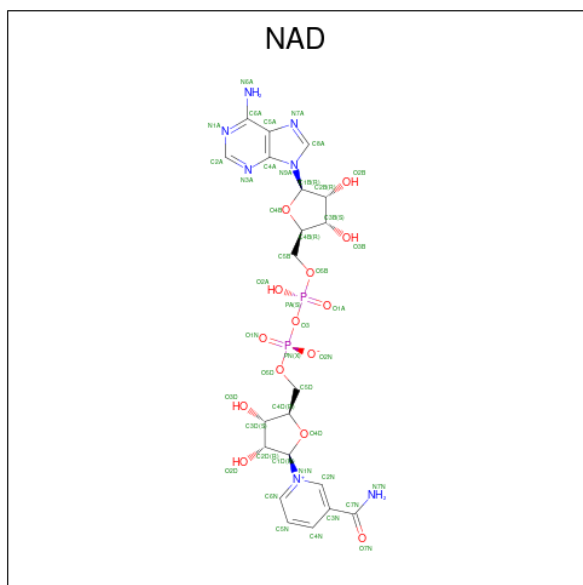
Chain	Residue	Modelled	Actual	Comment	Reference
A	80	ARG	ALA	conflict	UNP P61889
A	307	GLN	GLU	conflict	UNP P61889

- Molecule 2 is CITRIC ACID (three-letter code: CIT) (formula: C₆H₈O₇).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	C	O		
2	A	1	13	6	7	0	0

- Molecule 3 is NICOTINAMIDE-ADENINE-DINUCLEOTIDE (three-letter code: NAD) (formula: C₂₁H₂₇N₇O₁₄P₂).



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

- Molecule 4 is water.

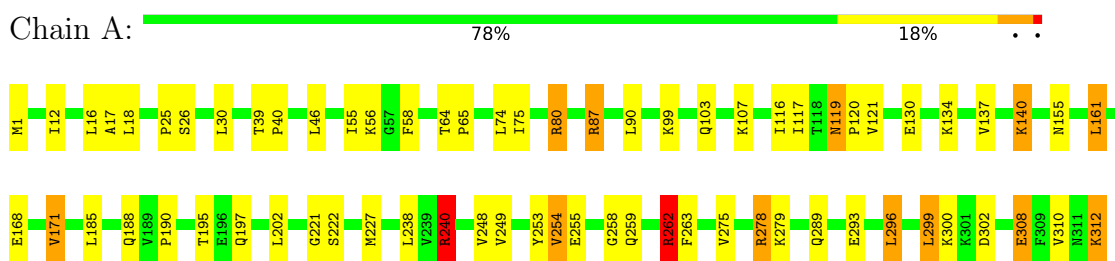
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	86	Total	O	0	0
			86	86		

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



4 Data and refinement statistics

Xtrriage (Phenix) and EDS were not executed - this section is therefore incomplete.

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	116.80Å 43.05Å 83.74Å 90.00° 130.10° 90.00°	Depositor
Resolution (Å)	(Not available) – 1.90	Depositor
% Data completeness (in resolution range)	(Not available) ((Not available)-1.90)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	X-PLOR	Depositor
R, R_{free}	0.195 , (Not available)	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	2421	wwPDB-VP
Average B, all atoms (Å ²)	20.0	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, CIT

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	0.57	1/2306 (0.0%)	0.81	4/3121 (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	A	0	6

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	258	GLY	C-N	-5.50	1.21	1.34

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	259	GLN	CA-CB-CG	20.46	158.42	113.40
1	A	259	GLN	N-CA-CB	11.19	130.73	110.60
1	A	259	GLN	CB-CA-C	-6.68	97.05	110.40
1	A	87	ARG	NE-CZ-NH1	-6.06	117.27	120.30

There are no chirality outliers.

All (6) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	240	ARG	Sidechain
1	A	253	TYR	Sidechain

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Mol	Chain	Res	Type	Group
1	A	262	ARG	Sidechain
1	A	278	ARG	Sidechain
1	A	80	ARG	Sidechain
1	A	87	ARG	Sidechain

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	2278	0	2366	57	0
2	A	13	0	6	2	0
3	A	44	0	26	20	0
4	A	86	0	0	1	0
All	All	2421	0	2398	58	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 12.

