



Full wwPDB X-ray Structure Validation Report ⓘ

May 29, 2020 – 04:29 am BST

PDB ID : 1FUP
Title : FUMARASE WITH BOUND PYROMELLITIC ACID
Authors : Weaver, T.; Banaszak, L.
Deposited on : 1996-08-29
Resolution : 2.30 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 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)
Xtriage (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) : 2.11

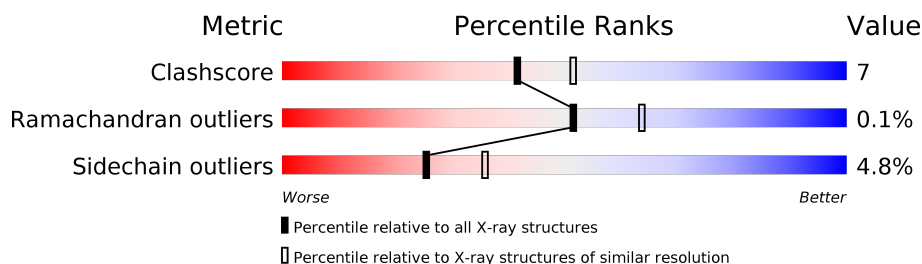
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.30 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	5643 (2.30-2.30)
Ramachandran outliers	138981	5575 (2.30-2.30)
Sidechain outliers	138945	5575 (2.30-2.30)

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 on 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	472	
1	B	472	

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	MLT	A	473	X	-	-	-
2	MLT	B	473	X	-	-	-

2 Entry composition [i](#)

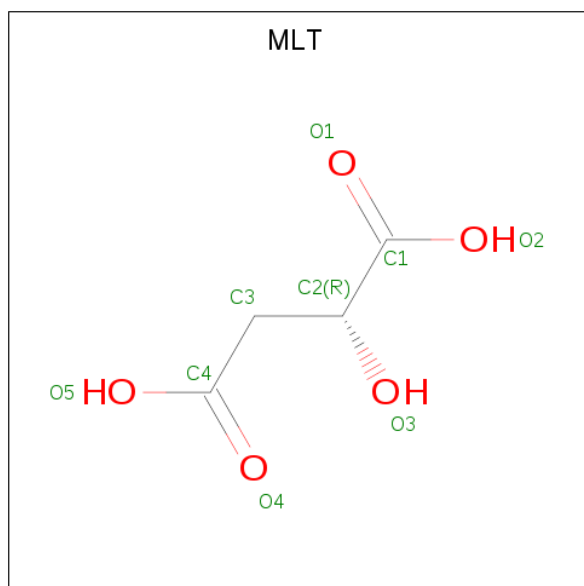
There are 4 unique types of molecules in this entry. The entry contains 7305 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 FUMARASE C.

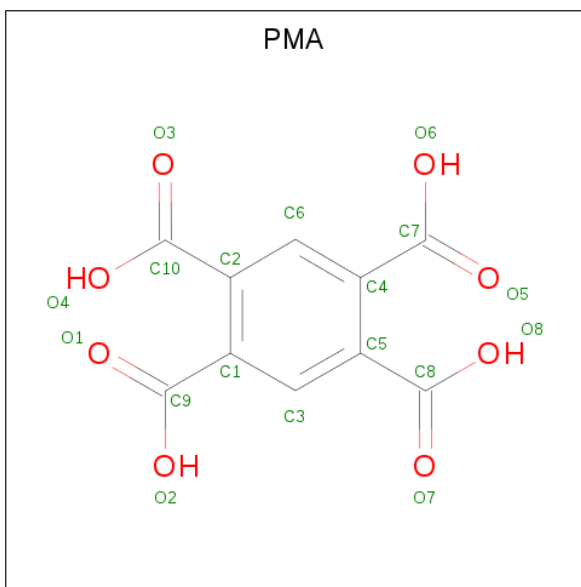
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	455	Total	C	N	O	S	0	0	0
			3449	2153	616	657	23			
1	B	455	Total	C	N	O	S	0	0	0
			3455	2157	617	657	24			

- Molecule 2 is D-MALATE (three-letter code: MLT) (formula: $C_4H_6O_5$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	C	O	0	0
			9	4	5		
2	B	1	Total	C	O	0	0
			9	4	5		

- Molecule 3 is PYROMELLITIC ACID (three-letter code: PMA) (formula: $C_{10}H_6O_8$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			18	10	8		
3	B	1	Total	C	O	0	0
			18	10	8		

- Molecule 4 is water.

