



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 09:31 PM UTC

PDB ID : 1E9C / pdb_00001e9c
Title : Mutant human thymidylate kinase complexed with TMP and APPNP
Authors : Ostermann, N.; Lavie, A.; Padiyar, S.; Brundiers, R.; Veit, T.; Reintein, J.;
Goody, R.S.; Konrad, M.; Schlichting, I.
Deposited on : 2000-10-10
Resolution : 1.60 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 : 4-5-2 with Phenix2.0
Mogul : 2022.3.0, CSD as543be (2022)
Xtriage (Phenix) : **NOT EXECUTED**
EDS : **NOT EXECUTED**
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

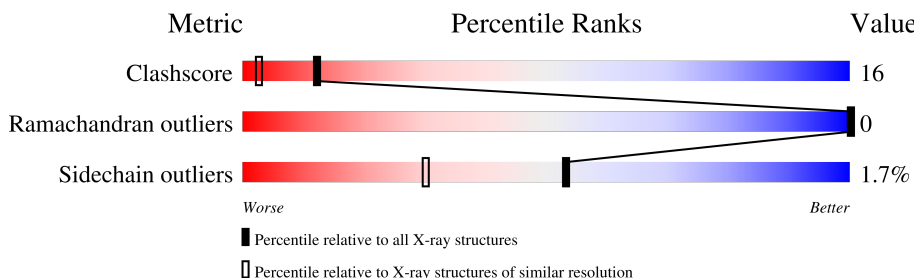
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.60 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	4931 (1.60-1.60)
Ramachandran outliers	187476	4831 (1.60-1.60)
Sidechain outliers	187428	4830 (1.60-1.60)

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	215	 74% 21% . .

2 Entry composition [i](#)

There are 6 unique types of molecules in this entry. The entry contains 2018 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.

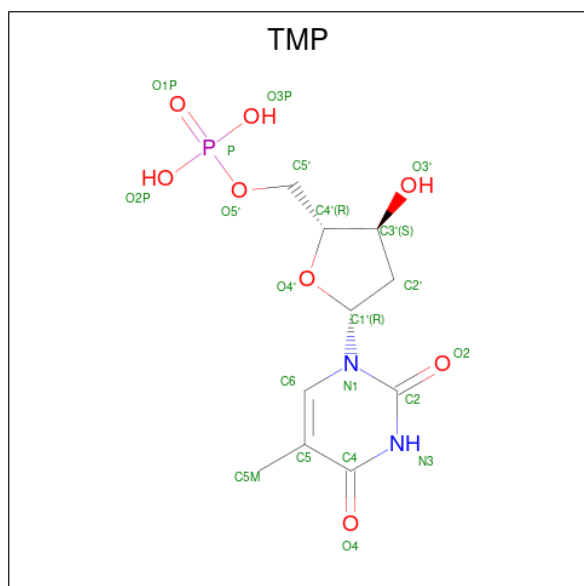
- Molecule 1 is a protein called THYMIDYLATE KINASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	209	Total	C	N	O	S	0	2	0
			1669	1055	298	311	5			

There are 7 discrepancies between the modelled and reference sequences:

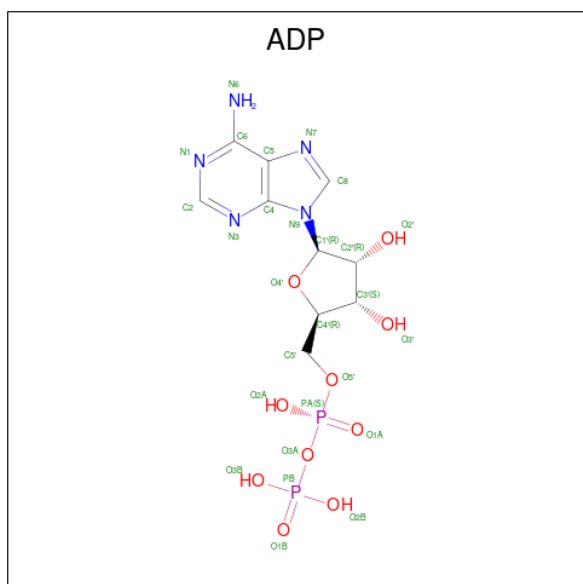
Chain	Residue	Modelled	Actual	Comment	Reference
A	200	ALA	ARG	engineered mutation	UNP P23919
A	183	SER	ARG	conflict	UNP P23919
A	190	ASP	GLU	conflict	UNP P23919
A	184	ILE	LEU	conflict	UNP P23919
A	191	ILE	LEU	conflict	UNP P23919
A	105	TYR	PHE	conflict	UNP P23919
A	208	LYS	GLY	conflict	UNP P23919

