



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 10, 2026 – 05:28 AM UTC

PDB ID : 1F4E / pdb_00001f4e
Title : CRYSTAL STRUCTURE OF E. COLI THYMIDYLATE SYNTHASE COM-
PLEXED WITH TOSYL-D-PROLINE
Authors : Erlanson, D.A.; Braisted, A.C.; Raphael, D.R.; Randal, M.; Stroud, R.M.;
Gordon, E.; Wells, J.A.
Deposited on : 2000-06-07
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 : 4-5-2 with Phenix2.0
Mogul : 2022.3.0, CSD as543be (2022)
Xtrriage (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

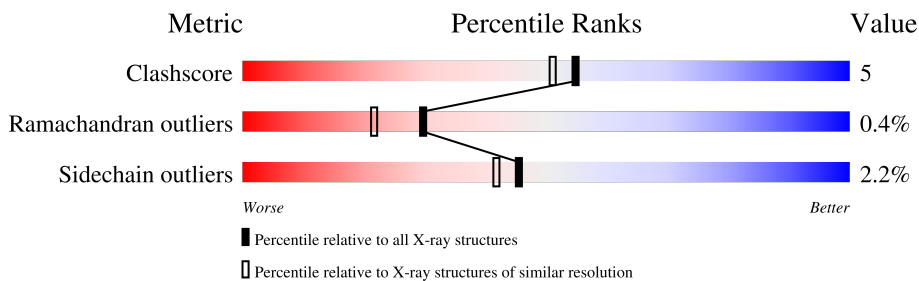
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.90 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	190562	8410 (1.90-1.90)
Ramachandran outliers	187476	8333 (1.90-1.90)
Sidechain outliers	187428	8333 (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	264	 80% 17%

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 2461 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 SYNTHASE.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	264	2168	1386	374	396	12	0	3	0

There is a discrepancy between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1	CXM	MET	engineered mutation	UNP P0A884

- Molecule 2 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



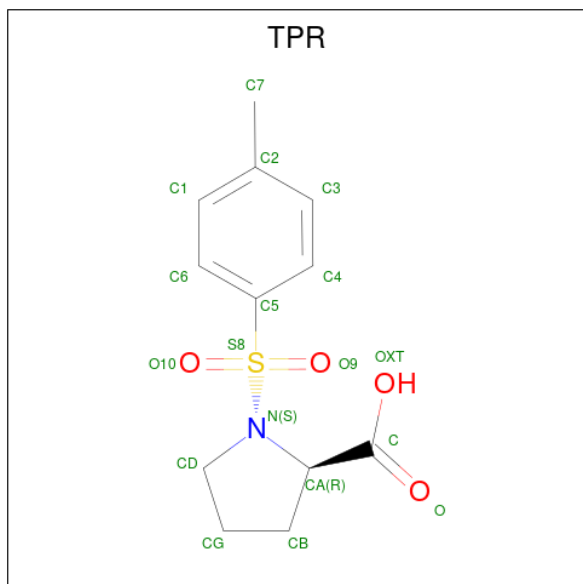
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
			Total	O	S		
2	A	1	5	4	1	0	0
2	A	1	5	4	1	0	0
2	A	1	5	4	1	0	0

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Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	O	S	0	0
			5	4	1		

- Molecule 3 is TOSYL-D-PROLINE (CCD ID: TPR) (formula: C₁₂H₁₅NO₄S).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf	
3	A	1	Total	C	N	O	S	0	0
			18	12	1	4	1		
3	A	1	Total	C	N	O	S	0	0
			18	12	1	4	1		

- Molecule 4 is GLYCEROL (CCD ID: GOL) (formula: C₃H₈O₃).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
4	A	1	Total C O 6 3 3	0	0
4	A	1	Total C O 6 3 3	0	0
4	A	1	Total C O 6 3 3	0	0

- Molecule 5 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	219	Total O 219 219	0	0

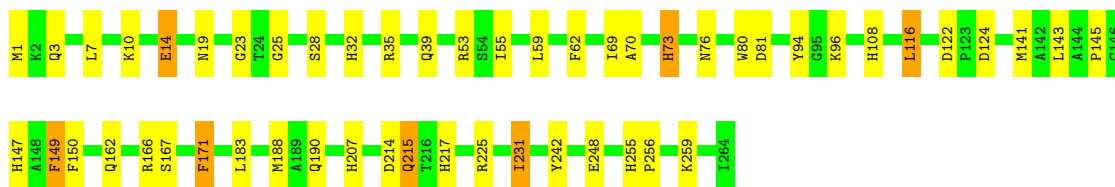
3 Residue-property plots [i](#)