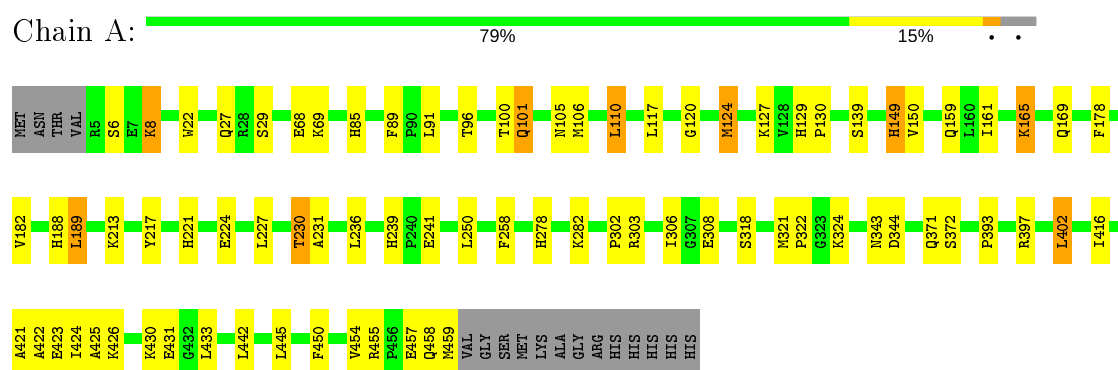
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	191	Total	O	0	0
			191	191		
4	B	156	Total	O	0	0
			156	156		

3 Residue-property plots

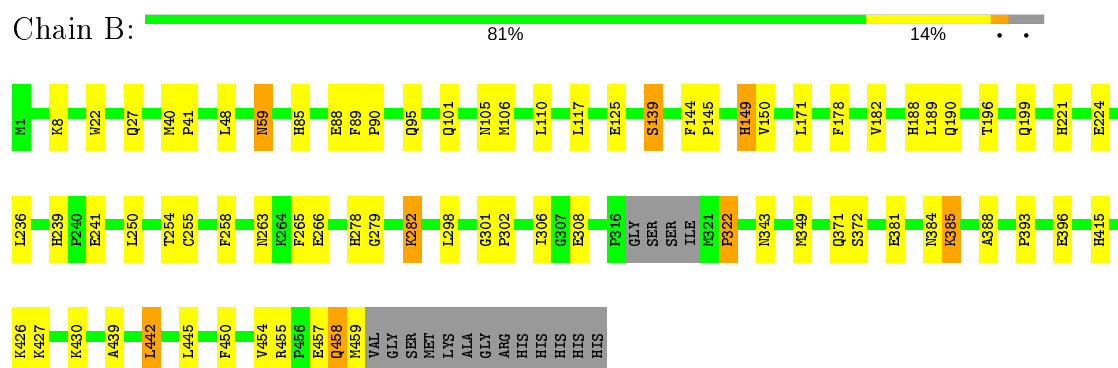
These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. Residues are color-coded according 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: FUMARASE C



• Molecule 1: FUMARASE C



4 Data and refinement statistics

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

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants a, b, c, α , β , γ	104.00 Å 219.90 Å 86.70 Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	8.00 – 2.30	Depositor
% Data completeness (in resolution range)	(Not available) (8.00-2.30)	Depositor
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
Refinement program	X-PLOR	Depositor
R, R_{free}	0.185 , 0.234	Depositor
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	7305	wwPDB-VP
Average B, all atoms (Å ²)	29.0	wwPDB-VP

5 Model quality

5.1 Standard geometry

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

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	0.34	0/3507	0.59	0/4750
1	B	0.35	0/3512	0.58	0/4756
All	All	0.34	0/7019	0.58	0/9506

There are no bond length outliers.

There are no bond angle outliers.