- Molecule 2 is THYMIDINE-5'-PHOSPHATE (CCD ID: TMP) (formula: $C_{10}H_{15}N_2O_8P$).



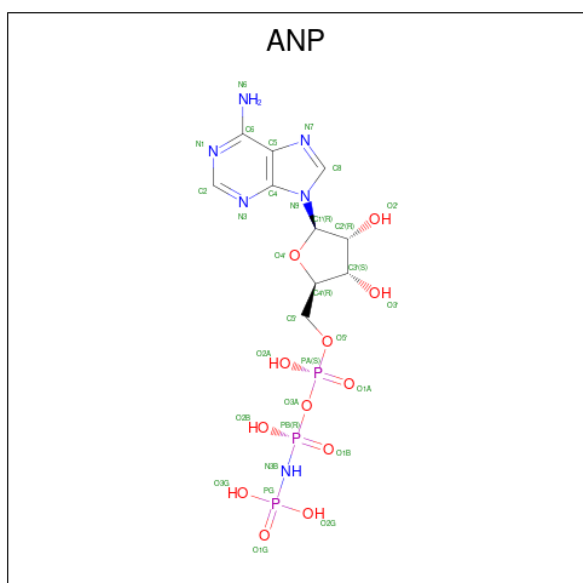
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	A	1	Total	C	N	O	P	0	1
			27	11	2	12	2		

- Molecule 3 is ADENOSINE-5'-DIPHOSPHATE (CCD ID: ADP) (formula: $C_{10}H_{15}N_5O_{10}P_2$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
3	A	1	Total	C	N	O	P	0	0
			27	10	5	10	2		

- Molecule 4 is PHOSPHOAMINOPHOSPHONIC ACID-ADENYLATE ESTER (CCD ID: ANP) (formula: $C_{10}H_{17}N_6O_{12}P_3$).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
4	A	1	Total	C	N	O	P	0	0
			31	10	6	12	3		

- Molecule 5 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	2	Total	Mg	0	0
			2	2		

- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	262	Total	O	0	0
			262	262		

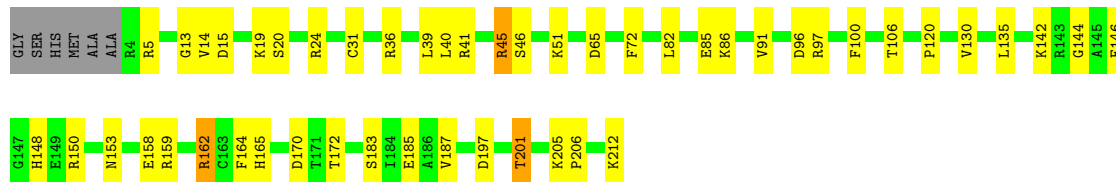
3 Residue-property plots [i](#)

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: THYMIDYLATE KINASE

Chain A:  74% 21% ..



4 Data and refinement statistics

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

Property	Value	Source
Space group	P 43 21 2	Depositor
Cell constants a, b, c, α , β , γ	101.30Å 101.30Å 49.20Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	70.00 – 1.60	Depositor
% Data completeness (in resolution range)	93.0 (70.00-1.60)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	0.08	Depositor
Refinement program	REFMAC	Depositor
R, R_{free}	0.209 , 0.268	Depositor
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	2018	wwPDB-VP
Average B, all atoms (Å ²)	19.0	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: TMP, MG, ANP, ADP

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	0.77	0/1705	1.59	17/2297 (0.7%)

There are no bond length outliers.