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: THYMIDYLATE SYNTHASE

Chain A:  80% 17%



4 Data and refinement statistics

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

Property	Value	Source
Space group	I 21 3	Depositor
Cell constants a, b, c, α , β , γ	131.88Å 131.88Å 131.88Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	10.00 – 1.90	Depositor
% Data completeness (in resolution range)	99.9 (10.00-1.90)	Depositor
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	REFMAC	Depositor
R, R_{free}	0.192 , 0.238	Depositor
Estimated twinning fraction	No twinning to report.	Xtrriage
Total number of atoms	2461	wwPDB-VP
Average B, all atoms (Å ²)	36.0	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: SO4, CXM, TPR, GOL

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	0.69	0/2234	1.68	32/3033 (1.1%)

There are no bond length outliers.

All (32) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	149[A]	PHE	CA-CB-CG	13.12	126.92	113.80
1	A	149[B]	PHE	CA-CB-CG	13.12	126.92	113.80
1	A	147	HIS	CA-CB-CG	9.26	123.06	113.80
1	A	256	PRO	CA-C-N	9.08	128.64	119.92
1	A	256	PRO	C-N-CA	9.08	128.64	119.92
1	A	215	GLN	OE1-CD-NE2	-9.03	113.57	122.60
1	A	62	PHE	CA-CB-CG	8.56	122.36	113.80
1	A	53	ARG	NE-CZ-NH2	-8.36	111.68	119.20
1	A	150	PHE	CA-CB-CG	7.45	121.25	113.80
1	A	76	ASN	OD1-CG-ND2	-7.27	115.33	122.60
1	A	124	ASP	CA-CB-CG	7.05	119.65	112.60
1	A	108	HIS	CA-CB-CG	-6.92	106.88	113.80
1	A	214	ASP	CA-CB-CG	6.43	119.03	112.60
1	A	207	HIS	N-CA-C	6.30	118.75	109.24
1	A	256	PRO	CA-C-O	6.17	128.72	121.56
1	A	225	ARG	CD-NE-CZ	6.16	133.03	124.40
1	A	122	ASP	CA-C-N	5.85	126.26	119.47
1	A	122	ASP	C-N-CA	5.85	126.26	119.47
1	A	255	HIS	CA-CB-CG	5.79	119.58	113.80
1	A	70	ALA	CA-C-O	-5.73	114.44	120.63
1	A	73[A]	HIS	CA-C-O	-5.56	114.66	120.55
1	A	73[B]	HIS	CA-C-O	-5.56	114.66	120.55
1	A	23	GLY	N-CA-C	-5.50	107.19	114.95
1	A	162	GLN	OE1-CD-NE2	-5.35	117.25	122.60

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	171	PHE	CA-CB-CG	-5.30	108.50	113.80
1	A	28	SER	N-CA-CB	-5.28	101.68	111.13
1	A	96	LYS	CB-CG-CD	5.24	123.36	111.30
1	A	217	HIS	CA-CB-CG	-5.10	108.70	113.80
1	A	259	LYS	CA-C-O	5.07	127.30	121.47
1	A	255	HIS	N-CA-C	-5.06	101.68	109.87
1	A	69	ILE	CA-C-O	-5.05	114.46	120.78
1	A	231	ILE	CA-CB-CG2	5.01	119.02	110.50

There are no chirality outliers.

There are no planarity outliers.

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	2168	0	2092	21	0
2	A	20	0	0	0	0
3	A	36	0	30	2	0
4	A	18	0	24	2	0
5	A	219	0	0	2	0
All	All	2461	0	2146	21	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 5.

All (21) 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:166:ARG:HH12	4:A:401:GOL:H11	1.38	0.87
1:A:3[A]:GLN:NE2	1:A:35:ARG:O	2.07	0.86
1:A:55:ILE:HD11	3:A:301:TPR:HC1	1.71	0.72
1:A:73[A]:HIS:NE2	1:A:81:ASP:OD1	2.23	0.71
1:A:248:GLU:HA	4:A:402:GOL:H12	1.79	0.64
1:A:59:LEU:HD23	1:A:183:LEU:HD23	1.80	0.64
1:A:19:ASN:HD22	1:A:25:GLY:HA2	1.72	0.53