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	3449	0	3464	55	0
1	B	3455	0	3473	45	0
2	A	9	0	3	2	0
2	B	9	0	3	0	0
3	A	18	0	2	1	0
3	B	18	0	2	2	0
4	A	191	0	0	5	0
4	B	156	0	0	3	0
All	All	7305	0	6947	97	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 7.

All (97) 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:431:GLU:HB3	1:A:433:LEU:HD13	1.57	0.86
1:A:230:THR:HG23	1:A:231:ALA:H	1.47	0.77
1:A:343:ASN:HD21	1:A:371:GLN:HE21	1.35	0.75
1:A:455:ARG:HH11	1:A:458:GLN:HE22	1.39	0.70
1:B:263:ASN:HD22	1:B:266:GLU:H	1.41	0.69
1:B:427:LYS:HE2	1:B:442:LEU:HD13	1.75	0.67
1:B:439:ALA:HB1	1:B:445:LEU:HD21	1.77	0.66
1:A:230:THR:CG2	1:A:231:ALA:H	2.09	0.66
1:A:22:TRP:HE1	1:A:27:GLN:NE2	1.95	0.64
1:A:230:THR:HG22	4:A:492:HOH:O	1.98	0.64
1:A:423:GLU:HA	1:A:426:LYS:HD2	1.79	0.63
1:B:427:LYS:HE2	1:B:442:LEU:CD1	2.29	0.62
1:B:89:PHE:HA	1:B:105:ASN:HD21	1.64	0.62
1:A:85:HIS:HD2	4:A:543:HOH:O	1.83	0.60
1:B:415:HIS:HD2	4:B:566:HOH:O	1.84	0.60
1:B:22:TRP:HE1	1:B:27:GLN:NE2	1.99	0.60
1:A:445:LEU:HD13	1:A:450:PHE:HB2	1.84	0.60
1:A:129:HIS:ND1	2:A:473:MLT:H32	2.17	0.59
1:B:343:ASN:HD21	1:B:371:GLN:HE21	1.51	0.59
1:A:324:LYS:HZ3	1:B:190:GLN:HB2	1.67	0.59
1:A:91:LEU:HD13	1:A:101:GLN:HB3	1.85	0.58
1:A:188:HIS:O	1:A:189:LEU:HB2	2.03	0.58
1:A:306:ILE:HG22	1:A:308:GLU:HG3	1.84	0.58
1:B:125:GLU:HG2	4:B:584:HOH:O	2.01	0.58
1:A:318:SER:HB2	1:A:321:MET:HB2	1.85	0.58
1:B:415:HIS:HE1	4:B:565:HOH:O	1.87	0.57
1:B:450:PHE:CE1	1:B:454:VAL:HG11	2.40	0.57
1:A:149:HIS:HD2	1:A:224:GLU:O	1.89	0.56
1:A:230:THR:CG2	1:A:231:ALA:N	2.68	0.56
1:B:450:PHE:O	1:B:454:VAL:HG12	2.06	0.55
1:A:161:ILE:HG22	1:A:165:LYS:HE2	1.88	0.55
1:B:188:HIS:O	1:B:189:LEU:HB2	2.07	0.54
1:A:230:THR:HG21	1:A:236:LEU:O	2.08	0.54
1:A:89:PHE:HA	1:A:105:ASN:HD21	1.73	0.54
1:B:196:THR:H	1:B:199:GLN:NE2	2.06	0.54
1:B:139:SER:HB2	3:B:474:PMA:O1	2.08	0.54
1:B:239:HIS:HD2	1:B:241:GLU:H	1.55	0.53
1:A:421:ALA:O	1:A:424:ILE:HG12	2.09	0.53
1:A:124:MET:N	1:A:124:MET:SD	2.75	0.52
1:B:306:ILE:HG22	1:B:308:GLU:HG3	1.91	0.51