All (58) 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:227:MET:SD	3:A:314:NAD:H4N	1.99	1.02
1:A:227:MET:HG2	3:A:314:NAD:H5N	1.47	0.96
1:A:119:ASN:H	3:A:314:NAD:H1D	1.47	0.80
1:A:227:MET:SD	3:A:314:NAD:C4N	2.75	0.75
1:A:195:THR:OG1	1:A:197:GLN:HG2	1.91	0.70
1:A:227:MET:CG	3:A:314:NAD:H5N	2.22	0.69
1:A:262:ARG:HD2	1:A:263:PHE:CE2	2.29	0.68
1:A:12:ILE:CD1	3:A:314:NAD:H6N	2.24	0.67
1:A:80:ARG:HD2	1:A:222:SER:H	1.58	0.66
1:A:296:LEU:O	1:A:300:LYS:HG2	1.96	0.65
1:A:117:ILE:O	3:A:314:NAD:C2N	2.45	0.65
1:A:99:LYS:HE2	1:A:103:GLN:HE22	1.62	0.65
1:A:30:LEU:HD23	1:A:55:ILE:HD12	1.82	0.62
1:A:140:LYS:H	1:A:140:LYS:HD2	1.64	0.62
1:A:161:LEU:HD12	1:A:202:LEU:HD11	1.82	0.61

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:308:GLU:O	1:A:312:LYS:HG3	2.01	0.61
1:A:140:LYS:H	1:A:140:LYS:CD	2.14	0.61
1:A:12:ILE:HD12	3:A:314:NAD:H51N	1.84	0.60
1:A:117:ILE:HG23	3:A:314:NAD:C5N	2.33	0.59
1:A:119:ASN:N	3:A:314:NAD:H1D	2.15	0.59
1:A:155:ASN:HD21	1:A:171:VAL:H	1.52	0.57
2:A:313:CIT:O3	3:A:314:NAD:C2N	2.55	0.55
1:A:119:ASN:HB2	3:A:314:NAD:O2D	2.06	0.54
1:A:75:ILE:O	1:A:117:ILE:HB	2.08	0.54
1:A:289:GLN:O	1:A:293:GLU:HG3	2.08	0.53
1:A:240:ARG:HH12	1:A:248:VAL:HG22	1.74	0.53
1:A:80:ARG:CD	1:A:222:SER:H	2.21	0.52
1:A:188:GLN:O	1:A:190:PRO:HD3	2.10	0.52
1:A:155:ASN:HD22	1:A:171:VAL:HG13	1.75	0.52
1:A:119:ASN:OD1	1:A:120:PRO:HA	2.11	0.51
1:A:255:GLU:HB2	1:A:263:PHE:CE1	2.45	0.51
1:A:39:THR:HB	1:A:40:PRO:HD3	1.94	0.50
1:A:64:THR:HB	1:A:65:PRO:HD3	1.93	0.50
1:A:117:ILE:CG2	3:A:314:NAD:C5N	2.90	0.50
1:A:119:ASN:ND2	3:A:314:NAD:H2N	2.27	0.49
1:A:103:GLN:O	1:A:107:LYS:HG2	2.12	0.49
1:A:58:PHE:HB3	4:A:327:HOH:O	2.13	0.49
1:A:140:LYS:HD2	1:A:140:LYS:N	2.28	0.47
1:A:121:VAL:HG23	3:A:314:NAD:H71N	1.79	0.47
1:A:155:ASN:ND2	1:A:171:VAL:H	2.13	0.46
1:A:140:LYS:H	1:A:140:LYS:CE	2.29	0.46
1:A:75:ILE:HD12	1:A:116:ILE:HD13	1.97	0.45
1:A:80:ARG:NH1	1:A:221:GLY:HA3	2.31	0.45
1:A:130:GLU:HB3	1:A:310:VAL:HG11	1.98	0.45
1:A:121:VAL:CG2	3:A:314:NAD:N7N	2.80	0.44
1:A:254:VAL:HG13	1:A:278:ARG:HH11	1.82	0.44
1:A:12:ILE:HD13	3:A:314:NAD:H5N	2.00	0.42
1:A:140:LYS:CD	1:A:140:LYS:N	2.82	0.42
1:A:238:LEU:HA	1:A:238:LEU:HD23	1.82	0.41
1:A:17:ALA:HB1	1:A:46:LEU:HD11	2.03	0.41
1:A:119:ASN:ND2	2:A:313:CIT:O3	2.54	0.41
1:A:140:LYS:HB3	1:A:140:LYS:HE3	1.71	0.41
1:A:202:LEU:HD23	1:A:202:LEU:HA	1.95	0.41
1:A:117:ILE:HG22	3:A:314:NAD:C6N	2.51	0.41
1:A:121:VAL:HG21	3:A:314:NAD:N7N	2.35	0.40
1:A:299:LEU:O	1:A:302:ASP:HB2	2.21	0.40