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:80:TRP:CZ3	1:A:143:LEU:HD21	2.48	0.49
1:A:73[A]:HIS:HE2	1:A:81:ASP:CG	2.20	0.47
1:A:190:GLN:NE2	1:A:242:TYR:OH	2.42	0.47
1:A:80:TRP:HZ3	1:A:143:LEU:HD21	1.80	0.45
1:A:141:MET:SD	1:A:145:PRO:HD3	2.57	0.45
1:A:143:LEU:HD23	1:A:143:LEU:N	2.32	0.45
1:A:7:LEU:HD13	1:A:32:HIS:CD2	2.54	0.43
1:A:55:ILE:HG12	5:A:570:HOH:O	2.19	0.42
1:A:116:LEU:HD13	1:A:188:MET:CE	2.49	0.42
1:A:166:ARG:HG3	1:A:167:SER:N	2.34	0.42
1:A:171:PHE:CZ	1:A:215:GLN:HB3	2.56	0.41
1:A:10:LYS:O	1:A:14:GLU:HG2	2.21	0.41
1:A:80:TRP:CZ2	3:A:301:TPR:HCB2	2.55	0.41
1:A:73[B]:HIS:CD2	5:A:458:HOH:O	2.73	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	265/264 (100%)	260 (98%)	4 (2%)	1 (0%)	30 22

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	94	TYR

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	235/232 (101%)	229 (97%)	6 (3%)	40 35

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	14	GLU
1	A	39	GLN
1	A	116	LEU
1	A	149[A]	PHE
1	A	149[B]	PHE
1	A	231	ILE

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	19	ASN
1	A	108	HIS
1	A	190	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](#)

1 non-standard protein/DNA/RNA residue is 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
1	CXM	A	1	1	9,10,11	2.26	1 (11%)	9,11,13	5.11	4 (44%)

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
1	CXM	A	1	1	-	3/9/10/12	-

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	1	CXM	CA-N	-6.21	1.37	1.46

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	1	CXM	ON1-CN-N	-12.99	103.56	124.86
1	A	1	CXM	CA-N-CN	-7.20	108.91	122.11
1	A	1	CXM	O-C-CA	-2.78	117.61	124.77
1	A	1	CXM	ON2-CN-ON1	-2.11	105.62	121.85

There are no chirality outliers.

All (3) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	A	1	CXM	ON2-CN-N-CA
1	A	1	CXM	O-C-CA-CB
1	A	1	CXM	ON1-CN-N-CA

There are no ring outliers.

No monomer is involved in short contacts.

5.5 Carbohydrates i

There are no oligosaccharides in this entry.

5.6 Ligand geometry

9 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	SO4	A	404	-	4,4,4	0.70	0	6,6,6	0.25	0
4	GOL	A	401	-	5,5,5	0.63	0	5,5,5	1.07	1 (20%)
3	TPR	A	302	-	19,19,19	4.70	4 (21%)	28,28,28	1.91	8 (28%)
2	SO4	A	403	-	4,4,4	0.61	0	6,6,6	0.16	0
4	GOL	A	408	-	5,5,5	0.98	0	5,5,5	0.19	0
2	SO4	A	409	-	4,4,4	0.70	0	6,6,6	0.29	0
4	GOL	A	402	-	5,5,5	0.72	0	5,5,5	0.47	0
2	SO4	A	405	-	4,4,4	0.63	0	6,6,6	0.29	0
3	TPR	A	301	-	19,19,19	5.15	4 (21%)	28,28,28	1.70	3 (10%)

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	TPR	A	301	-	-	6/16/26/26	0/2/2/2
3	TPR	A	302	-	-	0/16/26/26	0/2/2/2
4	GOL	A	408	-	-	4/4/4/4	-
4	GOL	A	402	-	-	4/4/4/4	-
4	GOL	A	401	-	-	0/4/4/4	-

All (8) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	301	TPR	O10-S8	14.56	1.59	1.43
3	A	301	TPR	O9-S8	14.26	1.58	1.43
3	A	302	TPR	O9-S8	12.85	1.57	1.43
3	A	302	TPR	S8-N	11.13	1.79	1.63
3	A	302	TPR	O10-S8	10.71	1.54	1.43

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Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	A	301	TPR	S8-N	8.81	1.76	1.63
3	A	302	TPR	OXT-C	2.22	1.37	1.30
3	A	301	TPR	OXT-C	2.03	1.37	1.30