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:139:SER:CB	3:B:474:PMA:O1	2.58	0.51
1:B:22:TRP:HE1	1:B:27:GLN:HE21	1.58	0.50
1:A:324:LYS:NZ	1:B:190:GLN:HB2	2.27	0.49
1:A:425:ALA:HB1	1:B:322:PRO:HG2	1.94	0.49
1:A:302:PRO:HG2	1:A:303:ARG:HG2	1.93	0.49
1:A:278:HIS:HD2	1:A:344:ASP:OD1	1.94	0.48
1:A:22:TRP:HE1	1:A:27:GLN:HE21	1.59	0.48
1:B:263:ASN:ND2	1:B:266:GLU:H	2.08	0.48
1:A:213:LYS:HD2	1:A:217:TYR:CE2	2.49	0.47
1:A:178:PHE:CZ	1:A:393:PRO:HD3	2.49	0.47
1:B:178:PHE:CZ	1:B:393:PRO:HD3	2.49	0.47
1:B:455:ARG:O	1:B:458:GLN:HG3	2.14	0.47
1:A:68:GLU:HG3	1:A:69:LYS:N	2.30	0.47
1:A:454:VAL:O	1:A:454:VAL:HG13	2.15	0.47
1:B:8:LYS:HE3	1:B:8:LYS:HB2	1.67	0.46
1:A:130:PRO:HG2	2:A:473:MLT:O1	2.16	0.46
1:B:59:ASN:HA	1:B:59:ASN:HD22	1.62	0.46
1:A:150:VAL:HA	1:A:258:PHE:CZ	2.50	0.46
1:A:8:LYS:HB2	1:A:8:LYS:NZ	2.31	0.46
1:B:196:THR:H	1:B:199:GLN:HE21	1.63	0.45
1:A:455:ARG:NH1	1:A:458:GLN:HE22	2.08	0.45
1:A:149:HIS:HE1	4:A:506:HOH:O	1.98	0.45
1:B:426:LYS:O	1:B:430:LYS:HD3	2.17	0.45
1:A:424:ILE:HG22	1:A:442:LEU:HD23	1.99	0.45
1:B:144:PHE:HB3	1:B:145:PRO:HD3	1.99	0.45
1:B:95:GLN:HB2	1:B:101:GLN:NE2	2.31	0.45
1:A:106:MET:O	1:A:110:LEU:HB2	2.17	0.44
1:A:239:HIS:CD2	1:A:241:GLU:H	2.35	0.44
1:A:6:SER:O	1:A:124:MET:SD	2.75	0.44
1:A:120:GLY:CA	1:A:127:LYS:HE2	2.47	0.44
1:A:416:ILE:HG23	1:A:421:ALA:HB2	1.99	0.43
1:A:29:SER:OG	1:A:101:GLN:HG3	2.18	0.43
1:B:85:HIS:HB3	1:B:88:GLU:HG3	2.00	0.43
1:B:182:VAL:HG21	1:B:457:GLU:HA	1.98	0.43
1:A:343:ASN:HD21	1:A:371:GLN:NE2	2.09	0.43
1:A:422:ALA:O	1:A:426:LYS:HG3	2.19	0.43
1:A:424:ILE:HG22	1:A:442:LEU:CD2	2.49	0.43
1:A:96:THR:HG21	1:A:100:THR:HB	1.99	0.43
1:B:263:ASN:HD21	1:B:265:PHE:HB2	1.84	0.43
1:B:384:ASN:HA	1:B:388:ALA:HB3	2.00	0.42
1:B:150:VAL:HA	1:B:258:PHE:CZ	2.54	0.42

Continued on next page...

Continued from previous page...

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:301:GLY:HA3	1:B:302:PRO:HA	1.85	0.42
1:B:279:GLY:O	1:B:282:LYS:HG3	2.20	0.42
1:A:278:HIS:HE1	1:A:372:SER:OG	2.02	0.41
1:B:106:MET:O	1:B:110:LEU:HB2	2.20	0.41
1:A:139:SER:HB2	3:A:474:PMA:O1	2.20	0.41
1:B:40:MET:HA	1:B:41:PRO:HD3	1.95	0.41
1:A:182:VAL:HG12	1:A:402:LEU:HD11	2.02	0.41
1:A:182:VAL:HG21	1:A:457:GLU:HA	2.02	0.41
1:A:227:LEU:HD23	1:A:227:LEU:HA	1.88	0.41
1:B:278:HIS:HE1	1:B:372:SER:OG	2.04	0.41
1:A:450:PHE:O	1:A:454:VAL:HG12	2.20	0.41
1:B:381:GLU:HG2	1:B:385:LYS:HE2	2.03	0.41
1:A:322:PRO:HD2	4:A:611:HOH:O	2.21	0.41
1:B:254:THR:O	1:B:255:CYS:HB2	2.21	0.40
4:A:635:HOH:O	1:B:349:MET:HE3	2.22	0.40
1:B:149:HIS:HD2	1:B:224:GLU:O	2.05	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	453/472 (96%)	434 (96%)	19 (4%)	0	100	100
1	B	451/472 (96%)	435 (96%)	15 (3%)	1 (0%)	47	58
All	All	904/944 (96%)	869 (96%)	34 (4%)	1 (0%)	51	64