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:30:LEU:O	1:A:55:ILE:HA	2.21	0.40
1:A:227:MET:SD	3:A:314:NAD:C5N	3.09	0.40

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	310/312 (99%)	306 (99%)	4 (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	242/242 (100%)	216 (89%)	26 (11%)	6 2

All (26) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	1	MET
1	A	16	LEU
1	A	18	LEU
1	A	25	PRO

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Mol	Chain	Res	Type
1	A	26	SER
1	A	56	LYS
1	A	74	LEU
1	A	90	LEU
1	A	119	ASN
1	A	134	LYS
1	A	137	VAL
1	A	140	LYS
1	A	161	LEU
1	A	168	GLU
1	A	171	VAL
1	A	185	LEU
1	A	240	ARG
1	A	249	VAL
1	A	254	VAL
1	A	262	ARG
1	A	275	VAL
1	A	279	LYS
1	A	296	LEU
1	A	299	LEU
1	A	308	GLU
1	A	312	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	14	GLN
1	A	103	GLN
1	A	155	ASN
1	A	207	GLN
1	A	259	GLN
1	A	266	GLN
1	A	307	GLN
1	A	311	ASN

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](#)

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
2	CIT	A	313	-	12,12,12	3.03	7 (58%)	17,17,17	2.79	11 (64%)
3	NAD	A	314	-	42,48,48	1.36	2 (4%)	50,73,73	2.05	17 (34%)

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	CIT	A	313	-	-	1/16/16/16	-
3	NAD	A	314	-	-	6/26/62/62	0/5/5/5

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	313	CIT	C3-C6	-6.33	1.46	1.53
3	A	314	NAD	C2N-N1N	5.71	1.41	1.35
2	A	313	CIT	C2-C3	5.62	1.60	1.53
3	A	314	NAD	O4D-C1D	3.44	1.45	1.41
2	A	313	CIT	C4-C3	3.44	1.58	1.53
2	A	313	CIT	O7-C3	2.87	1.48	1.43

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	313	CIT	O4-C5	2.31	1.38	1.30
2	A	313	CIT	C4-C5	-2.23	1.43	1.50
2	A	313	CIT	O2-C1	-2.03	1.23	1.30

All (28) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	313	CIT	O5-C6-C3	-5.36	114.66	122.25
3	A	314	NAD	C6N-N1N-C2N	-5.17	117.26	121.97
2	A	313	CIT	C3-C4-C5	-4.64	102.59	113.81
3	A	314	NAD	C1B-N9A-C4A	-4.43	118.86	126.64
2	A	313	CIT	O4-C5-C4	4.20	127.85	114.35
3	A	314	NAD	C2N-N1N-C1D	3.88	127.79	119.14
3	A	314	NAD	C3D-C2D-C1D	-3.59	95.57	100.98
2	A	313	CIT	O1-C1-C2	-3.59	112.47	122.94
3	A	314	NAD	O5D-C5D-C4D	3.48	120.98	108.99
3	A	314	NAD	C3N-C7N-N7N	-3.41	113.66	117.75
3	A	314	NAD	C5A-C6A-N6A	3.24	125.27	120.35
3	A	314	NAD	N3A-C2A-N1A	-3.08	123.87	128.68
2	A	313	CIT	O7-C3-C6	2.85	112.87	108.86
2	A	313	CIT	O4-C5-O3	-2.79	116.35	123.30
3	A	314	NAD	C4A-C5A-N7A	2.78	112.30	109.40
2	A	313	CIT	O3-C5-C4	-2.70	115.06	122.94
3	A	314	NAD	O2D-C2D-C1D	2.63	120.55	110.85
3	A	314	NAD	C3B-C2B-C1B	-2.61	97.04	100.98
2	A	313	CIT	O6-C6-O5	2.47	131.68	123.82
2	A	313	CIT	C2-C3-C6	-2.32	105.12	110.11
3	A	314	NAD	O2N-PN-O5D	2.28	118.34	107.75
3	A	314	NAD	C5A-C6A-N1A	-2.26	115.23	120.35
2	A	313	CIT	O7-C3-C4	-2.26	104.12	109.40
3	A	314	NAD	C2N-C3N-C4N	2.25	120.80	118.26
2	A	313	CIT	C3-C2-C1	-2.18	108.54	113.81
3	A	314	NAD	O4D-C1D-C2D	-2.13	103.82	106.93
3	A	314	NAD	O4D-C4D-C5D	-2.09	102.50	109.37
3	A	314	NAD	C2A-N1A-C6A	2.02	122.21	118.75

There are no chirality outliers.