All (17) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	165	HIS	CA-CB-CG	-7.77	106.03	113.80
1	A	45	ARG	CD-NE-CZ	-7.21	114.30	124.40
1	A	65	ASP	CA-CB-CG	7.17	119.77	112.60
1	A	72	PHE	CA-CB-CG	7.03	120.83	113.80
1	A	13	GLY	CA-C-O	-5.91	116.14	122.05
1	A	120	PRO	O-C-N	5.90	129.84	122.22
1	A	96	ASP	CA-CB-CG	5.66	118.25	112.60
1	A	5	ARG	NE-CZ-NH1	-5.64	115.86	121.50
1	A	130	VAL	CB-CA-C	-5.47	104.70	111.32
1	A	96	ASP	N-CA-CB	-5.46	102.21	110.35
1	A	164	PHE	CA-CB-CG	5.41	119.21	113.80
1	A	130	VAL	CA-C-O	-5.36	113.72	120.69
1	A	100	PHE	CA-CB-CG	-5.20	108.60	113.80
1	A	106	THR	N-CA-C	-5.14	105.75	112.23
1	A	31	CYS	O-C-N	5.07	127.49	122.12
1	A	153	ASN	CA-C-N	5.01	125.65	119.99
1	A	153	ASN	C-N-CA	5.01	125.65	119.99

There are no chirality outliers.

There are no planarity outliers.

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	1669	0	1681	53	0
2	A	27	0	6	1	0
3	A	27	0	8	0	0
4	A	31	0	9	1	0
5	A	2	0	0	0	0
6	A	262	0	0	19	0
All	All	2018	0	1704	54	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 16.

All (54) 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:205:LYS:HE2	6:A:2158:HOH:O	1.58	1.04
1:A:36:ARG:CZ	1:A:91:VAL:CG2	2.44	0.96
1:A:36:ARG:HD3	6:A:2045:HOH:O	1.66	0.94
1:A:36:ARG:NE	1:A:91:VAL:HG22	1.85	0.92
1:A:41:ARG:NH1	6:A:2052:HOH:O	2.04	0.89
1:A:36:ARG:CZ	1:A:91:VAL:HG21	2.03	0.87
1:A:36:ARG:CD	1:A:91:VAL:HG22	2.06	0.85
1:A:170:ASP:OD1	1:A:172:THR:N	2.13	0.81
4:A:303:ANP:O1G	6:A:2261:HOH:O	1.99	0.80
1:A:36:ARG:NE	1:A:91:VAL:CG2	2.47	0.77
1:A:15[B]:ASP:OD2	6:A:2015:HOH:O	2.02	0.76
1:A:82:LEU:HD11	1:A:86:LYS:HE2	1.76	0.68
1:A:170:ASP:CG	1:A:172:THR:HG1	2.00	0.68
1:A:185:GLU:OE2	6:A:2205:HOH:O	2.12	0.67
1:A:46:SER:O	1:A:51:LYS:NZ	2.28	0.66
1:A:170:ASP:OD2	1:A:172:THR:OG1	2.13	0.66
1:A:36:ARG:HD3	1:A:91:VAL:HG22	1.78	0.64
1:A:97:ARG:HE	2:A:301[A]:TMP:P	2.23	0.61
1:A:36:ARG:CZ	1:A:91:VAL:HG22	2.22	0.60
1:A:206:PRO:HD2	6:A:2234:HOH:O	2.00	0.60
1:A:170:ASP:OD1	1:A:170:ASP:C	2.44	0.59