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	322	PRO

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	367/381 (96%)	349 (95%)	18 (5%)	25	35
1	B	368/381 (97%)	351 (95%)	17 (5%)	27	38
All	All	735/762 (96%)	700 (95%)	35 (5%)	25	36

All (35) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	8	LYS
1	A	101	GLN
1	A	110	LEU
1	A	117	LEU
1	A	124	MET
1	A	149	HIS
1	A	159	GLN
1	A	165	LYS
1	A	169	GLN
1	A	189	LEU
1	A	221	HIS
1	A	230	THR
1	A	250	LEU
1	A	282	LYS
1	A	397	ARG
1	A	402	LEU
1	A	430	LYS
1	A	459	MET
1	B	48	LEU
1	B	59	ASN
1	B	90	PRO
1	B	117	LEU
1	B	139	SER
1	B	149	HIS
1	B	171	LEU
1	B	221	HIS
1	B	236	LEU

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
1	B	250	LEU
1	B	282	LYS
1	B	298	LEU
1	B	385	LYS
1	B	396	GLU
1	B	442	LEU
1	B	458	GLN
1	B	459	MET

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (35) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	27	GLN
1	A	85	HIS
1	A	105	ASN
1	A	149	HIS
1	A	163	GLN
1	A	169	GLN
1	A	172	ASN
1	A	210	HIS
1	A	239	HIS
1	A	278	HIS
1	A	329	GLN
1	A	339	GLN
1	A	368	ASN
1	A	371	GLN
1	A	386	HIS
1	A	399	ASN
1	A	458	GLN
1	B	27	GLN
1	B	59	ASN
1	B	101	GLN
1	B	105	ASN
1	B	149	HIS
1	B	163	GLN
1	B	169	GLN
1	B	199	GLN
1	B	214	HIS
1	B	239	HIS
1	B	263	ASN
1	B	278	HIS
1	B	329	GLN

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
1	B	339	GLN
1	B	368	ASN
1	B	371	GLN
1	B	415	HIS
1	B	429	HIS

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

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

5.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

5.6 Ligand geometry ⓘ

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	$\# Z > 2$
3	PMA	B	474	-	10,18,18	2.45	2 (20%)	6,26,26	0.38	0
3	PMA	A	474	-	10,18,18	2.08	2 (20%)	6,26,26	0.47	0
2	MLT	B	473	-	2,8,8	1.03	0	3,10,10	7.34	3 (100%)
2	MLT	A	473	-	2,8,8	0.60	0	3,10,10	7.43	3 (100%)

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	PMA	B	474	-	-	0/0/16/16	0/1/1/1
3	PMA	A	474	-	-	0/0/16/16	0/1/1/1
2	MLT	B	473	-	1/1/3/3	1/2/8/8	-
2	MLT	A	473	-	1/1/3/3	1/2/8/8	-

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
3	B	474	PMA	C1-C9	6.12	1.53	1.47
3	A	474	PMA	C2-C10	5.60	1.52	1.47
3	B	474	PMA	C2-C10	3.71	1.51	1.47
3	A	474	PMA	C1-C9	3.04	1.50	1.47

All (6) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	473	MLT	O3-C2-C3	11.93	134.71	108.50
2	B	473	MLT	O3-C2-C3	11.82	134.48	108.50
2	A	473	MLT	C3-C2-C1	4.00	116.18	111.10
2	B	473	MLT	C3-C2-C1	3.85	115.99	111.10
2	A	473	MLT	O3-C2-C1	-2.75	103.39	111.66
2	B	473	MLT	O3-C2-C1	-2.63	103.74	111.66

All (2) chirality outliers are listed below:

Mol	Chain	Res	Type	Atom
2	B	473	MLT	C2
2	A	473	MLT	C2

All (2) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
2	B	473	MLT	C1-C2-C3-C4
2	A	473	MLT	C1-C2-C3-C4

There are no ring outliers.