All (7) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	314	NAD	PN-O3-PA-O5B
3	A	314	NAD	C5D-O5D-PN-O3

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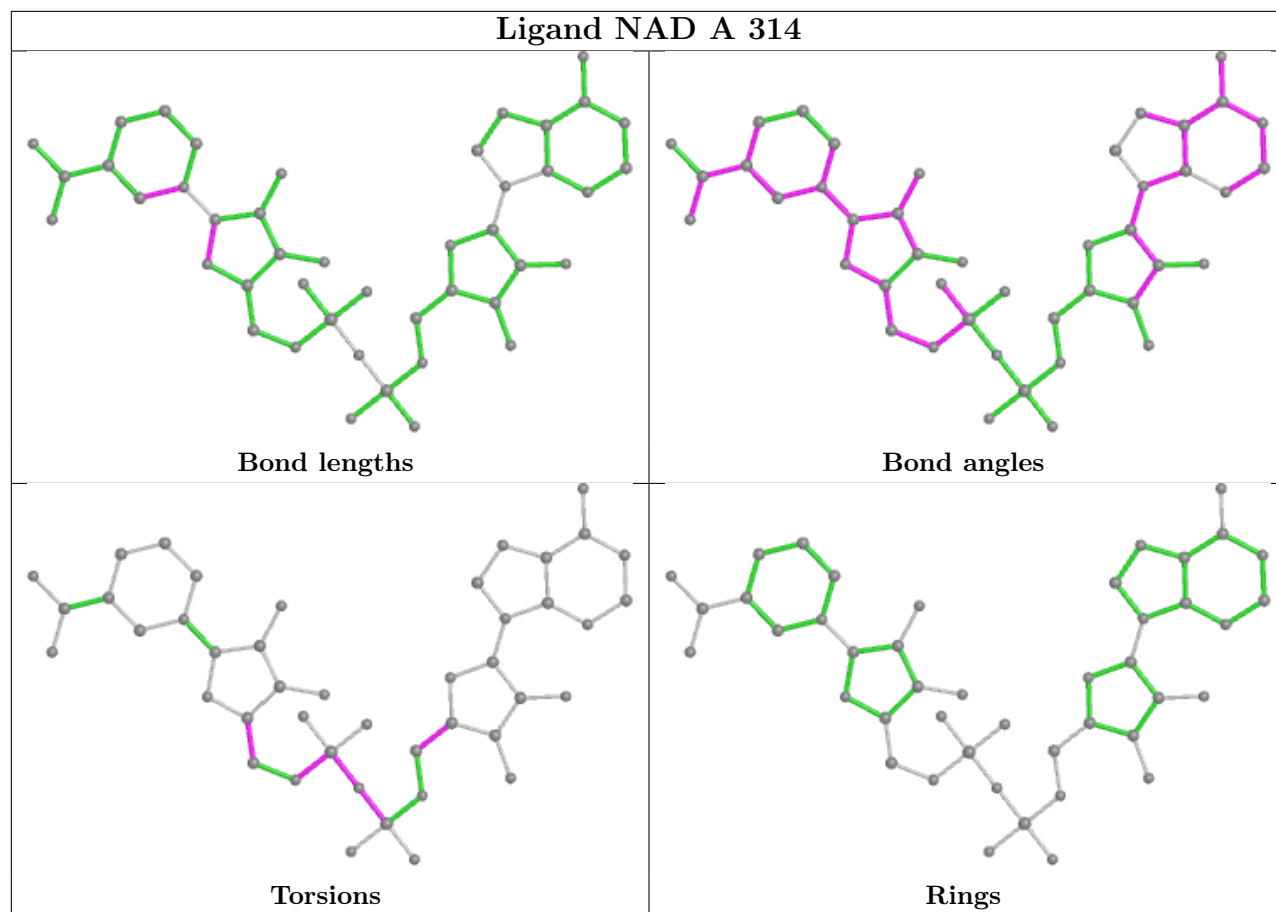
Mol	Chain	Res	Type	Atoms
3	A	314	NAD	C5D-O5D-PN-O1N
3	A	314	NAD	O4D-C4D-C5D-O5D
3	A	314	NAD	PA-O3-PN-O2N
3	A	314	NAD	O4B-C4B-C5B-O5B
2	A	313	CIT	C6-C3-C4-C5

There are no ring outliers.

2 monomers are involved in 21 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	313	CIT	2	0
3	A	314	NAD	20	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.