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:36:ARG:HG2	1:A:91:VAL:HG13	1.84	0.58
1:A:36:ARG:NH2	1:A:91:VAL:HG21	2.19	0.57
1:A:159:ARG:HG3	6:A:2181:HOH:O	2.06	0.55
1:A:85:GLU:OE1	6:A:2122:HOH:O	2.19	0.53
1:A:150:ARG:HG3	6:A:2177:HOH:O	2.09	0.51
1:A:212:LYS:CG	1:A:212:LYS:OXT	2.57	0.51
1:A:36:ARG:CD	6:A:2045:HOH:O	2.40	0.49
1:A:162:ARG:HH11	1:A:162:ARG:CB	2.26	0.48
1:A:82:LEU:HD11	1:A:86:LYS:CE	2.43	0.48
1:A:15[A]:ASP:OD2	1:A:146:PHE:HE1	1.98	0.47
1:A:205:LYS:HE3	6:A:2157:HOH:O	2.16	0.46
1:A:15[A]:ASP:OD2	1:A:146:PHE:CE1	2.69	0.45
1:A:36:ARG:CG	6:A:2043:HOH:O	2.64	0.45
1:A:19:LYS:HE3	1:A:97:ARG:CZ	2.47	0.45
1:A:45:ARG:HH11	1:A:45:ARG:HD3	1.42	0.44
1:A:162:ARG:HH11	1:A:162:ARG:HB3	1.81	0.44
1:A:39:LEU:C	1:A:40:LEU:HD12	2.43	0.43
1:A:197:ASP:O	1:A:201:THR:HG23	2.19	0.43
1:A:14:VAL:C	6:A:2129:HOH:O	2.62	0.42
1:A:212:LYS:HE3	6:A:2061:HOH:O	2.17	0.42
1:A:142:LYS:O	1:A:144:GLY:N	2.52	0.42
1:A:170:ASP:CG	1:A:172:THR:OG1	2.61	0.42
1:A:172:THR:HG21	6:A:2188:HOH:O	2.18	0.42
1:A:20:SER:O	1:A:24:ARG:HG3	2.20	0.41
1:A:205:LYS:HA	1:A:206:PRO:HD3	1.86	0.41
1:A:148:HIS:HA	6:A:2175:HOH:O	2.21	0.41
1:A:162:ARG:HH11	1:A:162:ARG:CG	2.33	0.41
1:A:36:ARG:HG2	6:A:2043:HOH:O	2.21	0.40
1:A:36:ARG:NH1	1:A:91:VAL:CG2	2.83	0.40
1:A:135:LEU:N	1:A:135:LEU:HD23	2.37	0.40
1:A:162:ARG:CG	1:A:162:ARG:NH1	2.84	0.40
1:A:183:SER:O	1:A:187:VAL:HG23	2.22	0.40
1:A:150:ARG:CG	6:A:2177:HOH:O	2.69	0.40

There are no symmetry-related clashes.

5.3 Torsion angles

5.3.1 Protein backbone

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	209/215 (97%)	203 (97%)	6 (3%)	0	100	100

There are no Ramachandran outliers to report.

5.3.2 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	178/179 (99%)	175 (98%)	3 (2%)	53	30

All (3) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	158	GLU
1	A	162	ARG
1	A	201	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	58	GLN
1	A	165	HIS
1	A	166	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 6 ligands modelled in this entry, 2 are monoatomic - leaving 4 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$
3	ADP	A	302	-	28,29,29	1.14	2 (7%)	43,45,45	1.35	4 (9%)
2	TMP	A	301[B]	-	22,22,22	2.26	4 (18%)	32,33,33	2.92	13 (40%)
4	ANP	A	303	5	33,33,33	1.38	5 (15%)	45,52,52	1.42	4 (8%)
2	TMP	A	301[A]	-	22,22,22	2.26	3 (13%)	32,33,33	2.88	12 (37%)

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	ADP	A	302	-	-	1/16/32/32	0/3/3/3
2	TMP	A	301[B]	-	-	0/10/22/22	0/2/2/2
4	ANP	A	303	5	-	4/18/38/38	0/3/3/3
2	TMP	A	301[A]	-	-	1/10/22/22	0/2/2/2

All (14) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	301[A]	TMP	O4-C4	8.55	1.39	1.23
2	A	301[B]	TMP	O4-C4	8.55	1.39	1.23
4	A	303	ANP	PB-O2B	-3.88	1.46	1.56
2	A	301[A]	TMP	C4-C5	3.88	1.51	1.44
2	A	301[B]	TMP	C4-C5	3.88	1.51	1.44
2	A	301[A]	TMP	C2-N1	3.36	1.43	1.38
2	A	301[B]	TMP	C2-N1	3.36	1.43	1.38
4	A	303	ANP	PG-O3G	-3.32	1.48	1.56
3	A	302	ADP	PA-O3A	3.11	1.62	1.59
3	A	302	ADP	C4-N9	2.49	1.42	1.37
4	A	303	ANP	PG-O2G	-2.36	1.50	1.56
4	A	303	ANP	PB-O1B	2.21	1.49	1.46
4	A	303	ANP	PG-O1G	2.11	1.49	1.46
2	A	301[B]	TMP	P-O3P	2.04	1.62	1.54