All (12) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	301	TPR	O10-S8-O9	-6.58	109.32	119.59
3	A	302	TPR	O10-S8-C5	5.48	114.92	108.10
3	A	302	TPR	CA-N-S8	-4.33	109.94	119.77
3	A	302	TPR	C6-C5-S8	-3.29	116.47	119.73
3	A	302	TPR	C4-C5-S8	2.66	122.37	119.73
3	A	301	TPR	CB-CA-C	2.61	116.81	111.26
3	A	302	TPR	O10-S8-N	-2.54	102.53	106.97
3	A	302	TPR	CD-N-S8	-2.53	113.21	119.00
3	A	302	TPR	O10-S8-O9	-2.38	115.87	119.59
3	A	302	TPR	CB-CA-C	2.35	116.27	111.26
3	A	301	TPR	O9-S8-C5	2.22	110.86	108.10
4	A	401	GOL	O3-C3-C2	2.18	120.20	110.38

There are no chirality outliers.

All (14) torsion outliers are listed below:

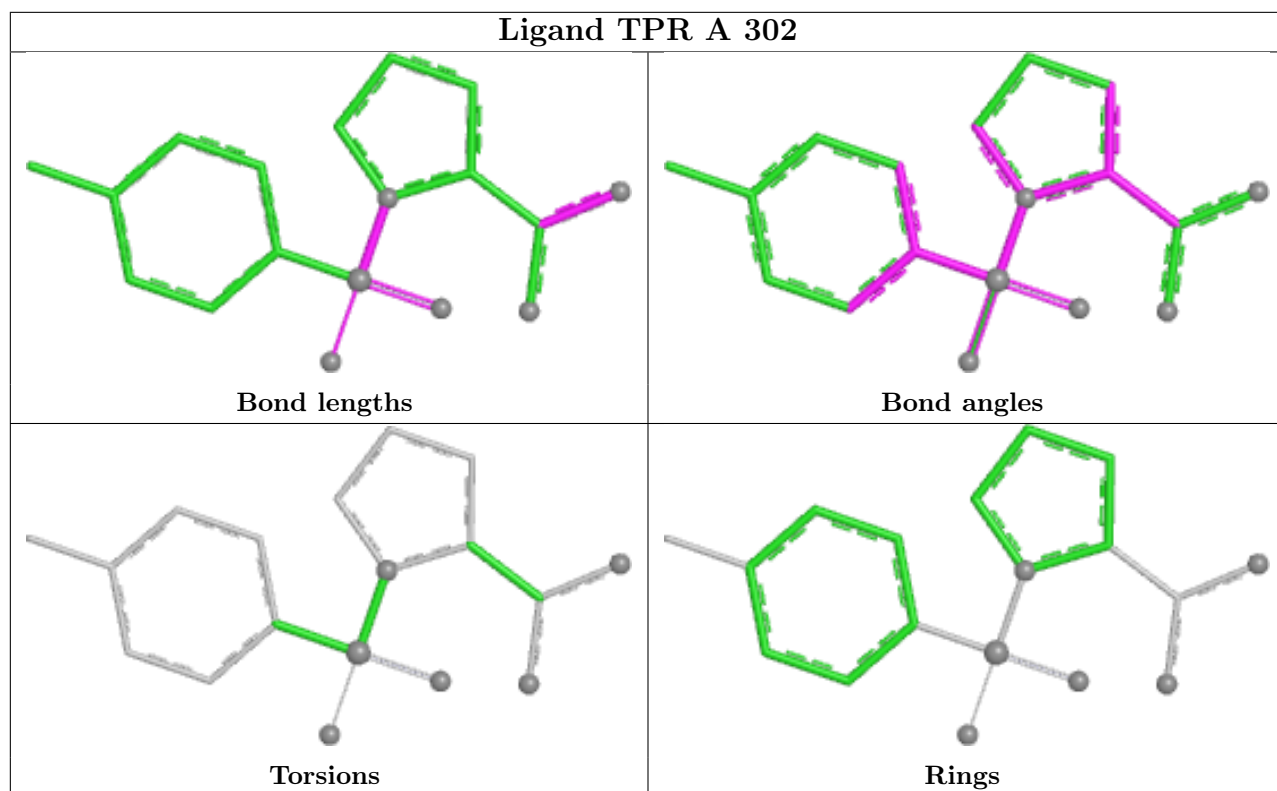
Mol	Chain	Res	Type	Atoms
3	A	301	TPR	CD-N-S8-C5
4	A	402	GOL	O1-C1-C2-C3
4	A	402	GOL	C1-C2-C3-O3
4	A	408	GOL	O1-C1-C2-C3
4	A	408	GOL	O1-C1-C2-O2
3	A	301	TPR	CA-N-S8-O9
3	A	301	TPR	CD-N-S8-O9
3	A	301	TPR	CD-N-S8-O10
4	A	408	GOL	C1-C2-C3-O3
4	A	402	GOL	O1-C1-C2-O2
4	A	402	GOL	O2-C2-C3-O3
3	A	301	TPR	CA-N-S8-C5
4	A	408	GOL	O2-C2-C3-O3
3	A	301	TPR	CA-N-S8-O10