3 monomers are involved in 5 short contacts:

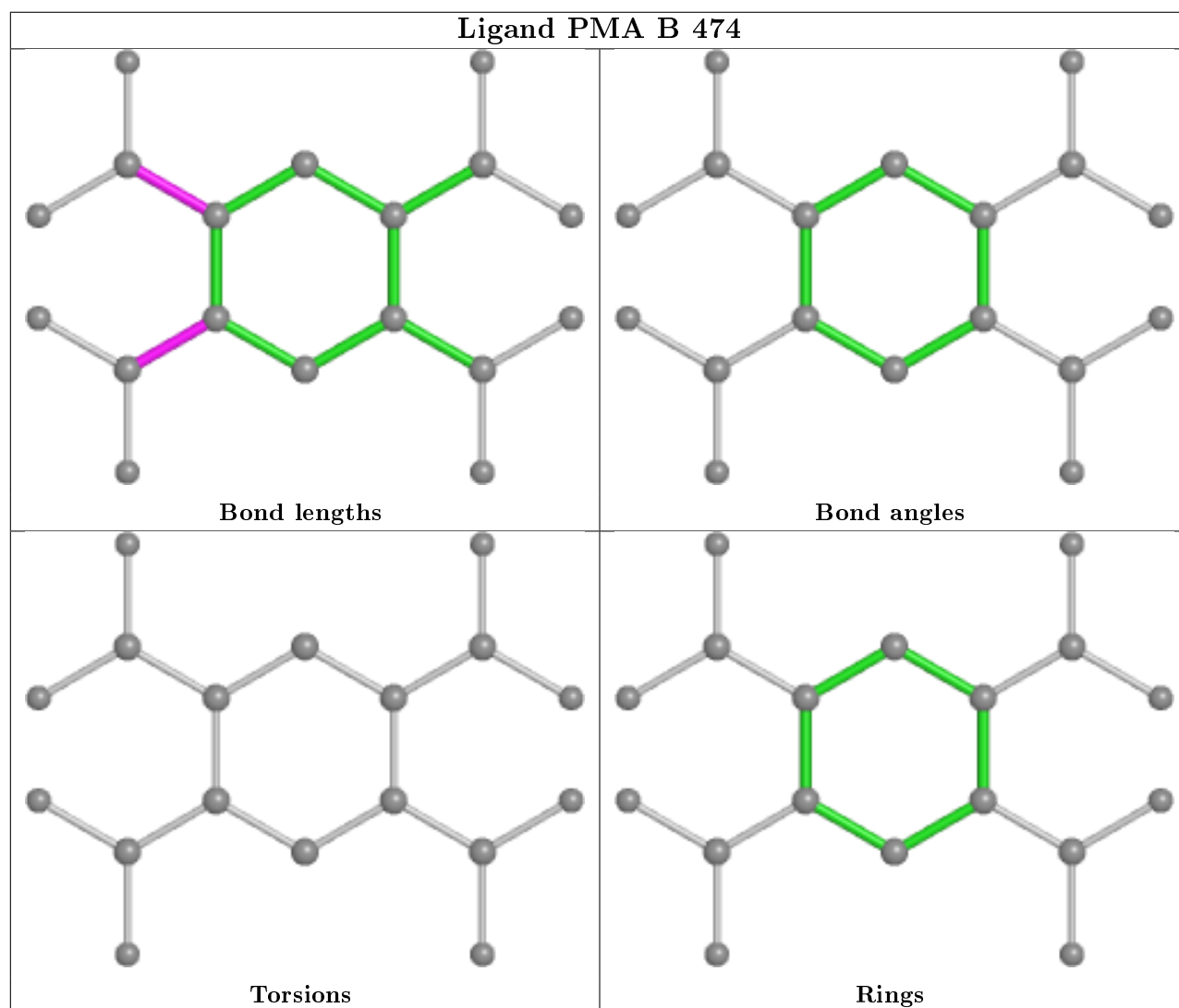
Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	B	474	PMA	2	0