All (33) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	301[A]	TMP	O4-C4-C5	-7.18	116.70	124.92
2	A	301[B]	TMP	O4-C4-C5	-7.18	116.70	124.92
4	A	303	ANP	O1G-PG-N3B	-5.72	103.35	111.77
2	A	301[A]	TMP	C5-C4-N3	5.66	120.25	115.32
2	A	301[B]	TMP	C5-C4-N3	5.66	120.25	115.32
2	A	301[A]	TMP	C6-N1-C2	5.58	126.86	121.30
2	A	301[B]	TMP	C6-N1-C2	5.58	126.86	121.30
2	A	301[A]	TMP	C6-C5-C4	-5.10	113.82	118.02
2	A	301[B]	TMP	C6-C5-C4	-5.10	113.82	118.02
2	A	301[A]	TMP	C5M-C5-C6	4.97	129.58	122.85
2	A	301[B]	TMP	C5M-C5-C6	4.97	129.58	122.85
2	A	301[A]	TMP	C1'-N1-C6	-4.56	113.08	120.74
2	A	301[B]	TMP	C1'-N1-C6	-4.56	113.08	120.74
2	A	301[B]	TMP	O3P-P-O5'	-4.56	94.79	106.67
3	A	302	ADP	C2-N1-C6	4.21	125.65	118.73
2	A	301[A]	TMP	C2'-C1'-N1	4.11	124.09	113.81
2	A	301[B]	TMP	C2'-C1'-N1	4.11	124.09	113.81
4	A	303	ANP	O2B-PB-O3A	3.67	116.89	104.64
4	A	303	ANP	O2G-PG-O3G	3.66	117.44	107.59
2	A	301[A]	TMP	O4'-C4'-C5'	3.61	120.89	109.33
2	A	301[A]	TMP	O3P-P-O5'	-3.33	97.97	106.67
2	A	301[A]	TMP	N3-C2-N1	-3.33	110.56	114.89
2	A	301[B]	TMP	N3-C2-N1	-3.33	110.56	114.89
3	A	302	ADP	C5-C4-N3	3.23	131.16	126.72

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	301[B]	TMP	O4'-C4'-C5'	3.22	119.65	109.33
3	A	302	ADP	N3-C2-N1	-2.86	124.26	128.58
2	A	301[B]	TMP	O2P-P-O1P	2.20	119.40	110.83
2	A	301[A]	TMP	C5M-C5-C4	-2.17	116.47	118.78
2	A	301[B]	TMP	C5M-C5-C4	-2.17	116.47	118.78
2	A	301[A]	TMP	O2-C2-N3	2.16	125.47	121.49
2	A	301[B]	TMP	O2-C2-N3	2.16	125.47	121.49
4	A	303	ANP	C2'-C1'-N9	-2.05	108.22	113.30
3	A	302	ADP	N6-C6-N1	2.01	122.86	118.38

There are no chirality outliers.

All (6) torsion outliers are listed below:

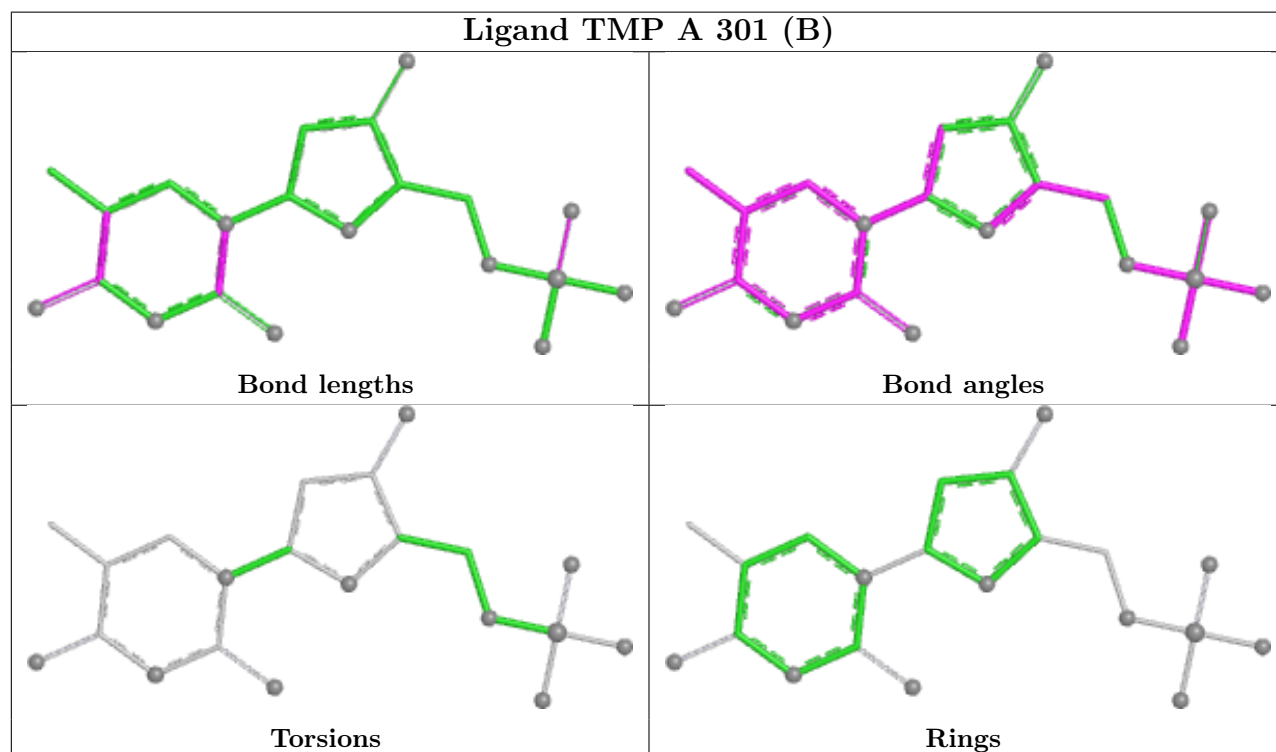
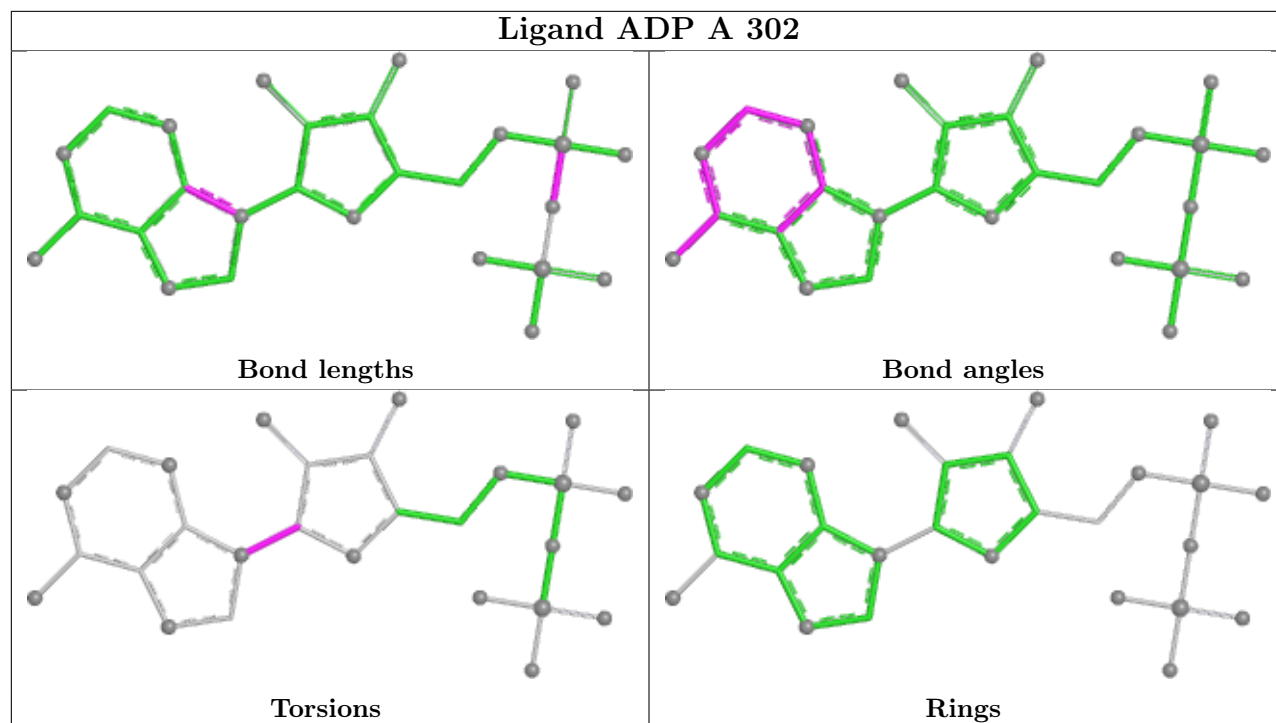
Mol	Chain	Res	Type	Atoms
4	A	303	ANP	PG-N3B-PB-O1B
4	A	303	ANP	PA-O3A-PB-O2B
4	A	303	ANP	C2'-C1'-N9-C8
2	A	301[A]	TMP	O4'-C4'-C5'-O5'
4	A	303	ANP	O4'-C1'-N9-C8
3	A	302	ADP	C2'-C1'-N9-C4