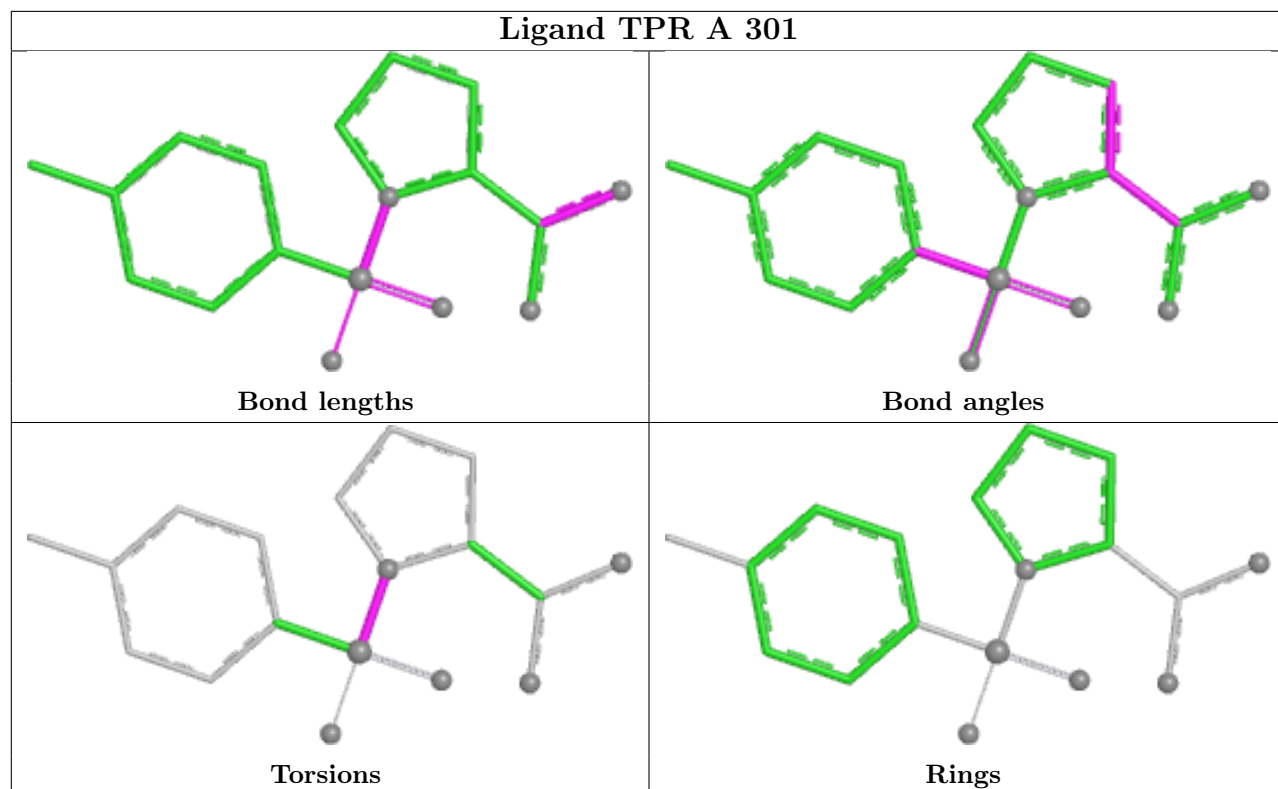
There are no ring outliers.

3 monomers are involved in 4 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	A	401	GOL	1	0
4	A	402	GOL	1	0
3	A	301	TPR	2	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 [i](#)

6.1 Protein, DNA and RNA chains [i](#)

EDS was not executed - this section is therefore empty.

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

EDS was not executed - this section is therefore empty.

6.3 Carbohydrates [i](#)

EDS was not executed - this section is therefore empty.

6.4 Ligands [i](#)

EDS was not executed - this section is therefore empty.

6.5 Other polymers [i](#)

EDS was not executed - this section is therefore empty.