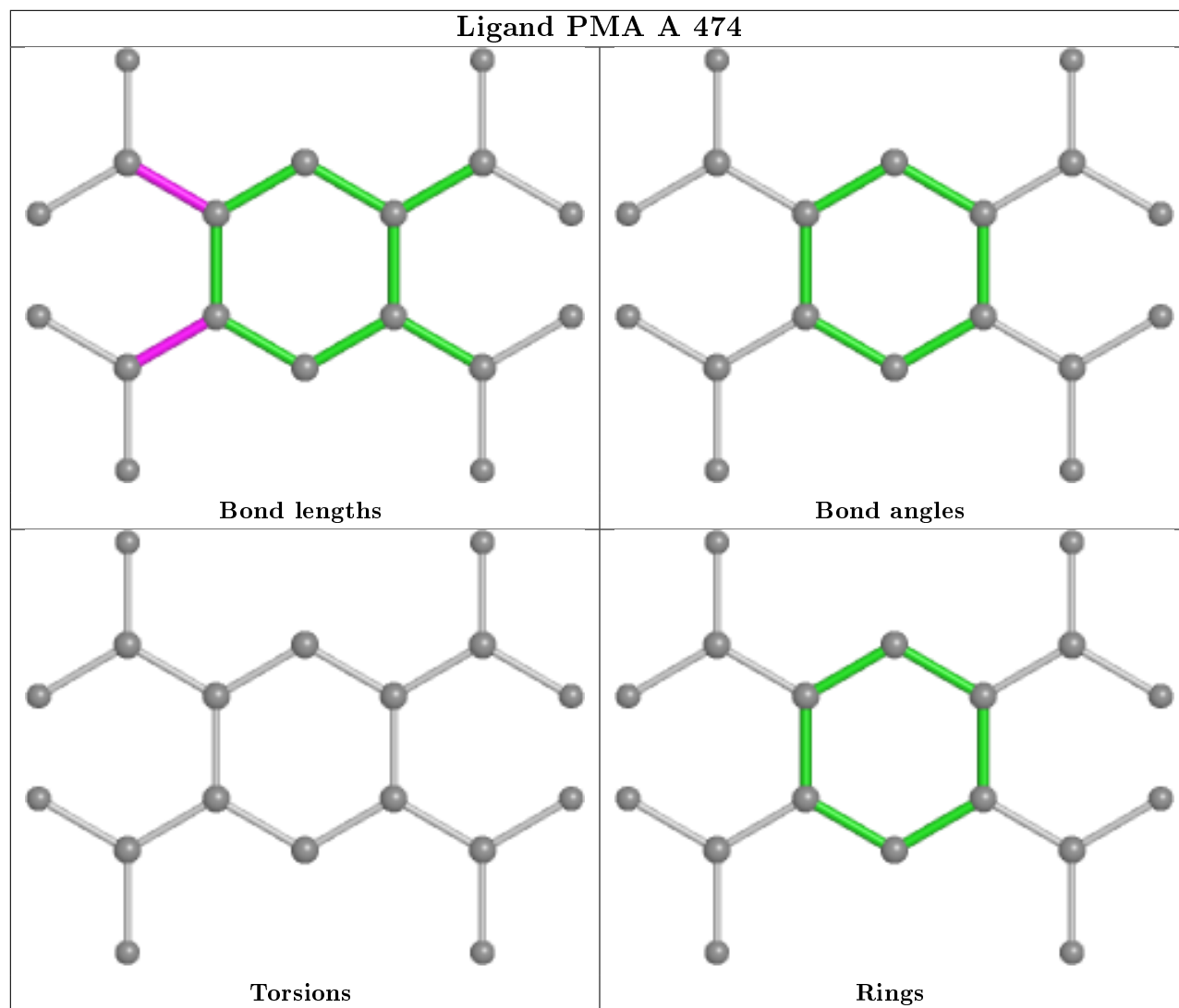
Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	474	PMA	1	0
2	A	473	MLT	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 ⓘ

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.