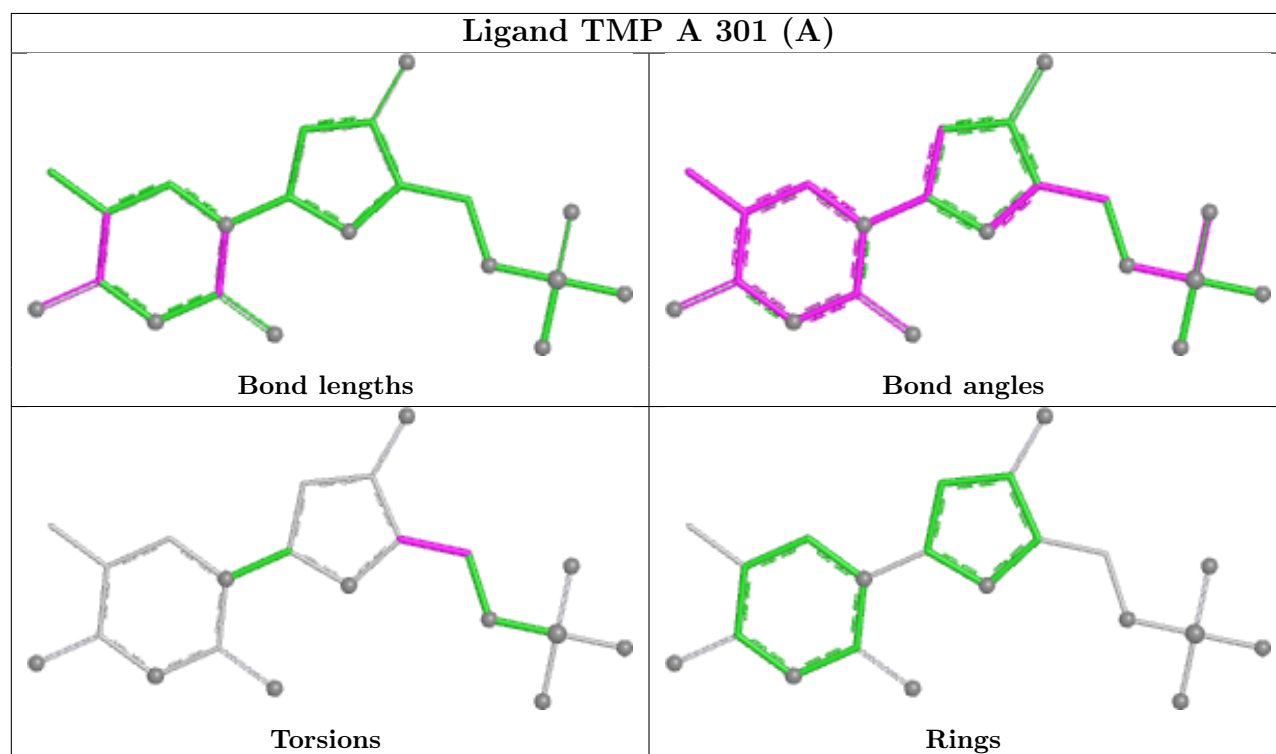
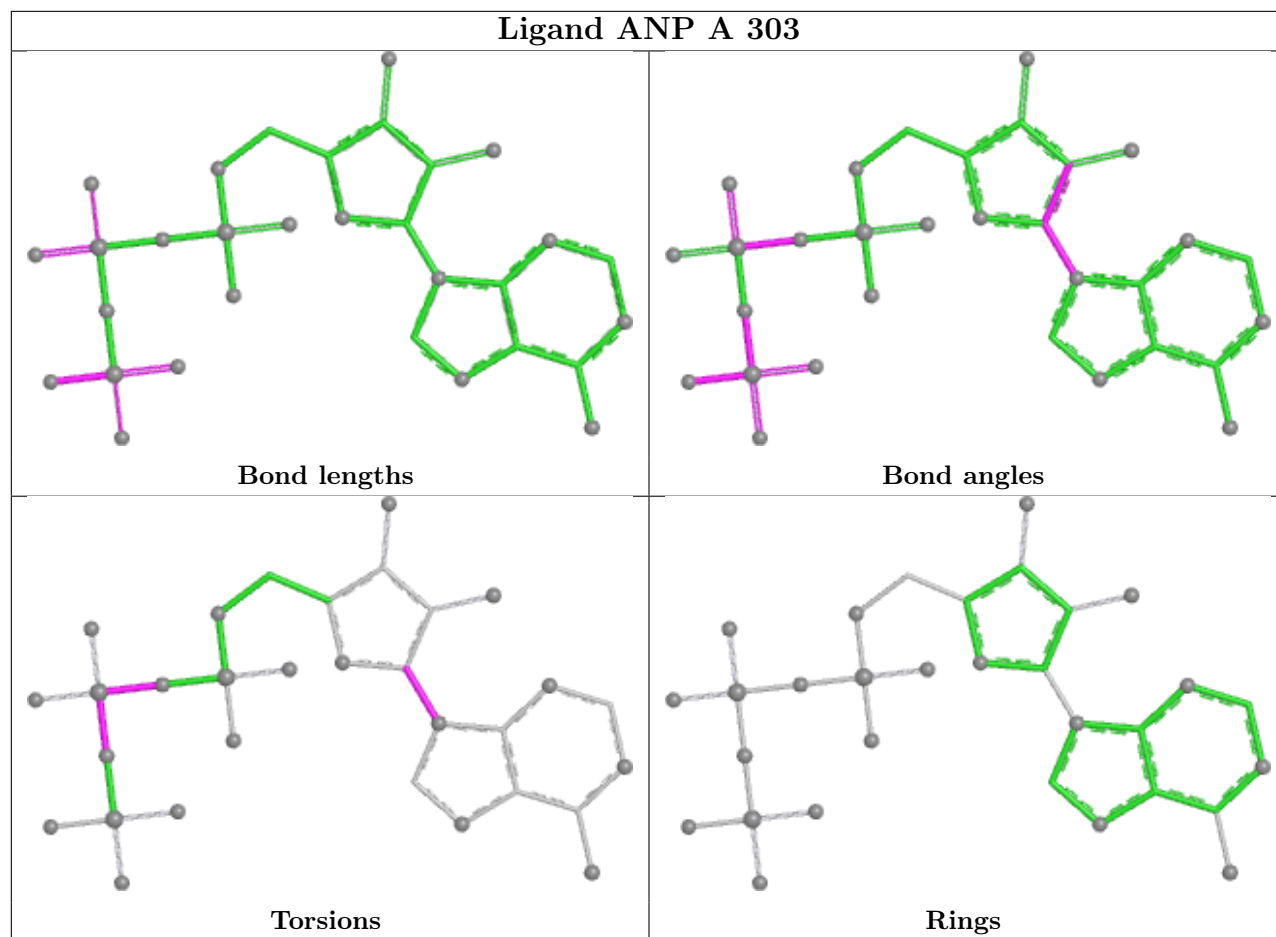
There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	A	303	ANP	1	0
2	A	301[A]	TMP	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 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

There are no such residues in this entry.

5.8 Polymer linkage issues

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.